SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-4

GOVERNOR SYSTEM SPECIFICATIONS (SPGOV)

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-4

GOVERNOR SYSTEM SPECIFICATIONS (SPGOV)

SPGOV1 GENERAL

1.1 Definitions

In this Appendix 6-4 [Governor System Specifications (SPGOV)], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Auto-Mode**" has the meaning set out in SPGOV 3.2(a)(i);

"**Deadtime**" has the meaning set out in SPGOV 2.4;

"**Droop**" has the meaning set out in SPGOV 2.2(c)(ii);

"**Gate Limit Setpoint**" has the meaning set out in SPGOV 3.3(a);

"**Gate Position Error**" has the meaning set out in SPGOV 2.2(b)(i);

"**Gate Position Setpoint**" or "**Gate Setpoint**" has the meaning set out in SPGOV 2.1(b);

"**Gate Position Switch**" has the meaning set out in SPGOV 4.6;

"**Generate Mode**" has the meaning set out in SPGOV 3.2(d)(i);

"**Generator VT Speed Sensing System**" has the meaning set out in SPGOV 4.2.1;

"**Governor Configuration Software**" has the meaning set out in SPGOV 3.13.2;

"**Governor Control Cabinet**" or "**GCC**" has the meaning set out in SPGOV 5.2;

"**Governor Design Pressure**" has the meaning set out in SPGOV 6.1.2;

"**Governor Hardwired Controls**" has the meaning set out in SPGOV 5.2.4;

"**Governor HPU**" has the meaning set out in SPGOV 6.1.1;

"**Governor PLC**" has the meaning set out in SPGOV 5.2.2;

"**Governor Setpoint**" has the meaning set out in SPGOV 3.4;

"**Governor Shutdown Solenoid**" has the meaning set out in SPGOV 6.10;

"**Governor Software**" has the meaning set out in SPGOV 3.13.1;

"**Governor Speed Switch**" has the meaning set out in SPGOV 4.5;

"**Governor System**" or "**Governor**" has the meaning set out in SPGOV 1.2;

"**Governor System Data Table**" has the meaning set out in SPGOV 3.13.4;

"**Isolated Load Mode**" has the meaning set out in SPGOV 3.2(c)(iii);

"**Isolated Load Settings**" has the meaning set out in SPGOV 3.2(c)(iii)(B);

"**Isolation Detector**" has the meaning set out in SPGOV 4.8;

"**Manual Mode**" has the meaning set out in SPGOV 3.2(a)(ii);

"**Maximum Offline Wicket Gate Limit**" has the meaning set out in SPGOV 3.3(d)(iv);

"**Maximum Online Wicket Gate Limit**" has the meaning set out in SPGOV 3.3(d)(v);

"**Measured Gate Position**" has the meaning set out in SPGOV 4.4;

"**Measured Running Bus Frequency**" has the meaning set out in SPGOV 4.2.3;

"**Measured Unit Power**" has the meaning set out in SPGOV 4.7;

"**Measured Unit Speed**" has the meaning set out in SPGOV 4.2.4;

"**Offline Mode**" has the meaning set out in SPGOV 3.2(c)(i);

"**Offline Settings**" has the meaning set out in SPGOV 3.2(c)(i)(B);

"**Online Mode**" has the meaning set out in SPGOV 3.2(c)(ii);

"**Online Settings**" has the meaning set out in SPGOV 3.2(c)(ii)(B);

"**PD Transfer Function**" has the meaning set out in SPGOV 2.2(b);

"**Permanent Speed Droop**" has the meaning set out in SPGOV 2.2(c);

"**PID Transfer Function**" has the meaning set out in SPGOV 2.2(a);

"**Power Droop**" or "**Speed Regulation**" has the meaning set out in SPGOV 3.2(b)(i);

"**Power Error**" has the meaning set out in SPGOV 2.2(c)(i);

"**Power Setpoint**" has the meaning set out in SPGOV 2.1(c);

"**Running Bus VT Speed Sensing System**" has the meaning set out in SPGOV 4.2.3;

"**Setpoint Feedforward**" has the meaning set out in SPGOV 2.2(d);

"**Soft Start Stages**" has the meaning set out in SPGOV 3.6.2(b);

"**Speed Deadband**" has the meaning set out in SPGOV 2.4;

"**Speed Error**" has the meaning set out in SPGOV 2.2(a)(i);

"**Speed Setpoint**" or "**Speed Reference**" has the meaning set out in SPGOV 2.1(a);

"**Synchronous Condense Mode**" has the meaning set out in SPGOV 3.2(d)(ii);

"**Wicket Gate Droop**" has the meaning set out in SPGOV 3.2(b)(ii); and

"**ZVPU Probe**" has the meaning set out in SPGOV 4.2.2(a).

In addition to the above, words and phrases used in this Appendix 6-4 [Governor System Specifications (SPGOV)] which are not defined elsewhere in this Agreement but which are defined in Section 3 (Definitions) of IEEE125 will have the meanings assigned to them such Section 3 (Definitions).

1.2 Scope of Work

The Contractor will provide a Turbine governor system (the "**Governor System**" or "**Governor**") with each Unit, designed to achieve control of Turbine speed and power via hydraulic actuation of wicket gate servomotors. The Governor System will be of the electro-hydraulic type, and include:

(a) a Governor Control Cabinet;

(b) instrumentation systems, including:

  (i) Turbine speed sensing systems;

  (ii) Turbine wicket gate and distributing valve position sensing systems; and

  (iii) pressure, level, and temperature sensing systems;

(c) a hydraulic power unit and accumulator;

(d) Governor compressed air system;

(e) all necessary interconnections between the components listed above and to other Equipment; and

(f) all other parts and materials necessary to achieve functionality outlined in the requirements of Schedule 6 [Specifications and Drawings].

1.3 Submittals

In addition to the requirements of Appendix 6-1 [General Specifications (SPGS)] the following will be submitted:

(a) Calculation Reports to include sizing of all mechanical components of the HPU;

(b) Calculation Reports to include all requirements of SPGOV 2.6;

(c) Calculation Reports to include Governor models and data in PTI PSS/e format as required for system studies by Others;

(d) Calculation Reports to include results of computer model simulation studies conducted by the Contractor pursuant to section 6.1.3 and 6.1.4 of IEEE 125;

(e) Governor Software Design Plan;

(f) Governor Software at 30%, 70% and 90% Design intervals in native file format and as a [.pdf];

(g) final Governor Software in native file format and as a [.pdf]; and

(h) Block Diagrams of the Governor System that include:

(i) illustration of all AC and DC circuits, protection devices/modules, control devices/modules, isolation points, data communications links, and interconnections; and,

(ii) a representation of the dynamic relationship between Turbine speed and wicket gate servo positions, in Laplace transform notation, and including details of all significant non-linearities in the electrical and hydraulic equipment.

SPGOV2 GOVERNOR SYSTEM PERFORMANCE REQUIREMENTS

2.1 Control Algorithm

The Governor System will include a programmable closed-loop control algorithm intended to achieve accurate and stable control of the Turbine, as appropriate for the specific operating mode that the Governor System may be in, and according to the following control setpoints:

(a) the Unit speed setpoint (the "**Speed Setpoint**" or "**Speed Reference**") is the desired speed of the Unit;

(b) the Unit wicket gate position setpoint (the "**Gate Position Setpoint**" or "**Gate Setpoint**") is the desired position of the Turbine wicket gates; and

(c) the Unit power setpoint (the "**Power Setpoint**") is the desired real power output of the Unit.

2.2 Control Algorithm Elements

The Governor System programmable closed-loop control algorithm will be based on the following elements:

(a) a three-element PID (proportional, integral, derivative) transfer function (the "**PID Transfer Function**"), that includes:

(i) a summing junction that determines the difference (the "**Speed Error**") between its two inputs, Speed Setpoint and Measured Unit Speed;

(ii) proportional and integral functions that each utilize Speed Error as an input;

(iii) a derivative function that allows either Speed Error or Measured Speed to be selected as the input; and

(iv) a summing junction that adds output signals from the proportional, integral, and derivative elements to produce a Gate Position Setpoint signal as its output;

(b) a two-element PD (proportional, derivative) transfer function (the "**PD Transfer Function**"), connected in series with the PID Transfer Function, that includes:

(i) a summing junction that determines the difference (the "**Gate Position Error**") between its two inputs, Gate Position Setpoint and Measured Gate Position;

(ii) a proportional function that utilizes Gate Position Error as its input;

(iii) a derivative function that allows either Gate Position Error or Measured Gate Position to be selected as the input; and

(iv) a summing junction that adds output signals from the proportional and derivative functions to produce a wicket gate control command signal as its output;

(c) permanent speed droop functionality ("**Permanent Speed Droop**"), that allows the Unit to share power system load changes in proportion to its rated output, and that:

(i) includes a summing junction that determines the difference (the "**Power Error**") between its two inputs, Power Setpoint and Measured Unit Power;

(ii) includes a droop gain (the "**Droop**") that allows either Power Error or Gate Position Error to be selected as the input (the droop feedback parameter), and has its output connected to modify (i.e., sum with) the Speed Setpoint; and

(iii) causes the Unit to perform linearly, such that the change in Unit speed will be the same for equal changes of the feedback parameter (Power Error or Gate Position Error).

(d) a method of compensation ("**Setpoint Feedforward**"), intended to achieve a faster Governor System response to a change in Power Setpoint. Setpoint Feedforward functionality will include application of compensation for the nonlinear wicket gate versus power characteristic of the Turbine at rated NSHE. For information and reference and without limiting this requirement, one possible method of providing Setpoint Feedforward functionality is described here for reference:

(i) the Power Setpoint is converted to the estimated Gate Position Setpoint using a programmable quadratic equation. When the Governor is operating in Wicket Gate Droop mode the quadratic equation will be replaced with a unity gain;

(ii) the estimated wicket gate setpoint is fed forward through a first-order lag function that:

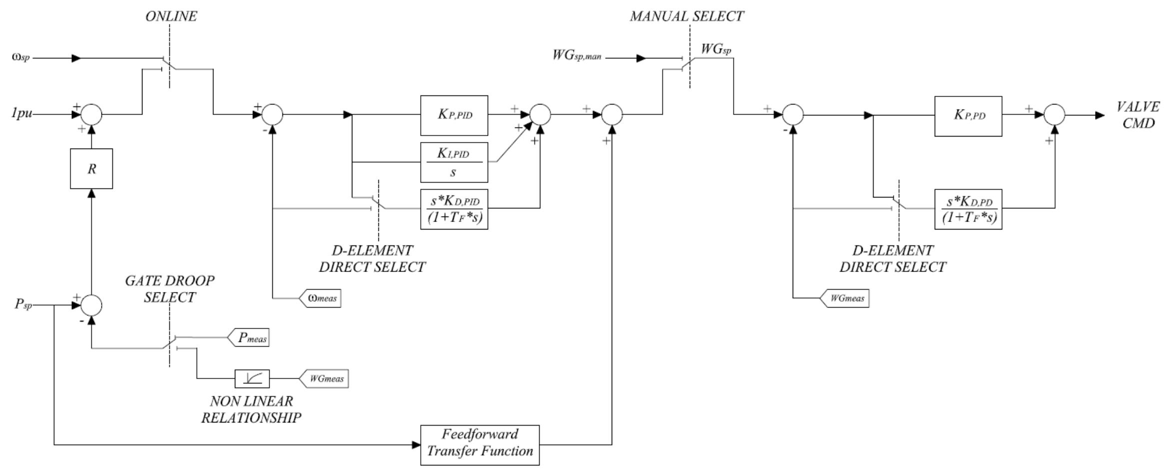
(A) includes a rate limit, expressed as a percentage of the maximum range of the input, that is on-line tunable from 0.1% per second to 100% per second, in steps of 0.1% or less;

(B) includes a first-order lag time constant (i.e., the time required for the output to reach 63% of its final steady state value in response to a step input), that is on-line tunable from 0 to 50 seconds in steps of 0.1 seconds or less; and

(C) includes a validation check of settings assigned to the rate limit and first-order lag time constant, to flag when the combination of selected settings may inhibit functionality; and

(iii) the output of the first-order lag function is used to modify (i.e., sum with) the Gate Position Setpoint.

The illustration below provides an overview of an implementation of the control algorithm described above:



2.3 <u>Stability</u>

The Governor System will be capable of controlling and regulating the Turbine speed, wicket gate position, and power, with an adequate margin of stability (as outlined below), under each of the following conditions, or any combination of these conditions:

(a) during isolated operation (connected to a load, with few or no other generating units operating in parallel with it);

(b) during offline operation, including Unit startup and synchronization;

(c) during Unit shutdown (including normal and protection-initiated shutdown sequences);

(d) any Unit power output over the full range of Unit power outputs from zero to Maximum Unit Output; and

(e) during transient conditions including generation ramping, load shedding, load rejection, or power system disturbances.

The Governor System will meet the following minimum stability requirements:

(f) <u>Sustained Conditions</u>:

(i) *Steady-State Governing Speed Band (speed stability index)*: The magnitude of the envelope of the steady state speed oscillation caused by the Governor System will not exceed 0.1% of rated speed when:

(A) when the Unit is offline (speed-no-load condition);

(B) when the Unit is online, at rated speed, connected to a constant isolated load with Droop set at 5%.

(ii) *Steady-State Governing Load Band (power stability index)*: The magnitude of the envelope of the steady-state Unit output power oscillation caused by the Governor System will not exceed 0.2% of the Maximum Unit Output when:

(A) the Unit is operating online, with a constant power setpoint, in parallel with many other units in an integrated multi-plant power system, with the Droop set at 5%, and excluding operation in any designated Turbine rough load zones;

(B) the Unit is operating online, with a constant wicket gate setpoint, in parallel with many other units in an integrated multi-plant power system, with the Droop set at 5%, and excluding operation in any designated Turbine rough load zones.

(g) <u>Load Rejection</u>: Subsequent to rejection of any Unit load (up to and including the Maximum Unit Output), the Governor System will act to restore the Unit speed to the nominal speed reference, as may be modified by the Speed Regulation setting, without exceeding:

(i) the Spiral Case Design Pressure specified in Appendix 6-3 [Turbine Specifications (SPT)];

(ii) one Unit underspeed deviation (of 5% or less of rated speed); and

(iii) one Unit overspeed deviation (of 2% or less of rated speed) subsequent to the initial Unit overspeed and underspeed deviation.

(h) <u>Speed control during fluctuating isolated load operation</u>: With the Unit operating connected to an isolated resistive load of 90% of the Maximum Unit Output, and with hydraulic head anywhere between +/-10% of rated head, the Governor System will be capable of providing damped control of Turbine speed that:

(i) when the Unit is subjected to a sudden load change of +5% of Maximum Unit Output, achieves attenuation of the peak amplitude of the second Turbine underspeed deviation to at least 25% that of the first; and

(ii) when the Unit is subjected to a sudden load change of -5% of Maximum Unit Output, achieves attenuation of the peak amplitude of the second Turbine overspeed deviation to at least 25% that of the first.

The Contractor will perform stability studies in accordance with Sections 6.1.3 and 6.1.4 of IEEE 125.

2.4 <u>Speed Deadband and Deadtime</u>

The Governor speed deadband (the "**Speed Deadband**") is the maximum change in steady-state Unit speed, expressed as a percentage of rated speed, and with Droop set to zero, required to reverse the direction of travel of the wicket gate servomotors. The Speed Deadband at rated speed will not exceed 0.02% of rated speed at any wicket gate position. One half of the Speed Deadband is the Governor speed insensitivity.

The Governor deadtime (or "**Deadtime**") is the elapsed time between a change in Unit speed and the onset of wicket gate servomotor movement as a result of corrective action by the Governor System. The Governor System will function such that the Deadtime does not exceed 0.2 s for a Speed Setpoint change of 0.1 Hz or larger.

2.5 Select Before Operate Control

Except where otherwise explicitly stated in this Appendix 6-4 [Governor System Specifications (SPGOV)], control commands issued to the Governor System by a Worker using the Governor HMI will be issued via a two-step select-before-operate (SBO) process (intended to cause deliberate operator action and reduce the possibility of operator error), whereby:

(a) Step 1: the Worker issues a command to select the control point to be acted upon, this selection is latched in by the Governor System, and indication of the latched-in selection is sent back to the Governor HMI as a permissive for the control command; and then

(b) Step 2: the Worker either:

(i) issues a “close/on/raise” command to send an assertion or increase command associated with the selected control point, or an “open/off/lower” command to send a de-assertion or decrease command associated with the selected control point; or

(ii) issues a one-step reset command, which un-latches and de-selects the currently selected control point.

The Governor System will not accept control commands from the Governor HMI if no control point is selected.

Commands that will not follow the SBO procedure include:

(c) commands from protective devices (either within or external to the Governor System) to shut down the Governor System;

(d) commands from emergency stop pushbuttons (either within or external to the Governor System) to shut down the Governor System; and

(e) the local/remote transfer switch included as part of the Governor Hardwired Controls.

2.6 Seismic Withstand

The completely assembled and installed Governor System will meet the high-performance level as defined in the IEEE 693. The Contractor will:

(a) employ a qualified seismic specialist to perform the work described in SPGOV 2.6;

(b) demonstrate the seismic withstand capability of the completely assembled and installed Governor System, through analysis and/or test in accordance with IEEE 693;

(c) utilize Annex A of IEEE 693 as general requirements for seismic qualification procedures for the Governor System (taking particular note of the equipment anchorage requirements);

(d) utilize Annex M of IEEE 693 as specific requirements for seismic qualification procedures for the Governor Control Cabinet;

(e) utilize Annex B of IEEE 693 as specific requirements for seismic qualification procedures for Governor System components other than the Governor Control Cabinet;

(f) prepare a seismic outline Drawing of the Governor System, including details of seismic bracing and anchoring, as well as a table showing all of the forces to be transferred at each anchor location; and

(g) prepare a seismic analysis qualification Report and/or a seismic test qualification Report, including seismic Calculations performed, signed by the Contractor's seismic specialist, and demonstrating that the Governor System complies with the high-performance level as defined in IEEE 693.

SPGOV3 GOVERNOR SYSTEM FUNCTIONAL REQUIREMENTS

3.1 Governor System Local/Remote Control Transfer

The Governor System will include functionality to operate in and transfer between local and remote control modes. In remote control mode, the Governor System will only accept control commands from devices external to the Governor System. In local control mode, the Governor System will only accept control commands from the Governor HMI (except for emergency stop commands from external protective devices).

3.2 Governor System Control Modes

(a) Auto and Manual Modes: The Governor System will include automatic and manual control modes as follows, as well as capability to transfer between them depending on whether the Governor System is in local or remote control mode:

(i) *Automatic Mode*: "**Auto Mode**" will be provided as the default and normal operating mode for the Governor System (i.e., when Manual Mode is not selected) and provide automated control of the Turbine.

(ii) *Manual Mode*: "**Manual Mode**" will be provided to allow specialized testing of the Governor System and Unit. Transfer to Manual Mode will only be allowed when the Governor System is in local control mode. If the Governor is transferred from local control mode to remote control mode while in Manual Mode, it will immediately and automatically transfer to Auto Mode. Manual Mode will include the following functionality:

(A) Automated servomotor timing test functionality for testing the opening and closing times will be provided, and will:

(I) include permissive interlocks that only allow testing to be conducted when the Unit is offline and after a password has been entered by a Worker;

(II) include capability to control the wicket gates from the Governor HMI;

(III) override all other control modes;

(IV) include a Governor HMI menu option for testing opening times, which, when selected by a Worker, will cause the servomotors to open from 0% to 100% of stroke, at the maximum rate allowed by the main distributing valve, and then display, on the Governor HMI, the resulting servomotor times for full travel from 0 to 100% and for half travel from 25% to 75%, accurate to the nearest tenth of a second;

(V) include a Governor HMI menu option for testing closing times, which, when selected by a Worker, will cause the servomotors to close from 100% to 0% of stroke, at the maximum rate allowed by the main distributing valve, and then display, on the Governor HMI, the resulting servomotor times for full travel from 100% to 0% and for half travel from 75% to 25%, accurate to the nearest tenth of a second;

(VI) include an explanation of the test Procedure and proper safety precautions (which will be supplied by BC Hydro), displayed on the Governor HMI.

(B) Distributing valve configuration functionality will be provided, including the ability to tune the valve’s response, and adjust the valve dither and bias.

(C) Other manual testing functions recommended by the Contractor.

(b) Power Droop and Wicket Gate Droop Modes: The Governor System will include Power Droop and Wicket Gate Droop control modes as follows, as well as capability to transfer between them independent of whether the Governor System is in local or remote control mode (note that IEEE Annex C illustrates a method for implementing logic to transfer between Power Droop and Wicket Gate Droop modes):

(i) *Power Droop Mode*: “**Power Droop**” or “**Speed Regulation**” mode will:

(A) refer to operating conditions where the Governor System is configured to use Power Error as the feedback parameter to the Permanent Speed Droop function, causing the Governor System to regulate Unit real power output to the Power Setpoint;

(B) be the normal/default operating mode;

(C) automatically detect when the Governor MW transducer output becomes unavailable or is determined to be faulty, and cause the Governor System to automatically change to Wicket Gate Droop mode; and

(D) cause the Governor System to continually adjust the Gate Position Setpoint such that it tracks the Power Setpoint in a manner that, upon a Governor System transfer to Wicket Gate Droop mode, would not introduce a signal disturbance into the summing junction that determines Speed Error.

(ii) *Wicket Gate Droop Mode*: “**Wicket Gate Droop**” mode will:

(A) refer to operating conditions where the Governor System is configured to use Gate Position Error as the feedback parameter to the Permanent Speed Droop function, causing the Governor System to regulate Unit wicket gate position to the Gate Position Setpoint; and

(B) cause the Governor System to continually adjust the Power Setpoint such that it tracks the Gate Position Setpoint in a manner that, upon a Governor System transfer to Power Droop mode, would not introduce a signal disturbance into the summing junction that determines Speed Error.

(c) Offline Mode, Online Mode, and Isolated Load Mode: The Governor System will include an Offline Mode, Online Mode, and an Isolated Load Mode, as well as capability to transfer between them, as follows:

(i) *Offline Mode*: “**Offline Mode**” will:

(A) refer to conditions where the Unit circuit breaker is open;

(B) include a dedicated set of PID Transfer Function and Droop settings (the "**Offline Settings**") that are made to be the settings used by the Governor System when in Offline Mode; and

(C) include logic to transfer to Online Mode when the Unit circuit breaker closes.

(ii) *Online Mode*: "**Online Mode**" will:

(A) refer to conditions where the Unit circuit breaker is closed and the Unit is not operating in Isolated Load Mode (as determined by the Isolation Detector):

(B) include a dedicated set of PID Transfer Function and Droop settings (the "**Online Settings**") that are made to be the settings used by the Governor System when in Online Mode;

(C) cause the Governor System to transfer to Offline Mode when the Unit circuit breaker opens; and

(D) cause the Governor System to transfer to Isolated Load Mode when the Isolation Detector operates.

(iii) *Isolated Load Mode*: "**Isolated Load Mode**" will:

(A) refer to conditions where the Unit circuit breaker is closed and the Isolation Detector has operated;

(B) include a dedicated set of PID Transfer Function and Droop settings (the "**Isolated Load Settings**") that are made to be the settings used by the Governor System when in Isolated Load Mode;

(C) disable Setpoint Feedforward functionality;

(D) cause the Governor System to transfer to Isolated Load Mode when the Isolation Detector operates; and

(E) cause the Governor System to transfer to Online Mode when the Isolation Detector resets.

(d) <u>Generate and Synchronous Condense Modes</u>: The Governor System will include Generate and Synchronous Condense control modes as follows, as well as capability to transfer between them, depending whether the Governor System is in local or remote control mode:

(i) *Generate Mode*: "**Generate Mode**" will:

(A) refer to operating conditions where the Governor System is in either local or remote control mode, has not accepted a command to transfer to Synchronous Condense Mode, and is controlling the Turbine in either Power Droop or Wicket Gate Droop mode in order to generate power;

(B) be the normal/default operating mode;

(C) only allow transfer to Synchronous Condense Mode when the Governor System is in remote control mode; and

(D) upon accepting a command (from a device external to the Governor System and provided by Others) to transfer the Unit to Synchronous Condense Mode, cause the Governor System to close the wicket gates, provide cooling water to the runner seals, and operate the Turbine air depression system to depress the water level in the draft tube.

(ii) *Synchronous Condense Mode*: “**Synchronous Condense Mode**” will:

(A) refer to operating conditions where the Governor System is in remote control mode, has accepted a command (from a device external to the Governor System and provided by Others) to transfer from Generate Mode to Synchronous Condense Mode, and is controlling the Turbine, including the runner seal cooling water valve, and Turbine air depression system, to allow the Generator to operate as a synchronous condenser with minimized motoring power;

(B) only be possible when the Governor System is in remote control mode;

(C) in the event that the Governor System is transferred from remote to local control mode, cause the Governor System to automatically transfer to Generate Mode;

(D) upon accepting a command (from an external device provided by Others) to transfer the Unit from Synchronous Condense Mode to Generate Mode, cause the Governor System to exhaust the air out of the draft tube, open the wicket gates, and close the runner seal cooling water valve; and

(E) upon receiving a stop command (normal shutdown or protection initiated), cause the Governor System to exhaust the air out of the draft tube via the exhaust valve, close the runner seal cooling water valve, and perform automatic stop control.

3.3 Wicket Gate Limit Functionality

The Governor System will include wicket gate limit functionality that:

(a) overrides all other functionality within the Governor System to limit the opening of the Turbine wicket gates to any Worker-Adjustable position (the “**Gate Limit Setpoint**”) within the full range of wicket gate travel, in steps of 0.1% or less;

(b) allows a local Worker to manually adjust the Wicket Gate Limit via raise/lower buttons provided on the Governor HMI;

(c) allows a remote Worker to adjust the Wicket Gate Limit via raise/lower hardwired inputs (provided by Others) to the Governor System; and

(d) includes settings as follows:

(i) A shutdown setting, which the Governor PLC will automatically set the Wicket Gate Limit to when the Governor System has accepted a shutdown command.

(ii) A Software-Adjustable offline Gate Limit Setpoint target, to which the Governor System automatically ramps the Gate Limit Setpoint when the Unit transitions to running offline.

(iii) A Software-Adjustable online Gate Limit Setpoint target, to which the Governor System automatically ramps the Gate Limit Setpoint when the Unit transitions to running online.

(iv) A Software-Adjustable maximum offline setting (the "**Maximum Offline Wicket Gate Limit**"), intended to prevent a Worker from adjusting the Gate Limit Setpoint to a point that would cause the Unit to go significantly above 100% speed when the Unit circuit breaker is open. The Maximum Offline Wicket Gate Limit will be adjustable, in steps of 0.1% or less.

(v) A Worker-Adjustable maximum online setting (the "**Maximum Online Wicket Gate Limit**"), intended to allow a Worker to change the maximum Gate Limit Setpoint allowed when the Unit is operating online with operating restrictions in effect. The Maximum Online Wicket Gate Limit will be adjustable in steps of 0.1% or less.

(vi) A Gate Limit Setpoint ramp rate that is Software-Adjustable, in steps of no greater than 0.01%/s.

When the Wicket Gate Limit function is in control of the Turbine (i.e., is calling for a lower wicket gate position than the PID Transfer Function output), the Power Setpoint will track the Measured Unit Power, in order to ensure bumpless transfer in the event a Worker raises the Wicket Gate Limit to a setting that causes control of the Turbine to be passed back to the PID Transfer Function. Other suitable techniques will be employed to avoid undesirable integrator wind-up or wind-down conditions.

3.4 Governor Setpoints

The Governor System will include the following setpoints (each a "**Governor Setpoint**") within the Governor PLC:

(a) Speed Setpoint;

(b) Power Setpoint;

(c) Gate Position Setpoint, and

(d) Gate Limit Setpoint.

Governor Setpoints will be Worker-Adjustable and will be modified by the Governor System according to:

(e) raise/lower adjustment commands accepted by the Governor PLC (by raising or lowering the current Governor Setpoint value by Software-Adjustable raise/lower ramp rates); and

(f) automatic overwrite of a Governor Setpoint value, according to automatic control algorithms within the Governor Software (for example, automatically overwriting the Power Setpoint with a value of 0 MW subsequent to the Governor System accepting a shutdown command).

Two sets of raise/lower commands are required (via select-before-operate controls) within the Governor System, used to adjust the Governor Setpoints as follows:

(g) one set of raise/lower commands for the Gate Limit Setpoint; and

(h) one set of raise/lower commands for shared use to adjust Speed Setpoint, Power Setpoint, or Gate Position Setpoint, based on the Unit circuit breaker status (e.g., Worker-adjustment of the Speed Setpoint will not be possible when the Unit circuit breaker is closed) and the Governor control mode (e.g., Worker-adjustment of the Gate Position Setpoint will not be possible when in Power Droop mode).

The Speed Setpoint will be:

(i) Worker-Adjustable between 85% and 105%, in increments of 0.01% or less when the Unit circuit breaker is open, at a Software-Adjustable ramp rate;

(j) set to 100% when the Unit circuit breaker is closed (required to ensure a return to rated speed if the Unit circuit breaker opens); and

(k) set to 0% when the Governor System has accepted a normal or protection-initiated stop command.

The Power Setpoint will be:

(l) Worker-Adjustable between Software-Adjustable upper and lower limits, in increments of 1% or less, and at a Software-Adjustable ramp rate;

(m) set to 0% when the Unit circuit breaker is open, and also when the Governor System has accepted a normal or protection-initiated stop command;

(n) ramped at a Software-Adjustable rate from 0% to a Software-Adjustable target value immediately upon closure of the Unit circuit breaker (this is required to prevent Unit operation in reverse power and any Turbine rough load zones immediately after the Unit circuit breaker is closed); and

(o) ramped at a Software-Adjustable rate to a Software-Adjustable value immediately upon transfer from Synchronous Condense Mode to Generate Mode (this is required to prevent Unit operation in reverse power).

The Gate Position Setpoint will be:

(p) Worker-Adjustable between Software-Adjustable limits, in increments of 0.01% or less, at a Software-Adjustable ramp rate; and

(q) set to the Software-Adjustable lower limit when the Governor System has accepted a normal or protection-initiated stop command.

The Gate Limit Setpoint will be:

(r) Worker-Adjustable between Software-Adjustable limits, in increments of 0.01% or less, at a Software-Adjustable ramp rate; and

(s) set to the Software-Adjustable lower limit when the Governor System has accepted a normal or protection-initiated stop command.

3.5 Transfer Function Setting Adjustments

The gains and time constants of each element of the PID Transfer Function and PD Transfer Function will be independently Software-Adjustable over the following ranges:

(a) Proportional elements: The proportional element gain (i.e., the ratio of the element’s per unit output to its per unit input), will be adjustable in increments of 0.01 or less over its full range.

(b) Integral elements: The integral element gain (i.e., the reciprocal of the time required for the element’s per unit output to be equal in magnitude to its per unit input, where the input is a step function), will be adjustable in increments of no more than 0.001 per second, over its full range.

(c) Derivative elements: The derivative element gain (i.e., the ratio of the element's per unit output to the time derivative of its per unit input), will be adjustable in increments of 0.01 second or less over its full range.

3.6 Automatic Start Control

3.6.1 Normal Automatic Start Control

Upon the Governor System accepting an automatic start command, it will:

(a) set the Speed Setpoint to 100% (or less as required by soft start control);

(b) release the gate lock;

(c) raise the Wicket Gate Limit setting from the shutdown setting (0%) to a Software-Adjustable setting according to the selected start mode (Soft Start or Fast Start);

(d) open the wicket gates according to the selected start mode (Soft Start or Fast Start);

(e) set the Wicket Gate Limit to the Maximum Offline Wicket Gate Limit once the Unit reaches a Worker-Adjustable speed for the selected start mode (Soft Start or Fast Start);

(f) enable Governor System automatic control algorithms to achieve control of Unit speed for the offline condition, in accordance with the requirements of Schedule 6 [Specifications and Drawings]; and

(g) await a command to either shut down, or begin automatic Unit synchronization.

3.6.2 Soft Start Control

The Governor System will include a soft start function, implemented in software within the Governor PLC as the default/normal start control mode, that:

(a) provides slow wicket gate opening speed during Unit start-up, in order to minimize Turbine stresses;

(b) includes a Software-Adjustable number of stages (the "**Soft Start Stages**");

(c) provides a minimum of three Soft Start Stages, with each stage including an independently Software-Adjustable:

(i) target Unit speed (adjustable in steps of 0.1% or less);

(ii) maximum wicket gate position (adjustable in steps of 0.1% or less); and

(iii) wicket gate position ramp rate (adjustable in steps of 0.1% per second or less).

3.6.3 Fast Start Control

The Governor System will include a Worker-selectable fast start control function, implemented in software within the Governor PLC, that:

(a) provides faster acceleration of the Unit from standstill to near rated speed during automatic start-up (when compared to soft start control), in order to minimize Unit start-up impacts to the Generator Thrust Bearing;

(b) includes a Software-Adjustable wicket gate “breakaway” opening setting, which indicates the position the Governor System will immediately open the wicket gates to when performing a fast start;

(c) includes a wicket gate breakaway setting that is Software-Adjustable in steps of 0.1% or less;

(d) temporarily sets the Wicket Gate Limit to the wicket gate breakaway setting, until the Unit reaches a Software-Adjustable breakaway speed, at which point the Wicket Gate Limit will be restored to its offline setting; and

(e) includes a breakaway speed that is Software-Adjustable in steps of 0.1% or less.

3.6.4 Speed Match Control (during automatic Unit synchronizing)

When the Unit is running offline, the Governor System is in remote control mode, and the Governor System receives a signal from synchronizing equipment (provided by Others) indicating that synchronizing of the Unit to the Running Bus is to begin, the Governor System will control Unit speed to follow the sum of the Measured Running Bus Frequency and a small Software-Adjustable frequency bias (default 0.07 Hz).

The above approach ensures that the incoming (Unit) and running (power system) voltage waveforms will be in-phase with each other, presenting a possible opportunity to close the Unit circuit breaker, approximately once every 14 seconds, and eliminates the need to use a synchronizing “kicker pulse” speed adjustment. In addition, the use of a positive bias will ensure the Unit will pick up positive load immediately after synchronization (avoiding the possibility of encroaching onto any reverse-power protection).

The Governor System will include functionality to block speed matching if the Measured Running Bus Frequency is outside of a range that is Software-Adjustable between 58 and 62 Hz, in steps no greater than 0.01 Hz.

3.7 Automatic Stop Control

3.7.1 Normal Automatic Stop

The Governor System will stop the Unit in the following sequence when it receives a stop command:

(a) the Governor Shutdown Solenoid will be de-energized, causing the wicket gates to start closing;

(b) the Speed Setpoint will be set to 0%, the Power Setpoint will be set to 0 MW, and the Gate Position Setpoint will be set to its Software-Adjustable lower limit; and

(c) once the wicket gates are fully closed, the wicket gate lock will be applied.

3.7.2 Wicket Gate Closing Law

If a multi-stage closing law is required for the shutdown closing sequence, the multi-stage control will be performed by mechanical means without the need for Governor input or feedback during the operation. The mechanical control device(s) will be installed on the Turbine Servomotor(s).

3.7.3 Non Lock-Out Partial Shutdown Sequence

A Unit partial shutdown function will be implemented by Others that, when initiated, will include a command to the cause an immediate Unit circuit breaker trip, but will allow the Unit to continue running offline to await a re-synchronize command.

If the Governor System receives indication that the Unit circuit breaker has opened, it will continue to regulate Turbine speed using Offline Settings.

3.8 Governor System Protection

Non-critical Governor System failures will cause a Governor Alarm.

Protective elements within the Governor PLC will include those described in section 5 and Appendix D of BC Hydro design practice DP 45-Z0031 R1.

Critical Governor System failures will cause the Governor System to initiate an immediate Unit shutdown (trip) that causes the wicket gates to go to the fully closed position. Critical failures will include:

(a) Governor PLC failure;

(b) loss of the Measured Gate Position signal;

(c) loss of the Measured Unit Speed signal;

(d) failure of any pilot valve (PV), PV wiring, or PV power failure;

(e) loss of accumulator oil level sensing;

(f) accumulator oil level at low level trip;

(g) accumulator oil level at high level trip; and

(h) accumulator pressure at low pressure trip.

Control circuits and Software for critical signals (including Wicket Gate position, Unit power output, Unit speed) within the Governor System will be designed and configured to cause Wicket Gate closure on signal loss, power supply loss, during normal shutdowns, and during emergency shutdowns. Inherent safety will be built in to the Governor System in this regard, considering the entire signal path and all devices in the signal path.

3.9 Air Admission

The Governor System will include all control logic and hardware necessary to operate the Turbine air admission system described in Appendix 6-3 [Turbine Specifications (SPT)]. The Governor System will operate the air admission system to meet the performance requirements of the Turbine and the operational requirements of the Turbine air depression system for synchronous condenser operation.

Capability will be provided to manually open the Turbine air admission valve via an “open/auto” control switch (two-position, pistol-grip, mechanically-latched style) located inside the GCC. An alarm will be raised any time the automatic air admission controls are overridden.

3.10 Turbine Air Depression for Synchronous Condenser Operation

The Governor System will include the following functionality:

(a) The Governor System will include all protection and control logic, and hardware, necessary to operate the Turbine air depression system including:

    (i) operating the main air depression valve;

(ii) operating the maintenance air depression valve for initial air depression and as required to maintain the draft tube water level;

(iii) operating the exhaust air valve;

(iv) operating the runner seal cooling water valve; and

(v) operating the Turbine air admission valve.

(b) Capability will be provided to manually operate the main air depression valve, maintenance air valve, and exhaust valve via momentary-contact, spring-return, manual operate buttons located inside the GCC; manual control of these valves will not be provided on the Governor HMI.

3.11 High-Pressure Oil System

(a) General: The two main electric motor driven high-pressure oil pumps, and the jockey pump, for the Governor high-pressure oil will:

(i) have smooth and positive loading and unloading action with no partially unloaded state;

(ii) each include a starter; and

(iii) include controls that include an adjustable pressure differential between the loaded and unloaded position of each unloader.

(b) Controls: The pump controls will:

(i) include automatic control to start and stop each pump motor when the oil pressure in the accumulator falls and rises, respectively, to pre-set values. The control equipment will be arranged to start and stop each pump motor with the pump unloaded - during normal operation, or after power is restored following a power failure when the pump may have been loaded;

(ii) include automatic control to run the pumps in the following order based on the accumulator oil pressure falling: jockey pump, lead pump, and lag pump;

(iii) include a lead/lag selector switch to permit either of the main pumps to be selected as the lead pump and have the Lead-Lag mode initiated by pressure transducers and the Governor PLC. The lead pump will start and load first before the lag pump, which will operate later if accumulator pressure continues to fall;

(iv) include automatic control of the jockey pump for kidney loop filtering and warming of the sump oil;

(v) include unloader controls on each pump that are functional in both Manual and Auto mode;

(vi) include one stand-alone, non-volatile run-time counter for each pump motor; and

(vii) include the following indication lights on the Governor HPU local control panel to show running of the pump motors:

(A) Pump #1 on red light; and

(B) Pump #1 off green light;

(C) Pump #2 on red light; and

(D) Pump #2 off green light.

3.12 Make-up Air

The make-up air control will include automatic control of the make-up air valve for restoring the air-to-oil ratio of the accumulator when the oil level is too high. Operation of the make-up air valve will be coordinated with the operation of the high-pressure oil pumps

3.13 Software

3.13.1 Application Configuration Files (Governor Software)

"**Governor Software**" includes Application Configuration Files for the Governor System, and will be provided.

3.13.2 Configuration Tool Software (Governor Configuration Software)

"**Governor Configuration Software**" includes Configuration Tool Software for the Governor System, and will be provided.

3.13.3 Governor System Events

The Governor PLC, together with its Application Configuration Files designed by the Contractor, will include an Event Buffer that monitors and records Events identified in the Event List, and that uses the Event Data Structure. Functionality will also be included to communicate buffered Events to a device external to the Governor PLC (using a custom communication protocol defined by BC Hydro and provided to the Contractor), and subsequently remove these Events from the buffer once successful communication has been confirmed.

The Governor System will include Alarms for conditions that include:

(a) power supply failures (including fuse failures);

(b) Governor PLC health, including low battery and input/output channel or card failures;

(c) abnormal control status (test mode, Isolated Control Mode, device not in auto, device not in remote);

(d) abnormal device status (e.g., filter dirty, servomotor limit reached, pressure low/high, temperature high, level low/high); and

(e) unexpected or abnormal device operation, device failure, or unknown device status (e.g., speed signal trouble, power signal trouble, level signal trouble, temperature signal trouble, gate lock failure to apply/release, pump failure to operate, lag pump running).

One Target will be provided for each protective function within the Governor System, to indicate when the protective function has operated.

3.13.4 Governor System Data Table

The Contractor's Governor Software for the Governor PLC will include functionality to make all discrete and analog Governor System data that is deemed operationally relevant by the Contractor or by BC Hydro (the "**Governor System Data Table**") available in definite-address 4x register memory for polling by external devices via the Ethernet based Modbus TCP protocol. The data will be grouped into as small a range as practical in order to be read or written in a small number of packets (of approximately 100 registers each). Within the data table, analog values will be formatted in ANSII standard 32-bit floating numbers, spanning two 4x registers each. The analog values will be scaled in engineering units such as kV and MW. Discrete data such as on/off controls, statuses and alarms will be available as individual bits packed into the 4x registers. For example, alarms 1 to 16 would be in bits 1 to 16 of register 400001, alarms 17 to 32 would be in bits 1 to 16 of register 400002, and so on. All alarms and statuses will be included in the data table, and will be non-latching.

The Governor System Data Table will be developed collaboratively between the Contractor and BC Hydro until the first Unit is placed in full commercial service.

The Governor System Data Table will include:

(a) Analog (floating-point) Governor System data, including:

(i) Speed Setpoint, Measured Unit Speed;

(ii) Gate Position Setpoint, Wicket Gate Limit, Measured Gate Position;

(iii) Power Setpoint, Measured Unit Power;

(iv) Accumulator pressure, accumulator level;

(v) Sump oil temperature, sump oil level;

(vi) Servomotor timing test information; and

(vii) Draft tube level; and

(b) Discrete (integer or binary) Governor System data, including:

(i) Governor PLC heartbeat;

(ii) auto/manual status;

(iii) local/remote status;

(iv) control mode;

(v) start/stop status;

(vi) generate/condense status;

(vii) Isolated Load Mode status;

(viii) fast/slow/normal start mode;

(ix) lead pump status (pump #1 or pump #2);

(x) bits indicating the current status (i.e., on or off) of all of the items in the Event List for the Governor System;

(xi) Governor System device health status;

(xii) Governor System device control status; and

(xiii) pump status bits.

SPGOV4 GOVERNOR SYSTEM TECHNICAL REQUIREMENTS – INSTRUMENTATION

4.1 General

Unless otherwise specified, instrumentation described in SPGOV4 will be connected to and monitored by the Governor PLC.

Where redundant transducers are provided and connected to the Governor PLC, the Governor PLC will include adjustable mismatch detection functionality (i.e., an Alarm will be raised if the Governor PLC detects that the difference in indications received from the redundant transducers differs by an adjustable amount).

4.2 Unit and Running Bus Speed Sensing

The Work includes a minimum of three speed sensing systems including:

4.2.1 Generator VT Speed Sensing System

A Generator voltage transformer (VT) speed sensing system (the "**Generator VT Speed Sensing System**") will be provided to provide a measurement of Unit speed that is within 0.005% of the true Unit speed while the Unit is operating between 95% and 105% of Rated Speed, and will utilize the following elements:

(a) a signal conditioner that:

(i) has its input connected to a Generator VT output;

(ii) accepts 125 Vdc as its power input (AC powered devices are not acceptable);

(iii) operates correctly over a range of Generator speeds spanning at least from 20% of Rated Speed to 200% of Rated Speed;

(iv) operates correctly over a range of Generator terminal Voltage amplitudes spanning at least from 125% of rated Generator terminal Voltage, down to 1% of rated Generator terminal Voltage;

(v) includes immunity to electromagnetic interference expected to be experienced within an operating generating station;

(vi) includes at least 5 kV of galvanic isolation between its input and output;

(vii) ignores saturation effects of the Generator VT at lower frequencies; and

(viii) provides at its output, a pulse train that provides indication of Unit speed; and

(b) a high-speed counter-type electronic PLC module (frequency transducers will not be used) that:

(i) is part of the Governor PLC;

(ii) has its input connected to the output of the signal conditioner discussed above; and

(iii) provides indication of Unit speed to the Governor PLC.

The Generator VTs will be provided by Others.

4.2.2 Toothed-Wheel Speed Sensing System

A Toothed-Wheel Speed-Sensing system will be provided to provide a measurement of Unit speed that is within 0.005% of the true Unit speed while the Unit is operating between 95% and 105% of Rated Speed, and will utilize the following elements:

(a) a minimum of three magnetic proximity probe sensing devices (each a "**ZVPU Probe**"), two of which are to be used by Others to provide speed sensing signals to a system external to the Equipment, and that meet the following specifications:

(i) are of the zero-velocity pickup type (i.e., probes that are capable of correctly sensing and indicating a tooth or space when the Toothed-Wheel is not rotating), and are of adequate response time to ensure an accurate speed signal is generated, considering the number of teeth on the Toothed-Wheel and that the Toothed Wheel is rotating at the runaway speed of the Unit;

(ii) are arranged around the Toothed-Wheel to allow:

(A) each to distinctly and consistently sense teeth and spaces as they pass by when the Toothed-Wheel rotates;

(B) the two probes to be used by Others to be used for creep detection, by arranging them such that one probe is facing a tooth edge while the other probe is facing a tooth face;

(C) each enough clearance to the teeth of the Toothed-Wheel to ensure that contact with the Toothed-Wheel will never occur during Unit operation; and

(D) each enough clearance to the teeth of the Toothed-Wheel to allow a Worker to conveniently pass a thin metal object between the ZVPU Probe and the Toothed-Wheel for maintenance testing purposes when the Unit is stopped;

(b) a minimum of three ZVPU Probe signal conditioners, identical to the signal conditioner utilized for the Generator VT Speed Sensing System, except that the input of each ZVPU Probe signal conditioner will be connected to the output of a ZVPU Probe;

(c) a high-speed counter type electronic PLC module as part of the Governor PLC, and identical to the one utilized for the Generator VT Speed Sensing System;

(d) a Toothed-Wheel in accordance with Appendix 6-5 [Generator Specifications (SPG)]; and

(e) a simple system of ZVPU probe brackets and fasteners in accordance with Appendix 6-5 [Generator Specifications (SPG)].

4.2.3 Running Bus VT Speed Sensing System

A running bus voltage transformer (VT) speed sensing system (the "**Running Bus VT Speed Sensing System**") will be provided to measure running bus frequency, and will utilize elements that are identical to the Generator VT Speed Sensing System, with the exception that the signal conditioner will be connected to the running bus VT instead of the Generator VT. The Running Bus VT Speed Sensing System will be utilized to provide a measurement of the running bus speed (the “**Measured Running Bus Frequency**”) to the Governor System for use during speed matching.

The running bus VT will be provided by Others.

4.2.4 Speed Signal Selection

The Governor PLC will select the signal provided by either the Generator VT Speed Sensing System or the Toothed-Wheel Speed Sensing System as the indication of Unit speed (the “**Measured Unit Speed**”) to be utilized by the Governor System. When both the Generator VT Speed Sensing System and the Toothed-Wheel Speed Sensing System are healthy, the Generator VT Speed Sensing System will be selected by the Governor PLC as the default Measured Unit Speed. If the Generator VT Speed Sensing System fails or is determined to be unavailable or unhealthy by the Governor PLC, the Governor PLC will immediately, automatically, and bumplessly transfer to utilize the signal provided by the Toothed-Wheel Speed Sensing System as the Measured Unit Speed; once the Generator VT Speed Sensing System is available or healthy again, the Governor PLC will immediately, automatically, and bumplessly transfer back to utilizing the signal provided by the Generator VT Speed Sensing System as the Measured Unit Speed. Alarms will be generated if either speed sensing system fails.

4.3 Pilot Valve Position Sensing

A position transducer will be provided with the Governor System, to provide as its output a measurement of pilot valve position, and will be:

(a) of the linear variable differential transformer type;

(b) built for 4-20 mA output operation; and

(c) either integrated with the pilot valve or if not integrated with the pilot valve, be mounted externally to the pilot valve to facilitate inspection, removal, replacement, and adjustment.

Contact wiper potentiometer type devices will not be provided.

4.4 Wicket Gate Position Sensing

A minimum of two wicket gate position transducers will be provided with the Governor System, each to provide as its output a measurement (the “**Measured Gate Position**”) of actual Turbine wicket gate position, and will be:

(a) of the magnetostrictive linear displacement transducer type;

(b) built for 4-20 mA output operation;

(c) mounted externally to servomotors (each to a different servomotor) to facilitate inspection, removal, replacement, and adjustment; and

(d) installed in a manner that permits each to measure the full range of the servomotor stroke, plus a minimum margin of 2.5% past each end of the servomotor stroke.

Contact wiper potentiometer type devices will not be provided.

One gate position transducer will be used by the Governor System and the other will be used by Others to provide wicket gate position indication to systems external to the Equipment.

The calibration gain and offset of each transducer will be independent and separately configurable.

If more gate position transducers are provided by the Contractor, each will be mounted on a different wicket gate servomotor, in order to avoid common mode failures.

Wicket gate position transducers will be supplied with protective covers to prevent inadvertent damage to the transducers.

4.5 Speed Switches

The Governor System will include one set of speed switches (each a "**Governor Speed Switch**"), consisting of auxiliary relays that are operated by the Governor PLC, according to the Measured Unit Speed.

The pick-up and drop-out value of each Governor Speed Switch, including whether pick-up is above or below the setpoint value, will be Software-Adjustable from 0.5% to 200% speed, and will be accurate to within 0.5% of the true Unit speed over this entire range.

The Governor PLC will operate the Governor Speed Switches with a hysteresis that is Software-Adjustable on a per-switch basis, with pick-up and drop-out values independently programmable over a range of from 0.5% to 5% hysteresis, in steps of no more than 0.1%.

Each Governor Speed Switch will be equipped with output relays. Relay contacts will be as specified in Appendix 6-2 [General Technical Specifications (SPGT)].

A summary of the preliminary speed switch requirements is included below:

Governor Speed Switch Function	Value
Overspeed trip	TBD
Overspeed if isolated and in manual	108%
Excitation initiation	95%
Vibration monitor supervision	85%
Emergency brake application	50%
Normal brake application	25%
Spare	TBD
Spare	TBD
Spare	TBD

A second, fully redundant, speed sensing system that is completely independent of the Governor System and that also trips into the Unit protection systems (thus providing a fully redundant protection) will be provided by Others. This system will be in accordance with independent electronic systems described in IEEE 125 Section 5.2.14.1 and IEC 61632 Section 5.15.3.

4.6 Wicket Gate Position Switches

The Governor System will include one set of wicket gate position switches (each a "**Gate Position Switch**"), consisting of auxiliary relays that are operated by the Governor PLC, according to the Measured Gate Position.

The pick-up and drop-out value of each Gate Position Switch, including whether pick-up is above or below the setpoint value, will be Software-Adjustable, and will be accurate to within 0.5% of the true wicket gate position over this entire range.

The Governor PLC will operate the Gate Position Switches with a hysteresis that is Software-Adjustable on a per-switch basis, with pick-up and drop-out values independently programmable over a range of from 0.1% to 5% hysteresis, in steps of no more than 0.1%.

Each Gate Position Switch that is to be connected to equipment external to the Governor will be equipped with output relays. Relay contacts will be as specified in Appendix 6-2 [General Technical Specifications (SPGT)].

A summary of the preliminary Gate Position Switch requirements is included below:

Gate Position Switch	Value
Gate Position Switch #1	1%
Gate Position Switch #2	speed-no-load
Spare	TBD
Spare	TBD

4.7 Governor MW Transducer

A three-element, four-wire Governor megawatt transducer will be provided within the Governor System to provide measurement of Unit output power (the "**Measured Unit Power**") to the Governor System. The output from the MW transducer to the Governor PLC will be 4-20 mA.

The range of power measurement will span at least from minus 20% of Generator Rated Output to 120% of Generator Rated Output.

The Governor MW transducer will have an accuracy of at least 0.5% throughout the entire range, a temperature coefficient of accuracy of no more than 0.005% per ºC, and the step response time will be no more than 0.1 second.

4.8 Isolation Detector

The Governor System will include a device (the "**Isolation Detector**") that utilizes measured electrical quantities (such as frequency deviation or other means), to detect and operate when the Unit is operating in Isolated Load Mode where it is connected to many fewer other turbine-generators, as compared to normal grid-connected operation where it is connected to many other turbine-generators as part of the Western North American interconnected power grid (a condition that, when detected, will cause the Isolation Detector to reset).

Isolated Load Mode may arise suddenly due to power system device operations external to the Unit. The intent of this functionality is to ensure adequate damping is provided by the Governor System, if the operating condition of the Unit changes abruptly between grid-connected and isolated load conditions.

It will be possible to:

(a) enable and disable the Isolation Detector via a Governor PLC discrete input; and

(b) force the Governor System to and from Isolated Load Mode via the Governor HMI.

4.9 Accumulator Instrumentation and Controls

4.9.1 Accumulator Pressure Sensing

Accumulator pressure sensing functionality provided with the Governor System will include:

(a) two adjustable pressure switches to indicate extreme low pressures (low pressure trip) in the accumulator and be fully redundant; and

(b) a minimum of two pressure transducers, each installed to measure accumulator pressure and be fully redundant.

The accumulator will have two instrument pressure headers each equipped with an isolation valve, pressure gauge, a test port, one of the above pressure switches, one of the above pressure transducers, and two spare ports (suitably plugged) for future use. If the Contractor requires additional pressure sensing devices they will also be installed on a similar instrument pressure header.

4.9.2 Accumulator Oil Level Sensing

Accumulator oil level sensing functionality provided with the Governor System will include:

(a) one guided-wave radar level transducer, and one magnetic float transducer, each installed to measure accumulator level and be fully redundant with regard to the other; and

(b) mechanical indication of accumulator oil level using magnetic semaphore flag indicators arranged around the sensing column of the accumulator level magnetic float transducer, in a manner that utilizes that transducer’s magnetic float to operate the semaphore flag indicators (a pressurized oil level sight glass is not acceptable).

4.10 Oil Sump Instrumentation and Controls

The Work will include provision of:

(a) a sump oil level transducer (that may be inserted directly into the sump without a stilling well);

(b) a sump oil level sight glass with mechanical protection (that may be attached directly to the sump without a stilling well); and

(c) a sump oil temperature transducer.

4.11 Servomotor Pressure Transducers

The Work will include provision of pressure transducers and pressure gauges in the piping to the servomotors located near or on the HPU, to indicate the pressure in the wicket gate opening and closing lines.

4.12 Draft Tube Level Transducer

The draft tube level transducer described in Appendix 6-3 [Turbine Specifications (SPT)] will be connected to the Governor PLC.

SPGOV5 GOVERNOR SYSTEM TECHNICAL REQUIREMENTS – ELECTRICAL

5.1 High-Pressure Oil Pump Motors

Motors and starters provided to drive the main and jockey-high pressure oil pumps will:

(a) be rated for continuous service, considering the pump each motor is connected to;

(b) meet the requirements of Appendix 6-2 [Generator Technical Specifications (SPGT)] for motors and starters;

(c) include full-voltage, non-reversing starters, with power supplies connected such that failure of the power supply to one motor starter does not affect operation of the other motor;

(d) include full enclosure of exposed rotating parts (such as motor-pump couplings) to prevent accidental contact with Workers and other equipment;

(e) include engineered lifting points, supplied with a rigging plan and all necessary lifting equipment; and

(f) each have its output shaft flange-mounted to the input shaft of its respective high-pressure oil pump.

5.2 Governor Control Cabinet

A Governor control cabinet (the "**Governor Control Cabinet**" or "**GCC**") Enclosure will be provided, to mount major Governor System electrical and electronic system hardware, and to act as the primary interface for Workers using the Governor System.

The GCC will have:

(a) the Governor HMI, local/remote control transfer switch, emergency stop pushbutton, CT entrance FT-1 block, VT entrance FT-1 block, Governor MW transducer combination FT-1 block, and compact iso/test block mounted to its door;

(b) the Governor PLC, Governor Speed Switches, and Gate Position Switches mounted to its interior; and

(c) other devices and components mounted to it, as required to meet the requirements of Schedule 6 [Specifications and Drawings].

5.2.2 Governor PLC

The Governor System will utilize a Modicon Quantum or M580 type digital microprocessor-based programmable logic controller (the "**Governor PLC**") and associated hardware, to implement algorithms that:

(a) sense instrumentation and other inputs from the Governor System;

(b) perform Governor System diagnostic functions;

(c) provide Governor System indication and annunciation signals;

(d) implement Governor System control algorithms and determine Governor System control signals, including damping signals (dashpot type mechanical damping systems and mechanical type restoring systems are not acceptable);

(e) implement a Governor System sequence of events buffer for communication to a device external to the Governor System; and

(f) handle data communications, using:

   (i) Modbus TCP, between Governor System devices, and between the Governor System and devices external to the Governor System; and

   (ii) Modbus between the Governor PLC and the Governor HMI.

Governor PLC hardware will include the following:

(g) 125 Vdc redundant power supply modules;

(h) Modbus TCP communications capability;

(i) Modbus communications capability;

(j) 125 Vdc discrete input modules, to be utilized for all Governor PLC discrete inputs, that provide an IRIG-B (1 ms accuracy) GPS time-synchronized time-stamp for each change of state of each discrete input;

(k) Other input and output modules as required to meet the requirements of Schedule 6 [Specifications and Drawings];

(l) Spare hardwired analog and discrete input and output ports equivalent to at least 30% of the utilized inputs and outputs of each type (except for inputs and outputs associated with high-speed counter electronic PLC modules for the Toothed-Wheel Speed-Sensing system and Generator VT Speed-Sensing system, for which no spares are necessary);

(m) IRIG-B GPS time synchronization input hardware (IRIG-B signal to be provided by Others) that will be used by the Governor PLC to ensure the PLC clock is always synchronized to the IRIG-B timing signal, and also to timestamp Governor PLC hardwired discrete inputs to IRIG-B accuracy;

(n) Hardwired Analog Inputs and Outputs: All Governor PLC hardwired analog inputs and outputs will:

   (i) include a pair of wires per input or output (i.e., channels will be isolated, with no commoning);

   (ii) be 4-20 mA and user programmable on a per-channel basis;

   (iii) be galvanically isolated from ground and other channels;

   (iv) include short circuit protection; and

   (v) have their associated current value (measured input values in the case of analog inputs and calculated output values in the case of analog outputs) made available in Governor PLC registers for polling by external devices.

The following hardwired analog inputs to the Governor PLC will be provided by the Contractor. (additional analog inputs and outputs may be required by BC Hydro and identified at a later time):

(vi) Measured Gate Position;

(vii) pilot valve position;

(viii) Measured Unit Power;

(ix) accumulator pressure (two inputs);

(x) accumulator oil level (two inputs);

(xi) sump oil level;

(xii) sump oil temperature; and

(xiii) a test input (to be used by Others during maintenance and testing activities).

The following hardwired analog outputs from the Governor PLC will be provided by the Contractor:

(xiv) pilot valve command;

(xv) test output indication #1 (to be used by Others during maintenance and testing activities); and

(xvi) test output indication #2 (to be used by Others during maintenance and testing activities).

The Contractor will propose any additional hardwired analog inputs or outputs that may be of value to BC Hydro.

(o) Hardwired Discrete Inputs and Outputs: No discrete hardware indicators such as indicating lamps will be used.

Governor PLC binary discrete inputs will be 125 Vdc, and will have their current associated states (measured input states in the case of discrete inputs and calculated output states in the case of discrete outputs) made available in Governor PLC registers for polling by external devices.

The following hardwired discrete inputs (statuses and commands) to the Governor PLC will be provided by the Contractor:

(i) power supply and fuse monitoring (one per power supply/fuse);

(ii) filter clean/dirty indication (one per filter);

(iii) acceptable hydraulic pressure available to the distributing valve;

(iv) Unit breaker status;

(v) Governor Shutdown Solenoid pickup/dropout status;

(vi) pump running status (one per pump);

(vii) gate lock applied status;

(viii) gate lock fully released status;

(ix) Unit protection cleared status;

(x) pump control in auto status (one per pump);

(xi) pump control in manual status (one per pump);

(xii) Governor System local/remote status;

(xiii) Governor System Isolated Load Mode status;

(xiv) air admission valve status;

(xv) main air depression valve status;

(xvi) maintenance air depression valve status;

(xvii) exhaust air valve status;

(xviii) runner seal valve status;

(xix) speed no load command (commands the Governor System to control the Unit to speed no load);

(xx) synchronize command (commands the Governor System to control the Unit speed for synchronization to the running bus);

(xxi) start command;

(xxii) stop command;

(xxiii) generation to synchronous condense transfer command;

(xxiv) synchronous condense to generation transfer command;

(xxv) grid load operation to Isolated Load Mode transfer command;

(xxvi) Isolated Load Mode to grid load operation transfer command;

(xxvii) gate limit raise command;

(xxviii) gate limit lower command;

(xxix) raise command (used for MW, speed, and gate position); and

(xxx) lower command (used for MW, speed, and gate position).

The following hardwired discrete outputs from the Governor PLC will be provided by the Contractor (additional discrete inputs and outputs may be required by BC Hydro and identified at a later time):

(xxxi) Governor PLC major fault;

(xxxii) Governor PLC minor fault;

(xxxiii) urgent alarm asserted;

(xxxiv) non-urgent alarm asserted;

(xxxv) lag pump running;

(xxxvi) Isolated Load Mode selected;

(xxxvii) Wicket Gate Droop selected;

(xxxviii) Governor not in remote;

(xxxix) Governor not in auto;

(xl) run-time meter 1 running;

(xli) run-time meter 2 running;

(xlii) run-time meter 3 running;

(xliii) run-time meter 4 running;

(xliv) fast start mode enabled;

(xlv) Servomotor limit reached;

(xlvi) Gate Position Switch #x asserted (one output per Gate Position Switch will be provided);

(xlvii) speed switch #x asserted (one output per speed switch will be provided);

(xlviii) Governor start command (energize shutdown solenoid);

(xlix) Governor stop command (de-energize shutdown solenoid);

(l) gate lock release command;

(li) jockey pump start command;

(lii) jockey pump load command;

(liii) high-pressure main oil pump 1 start command;

(liv) high-pressure main oil pump 1 load command;

(lv) high-pressure main oil pump 2 start command; and

(lvi) high-pressure main oil pump 2 load command.

The Contractor will propose any additional hardwired discrete inputs or outputs that may be of value to BC Hydro.

(p) Preventative Maintenance Triggers: Preventative maintenance trigger functionality will be provided with the Governor System, to alert operations personnel (via one or more Governor Alarms) to Governor System performance that, over time, has drifted outside of a Worker-Adjustable range and may require maintenance. Preventative maintenance trigger information and Worker-adjustment functionality will be displayed on the Governor HMI. Preventative maintenance triggers will include:

(i) Wicket gate tracking error (e.g., steady-state Measured Gate Position and Gate Position Setpoint mismatched by a Worker-Adjustable percentage);

(ii) Abnormal Governor System start sequence time (e.g., one or more devices or subsystems within the Governor System took excessive time to start up);

(iii) Abnormal Governor System stop sequence time (e.g., one or more devices or subsystems within the Governor System took excessive time to stop);

(iv) excessive pump cycling;

(v) excessive oil pump up time; and

(vi) excessive oil leakage.

(q) Communications Links:

(i) *Physical Layer*: The Governor PLC will include a minimum of two communication ports as follows:

(A) an RJ 45 port used for Ethernet communications (100 Base-TX Full Duplex), to be connected to the generating station plant LAN using Modbus TCP; and

(B) a DB9 serial communications port, used for RS232/485 communications via a direct connection to the Governor HMI.

(ii) *Communication Layer*: The Governor PLC will be able to communicate Modbus RTU in addition to any proprietary communications protocols that may be required. The Ethernet communications will be TCP/IP with a user adjustable IP address, subnet mask and gateway. TCP/IP will include the following:

(A) data stream reconstruction from packets received;

(B) receipt acknowledgements;

(C) socket services providing for at least four connections (six or more preferred) to ports on the remote host;

(D) packet verification and error control;

(E) packet sequencing and recording; and

(F) conformity to IEEE 802 standards.

(iii) *Software Layers*: The Governor Software used in the Governor PLC will be arranged as follows:

(A) Maintenance level: This is defined as the level where the manufacturer's software is used to view, modify, and extract or download the program and data records. The ability to modify the operating software in any way (including parameter changes) will be password protected. The viewing of the variables and other data parameters will not be password protected.

(B) Control/data level: This is defined as the level that is used to send control commands to the unit and read any status/metering quantity in real-time. There will be no password required. The control commands (raise, lower, start, stop, etc.) and operating variables will scan at a rate of less than 500 msec.

Any passwords used by the Contractor must be provided to BC Hydro, and locking out any code or sections of Governor Software is not acceptable.

5.2.3 Governor HMI

A colour touchscreen Governor human machine interface (HMI) will be provided by the Contractor, as the primary means to:

(a) communicate visual display of Governor System indication, annunciation, metering, and monitoring, including those listed in Annex D of IEEE 125, to Workers using the Governor System; and

(b) accept Worker input commands from Workers using the Governor System.

The Governor HMI will:

(c) be a colour LCD touchscreen device, with a minimum diagonal screen size of 300 mm;

(d) have no moving parts (i.e., no hard disk drives or fans);

(e) have graphics designed to maximize readability, and consider the relative importance of data when arranging screen graphics. Simplicity and readability are valued over graphically accurate depictions of equipment; and

(f) communicate with the Governor PLC via a DB9 serial communications port, used for RS232/485 communications, and connected directly to the Governor PLC.

5.2.4 Governor Hardwired Controls

The following hardwired controls (the "**Governor Hardwired Controls**") will be provided with the Governor System:

(a) An "emergency stop" pushbutton, used to issue a command to cause immediate emergency shutdown of the Unit (including intake gate closure). This will be a red, mechanically-latched/reset pushbutton with mushroom operator, and a shroud to minimize the possibility of inadvertent operation.

(b) A "local/remote" control transfer switch (two-position, pistol-grip, mechanically-latched style), used to select the Governor System local/remote control mode.

All other control inputs to the Governor PLC will be via the Governor HMI or via hardwired control commands from a remote device external to the Governor System.

5.2.5 Power Supplies

The Governor System will include two power supplies as follows:

(a) connected in a redundant configuration using diode circuits, to ensure the Governor System will continue to operate if one of the power supplies fails;

(b) input and output voltages of each power supply will be 125 Vdc and 24 Vdc, respectively;

(c) power supply input and output terminals will have galvanic isolation with respect to each other of at least 2000 Vdc;

(d) each power supply will be powered from an independent 125 Vdc source, provided by Others. DC sources provided by Others are ungrounded and will not be grounded by the Governor System equipment; and

(e) each power supply will be rated to supply the entire Governor System load to which they are connected, under all operating conditions.

Governor System Equipment connected to the redundant power supply will include the Governor PLC, the Governor Shutdown Solenoid, and the pilot valve (electro-hydraulic transducer).

The Contractor will ensure that a Governor Alarm occurs if either or both of the power supplies fails as a result of input or output faults. The Contractor will ensure that local indications are provided with each of the supplies for input failure and output failure.

The Governor System will initiate an immediate Unit shutdown/trip if both power supplies fail.

Provided that adequate accumulator tank oil pressure exists and that at least one 125 Vdc control power source is available to the Governor System, the Governor System will be capable of starting or stopping the Turbine with no AC power available.

5.2.6 Run-Time Counters

Four elapsed time (run-time) counters will be supplied with the Governor System, and will each:

(a) be a stand-alone device;

(b) be mounted on the GCC door;

(c) be non-volatile (i.e., will not lose their stored count upon loss of power or failure of the Governor PLC); and

(d) be operated by the Governor PLC such that any quantity/condition or combination of quantities/conditions available to the Governor PLC can be tracked with each counter (e.g., Turbine run-time, synchronous condense run-time, rough load zone run-time, cavitation zone run-time, etc.).

SPGOV6 GOVERNOR SYSTEM TECHNICAL REQUIREMENTS - MECHANICAL

6.1 Mechanical Design Criteria

6.1.1 Governor Oil Systems

The Work as part of the Governor oil system includes a hydraulic power unit (the "**Governor HPU**"). The Governor HPU will, as a minimum, include:

(a) an oil sump;

(b) main pumps with unloaders, and associated motors;

(c) a jockey pump with unloader, and associated motor, complete with kidney-loop filter system;

(d) an electro-hydraulic control valve manifold;

(e) a hydraulic distributing valve assembly;

(f) a make-up air receiver;

(g) wicket gate lock equipment;

(h) pressure accumulator tank(s);

(i) instrumentation for monitoring oil pressure, temperature, and level;

(j) hydraulic oil piping and valves, including interconnection piping between the oil sump, accumulator, and servomotors, and all required drain and fill piping; and

(k) compressed air piping and valves, including interconnection piping between the compressor, air receiver, and accumulator.

Test points using "quick coupling with ball check" will be incorporated strategically throughout the hydraulic circuit to aid in troubleshooting.

Components of the Governor HPU, including test points, will be permanently identified using the same notations as in the hydraulic schematic. A plaque of the schematic, including all relevant operating and design data, will be attached to a visible location on the Governor HPU. BC Hydro may specify names and device numbers for some components that are to be incorporated into the Contractor's drawings.

Governor HPU components except for the sump and air-over-oil style accumulator tanks will be standard industrial hydraulic products that are readily available commercially in North America. In general the hydraulic systems will conform to the SAE J514 standard.

Drains for hydraulic components will be piped back to the HPU sump.

6.1.2 Design, Operating, and Test Pressures

The nominal operating pressure of the Governor HPU will be 6,900 kPa.

For all components the Governor design pressure (the "**Governor Design Pressure**") will be 1.1 times the nominal operating pressure of the Governor HPU. The Contractor will be able to demonstrate successful experience at the selected nominal operating pressure with reference Turbine(s) of similar size to the proposed Turbine. The Governor nominal pressure will be the normal maximum allowable operating pressure of the Governor HPU and associated components.

The test pressure for all mechanical equipment, including tanks falling under the Boiler and Pressure Vessel code, will be 1.5 times the Governor Design Pressure.

6.2 High-Pressure Oil Pumps

6.2.1 General

(a) Exposed rotating parts, such as motor-pump couplings will be fully-enclosed to prevent accidental contact with Workers and other equipment.

(b) Pumps will be equipped with a means of lifting, supplied with a rigging plan and all necessary lifting equipment.

(c) All motor-pump units will be rated for continuous service, and be provided with a separate adjustable pressure relief valve of adequate capacity.

(d) Each pump will be flange-mounted to its respective electric motor.

(e) All oil pumps will be provided with unloader valves for starting the motors in an unloaded condition.

6.2.2 Main Pumps

Each Governor HPU system will have two identical main pumps of the three-screw fixed-displacement type.

The combined pumping capacity will not be less than 1/4 of the sum of the maximum oil flow rate in the servomotors during a closing or an opening operation, whichever results in a greater flow rate, in accordance with IEEE 125.

6.2.3 Jockey Pump

Each Governor HPU system will include a jockey pump for pressure maintenance during normal unit operation.

The jockey pump will include a fixed displacement pump, an unloader, and function as the pump for the kidney-loop filter system.

The jockey pump will be able to provide a minimum of two times the expected oil consumption during steady-state operating conditions taking into account normal deterioration of components, or be capable of recirculating and filtering the nominal volume of oil in the Governor HPU sump once per hour, whichever is greater.

6.3 Oil Sump

6.3.1 Construction

The Governor oil sump tank will:

(a) have a capacity equal to at least 110% of the total oil volume in the Governor hydraulic system;

(b) be of welded steel construction;

(c) have base supports for floor mounting;

(d) have Lifting Points;

(e) have a filler pipe with cover;

(f) have a desiccant breather with replaceable 3-micron filter;

(g) have a clean-out cover, located on top of the sump, of a minimum size of 550 x 550 mm;

(h) have an additional smaller cover (approximately 250 x 250 mm) located distant from the clean-out cover for ventilation purposes;

(i) have a floor with a slight slope down to the low point of the sump;

(j) have the necessary valves and piping for filling and draining the sump, with the drain valve at the low point of the sump;

(k) have separate piping for filling and draining oil from the sump;

(l) have fill and drain piping that is at least 50 mm in nominal diameter, and will terminate with flanged connections the same size as used for the Turbine and Generator Bearing oil reservoirs at a location which the Contractor will submit for Review;

(m) have a sight glass for the full height of the sump;

(n) be equipped with oil sampling ports and connections for external filtering of the oil;

(o) have baffles separating the suction and return lines that are properly designed based on the hydraulic fluid used and ASTM Air Release Test Data, and including a removable strainer between the two sections;

(p) have on each pump suction line a strainer that is readily accessible;

(q) have all return lines terminate below the oil level with major lines fitted with diffusers to minimize aeration of the oil; and

(r) have, prior to application of any coatings, the sump tank tested for leaks with at a minimum air pressure of 30 kPa.

6.3.2 Oil Heating and Cooling

(a) Oil Cooling: If oil cooling is required, the Work includes a water-cooled heat exchanger with double wall tubes and all oil and water piping and valves for the exchanger.

(b) Oil Heating: To prevent condensation heating of the oil by a non-contact heater or other means (jockey pump fed kidney-loop) will be provided to maintain the oil temperature to at least 10ºC above the Powerhouse ambient temperature.

6.4 Accumulators

6.4.1 Design

In addition to all the requirements for air receivers each accumulator will be equipped with:

(a) an auxiliary inlet with an isolating and a check valve to allow each accumulator to be filled by an external air source;

(b) Lifting Points;

(c) a drain line, complete with dual-redundant isolation valves to allow the accumulator to be drained and serviced;

(d) a pressure-venting line, with dual-redundant isolation valves, complete with muffler;

(e) a float valve to prevent depressurization on low oil levels (the float valve will not inadvertently close at higher oil levels at maximum design oil flows);

(f) a small bypass line to pressure balance the system before opening the main isolating valve on the accumulator tank oil supply side;

(g) external bolted on stilling wells for the guided wave radar level transducers and for the magnetic float that operates the semaphore flag indicators including isolating and drain valves; and

(h) an inward hinged access hatch with an opening size of at least 600 mm x 400 mm that will be located approximately 1 m off the floor. A Worker will not be required to carry the weight of the hatch in order to open the access.

6.4.2 Volume

Sizing of the accumulators will be in accordance with IEEE 125 and IEEE 1207 and will meet the following minimum requirements:

(a) the accumulator will provide at least 1.5 servomotor volumes of oil between the Governor accumulator low level trip and the float valve closure; and

(b) the accumulator will hold an active tank volume (volume above the float valve) of at least 20 times the combined oil volume of the Turbine servomotors. With normal operating pressure in the accumulators, the oil will occupy 1/4 of total accumulator volume, the remaining 3/4 being occupied by air.

6.5 Governor Compressed Air System

A Governor compressed air system will be supplied for pre-charging the Governor accumulators and for maintaining pressure in the Governor accumulators.

The Governor compressed air system will be connected to the Governor accumulator tanks via a Governor air header pipe supplied and installed by Others that will terminate at an isolation valve adjacent to the Governor HPU for each Unit. The Work includes the connection from this isolation valve to the Governor HPU.

For each Unit, an electrically operated solenoid valve will control the pre-charging and make-up air to the accumulator tanks. The solenoid valve will have a handle for manual operation.

(a) General: The Governor air compressor system will be complete with:

  (i) a minimum of two air compressors;

  (ii) an intercooler for each compressor;

  (iii) an aftercooler for each compressor;

  (iv) twin tower desiccant air dryers for each compressor;

  (v) an air receiver for each compressor with a minimum combined volume equal to one Governor accumulator; and

  (vi) all necessary piping, valves, drains and controls for automatic admission of air to the Governor air header pipe.

(b) Air Compressors: Each air compressor for the Governor compressed air system will:

(i) be of reciprocating type capable of completely charging the accumulator for one unit, without using the air receivers, from ambient pressure to full operating pressure in eight hours (four hours with two compressors);

(ii) be driven by an electric motor;

(iii) have a motor, an MCC, and controls;

(iv) be air-cooled;

(v) have an operating pressure a minimum of 2000 kPa above the accumulator nominal pressure to charge the Governor makeup-air receivers;

(vi) have a design pressure not less than 1.1 times the nominal operating pressure;

(vii) have a valve system that permits the two air compressors to charge a Governor accumulator with one or both air receivers isolated;

(viii) include an after cooler and moisture separator such that all condensed liquid water is removed from the inlet air stream; and

(ix) operate in a lead-lag mode that is manually selectable.

(c) Desiccant Air Dryers: Each desiccant air dryer for the Governor air compressor system will:

(i) have particulate and coalescing pre-filters;

(ii) an particulate after filter;

(iii) use an actuated ball valve to switch between towers;

(iv) cycle the saturated inlet air alternately through each of two desiccant beds. One desiccant bed is on-line at full line pressure and flow, absorbing water vapor from the saturated inlet air while the second desiccant bed is being regenerated at atmospheric pressure by a depressurized portion of the dried outlet air; and

(v) have a bypass line around the desiccant air dryer system with bubble-tight isolation valve.

(d) Air Receivers: Each air receiver for the Governor air compressor system will be located in close proximity to the air compressors.

(e) Enclosures: If acoustic Enclosures are required for the Governor air compressors, then these Enclosures will be provided with suitable cooling systems.

(f) Make-up Air: Each Governor HPU will be supplied with a suitable make-up air receiver to prevent excessive cycling of the compressed air system and to minimise the impact when the Governor compressed air system is charging another accumulator. The size of the air receiver will be sufficient to provide 24 hours of make-up air during normal operation without the air compressors in service.

6.6 Valves

Lockable ball valves will be provided to isolate all major pieces of equipment including, as a minimum:

(a) servomotor piping with valves located adjacent to Governor HPU (Double Valve and Drain arrangement);

(b) wicket gate lock;

(c) accumulator;

(d) oil pumps (Double Valve and Drain arrangement);

(e) air compressors (Double Block and Bleed arrangement);

(f) pressure supply line to the hydraulic distributing valve (Double Valve and Drain arrangement);

(g) pressure instrumentation;

(h) filters;

(i) drains (redundant where specified);

(j) compressed air supply to Accumulator (Double Block and Bleed arrangement); and

(k) compressed air exhausts/vents (redundant valves).

6.7 Oil Filtration

The jockey pump filter will be equipped with a duplex filter assembly on the discharge side of the pump that operates at nominal system pressure when pressurizing the Governor HPU system, and as a kidney loop filter system, after normal system pressure has been established, with the discharge being directed to the sump for the purposes of filtration and heating.

All pilot oil will be separately filtered with its own duplex filter assembly and it will be filtered to a higher standard than the jockey pump kidney loop filter system.

All filter assemblies will use disposable elements that have a minimum pressure loss, be mounted in a convenient and accessible location, and be capable of being replaced safely while the Governor HPU and Unit are in normal operation.

Filter replacement will not be required more frequently than once every six months.

Each filter will have a visual indication, and pressure switch to indicate a plugged element and an internal bypass at a higher differential pressure.

6.8 Distributing Valve Assembly

The Governor HPU will be equipped with a wicket gate distributing valve assembly for controlling oil flow to the wicket gate servomotors. It will consist of a single four-way directional valve controlled by an electrically operated proportional pilot valve (electro-hydraulic transducer). The valves will be capable of operating with continuous dither to prevent sticking or sluggish operation.

The pilot valve will operate with a 4-20 mA signal and be capable of interfacing with the Governor PLC. Upon loss of electrical signal to the pilot valve, the distributing valve assembly will move the servomotors in the closing direction at a controlled rate that is Site adjustable. During a shutdown of the Unit, the Governor System will interrupt the electrical signal to the pilot valve.

The distributing valve will also be biased to close upon loss of pilot valve pressure.

The pilot and four-way valves will be designed with minimum internal oil leakage in the neutral position.

6.9 Servomotor Timing Devices

The Governor HPU will be equipped with a means of adjusting the oil flow rate to control the opening and closing times of the servomotors controlling the wicket gates. Travel time in each direction of the servomotors will be independently adjustable. However, once adjusted, it will not be possible for the servomotor to move at a rate faster than the set rates. Secure and positive means of locking the timing adjustments will be provided. Such devices will take the form of continuously adjustable position stops in the distributing valve that directs oil to the servomotors, or an external continuously adjustable flow control valve. Fixed orifices are not permitted.

The effective opening time and closing time will be defined, respectively, as twice the time required for the servomotor(s) to open from 25% to 75%, or to close from 75% to 25% of full travel.

6.10 Governor Shutdown Solenoid Valve

The Governor HPU will be equipped with one electrically operated solenoid valve (the "**Governor Shutdown Solenoid**") to permit start/stop operation from a remote location. The shutdown solenoid will be energized to permit starting and running of the Turbine. When de-energized, the solenoid valve will initiate complete closure of the servomotors at the maximum rate set by the timing devices, assuming an adequate supply of pressure oil is available. The solenoid valve will cause the servomotors to close regardless of any control action from the digital Governor System.

The solenoid coil will be rated for continuous service at 24 Vdc.

The shutdown solenoid circuit will be designed so that when it is de-energized, the pilot valve (electro-hydraulic transducer) power will also be removed.

6.10.1 Manual Shutdown Valve

The Governor HPU will be equipped with one manually operated valve, with a lockable handle if applicable, to permit a Worker to manually cause the Governor System to shut down the Turbine, and issue a signal to equipment external to the Governor System to initiate immediate emergency shutdown of the Unit. The function of this manual valve is identical to the shutdown solenoid valve described above. The manual valve will be accessible by a Worker standing beside the HPU.

6.11 Wicket Gate Lock Solenoid Valve

The Work includes a Governor HPU-mounted electrically-operated wicket gate lock solenoid valve and connection of it to the pressure oil supply within the Governor HPU. The wicket gate lock mechanism (hydraulic cylinder, locking device, and associated limit switches) external to the Governor HPU will be supplied and installed as described in Appendix 6-3 [Turbine Specifications (SPT)].

6.12 Oil Containment Pit

The Governor HPU sump and accumulator tanks will be contained in a separate concrete oil containment pit. The volume of the pit will be sized to contain the total volume of oil in the Governor System. The oil containment pit will have a small drainage sump with outlet valve and drain to the Powerhouse oil water separator. The outlet valve will be normally closed to retain any leaked oil within the oil containment pit.

The Work includes suitable gratings and guardrails as required to safely cover open areas of the oil containment pit and still maintain clear access to equipment for maintenance and isolation. The design of the gratings will be as specified in Appendix 6-2 [General Technical Specifications (SPGT)].

The top of the Governor HPU sump will be low enough to the gratings such that handrails and ladders are not required to access to top of the Governor HPU sump. Steps will be provided if the level of the sump is higher than 300 mm above the concrete floor.

If it is necessary to access the top of the sump for routine isolation of equipment, there will be a clear unobstructed path to that equipment.

6.13 Specialized Testing Equipment

The Work includes provision of means to test the Toothed-Wheel Speed Sensing System by passing teeth or other suitable metal object past the ZVPU Probes, in order to simulate motion of the Toothed Wheel. Means provided to accomplish this will not require disturbance of the ZVPU Probes (i.e., testing will be possible with the ZVPU Probes mounted in their in-service position).

The method of providing this testing capability will be submitted.

6.14 Equipment Identification

6.14.1 Governor System Nameplate Placard

The Governor System will be provided with a nameplate placard in a prominent location on the outside of the Governor Enclosure. The information on the nameplate will:

(a) be in accordance with IEEE 125; and

(b) include:

- (i) manufacturer’s name and address;
- (ii) type of equipment;
- (iii) serial number of the Governor System;
- (iv) model number and type number of the Governor System;
- (v) date of manufacture;
- (vi) hydraulic oil type;
- (vii) hydraulic oil volume (total) (L);
- (viii) ambient temperature rating (°C);
- (ix) BC Hydro contract number; and
- (x) BC Hydro purchase order number.

SPGOV7 TEST AND ISOLATION FACILITIES

7.1 Test Points

There will be 4-20 mA discrete-to-analog (D/A) outputs from the Governor PLC, wired to terminal blocks within the GCC. Each D/A output will be updated on each computational cycle of the Governor PLC. The selection of the digital values to be converted for each analog output, as well as the associated scaling, filtering, will be adjustable via settings from the connected laptop computer. The following signals will be provided as a minimum:

(a) wicket gate position;

(b) spool positions of both the pilot and distributing valves;

(c) Turbine speed;

(d) running frequency;

(e) MW;

(f) incoming frequency;

(g) frequency reference;

(h) frequency error;

(i) power reference;

(j) MW error;

(k) four spare, configurable independent D/A outputs; and

(l) eight other signals internal to the Governor System computer to be specified by BC Hydro after Contract award.

In addition to the above there will be live signal injection capability. The scaling will be 4 mA to 20 mA, or 0-10 Vdc, for 0 to 100% of the signal scaling. The scaling factor will be available through the laptop computer. Signal isolation will be provided in the Governor System. The signal will be converted and injected in the computation loop on each cycle. The isolation circuit and conversion will have a flat frequency response to at least 100 Hz. Two inputs selectable from the laptop computer will be provided. The following signals will be available as a minimum:

(m) Wicket gate position amplifier summing junction;

(n) frequency (speed) amplifier summing junction; and

(o) MW amplifier summing junctions.

7.2 Isolation Facilities

7.2.1 CT Entrance FT-1 Block

An entrance CT isolation and test block (ABB type FT-1) will be provided and connected in accordance with BC Hydro ES 45-X0010 for the Generator CT input to the Governor System.

7.2.2 VT Entrance FT-1 Blocks

An entrance VT isolation and test block (ABB type FT-1) will be provided and connected in accordance with BC Hydro ES 45-X0010 for each of:

(a) the Generator VT input to the Governor System; and

(b) the running bus VT input into the Governor System.

7.2.3 Compact Iso/Test Subpanel

A compact iso/test subpanel will be provided and connected in accordance with BC Hydro ES 45-X0011, and will be used to isolate:

(a) VT inputs between the VT entrance block and each downstream device;

(b) Governor PLC trip outputs between the Governor PLC and each downstream device; and

(c) other points agreed to between the Contractor and Hydro's Representative.

7.2.4 Combination FT-1 Block

A combined voltage and current isolation and test block, as outlined in section 4.6 of BC Hydro ES 45-X0010 (ABB type FT-1 670B197G18), will be provided and connected between the Governor MW transducer and CT/VT entrance blocks, to allow the Governor MW transducer to be isolated from Generator CT and VT circuits, and tested by Others via connection of test equipment.

SPGOV8 MANUFACTURING, INSPECTION AND TEST REQUIREMENTS

8.1 Shop Inspection and Tests

8.1.1 General

The Work includes performance testing of the Governor System to demonstrate the functionality for all operating conditions. The Equipment will be fully integrated to the maximum extent possible. Where it is not practical to integrate sub-systems of the equipment, or to test full functionality, the Equipment may be tested by simulating the operating conditions or interconnection required to demonstrate system performance. Simulation methods will be submitted for Consent.

Governor System shop inspection and tests will include the inspection and testing recommended in and be performed in accordance with IEEE 125, IEEE 1207, and IEC 60308 except as otherwise specified.

8.1.2 Governor Control Cabinet

The fully-integrated Governor Control Cabinet will be tested with the HPU. Simulated control of the HPU will not be accepted.

Testing of the controls for the air depression system for synchronous condenser operation, and the air admission system, may be deferred until the Equipment is on Site.

8.1.3 HPU

The HPU will be tested as a complete system including the accumulator.

Pumps will be operated a minimum of 4 hours continuously under load.

8.1.4 Compressed Air System

The compressed air system may be tested as a standalone system and is not required to be integrated with the rest of the Governor equipment.

SPGOV9 SITE ACCEPTANCE AND COMMISSIONING TESTS

9.1 General

Governor System site acceptance and commissioning tests will include the tests recommended in and be performed in accordance with IEEE 125, IEEE 1207, and IEC 60308 except as otherwise specified.

9.2 Governor System Tests by the Contractor

The Governor System will be thoroughly tested to confirm that its performance as an integrated part of the Unit is acceptable, considering all Unit and Governor System operating conditions outlined in the Specifications.

To the maximum extent possible, the Contractor will functional test and verify the performance of all aspects of the Governor system prior to watering up the Unit. As part of these tests, speed and power inputs will be simulated.

Governor System tests will include:

(a) Dry tests, including:

- (i) verifying performance of the HPU system and components including pumps, motors, instrumentation, valves;
- (ii) wicket gate position transducer calibration testing;
- (iii) wicket gate servo control loop response testing;
- (iv) gate lock testing;
- (v) wicket gate timing tests;
- (vi) limiter tests;
- (vii) control transfer (auto/manual and local/remote) testing (including loss of sensing tests);
- (viii) manual mode control, stability, and response testing (including “bump” disturbance testing);
- (ix) automatic mode control, stability, and response testing (including “bump” disturbance testing);
- (x) isolated mode control, stability, and response testing (including “bump” disturbance testing);
- (xi) turbine air depression system testing; and

(xii) synchronous condense mode control and transfer testing.

(b) Wet offline tests, including:

(i) start-up and speed-no-load control and response testing (including “bump” disturbance testing);

(ii) stop control and response testing;

(iii) limiter tests;

(iv) control transfer (auto/manual and local/remote) testing;

(v) synchronizing control testing (speed matching);

(vi) turbine air depression system testing; and

(vii) synchronous condense mode control and transfer testing.

(c) Wet online tests, including:

(i) manual mode control, stability, and response testing (including “bump” disturbance testing);

(ii) automatic mode control, stability, and response testing (including “bump” disturbance testing);

(iii) isolated mode control, stability, and response testing (including “bump” disturbance testing);

(iv) control transfer (auto/manual and local/remote) testing (including loss of sensing tests);

(v) limiter tests;

(vi) synchronous condense mode transfer and control testing; and

(vii) load rejection testing.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-5

GENERATOR SPECIFICATIONS (SPG)

TABLE OF CONTENTS

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-5

GENERATOR SPECIFICATIONS (SPG)

SPG1 GENERAL

1.1 Definitions and Interpretation

In this Appendix 6-5 [Generator Specifications (SPG)], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Connection End**" means the end of the Generator that has the circuit-ring bus and main Generator terminals;

"**Drive End**" means the end of the Generator that is driven by the Turbine;

"**Generator**" has the meaning set out in SPG 1.2.1(a);

"**Generator Enclosure**" has the meaning set out in SPG 2.10.1;

"**Generator Losses**" has the meaning set out in SPG 2.1.1;

"**Generator Pit**" means the area inside the Generator Enclosure that is within the circumference of the stator bore, below the rotor, and above the Turbine Pit;

"**Generator Pit Maintainable Components**" has the meaning set out in SPG 2.11.1;

"**Generator Rated Field Current**" has the meaning set out in SPG 2.2.3;

"**Generator Rated Operating Conditions**" has the meaning set out in SPG 2.2.4;

"**Generator Rated Output**" has the meaning set out in SPG 2.2.2;

"**Generator RTD Terminal Cabinet**" has the meaning set out in SPG 2.17.3;

"**Generator Terminal Cabinet**" has the meaning set out in SPG 2.17.2;

"**Regulated Cold Air Temperature**" has the meaning set out in SPG 2.4.6;

"**Toothed-Wheel**" or **"TW"** has the meaning set out in SPG 2.16.2(a)(i);

"**Toothed-Wheel Speed Sensing System**" or "**TW Speed Sensing System**" has the meaning set out in SPG 2.16.2; and

"**TW Housing**" has the meaning set out in SPG 2.15.

1.2 Scope of this Specification

1.2.1 Scope of Work for the Generators

Six identical Generators are required for the Project, together with related Work, as follows:

(a) each generator (a "**Generator**") includes the sole-plates, stator frame, stator core, stator winding, circuit-rings, main and neutral leads, rotor hub, rotor spider, rotor rim, rotor poles, thrust and guide bearings, brushgear housing, brushgear, field bus and cables, upper bracket, lower bracket (as applicable), brakes, jacking system, cooling systems, and instrumentation.

1.2.2 Scope of Related Work

The Work related to each Generator includes:

(a) a conceptual design of a stator Lifting Device and support pedestals for a Generator stator even if the Contractor does not require a stator Lifting Device or support pedestals for the Work;

(b) tooling and Lifting Devices;

(c) all specialized test instrumentation, current measurement, and voltage measurement required to complete the Generator acceptance and commissioning tests;

(d) the Generator short-circuit connection required for the Generator testing; and

(e) the Generator shorting breaker and shorting bus or cables required for the Generator sudden short circuit testing. BC Hydro can make available a shorting breaker on an as-is, where-is basis at no cost to the Contractor upon request. BC Hydro makes no representation or warranty as to the suitability of the BC Hydro-provided breaker for the required testing, and if the breaker does not work or is for any reason not suitable, the Contractor will provide a breaker for the required testing at no additional cost or expense to BC Hydro.

1.2.3 Work Not Included

Not Used.

1.3 Submittals

1.3.1 Generator Drawings

(a) Generator: The Generator Drawings will include:

(i) lower bracket / support cone, embedded parts and anchors, and supports;

(ii) upper bracket and top covers;

(iii) Generator shaft (if any), thrust block, connecting flanges, and shaft seal system;

(iv) thrust and guide bearing enclosures, thrust pads, and thrust collar;

(v) bearing lubrication system, jacking system, and oil cooling system;

(vi) bearing oil mist containment and removal system;

(vii) bearing insulation system;

(viii) brakes and jacking system, track and supports, and dust collection system;

(ix) cooling system including air coolers, bearing coolers, isolating valves, piping, and supports;

(x) fire protection system including detectors, sprinklers, and piping;

(xi) all instrumentation and wiring inside the Generator Enclosure; and

(xii) auxiliary systems equipment.

(b) Stator: The Generator stator Drawings will include:

(i) sole-plates and embedded parts and anchors, frame, and core;

(ii) core laminations, air ducts, key bars, core studs, clamping fingers, and details;

(iii) bar dimensions, materials, and cross-section;

(iv) stator winding bars assembled in the core, support rings, and bar end-turn support system;

(v) winding circuit-rings and main and neutral leads;

(vi) winding connections, including series clips, group jumpers, bar taps, circuit-ring taps, main and neutral leads taps, flexible links, and ferrules;

(vii) bar transposition drawing showing the development of strand cross-over, strand ends start and finish numbering system, method of insulating cross-over points, and strand interconnections;

(viii) bar design including sectional views of stator bars in the slot with all dimensions, showing stranding, strand and ground insulation, fillers, springs, wedges, and resistance temperature detectors;

(ix) winding design including overall dimensions and angles of the bars and defining whether the bars are left or right when viewed from inside the stator bore, slot skew (if any) end-turns, end-turn span and drop dimensions, support ring locations, bar-end supports, tying procedures, and insulation requirements for all components;

(x) copper cross-section area for the stator bars, circuit-rings, and main and neutral leads;

(xi) winding diagram, including:

(A) showing the parallel paths in each phase and showing the slot numbering system;

(B) showing the slot number in which each bar is located, and whether the bar is located in the front or back position;

(C) a tabulation listing the slot number and the corresponding phase in the slot and location from the line or neutral end of the parallel; and

(D) in all winding diagrams, showing in which slot, and the location in the slot, of the RTDs;

(xii) plan and sectional views of circuit-rings, blocking system, and connections between bars, between bars and circuit-rings, and between circuit-rings and the main and neutral leads;

(xiii) a step-by-step description of the insulation system (materials and application) including:

(A) description and thickness of the strand and groundwall insulation systems;

(B) net mica thickness and voltage stress in kV/mm of the ground insulation; and

(C) description of the insulation and partial discharge suppression system including a list of materials.

(xiv) frame, core, and winding RTDs plan and sectional views;

(xv) bar surface resistivity measurement device; and

(xvi) slot wedging details.

(c) Rotor: The Generator rotor Drawings will include:

(i) hub, spider, and rim, and rim keying system;

(ii) pole bodies, laminations, field coils, and pole keying system;

(iii) field bus and connections;

(iv) brushgear and carbon dust collection system; and

(v) field winding short-time thermal capability curve for setting the field thermal overload protection.

1.3.2 Generator Calculations

In general, Calculations will verify the ability of the Generator to withstand the operating conditions for the Equipment in accordance with Appendix 6-2 [General Technical Specifications (SPGT)].

(a) Generator: The Generator Calculations will include:

(i) rotor/stator airgap stability considering the stiffness of the mechanical and magnetic components. The Calculation will:

(A) demonstrate the adequacy of the mechanical components to maintain airgap stability and the specified minimum airgap under the operating conditions specified in Appendix 6-2 [General Technical Specifications (SPGT)]; and

(B) be compared with existing generators of similar capacity and physical size to demonstrate the geometrical stability and long-term reliability of the stator and rotor;

(ii) electro-magnetic design;

(iii) fault calculations and mechanical damping factors during faults;

(iv) Generator cooling and ventilation; and

(v) demonstration of the safety and stability of any equipment mounted in the airgap;

(b) Stator: The Generator stator Calculations will include:

(i) stator core compression and buckling;

(ii) stator core full-flux test electrical requirements;

(iii) stator winding components current density;

(iv) stator winding temperature rise;

(v) bar forces in the slots;

(vi) the maximum short-circuit force between conductors and the required spacing between ring bus supports;

(vii) stator slot ripple spring and wedges;

(viii) maximum allowable armature winding deflection during the sudden short circuit test; and

(ix) stator deflection during and after handling (if assembled on the Powerhouse service bay);

(c) Rotor: The Generator rotor Calculations will include:

(i) rim separation speed and required shrink interference value (if applicable);

(ii) current density for all field winding components;

(iii) field winding temperature rise;

(iv) field bus connections including the contact pressure and stress; and

(v) demonstration of the safety and stability of any equipment mounted on the rotating components.

1.3.3 Generator Procedures

(a) Generator: The Generator Procedures will include:

(i) lower bracket or thrust cone installation;

(ii) bearing(s) installation;

(iii) thrust block and shaft installation;

(iv) stator installation in the Generator Enclosure (if assembled in the Powerhouse service bay);

(v) rotor installation in the Generator Enclosure;

(vi) upper bracket and top cover installation;

(vii) brushgear and carbon dust collection system installation; and

(viii) brakes, jacking, and brake dust collection systems installation.

(b) Stator: The Generator stator Procedures will include:

(i) embedded parts, anchors, and sole-plate installation;

(ii) frame construction including the methods for levelling and maintaining the specified verticality, circularity, and concentricity;

(iii) method of checking and adjusting stator core compression and levelness including clamping pressure;

(iv) preparation of the core to receive the new winding;

(v) winding installation including connection and insulating methods;

(vi) determination of the amount of slot side packing required, the installation method, and the method used to confirm that there is sufficient contact between the stator bar and the side packing and between the side packing and the stator core;

(vii) wedging system installation including the method of measurement of bar tightness in the slot and of amount of spring-type filler compression;

(viii) installation of the circuit-rings and main and neutral leads including connection and insulating methods; and

(ix) winding testing during installation and when fully installed.

(c) Rotor: The Generator rotor Procedures will include:

(i) hub and spider construction;

(ii) rim construction including rim shrink and circularity, concentricity, and verticality measurements;

(iii) pole installation including key installation and elevation, circularity, concentricity, and verticality measurements;

(iv) field bus installation; and

(v) winding testing during installation and when fully installed.

SPG2 GENERATOR TECHNICAL DATA AND REQUIREMENTS

2.1 Generator Losses and Uncertainties

2.1.1 Losses

Generator losses (the "**Generator Losses**") means the total of the Generator fixed and variable losses as measured in accordance with SPG 5.2.20. Generator Losses will:

(a) be corrected to the Regulated Cold Air Temperature;

(b) include the bearing losses for the Generator guide bearing, Generator thrust bearing (including the contributions from both the weight of all rotating components and the Turbine hydraulic thrust at the corresponding Generator load) and the Turbine guide bearing;

(c) for synchronous condense operation, be the Generator Losses when the Generator is operating under-excited with a reactive power output in kVAr measured at the Generator terminals equal to 50% of the Generator Rated Output (kVA) excluding Turbine runner windage losses; and

(d) not exceed those stated in the tables in the Generator TDIF.

2.1.2 Uncertainties

The Generator Losses test uncertainties as stated in the tables in the Generator TDIF:

(a) will, for any operating point, not exceed the tolerances stated in IEC 60034-1 Table 20; and

(b) are considered final and will not be revised.

2.1.3 Updates to the Generator Losses Tables in the Generator TDIF

The Generator Losses tables in the Generator TDIF will be updated by BC Hydro with the Generator Losses measured during the site acceptance and commissioning tests using the following methodology:

(a) windage and fixed core losses will be assumed to be constant for all Turbine Weighting Regimes and equal to the values obtained in SPG 5.2.20;

(b) Turbine and Generator guide bearing losses and fixed Generator thrust bearing losses will be assumed to be constant for all Turbine Weighting Regimes and equal to the values obtained in SPG 5.2.20;

(c) Generator thrust bearing variable losses will be based on the values provided in the Generator TDIF and corrected for the actual hydraulic thrust measured in accordance with Appendix 6-2 [General Technical Specifications (SPGT)] versus the hydraulic thrust provided in the Turbine TDIF;

(d) armature I^2R and field I^2R losses will be calculated from the resistances measured in SPG 4.7.4 and SPG 4.9.4 using the square of the respective currents required for each Turbine Weighting Regime; and

(e) stray load losses will be interpolated from the values obtained in SPG 5.2.20 using the square of the armature current required for each Turbine Weighting Regime.

2.2 General Design Criteria

2.2.1 General

Except as otherwise expressly specified in this Appendix 6-5 [Generator Specifications (SPG)], the Generator will meet the requirements of IEEE C50.12.

Except as otherwise expressly specified in the Contract Documents, Generator power factor is for the over-excited operating condition.

2.2.2 Rated Output

The Generator rated output (the "**Generator Rated Output**") is the highest achievable continuous Generator output measured in megavolt amperes (MVA) at the Generator terminals while meeting all requirements of the Contract Documents and the following:

(a) Rated Power: The highest achievable continuous Generator power output measured in megawatts (MW) at the Generator terminals when the Generator is operated at rated power factor (pf).

(b) Reactive Power Capability: The Generator will be rated for continuous operation anywhere within its reactive power capability curve.

(c) Rated Power Factor (pf): The Generator will be rated for continuous operation at 0.95 pf over-excited.

(d) Rated Voltage (kV): The rated line-to-line rms voltage of the Generator will be in the range of 12 kV ≤ and ≤ 16 kV.

(e) Rated Frequency: The Generator rated frequency will be 60 Hz.

(f) Number of Phases: The Generator will have three phases.

The Contractor will determine the Generator Rated Output for the Generator operating at the Rated Operating Conditions.

The Generator will be rated so that the input power to the Generator is coincident with the Turbine Rated Output.

2.2.3 Rated Field Current

The Generator rated field current (the "**Generator Rated Field Current**") is the field current required in the Generator rotor field winding required to operate the Generator continuously at the Generator Rated Output.

2.2.4 Rated Operating Conditions

When the Generator is operating at the Generator Rated Output and with the cooling water at the Maximum Cooling Water Supply Temperature, the Generator rated operating conditions (the "**Generator Rated Operating Conditions**") will be as follows:

(a) Cold Air Temperature: The temperature of the air leaving the Generator air coolers as measured by RTDs will not exceed 40 °C.

(b) Stator Winding Temperature Rise: The temperature rise of the stator winding as measured by any embedded stator winding RTD over the slot length of the winding will not exceed 75°C[1].

(c) Stator Circuit-ring and End-winding Temperature Rise: The maximum temperature rise of the stator circuit-ring and end-windings as measured in accordance with SPG 5.2.17(f) will not exceed 80°C.

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[1] Temperature rise for V = 12 kV rated Generator only. Refer to IEEE C50.12 Clause 7.1.1 for V > 12 kV temperature rise limit reductions.

(d) Rotor Winding and Field Bus Temperature Rise: The temperature rise of the rotor winding and field bus as measured by the resistance method will not exceed 70°C.

The temperature rise limit calculations do not need to include the variation of rated frequency and rated voltage as specified in IEEE C50.12.

2.2.5 Out of Phase Synchronizing

The positive sequence equivalent Thevenin impedance looking into the network from the Generator terminals when one Generator is offline while the other five Generators are online is: 0.0021 + j0.102 pu. This value is based on 13.8 kV, 100 MVA base. The 500 kV bus Thevenin impedance is: 0.00132 + j0.01135 pu.

The Generator will be designed to withstand a non-synchronous closure (up to 180° out of phase) on to this external system when the Generator is operating at 110% of Rated Voltage and with the system at 110% of Rated Voltage. The duration of such closure will be assumed to be less than 160 ms.

2.2.6 Materials

All materials used in the Generator electrical or magnetic current carrying components, will:

(a) for winding insulation, have a thermal rating equal to or better than Class 155 (F);

(b) for core laminations, have a thermal rating equal to or better than Class 155 (F);

(c) for other components, have a thermal rating equal to or better than Class 130 (B);

(d) be mutually compatible;

(e) be fully-cured before completion of the Work;

(f) be capable of withstanding the stresses experienced during all operating conditions;

(g) have a voltage rating that is appropriate for the Generator stator and rotor rated voltages; and

(h) use blocking, filler, collar, wedging, etc., materials with properties equivalent to or better than NEMA G10.

Notwithstanding the above, the Generator, as a system, will be rated Class 155 (F).

2.3 Electrical Design Criteria

2.3.1 Reactances

(a) Synchronous Reactance: The direct-axis synchronous reactance (unsaturated) X_d will be 0.82 pu ± 10%.

(b) Direct-Axis Transient Reactance: The direct-axis transient reactance (unsaturated) X'_d will be 0.28 pu +0%, -10%.

(c) Direct-Axis Sub-transient Reactance: The direct-axis sub-transient reactance (unsaturated) X''_d will be 0.21 pu +10%, -0%.

(d) Reactance Ratio: The ratio of the quadrature-axis sub-transient reactance to the direct-axis sub-transient reactance (X''_q/X''_d) will be less than 1.35.

2.3.2 Short Circuit Ratio

The short circuit ratio (SCR) will be greater than 1.1.

2.3.3 Variation from Rated Voltage

The Generator will:

(a) operate satisfactorily at the Generator Rated Output within a voltage range of ±5%;

(b) be capable of occasional operation, such as increasing transmission circuit loading temporarily in the event of contingency outages of other transmission lines and transmission system equipment, when at Generator Rated Output within a voltage range of ±10%;

(c) be capable of withstanding for at least 30 minutes, and without operator intervention, a transmission system disturbance that results in the Generator terminal voltage of ±10% when the Generator is operating at any point within the capability curve; and

(d) be capable of operating for a period of at least 30 s at any Generator terminal voltage between 10% and 120% of the rated terminal voltage with Generator circuit breaker open to enable the Generator open-circuit saturation test to be conducted.

2.3.4 Variation from Rated Frequency

The Generator will operate satisfactorily at Generator Rated Output, but within a frequency range of ±2%.

2.3.5 Short Circuit and Negative Sequence Current Requirements

The Generator will be capable of withstanding without damage a 30 s, three-phase, short circuit at the terminals when operating at Generator Rated Output, with a 5% over-voltage and with fixed excitation in accordance with IEEE C50.12 Clause 4.2.1.

The I_2^2t characteristics and the continuous negative sequence current capability of the Generator will be in accordance with IEEE C50.12 Clause 4.2.1.

2.3.6 Phase Sequence

The phase sequence at the Generator terminals will be such that when facing the Generator phase terminals from outside the Generator, the terminals will be arranged in the horizontal order “A”, “B”, “C” reading from left to right and the voltages at the terminals will reach their maximum positive values (phase sequence) in the same order.

In addition to the terminal marking stated in IEEE C50.12, the Generator phase terminals will be marked with “A”, “B” and “C”.

2.4 Mechanical Design Criteria

2.4.1 Speed

(a) Rated Speed: The rated synchronous speed of the Generator will be determined by the Contractor and will match the Rated Speed of the Turbine.

(b) Runaway Speed: The runaway speed of the Generator will be determined by the Contractor and will match the runaway speed of the Turbine.

2.4.2 Inertia Constant

The Generator moment of inertia, J_G, and the Generator inertia constant, H_G, will be determined by the Contractor based on the requirement for the Unit inertia constant, H_{GT}, in Appendix 6-2 [General Technical Specifications (SPGT)] at Generator Rated Output.

2.4.3 External Thrust

The total external thrust, including the weight of the Turbine shaft and runner, between the no-load operating condition and the Generator Rated Output operating condition, will be determined by the Contractor. The total vertical deflection of the Generator thrust bearing support system caused by the maximum hydraulic down-thrust will be less than 5 mm.

2.4.4 Airgap

The Generator airgap is the minimum distance between the Generator rotor pole faces and the Generator stator core bore. The nominal design stationary airgap will be not less than 0.13% of the Generator rotor diameter.

At all times when the Unit is in operation, the airgap will have a total variation (minimum to maximum) that does not exceed 30% of the measured average stationary airgap excluding the contribution to the variation that is resultant from long-term movement of the Powerhouse substructure.

2.4.5 Dimensional Requirements

The Generator will be designed, manufactured, and erected in accordance with the Drawings and within the tolerances set out in the CEATI Report No. T052700-0329 Part II. The robustness of the Generator design will be such that these erection tolerances are not exceeded during the Design Life of the Generator except:

(a) in instances where an erection tolerance is exceeded due to movement of the Powerhouse substructure; and

(b) as noted in SPG 2.5.4(f) for the Generator Stator core.

With reference to the CEATI Report No. T052700-0329 Parts I and II:

(c) for all circularity measurements, the nominal design diameter of the measured component will be contained within the circularity tolerance zone;

(d) any measurements for circularity or concentricity of the Generator rotor will be based on the rotor pole faces or the rotor rim flats; and

(e) the level tolerance for the Generator stator core will be deemed to apply to any axial location of the stator rather than just the mid-height of the stator.

2.4.6 Generator Temperature Regulation

The air temperature within the Generator Enclosure (the cold air temperature) will be regulated to a constant temperature (the "**Regulated Cold Air Temperature**"). The set point for this Regulated Cold Air Temperature will be adjustable, but under no circumstances will the Regulated Cold Air Temperature, including any hysteresis around the set point, exceed the maximum allowable cold air temperature specified in the Generator Rated Operating Conditions.

2.5 Stator

2.5.1 General

The Generator stator will:

(a) be of sufficient strength and stiffness to ensure a stable shape and airgap uniformity under all operating conditions;

(b) be capable of withstanding all stresses under all conditions including a Generator short circuit (whether on the transmission system or Generator stator), synchronizing out of phase, seismic accelerations, during braking, or any other relevant condition;

(c) have uniform thermal expansion and contraction to ensure circularity and the radial and axial alignment of the stator bore under all operating conditions;

(d) have uniform temperature over the axial height of the stator bore and stator winding under all normal operating conditions; and

(e) have sufficient space around the stator winding Drive End to allow a Worker to inspect and clean the lower end of the Generator without the need to remove the Generator rotor.

2.5.2 Stator Weight Requirements

The total combined weight of the Generator stator and with the Generator stator Lifting Device attached will not exceed the combined lifting capacity of the Powerhouse bridge cranes.

2.5.3 Stator Frame

(a) General: Stress and deformations in the Generator stator frame will be kept to minimum practicable values consistent with operating conditions before, during, and after grouting.

(b) Adjustment: The Generator stator sole-plates and frame will have means for future adjustment of the stator frame both laterally and vertically after final grouting. As a minimum there will be 10 mm of adjustment in all directions.

(c) Vibration Amplitude: When the Generator is operating in a stabilized condition (constant power and temperature) at any output within the capability curve, the radial vibration amplitude of the Generator stator frame at 120 Hz will be less than 0.025 mm peak-to-peak (measured at the top of the stator frame).

(d) External Loads: The Generator stator frame will support the Generator upper bracket and any loads that the Generator upper bracket is designed to carry.

(e) Access Hatches: Access hatches or hinged doors in the Generator stator frame wrapper plate will be provided so that the back of the entire stator core can be inspected by Workers. There will be a minimum of one inspection hatch located between every pair of Generator air coolers. It will be possible for a Worker to inspect the back of the core at each frame shelf.

As an alternative to, or in combination with, the access hatches, the core can be inspected through the Generator air cooler openings provided that:

(i) convenient provisions are made to remove the coolers without hoisting the coolers;

(ii) disassembly of other equipment is not required;

(iii) no more than two Workers to remove the coolers; and

(iv) this alternative is accepted.

(f) Sole-Plates and Anchors: The Generator stator frame sole-plates and anchors will incorporate:

(i) design features that provide for free radial movement due to thermal expansion of the stator frame while simultaneously limiting any tangential or vertical movement;

(ii) design that incorporates radial stops to limit any inward movement of the stator frame;

(iii) design features on the sole-plates to restrain the radial component of loads;

(iv) provisions for grouting voids after backfilling the concrete blockout;

(v) design features that provide for self-centering the stator during cool down;

(vi) self-lubricating anti-friction materials on the bearing surfaces to facilitate the radial movement of the frame on the sole-plates;

(vii) the ability to remove the self-lubricating anti-friction materials and the radial keys without jacking the entire stator so that they can be routinely inspected or replaced;

(viii) match marks that mark the relative position of the stator frame to the stator sole plate after the Generator has been assembled and aligned; and

(ix) a mechanical indication device that enables a Worker to visually monitor or to measure the movement of the stator frame relative to the stator sole plates.

2.5.4 Stator Core

(a) Diameter: The Generator stator core inside diameter will be large enough to pass the Turbine headcover and runner through it.

(b) Interleaved Design: The Generator stator core laminations will be completely interleaved for the entire stator circumference. A segmented stator core design will not be accepted.

(c) Vibration Amplitude: When the Generator is operating in a stabilized condition (constant power and temperature) at any output within the capability curve, the radial vibration amplitude of the stator core at 120 Hz will be less than 0.038 mm peak-to-peak (measured at the top of the stator core).

(d) Magnetic Flux Density: The magnetic flux density in the Generator stator core will be less than 1.4 T in the yoke and less than 1.9 T in the teeth.

(e) Thermal Requirements: As measured by RTDs permanently mounted in the back of the Generator stator core and stator frame, the maximum temperature:

(i) variation around the circumference of the stator core will be less than 5°C;

(ii) variation between the top and bottom of the stator core will be less than 5°C; and

(iii) difference between the back of the stator core and the stator frame will be 5°C less than the maximum permissible temperature difference used in the stator core stability and stator core buckling calculations.

(f) Core Waves: The Generator stator core will meet the following requirements:

(i) there will be no core waves, buckling, or substantial loss of core pressure during installation or operation. After commencement of Commercial Operation, in any location of the stator core, the core will pass the knife test specified in SPG 4.5.1;

(ii) at any axial elevation, variation of the core level will not exceed 5 mm during the Design Life of the Unit; and

(iii) any variation of the core level will be stable and not change over time.

(g) Laminations: The Generator stator core laminations will:

(i) be of low-loss, high-grade, non-orientated electrical silicon steel;

(ii) use materials and have workmanship and a finish in accordance with ASTM A677/A677M, DIN EN 10106, or better;

(iii) be free from burrs before the insulating coating is applied;

(iv) be coated on both sides with an insulating, inorganic insulating material to minimize eddy current losses;

(v) use a coating that is not affected by: normal operating temperature, atmospheric humidity, or solvents that may be used to clean the stator core or stator winding; and

(vi) be adequately keyed or dovetailed to the stator frame.

(h) Air Ducts: The Generator stator core air ducts between stator core packets will be arranged to make the air flow smooth and quiet, minimize air friction loss, and uniformly cool the core and winding.

(i) Key-bars: The Generator stator core key-bars will:

(i) have uniform spacing around the inner periphery of the frame;

(ii) be installed in such a way that the errors in the location of the key bars are not cumulative; and

(iii) be independent from the stator core studs.

(j) Core Studs: The Generator stator core studs will:

(i) avoid resonant-frequency vibration during all Unit operating conditions including excitation and de-excitation of the Generator rotor field winding;

(ii) be independent from the Generator stator core key bar system; and

(iii) be arranged such that it is possible to verify core compression without any disassembly. Locking of the core stud nuts by welding will not be permitted.

If the stator core studs pass through the stator core laminations, the stator core studs will be coated with an insulating material so that no current can pass between the stator core and the stator core studs. The insulating material will be epoxy powder coating with a cured thickness of at least 0.25 mm.

(k) Stacking: When stacking the stator core the Generator stator core laminations will be pressed uniformly and at specific intervals. Intermediate pressings of the stator core will be performed:

(i) when the stator core is less than 500 mm in height as measured from the bottom stator core pressure fingers;

(ii) at an interval of less than 500 mm of stator stack height since the previous stator core pressing; and

(iii) at 100 mm before reaching the top of the stator core.

At each press:

(iv) the circularity, verticality, straightness, and horizontality will be measured in accordance with the same requirements that will be used for the final verification. Those tolerances will be met at each intermediate press. Corrections will be made as the stacking progresses to meet the tolerance required for the final verification;

(v) the inside and outside height of the stator core will be measured at the same locations and corrections will be made as the stacking progresses to meet the tolerance required for the final verification. The horizontality tolerance applies for this radial verification; and

(vi) the stator core will be tested using a Richard's L-3 knife at the bore and core back for loss of stator core pressure. In any location of the stator core it will be impossible to insert the knife more than 13 mm by hand without prying against a fixed object.

(l) Clamping: The Generator stator core clamping system will:

(i) ensure that the design clamping pressure is maintained throughout the Design Life of the Generator;

(ii) provide uniform clamping pressure throughout the axial and radial dimension of the stator core;

(iii) be adjustable to accommodate core settlement;

(iv) have adjustable clamping plates by means of screw threads or other acceptable device; and

(v) provide sufficient elasticity to accommodate minor dimensional changes in the core and to accommodate for core settlement.

(m) Core Slot Walls: The assembled Generator stator core slot walls will be:

(i) smooth with no protruding laminations, burrs, sharp points, or edges inside the slots; and

(ii) coated with semi conducting slot paint prior to winding installation.

(n) Penetrating Resin: The Generator stator core will have:

(i) penetrating resin applied to the stator core bore face. The resin will be applied in such a manner to not interfere with the installation or removal of the stator winding wedges; and

(ii) no penetrating resin applied to the back of the stator core.

2.5.5 Stator Winding

(a) General: The Generator stator winding includes the stator winding bars, stator circuit-rings, the main and neutral leads, and all connections between and support of the various components.

(b) Connections: The Generator stator winding will:

(i) be designed for wye connection;

(ii) have the parallel path circuits of each phase arranged and connected so that they can be easily disconnected for winding resistance and insulation resistance measurements;

(iii) have the main and neutral leads that:

(A) are arranged to allow for application of portable safety ground connections;

(B) have flexible and removable links. The links will:

(I) be designed to allow for thermal expansion of the stator;

(II) be designed and positioned to enable Workers to easily remove them to facilitate Generator maintenance (isolation and testing);

(III) when removed, provide an open gap clearance of at least 225 mm; and

(IV) when removed, separate the parallel stator winding circuits so that each circuit can be isolated and tested;

(iv) have neutral leads that:

(A) are insulated from ground for full line-to-line voltage;

(B) are wye-connected internally within the Generator Enclosure; and

(C) are terminated in a manner suitable for connection to the metal-enclosed Generator neutral cubicle (by Others) located outside the Generator Enclosure. The neutral cubicle will ground the Generator stator winding through a high resistance ground;

(v) be arranged to accept protection and monitoring systems as outlined in SPG 2.16;

(vi) have all clamps supporting the stator winding chamfered to ensure that the winding insulation is not damaged during thermal expansion and contraction; and

(vii) have any taped or encapsulated joint free from air pockets and voids.

(c) Stator Bar Construction: Each Generator stator winding bar will:

(i) be of Roebel design with a minimum 360° Roebel transposition in the slot portion of the bar;

(ii) consist of two stacks of multiple copper conductor strands with an insulated separator between the stacks;

(iii) use a glass-fibre material to insulate each conductor strand. The crimping process which forms the Roebel crossovers will not damage the strand insulation; and

(iv) use additional specific insulation at each Roebel transposition location.

(d) Finish: All parts of the Generator stator winding will:

(i) be smoothly and uniformly taped such that folded tapes in the groundwall insulation do not occur;

(ii) have no sharp points, edges, crevices, or abrupt change in shape and dimension;

(iii) once bars are installed in the core, the end-winding configuration will produce a consistent space between adjacent end-turns. This space will be such that partial discharge does not occur;

(iv) have ties and lashings with smooth finishes to eliminate sharp points or edges;

(v) be consistent in shape and dimension: front stator bars will be identical and back stator bars will be identical; and

(vi) ensure all that leads:

(A) are pre-formed in the factory, cleaned and readied for immediate connection at the Site. There will not be any residue of resin or remnants of other surface contaminants from the manufacturing process;

(B) have the ends aligned in all planes to facilitate brazing at the Site; and

(C) have sufficient length of exposed copper to make the required connections. The exposed copper will include sufficient space for heat-sinks required for brazing.

(e) Ground Insulation System: The Generator stator winding ground insulation system will:

(i) use a mica-tape, polyester- or epoxy-based groundwall insulation for the insulation between the conductor strands and the stator core;

(ii) use service-proven technology of more than 10 years in a similar application;

(iii) have the same insulation thickness throughout the length of the slot portion of the stator bar;

(iv) based on the rated line-to-ground voltage, have a design and measured voltage stress based on production samples that does not exceed 2.75 kV/mm. For the calculation of voltage stress, the insulation thickness is to be measured excluding the semi-conductive tape at the center of the broad (radial) side of the stator bar in accordance with IEEE 1043 Section 7.4, Figure 4; and

(v) in the slot and the end-turn portion of a stator bar, have the same number of tape layers and overlap area.

(f) Partial Discharge (corona) Suppression System: The Generator stator winding will:

(i) have an internal partial discharge suppression system applied at the stator bar Roebel crossovers and gaps on the surfaces of the transposed bar prior to application of ground insulation. The partial discharge suppression material will be conductive tapes and mastic;

(ii) have an external (slot) partial discharge suppression system for the slot portion of the winding groundwall. The partial discharge suppression system will be pre-impregnated, conductive polyester or epoxy tapes;

(iii) have a voltage grading system to prevent partial discharge at the end-turn portion of the winding. The voltage grading system will use semi-conductive tapes; and

(iv) ensure proper contact for the bond to the insulation surface and the overlap between the slot and end-turn partial discharge suppression tapes at the slot exit to prevent partial discharge.

Paint-based system partial discharge suppression systems are not allowed.

(g) Slot Support System, including Wedges: The Generator stator winding slot support system (including wedges) will:

(i) use slot packing materials that are semi-conductive throughout their volume if they are in contact with the stator bars;

(ii) exert sufficient force to prevent stator bar vibration caused by the electromagnetic forces;

(iii) use a service-proven, resilient side packing system to maintain continuous contact between the stator winding and the stator core in the circumferential direction and that will compensate for insulating material shrinkage;

(iv) use a service proven ripple spring follow up system to maintain continuous pressure on the winding in the radial direction and that will compensate for insulating material shrinkage; and

(v) use slot wedges that have a two-piece design such as a counter, piggy back or taper wedge design.

(h) Support: The Generator stator winding support system will:

(i) include sufficient blocking and other restraining measures to prevent movement and damage under sudden three-phase short circuit at the Generator terminals when the Generator is operated at Generator Rated Output and Generator Rated Operating Conditions and when operated according to the test parameters specified in SPG 5.2.21;

(ii) not have blocking or lashing placed over any of the partial discharge suppression systems;

(iii) have sufficient clearance to prevent tracking and discharge between conductors of different voltages;

(iv) have end-turn T-spacing designed to be at least (1 mm/kV * E)*1.05 where E is the rated line-to-line rms voltage of the Generator; and

(v) have measures to allow for thermal expansion.

2.5.6 Stator Lift Requirements

To enable end-of-life replacement, the Generator stator will:

(a) be designed to be removed from the Generator Enclosure to the Powerhouse service bay in one complete piece; and

(b) have all necessary stiffeners, pre-threaded bolt holes, adaptor plates, etc., necessary to facilitate the attachment of a stator Lifting Device to the Generator stator frame and to facilitate the lift itself.

In addition to the above, if the Generator stator is assembled in the Powerhouse service bay, the Generator stator will:

(c) be designed to be moved from the Powerhouse service bay to the Generator Enclosure in one complete piece; and

(d) be designed to minimize Generator stator core deflection during lifting and to ensure that the stator core bore dimensions remain within the allowable tolerances after lifting.

2.6 Rotor

2.6.1 General

The Generator rotor will:

(a) be designed to accommodate equipment required for air admission and/or synchronous condenser operation. Such equipment may include, an air head, air piping, and water piping; and

(b) have provisions for the installation of a TW Speed Sensing System.

2.6.2 Rotor Weight Requirements

The total combined weight of the Generator rotor, with all poles assembled, and with the Generator rotor Lifting Device attached will not exceed the combined lifting capacity of Powerhouse bridge cranes.

2.6.3 Rotor Rim

(a) Circularity: The Generator rotor circularity and concentricity will remain within the tolerances set out in the CEATI Report No. T052700-0329 Part II under all operating conditions, including runaway.

(b) Shrink: The Generator rotor rim will be shrunk fit to the rotor spider such that it remains in contact with the rotor spider up to a minimum separation speed of 110% of the Rated Speed.

(c) Structure: The Generator rotor rim will present a smooth continuous surface for the placement of the rotor pole bodies, keys, and field winding insulating collars.

(d) Stacking: The Generator rim stacking pattern will be designed to minimize the risk of rim kinking. Vent spacers will be welded.

(e) Keys: The Generator rim keys in the rim guiding system will be adjusted in the rotor spider keyways thus avoiding any undue clearance that could weaken the quality of the rim guidance. The torque between the rim and spider will be completely transmitted by shear stress in the keys. The keys will be designed for stability in their keyways thus preventing the possibility that the keys could twist due to the driving torque. The rim shrinking radial effort will be transmitted between the rim and each rotor spider arm through a key over the full length of the rim.

2.6.4 Rotor Poles

(a) Arrangement: The Generator and the Generator rotor poles will be arranged so that:

(i) it is possible to remove individual rotor poles to give access for repairs to the Generator stator core bore and stator winding; and

(ii) the rotor poles can be removed from the rotor without removing the Generator upper bracket or the complete Generator rotor.

(b) Keys: Where the tapered-key method of Generator rotor pole and rim assembly is used, the keys will project sufficiently above the rotor rim surface to allow use of a rotor pole key extraction system.

(c) Amortisseur Winding: The Generator rotor will be equipped with an amortisseur winding. The amortisseur winding will:

(i) be designed for maximum stability and minimum voltage distortion under fault conditions and will meet the reactance ratio requirements of SPG 2.3.1(d);

(ii) be designed so that the amortisseur damper bars remain tight in the pole body. There will be sufficient provision for thermal expansion of the damper bar. If an open slot system is used, positive grounding of the bar will be provided by swaging the slot opening in at least five locations equally spaced along the slot;

(iii) have means in the amortisseur winding for the flow of currents between poles, such as direct inter-polar connections or an embedded copper plate at each end of the rotor pole. Direct inter-polar damper connections will not use ferromagnetic materials;

(iv) ensure individual damper bar connections are silver-brazed. No brazing will be performed near any critically loaded section of the amortisseur winding; and

(v) be designed to withstand negative phase sequence currents of I_2^2t less than 40.

(d) Pole Bodies: The Generator rotor pole bodies, including pole end-plates, will:

(i) be fabricated from punched thin sheets stacked and pressed between pole end-plates;

(ii) not exceed the allowable temperature rise of the Generator when operating at the Generator Rated Output at the Generator Rated Operating Conditions;

(iii) present a smooth continuous surface for the placement of the rotor pole keys and the rotor pole field winding insulating collars;

(iv) have pole stop blocks that allow easy adjustment of the pole elevation for alignment to the rotor magnetic centre; and

(v) be designed such that the lifting device(s) bolts to the pole body and does not clamp to, or sling around, the pole body. In addition the lifting device(s) will facilitate placing the pole on the ground and rotating it vertical to horizontal to vertical without the use of any temporary blocking.

(e) Pole Numbering: The Generator rotor poles will:

(i) have the numbers permanent and visible from the top, bottom, and exterior (stator view) of the rotor;

(ii) be punched and at least 18 mm tall;

(iii) be orientated so that they can be read from the rotor rim for the numbers on the pole-ends;

(iv) be orientated so that they can be read from standing outside the rotor for the numbers on the pole-face side;

(v) be numbered as Pole 1 for the first pole connected to the field bus in the direction of rotation;

(vi) be numbered in an increasing order for subsequent poles in the direction of rotation;

(vii) be the highest pole-number for the last pole that is connected to the field bus;

(viii) be based on the direction of rotation as seen from the stator Connection End; and

(ix) be based on the direction of rotation from a rotor-centric view.

2.6.5 Rotor Interpolar Baffles

The Generator rotor inter-polar baffles (or V-blocks), if required, will:

(a) be constructed from non-conductive materials;

(b) be easily removable with the complete Generator rotor installed; and

(c) withstand the forces incurred during Unit runaway speed.

2.6.6 Rotor Pole (Field-coil) Winding

(a) Field Winding: The Generator rotor pole field-coil winding will:

(i) be made of copper;

(ii) consist of one series-connected circuit;

(iii) have winding turns that are evenly compressed and bonded together;

(iv) be pressed on identical fixtures or jigs instead of the pole bodies;

(v) be designed to minimize mechanical stresses in the corner areas of the winding turns;

(vi) have the thermal expansion and contraction restricted to one sliding face; and

(vii) be protected with a chemical- and moisture-resistant coating.

(b) Turn Insulation: The Generator rotor pole field coil winding turn insulation will:

(i) be designed to prevent electrical creepage and shorts between turns;

(ii) maintain the rotor pole windings in the designed shape without distortion or separation of the winding turns; and

(iii) use a minimum of two layers of insulation. The joints in one layer will be overlapped by the other layer.

(c) Ground Insulation: The Generator rotor pole field-coil winding ground insulation system including collars will:

(i) be designed to prevent electrical creepage due to the collection of contaminants;

(ii) be composed of rigid materials;

(iii) be such that there is no displacement of the insulation system components;

(iv) be sealed by Permatex Ultrablue RTV to prevent the ingress of moisture or contaminants; and

(v) be easy to dismantle from the rotor pole body for repair.

2.6.7 Rotor Pole Inter-connections

The Generator rotor pole field winding pole-to-pole inter-connections will:

(a) have a conducting and contacting cross-section at least equal to the nominal winding cross-section;

(b) be rigid copper bars or flexible-braid copper conductors;

(c) not be insulated;

(d) have connections that are tin or silver-plated;

(e) enable individual poles to be disconnected for testing or for removal while the Generator rotor is installed. Soft-solder or brazed connections will not be used; and

(f) be capable of withstanding mechanical stresses of normal in-service vibration and thermal cycling, and also the stresses incurred at runaway speed.

2.6.8 Field-Bus

The Generator field-bus connects the Generator rotor poles to the Generator rotor brushgear and also connects the Generator rotor brushgear to the Excitation System at the interface connection located at the transition point from the Generator upper bracket to the Generator Enclosure wall. The Generator field-bus will:

(a) be configured such that the bus connects to the first and last Generator rotor poles;

(b) be constructed of rigid copper bus bars firmly supported at regular intervals;

(c) be protected with a chemical- and moisture-resistant coating;

(d) have flexible links in the bus to compensate for mechanical and thermal expansion at, as a minimum the rotor spider-to-rim interface and the Generator with respect to the Generator Enclosure;

(e) have NEMA-type bolted connections at the Generator rotor brushgear such that the field-bus can be disconnected to allow the Generator rotor brushgear to be removed;

(f) have NEMA-type bolted connections at the transition point from the Generator field-bus on the Generator upper bracket to the Excitation System dc bus such that they can be disconnected to allow the Generator upper bracket to be removed;

(g) have connections that are tin or silver-plated and covered with an insulating boot;

(h) be configured such that the field-bus polarity can be changed at the Generator rotor collector brushgear connection-end; and

(i) for Worker safety protection have means to ground the field-bus on top of the rotor. Both leads (polarities) of the two field buses will have permanently-installed ground ball-studs that are accessible after minimal disassembly of the Generator.

Use of cables to connect the Generator rotor brushgear to the Excitation System instead of rigid copper bus bars is acceptable provided the cables meet the requirements described in this SPG 2.6.8 with the exception of SPG 2.6.8(b) and meet the requirements for the Excitation System field cables in accordance with Appendix 6-6 [Excitation System Specifications (SPEXC)].

2.6.9 Rotor Brushgear

The Generator rotor brushgear includes: the collector brushgear assembly (comprised of the stationary brushgear components including collector brush holder support rings, insulators, stand-off bolts, collector brush holders, and collector brushes), collector slip ring assembly (comprised of the rotating brushgear components including collector slip rings (a positive slip ring and a negative slip ring), insulators, and clamping bolts), and instrument brush holders and brushes. The Generator rotor brushgear will meet the requirements of SPG 2.14 and:

(a) have means to ensure the temperatures of the collector slip rings and collector brushes do not exceed the brush manufacturer’s recommended maximum temperature limits under all operating conditions;

(b) ensure the temperature of the collector slip ring surfaces and each collector brush remains between 50°C and 85°C under all operating conditions;

(c) ensure the absolute temperature variance among all collector brushes is not greater than 20°C under all operating conditions;

(d) ensure that the brushes are installed in a staggered manner;

(e) ensure the collector slip rings and brushes are mounted so that inspection of the brushes while the Generator is running is both practical and safe for Workers;

(f) ensure that both the collector slip rings and brush holder support rings are each separated by an insulating barrier;

(g) use a solid (non-grooved) collector slip ring;

(h) ensure the collector slip rings are round with a total indicated run-out of less than 0.05 mm;

(i) ensure the run-out during operation of the collector slip rings is between 0.25 mm to 0.40 mm;

(j) ensure the surface finish of the collector slip rings is between 0.75 micrometres to 1.25 micrometres;

(k) ensure the degree of collector brush run-out, vibration and chatter, as measured by the motion at the back of the brushes, tracks the motion of the collector slip rings to within 5% of the measured displacement of the rings;

(l) have insulated brush holders to ensure that all of the current goes through the shunts/brush leads;

(m) use constant-pressure-type holders for all brushes including the collector brushes and instrument brushes;

(n) ensure the spring tension of the brush holders is within 10% of the recommended spring tension for the grade of brush used;

(o) ensure the collector brushes do not bounce, chatter, or excessively arc to ensure that the brush face surface is not detrimentally affected;

(p) ensure the collector brushes do not have highly polished or visibly worn areas on the sides of the brushes;

(q) have brushes of sufficient length and grade that they can remain in continuous operation for a minimum period of two years without having to be maintained;

(r) have clamps for holding the pig tails of the carbon brushes to the collector brushgear assembly. Threaded components will not be used for connecting the brush pig tails to the collector brushgear assembly; and

(s) ensure the audible noise emitted by the brushgear system does not exceed the values specified by the relevant standard and will not include any high-frequency components.

2.6.10 Rotor Ground and Field Ground Detection

The Generator will have an insulated rotor (or shaft) grounding brush to be used for field ground detection. The rotor ground brush will:

(a) be installed in an easily accessible location;

(b) be wired to the Powerhouse ground grid using insulated #2/0 AWG copper conductor; and

(c) meet the requirements of SPG 2.6.9 except for ventilation and temperature.

The Generator field ground detection system is included in the scope of Work for the Exciter.

2.6.11 Rotor Lift Requirements

(a) General: The Generator rotor will:

- (i) be designed such that once any turbine air admission and brushgear components are removed, the rotor can be removed from the Generator Enclosure to the Powerhouse service bay in one complete piece;

(ii) have all necessary stiffeners, pre-threaded bolt holes, adaptor plates, etc., necessary to facilitate the attachment of a rotor Lifting Device to the rotor hub and to facilitate the lift itself; and

(iii) be designed to minimize rotor deflection during lifting.

(b) Removal and Installation: The number of person-hours required to perform all necessary activities to remove or install the Generator rotor will be less than or equal to 400 person-hours, considering:

(i) removal is deemed to commence after a Unit has been isolated and dewatered, but before any disassembly of the Unit has commenced;

(ii) removal is deemed to be complete when the rotor has been set down in the service bay and the Powerhouse bridge cranes have been disconnected from the rotor Lifting Device;

(iii) installation is deemed to commence when the powerhouse bridge cranes have been made available to connect to the rotor Lifting Device for use in the rotor lift;

(iv) installation is deemed to be complete when the Unit is ready to be de-isolated and returned to commercial operation;

(v) removal or installation includes all activities required to prepare the rotor Lifting Device for use prior to the lift and to prepare the rotor Lifting Device for storage after the lift;

(vi) the personnel available to perform Generator rotor removal or installation include:

(A) one General Trades personnel;

(B) four Mechanical Trades personnel;

(C) four Electrical Trades personnel; and

(D) one powerhouse bridge Crane Operator;

with additional personnel required during actual rotor lift and transport to the Powerhouse service bay floor (assume two hours):

(E) two General Trades personnel;

(F) two Mechanical Trades personnel; and

(G) two Electrical Trades personnel.

The Work includes any special tools, lifting equipment, rotor pedestal required for the removal and placement of the rotor on the Powerhouse service bay.

2.7 Coupling

2.7.1 General

The coupling of the Generator rotor to the Generator thrust block and of the Generator thrust block to the Turbine shaft will:

(a) enable the Generator rotor to be removed without blocking or shimming the Turbine shaft and runner on the discharge ring;

(b) enable the Generator rotor to be removed with minimal disturbance to the alignment of the Unit; and

(c) be designed such that the Generator rotor hub can be separated from the Generator thrust block without removing the Turbine shaft-to-thrust block coupling bolts.

2.7.2 Drilling Template

A drilling template and pin gauge for the coupling of the Generator thrust block to the Turbine shaft will be provided. The Contractor will drill the coupling holes undersize in the Turbine coupling to suit the Generator thrust block coupling flange.

2.7.3 Shaft Runout

The indicated shaft run-out is the maximum vibratory peak-to-peak displacement of the shaft in accordance with the ISO 7919 5.

For all steady-state operating regimes at Rated Speed, excited or unexcited, the total indicated shaft run-out referenced to the Generator guide bearing support or bearing housing and combining the synchronous and asynchronous run-outs, will not exceed the following limits:

(a) 0.15 mm in Operating Zone 1;

(b) 0.20 mm in Operating Zone 2; and

(c) 0.13 mm in Operating Zone 3.

The Generator guide bearing clearance selected by the Contractor will allow for a minimum 0.1 mm instantaneous oil film thickness between the rotating shaft and guide bearing pads at the operating conditions with the highest run-out and/or eccentricity of the shaft within the bearing.

The synchronous shaft run-out at the Generator guide bearing for all steady state operating regimes will not exceed the limits specified in the CEATI International Report No. T052700-0329 Hydroelectric Turbine Generator Units Guide for Erection Tolerances and Shaft System Alignment – Part II – Table 10.

In addition to the above requirements the non-rotating parts will meet the requirements of ISO 10816-5 evaluated for Zone A based on displacement measurements.

2.8 Generator Bearings

2.8.1 General

The Generator bearings will:

(a) be a combined Generator thrust and guide bearing installed below the Generator rotor;

(b) be mounted on bearing brackets which include sole-plates, foundation anchor bolts, nuts, washers and sleeves; and

(c) have a thrust block arrangement that allows for removal of the Generator rotor without disruption to the thrust block / Turbine shaft connection and alignment.

The Work includes all the handling and servicing equipment required for Generator bearing maintenance, including a removable platform if required.

2.8.2 Lower Bracket

The Work includes a Generator lower bracket. The lower bracket will:

(a) be used to support the Generator thrust bearing;

(b) be supported by the Powerhouse concrete (i.e., it will not be supported by any Generator or Turbine components);

(c) be designed to be adjustable to facilitate future leveling and centering of the Generator rotor within the Generator stator bore both laterally and vertically after final grouting of the sole-plates without cutting or welding. As a minimum there will be 10 mm of adjustment in all directions; and

(d) have sole-plates and anchors that incorporate the following:

    (i) design features that provide for free radial movement due to thermal expansion of the lower bracket if the design requires the lower bracket to slide on the sole plate;

    (ii) if so required by the design, incorporate radial stops to limit movement;

    (iii) be provided with lateral anchors to restrain the radial component of loads that are directed towards the centre of the Unit;

    (iv) have provisions for grouting voids after backfilling the concrete blockout;

    (v) design features that provide for self-centering if the lower bracket is required to slide on the sole-plate; and

    (vi) self-lubricating anti-friction materials to facilitate the radial movement of the lower bracket if it is required to slide on the sole-plates.

2.8.3 Thrust Bearing

The Generator thrust bearing will:

(a) be of the segmented, babbitted type, that automatically load-equalizes while in operation, and is designed to provide uniform distribution of the load among the bearing pads;

(b) have a continuous thrust runner surface (i.e., not split);

(c) have a removable/replaceable thrust runner surface;

(d) be self-lubricating without requiring the use of auxiliary pumps for normal operation;

(e) be designed to carry the weight of all rotating parts of the Generator and Turbine and all external thrusts under all operating conditions, including starting, running, overspeed, Generator faults, and stopping; and

(f) when the lift pump is not available, be capable of handling Unit starting and stopping without damage to the bearing babbitt surfaces. For the case where the Unit is being started, it will be possible to do so at any time within 24 hours after the Unit last stopped.

Removal of the Generator thrust bearing thrust runner will require no, or very limited, disassembly of Turbine components.

2.8.4 Guide Bearing

The Generator guide bearing will be designed and constructed in accordance with Appendix 6-2 [General Technical Specifications (SPGT)].

2.8.5 High-Pressure Oil Injection System (Lift Pump)

The Generator thrust bearing will be equipped with a high-pressure oil injection system (lift pump). The lift pump will:

(a) include the oil pump, a 600 V, 3-phase high-efficiency pump motor, instrumentation, valves and piping necessary to deliver high-pressure oil to all Generator thrust bearing pads;

(b) have sufficient capacity to lift all rotating components, including the Generator rotor, Turbine shaft, and Turbine runner when starting and stopping the Unit;

(c) have a motor starter (MCC) that is either integral with the lift pump assembly or mounted on the wall near the assembly;

(d) have any necessary piping, valves, and pressure gauges to enable a Worker to verify that the check valves are working correctly;

(e) be located outside of the Generator Enclosure and Turbine Pit; and

(f) have a common standard Swagelok manifold complete with isolation valves for the pressure gauge(s), pressure transducer, pressure switches, etc., to permit isolation of the pumping circuit for testing and calibration of the devices.

The Work includes the wiring for all control, auxiliary, instrumentation, and pressure switch contacts to the Generator Terminal Cabinet. The power cables to the lift pump motor starter will be supplied by Others.

2.8.6 Protection Against Moisture Ingress

The Generator bearing will be designed to prevent moisture ingress to the Generator bearing lubrication system, including in scenarios where there may be a significant amount of moisture in the air within Generator Enclosure such as during operation of the Generator fire protection system.

Scenarios of significant moisture in the air within the Generator Enclosure will not:

(a) affect the normal and proper operation of the bearing lubrication system; and

(b) have any adverse effect on the Generator bearing operation.

2.8.7 Protection Against Generator Enclosure Pressurization

The Generator thrust bearing will be designed to ensure that the air pressure in all air-containing spaces within the Generator thrust bearing lubricating oil reservoir remain equal, including in extreme scenarios such as when the Generator Enclosure pressure relief device fails to operate during a Generator stator winding phase-to-phase fault event.

2.8.8 Maintainability and Access

Arrangement and design of the Generator bearings will:

(a) have four removable access hatches in the Generator guide bearing top cover(s) located at 90 degrees around the circumference of the Generator guide bearing to enable the installation of temporary shim and/or to enable temporary adjustment of four Generator guide bearing pads by a Worker to enable "spiking" or centering of the rotor to facilitate maintenance on the Unit. There will not be any instrumentation installed in or over these access hatches;

(b) have the ability to remove any thrust pad, for inspection or replacement, without significant disassembly such as rotor removal, oil cooler removal, disassembly of the oil reservoir, guide bearing disassembly; and

(c) ensure that the inspection or maintenance hatches located in the side of the Generator bearing oil pot(s) have a hatch design that will prevent a rapid, uncontrolled release of the oil from the bearing pot will one or more hatch fasteners become loose or fail. The rate of leakage will be such that there is sufficient time to shut down a Unit without damage occurring to the bearing after detection of a low bearing oil level.

2.9 Generator Brakes and Jacks

2.9.1 General

The Generator will be equipped with a combined rotor brake and jacking system. The rotor brake and jacking system will:

(a) have brakes that are pneumatically operated and capable of repeatedly bringing the Unit rotating components to a complete stop within the time specified in Appendix 6-2 [General Technical Specifications (SPGT)], with the field excitation removed, and with the Turbine wicket gates closed, but with normal leakage through the Turbine wicket gates;

(b) have a Generator rotor jacking system that is hydraulically-operated and capable of lifting all rotating components, including the Generator rotor, Turbine shaft, and Turbine runner to a distance sufficiently high enough to permit removal of all maintainable Generator thrust bearing components;

(c) be easily accessible by a Worker for operating the Generator rotor jacking system blocking device(s) or to replace the brake shoes without the need for a ladder or scaffolding; and

(d) include sole-plates if concrete pedestals are required.

A type of Generator brake in which oil is present in the brake cylinder during a Generator rotor braking operation will not be permitted.

The Work includes all control, instrumentation, limit switches, and pressure switch contacts needed for the operation of the Generator brakes and Generator rotor jacking system and includes wiring this equipment to the Generator Terminal Cabinet. The control PLC and control logic for automatic and manual admission to, and release of, air from the operating cylinders of the Generator brakes will be supplied by Others.

2.9.2 Brake Cylinder Assemblies

The pistons in the Generator brake cylinder assemblies will:

(a) be fitted with suitable synthetic composite piston rings shaped to make close contact and apply uniform pressure on the cylinder walls;

(b) have suitable rider bands of similar material to ensure no contact between the piston and cylinder wall; and

(c) have mechanical stops incorporated in each Generator brake cylinder assembly that physically limits the maximum stroke of the cylinder to a distance not greater than the maximum allowable jacking distance under a jacking operation.

2.9.3 Brake Shoes

The Generator brake shoes will:

(a) bear against the brake track wearing surfaces on the lower side of the rotor;

(b) be easily removable by a Worker to facilitate replacement;

(c) be keyed or otherwise securely fastened; and

(d) contain no hazardous substances.

2.9.4 Brake Track

The Generator brake track will:

(a) have segmented brake track wearing surfaces;

(b) have provisions to accommodate thermal expansion;

(c) be installed on a machined surface or on machined spacers to minimize the need for shimming;

(d) have means to adjust the track such that:

  (i) the flatness of the entire brake track can be set to within 2.5 mm; and

  (ii) the vertical gap between segments can be set to be between 0 mm to 0.35 mm and such that the step appears to be a step down to the brake pad as the brake pad rides against the brake track; and

(e) be secured using bolts that are mechanically locked by a means that can be verified visually.

2.9.5 Brake Compressed Air

The Generator brake compressed air system for each Unit will:

(a) have a dedicated Generator brake air receiver designed for three full stops of the Unit without additional air from the Powerhouse brake air system and will be sized sufficiently so that the third full stop of the Unit takes no more than 20% longer than the first full stop;

(b) have a check valve located downstream of the Powerhouse brake air supply Double Block and Bleed isolation valves, but before the Generator brake air receiver;

(c) have an electrically operated solenoid valve for actuation of the brakes, that operates on 125 Vdc input power, and also includes a manual operation handle or lever with a mechanical lock to keep the brakes applied;

(d) have a pressure gauge on the supply side and the brake side of the solenoid valve; and

(e) have a silencer on the exhaust of the solenoid valve described above.

2.9.6 Brake Dust Collection System

The Generator brake dust collection system will:

(a) be fully self-contained, fireproof brake dust vacuum removal and collection system used to prevent brake dust contamination of the Generator pit and windings;

(b) be activated only on Unit shutdown;

(c) start approximately 15 s (adjustable) prior to brake application;

(d) stop approximately 120 s (adjustable) after the Unit has come to a complete stop;

(e) be interlocked with the fire protection system to prevent operation in the event of a suspected fire;

(f) have a dust collection system designed in accordance with the American Conference of Government Industrial Hygienists publication “Industrial Ventilation, a Manual of Recommended Practice for Design”, latest edition;

(g) have a dust collection hood for each Generator brake assembly. The dust collection hood will be:

    (i) designed with replaceable seals that are pressed against the brake track during the braking sequence to ensure containment of brake dust; and

    (ii) designed and installed to facilitate brake pad replacement;

(h) have ductwork that:

    (i) is designed in accordance with SMACNA standards;

    (ii) has a minimum transport velocity of 20 m/s in the main duct and 23 m/s in branch ducts;

    (iii) minimizes interference with Worker mobility;

    (iv) is sufficiently robust that a Worker can stand on the ductwork without causing damage to the ductwork;

(v) minimizes the use of flexible ductwork;

(vi) has a layout that minimizes the number of bends;

(vii) has branch entries and transitions that are fabricated in metal;

(viii) has branches that enter the main duct at the top or the sides and at an angle of 30 degrees or less;

(ix) has cleanouts to inspect and clean the ductwork; and

(x) is well sealed at all joints;

(i) have ON, OFF, and REMOTE control capability. The contact for REMOTE control will be a form C contact; and

(j) be located outside of the Generator Pit and Turbine Pit.

2.9.7 Braking Sequences

The Equipment and the Generator brakes will be designed for two braking sequences:

(a) Normal Shutdown: For a normal Unit shutdown operation the Generator brakes will be:

(i) capable of being applied between 30% and 5% of Rated Speed;

(ii) capable of stopping the Generator a minimum of four times in each hour; and

(iii) continuously applied during the braking sequence and when the Generator is at rest.

(b) Emergency Shutdown: For an emergency Unit shutdown operation such as when there is a problem with the Generator thrust bearing or a Turbine wicket gate, the Generator brakes will be:

(i) applied at approximately 50% of Rated Speed;

(ii) designed to bring the rotating parts to a stop in less than 10 minutes with a leakage torque applied to the Turbine sufficient to maintain the Generator at 25% of Rated Speed; and

(iii) continuously applied during the braking sequence and when the Generator is at rest.

For both cases the field excitation is removed, and the generator disconnected from the system.

2.9.8 Rotor Jacking System

The Generator rotor jacking system will:

(a) use a portable Generator rotor jacking pump assembly to supply the hydraulic pressure required for the jacking operation;

(b) have means for easily and quickly blocking the rotor in the fully raised position at the completion of a jacking operation. The blocking devices will be such that it will not be necessary to maintain hydraulic pressure on the jacks while the rotor is in the raised position;

(c) have limit switches to prevent Turbine or Generator components from contacting other components during a jacking operation such as the runner contacting the headcover or the runner seals contacting the stationary seals;

(d) be lockable such that when the rotor is in the fully-raised position and with the blocking devices in place, a Worker cannot pressurize the jacking system; and

(e) have all required piping and control wiring routed to a location outside the Generator Enclosure or Turbine Pit that can be easily accessed by a Worker with the Generator rotor jacking pump.

2.9.9 Brake and Jack System Piping

The piping for the Generator brakes and Generator rotor jacking system will:

(a) include all piping, valves, pressure regulators, pressure relief valves, exhaust silencer, etc., necessary to deliver air and oil to the system and necessary to drain oil from the system;

(b) have the oil used in the jacking operation drain to the jacking oil pump sump after a jacking operation;

(c) collect oil that leaks past the brake pistons and return the oil to the jacking oil pump sump;

(d) allow all oil to be scavenged from the brake cylinders after a jacking operation;

(e) have an oil trap to collect oil that has remained in the Generator rotor jacking system after a jacking operation and capture oil mist during braking. This trap will be easily accessible by a Worker to permit draining of the oil from the trap;

(f) not permit oil used during or after a jacking operation to contaminate the Generator brake and process air system; and

(g) have a common standard Swagelok manifold complete with isolation valves for all pressure gauge(s), pressure transducer, pressure switches, etc., to permit isolation of the pumping and air delivery circuits for testing and calibration of the devices.

2.10 Generator Enclosure

2.10.1 General

The Generator enclosure system (the “**Generator Enclosure**”) consists of formed concrete walls surrounding the Generator, the Generator upper bracket, the Generator top covers and a Worker access platform or concrete floor above the Turbine Pit. The Work includes:

(a) all necessary steel parts, anchor bolts, and other Equipment components required for embedment in the Generator Enclosure concrete by Others; and

(b) supply and installation of all supplementary steel work and supports as may be necessary for Equipment after the Generator Enclosure walls and floor have been installed.

The Generator Enclosure will:

(c) be sealed to minimize air leakage into or out of the Generator Enclosure;

(d) have means for controlled relief of excess air pressure within the Generator Enclosure as a result of a severe Generator stator winding fault. The pressure relief device(s) will be sized to relieve the pressure quickly enough to prevent distortion or lifting of other Generator Enclosure components such as the Generator top covers;

(e) have permanent light fixtures. The number and arrangement of light fixtures required will be such that the illumination requirements of Appendix 6-2 [General Technical Specifications (SPGT)] are met in all areas of the Generator Enclosure; and

(f) have 600 V and 120 V power receptacles located so that no point on the Generator Enclosure walls is more than 8 m away from each type of receptacle.

2.10.2 Noise Insulation

The Generator Enclosure will have measures to minimize noise emission from within the Generator Enclosure, such that the maximum noise level outside the Generator Enclosure meets the requirements of Appendix 6-2 [General Technical Specifications (SPGT)]. Additional measures to reduce the noise level outside the Generator Enclosure will include:

(a) Generator Enclosure doors that are acoustically treated and provided with airtight seals resulting in sound transmission class ratings of 50 or greater;

(b) sealing all openings, etc., linking the Generator Enclosure to the Powerhouse to an equivalent sound transmission class rating of not less than 50; and

(c) acoustic treatment of the Generator top covers which will result in an overall sound transmission class rating of 50 or greater.

2.10.3 Enclosure Heaters

If required for the Contractor's design, the Work includes electric space heaters installed within the Generator Enclosure. The space heaters will:

(a) have sufficient capacity to prevent moisture condensation from forming on the Generator stator and rotor windings when the Generator is not in service;

(b) be capable of keeping the winding temperatures at least 5°C above the coolest expected ambient in the Powerhouse when all of the Generator Enclosure doors are closed and when the Generator top covers are in place;

(c) be designed to operate at 600 V and not more than 12 kW per heater circuit;

(d) have a HAND-OFF-REMOTE control switches that allows operation of the heaters manually or remotely;

(e) have fused disconnect switch and contactor assemblies for each heater circuit;

(f) have an integral thermostatic control switch for the heaters that turns the heaters on when the temperature within the Generator Enclosure drops to below 15°C; and

(g) be wired to the Powerhouse 600 V station service breaker panel for each Unit.

2.10.4 Access into the Generator Enclosure

Generator Enclosure access doors from the Powerhouse to the area behind the stator frame, each a part of an Access Route, will be provided. If the design of the Generators, together with the Generator Enclosures, allows Standing Workers to walk around the complete outside circumference of the

Generator stator, then a minimum of two Generator Enclosure doors will be provided for each Generator Enclosure. If it is not possible for Standing Workers to walk around the complete outside circumference of the stator, four Generator Enclosure doors will be provided (one per Generator quadrant).

The Generator Enclosure doors will:

(a) be arranged such that no tripping hazard is posed to Workers travelling through the door (floor surfaces located immediately inside and immediately outside the doors will be level, and the door sill will be flush with the adjacent floor surface);

(b) each have an access opening cross-section that is rectangular or rounded/chamfered-rectangular in shape, is unobstructed, and is of minimum clear dimensions 2000 mm high and 915 mm wide;

(c) when fully open, be hinged to swing wide enough open to allow the door to be flush against the outside wall of the Generator Enclosure;

(d) be equipped with a system that causes closing tendency, as well as a damper system to prevent slamming of the door (considering air pressure inside the Generator Enclosure);

(e) be equipped with a mechanism to enable it to be latched in the fully-open position during prolonged maintenance periods;

(f) have means to allow quick egress from the Generator Enclosure in the event of an emergency;

(g) be of adequate strength to withstand and be designed to remain completely closed if the Generator Enclosure is rapidly pressurized during a severe Generator stator winding fault or other similar event; and

(h) have a latching system that permits Workers inside and outside the Generator Enclosure to open the door, even after a sudden pressurization event.

2.10.5 Access within Generator Enclosure

The Generator Enclosure will be of sufficient size to enclose and provide Access Routes to the stator, Generator air coolers, piping and electrical connections and other parts of the Generator.

The design of the Generator, together with the Generator Enclosure and Generator Enclosure doors will provide Access Routes that allow:

(a) a Worker to inspect the back, bottom, and top of the Generator stator around its entire circumference;

(b) a Worker to inspect all Generator air coolers;

(c) two Workers to conduct a Rescue Operation involving a Patient in any location within the Generator Enclosure without requiring the use of overhead lifting equipment; and

(d) a Worker at any location inside the Generator Enclosure to have a minimum of two Access Routes available. The Access Routes and equipment within the Generator Enclosure will be arranged such that during normal operation and maintenance activities at least one Access Route will always be available if the alternate Access Route becomes unavailable.

Each Access Route will either:

(e) allow a Worker to be at all times at least 3.0 m from a normally energized component of a Unit or any other electrical Hazards; or

(f) if a distance of 3.0 m is not practicable, provide barriers to protect a Worker from normally energized components of a Unit or any other electrical Hazards.

2.11 Generator Pit

2.11.1 Generator Pit Maintainable Components

Each maintainable component within the Generator Pit (the "**Generator Pit Maintainable Components**") will be designed and will have a Procedure for moving it between its respective in-service position and a location outside of the Generator Pit, without removal of the Generator rotor. The Procedure will include consideration of the necessary tools, equipment, Worker complement, and lifting equipment. The key objective will be to eliminate all manual transfers and manipulation of any Generator Pit Maintainable Component by a Worker from the location where the component was removed to where it is set down on a Cart or other device.

The Generator Pit Maintainable Components include any Unit components installed in the Generator Pit that may require maintenance activities performed on them at any point during their Design Life, as required by the Contractor's Equipment design and Equipment maintenance schedule. Generator Pit Maintainable Components include:

(a) Generator bearing components:

  (i) all pads and shoes;

  (ii) coolers;

  (iii) covers; and

  (iv) instrumentation;

(b) Generator brakes (all components);

(c) permanently-installed rotor-turning device; and

(d) piping, valves, couplings, and instrumentation.

2.11.2 Lighting and Receptacles

The Generator Pit will:

(a) have permanent light fixtures. The number and arrangement of light fixtures required will be such that the illumination requirements of Appendix 6-2 [General Technical Specifications (SPGT)] are met in all areas of the Generator Pit; and

(b) have a minimum of one 120 V receptacle installed on each Generator brake pedestal.

2.11.3 Access to Generator Pit

A minimum of two Access Routes to the Generator Pit will be provided; neither of which can include a ladder. Access Routes to the Generator Pit from within the Generator Enclosure, Turbine Pit, or directly from the Powerhouse are acceptable. Access Routes sized to accommodate a Standing Worker are preferred to those sized to accommodate a Crouching Worker (sizing to accommodate Crouching Worker clearances will be considered a minimum requirement).

Access Routes will not expose a Crouching Worker to mechanical Hazards, including to Hazards associated with rotating equipment.

If staircase access to the Generator Pit is not provided, at least one Access Route will allow a Crouching Worker to conduct a Rescue Operation or to remove Generator Pit Maintainable Components by pushing a Cart, loaded with a Patient or Generator Pit Maintainable Components, from immediately beside the Generator bearings to either the Generator Enclosure or one of the Powerhouse floors.

Doors to the Generator Pit will be provided that meet the same criteria as for the Generator Enclosure access doors.

2.11.4 Access Within Generator Pit

The Worker access platform spanning from the Generator Pit concrete floor to the Generator bearings will be permanent (i.e., it can be left installed during Unit operation) and will have a surface that allows a Cart to move on it without its wheels getting caught in spaces or joints that may be present as part of the floor.

There will be adequate clearance between the Generator Pit floor or Worker access platform and the bottom of the rotor in the locations where Crouching Workers would be positioned to push the rotor to rotate it to a different position during maintenance activities. This push path will also be as free of tripping hazards as possible. The design will permit a Crouching Worker to manoeuver or push the rotor through a complete revolution in a continuous manner without the Crouching Workers needing to reposition themselves or otherwise interrupting pushing.

2.11.5 Access to Generator Bearings (Thrust and Guide Bearings)

The minimum clearance between the floor or permanent platform surface inside the Generator Pit and the bottom of the rotor, and around the periphery of the Generator bearing(s), will be sized and arranged to allow Standing Workers to perform inspection and maintenance work on the Generator bearing(s), using necessary tools and equipment.

The clearance between the top of the Generator thrust (and guide) bearing and the underside of the rotor will be sufficient to allow Workers to disassemble, inspect, maintain, and assemble the bearing(s) in accordance with the bearing maintenance Procedures.

2.11.6 Access to the Lower Bracket Sole-Plates

If the Generator design includes a lower bracket and if that lower bracket design is such that the Worker access platform spanning from the Generator Pit concrete floor to the Generator bearings is flush with the top of the lower bracket cross arms, access hatches will be provided to facilitate Worker access to the locations where the lower bracket cross arms rest on the lower bracket sole-plates. The hatches will be secured with latches that are operable from both inside the Generator Pit and the Turbine Pit.

2.12 Generator Ventilation and Cooling

2.12.1 Generator Ventilation System

(a) General: The Generator ventilation system will:

  (i) meet the requirements of the Cooling Water System in Appendix 6-2 [General Technical Specifications (SPGT)];

(ii) be self-ventilating by means of the rotor acting as the fan;

(iii) be a closed circuit system in which the cooling air will be forced outward through the rotor, ventilating the rotor poles, the stator winding and the stator core, then passed through the Generator air coolers mounted on the outside of the stator frame and then re-circulated back into the rotor;

(iv) have sufficient capacity to ensure that the Generator is able to operate at Generator Rated Output at the Generator Rated Operating Conditions with one Generator air cooler out of service and with no heat being removed from the Generator by the heat recovery system; and

(v) have means to prevent vibration of components used in the ventilation system including, metal duct, acoustic silencers, steel plate, and shrouds.

(b) Stator and Rotor Shrouds: If the Generator ventilation system includes the use of shrouds over the stator end-windings, stator circuit-rings or over the rotor field poles and/or rim, the shrouds will:

(i) provide sufficient clearance to the stator end-windings, stator circuit-rings, the rotor field poles, or the rotor rim to prevent inadvertent contact with these components;

(ii) avoid the use of fasteners, anchors, hangers, or other components that might work loose and drop into the Generator;

(iii) be designed such that a Worker can remove the stator shrouds while the Generator rotor is in place; and

(iv) be made of light-weight material for easy removal by a Worker, but still retain sufficient mechanical strength to not distort or vibrate in service.

(c) Generator Air Coolers: The Generator air coolers will be water-cooled heat exchangers. The Generator air coolers will:

(i) be heavy duty, rugged construction, fin and tube heat exchangers;

(ii) have heat exchanger tubes made of 90/10 copper/nickel, seamless, soft annealed, ASTM B111 UNS C70600 Temper O61;

(iii) be designed so that individual tubes can be plugged with wooden dowels and still allow the Generator air cooler to function;

(iv) be designed to keep the rate of cooling water flow high enough at all times to prevent fouling the heat exchanger tubes. 10% extra surface area will be provided as a fouling margin;

(v) include isolation valves on the inlet and outlet cooling water piping to the Generator air cooler to enable a failed Generator air cooler to be quickly isolated;

(vi) include a manual balancing valve on the discharge side of each Generator air cooler;

(vii) have a condensation capture system or traps that drain to the sump. The drains from the capture system will drain through pipe(s) to the nearest floor drain;

(viii) be complete with a 25 mm drain connection. The drainage outlet will be connected to a gravity drain header terminating at a location to be determined by Hydro's Representative;

(ix) be complete with air vents at the top of each Generator air cooler to facilitate the purging of air when the Generator air coolers are being filled with water and to prevent a vacuum from forming in the Generator air coolers when cooling water is drained from the Generator air coolers; and

(x) be designed to automatically vent air if air becomes trapped in the cooling coils.

(d) <u>Heat Recovery System Heat Exchangers</u>: The heat exchangers used for the Generator heat recovery system specified in SPG 2.12.2 will meet the same requirements as the Generator air coolers.

Heat recovery system heat exchangers could be comprised of either:

(i) additional air coolers located between the stator frame and the conventional Generator air coolers; or

(ii) a number of Generator air coolers or portions of air coolers (split cooler configuration) capable of operating in a closed loop with the Powerhouse heating system (heat recovery mode) or as normal coolers (bypass mode) by actuation of three way valves.

The Generator heat recovery system heat exchangers will be connected to separate piping to the rest of the Generator air coolers. Refer to SPG 2.12.2 for additional details.

2.12.2 <u>Generator Heat Recovery System</u>

A Generator heat recovery system (HRS) will use heat from the Generator to supplement Powerhouse heating on demand from the Powerhouse heating system. The Generator heat recovery system will:

(a) have a total cooling capacity per Generator of 500 kW under the following conditions:

(i) Generator is operating at the Generator Rated Output;

(ii) water temperature entering the HRS heat exchangers is 25°C;

(b) operate in a closed loop between the Generator and the Powerhouse heating system to optimize the heat recovery temperature from the Generator; and

(c) not impede the ability of the Generator to operate at Generator Rated Output when at Generator Rated Operating Conditions.

The Work includes:

(d) the interconnecting wiring to the Generator Terminal Cabinet;

(e) the control valves, supply and return piping, and control and monitoring equipment/systems up to terminal point outside the Generator Enclosure; and

(f) collaboration with the Powerhouse heating system contractor on the design and interface with the Powerhouse heating system.

The Generator heat recovery system will have provision for thermal expansion of the water when operating as a closed loop. This will be located outside of the Generator Enclosure and be provided by Others.

2.12.3 Cooling Water and Piping Requirements

Generator cooling water piping system will be provided to deliver cooling water to the Generator air coolers, Generator bearings, and other Generator components as required.

Separate piping is required to circulate water to and from the Generator heat recovery system heat exchangers and the Powerhouse heating system.

The Generator cooling water and heat recovery system piping Work includes all piping up to the terminal points outside of Generator Enclosure or Turbine Pit. Final terminal points are to be accepted.

All the valves, meters, and monitoring devices that are part of the Generator cooling water piping, except for the:

(a) the individual Generator air coolers isolation and balancing valves;

(b) individual Generator bearing isolation valves;

(c) individual Generator air coolers drain valves; and

(d) any required air bleed and vacuum break assemblies,

will be installed outside the Generator Enclosure to facilitate ease of access for Workers to inspect and maintain this equipment.

2.12.4 Generator Cooling Water Flow Regulating Valve

A Generator cooling water flow regulating valve and temperature control equipment will be used to automatically regulate the cooling water discharged from the Generator air coolers to maintain a constant average air temperature leaving the Generator air coolers.

The Generator cooling water flow regulating valve will:

(a) be a globe valve rated for 1 MPa (150 pound ANSI), sized to pass the required maximum rate of flow of cooling water, and operate without cavitation throughout the range of flow based on the Cooling Water System design pressure;

(b) be either an air-operated actuator controlled by an electro-pneumatic valve positioner, or an electric actuator, and include an adjustable stop to block the valve from closing completely;

(c) use an electronic valve controller that, as a minimum, has an auto-manual control switch with the capability of manually setting the valve position, electronic valve position indication;

(d) fully open upon loss of the control signal or control pressure, or otherwise fail to the open position;

(e) be located outside the Generator Enclosure at a location accessible by a Standing Worker at floor level, to enable servicing and maintenance of the valve, actuator, and other components; and

(f) have a bypass piping arrangement to enable removal of the valve for maintenance. Two manual isolation valves and a manual balancing valve will be provided for the bypass, to enable operation of the Generator when the Generator cooling water flow regulating valve is out of service.

The Work for the Generator cooling water flow regulating valve includes:

(g) the Generator cooling water flow regulating valve;

(h) all interconnecting wiring from the valve to the Generator Terminal Cabinet;

(i) all wiring for the required instrumentation and indication devices to the Generator Terminal Cabinet; and

(j) the process air piping from the terminal point outside the Generator Enclosure to the valve positioner including the:

    (i) pressure regulator;

    (ii) pressure gauge; and

    (iii) any filter or dryer that may be required.

Powerhouse process air will be supplied by Others to a terminal point outside the Generator Enclosure.

2.12.5 Temperature Control System

The control logic and PLC for the Generator temperature control system will be provided by Others. The control logic will, as a minimum:

(a) use a Generator cooling control PLC located in the Unit Control Board;

(b) provide the 4-20 mA control signal to the Generator cooling water flow regulating valve;

(c) use the temperature signals from all of the Generator air cooler outlet air RTDs;

(d) have logic that filters out invalid RTD signals prior to averaging the RTDs signals together;

(e) average the RTD;

(f) use the 4-20 mA output signals for the valve position and the running and set temperature indication;

(g) provide control of the three-way valves for the Generator heat recovery system; and

(h) have provisions that allow for manual control from the Unit Control Board.

The Generator temperature control system will cause the Generator heat recovery system to go into bypass mode upon occurrence of:

(i) a Generator stop;

(j) a Generator trip;

(k) Generator equipment exceeding the Rated temperatures;

(l) when the cooling water exceeds a temperature at which the remaining coolers not used for heat recovery (with one cooler out of service) would be unable to adequately cool the Generator at Generator Rated Output;

(m) the Powerhouse heating not being required; or

(n) an initiation of the Powerhouse or Generator fire suppression system.

The Work includes provision of the control and instrumentation devices and wiring necessary to achieve the above Generator temperature control system features.

2.12.6 Maintainability and Access

(a) Inspection: The Generator, Generator Enclosure, Generator brake pedestals and Generator ventilation system will be designed with clearances that will permit Workers to comfortably complete a visual inspection of the core clamping system and the front and back of the complete stator end-winding system.

(b) Rotor Shrouds: To permit Workers to conduct inspections, if the Generator ventilation system includes shrouds over the rotor field poles and/or rim:

(i) it will be possible for two Workers to remove the shrouds without the aid of any lifting equipment. The effort and time required to remove the shrouds will be minimized; and

(ii) lifting handles will be provided on the shrouds to facilitate removal.

(c) Stator Shrouds: If the Generator ventilation system includes shrouds over any of the stator end-windings or stator circuit-ring:

(i) means, such as hinged inspection hatches in each shroud, will be incorporated to perform a cursory inspection of the stator winding and stator circuit-ring without the need to remove the shrouds;

(ii) it will be possible for two Workers to remove the shrouds without the aid of any lifting equipment. The effort and time required to remove the shrouds will be minimized; and

(iii) lifting handles will be provided on the shrouds to facilitate removal.

(d) Generator Air Cooler Removal: The arrangement of the Generator upper bracket will be such that it does not obstruct removal of the Generator air coolers. Each Generator air cooler will have permanently attached Lifting Points for removal using the Powerhouse bridge cranes.

(e) Generator Air Cooler Cleaning: Cooler waterboxes will be removable to permit access to the heat exchanger tubes for inspection and cleaning, and to enable the insertion of wooden dowel plugs in damaged or failed tubes.

2.13 Upper Bracket and Top Covers

A Generator upper bracket system that supports the Generator top covers, brushgear housing, TW Housing, Workers and small tools and equipment will be provided.

(a) General: The Generator upper bracket and Generator top covers will:

(i) completely cover the top of the Generator Enclosure to prevent contamination from entering or exiting the Generator Enclosure;

(ii) serve as a platform for Workers and equipment on the main floor of the Powerhouse;

(iii) be designed to accommodate a minimum uniform live load of 5 kPa;

(iv) have vibration isolators and gaskets;

(v) allow for appropriate circulation and temperature control of the air within the Generator Enclosure;

(vi) avoid the use of fasteners, anchors, hangers, or other components that might work loose and drop into the Generator; and

(vii) be designed to prevent the Generator upper bracket and the Generator top covers from lifting off of the Generator Enclosure if the Generator Enclosure is rapidly pressurized during a severe Generator stator winding fault or other similar event. Pressure relief device(s) can be used as one method to help limit the air pressure rise within the Generator Enclosure during such events. The system employed will minimally impact the effort required to remove the Generator top covers during Generator inspection and maintenance.

(b) Lighting and Receptacles: The Generator upper bracket will:

(i) have permanent light fixtures. The number and arrangement of light fixtures required will be such that the illumination requirements of Appendix 6-2 [General Technical Specifications (SPGT)] are met in all areas above the Generator rotor; and

(ii) have a minimum of eight 120 V receptacles equally spaced apart.

(c) Drainage: The Generator upper bracket and Generator top covers will:

(i) have Generator top cover panels that are designed to prevent liquids from leaking through the joints between each panel and between the panels and the Generator Enclosure walls;

(ii) have Generator top cover panels that are designed to prevent liquids from leaking through any openings on the Generator top cover surface; and

(iii) have a perimeter gutter and drainage system embedded in Generator Enclosure around the periphery of the Generator upper bracket and Generator top covers to collect liquids that have spilled onto the Generator top covers.

(d) Removal and Installation: The Generator top covers and Generator upper bracket will:

(i) for the Generator top covers, have means such as removable or built-in (preferred) Lifting Points to enable the use of one Powerhouse bridge crane to lift the Generator top covers off of the Generator upper bracket;

(ii) for the Generator upper bracket, have means such as removable or built-in (preferred) Lifting Points or provision for a Lifting Device to enable the use of one Powerhouse bridge crane to lift the Generator upper bracket off of the Generator with minimal disassembly of the Generator upper bracket (the Generator top covers can be removed in advance); and

(iii) have means to protect any noise insulation, isolators, gaskets, etc., installed on the Generator top covers and Generator upper bracket from mechanical damage during removal, storage, and reinstallation of the Generator top covers.

(e) Guardrails: The Generator upper bracket and Generator top covers will have a lightweight aluminum guardrail system that can be installed and removed by hand by one Worker. The guardrail system will:

(i) prevent Worker fall hazards;

(ii) be designed so that it is possible for a Worker to install the guardrails prior to removal of one or more Generator top covers;

(iii) be designed so that it is possible to configure the guardrails as necessary to completely enclose the open area created by the removal of one or more Generator top covers;

(iv) have sufficient quantity of guardrails to be able to completely enclose two Generator Enclosures in the event that all of the Generator top covers have been removed from two Units;

(v) have guardrail post hole pockets located around the periphery of each Generator Enclosure such that it is possible to place any guardrail in any location with minimal effort;

(vi) have, in addition to the above, guardrails for two Units that can be installed on the Generator top covers to create a safe pathway for Workers and Carts to access to the brushgear housing or to the Generator rotor access stairs from the Powerhouse main floor. A design where these pathway guardrails are identical to the Generator Enclosure guardrails is preferred;

(vii) have liquid tight Generator top cover post hole pockets; and

(viii) have at least twelve guardrail sections with a built in self-closing gate to enable Workers and Carts to get onto and off of the Generator top covers and onto and off of the Generator rotor access stairs when the guardrails are in place.

(f) Generator Rotor Inspection Hatch: A Generator rotor inspection hatch will be incorporated into the Generator top covers to enable Workers to access the Generator rotor spider from the top covers without the need to remove the top covers. The Generator rotor inspection hatch will:

(i) be hinged and include a latching mechanism that can be unlatched from the top cover side and rotor side of the hatch;

(ii) include a permanently fixed ladder that a Worker can use to climb down to the Generator rotor spider;

(iii) if necessary, include a removal extension for the ladder that provides something for Workers to hold onto when first starting to climb down from the top covers; and

(iv) be provided with removable handrails and a safety gate to prevent fall hazard when the hatch is in use.

2.14 Brushgear Housing

An enclosure, the brushgear housing, will be provided to house the Generator rotor brushgear.

2.14.1 Access and General Arrangement

The Generator brushgear housing will be configured such that:

(a) Workers can access the brushgear housing while the Generator is in operation;

(b) Workers can access the brushgear housing and brushgear assembly in the Standing position;

(c) there is sufficient height and width for a Standing Worker to walk around the entire circumference of the collector slip rings while the Unit is in service;

(d) there are no tripping hazards within the brushgear housing;

(e) the use of ladder(s) is not required for the primary means of access to the brushgear housing. Staircase access is acceptable;

(f) two Workers can conduct a Rescue Operation;

(g) there is a secondary means of egress for use during an emergency. This emergency egress will be located approximately 180 degrees opposite the primary means of access. Use of a ladder for the secondary means of egress is acceptable. This egress will have a minimize size sufficient to evacuate a Supine Worker;

(h) there is clear Lexan® viewing window to allow Workers to visually verify that it is safe to enter the brushgear housing when the unit is in service; and

(i) a Powerhouse bridge crane auxiliary hook can be used to remove the brushgear housing with minimal disassembly of the brushgear housing and, if the TW Speed Sensing System is located above the rotor, the TW Housing.

2.14.2 Ventilation and Cooling

The Generator brushgear housing will:

(a) if the brushgear equipment requires cooling, have a ventilation system that requires minimal maintenance (e.g., only filter changes) or electrical power;

(b) have means of adjusting (increasing or decreasing) the amount of ventilation in order to vary collector slip ring and brush operating temperatures; and

(c) have means to keep all brush (carbon) dust completely contained within the housing.

During the winter months, atmospheric humidity can drop below what is considered acceptable for the optimum function of the carbon brushes. A passive means will be provided, such as a place to secure a plastic ~20 L bucket full of water that can be safety removed from the brushgear housing by a Worker while the Unit is in service, to introduce additional moisture into the air within the brushgear housing.

2.14.3 Lighting and Receptacles

The Generator brushgear housing will:

(a) have permanent light fixtures. The number and arrangement of light fixtures required will such that the illumination requirements of Appendix 6-2 [General Technical Specifications (SPGT)] are met in all areas of the Generator brushgear housing; and

(b) have a minimum of one 120 V receptacle on the brushgear housing wall every 180 degrees.

2.14.4 Maintainability and Access

To facilitate inspection and maintenance of the Generator rotor brushgear, the brushgear housing will be configured such that there are:

(a) barriers as required to prevent Workers from being exposed to hazards when completing brushgear inspections while the Unit is in service;

(b) sufficient openings to permit Workers to visually inspect the brushgear assembly including the collector brushgear assembly and the collector slip ring assembly while the Unit is in service;

(c) sufficient openings to permit Workers to use an infrared temperature probe to measure the temperature of the brushgear assembly including all brush holders, all carbon brushes, the brush support ring, and the collector slip ring surfaces while the Unit is in service;

(d) sufficient openings or removable covers sized large enough to permit Workers to use a 203 mm x 152 mm collector slip ring stone on the collector slip rings in situ with minimal disassembly of the brushgear housing;

(e) sufficient openings or removable covers sized large enough to permit Workers to maintain the brushgear assembly including all brush holders, all carbon brushes, the brush support ring, and the collector slip ring surfaces with minimal disassembly of the brushgear housing; and

(f) sufficient passive ventilation to enable Workers to complete brushgear inspection and maintenance without the need for supplemental ventilation.

2.15 Toothed-Wheel Speed Sensing System Housing

If the Contractor's design utilizes a Toothed-Wheel that is installed above the Generator rotor, then the Contractor will provide a Toothed-Wheel housing (the "**TW Housing**") to house the Toothed-Wheel, ZVPU Probes and their mounting bracket system, and other parts of the Toothed-Wheel Speed Sensing System as required, and that:

(a) is located above the Generator brushgear housing;

(b) prevents Worker contact with moving parts of the TW Speed Sensing System while the Unit is in service;

(c) is sized large enough to permit Workers to access and maintain the TW Speed Sensing System in its in-service location and position, considering Workers using tools and equipment necessary for maintenance;

(d) includes clear Lexan® viewing windows to allow Workers to visually inspect the TW Speed Sensing System equipment while it is in operation, without disassembling or opening any part of the TW Housing;

(e) includes permanent light fixtures if required in order to meet the illumination requirements of Appendix 6-2 [General Technical Specifications (SPGT)] in all areas of the TW Housing;

(f) includes a 120 V receptacle; and

(g) includes stairs, and guardrails, if necessary, to provide access the TW Speed Sensing System for inspection and maintenance.

2.16 Instrumentation

2.16.1 General

(a) Except as otherwise expressly specified in the Contract Documents, all Generator instrumentation will be wired to and terminated in the Generator Terminal Cabinet.

(b) For clarity some instrumentation descriptions/requirements are located in other sections of Specifications.

2.16.2 Toothed-Wheel Speed-Sensing System

The Work includes a toothed-wheel speed-sensing system (the "**Toothed-Wheel Speed-Sensing System**" or "**TW Speed Sensing System**"), designed and arranged to measure Unit speed, and that:

(a) utilizes the following elements:

(i) a "**Toothed-Wheel**" or **"TW"** that:

(A) is made of steel;

(B) consists of alternating protruding sections (teeth) and recessed sections (spaces), that allow distinct sensing of its teeth and spaces by ZVPU Probes arranged around it;

(C) is firmly attached to the Turbine shaft or Generator shaft in a manner that ensures the rotational speed always matches the rotational speed of the Unit, and that includes any features necessary to accommodate movement of the Generator rotor (horizontally within the Generator guide bearing and vertically due to hydraulic thrust from the Turbine or rotor jacking operations) in a manner that ensures the ZVPU Probes will be able to sense Unit speed continuously during such movements;

(D) includes sufficient teeth to ensure accurate speed-sensing up to at least 105% of Unit runaway speed, and creep detection resolution of at least 3 degrees; and

(E) includes few enough teeth to allow a ZVPU Probe to distinctly and consistently distinguish between adjacent teeth or spaces;

(ii) ZVPU Probes in accordance with Appendix 6-4 [Governor System Specifications (SPGOV)];

(iii) a simple system of ZVPU probe brackets and fasteners, and that:

(A) ensures each ZVPU Probe will not move during Unit operation (considering vibration, windage, thermal cycling, and any other mechanical disturbances that may be experienced during Unit operation);

(B) ensures vertical alignment of the centre points of the ZVPU Probes' sensing faces with the plane that passes through the centreline of all of the teeth on the Toothed-Wheel; and

(C) allows for adequate radial, axial, and circumferential (relative to the Toothed-Wheel) adjustment of each ZVPU Probe, considering factors such as vertical movement due to lift pump operation, shaft runout and vibration, and Unit shimming and realignment that may be performed in the future;

(iv) signal conditioners in accordance with Appendix 6-4 [Governor System Specifications (SPGOV)]; and

(v) a high-speed counter-type electronic PLC module in accordance with Appendix 6-4 [Governor System Specifications (SPGOV)];

(b) includes all equipment and wiring necessary to generate the speed signals necessary for the correct operation of the Governor;

(c) includes sufficient allowance for movement to accommodate a rotor jacking operation; and

(d) if installed above the Generator rotor:

(i) be installed in the TW Housing; and

(ii) does not impede the ability to install an instrument slip ring assembly in the TW Housing to enable instrument signals to pass from the Generator rotor to the instrument slip ring assembly.

2.16.3 Stator Frame RTDs

The Generator stator frame will have a minimum of six RTDs. The stator frame RTDs will:

(a) be installed at the top, middle, and bottom of the frame in a minimum of two locations: at upstream and orthogonal to upstream in the opposite direction of rotation;

(b) be radially and vertically aligned in each location;

(c) be installed in the radial centre of the frame so that the frame temperature, and not the air temperature, is measured; and

(d) be replaceable without the need to disassemble the Generator.

One of the RTDs installation locations will be in the circumferential centre of an air cooler and one will be between two air coolers.

2.16.4 Stator Core RTDs

The Generator stator core will have a minimum of twelve RTDs. The stator core RTDs will:

(a) be embedded in and installed on the stator core at the top, middle, and bottom of the core in a minimum of two locations: at upstream and orthogonal to upstream in the opposite direction of rotation;

(b) be radially and vertically aligned in each location;

(c) measure the temperature in the stator core yoke approximately half the distance between the back of the slot and the back of the core. It is acceptable to glue these RTDs in the air-duct;

(d) measure the temperature of the back of the stator core. It is acceptable to glue these RTDs to the stator core back;

(e) be installed so that the core temperature, and not the air temperature, is measured; and

(f) be replaceable without the need to disassemble the Generator.

One of the RTDs installation locations will be in the circumferential middle of an air cooler and one will be between two air coolers.

2.16.5 Stator Winding RTDs

The Generator stator winding slots portion will have:

(a) at least two RTDs per circuit;

(b) at least one RTD per 15 stator slots; and

(c) a number of RTDs divisible by three.

The Generator stator winding slot RTDs will:

(d) be equally distributed around the circumference of the stator bore with one third located on the axial-top of the stator stack, one third in the axial-middle of the stack, and one third at the axial-bottom of the stack;

(e) be installed in the stator bar slots between the front and the back bars with the lead wire coming out of the top of the slot;

(f) be installed close to the neutral end of the winding;

(g) be of the dual-element type; and

(h) be integrated into filler strips that have the same dimensions and material properties as the stator winding slot centre fillers.

The Generator stator winding circuit-rings will have at least one RTD installed on each circuit-ring.

2.16.6 Field Winding RTDs

RTDs embedded in the rotor field windings are not required.

2.16.7 Generator Air Cooler RTDs

The Generator air coolers will each have two temperature averaging RTDs. Each RTD will:

(a) be installed in a zigzag pattern across the surface area of each Generator air cooler in order to measure the approximate average air temperature. One RTD will be on the hot side of the Generator air cooler for air leaving the Generator, and the other will be on the cool side for air leaving the Generator air cooler; and

(b) be terminated in such a manner that the RTDs can be easily disconnected to facilitate the removal of each Generator air cooler.

2.16.8 High-pressure Oil Injection System (Lift Pump)

The Generator lift pump will have the following instrumentation and controls:

(a) an oil pressure gauge for visual indication of the oil pressure;

(b) a temperature compensated pressure transducer; and

(c) pressure switch contacts with:

(i) one normally open contact that closes when adequate oil pressure has been established following a pump start when the Unit is at standstill; and

(ii) one normally closed contact that opens when oil pressure has been established following a pump start and remains open when adequate oil pressure is present during acceleration or deceleration of the Unit.

2.16.9 Brake Limit Switches

Each Generator brake assembly will be fitted with a limit switch that:

(a) indicates when the Generator brake cylinder is in the fully retracted position;

(b) is wired out to the Generator Terminal Cabinet such that it is possible to determine which Generator brake cylinder is not in the fully retracted position by measurement of the circuit resistance at the Generator Terminal Cabinet (i.e., the brake limit switches will not be wired in series); and

(c) is capable of adjustment for initial calibration purposes, and, where applicable, adjustment to accommodate brake shoe wear.

A red indicating LED for each brake limit switch will be provided in Generator Terminal Cabinet, and will be connected such that it will extinguish to indicate whenever the brake has released. The LED indication will:

(d) use terminal blocks that include LED indication integral to their design; and

(e) be arranged and clearly labelled such that a Worker viewing the LEDs from a distance of 1 m can easily distinguish the status of each specific brake when the door of the Generator Terminal Cabinet is open.

A cable, provided and terminated by Others in the Generator Terminal Cabinet, will be used to connect each brake limit switch to an external brake position monitoring system provided by Others.

2.16.10 Brake Air Pressure Switches

The Generator brake valve will:

(a) have a pressure switch installed upstream of it, used to indicate when the air supply pressure to the Generator brake valve is low, that is adjustable between 170 kPa and 1000 kPa; and

(b) have a pressure switch installed downstream of it, used to indicate that the valve has operated, that is adjustable between 170 kPa and 1000 kPa.

2.16.11 Rotor Jacking System Limit Switches

The Generator rotor jacking system will be fitted with limit switches that:

(a) are interlocked with the Generator rotor jacking system hydraulic control system such that hydraulic pump is automatically shut off when the maximum allowable jack travel has been reached; and

(b) are capable of adjustment for calibration purposes.

2.16.12 Current Transformers

(a) Protection and Metering Current Transformers: The Work includes two protection-class current transformers (CTs) per phase that will be installed inside the Generator Enclosure at the neutral end of the Generator stator winding. These current transformers will be used for primary and standby Generator protection.

The CTs will be supplied in accordance with ES 44-Z0510, IEEE C37.110 and IEC 60044-1 unless specifically noted otherwise. The CTs will be indoor, window-type with the ratings specified in Table 2.16.12(a). The CTs will not saturate under transient fault conditions.

Table 2.16.12(a) – CT Ratings

CT rated primary current	To be determined
CT rated secondary current	5 A
Type	TPS
Continuous current rating factor for secondary winding	1.5
Voltage class/BIL	To be determined
Accuracy limiting secondary exciting voltage (V_{al})	To be determined by BC Hydro
Accuracy limiting secondary exciting current (I_{al})	To be determined by BC Hydro
Mechanical short-time rating (crest)	To be determined
Thermal short-time rating (rms symmetrical)	To be determined
Maximum secondary resistance at 75°C	1.8 Ω
Frequency	60 Hz

In addition to the above, a third current transformer in each phase at the neutral end will be a metering class CT with a metering accuracy of 0.15B1.8. This transformer will be used for Unit efficiency testing and will be specially calibrated by the manufacturer with burdens of 0.1, 0.2, 0.5, 1.0 and 1.8 ohms and at 0.5, 1.25, 2.5, 3.75, 5.0 and 6.25 secondary amps.

(b) Neutral Balance CT: Neutral balance CT(s) will be installed at the neutral phase connection point(s).

(c) Neutral CT Compensating Windings: Previous BC Hydro experience with neutral current transformers, where the neutral connection of the Generator has been made in a limited space within the Generator Enclosure, has resulted in unacceptable current transformer performance. Compensating windings were required to correct the problem. The design of the neutral connection and the placement of the current transformers will be such that adequate spacing is used, which precludes the use of compensating or flux balancing windings.

(d) Split-Phase Current Transformers: Split-phase current transformers are not required.

(e) Current Transformer Construction and Wiring: Every current transformer will:

(i) have the secondary wiring of each current transformer fully distributed over the whole length of the core;

(ii) be made immune to proximity effects; and

(iii) be directly wired out to terminal blocks in an external junction box. Connections and terminations will be made as detailed in Appendix 6-2 [General Technical Specifications (SPGT)].

(f) Current Transformer Testing:

(i) If acceptable Type Test certificates and Reports (on identical CTs) are not available for submission, then type tests will be performed in accordance with IEC 60044-1.

(ii) Routine tests will be performed on each current transformer in accordance with IEC 60044-1.

(iii) The test Reports submitted for each current transformer will:

(A) include the manufacturer's serial number; and

(B) include record of calibration sheets that are included in the Report and submitted separately as Drawings.

(g) Protection-class CT: Protection-class CT(s) will have their accuracy class stated and stamped on the CT label according to CSA C60044-1:07 Table 1B.

2.16.13 Airgap Monitoring System

The Work includes a GE – Bently Nevada continuous online airgap monitoring system (AGMS). The AGMS will:

(a) be designed and installed in accordance with BC Hydro ES 44 Z0330;

(b) have four rotor- and four stator-mounted probes in accordance with the "slow", "tall" generator, "full" system design of BC Hydro ES 44 Z0330 (four rotor probes and four stator probes);

(c) be compatible with the Bently Nevada 3500 vibration monitoring rack;

(d) be compatible with the Bently Nevada 3500/46M hydro monitor modules;

(e) utilize Series 4000 50 mm BC Hydro-customized sensor probes, BC Hydro-customized extension cables, and signal conditioners;

(f) include the rotor- and stator-mounted AGMS Enclosures;

(g) be wired out to and terminated in rotor- or stator-mounted AGMS Enclosures; and

(h) be wired from the rotor- and stator-mounted AGMS Enclosures to the Generator Terminal Cabinet.

Others will supply and install the Bently Nevada 3500 vibration monitoring rack and the 3500/46M hydro monitor modules.

2.16.14 Partial Discharge Monitoring System

The Work includes an Iris Power Engineering Inc. continuous online partial discharge monitoring system. The partial discharge monitoring system will:

(a) be installed in accordance with the Iris PDA Coupler Installation Guide in a PDA differential mode;

(b) be compatible with the Iris Power Engineering, PDA-IV test instrument;

(c) have for each stator winding circuit, one epoxy-mica coupling capacitor installed;

(d) have, for each co-axial cable circuit, a surge arrester such the Network Technologies, Tii-355M, installed in an Enclosure near the epoxy-mica capacitor; and

(e) be wired out to and terminated in the continuous online partial discharge monitoring system monitoring cabinet mounted on the outside of the Generator Enclosure.

2.16.15 Field Temperature Monitoring System

A Field Temperature Monitoring System is not required.

2.16.16 Instrument Brushgear

The Generator rotor brushgear will include one set of permanently installed, insulated instrumentation brush holders and brushes for measurement of the Generator field voltage at the collector slip rings. The instrumentation brushes will be installed only during specialized Generator testing and otherwise removed from their holders when not in use. The grade of brush chosen will be such that the instrument brushes meet the requirements of IEEE 115.

2.17 Electrical Equipment and Devices

2.17.1 General

Except as otherwise expressly specified in the Contract Documents, Generator wiring and cabling will:

(a) for devices installed on the Generator upper bracket, be marshalled to a Generator upper bracket Enclosure mounted on the Generator upper bracket. Cabling from this Enclosure will be run in a common run of EMT or rigid conduit out of the Enclosure;

(b) for the stator winding RTDs, be marshalled to the Generator RTD Terminal Box;

(c) for devices installed on the Generator stator, except for the stator winding RTDs, be marshalled to the outside of the Generator stator frame in Enclosure(s); and

(d) for devices installed within the Generator Pit, be marshalled to a Generator bearing Enclosure(s) mounted on the side of or near the Generator bearing(s). Cabling from this Enclosure will be run in a common run of rigid conduit out of the Generator Pit.

The intent of marshalling wiring and cabling to a Generator upper bracket Enclosure and to a Generator bearing Enclosure is to minimize the amount of effort required to disconnect the instrumentation at these locations prior to removal of the Generator upper bracket or Generator bearing.

With the exception of the stator winding RTD cabling, cabling from the above Enclosures will be run to the Generator Terminal Cabinet.

Where feasible, tray systems may be substituted for conduit and the Contractor will submit the proposed tray systems for Consent.

2.17.2 Generator Terminal Cabinet

The wall-mounted Generator terminal cabinet (the "**Generator Terminal Cabinet**") will be located on the outside of the Generator Enclosure and will be supplied by Others. The Work includes cable entry and termination in the Generator Terminal Cabinet. The Generator Terminal Cabinet will:

(a) meet the requirements for Enclosures;

(b) except as otherwise expressly specified in this Appendix 6-5 [Generator Specifications (SPG)] or in Schedule 6 [Specifications and Drawings], be the final marshalling and termination point for all wiring and cabling located within the Generator Enclosure;

(c) have 30% extra space for future expansion;

(d) be supplied with hinged door(s), latches and handle; and

(e) have provision for cables, supplied and installed by Others, to enter the cabinet from either the top or bottom.

Wiring and cabling within the Generator Enclosure that will not be terminated in the Generator Terminal Cabinet include:

(f) stator winding RTD cabling;

(g) main and neutral CT cabling;

(h) partial discharge monitoring system coax cabling;

(i) lighting and outlet wiring within the Generator Enclosure; and

(j) the power cable for the lift pump.

Blockouts in the concrete wall will be installed by Others for transition of cables/conduits between the Generator Terminal Cabinet and devices/equipment inside the Generator Enclosure.

2.17.3 Generator RTD Terminal Cabinet

Special provision will be made for the termination of the Generator stator winding RTDs. A separate cabinet is required to remove exposure of the potentially high-voltage circuits from the other control and indication circuits.

The Work includes a wall-mounted Generator RTD terminal cabinet (the "**Generator RTD Terminal Cabinet**") to be located on the outside of the Generator Enclosure and adjacent to the Generator Terminal Cabinet. The Generator RTD Terminal Cabinet will:

(a) meet the requirements for Enclosures;

(b) have 20% extra space for future expansion;

(c) be the marshalling and termination point for the Generator stator winding RTDs;

(d) be supplied with hinged door(s), latches and handle;

(e) provide surge protection devices on each lead from each RTD. The surge protectors will be commercially available devices, such as the Network Technologies, Tii-355M;

(f) have provision for cables, supplied and installed by Others, to enter the cabinet from either the top or bottom; and

(g) be arranged in accordance with the drawings 1006-H04-01031-001 and 1006-H04-01031-002.

2.18 Grounding

2.18.1 Connection to Station Ground

The Generator stator frame, Generator lower bracket or other Turbine support structure, the Generator upper bracket, and Generator brushgear housing will have provision made for, and be connected, each in four locations, to exposed ground plates and ground busses embedded or installed by Others inside and outside the Generator Enclosure. The Generator top covers will be bonded to the Generator upper bracket.

2.18.2 Personal Protection Grounds

The design of the Generator rotor and stator windings and connections will be accepted and will allow for installation of approved personal protection grounding hardware as listed in ASTM F855 and IEEE 1246. The personal protection grounds will be applied using a hotstick.

2.19 Fire Protection

The Work includes a complete fire protection and automatic water-spray deluge system including all the piping, connections, interconnections, and supply from the various plant systems such as plant air, cooling water return, fire protection water supply, protection, control, and station alarms in accordance with this Appendix 6-5 [Generator Specification (SPG)] and BC Hydro Generation Technical Specification 01.20.SPEC.01.

2.20 Equipment Identification

2.20.1 Generator Nameplate Placard

The Generator will be provided with a nameplate placard on the outside, downstream wall of the brushgear housing. The information on the nameplate will:

(a) be in accordance with IEEE C50.12; and

(b) include:

(i) direction of rotation;

(ii) insulation class;

(iii) type of connection;

(iv) the Unit number;

(v) ambient temperature rating (degree C);

(vi) date of installation;

(vii) BC Hydro purchase order number; and

(viii) BC Hydro contract number.

2.21 Tooling and Lifting Devices

2.21.1 Miscellaneous Tooling

The Work includes all tooling required to inspect or maintain any Generator component. As a minimum the tooling will include:

(a) two bar-pushers (if required for stator winding installation);

(b) three guide and thrust bearings dismantling devices;

(c) three dismantling devices for the removal of the Generator brakes;

(d) one spool piece that can be installed in place of the Generator temperature flow regulating valve when the valve is removed for maintenance;

(e) two removable Generator rotor access staircases that can be installed to provide Worker access from the Generator top covers to the Generator rotor or alternatively from the Powerhouse main floor to the Generator rotor. A Worker will be able to install a removable staircase while standing on the Powerhouse floor side of the Generator top cover guardrails; and

(f) two Generator upper bracket storage devices. The storage devices will be designed to enable storage of a Generator upper bracket assembly overtop of another Unit that is in service.

2.21.2 Rotor Jacking System Oil Pump

The Work includes one portable, motor-operated Generator rotor jacking oil pump and oil sump tank mounted on a base with wheels. The Generator rotor jacking pump will:

(a) have sufficient capacity to lift the rotating Generator and Turbine components; and

(b) be 600 V, 3-phase.

All electrical and piping equipment necessary to attach the Generator rotor jacking pump to the Generator rotor jacking system will be supplied including:

(c) Swagelok QF series Quick Connect nipple, complete with metal dust cap;

(d) flexible hose with Swagelok QF series Quick Connect valved coupler, complete with metal dust plug;

(e) Hubbell Twist-Lock - 2 wire inlet, Cat. No. 8815A, with No. 7420 lift cover and adapter Plate No. 7452 (for jacking limit switches);

(f) Hubbell No. 7101C connector with No. 6024 cover (for jacking limit switches); and

(g) Crouse Hinds Plug No. APJ-3385 (for main power supply).

The sump tank for the Generator rotor jacking pump will be provided with fill, drain, vent, oil inlet, oil outlet, gauge glass connections, and hand-hole cover.

The Work also includes all necessary controls and equipment for operation of the Generator rotor jacking pump including:

(h) flexible oil-resistant power cable for the pump motor;

(i) two-conductor, flexible, oil-resistant cable to connect to the jacking limit switches;

(j) momentary-type contact, heavy-duty, oil resistant START-STOP pushbutton;

(k) red running indication light;

(l) combination magnetic starter with 600-115 V single phase control transformer, three overload devices and fused disconnect switches; and

(m) oil pressure switch and oil pressure gauge.

2.21.3 Rotor-turning Device

The Work includes one permanently installed Generator rotor turning device for each Unit. Each rotor-turning device will:

(a) be capable of safely rotating the Unit for maintenance and inspection purposes, with the lift pump operating and the runner submerged;

(b) be capable of turning the Unit at a continuously-variable range of speeds in the forward direction of between 0.1 RPM and 1 RPM for up to 15 minutes and in the reverse direction at a minimum speed;

(c) be operable without disassembly of any Generator components; and

(d) be located such that it does not interfere with the maintenance and inspection of the Equipment.

It is expected that the rotor-turning device will consist of a hydraulically retracted friction drive wheel that would operate against the brake track. A hydraulically powered rotor-turning device will consist of the following:

(e) permanently installed hydraulically operated drive system for each Unit;

(f) two portable hydraulic power units to power the drive system that are capable of being easily moved to each Unit;

(g) permanent piping from the drive system to a convenient point outside the Generator Enclosure where the hydraulic power unit would be connected; and

(h) a control system that can be operated from either the hydraulic power unit or adjacent to the drive system.

2.21.4 Rotor Pedestal

The Work includes two rotor pedestals for the Generator rotors. The rotor pedestals will be designed to:

(a) support the Generator rotor in a high enough position that a Crouching Worker can access the underside of the Generator rotor while the rotor is sitting on the rotor pedestal;

(b) allow a Worker to access the inside of the Generator rotor hub from the underside of the rotor by including Worker access ports or other means; and

(c) enable a Worker to inspect and conduct NDT tests on the rotor hub to Turbine shaft flange by inclusion of access ports or other means.

2.21.5 Lifting Devices and Lifting Points

(a) General: The Work includes all Lifting Points and Lifting Devices required to lift any Generator component.

(b) Lifting Points: As a minimum, each of these Generator Components will have designated Lifting Points:

(i) TW Housing;

(ii) TW Speed Sensing System;

(iii) Generator brushgear housing;

(iv) Generator rotor brushgear collector slip rings;

(v) Generator guide bearing pads;

(vi) Generator upper bracket;

(vii) Generator air coolers;

(viii) Generator rotor (as a complete assembly);

(ix) Generator rotor poles;

(x) Generator rotor pole coils;

(xi) Generator thrust block;

(xii) Generator lower bracket; and

(xiii) Generator stator.

(c) Miscellaneous Lifting Devices: As a minimum, the following Lifting Devices are required for the first Generator:

(i) two brushgear housing Lifting Devices;

(ii) two top cover Lifting Devices;

(iii) two Generator rotor access staircase Lifting Devices;

(iv) three rotor pole coil Lifting Devices;

(v) two Generator upper bracket Lifting Devices (if other than standard rigging is required); and

(vi) two Generator lower bracket Lifting Devices (if the Generator is equipped with a lower bracket and other than standard rigging is required).

(d) Rotor Lifting Device: The Work includes one Lifting Device for the Generator rotor. The Generator rotor Lifting Device will be designed:

(i) to utilize the Powerhouse bridge cranes with a lifting beam to lift the fully-assembled Generator rotor including the Generator rotor poles;

(ii) so that a Generator rotor can be lifted over a Generator rotor sitting on a rotor pedestal on the Powerhouse floor in the Powerhouse service bay;

(iii) so that a Generator rotor can be lifted over a Generator stator sitting on the Powerhouse floor in the Powerhouse service bay; and

(iv) to allow the Generator rotor to traverse to the Powerhouse service bay without disassembly of the other Units.

(e) Stator Lifting Device: If a Generator stator Lifting Device is required by the Contractor for the Work, the Work includes one stator Lifting Device that will be designed:

(i) to utilize the Powerhouse bridge cranes;

(ii) to limit deformation and distortion of the Generator stator during lifting, travelling, and installation of the stator into the Generator Pit or Generator Enclosure;

(iii) so that the Generator stator can be lifted over a Generator rotor sitting on a rotor pedestal on the Powerhouse floor in the Powerhouse service bay;

(iv) so that the Generator stator can be lifted over a Generator stator sitting on the Powerhouse floor in the Powerhouse service bay; and

(v) to allow the Generator stator to traverse to the Powerhouse service bay without disassembly of the other Units.

(f) Rotor Pole Key Extraction System: The Work includes three rotor pole key extraction systems that will be designed to:

(i) extract the rotor pole keys without the use of the Powerhouse bridge crane;

(ii) allow one Worker to perform efficiently the key extraction process; and

(iii) ensure any components that are exposed to wear are readily commercially available.

(g) Rotor Pole Lifting Device: The Work includes three rotor pole Lifting Devices that will be designed to:

(i) be installed by two Workers, one working at each of the top and bottom of the pole (excluding the Powerhouse crane operator); and

(ii) enable the pole to be rotated from vertical to horizontal and back without the need for additional equipment or protection.

SPG3 MANUFACTURING, INSPECTION AND TEST REQUIREMENTS

3.1 Stator Bar Pre-Production Run Type Tests

As soon as possible after the Effective Date, but prior to the production of the Generator stator winding, pre-Production Run Type Tests will be performed on prototype stator bars.

3.1.1 Standards

The pre-Production Run Type Tests will generally be performed in accordance with the following standards:

(a) IEEE 1043: Recommended Practise for Voltage-Endurance Testing of Form-Wound Bars and Coils;

(b) IEEE 1310: Recommended Practice for Thermal Cycle Testing of Form-Wound Stator Bars and Coils for Large Generators; and

(c) IEEE 1553: Standard for Voltage-Endurance Testing of Form-Wound Coils and Bars for Hydrogenerators.

3.1.2 Testing

The Generator stator bar pre-Production Run Type Test parameters will be as follows:

(a) the prototype bars will be identical to the production bars in all respects;

(b) it is preferred that the tests be performed prior to manufacture of the production bars. However, if the tests are conducted concurrently with manufacture of the production bars, the Contractor will accept all risks associated with bars failing the tests including rejection of all bars produced;

(c) tests will be performed on each prototype bar in accordance with Table 3.1.5A;

(d) Type Tests 3 through 10 in Table 3.1.5B will be conducted by Powertech Labs Inc.;

(e) all costs associated with performing the tests will be borne by the Contractor;

(f) bars failing any test will not be repaired, but will be rejected and not supplied as part of the Work;

(g) all test results will be submitted by the test lab simultaneously to both Hydro’s Representative and to the Contractor; and

(h) Hydro’s Representative may select additional samples for dissection at BC Hydro’s expense.

3.1.3 Test Results

The Generator stator bar pre-Production Run Type Test results will:

(a) include the test results of each and every prototype bar tested including rejects and test failures;

(b) be submitted electronically in the form of a Microsoft Excel workbook. The file will have a row for each bar and a column for each type of test data; and

(c) in addition to the Excel workbook, written Reports for each of the voltage endurance and thermal cycling test programs will be submitted.

3.1.4 Test Failures

If the Generator stator bar(s) fail the pre-Production Run Type Test program specified in SPG 3.1 then:

(a) the bar Production Run may be rejected;

(b) all bars that fail the test program will be dissected to identify the failure root cause;

(c) the Contractor will supply additional new bars for testing in which the failure cause has been corrected; and

(d) the additional supplied bars and testing of those bars will be at the Contractor’s expense.

3.1.5 Testing Additional Generator Bars

Hydro’s Representative may select additional Generator stator bars for testing from the Production Run(s). Testing of additional bars:

(a) will be at BC Hydro’s expense; and

(b) may be subjected to any or all of the pre-Production Run Type Tests.

Table 3.1.5A – pre-Production Run Type Tests – Bar Quantity

Quantity	Voltage Endurance Test Program	Thermal Cycling Test Program	Finish-check Test and Corona-Imaging Tests
Bars to be Supplied	6 minimum (3 front, 3 back)	7 minimum (3 front, 3 back, one of either)	
Bars to be Tested	4: (2 front, 2 back) 5th and 6th bars: allocated as test failure replacement	6: (3 front, 3 back) 7th bar: control sample	The number of both back and front bars equal to at least the winding pitch plus one

Table 3.1.5B – pre-Production Run Type Tests – Test Sequence

Sequence	Test Type	SPG Section	Voltage Endurance Test Program	Thermal Cycling Test Program
1	Finish-check Test	3.1.6	Not applicable	Not applicable
2	Stator Core Model Winding Corona-imaging Test	3.1.7	Not applicable	Not applicable
3	Evaluative Tests	3.1.8	Yes	Yes
4	High-potential Test	3.1.13	Yes	Yes
5a	Voltage Endurance Test	3.1.14	Yes	Not applicable
5b	Thermal Cycling Test	3.1.15	Not applicable	Yes
6	High-potential Test	3.1.13	No	Yes
7	Evaluative Tests	3.1.8	Yes	Yes
8	Dissection Test	3.1.16	Yes, a minimum of 1 bar	Yes, a minimum of 1 bar
9	Voltage Endurance Test	3.1.14	Not applicable	Yes on 4 bars (2 front, 2 back)
10	Evaluative Tests	3.1.8	Not applicable	Yes at 200 hour and at test end for information only

3.1.6 Finish-Check Test

A finish-check test will be performed to confirm the Generator stator bar surface finish and physical shape. An acceptable stator model resembling a full-length section of the Generator stator core, and with a minimum number of full-size slots equal to one complete winding pitch plus one, will be used to check for bar-shape conformity. The:

(a) test will be performed on the number of both back and front bars equal to at least the throw plus one;

(b) bar surface will be smooth and consistent in cross-section, without bumps, depressions, or other defects;

(c) bar shape will allow bar installation to be in accordance with SPG 4.6.4;

(d) bar span (circumferential direction) dimension, when measured at the bar connection end, will vary from the design by less than 4 mm;

(e) bar drop (radial direction) dimension, when measured at the bar connection end, will vary from the design by less than 6 mm; and

(f) bar-ends will be well-aligned in all planes.

3.1.7 Stator Core Model Winding Corona-Imaging Test

To validate the clearance between adjacent Generator stator bars, a stator core model winding corona-imaging test will be performed:

(a) in accordance with IEEE 1799;

(b) in the phase-to-phase clearance test configuration;

(c) at the IEEE 1799 maximum recommended test voltage for factory testing;

(d) with the number of back bars and the number of front bars equal to one complete winding pitch;

(e) with the top bars installed on top of the back bars; and

(f) using an acceptable corona-imaging camera.

3.1.8 Evaluative Tests

Where the phrase “evaluative tests” occurs in Table 3.1.5B, it means the following Generator stator bar tests that are to be performed in the order listed:

(a) physical measurements test in accordance with SPG 3.1.9;

(b) surface resistivity test in accordance with SPG 3.1.10;

(c) partial discharge test in accordance with SPG 3.1.11; and

(d) dissipation factor and tip-up test in accordance with SPG 3.1.12.

3.1.9 Physical Measurements Test

Physical measurements of the Generator stator bar size will be taken. Upon VE test or TC test completion the bars will not suffer any damage.

Measurements will be taken at a minimum of the following Generator stator bar locations, but no further apart than 450 mm:

(a) at the Connection End, in the slot section 50 mm from the interface point of the slot tape and gradient paint;

(b) in the of the slot section, at the mid-point;

(c) at the Drive End, in the slot section 50 mm from the interface point of the slot tape and gradient paint;

(d) at the connection-end, in the corner-bend transition from the slot section to the end-turn straight section; and

(e) at the connection-end, in the straight section of the end-turn.

The following will be determined at each Generator stator bar location:

(f) the circumferential dimension (width) of the bar;

(g) the radial dimension (depth) of the bar; and

(h) the voltage stress in kV/m (using only the mica tape, thickness, not the semi-conductive tape thickness).

3.1.10 Surface Resistivity Test

Surface resistivity tests will be performed on the conductive material used on the slot section of the Generator stator bar prior to the application of any elastomeric materials applied to the slot surface of the bar.

The Generator stator bar surface resistivity will be measured using two methods:

(a) Ohms per Square Measurement Method: The resistivity of the conductive material will be measured in at least three locations along the length of the bar, but no further apart than 450 mm. The measured value will be between 200 ohms per square and 15 kohms per square:

(i) the test will be performed by either using electrodes 25 mm long spaced 25 mm apart, or by using temporary conductive bands wound tightly around the perimeter of the bar at a distance equal to the perimeter length of the bar;

(ii) for the electrode method, measurements will be performed on the wider sides of the bar; and

(iii) using an ohmmeter, the resistance between the two electrodes or bands will be measured.

(b) Ohms Measurement Method: The resistivity of the conductive material will be measured along the bar slot section length. The measured value will be between 3000 ohms and 200 kohms:

(i) the test will be performed by using temporary conductive bands tightly wound around the perimeter of the bar, near the ends of the slot portion of the bar; and

(ii) using an ohmmeter, the resistance between the two bands will be measured.

3.1.11 Partial Discharge Tests

Partial discharge (PD) tests will be performed on the Generator stator bars in accordance with ASTM D1868. The test parameters will be as follows:

(a) the $|Q_m|_{max}$ values will be measured at a pulse rate of 10 pulses per second;

(b) the applied test voltage will be equal the rated Generator line-to-neutral voltage, and will be applied when the bars are at ambient temperature (20ºC approximately);

(c) a 1000 pF coupler capacitor will be used;

(d) the test unit will have a sensitivity of at least 2 mV. The preferred instrument for PD measurements is the IRIS Power Engineering, PDA-IV;

(e) PD pulses will be recorded over a one-minute period beginning two minutes after the application of the test voltage; and

(f) the number of pulses per second and phase angle will be categorized according to amplitude and polarity, and the results presented graphically in the form of 2D, 3D plots, and phase–resolved plots.

These Generator tests are for information only.

3.1.12 Dissipation Factor and Tip-up Test

Absolute dissipation factor and tip-up tests will be performed on the Generator stator bars according to IEEE 286.

The Generator stator bar tests will be performed at the voltages listed in Table 3.1.12A. The test results will be in accordance with Table 3.1.12B.

Table 3.1.12A – Dissipation Factor Test Voltages

Terminal Voltage [kV]	Dissipation Factor Test Voltages									Tip-Up Calc
	Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	
13.8	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	Col. 6-Col. 1
>14.3	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	Col. 7-Col. 1

Guard electrodes will be placed over the grading material where it overlaps the Generator stator bar semi-conductive slot material. The location of the guard electrodes will be in accordance with IEEE 286, paragraph 8.1.1 and Figure 4.

The Generator stator bar tests will be carried out at an ambient temperature between 15°C and 25°C.

Table 3.1.12B – Dissipation Factor and Tip-up Test

Criteria (for any one bar)	2 kV Dissipation Factor Value	Tip-up Value
Before either the VE Test or the TC Test	<= 1.2%	<= 0.6%
After either the VE Test or the TC Test	<= 1.5%	<= 0.9%
After the post-TC Test VE Test	for information only	for information only

3.1.13 High-potential Test

A 1 minute, 60 Hz high-potential test will be performed to ground on the Generator stator bars:

(a) prior to commencement of the VE or TC test program, at 1.40 times the total of twice the rated terminal voltage plus 1000 Vac (i.e., 1.40(2E+1);

(b) upon completion of the VE Test program, a high-potential test is not required; and

(c) upon completion of the TC Test program, in accordance with IEEE 1310.

During the Generator stator bar high-potential test, the slot portion of the bar will be in a grounded “dummy slot”.

3.1.14 Voltage Endurance Test

A voltage endurance (VE) test will be performed on the Generator stator bars in accordance with IEEE 1043 and 1553. The test voltage and duration will be according to the values shown in Table 1, Schedule A of IEEE 1553. The test temperature will be 110°C. There will be:

(a) no test failures prior to 200 hours of testing;

(b) not more than one failure after 200 hours of testing; and

(c) no damage to the corona suppression system such as de-bonding, carbonization, or coating deterioration.

For clarity, after 200 hours of testing, a maximum of one test failure will be permitted. In the case of any one failure after 200 hours, the failed bar will be replaced with two new bars. No additional failures will be accepted.

For information only, Hydro's Representative may decide to run some of the bars to failure at BC Hydro's expense.

3.1.15 Thermal Cycling Test

A thermal cycling (TC) test will be performed on the Generator stator bars in accordance with IEEE 1310. The bars will be tested for 500 cycles. The copper temperature will vary from 40°C to the thermal/temperature classification limit for Class 130 (B) systems. There will be:

(a) no de-bonding between the conductors and the groundwall insulation; and

(b) no delamination within the groundwall insulation.

At 50, 100, and 250 cycles, a tap test will be performed to determine if there are any obvious locations where the Generator stator bar insulation has delaminated.

At the completion of the thermal cycling test, Hydro's Representative will select a minimum of one bar for dissection.

3.1.16 Dissection Test

The Generator stator bar dissection will be performed:

(a) in accordance with the Contractor's Procedure;

(b) by the Contractor or the lab, at the preference of the Contractor; and

(c) while witnessed by both the Contractor and Hydro's Representative.

The Contractor's stator bar dissection Procedure will be submitted for Consent.

As a minimum, Generator stator bar dissections will be performed at the locations specified for physical measurements in SPG 3.1.9.

A tap test will be used to determine if there are any obvious locations where the Generator stator bar insulation has delaminated. If the tap test identifies one or more locations where the bar has delaminated, Hydro's Representative will select additional locations for dissection.

Each dissection will be visually inspected without the aid of a microscope. In the Generator stator bar slot section, there will be no delamination observed within the groundwall insulation or from the conductor. In the end-turn sections, unless significant delamination is observed, as determined by Hydro's Representative, acting reasonably, the dissections will be for information only. Delamination observed between the outer-two-most layers of ground insulation tape or in the outer-most 10% of the groundwall insulation thickness will be ignored.

For information only, Hydro's Representative may decide to dissect additional bars at BC Hydro's expense.

3.2 Stator Winding Factory Tests

3.2.1 General

(a) For each Generator stator bar shipment to the Site, test Reports for the factory tests specified in SPG 3.2, will be included in each crate.

(b) The following Production Tests will be performed on each Generator stator bar:

(i) strand-to-strand test in accordance with SPG 3.2.2;

(ii) bar surface resistivity test in accordance with SPG 3.2.3;

(iii) insulation resistance and high-potential test in accordance with SPG 3.2.4; and

(iv) dissipation factor and tip-up Test in accordance with SPG 3.2.5.

(c) The following Type Tests will be performed on Generator stator bars for each Production Run:

(i) finish-check test in accordance with SPG 3.2.6; and

(ii) stator core model winding corona-imaging test in accordance with SPG 3.2.7.

Type Tests will be performed on a number of front and back stator bars equal to the full winding pitch at the beginning of the manufacturing process when the first stator bars are produced.

(d) The Generator stator winding factory tests specified in SPG 3.2 are to be performed in accordance with the same tests specified in SPG 3.1 unless expressly stated otherwise.

(e) Generator stator bars not passing the tests specified in SPG 3.2 will not be reworked or refinished, but will be rejected and not supplied as part of the Work.

(f) Failure to pass any of the tests listed in SPG 3.2 may result in rejection of the bar Production Run.

3.2.2 Strand-to-Strand Test

The strand insulation of each combination of Generator stator bar strands will be tested for at least 1 second at 200 V, 60 Hz.

3.2.3 Bar Surface Resistivity Test

Surface resistivity tests will be performed on the Generator stator bars using both the ohms per square measurement method and the ohms measurement method:

(a) for the ohms per square measurement method, the results will be in the range of 200 ohm per square to 15,000 kohm per square; and

(b) for the ohms measurement method, the results will be in the range of 3000 ohm to 200 kohm.

3.2.4 High-potential Test

After completion of Generator stator bar manufacture and prior to shipment, a high-potential test of at least 1.5 times the total of twice the rated terminal voltage plus 1 kV (i.e., 1.5(2E+1)) at 60 Hz to ground for 1-minute will be performed on the Generator stator bars. During the test, the slot portion of the bar will be in a grounded “dummy slot”.

3.2.5 Dissipation Factor and Tip-up Test

Absolute dissipation factor and tip-up tests will be performed on the Generator stator bars. The test results will be in accordance with Table 3.2.5.

Table 3.2.5 – Dissipation Factor and Tip-up Test

Criteria (for any one bar)	2 kV Dissipation Factor Value for any one bar	Tip-up Value
Each bar Production Run	<= 1.2% maximum <= 1.0% average	<= 0.6% for 70% of the bars <= 0.8% for 30% of the bars

3.2.6 Finish-Check Test

A finish-check test will be performed on the Generator stator bars.

3.2.7 Stator Core Model Winding Corona-Imaging Test

A stator core model winding corona-imaging test will be performed on the Generator stator bars.

3.3 Stator Core Lamination Factory Tests

3.3.1 General

To ensure the integrity of the Generator stator core lamination steel and insulating material, Type Tests will be performed on the lamination punchings during each Production Run. Failure to pass any of the Type Tests listed in SPG 3.3 may result in rejection of the Production Run.

(a) The following Type Tests will be performed on the Generator stator core laminations:

(i) Epstein test in accordance with SPG 3.3.2;

(ii) Franklin test in accordance with SPG 3.3.3;

(iii) ductility test in accordance with SPG 3.3.4; and

(iv) enamel thickness test in accordance with SPG 3.3.5.

Generator stator laminations failing any Type Tests will not be reworked or refinished, but will be rejected and not supplied as part of the Work.

(b) Type Tests will be performed on punching samples during the Generator stator core lamination manufacturing. At each of the periods, a sufficient number of laminations will be selected to adequately perform the tests.

The Generator stator core Type Test periods are:

(i) at the beginning of the manufacturing process during the first few laminations produced;

(ii) approximately in the middle of the manufacturing process; and

(iii) near the end of the manufacturing of the process during the last few laminations produced.

3.3.2 Epstein Test

An Epstein test will be performed on the Generator stator core laminations in accordance with ASTM A 343 / A 343M. No annealing is required. The Epstein loss values at 1.0 T and 1.5 T before and after a thermal stabilization test will be within 5% of each other.

In addition to the Generator stator core lamination test results listed in ASTM A 343 / A 343M, the B-H permeability curves will be provided.

3.3.3 Franklin Test

A Franklin test will be performed on the Generator stator core laminations in accordance with ASTM A 717 / A 717M. The test will be performed with the lamination at room temperature.

The average current readings will be from readings taken on the Generator stator core lamination tooth sections and on the lamination core sections. The maximum value will not exceed 0.6 A and the average reading will not exceed 0.4 A.

3.3.4 Ductility Test

A ductility test will be performed on the Generator stator core laminations in accordance with ASTM A 720 / A 720M.

3.3.5 Enamel Thickness Test

An enamel thickness test will be performed on the Generator stator core laminations using a permascope electronic thickness gauge.

3.4 Rotor Pole Factory Tests

3.4.1 General

Prior to shipping from the manufacturer’s shop, each Generator rotor pole will:

(a) pass the following Production Tests:

(i) brazed connections test in accordance with SPG 3.4.2;

(ii) insulation resistance test in accordance with SPG 3.4.3;

(iii) high-potential test in accordance with SPG 3.4.4;

(iv) turn insulation test in accordance with SPG 3.4.5; and

(v) winding resistance test in accordance with SPG 3.4.6;

(b) be weighed and have a unique number assigned in accordance with SPG 3.4.7; and

(c) be completely assembled prior to testing.

3.4.2 Brazed Connections

All brazed connections in the Generator rotor pole coil construction and amortisseur winding will be checked using an approved process for brazing quality.

3.4.3 Insulation Resistance

A 1 minute, 2500 Vdc insulation resistance ($IR_{1\ min}$) test and a polarization index test will be performed on each Generator rotor pole in accordance with IEEE 43 and the result will be temperature corrected to 40°C. The temperature-corrected $IR_{1\ min}$ value will be greater than 10 Gohms.

3.4.4 High-potential

A 1 minute, 60 Hz high-potential test will be performed on the Generator rotor pole winding at a test voltage of a minimum of ten times the rated excitation voltage, but in no case less than 5000 Vac.

During the Generator rotor pole winding test, no type of temporary insulation will be used.

3.4.5 Turn Insulation

Tests will be performed on each Generator rotor pole to verify the turn insulation integrity including:

(a) a surge test using an impulse tester at a voltage equal to 120 V crest per turn and a rise time of 0.2 µs or shorter; and

(b) a high-frequency impedance test in accordance with BC Hydro MS 01.20.Test.05. A test at 415 Hz and a minimum of 30 A is preferred. The measured impedance value for each pole winding will not deviate from the average value by more than 5%.

3.4.6 Winding Resistance

A winding resistance test will be performed on each Generator rotor pole. The result will be recorded to five significant figures and then temperature corrected to the “reference temperature for use in determining I^2R losses” specified in IEEE C50.12. The temperature-corrected winding resistance value will not deviate from the calculated value by more than 2%.

If the temperature-corrected winding resistance value of the Generator rotor pole does not meet the above criteria, then the reason will be investigated and a written explanation submitted.

3.4.7 Weight and Number Assignment

Each Generator rotor pole will be weighed and the weight recorded. The pole weights will vary by less than 2%.

Based on the Generator rotor pole weights, the poles will be distributed around the rotor to minimize any out-of-balance condition. The rotor poles will be numbered in accordance with SPG 2.6.4(e).

3.5 Shop Testing and Assemblies Before Shipment

3.5.1 Generator Air Coolers

The Generator air coolers will be hydrostatically tested for two hours at a continuous water pressure of 1.5 times the Cooling Water System design pressure.

Leaks found during this test will be repaired and the air cooler retested.

3.5.2 Generator Brake Assemblies

Each Generator brake assembly will be pressure tested to 1.5 times the maximum Rotor Jacking Pressure system pressure to verify that:

(a) the mechanical stops have sufficient strength to limit the stroke of the brake cylinder without deformation of the stops; and

(b) there is no oil leakage past the brake cylinder seals after 1 hour under pressure.

The oil used for the Generator brake assembly test will be the same oil type used for the Generator rotor jacking system.

Leaks found during the Generator brake assembly test will be repaired and the Generator brake assembly will be retested to verify the repairs have been successful.

3.5.3 Lower Bracket

The Generator lower bracket boss, arms, and ring will be assembled together and the bearing oil coolers mounted.

3.5.4 Stator

The Generator stator frame will be assembled and the inside diameter checked. At least two layers of the stator core punchings will be stacked to check fit-up.

3.5.5 Rotor

At least 150 mm of the Generator rotor rim plates will be stacked to check fit-up. The rotor hub and arms will be bolted together.

3.6 Stress Relief Heat Treatments

Stress relief heat treatments will be executed on Generator large machined and weldment components. These include:

(a) the rotor hub;

(b) all rotating bearing components (if provided);

(c) the stub shaft (if provided); and

(d) the thrust bearing housing.

3.7 Brazing

3.7.1 General

Except as otherwise expressly specified in SPG 3.7, all brazed electrical connections will meet the specifications for welding as specified in Appendix 6-2 [General Technical Specifications (SPGT)].

For clarity, the words: brazing, braze, or brazer can generally be substituted for the words: welding, weld, or welder where used in the welding specifications in Appendix 6-2 [General Technical Specifications (SPGT)].

3.7.2 Standards

Brazing will be in accordance with AWS B2.2.

3.7.3 Qualifications

All personnel who perform brazing and all personnel who inspect brazed connections will be qualified to AWS B2.2 for every type of joint they work on or inspect.

3.7.4 Materials

The filler materials for brazing will be in accordance with AWS A5.8, Specification for Filler Metals for Brazing and Braze Welding.

3.7.5 Inspections

All brazed electrical connections, both those made in the factory and those made at the Site, will be 100% visually inspected.

SPG4 SITE WORK

4.1 Contractor's Work Force for Site Work

4.1.1 Winders

As a minimum, one-half but not less than two members of each shift of each Generator stator winding and Generator rotor winding installation crew will hold a valid British Columbia Certificate of Qualification in the trade of “Winder Electrician”. All Winder Electricians will have a minimum experience of six installation projects similar to that specified in the Contract. The Contractor may make a request in writing to Hydro's Representative for an exception to the Winder Electrician requirement provided the Contractor can demonstrate to Hydro's Representative's satisfaction that the qualifications or experience of the substitute worker is equivalent to that of a Winder Electrician.

Prior to commencement of installation, and each time the Contractor makes any change to installation crew personnel, resumes and any other documentation that Hydro's Representative may request will be provided promptly.

4.2 Site Measurements

4.2.1 Clearances, Dimensions, Runout and Shaft Verticality Measurements

The measurements to be taken and recorded by the Contractor for the Equipment during installation will include but not be limited to the following:

Item	No. of Readings
Rotor and stator shapes by rotating rotor through 360° and measuring Airgaps from:	
Top of pole No. 1 to stator	18
Bottom of pole No. 1 to stator	18
Upstream point on stator to top of each pole	All poles
Upstream point on stator to bottom of each pole	All poles
Clearance - upper and lower brackets to shaft	4

Item	No. of Readings
Clearance - Generator bearing journals to bearing support	8
Clearance - Generator guide bearing pads to journal	Every pad
Clearance - creep detector to shaft	As required
Runout check (number of points at each location) Includes measurements at all bearings, seals, Generator collector slip rings.	4
Shaft verticality check - 4 wires, 2 elevations (Single wire may be acceptable. An electronic level maybe used to supplement plumb wires.)	At least 2 rotations
Elevations: Rotor/stator centreline, bearing reference	As required to get a representative measurement

4.3 Electrical Power

For the Generator stator core full-flux, short-circuit saturation, open-loop excitation, and sudden-short-circuit test performed as part of Generator assembly, testing, acceptance and commissioning test:

(a) electric power at 600 V, 3-phase, 1600 A will be made available at the Powerhouse station service panel; and

(b) electric power at Generator Rated Voltage, 3-phase, 70 A will be made available at the Powerhouse station service panel.

The Work includes all cabling, distribution panel(s), cable connectors, bracing and any protection devices required to use these power sources.

4.4 Instrumentation Grounding during High-voltage Tests

During any high-voltage tests on either the Generator stator or rotor winding, all permanently installed instrumentation will be grounded. This instrumentation includes RTDs, AGMS probes, CT secondaries, and PT secondaries,

4.5 Stator Core Tests

The Generator stator core tests specified in this SPG 4.5 will be performed prior to installation of the Generator stator winding.

4.5.1 Stator Core Knife Test

The completed Generator stator core will be tested for loss of core pressure using a Richard’s L3 knife. Prior to this test there will be no resin applied to the core. In any location of the stator core, it will be impossible to insert the knife more than 13 mm by hand without prying against a fixed object.

4.5.2 Full-Flux Test

The completed Generator stator core will be electromagnetically compacted and tested for lamination and assembly quality by performing a full-flux test. The test will be witnessed by Hydro’s Representative.

(a) Flux density and duration: The stator core will be uniformly excited to at least 85% of the normal rated flux for a minimum of 1 hour.

(b) Search coil: Prior to connection to the voltmeter the search coil used to determine the magnetic flux density will have suitable fuses installed in both sides of the circuit.

(c) Temperature measurement: An infrared camera will be used for general scanning of hot spots and a contact-type temperature probe will be used to confirm hot-spot temperatures.

(d) Core-to-frame temperature differential: The temperature differential between the stator core and the stator frame will be:

(i) sufficiently small such that core waves or buckling does not occur; and

(ii) less than 10°C.

(e) Core temperature: The stator core temperature will not exceed the normal operating temperature. Any core lamination packet exhibiting a temperature deviation of:

(i) 5°C above the average core temperature will be considered defective; and

(ii) 10°C above the average core temperature will cause the test to be terminated and any defects corrected.

(f) Post-test cooling: After the test and prior to core retightening, the stator core will be left to cool until the average stator core temperature is cooler than 30°C.

(g) Retightening: After the core has sufficiently cooled, and prior to winding installation, the core will be retightened.

(h) Core losses: During each full-flux test the stator core input power (both kW and kVAr) will be measured for information only.

(i) Defect Repair: The Contractor will submit for Consent the proposed correction method for correcting defects. After defect repair, the full-flux test will be repeated to demonstrate that the defects have been repaired.

(j) El-Cid test: The use of an “El Cid” test may supplement the full-flux test for comparison purposes.

4.5.3 Stator Core Stud Insulation Resistance Test (if applicable)

For a Generator stator core designed with core studs passing through laminations, after the application of the slot semi-conductive paint, a 1-minute, 500 Vdc insulation resistance test of each core stud to ground will be performed. The $IR_{1\ min}$ value will be greater than 100 Mohms.

4.6 Generator Stator Winding Installation

4.6.1 Painting

The Generator stator winding will not be painted.

4.6.2 Bar Numbering

The Generator stator core slot number will be clearly and permanently marked:

(a) at every tenth stator slot;

(b) directly on the stator bar at a location near the core on the straight, oblique section of the bar;

(c) at both the connection-end and opposite-connection-end;

(d) on both the bore-side and core-back side of the winding; and

(e) so that the numbers are visible with the rotor in place.

Bar numbering marking by hand with legible printing using a paint pen is acceptable.

4.6.3 Clearances and Connections

Sufficient clearance will maintained to prevent any electrical discharge between the various current Generator stator winding carrying components and also ground including:

(a) front and back bars;

(b) bars and ground;

(c) winding series connections;

(d) bars and circuit-rings; and

(e) circuit-rings and ground.

4.6.4 Bar Installation

Generator stator bars will be installed:

(a) at the designed elevation in the stator core;

(b) uniformly maintaining consistent and designed spacing; and

(c) such that the T-spacing is consistent and meets the requirements of SPG 2.5.5(h)(iv) multiplied by 0.85.

4.6.5 Slot Clearance

Confirmation that each of the Generator stator front and back bars are completely inserted in each slot will obtained. The proposed Procedure used to obtain conformance will be submitted in advance.

Before installation of a Generator stator front bar on top of a back bar or before wedging, the tangential tightness of each bar in each slot will be checked using feeler gauges. The mean side clearance of any bar will not exceed 0.05 mm in any 100 mm section of the slot.

If the mean side clearance does not meet the above criteria, then adequate semi-conducting side packing materials will be added to provide continuous and positive contact between the bar and the core.

4.6.6 Brazing

All Generator winding connections, excluding the main and neutral terminals, will be brazed using copper clips, ferrules, or other acceptable method.

The brazing process will include thermal protection, preferably with the application of water jackets or chill blocks between the factory applied insulation system and the joints to be brazed. The insulation system will not be damaged.

If the insulation system is damaged, then the affected components will be replaced.

4.6.7 Connections

(a) End-Cap Connections: The series connections of Generator stator bars that use end-caps will:

(i) have the connection encapsulated with electrical grade insulating compound and use epoxy-glass end-caps;

(ii) utilize an end-cap installation Procedure that will ensure that there are no voids in the insulating compound;

(iii) have the end-cap overlap the bar groundwall insulation by a minimum of 25 mm; and

(iv) ensure that adjacent end caps have sufficient clearance to prevent any electrical discharge and ensure proper cooling.

(b) Other Connections: Generator connections other than those using end-caps will be covered with an insulation system that will:

(i) prevent any electrical discharge; and

(ii) be cured fully before completion of the Work.

4.6.8 Bar Surface Contact Resistance

(a) After installation of each Generator stator bar, the surface contact resistance to ground will be measured using an accepted device near the top, centre, and bottom of the bar. Use of a device with a 150 mm long by 12 mm wide woven copper strap is preferred.

(b) For the Generator stator back bars, this test will be performed prior to inserting the front bars, and for front bars this will be performed before wedging.

(c) For each Generator stator bar the surface contact resistance value will be between 200 ohms and 5000 ohms.

(d) If the surface contact resistance value does not meet the above criteria, then the reason will be investigated and a written explanation submitted prior to correction of the deficiency.

4.6.9 Slot Wedge Tightness Test

Generator stator core slot ripple spring compression will be measured for at least 10% of the slots. The measured slots will be evenly distributed around the stator bore. For the slots that are measured, the measurements will be performed at various elevations, but no fewer than four locations for each slot. The Contractor’s wedge installation Procedure and wedge tightness acceptance criteria will be submitted for Consent.

The Procedure will be suitable for use during maintenance when access is provided via a minimum of two removed poles. One such Procedure is by using holes drilled in the wedges for insertion of a depth gauge.

4.7 Stator Winding Tests

Unless otherwise specified, the Generator stator winding tests specified in this SPG 4.7 will be performed in accordance with the following standards:

(a) IEEE 115; and

(b) IEEE C50.12.

4.7.1 Insulation Resistance, Polarization Index, and High-potential Tests

After receipt at the Site, and during and after installation, insulation resistance, polarization index, and/or high-potential tests will be performed on the Generator stator bars and winding in accordance with Table 4.7.1.

Where listed in Table 4.7.1, the 1-minute, 5.0 kVdc insulation resistance to ground (IR1 min) and the 10-minute polarization index will be:

(a) measured;

(b) temperature corrected to 40°C; and

(c) accepted prior to performing a high-potential test.

For each Generator stator winding parallel, phase, or complete winding, the temperature-corrected $IR_{1\ min}$ will be greater than 100 Mohms.

Where listed in Table 4.7.1, 1 minute, 60 Hz high-potential tests will be performed to ground on the Generator stator winding at a voltage of at least "k_{hp}" times the total of twice the rated terminal voltage plus 1000 Vac (i.e., k_{hp} (2E+1)). For the various tests, the value of k_{kp} is listed in the table.

For all of the insulation resistance, polarization index, and high-potential Generator stator winding tests, all bars, circuits, or phases not under test will be grounded.

Table 4.7.1 Stator Winding High-Potential Tests

Item	When these tests will be performed…	IR and PI Test	High-potential Test (k_{hp})	Notes
1	…upon receipt at Site, on a random sample of bars consisting of not less than 4 bars in each Production Run.	IR, PI	1.40	The slot portion of the bar will be in a grounded "dummy slot" or simulated slot. It will be permissible to test multiple bars simultaneously.
2	…during winding installation, on each back (bottom) bar prior to installation of the front (top) bar.	IR	1.30	This test will be performed on a periodic basis on groups of bars at a time (for example at the end of each shift).
3	…during winding installation, on each front (top) bar prior to permanent wedge installation.	IR	1.30	This test will be performed on a periodic basis on groups of bars at a time (for example at the end of each shift).

Item	When these tests will be performed…	IR and PI Test	High-potential Test (k_{hp})	Notes
4	…during winding installation, on each front (top) and back (bottom) bar after a slot is wedged, but before the leads have been brazed.	No	1.20	This test will be performed on a periodic basis on groups of bars at a time (for example at the end of each shift).
5	…after circuit-ring installation, on all circuit-rings before connection to the bars.	IR	1.20	
6	…after the winding is completely installed	IR, PI	1.10	Each parallel of the winding will be tested separately.
7	…if applicable, after the stator has been lifted and placed in the Generator pit/enclosure, but before the rotor is installed.	No	1.05	Each phase of the winding will be tested separately.
8	…in accordance with SPG 5.2.6.	IR	1.00	Each phase of the winding will be tested separately. This test is the acceptance test.

4.7.2 Stator Winding Corona-Imaging Test

A Generator stator winding corona-imaging test will be performed:

(a) after the winding is completely installed;

(b) in accordance with IEEE 1799;

(c) in phase-to-ground clearance configuration and again in the phase-to-phase clearance test configuration;

(d) at the IEEE 1799 maximum recommended test voltage for fully assembled stator windings;

(e) on each Generator; and

(f) using an acceptable corona-imaging camera.

All corona discharge will be recorded with respect to location, intensity, and electrical position in the winding.

This test is for information only.

4.7.3 Winding Capacitance

After the Generator stator winding is completely installed, but prior to the neutral wye-point being connected, the capacitance to ground of each Generator stator winding phase and of the 3-phases connected together will be measured.

4.7.4 Winding Resistance

After the Generator stator winding has been completely installed, and prior to connection of the main-leads, a winding dc resistance test will be performed on each Generator stator winding phase. The results will be recorded to five significant figures and then temperature corrected to the “reference temperature for use in determining I^2R losses” specified in IEEE C50.12. The temperature-corrected resistance values will not deviate from the calculated value by more than 5%, and the temperature-corrected resistance difference between the highest and lowest phase values will not be greater than 0.5%.

If the temperature-corrected Generator stator winding resistance value does not meet the above criteria, then the reason will be investigated and a written explanation submitted.

4.7.5 RTD Tests

For each of the following RTDs, each Generator RTD element will pass a 1 minute, 1000 V, 60 Hz test to ground:

(a) stator core air-duct RTDs: after five laminations installed above each RTD; and

(b) stator winding RTDs: after each slot containing an RTD has been fully wedged and the bars in the slot have been lashed, but before any series connections have been made.

The $IR_{1\ min}$ value will be greater than 100 Mohms.

4.8 Partial Discharge Monitoring System Cables

Before the Generator stator winding partial discharge monitoring system cables are terminated permanently in the partial discharge monitoring system terminal box, Hydro’s Representative will witness and approve the calibration of the cables.

4.9 Rotor Winding Tests

Unless otherwise specified, the Generator rotor field winding tests specified in this SPG 4.9 will be performed:

(a) from the Generator rotor brushgear collector slip rings; and

(b) in accordance with the following standards:

(i) IEEE 115; and

(ii) IEEE C50.12.

4.9.1 Insulation Resistance

(a) Prior to Pole-coil Interconnection: Prior to interconnection of the Generator rotor pole-coil windings, a 1 minute, 1000 Vdc insulation resistance ($IR_{1\ min}$) test will be performed on each pole-coil winding in accordance with IEEE 43. The $IR_{1\ min}$ will be temperature corrected to 40°C. The temperature-corrected $IR_{1\ min}$ value will be greater than 10 Gohms. Any significant discrepancies between the test results obtained from the $IR_{1\ min}$ tests conducted in the factory and the $IR_{1\ min}$ results conducted at Site will be investigated and the findings submitted for Consent.

(b) After Rotor Assembly: After the Generator rotor field winding has been completely assembled up to and including the brushgear collector slip rings, a 1 minute, 1000 Vdc insulation resistance (IR_1

$_{min}$) test and a polarization index test will be performed on the Generator rotor field winding in accordance with IEEE 43. The $IR_{1\ min}$ will be temperature corrected to 40°C. The temperature-corrected $IR_{1\ min}$ value will be greater than 100 Mohms. The polarization index value will be for information only.

4.9.2 High-Potential

After the Generator rotor field winding has been completely assembled and the insulation resistance test specified in SPG 4.9.1(b) has been successfully completed, a 1 minute, 60 Hz high-potential test will be performed on the Generator rotor field winding at a test voltage of a minimum of ten times the rated excitation voltage, but in no case less than 5000 Vac.

During the Generator rotor field winding high-potential test, no temporary insulation may be used.

4.9.3 Turn Insulation

After the Generator rotor field winding has been completely installed, a high-frequency impedance test will be performed on the Generator rotor field winding in accordance with BC Hydro MS 01.20.Test.05. A test at 420 Hz and a minimum of 10 A is preferred. The impedance value for each pole winding will not deviate from the average value by more than 5%.

4.9.4 Winding Resistance

After the Generator rotor field winding has been completely installed, a winding resistance test will be performed on the Generator rotor field winding. The result will be recorded to five significant figures and then temperature corrected to the “reference temperature for use in determining I^2R losses” specified in IEEE C50.12. The temperature-corrected winding resistance value will not deviate from the calculated value by more than 1%.

If the temperature-corrected winding resistance value does not meet the above criteria, then the reason will be investigated and a written explanation submitted.

4.10 Generator Brake Dust Collection System

The Generator brake dust collection system will be tested in order to verify proper operation of the system and to verify the initial settings of blast gates to balance the system. Testing and balancing will be performed by an agency that specializes in this type of work. Balancing Procedures will be in accordance with National Environmental Balancing Bureau - Procedural Standards for Testing, Adjusting and Balancing Environmental Systems, SMACNA, and ASHRAE standards.

As a minimum, following successful start-up and balancing of the Generator brake dust collection system, the following tests and documented measurements are required:

(a) fan performance;

(b) volumetric flow rate at each hood pick up point and the total volumetric flow rate through the dust collection system;

(c) pressure drop across dust collector;

(d) total pressure and static pressure at fan inlet and fan outlet;

(e) static pressure measurements in each branch and in each main duct; static pressure at each hood opening; and

(f) air sampling analysis to determine the effectiveness of the dust collection system.

The Generator brake dust collection system will be designed such that it does not propagate fire.

SPG5 SITE ACCEPTANCE AND COMMISSIONING TESTS

5.1 General

Generator site acceptance and commissioning tests will be performed in accordance with IEEE C50.12 and IEEE 115, except as otherwise specified.

5.2 Generator Tests by the Contractor

5.2.1 Rotor Jacking System

The performance of the Generator rotor jacking system will be tested.

5.2.2 Current Transformer

After the Generator current transformers are installed, the following tests will be performed on all current transformers:

(a) insulation resistance;

(b) ratio; and

(c) polarity.

5.2.3 Generator Brakes

During the first set of mechanical runs, the performance of the Generator brakes will be tested for proper operation.

5.2.4 Rotor Unbalance (caused by Mechanical Imbalance)

The Generator rotor will be assessed for mechanical imbalance during the mechanical runs. If the rotor is unbalanced, then it will be balanced in accordance with a submitted Generator rotor balancing Procedure.

5.2.5 Generator Rotor Brushgear

The performance of the Generator rotor brushgear will be monitored during the acceptance testing.

An infrared temperature detector will be used to measure the temperature of the Generator rotor brushgear collector slip rings and brushes and confirm the temperature variances. The emissivity of the detector will be set appropriately.

5.2.6 Stator Winding Insulation Tests

After completion of all overspeed tests, the following tests will be performed on the Generator stator winding:

(a) insulation resistance;

(b) polarization index; and

(c) high-potential,

all in accordance with SPG 4.7.1.

Any discrepancies between the Generator stator winding insulation test results performed in SPG 4.7.1 and this SPG 5.2.6 will be submitted.

5.2.7 <u>Rotor Winding Tests</u>

After completion of all overspeed tests, the following tests will be performed on the Generator rotor winding:

(a) insulation resistance and polarization index tests in accordance with SPG 4.9.1(b);

(b) a high-potential tests in accordance with SPG 4.9.2;

(c) turn insulation tests in accordance with SPG 4.9.3; and

(d) a winding resistance test in accordance with SPG 4.9.4.

Any discrepancies between the Generator rotor winding test results performed in SPG 4.9 and this SPG 5.2.7 will be submitted.

5.2.8 <u>Short-circuit Saturation Curve</u>

A test will be performed to determine the Generator short-circuit saturation curve.

The Exciter will be operated in “open-loop” mode and supplied from the station service. The Work includes the supply cable and connections.

The Exciter open-loop voltage and current supply requirements will be accepted.

During this test, to verify the protection circuits, tests will be performed by Others.

5.2.9 <u>Open-circuit Saturation Curve</u>

A test will be performed to determine the Generator open-circuit saturation curve.

The Exciter will be operated in “open-loop” mode and supplied from the station service. The Work includes the supply cable and connections.

The Exciter open-loop voltage and current supply requirements will be accepted.

During this test, to verify the protection circuits, tests will be performed by Others.

5.2.10 <u>Phase Sequence</u>

The phase-sequence of the Generator stator will be tested.

5.2.11 Generator Parameters

Tests will be performed on each Generator to determine the following Generator parameters:

(a) direct axis synchronous reactance, X_d; and

(b) short circuit ratio, SCR.

Tests will be performed on one Generator to determine the following Generator parameters:

(c) direct axis, saturated transient reactance, $X'_{d, sat}$;

(d) direct axis, saturated sub-transient reactance, $X''_{d, sat}$; and

(e) zero sequence reactance, X_0.

5.2.12 Deviation Factor

The deviation factor of one Generator will be tested.

5.2.13 Telephone Influence Factor

The telephone influence factor of one Generator will be tested.

5.2.14 Bearing Insulation and Shaft Current Test

Tests will be performed to ensure the Generator bearing insulation effectiveness and to ensure shaft currents are not present.

5.2.15 Line Charging Capacity

The line charging capacity of one Generator will be determined. This test is for information only.

5.2.16 Zero Power Factor Saturation Curve

The zero power factor saturation curve of one Generator will be determined. The measurements will be taken:

(a) with the Generator connected to the system;

(b) at a minimum of three terminal voltage points; and

(c) with one of the measurement points at Rated Voltage.

5.2.17 Temperature Tests

Temperature tests will be performed on each Generator.

(a) Test Conditions: At a minimum the test will be performed at four test conditions. Recommended test conditions are: 0.50 pu, 0.71 pu, 0.87 pu, and 1.00 pu of the Generator Rated Output. The test will not be performed in the rough load zone. Test conditions will be submitted.

(b) Test Uncertainties: The absolute temperatures, reference coolant temperatures, and temperature rises will be calculated taking into account the test uncertainties stated in the Generator TDIF.

(c) Calculation or Extrapolation Method: If a specific calculation or extrapolation method is required for the test data, the method will be submitted.

(d) Cooling Water Flow and Temperature: For the purposes of confirming the Generator Rated Output, the cooling water flow through the air coolers at the Generator Rated Output will be at the Maximum Cooling Water Supply Temperature and will be calculated based on the measured cooling water flow and temperature at the maximum Generator output attainable at the time of the test.

For the Generator Rated Output, the calculated cooling water flow through the air coolers at the Maximum Cooling Water Supply Temperature must be less than or equal to the cooling water flow stated in the Generator TDIF.

(e) Stator and Rotor Winding Temperature Rise: For the purposes of confirming the Generator Rated Output, the stator and rotor winding absolute temperature and temperature rise will be calculated for the Generator Rated Output current by extrapolating the best-fit straight line through the respective test points plotted on a graph of temperature rise vs. per unit current squared.

At the Generator Rated Output current, the calculated:

(i) stator winding temperature rise must be less than or equal to that stated in SPG 2.2.4(b); and

(ii) rotor winding temperature rise must be less than or equal to that stated in SPG 2.2.4(d).

(f) Stator End Winding and Circuit-ring Temperature Measurement: At the Generator Rated Output current, the Generator stator end-windings and circuit-rings temperatures will be measured using thermal imaging or contact-type fibre optic sensors. If these measurement techniques are not feasible due to space or other physical limitations, the Contractor will propose an alternative measurement method for Consent. The alternative method will be capable of determining the hot-spot surface temperatures of the stator end-windings and circuit-rings.

The end-winding and circuit ring maximum copper temperature will each be no more than the temperature rise defined in SPG 2.2.4(c).

(g) Stator Core and Frame Temperature Measurement: At the Generator Rated Output, the Generator stator core and stator frame temperatures will be measured. The temperatures will meet the thermal limits defined in SPG 2.5.4(e).

5.2.18 Rotor Rim to Spider Separation

The degree of the Generator rotor rim shrink achieved will be tested after the majority of the Unit acceptance and commissioning tests have been completed including, the Unit overspeed test, the Unit runaway speed test, and the Generator temperature tests.

At least eight proximity probes will be provided to verify the Generator rotor rim separation and return with respect to the rotor spider. The probes will be spaced equally around the circumference of the rotor spider and distributed evenly between the top and bottom of the spider.

5.2.19 Rotor Unbalance (caused by Electrical Imbalance)

The Generator rotor will be assessed for electrical unbalance when the Generator is at Generator Rated Output and at Generator Rated Operating Conditions. If the rotor is unbalanced, then it will be balanced in accordance with a submitted Generator rotor balancing Procedure.

5.2.20 Generator Losses

(a) Losses: The Generator segregated-losses will be:

(i) measured on one Generator; and

(ii) measured by the heat transfer method.

(b) Compliance: For the purposes of determining compliance to the requirements of SPG 2.1.1 the test results obtained from testing one Generator will be assumed to be the same with respect to the other Generators unless tests of an additional Generator are requested.

Where tests conducted on a Generator indicate non-compliance of the requirements of SPG 2.1.1, the Contractor will have the right to request, in writing, a single re-performance of the tests on that Generator at the Contractor's expense. If the second test results differ from the first test results, the reasons for the difference(s) will be submitted. Hydro's Representative will determine which test is to be used to determine compliance to the requirements of SPG 2.1.1.

(c) Additional Generator Tests: An additional Generator may be loss tested if specifically requested by either party in writing. All costs of performing tests on an additional Generator will be borne by the party requesting such tests. Hydro's Representative will determine which test results are to be used to determine compliance to the requirements of SPG 2.1.1.

(d) Rated Operating Conditions: The Generator Rated Output operating conditions determined during the temperature tests described in SPG 5.2.17 will be used as a basis for the loss measurements described in this SPG 5.2.20. As a minimum, the Generator Losses will be measured at 0.50 pu, 0.71 pu, 0.87 pu and 1.00 pu of Generator Rated Output.

If, as a result of the temperature tests described in SPG 5.2.17, the Contractor is non-compliant with the Generator Rated Output requirements, Hydro's Representative will determine the maximum attainable operating conditions to be used for the loss measurements.

(e) Test Uncertainties: For the purposes of SPG 5.2.20, the actual losses will be the calculated value of losses determined from the tests minus the test uncertainties stated in the tables in the Generator TDIF for the same component of loss and operating condition.

(f) Calculation or Extrapolation Method: If a specific calculation or extrapolation method is required for the test data, the method will be submitted for Consent.

(g) Windage Losses: All windage losses determined will be considered to be Generator Losses. The best fit straight line drawn through the test points plotted on a graph of the cold air temperature vs. windage losses will be used to obtain the windage loss at the Regulated Cold Air Temperature.

(h) Bearing Losses: Generator bearing friction losses will be measured separately during the test. All bearing losses will be considered Generator Losses.

(i) I^2R Losses: The measured I^2R loss values of armature and field winding resistance will be temperature corrected using the reference temperature value stated in IEEE C50.12, Table 8, Class B.

The calculated Generator Rated Output armature and field I^2R losses will be respectively extrapolated from armature and field current measurements made at a voltage and power factor as close as possible to the Generator Rated Output, and at least three outputs between zero and the maximum output attainable at the time of the measurement.

(j) Air Temperature: Except for I^2R losses, all test results will be corrected to the Regulated Cold Air Temperature.

5.2.21 Sudden Short Circuit Tests

Sudden short circuit tests will be performed on one Generator.

Measurements will be made at a minimum of five voltage steps. If directed, sudden short circuit tests will be performed up to 110% of Rated Voltage.

(a) Instrumentation will be provided to measure:

(i) armature current;

(ii) terminal voltage using calibrated voltage transformers (VT) if the Generator VTs cannot be used;

(iii) stator frame displacement in three axis;

(iv) stator frame acceleration in three axis;

(v) stator winding end-turn strain; and

(vi) stator winding-end displacement.

All of the above-listed instrumentation will be first accepted.

(b) Make-switch for applying the sudden short circuit:

(i) the BC Hydro sudden short circuit test make-switch is rated 18 kV, 400 kA with 100 ms closing time and 50 ms opening time. The control voltage is 125 Vdc;

(ii) if the BC Hydro owned make-switch is not available or is considered by the Contractor to be insufficient for this test, then the Contractor will supply a make-switch;

(iii) the make-switch will be installed including the shorting bus work to the Generator main terminals; and

(iv) the timing of the make-switch will be verified (regardless of the make-switch being provided by BC Hydro or not).

(c) Exciter Settings: The Exciter settings will be temporarily modified to ensure that the exciter can provide the required field current and voltage, and so that the Exciter is otherwise fit to perform the test.

(d) Related Tests and Inspection: Before and after the sudden-short circuit test:

(i) an inspection will be performed. The Generator will be judged “fit for service” and, for both the stator winding and the rotor, no more than “minor repairs” as specified in IEEE C50.12 will be required;

(ii) an insulation resistance test will be performed on the field winding in accordance with SPG 4.9.1(b). This test will be performed prior to performance of the high-frequency impedance test;

(iii) a high-frequency impedance test will be performed on the field winding in accordance with SPG 4.9.3;

(iv) an insulation resistance and polarization index test will be performed on the stator winding in accordance with SPG 4.7.1. This test will be performed prior to performance of the HDV step tests or high-potential test;

(v) a three single-phase HDV step tests will be performed on the stator winding in accordance with SPG 5.3.3. The “before” and “after” test results will be within 10% of each other; and

(vi) three single-phase high-potential tests will be performed on the stator winding in accordance with SPG 4.7.1. The test voltage will be 0.95(2E+1).

5.2.22 Cooling Water Flow

The Contractor will measure the cooling water flow rate for the Generator air coolers with the Generator operating at Generator Rated Output at Generator Rated Operating Conditions and at an inlet water temperature of 6°C.

The cooling water flow rate for the Generator air coolers of one Unit operating at the Generator Rated Output at Generator Rated Operating Conditions with a penstock water temperature of 6 ° C and the Generator heat recovery system inactive (all Generator air coolers fully functioning but with no heat being removed from the Generator by the Generator heat recovery system) will not exceed the value for cooling water flow rate stated in the Generator TDIF.

In the event that the measurements cannot be performed at an inlet water temperature of 6°C, interpolation between measured data for lower and higher water temperatures will be considered provided that the measurements are taken when the water temperatures are in the range of 2°C to 10°C. The Contractor will propose a methodology for the interpolation and submit for Consent.

5.3 Generator Tests by BC Hydro

5.3.1 General

The tests as specified in SPG 5.3 may be performed by BC Hydro. All test instruments and data acquisition equipment will be supplied by BC Hydro. The Contractor will make provision in the integrated test schedule for these tests to be performed at no additional cost to BC Hydro.

5.3.2 Stator and Rotor Winding Insulation Resistance Tests

Generator stator (single-phase and 3-phase) and rotor winding insulation resistance (IR) and polarization index tests may be performed in accordance with BC Hydro MS 01.20.TEST.01. In accordance with the maintenance standard, the test results will result in an “Equipment Health Rating” of “good”.

5.3.3 Stator Winding HDV Step Tests

Generator stator winding (single-phase and 3-phase) HDV step tests may be performed in accordance with BC Hydro MS 01.20.TEST.02. In accordance with the maintenance standard, the test results will result in an “Equipment Health Rating” of “good”.

5.3.4 Stator Winding Partial Discharge Tests

Generator stator winding partial discharge (PD) tests may be performed in accordance with BC Hydro MS 01.20.TEST.03. These tests are for information only.

5.3.5 Corona Probe Test

A Generator stator winding corona probe tested may be performed in accordance with BC Hydro MS 01.20.TEST.04. In accordance with the maintenance standard, the test results will result in an "Equipment Health Rating" of "good".

The voltage supply to excite the stator winding to Rated Voltage will be supplied.

5.3.6 Stator Winding RTD Resistance and Insulation Resistance Tests

Generator stator winding RTD tests may be performed in accordance with BC Hydro MS 01.20.TEST.06. In accordance with the maintenance standard, the test results will result in an "Equipment Health Rating" of "good".

5.3.7 Airgap Monitoring Tests

Generator dynamic airgap monitoring tests may be performed.

5.3.8 Split-Phase Current Tests

Generator split-phase current tests (using temporarily installed flexible current probes) may be performed.

5.4 Generator Inspection and Testing After Commercial Operation

5.4.1 General

Upon completion of the Work, BC Hydro may inspect and test the Equipment at its own expense. During the Warranty Period the Contractor may participate in the inspections and testing at its own expense.

Any Equipment component that does not meet the acceptance criteria defined in relevant sections of SPG3, SPG4, and SPG5 is considered to have failed the requirements of Section 5.4.

5.4.2 Inspections

The Generator inspections may include verification that the Generator components meet the requirements of Schedule 6 [Specifications and Drawings] including that:

(a) winding and insulating materials are tight;

(b) blockings and lashings are tight;

(c) there is no evidence of partial discharge activity;

(d) stator laminations, core clamping studs, and fingers are tight;

(e) there is no overheating, hotspots, or discolourations;

(f) there is no presence of dust or powder which may be related to stator winding or core deterioration;

(g) there is no evidence of unusual movement, cracking, or distortion; and

(h) the cooling water, air, and oil piping systems are not leaking or becoming fouled.

5.4.3 Testing

The Generator testing may include:

(a) performance of any of the testing specified in SPG3, SPG4 and SPG5 except the following tests:

  (i) thermal cycling test in accordance with SPG 3.1.15;

  (ii) full-flux test in accordance with SPG 4.5.2; and

  (iii) sudden short circuit test in accordance with SPG 5.2.21;

(b) removal of one or more Generator stator bars to perform:

  (i) a visual inspection of the bar(s) and slot(s); and

  (ii) dissection tests in accordance with SPG 3.1.16.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-6

EXCITATION SYSTEM SPECIFICATIONS (SPEXC)

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 6-6

EXCITATION SYSTEM SPECIFICATIONS (SPEXC)

SPEXC1 GENERAL

1.1 Definitions and Interpretation

In this Appendix 6-6 [Excitation System Specification (SPEXC)], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Automatic Voltage Regulator**" or "**AVR**" has the meaning set out in SPEXC 2.12.6;

"**Ceiling Voltage**" has the meaning set out in SPEXC 2.1.6(b);

"**Excitation System**" or "**Exciter**" has the meaning set out in SPEXC 1.2.1(a);

"**Excitation System 30 Second Rating**" has the meaning set out in SPEXC 2.1.8(a);

"**Excitation System Data Table**" has the meaning set out in SPEXC 2.16.4;

"**Excitation System Rated Current**" has the meaning set out in SPEXC 2.1.2(b);

"**Excitation System Rated Output**" has the meaning set out in SPEXC 2.1.2;

"**Exciter Hardwired Controls**" has the meaning set out in SPEXC 2.14.2(d);

"**Exciter Human Machine Interface**" or "**Exciter HMI**" has the meaning set out in SPEXC 2.14.2(a);

"**Exciter Software**" has the meaning set out in SPEXC 2.16.1;

"**Exciter Transformer**" has the meaning set out in SPEXC 2.7.1;

"**ExcPCE**" has the meaning set out in SPEXC 2.12.1;

"**ExcRCE**" has the meaning set out in SPEXC 2.12.1;

"**Field Breaker**" has the meaning set out in SPEXC 2.4;

"**Field Discharge Resistor**" or "**FDR**" has the meaning set out in SPEXC 2.5.3;

"**Power Rectifier**" has the meaning set out in SPEXC 2.3.1;

"**Silicon Controlled Rectifier**" or "**SCR**" has the meaning set out in SPEXC 2.3.1; and

"**VT**" has the meaning set out in SPEXC 1.2.3(a).

1.2 Scope of this Specification

1.2.1 Scope of Work for the Excitation Systems

Six identical excitation systems are required for the Project, together with related Work, as follows:

(a) each static exciter (an "**Excitation System**" or "**Exciter**") includes the redundant control system, redundant power supplies for the control system, fusing, air cooling system, temperature monitoring system, solid state controlled rectifier power converter SCR assembly in redundant or N+1 configuration, field isolation and reversing links, DC shunt, field discharge equipment, excitation transformer, instrumentation, field breaker (AC or DC), buswork, cabling, connection to the Generator isolated phase bus, connection to the Generator field-bus, protection systems, monitoring systems, metering systems, Human Machine Interface (HMI) systems and software.

1.2.2 Scope of Related Work

The Work related to each Excitation System includes:

(a) the cabling required to connect the Excitation System to the Powerhouse station service for the open-loop excitation mode during the Generator acceptance and commissioning tests.

1.2.3 Work Not Included

The following work will be provided by Others:

(a) the Generator and bus voltage transformers ("**VT**") for voltage sensing; and

(b) the isolated phase bus from the Generator to the high-voltage side of the Excitation transformer.

1.3 Submittals

1.3.1 Excitation System Drawings

As a minimum, the Work includes submission of the following Excitation System Drawings:

(a) layout diagrams that detail all Equipment provided with the Excitation System, as well as its interconnections, including:

- (i) Enclosures and Equipment contained within them;
- (ii) the explosion-directed Exciter Transformer Enclosure;
- (iii) the connection between the excitation transformer and the Power Rectifier;
- (iv) Power Rectifier AC and DC buswork and its fastening system;
- (v) the Exciter Transformer iso-phase bus connection point;
- (vi) the Exciter Transformer manufacturer name, factory location, transformer type, insulation class, insulation type (e.g., VPI), winding construction (e.g., foil or other);
- (vii) cable entrances, including field lead cables;
- (viii) isolating facilities;

(ix) high-voltage phase barriers;

(x) ground connection points;

(xi) Enclosure anchor points; and

(xii) open-loop connection point details;

(b) Electrical Schematics and Electrical Wiring Diagrams of all Equipment provided with the Excitation System, as well as its interconnections, including:

(i) the Power Rectifier;

(ii) SCR bridge assembly;

(iii) field discharge equipment;

(iv) field breaker;

(v) the Exciter Transformer;

(vi) the single line and three line diagrams that will show all of the Excitation System equipment including the Exciter Transformer, SCRs, field breaker, field discharge resistor, CTs, VT, capacitor, etc., connections; and

(vii) protection, control, power, and instrumentation;

(c) a Nameplate or rating plate Drawing that shows all the Excitation System continuous and temporary ratings;

(d) a Nameplate or rating plate Drawing that will show all the excitation transformer continuous and temporary ratings;

(e) a Letter of Compliance, signed by a signing officer of the equipment manufacturer, for all major components of the Excitation System confirming that the Excitation System meets or exceeds the seismic requirements in these Specifications;

(f) a seismic outline drawing, as described in SPEXC 2.1.1(f); and

(g) Block Diagrams of the Excitation System that include illustration of all AC and DC circuits, protection devices/modules, control devices/modules, isolation points, data communications links, and interconnections.

1.3.2 Excitation System Procedures and Reports

As a minimum, the Work includes submission of the following Procedures and Reports:

(a) a Report with mechanical and civil Calculations demonstrating that the supporting steel structure to be supplied has adequate mechanical and structural safety factors for the most severe application mode including faults will be submitted within 90 Days after the Effective Date, to allow BC Hydro’s design to proceed;

(b) design documents covering as a minimum general product description, equipment option and ratings, the Static Excitation Systems ratings and related Calculations, type test information, and recommendations for grounding, erection and transportation;

(c) Procedure for rack-in/rack-out testing of Field Breaker rack-in/rack-out electrical connections;

(d) the power supply (voltage (Vac) and current (A)) requirements for operation of the Excitation System in an open-loop configuration;

(e) Procedure(s) for the configuration of and operation of the Excitation System in an open-loop configuration to complete the following Generator tests:

  (i) short circuit saturation test;

  (ii) open circuit saturation test;

  (iii) efficiency and segregated loss test by heat transfer or retardation method with the Turbine uncoupled; and

  (iv) three-phase sudden short circuit test;

(f) Procedure for the Excitation System heat run Production Test;

(g) Exciter Transformer factory heat run (resistive load) test Procedure; and

(h) the complete technical specifications provided by the Contractor to the manufacturer of the Exciter Transformer.

1.3.3 <u>Excitation System Calculations</u>

As a minimum, the Work includes submission of the following Calculations:

(a) seismic analysis qualification Report and/or seismic test qualification Report, in accordance with SPEXC 2.1.1;

(b) de-excitation SCR over-voltage trigger level Calculation;

(c) crowbar SCR over-voltage trigger level Calculation;

(d) FDR resistance and energy rating Calculation;

(e) field discharge time Calculation;

(f) all protective device settings and setting Calculations;

(g) harmonic content of load including FHL-we (Winding eddy current harmonic loss factor) and FHL-osl (Other stray loss harmonic loss factor);

(h) the amount of heat generated by the Excitation System for use by Others to calculate the HVAC requirements;

(i) the maximum allowable ambient temperature for the Excitation System for use by Others to calculate the HVAC requirements; and

(j) for the Exciter Transformer the:

  (i) hot-spot Calculation (predicted location of hottest spot on LV center winding and LV outer winding); and

(ii) predicted temperature differential between hottest spot and average and estimated additional temperature rise due to harmonic losses.

SPEXC2 EXCITER TECHNICAL DATA AND REQUIREMENTS

2.1 General Design Criteria

2.1.1 Seismic Withstand

The completely assembled and installed Excitation System will meet the high-performance level as defined in the IEEE 693. The Contractor will:

(a) employ a qualified seismic specialist to perform the work described in SPEXC 2.1.1;

(b) demonstrate the seismic withstand capability of the completely assembled and installed Excitation System, through analysis and/or test in accordance with IEEE 693;

(c) utilize Annex A of IEEE 693 as general requirements for seismic qualification Procedures for the Excitation System (taking particular note of the equipment anchorage requirements);

(d) utilize Annex G of IEEE 693 as specific requirements for seismic qualification Procedures for the Exciter Transformer;

(e) utilize Annex M of IEEE 693 as specific requirements for seismic qualification Procedures for all parts of the Excitation System except for the Exciter Transformer;

(f) prepare a seismic outline Drawing of the Excitation System, including details of seismic bracing and anchoring, as well as a table showing all of the forces to be transferred at each anchor location; and

(g) prepare a seismic analysis qualification Report and/or a seismic test qualification Report, including seismic Calculations performed, signed by the Contractor’s seismic specialist, and demonstrating that the Excitation System complies with the high-performance level as defined in IEEE 693.

2.1.2 Rated Output

The Excitation System rated output (the “**Excitation System Rated Output**”), as a minimum, will:

(a) enable the Generator to operate at the Generator Rated Output under Generator Rated Operating Conditions;

(b) have a rated output current (the “**Excitation System Rated Current**”) of no less than the Generator field current required for continuous operation of the Generator at Generator Rated Output under Generator Rated Operating Conditions when the Generator average airgap is 105% of the design average airgap; and

(c) enable the Generator to meet all other operational requirements of Schedule 6 [Specifications and Drawings].

The Excitation System will be capable of continuous operation at the Excitation System Rated Current while meeting all requirements of the Contract Documents.

2.1.3 Ambient Temperature

The Excitation System will be capable of continuous operation at the Excitation System Rated Output with a cooling air intake temperature of 40°C.

2.1.4 Voltage Operating Range

The Excitation System will be designed to operate:

(a) continuously over a range of 80% to 120% of Generator rated voltage;

(b) temporarily down to 2% of rated Generator rated voltage; and

(c) temporarily with over-voltages as defined in SPEXC 2.1.5 and SPEXC 2.1.6.

2.1.5 Transient and Dynamic Over-Voltages

The Excitation System will:

(a) have surge suppression devices, such as capacitors and/or MOVs, on the Excitation System AC bus;

(b) be capable of withstanding phase-to-ground fault conditions;

(c) be capable of withstanding switching surge voltages on the Generator output terminals of 2.75 times 1.414 of 1.10 times Generator rated voltage; and

(d) be capable of withstanding dynamic over-voltages of 1.30 times Generator rated voltage.

Switching surges are defined as having a rise time of several hundred microseconds and a decay time of several milliseconds, for instance 250/2500 µs.

The dynamic over-voltage waveform will be considered to be a 60 Hz waveform with decaying magnitude. The decay time of the dynamic over-voltage is defined as 1.0 s.

2.1.6 Response and Ceiling Voltage

The Excitation System will:

(a) be a high initial response type exciter as defined in IEEE 421.1;

(b) have maximum attainable Excitation System output voltage (the "**Ceiling Voltage**") of no less than 4.65 pu (where 1 pu is equal to the Generator field voltage at Generator Rated Output and Generator Rated Operating Conditions), while the Generator is operating at Generator Rated Output and Generator Rated Operating Conditions;

(c) when supplying the Generator (operating at Generator Rated Output and Generator Rated Operating Conditions), be capable of reaching, in 0.1 s or less, an output voltage that is greater than the Generator rated field voltage by 95% of the difference between the available Ceiling voltage and Generator rated field voltage; and

(d) have negative field forcing capability to no greater than minus 4.05 pu (where 1 pu is equal to the Generator field voltage at Generator Rated Output and Generator Rated Operating Conditions), while the Generator is operating at Generator Rated Output and Generator Rated Operating Conditions.

A Generator terminal voltage error of -2% will cause the excitation to be driven to Ceiling Voltage in no greater than 50 ms.

2.1.7 Voltage Regulation

The Excitation System will be equipped with an automatic voltage regulator (AVR). The AVR will be capable of automatically maintaining a steady-state Generator terminal voltage, without hunting, to:

(a) within ±0.5% of the set-point over the entire operating range of the Generator; and

(b) within ±0.5% of any set point within a range between plus 20% and minus 30% of the Generator rated voltage.

The Excitation System off-line small-signal step response (i.e., the 10% to 90% response in Generator terminal voltage to a 2% step) will not have an overshoot of more than 20%. The response time will not exceed 0.3 s.

2.1.8 Field Forcing Duty and Current Regulation

The Excitation System will be capable of periodic field forcing at:

(a) 1.6 times the Excitation System Rated Current (the "**Excitation System 30 Second Rating**") for 30 s, immediately preceded by continuous operation at Excitation System Rated Current, and immediately followed by continuous operation at Excitation System Rated Current to allow cooling of the SCR bridges; and

(b) an output current that permits operation of the Generator during an open-circuit saturation test, including continuous operation at rated voltage, followed by 30 seconds of operation at each of 105%, 110%, 115%, and 120% of Generator rated voltage.

The Excitation System will be capable of supplying and controlling its output current:

(c) from a minimum value of 1.5% of Excitation System Rated Current up to the Excitation System Rated Current on a continuous basis; and

(d) when operating on a temporary basis above the Excitation System Rated Current, up to the field forcing duty output currents described above.

Negative field current capability is not required.

2.1.9 Fault Capability and Duty Cycle

The Excitation System will be capable of withstanding the following, without causing the SCRs to exceed their allowable device junction temperature:

(a) Bus fault duty: any fault on the Generator bus for up to 60 s, followed by protection tripping of the Generator breaker and field circuit breaker.

(b) Reclose duty: any fault on the high-voltage side of the Generator step-up transformer, followed by protection clearing of the fault, a period of field forcing, reclosing onto the fault, clearing of the fault then closing into fault, then clearing the fault.

2.1.10 Frequency Operating Range

The Excitation System will be designed to operate correctly:

(a) in the event of Unit overspeed due to a load rejection, the frequency will be considered to be up to normal overspeed trip peak frequency. The duration of the over-frequency period will be considered to be up to 10 s rising and up to 35 s falling, during which time the Excitation System will operate correctly; and

(b) down to 90% of rated Generator speed, or to such lower speed as may later be decided with the Contractor as the desired Excitation System gating cut-off point during normal stopping of the Unit.

2.1.11 Generator Tests

The Excitation System will be capable of being used in the performance of the following Generator tests:

(a) three-phase sudden short circuit test up to 100% rated voltage[1];

(b) open-circuit saturation test from 2% of rated Generator terminal voltage to 120% of rated Generator terminal voltage[1];

(c) short-circuit saturation test (up to 110% of rated Generator current)[1];

(d) efficiency and segregated loss test by calorimetric method[1];

(e) overspeed test at runaway speed for up to 7 min;

(f) rated load saturation test at zero power factor;

(g) heat run temperature rise test;

(h) line charging capacity test;

(i) transient, sub-transient and negative sequence reactance measurement tests; and

(j) load rejection test.

2.2 Configuration

2.2.1 General

The Excitation System will:

(a) be entirely self-contained, independent of other generating Units and of external AC station service supplies;

(b) be capable of start-up with only the supply of Powerhouse 125 Vdc station service for control purposes. 120 Vac station service will be used only for such auxiliary services as will not restrict, or which are non-essential for start-up of the equipment; and

1 The Excitation System and/or the Exciter Transformer will be fed from the powerhouse station service.

(c) be normally self-excited by taking SCR bridge power sourced from the Generator via the Exciter Transformer, except during initial Generator start-up where an external power source for the field flashing equipment is required.

Each major component of the Excitation System will be housed in a suite of Enclosures that include the:

(d) Exciter Transformer Enclosure;

(e) Power Rectifier Enclosure(s), which will include the Field Breaker Enclosure; and

(f) Excitation System control system Enclosure.

Other subcomponents will be housed inside these cubicles. An AC bus will interconnect the Exciter Transformer and the Power Rectifier, and a DC bus will connect between the Power Rectifier and the Generator field-bus.

2.2.2 Component Standardization and Modularity

The Excitation System components will be of standardized, modular construction so that any card or module may be easily removed from the Excitation System without breaking or making soldered connections.

2.2.3 Excitation System Cooling System

Excitation System components will be cooled by fans (i.e. forced air). The forced air cooling system for each SCR bridge will:

(a) include cooling fans that are dedicated to its associated SCR bridge;

(b) have sufficient capacity to cool its associated SCR bridge while all parallel bridges are in service and the Excitation System is supplying the Generator operating continuously at Generator Rated Output and Generator Rated Operating Conditions;

(c) have sufficient capacity to cool its associated SCR bridge while one parallel bridge is out of service and the Excitation System is supplying the Generator operating continuously at Generator Rated Output and Generator Rated Operating Conditions;

(d) be activated either based on SCR bridge temperatures or upon failure of one SCR bridge;

(e) generate an Alarm upon the failure of a cooling fan;

(f) include means for a Worker to test the operation of all fans while the Excitation System is in operation without restricting the operation of the Excitation System in any way; and

(g) include an Alarm generated if a fan fails to operate correctly.

In addition to the above requirements, if during detailed design of the Powerhouse it is found that the localized heating load from the Excitation System is greater than the capacity for the Powerhouse HVAC system to regulate the air temperature in that localized area, then BC Hydro has the option to require as part of the Work that the air exiting the Excitation System be cooled using water-cooled heat exchanger(s) with similar design requirements to the Generator air coolers specified in Appendix 6-5 [Generator Specifications (SPG)]. The optional work associated with complying with such additional requirements will only be included in the Work if Hydro's Representative so directs in writing delivered to the Contractor's Representative, and in such event:

(h) Hydro's Representative will issue a Change Order for that optional work;

(i) the Contractor will perform that optional work as part of the Work; and

(j) the price for that optional work will be as set out in Appendix 11-1 [Payment Schedule].

2.3 Power Rectifier

2.3.1 Solid State Silicon Controlled Rectifier (SCR)

The Excitation System power rectifier (the "**Power Rectifier**") will utilize three-phase, full-wave, solid-state silicon-controlled rectifier ("**Silicon Controlled Rectifier**" or "**SCR**") bridge assemblies to rectify the Excitation System AC power input to produce the DC output to be used to excite the Generator field. The Power Rectifier will consist of multiple SCR bridges connected in parallel.

2.3.2 Bridge Configuration

A minimum of two parallel SCR bridges will be provided. The bridges will be sized to permit continuous operation at Excitation System Rated Current with one bridge out of service (N+1 redundancy).

If operating with one bridge out of service, the Excitation System will detect this condition and generate an Alarm. Operating with one bridge out of service will not de-rate the Excitation System.

2.3.3 SCR Assembly

Each Excitation System SCR bridge will consist of an integrated, six SCR assembly.

The chassis of each SCR assembly will be solidly grounded with a grounding strap that is sized to handle the SCR fuse let-through current. The ground strap will be easily removable. Grounding of the SCR chassis will be shown on the Drawings.

It will be possible to replace an entire SCR assembly in one piece (i.e., without removing individual SCRs) in approximately 30 minutes or less.

2.3.4 SCR Fusing

Each SCR bridge will be supplied with fuses that will be coordinated with the SCRs, both with respect to the inverse-time characteristics and the current-squared time capability of the SCRs (I^2t). The SCRs will be properly sized and coordinated so that a fault on the DC bus of the Excitation System will cause the fuses to blow and prevent the SCRs from being damaged.

Parallel fuses will not be used unless the Contractor can demonstrate that this is safe under worst-case conditions.

Each SCR and SCR fuse will be supervised by means of conduction-monitoring, or by another method submitted for Consent and accepted by Hydro's Representative and appropriately annunciated.

SCR bridge designs with SCRs in series will not be provided.

2.3.5 DC Shunt

A DC shunt will be installed in the Power Rectifier output circuit for purposes of measuring field current. A means for connecting external test equipment to the DC shunt will be provided (such as threaded studs).

Wiring from the DC shunt to the sensing device will be 5 kV class or higher, and will be routed in raceway separate from all other wiring.

The sensing device connected to the shunt will meet the electrical clearances specified for Enclosures.

2.3.6 Component Inter-Changeability

If an ABB Excitation System is supplied, then the Excitation System will comply with this Specification and have electronic AVR control components that are identical to, and therefore interchangeable with, all Type A, B, and C Excitation Systems supplied under BC Hydro Contract Q7-7711.

In addition BC Hydro would prefer that all other Excitation System components be identical to, and therefore interchangeable with, all Type A, B, and C Excitation Systems supplied under BC Hydro Contract Q7-7711 as much as reasonably practicable to enable BC Hydro to realize synergises such as fleet wide common Excitation System component spare parts.

2.4 Field Breaker

The Excitation System field breaker (the "**Field Breaker**") will be a power circuit breaker rated and arranged to disconnect the current path that runs from the Exciter Transformer low-voltage winding through the Power Rectifier to the Generator field-bus.

BC Hydro prefers a DC Field Breaker. The Field Breaker will be designed and constructed in accordance with IEEE C37.18 for a DC Field Breaker and IEEE C37.13 for an AC Field Breaker.

If an AC Field Breaker is used, the Excitation System will include capability to interrupt SCR bridge firing pulses fast enough to ensure that when an instantaneous trip command is issued to or by the Excitation System, the AC Field Breaker is commanded to open without delay, while:

(a) the de-excitation SCR is operated and Generator field current is forced to discharge through the FDR; and,

(b) Generator field current does not discharge through the Power Rectifier SCR bridges.

The Field Breaker will:

(c) for an AC breaker, be a three-pole spring-operated circuit breaker with motor-operated spring charging suitable for the purpose, with two trip coils for redundancy, and no built-in protection trips (such as overcurrent and undervoltage etc.), and must be charged before it closes;

(d) for a DC breaker, be a one or two-pole circuit breaker with two trip coils/releases for redundancy, and no built-in protection trips (such as overcurrent and undervoltage etc.), and must be charged before it closes;

(e) have each trip coil/release rated for 125 Vdc operation;

(f) have a minimum continuous current rating to withstand 110% of normal duty and 110% of fault duty of the Excitation System;

(g) have a maximum operating time of 133 ms (eight cycles or fewer), where the operating time is defined as the time from trip signal initiation (from external circuitry) to arc extinction;

(h) be rated for operation from the 125 Vdc station service supply as the auxiliary power supply (including motor charging);

(i) be electrically trip-free (anti pumping);

(j) include an operations counter, that will be independent of the Excitation System controller electronics such that failure of same does not cause the counter to reset to zero;

(k) have means to lock the circuit breaker in the “open” position for Worker safety isolation purposes;

(l) have means for a Worker to measure the resistance across the main electrical contacts;

(m) have means for a Worker to measure the breaker pole close and open times (i.e., breaker timing tests);

(n) have means for a Worker to inspect the arc chutes;

(o) include all necessary pushbuttons, switches, and LED lights necessary for local and remote control, indication, and interlocks with the Unit protection and control systems;

(p) be provided with a minimum of six unused form A and six unused form B breaker auxiliary contacts to be used by Others, with all contacts electrically independent and rated for 125 Vdc, 5 A;

(q) have a mechanical position indicator for the current position of the circuit breaker (i.e., open or closed), which is visible from outside the closed Enclosure front, and utilizes a red indicator for the close position and a green indicator for the open position;

(r) operate even in the event of a simultaneous failure of the ExcPCE and ExcRCE; and

(s) have necessary auxiliary contacts to trigger required internal Excitation System functions such as de-excitation, crowbar, etc.

2.5 Field Discharge Equipment

2.5.1 General

The field discharge equipment will be designed to discharge the electrical energy in the Generator field winding under the worst possible circumstances, including the following conditions:

(a) tripping of the Field Breaker upon an normal or emergency shutdown of the Generator;

(b) Generator pole slip; and

(c) short circuit at the Generator terminals.

The field discharge equipment will be mounted in the Power Rectifier Enclosure.

2.5.2 Method of Field Discharge

A method of rapidly discharging the Generator field will be provided, and will include: tripping the Excitation System, opening the Field Breaker, and triggering the de-excitation SCR switch to discharge the Generator field current through the FDR.

The Contractor will produce a Calculation to estimate the field discharge time under the following conditions:

(a) Unit trip and subsequent de-excitation while the Generator is operating at Generator Rated Output and Generator Rated Operating Conditions (with no fault on the Generator terminals);

(b) Unit trip and subsequent de-excitation due to a phase-to-phase fault on the Generator terminals while the Generator is operating at Generator Rated Output and Generator Rated Operating Conditions; and

(c) Unit trip and subsequent de-excitation due to a three-phase fault on the Generator terminals while the Generator is operating at Generator Rated Output and Generator Rated Operating Conditions.

2.5.3 Field Discharge Resistor (FDR)

The field discharge resistor (the "**Field Discharge Resistor**" or "**FDR**") will be a non-linear resistor such as a ceramic varistor. The FDR will:

(a) have a resistance value that is chosen considering the Generator field winding resistance and time constant, and is sized to be as large as possible in order to achieve as short a Generator field current discharge time as possible;

(b) be designed to limit the voltage rise at the Generator field winding and/or Exciter DC Field Breaker to within allowable over-voltage ratings of these components;

(c) be connected in series with the discharge-triggering SCR switches or other means described in SPEXC 2.5.4 and 2.5.5 and across the Generator field winding circuit; and

(d) be capable of absorbing the energy associated with worst-case Generator field discharge scenarios, without damage or need for replacement, including:

    (i) field suppression 100 ms subsequent to a three-phase short circuit that occurs at the Generator stator terminals when the Generator is operating at Rated Output and Generator Rated Operating Conditions; and

    (ii) field suppression subsequent to a Unit trip while the Generator is operating offline at 140% of rated terminal voltage (and the Excitation System is supplying Generator field current to cause this terminal voltage).

The Contractor will complete a Calculation to determine the resistance and the energy rating of the FDR.

2.5.4 De-excitation SCR Switch

If required for the Contractor's design, a de-excitation SCR switch will be provided for the purpose of conducting Generator field current through the FDR in the event that the Field Breaker is opened. The discharge control for the de-excitation SCR switch will operate even for failure of the ExcPCE and ExcRCE.

The de-excitation SCR switch will also have the capability to be triggered from an external protective or lockout relay contact. The controls will be designed so as to prevent field current from passing through the SCR bridges and instead force the current through the FDR.

The Contractor will complete a Calculation to determine the over-voltage trigger level.

2.5.5 Field Shorting SCR Switch (Crowbar)

A field shorting SCR switch or crowbar will be provided for the purpose of conducting the negative field current induced during pole slip and Generator terminal fault conditions through the FDR. The discharge control for the crowbar will operate even for failure of the ExcPCE and ExcRCE. The crowbar will also have the capability to be triggered from an external protective or lockout relay contact.

The Contractor will complete a Calculation to determine the over-voltage trigger level.

2.6 Field Flashing Equipment

2.6.1 General

The Work includes the power, protection, and control equipment required for the automatic field flashing sequence including the rectifier transformer, fused rectifier bridge, blocking and free-wheeling diodes, limiting resistors, field flashing contactor, and connections to the ExcPCE/ExcRCE. Field flashing control will be directed and controlled from the ExcPCE/ExcRCE. A field flashing current limiting circuit will be provided to limit the current from the external sources.

Field flashing will consist of a primary AC source and a backup DC source. The AC source will be a three-phase 600 V source as specified in Appendix 6-2 [General Technical Specifications (SPGT)].

Backup DC field flashing will be provided as an option with manual or auto source change over. The backup source will be 125 Vdc Powerhouse station service. The Contractor will provide a 3-position manual transfer switch to select the supply (off, AC or DC, or if the transfer is automatic, the switch will default to AC field flashing whenever the AC potential is available).

2.6.2 Automatic Field Flashing

The field flashing equipment will provide the initial excitation field current for Generator startup until the Generator output rises sufficiently for the SCR bridges to supply the regular excitation current. Field flashing will be terminated when the controller establishes automatic control of the excitation.

Alarm for loss of AC source will be provided.

2.6.3 Field Flash Cut-Off

Field flashing will be cut off at the moment the ExcPCE (or ExcRCE) determines successful field flashing has been accomplished or upon the timeout of a user-adjustable timer. Acceptable methods of determining a successful field flash include:

(a) the Generator terminal voltage has exceeded a user adjustable threshold; and/or

(b) the Exciter Transformer current/field current has exceeded a user adjustable threshold.

If a DC field circuit breaker is provided, interruption of the field flash current following an incomplete field flash will be designed in such a way to open the DC field circuit breaker while leaving the field flash contactor closed and de-excitation takes place. If an AC field circuit breaker is provided, the de-excitation module is to be triggered to provide a current path prior to opening of the field flash contactor. Alternatively, if the contactor is opened during these conditions, it will be rated for this interrupting duty.

The design of the field flashing system will be such that successful field flashing is guaranteed with either hot or cold field winding with 90% AC source nominal voltage.

2.6.4 Field Flash Current Limiting

The field flashing current limiting circuit will limit the current drain on the field flash source. The design parameters of the current limiting circuit will be accepted with due consideration given to:

(a) field-bus fault conditions;

(b) supply cable resistance;

(c) current capacity of source equipment; and

(d) breaker and/or fuses ratings of source equipment.

2.6.5 Field Flash Equipment Ratings:

The field flash contactor and other field flash components (diodes, transformer, etc.) will have the capability to make and carry the following currents:

(a) field-bus fault current until interrupted by fuse or breaker; and

(b) field flashing current until a timer operates indicating incomplete field flash.

The field flashing equipment will be designed to supply, as a minimum, the Generator field current required to achieve 25% of the Generator's rated voltage when the Generator is offline and at rated speed.

2.6.6 Other Field Flash Component Location

The isolation disconnect switch and all equipment required for field flashing will be located within the Excitation System Enclosures.

2.7 Exciter Transformer

2.7.1 Rating

A transformer (the "**Exciter Transformer**") will be provided to transform Generator terminal voltage down to a level required by the Power Rectifier, and will be an indoor, arc resistant, epoxy resin vacuum pressure impregnated and encapsulated, dry-type, three-phase, two-winding transformer rated for rectifier duty, and manufactured in accordance with CSA C9-M. The Exciter Transformer rating will be as follows:

(a) Capacity: as required to achieve the Excitation System Rated Output;

(b) Primary Voltage: be equal to or greater than the line-to-line rms voltage of the Generator at Generator Rated Output;

(c) Secondary Voltage: as required to meet the rated and ceiling voltage requirements of SPEXC 2.1.6;

(d) Type: ANN;

(e) Insulation Class: 220;

(f) Temperature rise: 80°C;

(g) Ambient temperature: 40°C;

(h) Primary BIL: 110 kV;

(i) Secondary BIL: 20 kV; and

(j) Frequency: 60 Hz.

2.7.2 Design

The Exciter Transformer will:

(a) be either one three-phase transformer or three single-phase transformers connected wye-delta (HV-LV);

(b) have a capability established according to IEEE C57.110, IEEE C57.96, and CSA C9-02;

(c) in addition to the requirements in IEEE C57.12.01 Section 4.1.6, be capable of operating at 150% rated voltage for 3 s without exceeding the limiting temperature rise;

(d) in order to match the Generator capabilities, be designed to withstand on:

  (i) a continuous basis, a 10% increase or decrease in the high-voltage terminal voltage when at the Excitation System Rated Output, and;

  (ii) an intermittent basis, a variation in frequency from 90% to 160% of rated frequency that would be expected to occur during a dynamic disturbance event such as a Generator load rejection, transmission system disturbance, or equipment failure;

(e) have the insulation system designed with consideration of the additional electrical stress due to the existence of constant SCR switching transients produced by static excitation systems;

(f) use thermal Class 220 insulation for the complete core and winding insulation system, designed for the specified temperature rise over the specified ambient temperature with the maximum hot-spot operating temperature of 150°C as in accordance with IEEE C57.96;

(g) be designed and fabricated to take into consideration the harmonics generated by DC rectifier operation mode. Stray losses in each winding and the additional stray losses caused by the harmonics present due to rectification will be kept to a minimum;

(h) be designed to withstand the full harmonic content of the unfiltered highly inductive full load at Excitation System Rated Output;

(i) have a harmonic loss factor F_{HL} suitable to meet the Excitation System Rated Output and that meets the more stringent of the following two methods of determination:

  (i) in accordance with IEEE C57.116; or

  (ii) a K-factor of 13 in accordance with UL 1561;

(j) have a noise level that is consistent with the values shown in CSA C9-M Table 8 measured at 1 m;

(k) in deviation from CSA C9-M requirements, be capable of withstanding without damage:

(i) a short circuit on one of the secondary terminals as described in IEEE C57.116 for a period determined by the Generator direct-axis transient open-circuit time constant specified in Appendix 6-5 [Generator Specifications (SPG)]; and

(ii) induced field current resulting from a Generator short circuit;

(l) be capable of operating with a frequency variation from 90% to 160% of the rated value. During a load rejection the time to rise is 10 s and the time to fall is 35 s. Because of regulation features of the static exciter, the Generator terminal voltage will not increase more than 1% during the over-speed period;

(m) conform to CSA C9-M1981; ANN for convection cooling, A - Air cooling, N - Natural convection, N - Natural circulation in contact with the windings; and

(n) satisfy the requirements outlined with IEEE C57.18.

2.7.3 Enclosure

The Exciter Transformer Enclosure will:

(a) be a “knock-down” type construction for ease of dismantling for shipping and re-assembly on Site;

(b) be made of 12-gauge steel metal plates (or thicker);

(c) be designed to facilitate removal and installation of the transformer without dismantling the Generator iso-phase bus-to-Enclosure connections;

(d) be provided with adequate electrical clearances for voltage and current to avoid magnetic heating of the steel enclosure panels and to avoid reducing the voltage withstand capability;

(e) be provided with either a 600 V or 120 V anti-condensation strip heaters with an adjustable temperature controller, suitable to keep the transformer dry when the Generator is out of service for an extended period. The temperature controller will be accessible from the outside of the transformer Enclosure;

(f) be of an explosion-directed design that:

(i) acts to vent products of an arcing fault or explosion inside the transformer Enclosure upwards;

(ii) includes explosion-venting Enclosure top sheet sections that are secured with light-duty shear bolts, and include hinges on one edge;

(iii) includes labels affixed to the transformer Enclosure beside each light-duty shear bolt, listing the type and size of each bolt, and warning that replacement with the same light duty bolt is mandatory.

(iv) includes means to protect low-voltage instrument or control compartments from arcing faults and explosions within the Exciter Transformer;

(v) includes means to ensure the Enclosure can withstand the maximum calculated internal pressure build-up caused by an internal three-phase fault (e.g., vertical side-sheets that are reinforced with heavy-duty bracing such as angle or channel steel); and

(vi) includes means to connect duct to the explosion vents, such that explosion products can be vented directly outside or elsewhere; and

(g) for single-phase Enclosures, only have openings for cooling vents, and there will be no connections between Enclosures that may allow plasma or hot gas to pass between phases.

2.7.4 Core and Frame

The Exciter Transformer core will:

(a) have a rust-preventative coating applied to prevent rust formation during operation and storage over extended periods of time;

(b) be insulated from the frame; and

(c) be grounded through a copper ground strap. The ground strap will be easily accessible and easily disconnected from ground to allow testing of the core to ground insulation resistance.

The Exciter Transformer frame will:

(d) have a rust preventative coating applied to prevent rust formation during operation and storage over extended periods of time;

(e) be connected to the facility ground bus through a copper ground strap;

(f) be equipped with four lifting eyes that, in combination, will carry the full weight of the completely assembled Exciter Transformer; and

(g) be provided with jacking steps and with base channels along both axis of the Exciter Transformer, or other means where by rollers can be placed under the transformer to facilitate installation and removal of the transformer.

All other handling features will be as described in CSA C9.

2.7.5 Windings and Angular Displacement

The Exciter Transformer will:

(a) have windings made from copper. Aluminum as a winding conductor material will not be accepted;

(b) have a high-voltage winding that is designed for an ungrounded wye connection. The neutral point of the transformer will be insulated to withstand a permanent ground fault on one of the three phases of the Generator terminals;

(c) for the single three-phase option, have high-voltage windings that are separated by insulating phase barriers (NEMA GP-03, NEMA GP-10, or better) or better between each phase coil assembly. These barriers will be large enough to fully segregate the high-voltage winding and connections. The intent is to virtually eliminate the possibility of a phase-to-phase fault on the high-voltage side of the transformer;

(d) have a low-voltage winding will that is delta connected. The angular displacement between primary and secondary will be 30°; and

(e) have all windings supported to withstand the short circuit described in SPEXC 2.7.2(k).

2.7.6 Taps

Taps on the Exciter Transformer are not required.

2.7.7 Fire Retardant Capability

The Exciter Transformer will comprise materials that result in minimal toxicity upon burning and do not support combustion.

2.7.8 Current and Voltage Transformers

(a) Current Transformers (CTs): Two sets of current transformers (primary and standby) will be provided on the high-voltage (HV) bushing assembly for Excitation System protection. Each set of current transformers will:

(i) be Type TPS;

(ii) include up to four taps (required quantity and ratios of taps will be provided by BC Hydro at the time of equipment order);

(iii) have a CSA standard CAN3-C13-M83 accuracy class that is acceptable and with accuracy limiting voltage (VAL) of 800 and limiting current (IAL) of 10%;

(iv) have mechanical and thermal short-time ratings such that they are able to withstand a three-phase short circuit on the high-voltage side of the Exciter Transformer while operating at any excitation level up to the rated overload field current;

(v) be supplied with a continuous secondary thermal current rating factor of 1.5 and a maximum secondary resistance of 1 ohm at 75°C;

(vi) have a secondary winding that is fully distributed at all nominal taps. The actual exciting current will not vary more than 20% in current from the exciting current characteristic up to the knee point. The current transformer core will be demagnetized after shop tests.

The Work includes wiring the leads from all CT taps to a suitably located CT junction box Enclosure. The CTs will be wired directly to the junction box Enclosure. Two independent connections to each wire in accordance with BC Hydro ES 45–V0371 will be provided.

(b) Voltage Transformers (VTs): Generator terminal voltage transformers will be provided by Others.

2.7.9 High-Voltage and Low-Voltage Buswork

The Exciter Transformer Enclosure will be provided with high-voltage (HV) and low-voltage (LV) buswork. The buswork will meet the following requirements:

(a) Isolation Links: The HV and LV buses and terminals will include removable links for isolation of the transformer during maintenance as in accordance with SPEXC 2.8.4. The links will be clearly labelled as to identify their correct location.

(b) HV Bus Phase Barriers: The HV bus will be equipped with phase barriers made of rigid NEMA GP-03, NEMA GP-10, or better insulating material.

(c) HV Bus Insulation: The HV bus will be insulated up to the connection points to a minimum of 15 kV for 13.8 kV Generators and to a minimum of 25 kV for Generators with a rated voltage greater than 13.8 kV but less than or equal to 16 kV.

(d) LV Bus Insulation: The LV bus will be insulated up to the connection points to a minimum of 5 kV.

(e) HV Termination: The Exciter Transformer Enclosure will include provisions for termination of isolated phase bus (supplied, installed, and terminated by Others), and will be provided with matching flanges, bushings, and flexible copper braid connectors, and designed to fit the Generator/iso-phase bus. Flexible copper braid connectors will be entirely located within the Exciter Transformer Enclosure, located and arranged to allow convenient inspection, connection, and disconnection by Workers. The Work includes provision of all transformer connection details and dimensions for interfacing with the IPB.

(f) LV Termination: If the Exciter Transformer Enclosure and Power Rectifier Enclosure are installed side-by-side, complete LV buswork, suitable for the direct bus connection between the transformer LV terminal and the Excitation System will be provided.

If the Exciter Transformer Enclosure is installed separate from the Power Rectifier Enclosure, both Enclosures will provide connection between the Exciter Transformer and Power Rectifier low-voltage buses. The LV terminations will be setup to accept two-hole cable lugs.

2.8 Excitation System Buswork and Terminations

2.8.1 Materials

(a) All buses will be of copper bus bar; and

(b) All buswork support structures and barriers will be:

(i) made of NEMA GP-03, NEMA GP-10, or better rated material; and

(ii) fastened using non-conductive bolts; or if bolts are conductive, they will be insulated.

2.8.2 Connections

All buswork connections and links will:

(a) include at least two fasteners at each end for terminating and/or connection purposes. Single-hole connections and links will not be provided;

(b) include removable insulating boots for all connection points;

(c) be silver- or tin-plated at all contact surfaces; and

(d) be staggered between phases to minimize the chance of a phase-to-phase fault.

2.8.3 Excitation System Field Lead Terminations

The positive and negative Excitation System buses will each include provision for up to eight cable connectors per pole.

There will be adequate space between the Excitation System DC poles to allow for Excitation System field lead connections.

2.8.4 Field Reversing Links

The Excitation System DC buswork will include removable field reversing links, designed to allow the polarity of the Generator field equipment to be reversed, when the Unit is shut down, by reversing the connections of the links, The reversing links will:

(a) be solid copper bus bars of nut and bolt configuration, with a minimum of four bolted connection points per termination (in NEMA two-by-two configuration);

(b) be completely removable, and be sized and arranged to provide sufficient physical isolation to allow high-voltage testing of the Excitation System to be conducted when they are removed;

(c) be designed and arranged for convenient removal by Workers;

(d) provide visible isolation, and be designed and arranged such that they are easily viewable by Workers;

(e) be provided with blocking and bracing to support the weight of the field leads when the links are removed; and

(f) be clearly labelled so as to identify their correct location.

Reversing switches will not be provided.

2.8.5 Minimum Strength

Bus bars, interconnections, clamps and supports will be of sufficient capacity to withstand the maximum short-circuit stresses.

2.8.6 Support

All buses and terminals will be adequately supported to ensure mechanical integrity during operation, transient, short-circuit, and seismic events.

2.8.7 Temperature Rise

The temperature rise will not exceed the limits stated in CSA C22 No. 31.

2.8.8 Insulation

All DC and low-voltage AC buswork will be insulated to a minimum 5 kV rating. The entire buswork will be insulated up to (but excluding) the connection points.

All energized components will be insulated to withstand a high-potential test of two times rated voltage plus 1000 Vac for 2 min.

Devices that have uninsulated leads will be provided with insulating sleeves.

Bus bar insulation material will be Class 180 rated for 120˚C temperature rise.

2.9 Excitation System AC and DC Cables

2.9.1 General

The Excitation System will include the following power connections and cables that will be installed in bus ducts:

(a) AC cables between the Exciter Transformer and Power Rectifier Enclosure, if the two Enclosures are separate; and

(b) DC Exciter field cables between the Exciter Power Rectifier Enclosure and Generator Enclosure for connection to the Generator field-bus at the interface connection located at the transition point from the Generator upper bracket to the Generator Enclosure wall.

2.9.2 Exciter Field Cables

The Exciter field cables connect the Excitation System to the Generator field bus. The Exciter field cables will:

(a) be continuous;

(b) be CSA RW90 type, 5000 V, stranded single copper conductors with cross linked polyethylene insulation, fire-retardant FT-4 rated PVC-jacketed, unshielded, and rated at 90°C;

(c) be sized for the Rated Field Current with an allowance for transient conditions experienced during unusual operating conditions such as faults on the transmission system or Generator acceptance and commissioning tests;

(d) be provided as multiple cables per pole, in order to ease installation and assembly/disassembly of the Unit by providing more flexible cables with a smaller minimum cable bend radius;

(e) be terminated with tin-plated copper NEMA lugs that are designed for two compression crimps per cable termination, and two bolted connections per cable termination;

(f) be supported and secured in a Raceway;

(g) enter the Generator Enclosure at a point nearest the Power Rectifier Enclosure; and

(h) not pass through the Generator Terminal Cabinet.

2.10 Open-Loop Configuration and Operation Requirements

To permit configuration of the Excitation System for open-loop operation (where the Excitation System is powered by a separate AC source other than the Generator terminals), means will be provided for conveniently, safely, and securely connecting one of two alternative open-loop source cables to the Excitation System to provide an external three-phase power supply to either the Exciter Transformer or the Power Rectifier as follows (both alternatives are required):

(a) Three-phase source connection (with voltage equal to rated Generator terminal voltage) to the high-voltage winding of the Exciter Transformer, including:

(i) means for open-loop source cable entry to the Exciter Transformer Enclosure (while preserving the performance of the explosion-directed design of the Exciter Transformer Enclosure);

(ii) means to securely harness the open-loop source cable near its entry point in the Exciter Transformer Enclosure;

(iii) means to securely terminate the open-loop source cable conductors to the Exciter Transformer termination point normally used for terminating the flexible copper braid connectors (these connectors will be removed to permit connection of the open-loop source cable);

(iv) an arrangement that provides adequate clearances between the Exciter Transformer high-voltage winding, the iso-phase bus terminals, and the open-loop source cable; and

(v) an arrangement that permits all panels and doors on the Exciter Transformer Enclosure to be closed and secured in their normal manner when the Excitation System is configured for open-loop operation.

(b) 600 V three-phase source connection to the Power Rectifier, including:

(i) means for open-loop source cable entry to the Power Rectifier;

(ii) means for securely harnessing the open-loop source cable near its entry point in the Power Rectifier;

(iii) means to disconnect the Exciter Transformer secondary bus from the Power Rectifier bus, in order to allow connection of the open-loop source cable;

(iv) means to securely terminate the open-loop source cable conductors to the Power Rectifier bus that is normally connected to the secondary terminals of the Exciter Transformer;

(v) an arrangement that provides adequate clearances between the Power Rectifier bus, the Exciter Transformer secondary bus, and the open-loop source cable; and

(vi) an arrangement that permits all panels and doors on the Power Rectifier Enclosure to be closed and secured in their normal manner when the Excitation System is configured for open-loop operation.

The Excitation System will be capable of operating continuously in open-loop operation without the need to modify or alter the Excitation System in any way other than to connect the open-loop source cable and change software set-points.

2.11 Communications Requirements and Protocol

Both the ExcPCE and the ExcRCE will have communications capability. Each controller will be capable of supporting a minimum of four concurrent communication connections. Any connection will be capable of access to the three levels of communications:

(a) Maintenance Level: The maintenance level will be used for uploading and downloading configuration files and/or firmware from/to a laptop computer. The maintenance level will have individual password protection and a hardware “setting change enable” switch.

(b) Control Level: The control level will be used for communicating real-time operating variables to other systems including all Alarms, statuses, metering/analog quantities and control commands (voltage raise/lower, Excitation System start/stop, etc.) as defined in SPEXC 2.14.3. The entire list of operating variables will be updated over the control level on a continuous basis every 500 ms or faster. The control level will conform to Modbus TCP protocol. The control level will have individual password protection. The password protection will have the ability to be disabled for the control level.

(c) Data Level: The data level will be used for uploading of Event records, oscillography records and internal Alarm logs to other systems. Password protection is not required for the data level.

All levels will be accessible via Ethernet.

A minimum of four RJ-45 Ethernet connection ports will be provided. Each port will have the ability to provide all three levels of communication concurrently.

Ethernet ports will be either 10BaseT or 100BaseT.

2.12 Control Requirements

2.12.1 Primary and Redundant Digital Computational Elements (ExcPCE and ExcRCE)

The Excitation System will utilize a primary computational element (an “**ExcPCE**”) and an Excitation System redundant computational element (an “**ExcRCE**”), each of which will be a Software-Driven Device. The ExcPCE and ExcRCE will be completely redundant and completely independent of each other, and each will have its own full set of input/output hardware. The ExcPCE and ExcRCE will:

(a) have Excitation System start/stop sequence control, automatic regulator closed-loop control, field flash control, manual control, reactance drop compensation, gate pulse generation, logging, and display of Excitation System events and Generator data;

(b) direct communication of Excitation System information via the communication channels;

(c) include the necessary logic to respond to external commands provided by Others;

(d) have the ability to compute limiting variables and apply the associated control actions;

(e) have a logic sequencer that is available to BC Hydro for modification (such as PLC logic);

(f) have the ability to simulate the input commands and status values via a connected Laptop or Exciter HMI;

(g) have the ability to drive multiple Exciter HMIs and/or individual digital meters;

(h) have the ability to detect internal and external failures and apply the appropriate control actions;

(i) have the power system stabilizer function;

(j) include functionality to automatically and bump-lessly transfer control of the Excitation System to the ExcRCE, if a failure to operate at any limit is detected, or upon ExcPCE detected failure; and

(k) accept an IRIG-B timing signal (provided by Others), and use it to synchronize the ExcPCE and ExcRCE clocks and also to timestamp Events that occur within the Excitation System.

Programming of the ExcPCE and ExcRCE will be Software-Adjustable.

Transfer of control of the Excitation System from the ExcRCE to the ExcPCE will only be Worker-Adjustable (i.e., this transfer will not occur automatically, and capability for a device remote from the Excitation System to execute this transfer will not be provided).

The Work includes provision of the complete programming libraries including support software so that the complete system may be rebuilt from a system without code or settings. The object is to be able to maintain the software furnished over a period of many years and to not be required to be reliant on the manufacturer to perform this function.

2.12.2 Start Sequence Control

Excitation System start-up will be initiated by an external dry contact supplied by Others. The external start contact will remain closed until the unit start sequence has been completed or a stop command has been issued. Excitation System start-up will be blocked if external permissive conditions are not met, including:

(a) the external Excitation System start command is de-asserted;

(b) the external Excitation System stop command is asserted;

(c) the external Excitation System emergency stop command is asserted; or

(d) the external 95% speed indication is de-asserted.

If the field breaker is open prior to the start command, the start command will close the field breaker.

2.12.3 Synchronizing

The Work includes provisions for a discrete input and a “running” voltage transformer analog input (115 Vac nominal) for voltage matching purposes. After a successful field flash, a signal will be sent by Others to this discrete input whereupon the Excitation System will adjust the excitation level until the Generator terminal voltage equals the “running” potential (i.e. voltages are matched and ready for synchronizing). The voltage matching will be blocked if the running potential is out of range. The range will be adjustable from a lower setting of 70% to 90% to an upper range of 100% to 120% of nominal voltage. Enabling the voltage match will block external voltage control as described in SPEXC 2.12.8.

2.12.4 Stop Sequence Control

The Excitation System will be de-excited rapidly (by going to negative ceiling voltage) when an external dry contact supplied by Others initiates the Excitation System de-excitation. The operation of the de-excitation contact will override the operation of the Excitation System start contact. The field breaker will not be tripped during this sequence. The de-excite signal will remain until the Generator terminal voltage reaches 20%.

2.12.5 Emergency Stop Sequence

There will be a 125 Vdc input fed by two or more parallel dry contacts supplied by Others to initiate an emergency Excitation System stop. The initiation of this input will cause rapid de-excitation as described in SPEXC 2.12.4 and instantaneous trip of the DC field breaker, or rapid de-excitation followed by a delayed trip of an AC field breaker. The delay time will be adjustable and set to an initial value of 3 s.

2.12.6 Automatic Voltage Regulator (AVR)

The Excitation System will include automatic voltage regulation (“**Automatic Voltage Regulator**” or “**AVR**”) functionality, in order to derive the desired generator terminal voltage, a Generator terminal voltage error signal from the Generator terminal voltage feedback signal and the Generator terminal voltage set-point signal will to cause the Excitation System to automatically adjust its output to correct for the error.

The Generator terminal voltage feedback signal will be derived from sensing circuitry that utilizes phase-to-phase voltages. Phase-to-ground sensing will not be used. The sensing circuitry will compute the average of the three-phase voltages and detect the failure of one or more phases.

The AVR will:

(a) incorporate a software-based digital-type voltage regulator and will respond to changes in Generator terminal voltage. A rectified voltage proportional to the average three-phase Generator terminal voltage will be continuously compared against an accurately controlled reference set-point, supplemented by appropriate stabilizing and limiting signals to be derived within the controller;

(b) be provided with switching facilities that permit disconnection of the stabilizing signal, and substitution by an alternative stabilizing signal to be provided by Others; and

(c) be provided with a method to connect an external analog test signal to a high-resolution, high-speed analog input, and sum this signal to the Generator terminal voltage error signal.

2.12.7 Voltage Regulator - Manual Control Reference Setting Requirements

For manual control of Generator excitation, a manual set-point will be provided in the regulating system to set and maintain Excitation System current or voltage, over a range sufficient to control the Generator terminal voltage from 30% to 120% of rated voltage at no-load. This set-point will:

(a) not be operative to control the Excitation System output current at any time during AVR control;

(b) be Worker-Adjustable at a Software-Adjustable rate; and

(c) be adjustable via hardwired Excitation System inputs from devices external to the Excitation System;

2.12.8 Voltage Regulator - Automatic Control Reference Setting Requirements

The operating range of the AVR will cover the complete operating range of the Generator (as modified by any Excitation System limiter functions that are active).

Setting of the desired Generator terminal voltage during automatic control will be provided for within the regulating system by a voltage set-point capable of setting the Excitation System output voltage over a range sufficient to control the Generator terminal voltage from 80% to 110% of Generator rated voltage.

The voltage set-point will:

(a) be Worker-Adjustable at a Software-Adjustable ramp rate;

(b) be adjustable via hardwired Excitation System inputs from devices external to the Excitation System;

2.12.9 Auto/Manual Regulators - Dual Follower

If the Generator voltage transformer (VT) inputs to the Excitation System will fail while the AVR is in control, the Excitation System will automatically transfer to manual regulation. To facilitate this transfer, voltage transformer potential supervision will be provided. To prevent inadvertent operation, during field flashing and system fault conditions, the VT voltage will be compared with the Exciter Transformer secondary voltage. The manual set-point will automatically go to a pre set value if the Excitation System is in manual and the unit breaker opens.

(a) Auto Manual Control Transfer: Transfer from AVR to manual regulation, as well as transfer from manual regulation to AVR will be Worker-Adjustable.

(b) Dual Follower: The Work includes follower functionality in the excitation control system which will, after successful field flash, balance the manual regulator set-point and the AVR set-point to ensure essentially bump-less transfer from the AVR to the manual regulator and vice versa.

2.12.10 Power System Stabilizer

The Work includes power system stabilizing (PSS) functionality integral to the ExcPCE and ExcRCE, in order to cause the Excitation System to aid in the damping of Generator and power system oscillations.

The PSS will consist of two elements. The first element will be an input section whose function is to derive necessary PSS input signals and other stabilizing signals from Generator voltage transformer and current transformer signals. The second section will consist of a configurable Laplace transfer function. External transducers will not be used to derive PSS input signals.

The first element will be of the dual input type (Delta P/Delta Omega design) IEEE 421.5 PSS Type 2A compliant. It will derive accelerating power by subtracting electrical power from derived mechanical power. The mechanical power and electrical power terms will be derived from the Generator voltage transformer and current transformer inputs alone.

The Laplace section will have a minimum of two poles, two zeros and a washout term. The lead and lag terms of the poles and zeroes will be user adjustable over a range of 15 ms to 6 s in 5 ms steps. The limiter maximum term will be user adjustable over a range of 0 to 0.3 pu in 0.01 pu steps. The limiter minimum term will be user adjustable over a range of -0.3 to 0 pu in 0.01 pu steps. The gain term will be user adjustable over a range of -50 to +50 Vref/pu speed in steps of 0.1.

It will be possible to isolate the PSS input and output from the remainder of the Excitation System and the PSS input and output will be switchable to external test points.

The A/D and D/A converter sampling rates will be 1 ms or faster.

2.12.11 External PSS Provisions

The PSS output will have the ability to be summed into the summing junction where the Vref and voltage feedback signals are summed or at a point beyond the limiter control (the PSS will remain in service even if a limiter is limiting). In addition, this summing junction will have capability to add an additional signal from an external PSS in the future. One spare external analog input channel for this purpose will be provided. The A/D converter sampling rate will be 1 ms or faster.

2.12.12 PSS On/Off Control

The PSS will be disabled when the Unit circuit breaker is open or when the PSS is switched off for test purposes, or when the Generator loading is below a Software-Adjustable lower limit set-point. For this purpose, two external discrete input channels - one for circuit breaker status, and a second for PSS on/off test purposes will be provided. The PSS on/off test input will be normally jumpered to the “on” position (no switch required).

2.12.13 Synchronous Condenser Mode

The PSS will have two sets of gains available. One set of gains will be for generate mode, and the other will be for synchronous condense mode. It will be possible to set either gain to a positive or a negative value. Transfer from generate mode to synch condense mode will be controlled by an external discrete input. The rate of change of the gain will be adjustable.

2.12.14 Over Excitation Limiter

The over-excitation limiter will be provided to prevent continuous operation of the Excitation System beyond the Excitation System and Generator field winding thermal limits by reducing field current. It will have a user adjustable field current setting with an inverse time characteristic so that it can be coordinated with the Generator rotor field heating characteristic. It will also have a user adjustable reset time. The Contractor will provide, with the Excitation System equipment, the necessary field current sensing for this function.

The over-excitation limiter will not inhibit field forcing requirements as required by the duty cycle nor will it limit the transient action of the power system stabilizer. When the limiter operates, there will be a visual indication at the Excitation System and a contact output will be provided for connection to the external BC Hydro Alarm system. The Alarm will be blocked when the Excitation System is shut off.

2.12.15 Under (minimum) Excitation Limiter

An under-excitation limiter will be provided to prevent the Generator from entering under-excited loading conditions which could result in loss of synchronization. Programmable multiple-point operating curve (P, Q type) is preferred with compensation to the square of the terminal voltage. Simple straight line type under-excitation limiter will not be used.

The under-excitation limiter will not inhibit field forcing requirements as required by the duty cycle nor will it limit the transient action of the power system stabilizer. When the limiter operates, there will be a visual indication at the Excitation System and a contact output will be provided for connection to the external BC Hydro Alarm system. The Alarm will be blocked when the Excitation System is shut off.

2.12.16 Volts/Hertz Limiter

A volts/hertz limiter will be provided to prevent over-excitation as Generator speed declines or during Generator over-voltage conditions. The volts/hertz limit will be continuously adjustable over the range of 0.75 to 1.25 pu volts/pu frequency. When the limiter operates, there will be a visual indication at the Excitation System and a contact output will be provided for connection to the external BC Hydro Alarm system. The limiter will be accurate over a frequency range `of 15 Hz to 180 Hz. The Alarm will be blocked when the Excitation System is shut off.

2.12.17 Regulator Control and Gain

The Excitation System regulators will include the following characteristics:

(a) a proportional gain element that can be set high enough to obtain fast response with small initial error after settling, and low enough to enable stable operation; and

(b) an integral element that can be set to allow for a slower response to remove any difference between the actual and desired output.

2.12.18 Transformer/Line Drop Compensator

Transformer and line drop compensation will be provided to permit regulation of voltage on the high-voltage side of the Generator transformer (or to compensate for a portion of the transformer impedance), or to provide a droop characteristic in the event multiple Generators are directly connected to the same bus. The compensation level and polarity will be user adjustable.

2.12.19 Pre-set Runback

Automatic positioning of the automatic and manual voltage set-point to a pre-determined setting will be provided to allow start-up to a nominal Generator voltage level of 1.00 pu. This runback action will occur upon initiation of the Excitation System start signal as described in SPEXC 2.12.2. Voltage set-point raise/lower control as specified in SPEXC 2.12.8 will be enabled after a successful field flash.

2.13 Protection and Monitoring Requirements

2.13.1 General

All devices and functionality considered necessary to protect the Excitation System equipment against damage resulting from unusual conditions during operation and from service interruptions will be provided. The protection will include the devices and functionality listed in the following Sections, and implementation of the protective functions described in section 6 and Appendix E of BC Hydro DP 45-Z0031.

2.13.2 Field Flashing Protection

Field flashing protection will be provided to remove field flashing in the event that field flashing has not succeeded within a Software-Adjustable pre-set time from the moment of field flash initiation. Operation will cause an Alarm and a protection output contact will be closed to initiate a Generator shutdown via circuitry provided by Others.

2.13.3 Loss of Generator Terminal Voltage Sensing Protection

Loss of Generator terminal voltage sensing protection will be provided and be as described in SPEXC 2.12.9. An Alarm output will be provided. The Excitation System output over-voltage protection will be independent of the field control system and capable of coordinating with the normal duty cycle.

2.13.4 AC Overcurrent Protection

Overcurrent protection will be provided and will:

(a) be implemented using two SEL 351 digital protective relays, in three-phase, fully redundant (primary/standby) configuration, completely independent of the ExcPCE and ExcRCE, with each connected to the associated primary/standby Exciter Transformer high-voltage current transformers;

(b) be adequate for detection of high-voltage winding as well as low-voltage winding Exciter Transformer faults;

(c) be adequate for detection of AC faults on the connection between the Exciter Transformer and the Power Rectifier;

(d) be adequate for detection of AC bus faults within the Power Rectifier; and

(e) be secure, that is, not operate during normal operating conditions which are specified as part of the Excitation System duty cycle.

2.13.5 Field Over-Voltage Protection

Field over-voltage protection functionality will be provided. This protection is intended to protect the field winding against excessive voltage in the event of failure in the voltage control system and it will:

(a) be independent of the field control system;

(b) be capable of coordinating with the normal duty cycle;

(c) be capable of protecting against both positive and negative over-voltage;

(d) initiate an Alarm and close a protection output contact to initiate Generator shutdown via circuitry provided by Others; and

(e) be provided in the Excitation System Enclosures.

2.13.6 Field Overcurrent Protection

Field overcurrent protection functionality will be provided. This protection is intended to protect the field winding against excessive current in the event of failure of the current control system and it will:

(a) be independent of the over excitation limiter control system;

(b) have similar user-adjustable inverse-time overcurrent characteristics as the control system;

(c) be capable of being set to coordinate with the Generator rotor field heating characteristic;

(d) be implemented in each of the two SEL-351 protective relays provided with the Excitation System;

(e) initiate an Alarm and close a protection output contact to initiate Generator shutdown via circuitry provided by Others; and

(f) be provided in the Excitation System Enclosure.

2.13.7 Pole Slip (Crowbar) Protection

The Excitation System will include a suitable means of protecting the excitation system and field windings from damage caused by the voltages and currents during pole slip. Crowbar protection operation will:

(a) be designed to have this protection initiated from an external contact; and

(b) initiate an Alarm and close a protection output contact to initiate Generator shutdown via circuitry provided by Others.

2.13.8 100% Field Ground Protection

One hundred percent (100%) field ground protection functionality will be provided. This protection will detect grounds over the entire field winding, the DC and AC bus and the Exciter Transformer secondary winding and it will:

(a) be designed such that inadvertent operation of the protection does not occur during field flashing sequence (at which time the field may be grounded via the station service supply);

(b) include a field ground detector with separate Alarm and trip outputs;

(c) include a filter network, if required, to isolate the field ground detector from the harmonics and field forcing voltage generated by the Excitation System;

(d) include the Alarm and trip pickup points (to be set in kiloOhms) be separately adjustable such that the Alarm output can be triggered at a more sensitive level than the trip output;

(e) include the Alarm and trip be time-delayed (with separate adjustable pickup delays from one to 200 s) to override possible transient operation of the detector during field flashing sequences;

(f) include one Alarm point to indicate correct test operation of the detector; and

(g) include a display of the field-to-ground resistance.

2.13.9 Field Current Low (Third Harmonic Suppression) Output

Two field current low outputs will be provided. The outputs will be form C or A/B configurable contacts provided for use in Unit protective equipment provided by Others. These outputs are intended to be used for disabling the third harmonic under-voltage protection function. The field current set points will be Software-Adjustable.

2.13.10 Conduction Monitoring Protection

Conduction failure monitoring functionality will be provided. The provided method will employ multiple current sensing elements on each bridge. The Excitation System will be able to determine precisely which SCR has failed and provide Worker indication of the failed SCR. An Alarm will be raised for single bridge failures and protection shutdown for multiple bridge failures as required.

2.13.11 Shaft Voltage Suppression

The Excitation System will include equipment to help suppress voltages that may be induced on the Unit shaft.

2.13.12 AC Line Filtering

The Excitation System will have equipment on the low-voltage AC bus to filter out high-frequency switching transients.

2.13.13 Computer or Power Supply Failure Protection

Computer or power supply failure protection functionality will be provided. The protection will operate for any of the following conditions:

(a) failure of both the ExcPCE and ExcRCE;

(b) failure of critical I/O cards (any cards used for control purposes); and

(c) failure of both of redundant power supplies with the field breaker closed.

Protection operation will initiate an Alarm and a protection output contact close to initiate Generator shutdown via circuitry provided by Others.

If the power supplies for the gate pulse amplifiers (GPA) are separate from those used for the ExcPCE and ExcRCE, a power supply failure detection circuit for the GPA supplies is not required because this failure contingency will be covered by the conduction monitoring protection (detailed in SPEXC 2.13.10).

An Alarm only will be generated in the event that only one of the two redundant power supplies fail.

2.13.14 Excitation System Temperature Monitoring

Temperature sensing of the rectifiers will be provided. For this purpose, RTDs insulated to a minimum of 5 kV will be installed in the rectifier Enclosure in such location(s) as to measure:

(a) the inlet air temperature; and

(b) the temperature of each SCR heat sink located as close as practical to the SCR.

2.13.15 Exciter Transformer Winding Over-Temperature Protection

The Exciter Transformer will be equipped with RTDs installed in the locations where the manufacturer expects the hottest operating temperatures to occur. The Work includes a Calculation to determine the Exciter Transformer hot-spots, where Exciter Transformer RTDs specified in this SPEXC will be installed. As a minimum, RTDs will be installed in the following locations:

(a) two RTDs located in each low-voltage winding coil in the hottest location (6 RTDs total). The RTDs will be located in wells that extend down approximately 1/3 the height of each low-voltage coil and as close to the inner lead as practical to most closely indicate the hot spot temperature of each winding; and

(b) two RTDs will be located on each transformer core leg in the hottest location (6 RTDs total).

RTDs will not be located in the cooling air ducts.

The RTDs will:

(c) meet the requirements of Appendix 6-2 [General Technical Specifications (SPGT)];

(d) be wired to a junction box located in the Exciter Transformer Enclosure; and

(e) have a minimum 5 kV class insulation to insulate the RTD from the low-voltage winding.

Half of the RTD pairs will be connected to the ExcPCE and the other half of the RTD pairs will be connected to the ExcRCE. Both the ExcPCE and ExcRCE will provide trip output contacts and a high-temperature Alarm.

The RTD junction box will:

(f) be flush mounted with the Exciter Transformer Enclosure; and

(g) be accessible from outside the Exciter Transformer Enclosure.

2.13.16 Rotor V-I Temperature Monitoring

A field temperature Calculation function will be provided. This field temperature Calculation will:

(a) provide an Alarm upon exceeding a user adjustable pre-set limit;

(b) be performed using field voltage and field current as input variables;

(c) include an user-adjustable setting to compensate for the voltage drop across the brushes; and

(d) be appropriately low-pass filtered to avoid false Calculations during field voltage transient conditions (including start-up transients.

2.13.17 Fault Recording

The capability to record user-specified analog quantities/variables both prior to and following Excitation System initiated protection shutdowns will be provided. The recorded variables will:

(a) have a field adjustable sampling rate which will be submitted for Review;

(b) be stored in each of the ExcPCE's and ExcRCE's memory;

(c) store a minimum of 15 s of pre-trigger and 60 s of post-trigger information; and

(d) be user-assignable without restriction (i.e., any of the ExcPCE's and ExcRCE's internal variables will be assignable).

It will be possible to record a minimum of eight variables in each of the ExcPCE's and ExcRCE's memory.

Display of the fault recorder's memory will be via a Windows 7 compatible laptop PC using software supplied by the Contractor. The display software will:

(e) display the recorded variables in graphical form along with the initiating protection operation and the associated date and time;

(f) have the option to save the data in an ASCII, comma-separated-variable (CSV) and raw text file;

(g) have provision for storing the recorded data to a laptop

(h) have provision for graphical data printout; and

(i) allow for the events to be downloaded via the Ethernet communication system.

2.13.18 Unit Protection Interface

There will be two relays designated 94EG and 94EN for interface with external circuits in accordance with BC Hydro drawing G417 H14 B9.

2.14 Interface Requirements - Control, Status, Alarm, and Protection

2.14.1 Select Before Operate Control

Except where otherwise explicitly stated in this Appendix 6-6 [Excitation System Specifications (SPEXC)], control commands issued to the Excitation System, either by a Worker using the Exciter HMI, or by an external device (provided by Others) via hardwired input, will be issued via a two-step select-before-operate (SBO) process (intended to cause deliberate operator action and reduce the possibility of operator error), whereby:

(a) Step 1: the Worker or external device issues a command to select the control point to be acted upon, this selection is latched in by the Excitation System, and indication of the latched-in selection is sent back to the external device (via hardwired output) and Exciter HMI as a permissive for the control command; and then

(b) Step 2: the Worker or external device either:

(i) issues a "close/on/raise" command to send an assertion or increase command associated with the selected control point, or an "open/off/lower" command to send a de-assertion or decrease command associated with the selected control point; or

(ii) issues a one-step reset command, which un-latches and de-selects the currently selected control point.

The Excitation System will not accept control commands if no control point is selected.

Commands that will not follow the SBO Procedure include:

(c) commands from protective devices (either within or external to the Excitation System) to shut down the Excitation System;

(d) commands from emergency stop pushbuttons (either within or external to the Excitation System) to shut down the Excitation System; and

(e) the local/remote transfer switch included as part of the Exciter Hardwired Controls.

2.14.2 Local Operator Interface

(a) General: A digital colour touchscreen Exciter human machine interface (or "**Exciter Human Machine Interface**" or "**Exciter HMI**") will be provided by the Contractor, as the primary means to:

(i) communicate visual display of Excitation System indication, annunciation, metering, and monitoring to Workers using the Excitation System; and

(ii) accept operator input commands from Workers using the Excitation System.

(b) Display: The Exciter HMI will:

(i) be a colour LCD touchscreen device, with a minimum diagonal screen size of 300 mm;

(ii) not include moving parts (i.e., no hard disk drives or fans);

(iii) include screen graphics that are designed to maximize readability, and consider the relative importance of data when arranging screen graphics. Simplicity and readability are valued over graphically accurate depictions of equipment;

(iv) communicate with the Exciter PLC via a DB9 serial communications port, used for RS232/485 communications, and connected directly to the Exciter PLC; and

(v) be mounted on the Excitation System control system Enclosure for use as local operator interface panel.

(c) HMI Control: It will be possible to control the Excitation System from the Exciter HMI, which will include the following functionality:

(i) Alarm acknowledge and reset;

(ii) Generator/field voltage raise (common for both auto and manual controls), in accordance with SPEXC 2.12.7;

(iii) Generator/field voltage lower (common for both auto and manual controls), in accordance with SPEXC 2.12.7;

(iv) auto/manual transfer (in accordance with SPEXC 2.12.9);

(v) ExcPCE/ExcRCE transfer (in accordance with SPEXC 2.12.1);

(vi) Excitation System start (in accordance with SPEXC 2.12.2);

(vii) Excitation System stop (de-excite – in accordance with SPEXC 2.12.4); and

(viii) Excitation System field breaker open control (in accordance with SPEXC 2.4).

(d) Exciter Hardwired Controls: The following hardwired controls (the "**Exciter Hardwired Controls**") will be provided with the Excitation System:

(i) An "emergency stop" pushbutton, used to issue a command to cause immediate emergency shutdown of the Unit. This will be a red, mechanically-latched/reset pushbutton with mushroom operator, and a shroud to minimize the possibility of inadvertent operation.

(ii) A "local/remote control transfer" pushbutton (two-position, pistol-grip, mechanically-latched style), used to select the Excitation System local/remote control mode.

All other control inputs to the Excitation System will be via the Exciter HMI, or via hardwired control commands from a remote device external to the Excitation System.

When in remote mode, all local Exciter HMI control and Exciter Hardwired Controls will be blocked. When in local mode, all remote control interface signals (SPEXC 2.14.3(a)) will be blocked. The local/remote will be a maintained-style rotary switch. The local/remote switch will not block external trips and Equipment indicators.

(e) Status: Status indications will be displayed on the Exciter HMI, including:

(i) field breaker open/closed (in accordance with SPEXC 2.4);

(ii) field current low;

(iii) manual/auto control status (in accordance with SPEXC 2.12.9(a));

(iv) ExcPCE/ExcRCE control status (in accordance with SPEXC 2.12.1(j));

(v) local/remote control status (in accordance with SPEXC 2.14.2(d)); and

(f) Alarms and Targets: Alarm and Target indications will be displayed on the Exciter HMI, including:

(i) Excitation System at minimum or maximum limit (all limiters as described in SPEXC 2.12.14, 2.12.15, 2.12.16, and 2.12.18);

(ii) field flash failure;

(iii) field flash in off position;

(iv) conduction failure;

(v) SCR fuse failure;

(vi) operation on redundant ExcRCE;

(vii) power supply failure;

(viii) inlet air high temperature;

(ix) SCR high temperature;

(x) Exciter Transformer winding temperature high;

(xi) open input and output detection for all 4-20 mA and RTD signals; and

(xii) individual latching targets for all applicable protections in SPEXC 2.13.

2.14.3 Remote Operator Interface Signals

The following remote operator interface signals are required for interconnection with equipment provided by Others that is external to the Excitation System. All circuits with the exception of the communication link will be capable of meeting surge requirements as detailed in Appendix 6-2 [General Technical Specifications (SPGT)].

(a) Control: Separate, hardwired, remote control inputs are required for each of the following:

(i) Generator/field voltage raise (common for both auto and manual controls), in accordance with SPEXC 2.12.7;

(ii) Generator/field voltage lower (common for both auto and manual controls), in accordance with SPEXC 2.12.7;

(iii) auto/manual transfer (in accordance with SPEXC 2.12.9(a));

(iv) Excitation System start control (in accordance with SPEXC 2.12.2);

(v) Excitation System stop (de-excite – in accordance with SPEXC 2.12.4);

(vi) Excitation System field breaker open control (in accordance with SPEXC 2.4).

(vii) synchronize (voltage match - in accordance with SPEXC 2.12.3);

(viii) emergency stop - primary protection (in accordance with SPEXC 2.12.5);

(ix) synchronous condense on/off; and

(x) four inputs for future use.

(b) Status Indications: Individual relay contacts are required for each of the statuses listed below, and are required for connection to UCB equipment (by Others) including discrete LEDs and in some cases PLC control circuits and protective relays. All statuses will also be available over the communications link in accordance with SPEXC 2.11 for communications with a UCB PLC supplied by Others. The status indications include:

(i) all status indications listed in SPEC 2.14.2(e);

(ii) two field current low (in accordance with SPEXC 2.13.9); and

(iii) four outputs for future use.

(c) Alarms and Protections: Individual relay contacts are required for each Alarm listed in SPEXC 2.14.2(f). This is required for connection to an Alarm and Event recording system supplied by Others.

Protection contacts will be as detailed in accordance with BC Hydro drawing G417-H14-B9.

(d) Control Input Electrical Requirements: The control inputs detailed in SPEXC 2.14.3(a) will be either relay coils or opto-couplers to facilitate galvanic isolation. Isolation will be a minimum of 2000 Vdc. The wetting voltages will be 125 Vdc nominal (range of 95 to 140 Vdc).

2.15 Interface Requirements - Metering and Analog

2.15.1 General

All metering and analog circuits will, with the exception of the serial communication link be capable of meeting surge requirements as detailed in Appendix 6-2 [General Technical Specifications (SPGT)].

2.15.2 Local Operator Interface

Local operator interface quantities will be displayed on the Exciter HMI. The following are required:

(a) Generator: terminal voltage (three-phase, line-to-line average, in kV), current (three-phase average, in A), active power (three-phase, in MW), reactive power (three-phase, in MVAr), apparent power (three-phase, in MVA), and power factor;

(b) field voltage (in V);

(c) field current (in A);

(d) individual SCR current (each bridge, in A);

(e) field winding temperature (in °C);

(f) field ground detector output (in ohms);

(g) PSS output (in pu);

(h) Exciter Transformer winding temperature (in °C);

(i) individual bridge input air temperature (each bridge, in °C); and

(j) individual SCR heat sink temperature (each SCR, in °C).

2.15.3 Remote Interface Signals

(a) General: The following analog interface signals will be provided for interconnection with equipment provided by Others that is external to the Excitation System. It is intended that some signals will be used for indication purposes while others will be used for interconnection with protection devices.

(b) Analog Inputs: Separate analog inputs will be provided for each of the following:

(i) external PSS signal;

(ii) external test input signal; and

(iii) four spare inputs for future use.

All analog inputs will be terminated in the Excitation System Enclosure.

(c) Analog Outputs: Separate analog outputs will be provided for remote metering purposes for each of the following:

(i) all local operator interface quantities listed in SPEXC 2.15.2 except for:

(A) the Generator interface quantities listed in SPEXC 2.15.2(a);

(B) SCR currents listed in SPEXC 2.15.2(d);

(C) bridge input air temperatures listed in SPEXC 2.15.2(i); and

(D) SCR heat-sink temperatures listed in SPEXC 2.15.2(j).

(ii) PSS output; and

(iii) four spare outputs for future use.

All analog outputs will be terminated in the Excitation System Enclosure.

In addition to the above, it will be possible to monitor all of the above quantities over the communications link in accordance with SPEXC 2.11 and SPEXC 2.16.4.

(d) Analog Input/Output Electrical Requirements: All hardwired analog inputs and outputs will:

(i) Include a pair of wires per input or output (i.e., channels will be isolated, with no commoning);

(ii) be 4-20 mA or ±10 Vdc, user programmable or per-channel basis, any mix allowed;

(iii) be galvanically isolated from ground and other channels; and

(iv) include short-circuit protection.

(e) Communications Requirements and Protocol: All metering and analog interface quantities will be in accordance with SPEXC 2.11 and SPEXC 2.16.4.

2.16 Software

2.16.1 Application Configuration Files (Exciter Software)

Application Configuration Files for the Excitation System (the "**Exciter Software**") will be provided.

2.16.2 Configuration Tool Software (Exciter Configuration Software)

Configuration Tool Software for the Excitation System will be provided.

2.16.3 Excitation System Events

The ExcPCE and ExcRCE, together with their Application Configuration Files designed by the Contractor, will include an Event Buffer that monitors and records Events identified in the Event List, and that uses the Event Data Structure. Functionality will also be included to communicate buffered Events to a device external to the Excitation System (using a custom communication protocol defined by BC Hydro and provided to the Contractor), and subsequently remove these Events from the buffer once successful communication has been confirmed.

Excitation System Alarms will monitor conditions that include:

(a) power supply failures (including fuse failures);

(b) Excitation System health, including ExcPCE/ExcRCE health, low battery and input/output channel or card failures;

(c) abnormal control status (e.g., device not in auto, device not in remote);

(d) abnormal device status (e.g., temperature high); and

(e) unexpected or abnormal device operation, device failure, or unknown device status.

One Excitation System Target will be provided for each protective function within the Excitation System, to indicate when the protective function has operated.

2.16.4 Excitation System Data Table

The Contractor's Exciter Software for the ExcPCE and ExcRCE will include functionality to make all discrete and analog Excitation System data that is deemed operationally relevant by the Contractor or by BC Hydro (the "**Excitation System Data Table**") available in definite-address 4x register memory for polling by external devices via the Ethernet based Modbus TCP protocol. The data will be grouped into as small a range as practical in order to be read or written in a small number of packets (of approximately 100 registers each). Within the data table, analog values will be formatted in ANSII standard 32-bit floating numbers, spanning two 4x registers each. The analog values will be scaled in engineering units such as kV and MW. Discrete data such as on/off controls, statuses and Alarms will be available as individual bits packed into 4x registers. For example, Alarms 1 to 16 would be in bits 1 to 16 of register 400001, Alarms 17 to 32 would be in bits 1 to 16 of register 400002, and so on. All Alarms and statuses will be output in the data table, and will be non-latching.

The Excitation System Data Table will be developed collaboratively between the Contractor and BC Hydro until the first Unit is placed in full commercial service.

The Excitation System Data Table will include:

(a) Analog (floating-point) Excitation System data, including:

(i) terminal voltage set-point;

(ii) Generator kV, kA, MW, MVAR, frequency;

(iii) SCR heat-sink temperatures;

(iv) channel (main and redundant) balance; and

(v) limiter and PSS outputs;

(b) Integer Excitation System data, including:

(i) ExcPCE and ExcRCE heartbeats;

(c) Binary Excitation System data, all of which will be packed into word data types by the Contractor's Exciter Software before writing to definite address registers, including:

(i) bits indicating the current status (i.e., on or off) of all of the items in the Event List for the Excitation System;

(ii) auto/manual status;

(iii) local/remote status;

(iv) control mode;

(v) start/stop status;

(vi) Excitation System device health status;

(vii) Excitation System device control status;

(viii) limiter status;

(ix) PSS status; and

(x) field breaker status.

2.16.5 Disturbance Analysis Software

Software for uploading and viewing of Event records and oscillography records will be provided.

2.16.6 Test Software

The Excitation System will have the ability to create computer generated test signals internal to the ExcPCE and ExcRCE. Test signal set-up and execution will be via a laptop IBM compatible computer. The software required to perform set-up and execution will be provided.

2.17 Control System Power Supplies

2.17.1 General

The Work includes two power supplies connected in a redundant configuration for supplying the Excitation System control system. The power supplies will:

(a) have outputs that are connected in parallel through diodes so that a failure of one power supply does not block or inhibit the ability of the other power supply to supply the load;

(b) each be rated to supply the entire load under all operating conditions including starting;

(c) each have an Alarm to indicate failure of the power supply; and

(d) have galvanic isolation of 2000 Vdc for the inputs and outputs of each power supply.

2.17.2 Power Supply Source

There will be two separate sources for the two Excitation System power supplies:

(a) One power source will be from the Powerhouse 125 Vdc station service system provided by Others. The nominal input voltage will be 125 Vdc with variations over a range from 95 Vdc to 140 Vdc.

(b) The other power source will be an AC supply operated from the Excitation System excitation transformer. The AC supply will operate over an input voltage range from 70% to 120% of the nominal transformer secondary voltage.

The output from each power supply will be monitored and Alarmed. Monitoring of each power supply voltage will be performed on the output (load) side of each the power supply.

2.18 Electrical Equipment and Devices

2.18.1 Enclosures

(a) General: All equipment in the Excitation System and other supplied equipment will:

(i) be factory installed into metal Enclosures, wired and tested; and

(ii) meet the requirements of Appendix 6-2 [General Technical Specifications (SPGT)] for electrical equipment and devices, except that the Excitation System is explicitly exempt from meeting the requirement to limit arc flash hazards to Category 2 or less.

(b) Arrangement: The Excitation System Enclosures will be mounted adjacent to one another to permit close-coupling of the Exciter Transformer low-voltage bus bars and the Power Rectifier bus bars and inter-panel wiring. If the Exciter Transformer enclosure and other Excitation System Enclosures are mounted separately, the Work includes the non-segregated phase cable bus between the two Enclosures.

(c) Provisions for External Cabling: Except for the high-current AC input and DC output cables, external cables, will be terminated on terminal blocks.

(d) Cable Entry: Excitation System AC and DC high-current cables will enter the Enclosure from the top. Cable clamps inside the Excitation System Enclosure for the cables will be provided.

(e) Operator Interface: Local operator interface facilities as defined in SPEXC 2.14.1 and SPEXC 2.15.2 will be located on the front of the Excitation System Enclosure.

(f) Access for Inspection and Maintenance: The Excitation System Enclosures will be designed and arranged to enable Workers to visually inspect, access, and maintain the Excitation System components including the control electronics, the SCR bridge assemblies, the Excitation transformer, electrical buses, electrical cables, electrical connections, and instrumentation with minimal disassembly of the Enclosures.

2.19 Safety Ground Provisions

All Excitation System buswork will include safety grounding ball studs to facilitating grounding of both high-voltage and low-voltage buswork in accordance with Appendix 6-2 [General Technical Specifications (SPGT)]. Safety grounding ball studs (used for connection of portable safety grounds) will be mounted on the:

(a) Excitation System AC bus;

(b) DC field leads (located on field side of reversing links);

(c) high-voltage connection for the Exciter Transformer; and

(d) Low-voltage connection for the Exciter Transformer.

The mounting locations will be at easily accessible locations inside the Excitation System Enclosures. It will not be possible to close an Enclosure door when portable safety grounds are installed.

2.20 Equipment Identification

2.20.1 Excitation System Nameplate Placard

The Excitation System will be provided with a nameplate placard in a prominent location on the outside of the Exciter Enclosure. The information on the nameplate will include:

(a) manufacturer's name and address;

(b) type of equipment;

(c) serial number of the Excitation System;

(d) model number and type number of the Excitation System;

(e) date of manufacture;

(f) the Excitation System Rated Output, including rated continuous output current (Adc) when operating at an output voltage equal to the Generator rated field voltage, and with at least N SCR Bridges in service (i.e., the Excitation System Rated Current);

(g) number of SCR Bridges;

(h) number of SCR Bridges required to achieve continuous operation at Excitation System Rated Output;

(i) field breaker configuration (AC or DC);

(j) the Excitation System 30 Second Rating (Adc);

(k) Ceiling Voltage (Vdc);

(l) ambient temperature rating (degrees Celsius);

(m) BC Hydro contract number; and

(n) BC Hydro purchase order number.

2.20.2 Exciter Transformer Nameplate Placard

The Exciter Transformer will be provided with a nameplate placard in a prominent location on the outside of the Exciter Transformer Enclosure. The information on the nameplate will include:

(a) manufacturer's name and address;

(b) type of equipment;

(c) serial number;

(d) model/type number;

(e) winding connection diagram;

(f) rating (kVA);

(g) rated primary voltage (kV);

(h) rated secondary voltage (V);

(i) number of phases;

(j) rated primary current (A);

(k) rated secondary current (A);

(l) rated power factor;

(m) rated frequency (Hz);

(n) insulation class;

(o) winding temperature rise (ºC);

(p) ambient temperature rating (ºC);

(q) BIL of primary insulation;

(r) K-factor;

(s) noise level at 1 m (dBA);

(t) positive and zero sequence impedance (%);

(u) indoor or outdoor application;

(v) dynamic earthquake withstand: IEEE 693;

(w) BC Hydro contract number; and

(x) BC Hydro purchase order number.

SPEXC3 TEST POINTS AND ISOLATION FACILITIES

3.1 Test Points

Two analog ±10 V inputs with a minimum sampling rate of one sample/ms (1 kHz) will be software configurable to facilitate test signal injection to the transfer function blocks of ExcPCE and ExcRCE.

Four analog ±10 V outputs with a minimum sampling rate of one sample/ms (1 kHz) will be software configurable to allow access to all values within the ExcPCE and ExcRCE.

The test points will be made available on rail-mounted terminal blocks.

3.2 Isolation Facilities

3.2.1 CT Entrance

An entrance CT isolation and test block (ABB type FT-1) will be provided and connected in accordance with BC Hydro ES 45-X0010 for each of the following inputs:

(a) Generator CT input to the Excitation System;

(b) primary Exciter Transformer CT input to the Excitation System; and

(c) standby Exciter Transformer CT input to the Excitation System.

3.2.2 VT Entrance

An entrance VT isolation and test block (ABB type FT-1) will be provided and connected in accordance with BC Hydro ES 45-X0010 for each of the following inputs:

(a) Generator VT input to the Excitation System; and

(b) running bus VT input into the Excitation System.

3.2.3 Compact Iso/Test Subpanels

Compact iso/test subpanels will be provided and connected in accordance with BC Hydro ES 45-X0011, with one associated with each of: the primary SEL 351 relay, the standby SEL 351 relay, and the exciter in general (i.e., all other isolation points that are not associated with the SEL 351 relays). These compact iso/test subpanels will be used to isolate:

(a) VT inputs between the VT entrance block and each downstream device;

(b) SEL 351 relay trip outputs between each SEL 351 relay and each downstream device;

(c) ExcPCE, ExcRCE, and other discrete device trip outputs between the initiating device and each downstream device; and

(d) other points agreed to between the Contractor and Hydro's Representative.

3.2.4 Combination FT-1 Blocks

A combined voltage and current isolation and test block, as outlined in section 4.6 of BC Hydro ES 45-X0010 (ABB type FT-1 670B197G18), will be provided and connected for each of the following devices:

(a) the ExcPCE;

(b) the ExcRCE;

(c) the primary SEL 351 protective relay; and

(d) the standby SEL 351 protective relay.

3.2.5 Field Flash Source Transfer Switch

Lockable isolation disconnect switches, separate from the field flash source transfer switch, will be provided for the purpose of isolating the field flash sources for Worker safety. The source isolation switch status will be visible without opening the cover (window type).

3.2.6 Field Ground Detection System Isolation Switch

One fused, lockable disconnecting switch with visual break such that it can be used for BC Hydro isolation and lockout purposes, as well as protection of the field ground circuitry, will be provided.

SPEXC4 MANUFACTURING, INSPECTIONS AND TEST REQUIREMENTS

4.1 General

Excitation System shop inspection and tests will include the inspection and testing recommended in and be performed in accordance with IEEE 421.2, IEEE 421.3 and IEEE 421.4 except as otherwise specified.

4.2 Heat Run and Burn-in Tests

4.2.1 Heat Run Test

The Excitation System Power Rectifier assembly will be subjected to an eight-hour heat run Production Test. The test will be conducted using a DC load of sufficient size and rating to allow Excitation System Rated Current to be passed through the load bank. The temperatures of every Excitation System heat sink will be recorded every 15 min. If the temperature of any heat sink deviates by more than plus or minus 1°C from the average, the test will be deemed a failure. In the event of a test failure, repairs will be made and the test repeated as many times as necessary to achieve a successful result.

The Work includes a Procedure for the Excitation System Power Rectifier heat run Production Test.

4.2.2 Burn-in Test

All Excitation System electronic components will be subjected to a 96 hour burn-in Production Test. During the test the components will be operated at rated voltage and at an elevated temperature (to be monitored during the test), and the components will be monitored during the test to confirm they are functioning normally.

If the components' operation will not be monitored continuously during the burn-in test, then:

(a) the interval between monitoring periods will be short enough that the probability of a component mis-operation during non-monitored periods is insignificant; and

(b) the burn-in test Procedure will illustrate how the interval between monitoring periods is selected, and how the probability of component mis-operation during non-monitored periods is insignificant.

If abnormal operation is observed during the burn-in test, then the test will be considered a failure, and the failed device will not be used in the Excitation System.

The Work includes a Procedure for burn-in testing of Excitation System electronic components.

4.3 Field Breaker Rack-In/Rack-Out Tests

If the Field Breaker is of draw-out type, to confirm mechanical and electrical reliability, the Field Breaker will be subjected to Production Testing whereby it is racked in and out ten times and all draw-out electrical connections tested for continuity after each rack-in/rack-out cycle. If continuity is not confirmed after any rack-in/rack-out cycle, then the test will be considered a failure, and the failed rack-in/rack-out electrical connectors will not be used in the Excitation System.

The Work includes a Procedure for rack-in/rack-out testing of Field Breaker rack-in/rack-out electrical connections.

4.4 Exciter Transformer Tests

4.4.1 Exciter Transformer Production Tests

Exciter Transformer tests specified under CSA C9-M including load loss and impedance voltage will be performed as Production Tests. In deviation from CSA C9-M, resistance measurements will be performed as a Production Test on all Exciter Transformers.

4.4.2 Exciter Transformer Type Tests

(a) Tests specified in CSA C9-M, including tests to verify ratio, polarity, angular displacement, no-load losses, load losses, dielectric strength, and resistance will be performed as Type Tests.

(b) An induced voltage Type Test at 400 Hz using 200% of the rated supply voltage will be performed to verify insulation.

(c) A partial discharge Type Test, with a maximum allowable corona pulse intensity of 50 pC, will be performed in the following manner:

- (i) increase the supply voltage to 200% of the rated line to ground voltage of the transformer (V_r) at 400 Hz. Measure and record the discharge inception voltage (R_1) and the discharge level;
- (ii) maintain 200% V_r for 7200 cycles;
- (iii) decrease the supply voltage, measure and record the discharge level at 120% V_r, (R_2). The maximum permissible discharge level at 120% V_r, is 50 pC;
- (iv) measure and record the discharge extinction voltage (R_3) and discharge level immediately prior to extinction. The discharge extinction voltage level must be greater than 110% V_r; and

(v) the maximum permissible ambient discharge level, with the measuring circuit connected and the transformer de-energized is 5 pC.

(d) A sound level Type Test will be performed to verify the specifications of SPEXC 2.7.2(j).

(e) Electromagnetic frequency emissions Type Tests will be performed.

(f) Impulse testing on the primary side of the transformer will be performed as a Type Test to verify the specifications of SPEXC 2.7.1.

(g) Heat run Type Testing on the Exciter Transformer as a complete unit will be performed, and will:

(i) be performed at the rated AC input current for the Exciter Power Rectifier or rated Exciter Transformer output current; whichever is greater;

(ii) be performed using a resistive load;

(iii) be performed using temperature probes as follows:

(A) installed at locations specified in SPEXC 2.13.15.

(B) two temperature probes installed at the top of the inner-most turn of the LV winding;

(iv) include temperature measurements sampled at a minimum of 15 minute intervals;

(v) demonstrate a final temperature rise consistent with the ratings specified in SPEXC 2.7.1; and

(vi) include infrared Photos.

(h) Type Tests to verify ratio, polarity, angular displacement, dielectric strength, resistance and saturation will be performed on each of the transformer primary CTs.

(i) Destructive Type Testing to verify robustness and performance of the explosion-directed Enclosure design will be performed in accordance with IEEE C37.20.7 by subjecting the Exciter Transformer to fault current, and will:

(i) include room simulation testing and determination of resulting application guidelines for indoor installation of the Exciter Transformer; and

(ii) verify that the Exciter Transformer meets the following performance criteria:

(A) Doors, covers, etc., secured in their closed position will not open. Bowing or other distortion will be permitted, provided no part bows or distorts as far as the position of the indicator mounting racks or walls (whichever is closest) on any surface. Exhausting gases will not be directed outward from the Enclosure sides where Workers may be standing.

(B) No fragmentation of the Enclosure will occur. Ejection of small parts, up to an individual mass of 60 g, from any external Enclosure surface above a height of 2 m, is acceptable. There is no restriction on the number of parts allowed to be ejected.

(C) No external surfaces will experience burn-through as a result of arcing. No internal surfaces intended to isolate low-voltage instrument or control compartments will experience burn-through as a result of arcing. It will be assumed that any opening in the Enclosure caused by direct contact with an arc will also ignite an indicator mounted outside of the Enclosure at that same point. Since it is not possible to cover the entire Enclosure with indicators, any opening in the Enclosure resulting from direct contact with an arc will be considered a failure. Openings above the indicator mounting rack height of 2 m that do not cause ignition of the horizontally-mounted indicators will be ignored.

(D) No indicators will ignite as a result of escaping gases. Indicators ignited as a result of the burning of paint or labels, glowing particles, etc., will be ignored. High-speed video may be utilized to evaluate the cause of indicator ignition. Holes in horizontally-mounted indicators caused by particles that do not ignite the indicator will be ignored. Surface discoloration or charring that does not result in glowing or flaming of the indicator cloth will be considered acceptable. Any indicator cloth with surface discoloration or charring will be replaced with new cloth prior to further testing.

(E) All grounding connections will remain effective.

SPEXC5 SITE ACCEPTANCE AND COMMISSIONING TESTS

5.1 General

Excitation System site acceptance and commissioning tests will include the testing recommended in and be performed in accordance with IEEE 421.2, IEEE 421.3 and IEEE 421.4 except as otherwise specified.

5.2 Excitation System Tests by the Contractor

The Work includes thoroughly testing the Excitation System to confirm that performance as an integrated part of the Unit is acceptable, considering all Unit and Excitation System operating conditions outlined in the Specifications. Excitation System tests will include:

(a) SCR bridge firing and control tests;

(b) SCR bridge current balance tests;

(c) automatic voltage regulator control, stability, and response tests (including “bump” disturbance tests);

(d) manual regulator control, stability, and response tests (including “bump” disturbance tests);

(e) channel and regulator transfer tests (including loss of sensing tests);

(f) limiter tests (offline and online);

(g) heat run tests;

(h) power system stabilizer control, stability, and response tests (including “bump” disturbance tests);

(i) synchronizing tests (voltage matching);

(j) field flashing response tests (including field flash failure);

(k) field discharge tests (including full load testing of crowbar and de-excitation performance and response);

(l) load rejection tests; and

(m) Exciter Transformer tests, including:

(i) winding insulation resistance and polarization index tests for the HV to LV + GND and LV to HV + GND. The HV winding will be tested at 5000 Vdc and the LV winding at 1000 Vdc;

(ii) core insulation resistance test at 500 Vdc;

(iii) winding resistance tests for the HV winding and the LV winding;

(iv) winding turns ratio test;

(v) high-voltage dissipation factor measurement on the HV winding and the LV windings; and

(vi) if possible, using the dissipation factor bridge, an excitation current test.

During the Generator heat run test, the Contractor will conduct temperature rise measurements at a minimum of 15 min intervals on the Exciter Transformer. The final temperature rise will be consistent with the ratings specified in SPEXC 2.7.1 and consistent with the temperature rise results determined during the heat run tests conducted as part of the design tests described in SPEXC 4.4.2(g). The temperature probes used for this test will be installed in the same locations as described in SPEXC 4.4.2(g).

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 7

ENVIRONMENTAL OBLIGATIONS

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 7

ENVIRONMENTAL OBLIGATIONS

1 INTERPRETATION

1.1 Definitions

In this Schedule 7 [Environmental Obligations], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**CEMP**" means the Site C Clean Energy Project Construction Environmental Management Plan dated February 4, 2016, as it may be amended from time to time, a copy of which is available from BC Hydro on request;

"**Environmental Aspect Register**" has the meaning set out in Section 3.1 of this Schedule 7 [Environmental Obligations];

"**Environmental Incident**" means an event, act or omission that is, or has the potential to cause, a violation of any of the Environmental Requirements (such as, for illustration, a spill of oil, fuel or hazardous chemicals, or an unauthorized alteration, disruption, or destruction of aquatic or terrestrial habitat);

"**Environmental Monitor**" has the meaning set out in Section 5.1 of this Schedule 7 [Environmental Obligations];

"**Environmental Protection Plan**" or "**EPP**" has the meaning set out in Section 4.4 of this Schedule 7 [Environmental Obligations];

"**Environmental Requirements**" has the meaning set out in the CEMP;

"**Environmental Specifications**" has the meaning set out in the CEMP;

"**Environmental Tailboard Meeting**" has the meaning set out in Section 7.3 of this Schedule 7 [Environmental Obligations];

"**Environmentally Sensitive Area**" has the meaning set out in the CEMP;

"**Independent Environmental Monitor**" means the person retained by BC Hydro under Section 2.2 of the CEMP to monitor the environmental impacts of the Project and report to government;

"**Pre-Work Orientation**" has the meaning set out in Section 7.2 of this Schedule 7 [Environmental Obligations];

"**Qualified Environmental Professional**" means the person(s) appointed by the Contractor under Section 4.1 of this Schedule 7 [Environmental Obligations]; and

"**Stop Work Procedure**" has the meaning set out in Section 4.4(m) of this Schedule 7 [Environmental Obligations].

2 GENERAL REQUIREMENTS

2.1 Compliance with Environmental Requirements and EPPs

The Contractor:

(a) will be, and will cause the Subcontractors to be, fully knowledgeable of and will, and will cause the Subcontractors to, implement and comply with all the Environmental Requirements and all EPPs as applicable to the performance of the Work at the Site;

(b) will cause its employees and agents, and the employees and agents of the Subcontractors to be fully knowledgeable of and will cause its employees and agents, and the employees and agents of the Subcontractors, to implement and comply with all EPPs as applicable to the performance of the Work at the Site;

(c) without limiting Section 6.1 of Schedule 2 [Design and Construction Protocols], will ensure that the construction means, methods, techniques, sequences and procedures for the Work comply with all the Environmental Requirements and all EPPs as applicable to the performance of the Work at the Site; and

(d) will collaborate with BC Hydro in the identification and design of mitigation measures within the Contractor's Work Area, where appropriate.

2.2 Costs borne by the Contractor

If unauthorized damage to the environment occurs, or threatens to occur, then the Contractor will, except to the extent the damage or threatened damage was or will be caused directly by BC Hydro, or a Person for whom BC Hydro is in law responsible (other than the Contractor and those engaged by or through the Contractor, including Subcontractors), pay all costs incurred to rectify that damage and comply with this Schedule 7 [Environmental Obligations].

3 ENVIRONMENTAL ASPECT REGISTER

3.1 Environmental Aspect Register

The Contractor will, within 90 days of the Effective Date, prepare and submit for Review an environmental aspect register (the "**Environmental Aspect Register**") in a form satisfactory to BC Hydro acting reasonably, setting out all of the environmental requirements applicable to the performance of the Work at the Site. The Environmental Aspect Register will include details such as:

(a) identification of applicable Environmental Requirement, including applicable provision of the relevant Permit, EAC condition or Federal Decision Statement condition;

(b) identification of applicable EPP;

(c) description of the nature and scope of Work covered by the EPP, including a description of the sub-components of the EPP;

(d) identification of Contractor representative responsible for Work covered by the EPP;

(e) method of environmental compliance;

(f) method and frequency of reporting;

(g) status of compliance with each EPP sub-component during the reporting period; and

(h) description of any events of non-compliance during the reporting period.

3.2 Environmental Aspect Register Updates

The Contractor will, as may be required from time to time, update the Environmental Aspect Register to reflect any additional requirements that may arise to reflect actual conditions encountered at the Site, and to reflect changes to the environmental obligations applicable to the performance of the Work at the Site, including changes in applicable Law (including regulatory requirements), changes in biophysical conditions at the Site or changes to the Contractor's means, methods, techniques, sequences and procedures for the performance of the Work, and submit such updated Environmental Aspect Register for Review.

3.3 Monthly Submission of Environmental Aspect Register

The Contractor will submit the then current Environmental Aspect Register to Hydro's Representative For Information Only on a monthly basis. The Contractor will cause each submitted Environmental Aspect Register to be signed by a Qualified Environmental Professional.

4 ENVIRONMENTAL PROTECTION PLAN

4.1 Qualified Environmental Professional

The Contractor will, with respect to every element of the Work to be performed at the Site, appoint a Qualified Environmental Professional(s) who:

(a) is knowledgeable about the scope of the Work that will be performed at the Site; and

(b) has experience and expertise,

to prepare an EPP as required by this Schedule 7 [Environmental Obligations].

4.2 Qualifications of Qualified Environmental Professional

Each Qualified Environmental Professional appointed pursuant to Section 4.1 of this Schedule 7 [Environmental Obligations] must be:

(a) an applied scientist or technologist who specializes in a relevant applied science or technology, including agrology, forestry, biology, engineering, geomorphology, geology, hydrology, hydrogeology or landscape architecture;

(b) a member in good standing registered with the appropriate professional association in British Columbia, acting under such association's Code of Ethics and subject to disciplinary action by such association; and

(c) reasonably relied on to provide advice within his or her area of expertise through demonstrated suitable education, experience, accreditation and knowledge relevant to his or her field.

4.3 Review of CEMP

The Contractor will require that each Qualified Environmental Professional appointed will review and be knowledgeable of the CEMP and identify the provisions that may be applicable to the scope of Work to be performed at the Site.

4.4 EPPs

In advance of any element of Work performed at the Site the Contractor will require a Qualified Environmental Professional to prepare a written, detailed environmental protection plan (an "**Environmental Protection Plan**" or "**EPP**") in respect of such Work that includes:

(a) a clear statement of objectives;

(b) a description of potential Project effects and safety hazards, through consideration of baseline conditions and sensitive receptors;

(c) clear documentation of applicable legislative requirements that must be adhere to, as well as BC Hydro policies, guidelines and other best management practices that will be followed;

(d) a description of worker qualifications and training requirements pertaining to each of the plans associated with the CEMP;

(e) a description of the particular Work activities and location to which the EPP applies, including mapping at a suitable scale;

(f) identification of the specific applicable Environmental Requirements, including applicable Environmental Specifications;

(g) identification of any Environmentally Sensitive Areas;

(h) a determination of required relevant mitigation measures;

(i) a description of environmental monitoring required during the performance of the Work at the Site covered by the EPP, including details regarding the type and frequency of observations and data collection, the methodologies of monitoring, and the protocols that will be followed. The environmental monitoring must be sufficient to reliably confirm that the performance of the Work complies with the EPP;

(j) a description of environmental reporting required during the performance of the Work at the Site covered by the EPP, including:

    (i) a reporting process or mechanism to confirm whether the performance of the Work or component of the Work at the Site to which such EPP relates complies with such EPP having regard to the nature of the Work or component of the Work, and to the Environmental Requirements and CEMP;

    (ii) any required testing or sampling to confirm that Work is proceeding in compliance with the Environmental Requirements;

    (iii) the type, content and frequency of the environmental reports to be prepared by an Environmental Monitor (using a template and format acceptable to BC Hydro) that the Contractor will submit to BC Hydro and to the Independent Environmental Monitor, which will include:

        (A) a description of Work performed at the Site covered by the report;

        (B) a description of environmental monitoring activities covered by the report;

        (C) results of testing of environmental attributes, if any, as they become available;

(D) a description of environmental issues and corresponding mitigation measures implemented, if any; and

(E) a description of photographs (accompanied by identifying information such as date and location) documenting the Work activities, environmental issues, and corresponding mitigation measures implemented; and

(iv) the content of an annual report (in the format as may be specified by BC Hydro) for each calendar year in which the Work or component of the Work at the Site to which the EPP relates is performed, submitted by the following January 15, including:

(A) the quantity of each type of fuel consumed at the Site during the preceding year; and

(B) the production throughput for the preceding year of on-Site processes that contribute to greenhouse gas emissions; and

(v) a requirement that each environmental report that the Contractor is required to submit under the EPP will be signed by a Qualified Environmental Professional;

(k) a noise management program that describes;

(i) any construction activities that create noise that could reasonably be expected to disturb residents in close proximity to the Site; and

(ii) the mitigation measures the Contractor will undertake to lessen the impact of the noise created by such construction activities;

(l) a description of the procedure to be followed in the event of an Environmental Incident, including identification and implementation of mitigation measures and remedial or corrective actions; and

(m) a description of the procedure to be followed in the event that an order to stop any of the Work is issued, including the identification of the person(s) with the authority to stop and restart the Work (the "**Stop Work Procedure**").

The Qualified Environmental Professional will sign the EPP(s) confirming that the Qualified Environmental Professional reviewed the CEMP in preparation for writing the EPP and that the EPP complies with the requirements of Section 4.4 of this Schedule 7 [Environmental Obligations] and with the CEMP, as it may be modified as of the date of the EPP.

4.5 Minimum Required EPPs

Without limiting any of the Contractor's obligations under Section 4.4 of this Schedule 7 [Environmental Obligations], the Contractor will, at a minimum, prepare EPPs in respect of the following scopes of Work:

(a) materials management;

(b) waste management;

(c) water management; and

(d) on-Site fabrication and assembly facilities.

4.6 Submittal of Environmental Protection Plans

At least 30 days before commencing the performance of any Work or component of Work at the Site, the Contractor will submit the EPP in respect of such Work, prepared in compliance with Section 4.4 of this Schedule 7 [Environmental Obligations], to BC Hydro for Review. The Contractor will not perform any element of Work at the Site for which an EPP has not been prepared and endorsed "Accepted".

4.7 Amendments to Environmental Protection Plans

The Contractor will cause the Qualified Environmental Professional to review and amend as necessary each EPP from time to time so that each EPP at all times complies with the CEMP and the Environmental Requirements. If at any time the Qualified Environmental Professional identifies the need for an amendment to an EPP, including an amendment to measures as described in the EPP or the addition of new measures, then the Contractor will stop or suspend the performance of the Work that is covered by the amendment as may be required to give effect to the pending amendment. Prior to implementing any amendments to an EPP, the Contractor will submit proposed amendments to Hydro's Representative for Review.

5 ENVIRONMENTAL MONITORS

5.1 Environmental Monitors

The Contractor will engage one or more qualified monitors (each, an "**Environmental Monitor**") to conduct the environmental monitoring as described and required in each EPP. An Environmental Monitor will be required to:

(a) perform the monitoring, if any, as specifically required in an EPP, and otherwise generally monitor the performance of the Work at the Site to confirm it is being performed in accordance with the requirements of the applicable EPP; and

(b) in the event that the Environmental Monitor observes any Work or component of the Work at the Site being conducted in breach of the applicable EPP, immediately notify the Contractor's designated person in accordance with the Stop Work Procedure. When an order to stop any of the Work is issued pursuant to the Stop Work Procedure, the Environmental Monitor will submit a report to BC Hydro and the Independent Environmental Monitor describing the particular Work, location and time of such breach, and the element of the EPP that was breached.

If any Work or component of the Work is stopped pursuant to the Stop Work Procedure, the Contractor will not restart the particular Work until the Environmental Monitor is satisfied that such Work can proceed in compliance with the applicable EPP.

Prior to an Environmental Monitor commencing any environmental monitoring of Work at the Site the Contractor will review with the Environmental Monitor the reporting procedures which the Environmental Monitor will follow in the event of an Environmental Incident as described in Section 6.2 of this Schedule 7 [Environmental Obligations]. The Contractor will engage a Qualified Environmental Professional to manage and supervise the Environmental Monitors that the Contractor has engaged.

6 ADDITIONAL ENVIRONMENTAL REPORTING

6.1 Environmental Completion Report

The Contractor will, at the completion of the performance of the Work or component of the Work at the Site to which an EPP relates, submit to BC Hydro and to the Independent Environmental Monitor a report prepared by an Environmental Monitor using the template and format specified by BC Hydro, which will, at a minimum, include the following:

(a) a summary of the Work activities on Site;

(b) a summary of the environmental management activities completed during the performance of the Work;

(c) a description of any environmental issues encountered during the Work on Site, and the management and mitigation measures used to resolve those issues; and

(d) representative Site photographs.

6.2 Environmental Incidents

The Contractor will establish reporting procedures to be followed by the Contractor and Subcontractors, and their respective employees in the event of an Environmental Incident, including reporting to the Qualified Environmental Professional and to the Contractor's Representative. The Contractor will submit the reporting procedure to BC Hydro for Review.

In the event of an Environmental Incident, the Contractor will:

(a) immediately report the Environmental Incident to BC Hydro and to the Independent Environmental Monitor and will, within five Business Days or such longer time as the circumstances may reasonably require, deliver to BC Hydro and to the Independent Environmental Monitor a written Environmental Incident report which includes, to the extent applicable to the Environmental Incident:

 (i) photo documentation of the Environmental Incident; and

 (ii) descriptions of:

  (A) the cause and nature of the Environmental Incident;

  (B) the approximate magnitude and duration of the Environmental Incident;

  (C) the area or habitat affected by the Environmental Incident;

  (D) the environmental resources affected by the Environmental Incident;

  (E) the results of any sample analyses taken in conjunction with the Environmental Incident;

  (F) mitigation measures taken to control or limit the activity causing the Environmental Incident;

  (G) additional proposed remedial or corrective actions recommended to address the Environmental Incident;

(H) communications held with Project personnel with respect to the Environmental Incident;

(I) communications with any third parties with respect to the Environmental Incident; and

(J) the collection of samples which were required to characterize the extent and nature of the Environmental Incident; and

(b) if the Environmental Incident is required under any applicable Laws or Permits to be reported to a Governmental Authority, immediately complete such report in accordance with the requirements of the applicable Laws or Permits.

Without limiting Section 6.2(a) of this Schedule 7 [Environmental Obligations], the Contractor will, in reporting an Environmental Incident, use the incident report form set out in Appendix 7-1 [Contractor Environmental Incident Report Form], or such other form as Hydro's Representative may from time to time require.

7 ORIENTATION, TRAINING AND ENVIRONMENTAL TAILBOARD MEETINGS

7.1 Environmental Overview Training

Prior to commencing the performance of the Work at the Site, the Contractor will hold, and will cause its field crew supervisors and Environmental Monitors to attend, an environmental overview and training workshop, which will include the following, as applicable to the scope of the Work at the Site:

(a) the requirements of the EPPs applicable to the scope of the Work;

(b) the roles and responsibilities of BC Hydro, the Contractor, the Qualified Environmental Professional(s) and the Environmental Monitors;

(c) environmental mapping of Environmentally Sensitive Areas; and

(d) procedures for reporting of Environmental Incidents and emergencies.

7.2 Pre-Work Orientation

The Contractor will hold, and will cause all of its employees and agents, and the Subcontractors and their employees and agents to attend, a pre-work orientation meeting (a "**Pre-Work Orientation**") prior to commencing the performance of the Work or component of the Work at the Site to inform its employees and agents, and the Subcontractors and their employees and agents of the Site-specific environmental requirements set out in the applicable EPP(s). The Contractor will document all Pre-Work Orientations and provide such documentation to BC Hydro upon request.

7.3 Environmental Tailboard Meetings

The Contractor will, prior to commencing the performance of the Work at the Site, and at regular intervals thereafter as required by the nature of the Work, hold field crew environmental tailboard meetings (each, an "**Environmental Tailboard Meeting**") to discuss information including the following, as applicable:

(a) Environmentally Sensitive Areas, potential effects and applicable mitigation measures; and

(b) construction activities planned.

The Contractor will document all Environmental Tailboard Meetings and provide such documentation to BC Hydro upon request.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 7-1

CONTRACTOR ENVIRONMENTAL INCIDENT REPORT FORM

(see attached)

CONTRACTOR ENVIRONMENTAL INCIDENT REPORT FORM

BC hydro FOR GENERATIONS

1. **Contractor:** Where Contractor's performance of Work causes an environmental incident (e.g. impact to the environment or near-miss incident) on the BC Hydro job site, the Contractor's representative shall as soon as practicable, notify Hydro's representative of the incident, and submit an environmental incident report.
    1. Complete this incident report form or your own environmental incident report as long as it contains the same information.
    2. Forward the completed incident report to Hydro's Representative in electronic or paper copy.

2. **Hydro's Representative:** Use this incident report to assist you with filing an Environmental Incident report (Spill/Pollution – Fish/Water – Other) in SAP Incident Management System (IMS).

Incident Date:	Incident Time: Click here to enter text. AM ☐ PM ☐

Incident Information

Incident Location (Address/City): Click here to enter text.	
Brief Incident Description: Click here to enter text.	
Immediate Corrective Actions Taken (if needed):Click here to enter text.	
Weather Conditions & Temperature: : Click here to enter text.	
Equipment Type: Serial Number (if available):	Material Released: Amount:
Area of Impact (Select all that apply): ☐ Air ☐ Asphalt or Concrete ☐ Surface Water or Ditch ☐ Soil ☐ Drainage System ☐ Watercourse ☐ Inside Building or Engineered Containment	Did you report this incident to any external agency? YES ☐ NO ☐ If YES, to whom:

Contractor Information

Contractor Company Name:	Click here to enter text.	
Name of Contractor's Representative:	Click here to enter text.	
Address:	Click here to enter text.	
Telephone#:	Click here to enter text.	
Hydro's Representative Contract #:	Click here to enter text.	BC Hydro Project #: Click here to enter text.
Are You Prime On Site?	Yes ☐ No ☐	
Hydro's Representative Name	Click here to enter text.	
E-Mail Address:	Click here to enter text.	
Telephone#:	Click here to enter text.	

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 8

QUALITY MANAGEMENT

TABLE OF CONTENTS

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS

SCHEDULE 8

QUALITY MANAGEMENT

1 INTERPRETATION

1.1 Definitions

In this Schedule 8 [Quality Management], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Audit**" has the meaning set out in ISO 9000;

"**Corrective Action**" has the meaning set out in ISO 9000;

"**Design Quality Management Plan**" has the meaning set out in Appendix 8-1 [Design Quality Management Plan];

"**External Quality Audit**" has the meaning set out in Section 6.1 of this Schedule 8 [Quality Management];

"**Final Quality Report**" has the meaning set out in Section 7.3 of this Schedule 8 [Quality Management];

"**Hold Point**" means a point in the performance of a component or element of the Work past which the Contractor will not proceed without the prior written approval of Hydro's Representative;

"**Inspection**" has the meaning set out in ISO 9000;

"**Inspection and Test Plans**" has the meaning as set out in Appendix 8-2 [Supply Quality Management Plan] and Appendix 8-3 [Installation Quality Management Plan] as the context requires;

"**Installation Quality Management Plan**" has the meaning set out in Appendix 8-3 [Installation Quality Management Plan];

"**Internal Quality Audit**" has the meaning set out in Section 6.1 of this Schedule 8 [Quality Management];

"**ISO 9001**" means the most current standard, developed and published by the International Organization for Standardization;

"**Nonconformity**" means an element of the Work that for any reason does not conform to the requirements of the Contract Documents;

"**Nonconformity Report**" has the meaning set out in Section 8.1(a)(ii) of this Schedule 8 [Quality Management];

"**Nonconformity Tracking System**" has the meaning set out in Section 8.2 of this Schedule 8 [Quality Management];

"**Preventive Action**" has the meaning set out in ISO 9000;

"**Quality**" has the meaning set out in ISO 9000;

“**Quality Documentation Submittals**” has the meaning set out in Section 3.1 of this Schedule 8 [Quality Management];

“**Quality Management**” has the meaning set out in ISO 9000;

“**Quality Management Plans**” means the Design Quality Management Plan, the Supply Quality Management Plan and the Installation Quality Management Plan;

“**Quality Management System**” or “**QMS**” has the meaning set out in ISO 9000;

“**Quality Manager**” has the meaning set out in Section 4.1 of this Schedule 8 [Quality Management];

“**Quality Manual**” has the meaning set out in Section 3.2 of this Schedule 8 [Quality Management];

“**Quality Objectives**” has the meaning set out in ISO 9000;

“**Quality Policy**” has the meaning set out in ISO 9000;

“**Quality Progress Report**” has the meaning set out in Section 4.2(h) of this Schedule 8 [Quality Management];

“**Quality Record**” has the meaning set out in Section 7.1 of this Schedule 8 [Quality Management];

“**Quality System**” has the meaning set out in ISO 9000;

“**Record**” has the meaning set out in ISO 9000;

“**Supply Quality Management Plan**” has the meaning set out in Appendix 8-2 [Supply Quality Management Plan]; and

“**Witness Point**” means a point in the performance of a component or element of the Work, as defined in the Contract Documents, for which BC Hydro is entitled to review the Work performed before the Contractor proceeds with related Work.

2 QUALITY MANAGEMENT SYSTEM

2.1 Quality Management System

The Contractor will develop and implement a Quality Management System in accordance with the requirements of this Schedule 8 [Quality Management] and terms of this Contract. The Contractor is solely responsible for the Quality of the Work and the Contractor acknowledges that a comprehensive Quality Management System is critical for the proper and timely completion of the Work.

2.2 Contractor Responsibilities

The Contractor is responsible for all Quality activities required to manage the performance of the Work including its own processes as well as those of all Subcontractors, and will require that all workers, including Subcontractors’ workers comply with the requirements of the Contractor’s Quality Management System.

2.3 Quality Management System Requirements

The Contractor’s Quality Management System will comply with:

(a) the requirements and principles of the ISO 9001 Standard;

(b) Good Industry Practice; and

(c) all other requirements set out in this Schedule 8 [Quality Management] and the other terms and conditions of this Contract.

3 QUALITY DOCUMENTATION SUBMITTALS

3.1 Submittals

Without limitation to the requirements of ISO 9001, the Contractor will prepare and submit all documents and deliverables required to be submitted to BC Hydro pursuant to the Contract Documents (collectively, the "**Quality Documentation Submittals**") in accordance with the requirements of this Schedule 8 [Quality Management], and, except as expressly stated in the Contract Documents to be submitted for Consent the Quality Documentation Submittals will be subject to Review. The Quality Documentation Submittals will include the following:

Deliverable Name	Due Date	Section Reference	Review, Consent or For Information Only
Quality Manual	Within 30 days after the Effective Date	3.2	Review
Design Quality Management Plan	Within 30 days after the Effective Date	Appendix 8-1	Consent
Supply Quality Management Plan	Within 60 days after the Effective Date	Appendix 8-2	Consent
Installation Quality Management Plan	Within 60 days after the Effective Date	Appendix 8-3	Consent
Inspection and Test Plans	30 days prior the start of inspection and testing	Appendix 8-2 Appendix 8-3	Consent
Quality Progress Reports	On or before the 15th day of the following month	7.2	For Information Only
Final Quality Report	Within 30 days after Substantial Completion of the Work	7.3	Review

3.2 Quality Manual and Quality Management Plans

The Contractor will prepare and submit for Review within 30 days after the Effective Date a Quality manual (the "**Quality Manual**") that describes the Quality Management System for all aspects of the Work. The Quality Manual will describe and establish the Quality Policy and Quality Objectives for all aspects of the Work and, in accordance with the requirements of the ISO 9001 Standard, will describe the processes that will be established, implemented, controlled, and continually improved to achieve the established Quality Policy and Quality Objectives.

The Contractor will prepare and submit for Consent Quality Management Plans in accordance with Appendix 8-1 [Design Quality Management Plan], Appendix 8-2 [Supply Quality Management Plan] and Appendix 8-3 [Installation Quality Management Plan] of this Schedule 8 [Quality Management].

3.3 Continuous Improvement in Quality Management System

The Contractor will implement a program and will have mechanisms in place, such as management reviews and Quality Audit programs, that will record, track, implement or close out all identified opportunities for improvement. The Contractor will conduct reviews of the continuous improvement program no less than annually.

The continuous improvement program will be applied to continually improve the effectiveness and efficiency of the Quality Management System. Improvements to the Quality Management System will be documented and updates will be submitted to BC Hydro so that BC Hydro at all times has the Contractor's current Quality Management System.

3.4 BC Hydro's Right to Audit QMS

BC Hydro may at any time and from time to time audit any element of the Contractor's Quality Management System. The Contractor will submit to BC Hydro any Quality Management procedures or Quality Management documentation in respect of the Work as may be requested by BC Hydro.

4 QUALITY MANAGER

4.1 Qualifications, Appointment and General Responsibilities

At all times during the performance of the Work the Contractor will employ a person as Quality manager (the "**Quality Manager**") with the qualifications as set out below who will, irrespective of such person's other responsibilities, have defined authority for ensuring the establishment, implementation and maintenance of the Quality Management System in the performance of the Work and auditing and reporting on the performance of the Quality Management System during the performance of the Work. The Quality Manager will be a full time role, with no other responsibilities. The Quality Manager will:

(a) report to or have delegation from the Contractor's Representative for Quality matters with respect to the Work independently from persons responsible for the performance of the Work;

(b) be either:

    (i) a certified QMS Lead Auditor, or

    (ii) have experience in a similar quality management representative role for a similar project; and successfully completed an ISO 9001 Lead Auditor course; and

(c) be either:

    (i) a Professional Engineer with a minimum of ten (10) years of relevant experience, or

    (ii) an individual with a minimum of twenty (20) years of relevant experience.

4.2 Specific Responsibilities

Without limiting the generality of the foregoing, the job specification and responsibilities of the Quality Manager will include the following:

(a) develop, implement and maintain, and ensure the effective operation of the Quality Management System;

(b) initiate management reviews, not less frequently than annually, and take other actions necessary to ensure the effective operation and continuous improvement of the Quality Management System;

(c) develop, implement and maintain, and ensure the effective operation of, the Quality Management Plans in the context of the Quality Management System;

(d) manage, and if appropriate delegate, Quality assurance and Quality control activities as part of the Quality Management Plans for the Work;

(e) lead a Quality team that is independent from the Contractor's team that is responsible for the execution and performance of the Work;

(f) prepare Quality Audit plans and schedule and coordinate Internal Quality Audits and External Quality Audits of key processes with the Contractor's workers and with the Subcontractors' workers (including as applicable the designers);

(g) as may be delegated from the Contractor's Representative liaise with Hydro's Representative with respect to Quality matters;

(h) prepare monthly reports concerning progress on Quality matters ("**Quality Progress Reports**") for submission to BC Hydro;

(i) ensure that relevant Quality Records are completed as required and retained in accordance with the Quality Management System; and

(j) develop and implement a program for Corrective Action and Preventive Action.

5 INSPECTION AND TESTING

5.1 Inspection and Testing Requirements

If in accordance with the provisions of the Contract Documents the Contractor is required to carry out any inspection or testing, the Contractor will perform, or cause the performance, of such inspection and testing in accordance with the provisions of Section 5 of this Schedule 8 [Quality Management] except if and to the extent such provision of the Contract Documents expressly directs or permits otherwise.

Any reference to inspection and testing by the Contractor will include inspection and testing performed by any third party or independent certified laboratory or agency engaged by the Contractor.

The Contractor will monitor the performance of the Work, including the inspection and testing, and all other actions required by the Quality Documentation Submittals that are performed by workers, Subcontractors, agents or independent test facilities and laboratories, to ensure compliance with the requirements of this Contract.

5.2 Accreditation Standards

All testing and inspection of the Work performed by or on behalf of the Contractor will be performed by personnel or entities that meet the following standards:

(a) all on and off site inspection and testing will be carried out by agencies, personnel and laboratories that are duly accredited in accordance with Good Industry Practice for the carrying out of inspection and testing of work similar in nature, scale and scope to the Work being tested or inspected;

(b) structural steel and welding will meet or comply with CSA W178.1, "Certification of Welding Inspection Organizations";

(c) protective coatings will meet the standards of the "National Association of Corrosion Engineers", as appropriate to the Work being carried out; and

(d) any other laboratory accreditations specifically identified in this Contract.

5.3 Notice of Inspection and Testing

The Contractor will give written notice to Hydro's Representative of all inspection and testing for which there is an associated BC Hydro Witness Point or Hold Point specified in the Contract Documents or in the relevant Inspection and Test Plan and any changes to an Inspection and Test Plan at least five days prior to the start of the inspection and testing for the relevant Work. All access and facilities necessary for Hydro's Representative to witness the performance of inspection and testing will be provided by the Contractor as part of the Work.

5.4 Test Records and Reports

All inspection and testing will be documented and each such document will be a Quality Record.

Unless otherwise agreed by BC Hydro in writing, all Quality Records will be available to BC Hydro upon request and will be retained in accordance with the requirements of Schedule 15 [Records].

Without limiting the requirements of the Contract Documents, the applicable standards and the Quality Documentation Submittals, all inspection and testing records will include:

(a) the item tested;

(b) test equipment used;

(c) actual results of the applicable inspection and testing;

(d) remarks regarding conformance with this Contract;

(e) photographs of the Work;

(f) calibration certificates and records for testing equipment used;

(g) name and position of the person who actually performed the measurements;

(h) name, position and signature of the person (e.g., Quality Manager, engineer of record) who verified and approved the measurements; and

(i) contact information of the entity (Contractor or Subcontractor) responsible for the applicable inspection and testing.

6 QUALITY AUDITS

6.1 Contractor's Quality Audits

The Contractor will conduct Audits of Quality ("**Internal Quality Audits**") and retain third parties to conduct Audits of Quality ("**External Quality Audits**") of the Contractor's and Subcontractors' Work in accordance with the requirements of this Schedule 8 [Quality Management], the Quality Management Plans and ISO 9001 to ensure that the Quality Management Systems and Quality Management Plans are effective, fully implemented and functioning in accordance with the Contract. The Contractor's Quality Audit process will identify non-compliances with the requirements of the Contract Documents, necessary Corrective Actions and Preventive Actions and facilitate continuous improvement.

The Contractor will document, or cause to be documented, the results of such Quality Audit in an audit report and make such report available to Hydro's Representative upon request.

The Quality Manager will schedule Internal Quality Audits and External Quality Audits to ensure that all key processes are reviewed regularly (at least annually).

Where necessary, follow-up Quality Audits will be scheduled to ensure that identified Corrective Actions and Preventive Actions are carried out by the Contractor in a timely fashion.

6.2 BC Hydro's Quality Audits

Hydro's Representative may, pursuant to the submission of the Quality Documentation Submittals in accordance with this Schedule 8 [Quality Management], review the Quality Documentation Submittals to identify the critical activities and processes identified in the Quality Manual and Quality Management Plans on which BC Hydro's auditing efforts and resources should be directed.

The Contractor will provide and will ensure its workers and Subcontractors provide Hydro's Representative with all documentation, records, access, facilities and assistance for the safety and convenience of Hydro's Representative.

Hydro's Representative may employ independent auditors, and inspection and testing agencies. These agents will be afforded the same facilitation provided to Hydro's Representative.

7 QUALITY DOCUMENTATION

7.1 Quality Records

The Contractor will establish and maintain a complete and accurate set of all Quality management records (each a "**Quality Record**"). The Contractor will ensure that a complete set of Quality Records is maintained in accordance with the requirements of Schedule 15 [Records].

The Quality Records will provide objective evidence of conformance with all requirements of the Contract Documents in the performance of the Work, compliance with the ISO 9001 Standard and the effective operation of the Quality Management System.

Each Quality Record will be traceable to the actual components of the Work to which it applies.

7.2 Quality Progress Reports

For each month of the Project, the Contractor will prepare and submit to Hydro's Representative on or before the 15th day of the following month, a comprehensive Quality Progress Report.

Each Quality Progress Report will address all Quality management activities under each of the Quality Management Plans for the applicable reporting period and any outstanding Quality issues from prior reporting periods.

The Quality Progress Reports will, as a minimum, include the following information separately identified for the Quality Manual and for each Quality Management Plan:

(a) a Nonconformity Report log summarizing the Nonconformity Tracking System, highlighting each Nonconformity's status and progress of disposition;

(b) Corrective Action and Preventive Action logs providing details of the Corrective Actions and Preventive Actions performed to date and their close-out status;

(c) a summary of any inspection and testing activities conducted, including identification and review status of all related inspection and testing plans;

(d) Internal Quality Audits and External Quality Audits including any third party Quality Audits performed;

(e) any continual improvement initiatives taken; and

(f) any changes made to the Quality Management System or the Quality Management Plans in compliance with the provisions of this Contract.

7.3 Final Quality Report

The Contractor will, not later than 30 days after Substantial Completion of Work, submit for Review a Final Quality Report (each, a "**Final Quality Report**") to provide objective evidence that the Quality of the Work satisfies the requirements of this Contract. The Final Quality Report will be a compilation of all the Quality Documentation Submittals produced during and in connection with the performance of the Work.

8 NONCONFORMITIES

8.1 Nonconformity Reporting Process

The Contractor will manage Nonconformities as follows:

(a) upon discovery of a Nonconformity, the Contractor will:

  (i) within one Business Day notify BC Hydro in writing of such Nonconformity; and

  (ii) within two Business Days enter a report of such Nonconformity into the Nonconformity Tracking System along with a proposed time frame in which to remedy and correct the Nonconformity (a "**Nonconformity Report**");

(b) the Contractor will finalize a proposed remedial plan to remedy and correct the Nonconformity within the time identified in the applicable Nonconformity Report and included in the Nonconformity Tracking System;

(c) the Contractor will verify implementation of the proposed remedial plan within the time identified in the applicable Nonconformity Report and included in the Nonconformity Tracking System;

(d) the Contractor will use reasonable efforts to identify and record all Nonconformities;

(e) the Contractor will implement effective Corrective Actions and Preventive Actions as identified in Quality Management Plans to prevent recurrences of Nonconformities; and

(f) if at any time Hydro's Representative becomes aware of a Nonconformity or risk of Nonconformity, Hydro's Representative may issue a written report describing the Nonconformity, without prejudice to any other right or remedy available to BC Hydro (although except as may be expressly stated otherwise in the Contract Documents, nothing in this Schedule 8 [Quality Management] will impose any obligation on BC Hydro to inspect the Work to identify Nonconformities, and any inspection of the Work by BC Hydro will be for the sole and exclusive benefit of BC Hydro).

8.2 Nonconformity Report Tracking System

The Contractor will establish and maintain a tracking system (the "**Nonconformity Tracking System**") to monitor the status of all Nonconformity Reports initiated by BC Hydro and the Contractor. The Nonconformity Tracking System will:

(a) comprise a single repository containing the Contractor and BC Hydro initiated Nonconformity Reports;

(b) have the ability to attach supporting material such as photos and documents to a Nonconformity Report;

(c) provide the Contractor and BC Hydro remote access by computer to the current Nonconformity Report status, dates, data and supporting material;

(d) be traceable to actual parts, components, locations, drawings and data sheets as appropriate; and

(e) have the date and time at which Nonconformities were identified or discovered, rectified and closed.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 8-1

DESIGN QUALITY MANAGEMENT PLAN

1 DESIGN QUALITY MANAGEMENT PLAN

1.1 With respect to any design of the Work for which, pursuant to the Contract Documents, the Contractor is responsible, the Contractor will prepare a Quality management plan (the "**Design Quality Management Plan**"), that describes how the Contractor intends to manage and provide evidence of the design processes for such design in accordance with the ISO 9001 Standard, the Quality Management System requirements stated in the Quality Manual and the provisions of this Contract, to BC Hydro. The Contractor will submit the Design Quality Management Plan for Consent within 30 days after the Effective Date.

1.2 In addition to any other requirements of the Contract Documents, the Design Quality Management Plan will include:

(a) an organizational chart identifying key design management personnel (including the Quality Manager) and the linkage with the Contractor's overall Quality Management System as documented in the Quality Manual;

(b) a description of the responsibilities, qualifications, and authority of the above personnel;

(c) identification of the lead persons responsible for the design;

(d) a communication strategy relating to Quality between all members of the Contractor's design team and BC Hydro including monthly meetings to discuss the Quality Progress Report concerning design for such month; and

(e) design review activities at various phases as specified in Appendix 6-1 [General Specifications (SPGS)].

1.3 The Design Quality Management Plan will, at a minimum, include or reference detailed Quality System procedures and process flow charts for the following processes:

(a) design input and output review;

(b) design verification to ensure that design input requirements have been met;

(c) design validation to ensure that the final product is capable of meeting its intended use;

(d) design changes at all Work stages;

(e) External Quality Audits of Subcontractor(s) engaged in Design activities;

(f) Internal Quality Audits;

(g) Corrective Actions, Preventive Actions and opportunities for improvement;

(h) document management; and

(i) control of design documents and Quality Records.

1.4 The Design Quality Management Plan (and updates to the plan) will be reviewed and approved by the Quality Manager prior to submittal to BC Hydro.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 8-2

SUPPLY QUALITY MANAGEMENT PLAN

1 SUPPLY QUALITY MANAGEMENT PLAN

1.1 The Contractor will prepare and submit a Supply and Delivery Work Quality management plan (the "**Supply Quality Management Plan**"), that describes how the Contractor intends to manage and provide objective evidence of the processes in connection with the Supply and Delivery Work activities in accordance with the ISO 9001 Standard, the Quality Management System requirements stated in the Quality Manual and the provisions of this Contract, to BC Hydro for Consent within 60 days after the Effective Date.

1.2 In addition to any other requirements of this Contract, the Supply Quality Management Plan will include:

(a) an organizational chart identifying key Supply and Delivery Work quality management personnel (including the Quality Manager) and the linkage with the overall Quality Management System as documented in the Quality Manual;

(b) a description of the responsibilities, qualifications, and authority of the above personnel;

(c) a description of the organizational interfaces between the above personnel and the design and other disciplines;

(d) identification of all Contractors and Subcontractors engaged in Supply and Delivery Work activities;

(e) identification of all laboratories, inspection agencies and inspectors used by the Contractor in connection with the Supply and Delivery Work activities, including evidence of their accreditations and contact information; and

(f) a communications strategy relating to Quality between the Contractor, Subcontractors and BC Hydro including Manufacturing kickoff meetings and monthly meetings to discuss the Quality Progress Report concerning Supply and Delivery Work for such month.

1.3 The Supply Quality Management Plan will, at a minimum, include or reference detailed Quality System procedures and process flow charts for the following processes:

(a) inspection, calibration, sampling, testing, trials and monitoring;

(b) materials identification and traceability;

(c) quality assessment of Subcontractors engaged in Supply and Delivery Work activities;

(d) purchasing process, information and verification;

(e) preservation of product (packaging, handling, shipping and storage);

(f) External Quality Audits of Subcontractors;

(g) Internal Quality Audits;

(h) control of nonconforming products;

(i) Corrective Actions, Preventive Actions and opportunities for improvement;

(j) document management; and

(k) control of documents and Quality Records.

1.4 The Supply Quality Management Plan will also include or reference any Inspection and Test Plans detailing all inspection and test activities for the Work performed by the Contractor and Subcontractors. BC Hydro may identify Witness Points or Hold Points for any steps and BC Hydro may, in its discretion decide, or establish inspection based on criticality and Quality risks associated with the Supply and Delivery Work. A Hold Point cannot be waived unless BC Hydro has specifically waived a Hold Point in writing.

1.5 The Contractor will submit the inspection and test plans (the "**Inspection and Test Plans**") for Consent. The Inspection and Test Plans will be submitted at least 30 days prior to the start of the applicable Supply and Delivery Work activities and include, at a minimum:

(a) description of the inspection, calibration, sampling, testing, trial and monitoring activity;

(b) reference to specific locations, components and Subcontractors as appropriate;

(c) frequency of inspection, calibration, sampling, testing, trials and monitoring;

(d) reference to standards, codes, specifications, and acceptance criteria;

(e) procedures, forms and checklists required;

(f) reports and other Quality Records produced from inspection, calibration, sampling, testing and trials; and

(g) personnel responsible for inspection, calibration, sampling, testing, trial and monitoring activities.

Complete Inspection and Test Plan records, and a certification that those records verify and confirm that the Work covered by the records has been completed in accordance with the requirements of the Contract Documents, will be retained by the Contractor in accordance with the requirements of Schedule 15 [Records].

1.6 The Supply Quality Management Plan will include procedures for Work for which the performance cannot be verified by subsequent monitoring or measurement.

1.7 The Supply Quality Management Plan (and updates to the plan) will be reviewed and approved by the Quality Manager prior to submittal to BC Hydro.

2 SUPPLY QUALITY AUDITS

2.1 Surveillance Quality Audits may be conducted by BC Hydro on a random basis or on specific areas of interest during the Supply and Delivery Work. The objective of surveillance Quality Audits will be to monitor the Contractor's activities involving its work practices, workmanship and general quality of materials.

2.2 Hydro's Representative may, during the performance by BC Hydro of a surveillance Quality Audit, record any observations and inform the Contractor of any deficiencies that require further evaluation and resolution.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 8-3

INSTALLATION QUALITY MANAGEMENT PLAN

1 INSTALLATION QUALITY MANAGEMENT PLAN

1.1 The Contractor will prepare and submit an Installation Work Quality management plan (the "**Installation Quality Management Plan**"), that describes how the Contractor intends to manage and provide objective evidence of the processes in connection with the Installation Work activities in accordance with the ISO 9001 Standard, the Quality Management System requirements stated in the Quality Manual and the provisions of this Contract, to BC Hydro for Consent within 60 days after the Effective Date.

1.2 In addition to any other requirements of this Contract, the Installation Quality Management Plan will include:

(a) an organizational chart identifying key Installation Work quality management personnel (including the Quality Manager) and the linkage with the overall Quality Management System as documented in the Quality Manual;

(b) a description of the responsibilities, qualifications, and authority of the above personnel;

(c) a description of the organizational interfaces between the above personnel and the design and other disciplines;

(d) identification of all Contractors and Subcontractors engaged in Installation Work activities;

(e) identification of all laboratories, inspection agencies and inspectors used by the Contractor in connection with the Installation Work activities, including evidence of their accreditations and contact information; and

(f) a communications strategy relating to Quality between the Contractor, Subcontractors and BC Hydro including Site kickoff meetings and monthly meetings to discuss the Quality Progress Report concerning Installation Work for such month.

1.3 The Installation Quality Management Plan will, at a minimum, include or reference detailed Quality System procedures and process flow charts for the following processes:

(a) inspection, calibration, sampling, testing, trials and monitoring;

(b) materials identification and traceability;

(c) quality assessment of Subcontractors engaged in Installation Work activities;

(d) preservation of product (unloading, handling and storage);

(e) External Quality Audits of Subcontractors;

(f) Internal Quality Audits;

(g) control of nonconforming products;

(h) Corrective Actions, Preventive Actions and opportunities for improvement;

(i) document management; and

(j) control of documents and Quality Records.

1.4 The Installation Quality Management Plan will also include or reference any Inspection and Test Plans detailing all inspection and test activities for the Work performed by the Contractor and Subcontractors. BC Hydro may identify Witness Points or Hold Points for any steps and BC Hydro may, in its discretion decide, or establish inspection based on criticality and Quality risks associated with the Installation Work. A Hold Point cannot be waived unless BC Hydro has specifically waived a Hold Point in writing.

1.5 The Contractor will submit the inspection and test plans (the "**Inspection and Test Plans**") for Consent. The Inspection and Test Plans will be submitted at least 30 days prior to the start of the applicable Installation Work activities and include, at a minimum:

(a) description of the inspection, calibration, sampling, testing, trial and monitoring activity;

(b) reference to specific systems, components and Subcontractors as appropriate;

(c) frequency of inspection, calibration, sampling, testing, trials and monitoring;

(d) reference to standards, codes, specifications, and acceptance criteria;

(e) procedures, forms and checklists required;

(f) reports and other Quality Records produced from inspection, calibration, sampling, testing and trials; and

(g) personnel responsible for inspection, calibration, sampling, testing, trial and monitoring activities.

Complete Inspection and Test Plan records, and a certification that those records verify and confirm that the Work covered by the records has been completed in accordance with the requirements of the Contract Documents, will be retained by the Contractor in accordance with the requirements of Schedule 15 [Records].

1.6 The Installation Quality Management Plan will include procedures for Work for which the performance cannot be verified by subsequent monitoring or measurement.

1.7 The Installation Quality Management Plan (and updates to the plan) will be reviewed and approved by the Quality Manager prior to submittal to BC Hydro.

2 INSTALLATION QUALITY AUDITS

2.1 Surveillance Quality Audits may be conducted by BC Hydro on a random basis or on specific areas of interest during the Installation Work. The objective of surveillance Quality Audits will be to monitor the Contractor's activities involving its work practices, workmanship and general quality of materials.

2.2 Hydro's Representative may, during the performance by BC Hydro of a surveillance Quality Audit, record any observations and inform the Contractor of any deficiencies that require further evaluation and resolution.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 9

COMMUNICATIONS ROLES

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 9

COMMUNICATIONS ROLES

1 INTERPRETATION

1.1 Definitions

In this Schedule 9 [Communications Roles], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Communications Manager**" has the meaning set out in Section 2 of this Schedule 9 [Communications Roles];

"**Community Liaison Committee**" has the meaning set out in Section 7.2(a) of this Schedule 9 [Communications Roles];

"**Construction Communications Plan**" means the plan described in Section 5 of this Schedule 9 [Communications Roles]; and

"**Supporting Role Construction Communications Plan**" has the meaning set out in Section 6.2 of this Schedule 9 [Communications Roles].

2 CONTRACTOR'S COMMUNICATIONS REPRESENTATIVE

The Contractor will appoint an individual (the "**Communications Manager**") to fulfill the Contractor's communications obligations relating to traffic management, community relations, public consultation and media relations set out and described in this Schedule 9 [Communications Roles]. The Contractor will cause the Communications Manager to work with the Contractor, Subcontractors and their respective directors, officers, representatives, employees and workers, including construction and traffic managers, to provide BC Hydro and the public with concise, accurate and understandable information.

The Communications Manager is a Key Individual and is required to be experienced in the field of traffic management communications, community relations, public consultation and media relations.

2.1 Role of Communications Manager

The Contractor will require the Communications Manager to:

(a) routinely notify Hydro's Representative of any unscheduled Work activities;

(b) submit to Hydro's Representative for Review details of any unscheduled Work activities not less than 96 hours in advance of the event or activity;

(c) notify Hydro's Representative of any Work interruption not less than 72 hours in advance of the event or activity;

(d) meet with Hydro's Representative, at the frequency directed by BC Hydro, to provide construction information, and share information about Work issues to the extent those issues may affect the public, and to check for consistency with BC Hydro's overall strategic approach and key messages;

(e) supply all information related to Work that may affect the public to Hydro's Representative for approval at the meeting described in Section 2.1(d) of this Schedule 9 [Communications Roles] before it is released;

(f) on a weekly basis, supply a three-week look-ahead schedule providing an overview of major Work activities to Hydro's Representative for use in community relations updates;

(g) attend community relations meetings and other public communications forums concerning the Work as required by BC Hydro;

(h) manage a communications register that records and tracks all external/public inquiries concerning traffic and responses and provide this once per week to Hydro's Representative; and

(i) forward accurate and timely information to Hydro's Representative so that BC Hydro may operate a public information phone line to respond to construction-related inquiries from the public.

3 CATEGORIES OF COMMUNICATION

The following are the communication categories for the Work:

(a) community relations: which involves building relationships with the public and keeping the public informed through on-going two-way communication and regular reporting concerning overall and specific work information and developments, and includes attending public meetings and dealing with inquiries from the public, providing work updates and problem solving on issues as they arise. Community relations excludes public consultation;

(b) public consultation: which involves gathering and receiving public input on the nature of the Work at the Site and considerations as they relate to interfaces with the public;

(c) media relations: which involves providing the media with progress reports and updates on the Work and responding to issues raised by the media as they arise; and

(d) traffic management communications: which is designed to keep the public advised on a timely basis about all matters relating to traffic flow, and includes specifically traffic incident and/or emergency management communication and timely notice of construction related delays, closures and detours, so as to minimize traffic disruption and maximize traffic predictability.

4 GENERAL

4.1 Desired Outcome

The desired outcome of all communication and consultation activities is to involve and inform the public concerning the value, benefits and progress of the Project and the Work.

4.2 Plan Summary

For convenience of reference only, the following table is a summary of the documents and deliverables required to be submitted by the Contractor under this Schedule 9 [Communications Roles] and the corresponding submission times. (If there is any inconsistency or omission in this table as compared to other provisions of this Schedule 9 [Communications Roles], then the other provisions of this Schedule 9 [Communications Roles] will govern.)

Plan	Due Date
Supporting Role Construction Communications Plan	No later than 90 days after the Effective Date. Annual update no later than 30 Business Days after anniversary of the previous plan.

5 CONSTRUCTION COMMUNICATIONS PLAN

BC Hydro has developed a construction communications plan (the "**Construction Communications Plan**"), which may be updated by BC Hydro from time to time. BC Hydro will make this plan and any updates available to the Contractor.

BC Hydro may, at its discretion, apply the Construction Communications Plan as a guideline to aid in the review of the plans which the Contractor is to prepare and submit pursuant to this Schedule 9 [Communications Roles].

6 ROLES

6.1 BC Hydro to Lead

BC Hydro will, at its cost, take the lead role in conducting and implementing community relations, public consultation, media relations and traffic management programs for the Project, which will include the matters referred to in Sections 7, 8 and 9 of this Schedule 9 [Communications Roles]. BC Hydro reserves the right to delegate this lead role on a case-by-case basis without waiver of its right to withdraw such delegation or to retain its lead role for the non-delegated matters.

6.2 Contractor to Support

The Contractor will, at its cost, take the support role in implementing the requirements of this Schedule 9 [Communications Roles].

The Contractor will, within 90 days after the Effective Date, prepare and submit to Hydro's Representative for Review a supporting role construction communications plan (the "**Supporting Role Construction Communications Plan**") that clearly describes how the requirements of this Schedule 9 [Communications Roles] will be implemented during the performance of the Work.

6.3 Communication Methods and Minimum Requirements – Work

The Supporting Role Construction Communications Plan will set out the Contractor's implementation of its obligations set out below.

Communication Tools	BC Hydro Requirements	Response time
Public Information Phone Line	Category: A media or urgent public call. Process: All public calls will be received and responded to by BC Hydro. Contractor’s Responsibility: To provide a contact person to discuss/collaborate on the issue with BC Hydro and to provide a written response to BC Hydro about the issue. BC Hydro will then use/modify the written response in support of BC Hydro's obligation to respond to the phone call.	1 hour from media or urgent public call to develop interim or holding key messages. (From 8:00 am to 5:00 pm – if outside of business hours, by 9:00 am next day.) 2 hours to develop final key messages. (From 8:00 am to 5:00 pm – if outside of business hours, by 10:00 am next day.)
Public Information Phone Line	Category: A day-to-day call about the Work, such as number of people working, current major Work activities, and similar information. Process: All public calls will be received and responded to by BC Hydro. Contractor’s Responsibility: To provide a contact person to discuss/collaborate on the issue and to provide a written response to BC Hydro about the issue. BC Hydro will then use/modify the written response in support of BC Hydro's obligation to respond to the phone call.	24 hours from receipt of a day-to-day phone call.
Communications Register	Category: Weekly communications register that records and tracks all external/public inquiries received by the Contractor. Process: Record and track all external/public inquiries received by the Contractor. Contractor’s Responsibility: To provide a written communications register that records and tracks all external/public inquiries received by the Contractor and its responses, where provided at BC Hydro’s direction.	Weekly report to BC Hydro.
E-mail Notification	Category: There will be scheduled e-mail notification on Project information approximately every month, or as identified by BC Hydro, to provide updates on Project activities as needed. Process: BC Hydro will proactively issue notification e-mails about Work information. Contractor’s Responsibility: To provide a written response to BC Hydro’s e-mail; BC Hydro will then use/modify the written response in support of BC Hydro's obligation to respond to the e-mail.	5 Business Days from written request by BC Hydro.

Communication Tools	BC Hydro Requirements	Response time
E-mail Response	Category: Response regarding media or urgent public issue. Process: BC Hydro will receive, issue and maintain all e-mail correspondence and notifications to the public with Work information. Contractor's Responsibility: To provide a contact person to discuss/collaborate on the issue with BC Hydro and then provide a written response to BC Hydro about the issue; BC Hydro will then use/modify the written response in support of BC Hydro's obligation to respond to the e-mail.	2 hours from receipt of notice of media or urgent public issue. (From 8:00 am to 5:00 pm – if outside of business hours, by 10:00 am next day.)
E-mail Response	Category: Response from a general email media or non-urgent public issue. Process: BC Hydro will receive, issue and maintain all e-mail correspondence and notifications to the public with Work information. Contractor's Responsibility: To provide a contact person to discuss the issue with BC Hydro and then provide a written response to BC Hydro about the issue; BC Hydro will then use/modify the written response in support of BC Hydro's obligation to respond to the e-mail.	24 hours from receipt of a day-to-day e-mail.
Direct Mail	Category: Direct mail may occur approximately quarterly and provide general Project information and updates. Process: BC Hydro will describe Project/Work and update the public as needed. Contractor's Responsibility: To provide a written response to BC Hydro about an issue; BC Hydro will then use/modify the written response in support of BC Hydro's direct mail piece.	5 Business Days from written request by BC Hydro.
Advertising	Category: There will be scheduled advertisements on Project information along with possible broader BC Hydro corporate advertising. Process: BC Hydro will develop and issue the advertisements. Contractor's Responsibility: To provide a written response to BC Hydro's requests concerning its advertisement design and content; BC Hydro will then use/modify the written response in support of BC Hydro's advertisement.	5 Business Days from written request by BC Hydro.
Website	Category: Updates to the Site C Project Website (www.sitecproject.com) on the Work will be as needed. Process: Project Website to be maintained by BC Hydro. Contractor's Responsibility: To provide written materials and Work pictures to BC Hydro for these updates.	5 Business Days from written request by BC Hydro.

Communication Tools	BC Hydro Requirements	Response time
Work Information Updates / Community Notices	Category: Public notices for Work activities or general updates about the status of Work. Process: BC Hydro will be the lead on all public/media releases, and will distribute them. Contractor’s Responsibility: To provide written information to BC Hydro for public release; BC Hydro will then use/modify the written information in support of BC Hydro's obligation to issue the public notification. To advise BC Hydro of any public notices for Work activities/closures and submit such notices to Hydro’s Representative.	10 Business Days prior to an activity/closure date.
Media Releases	Category: Incident management issues which require immediate issuance of media release. Process: BC Hydro will issue and be the lead on all media releases. The Contractor will work with BC Hydro for incident management issues which require immediate issuance of media release. Contractor’s Responsibility: Provide BC Hydro with a person to contact and an emergency number to discuss/collaborate on the issue and to provide written information to BC Hydro for the news release; BC Hydro will then use/modify the written information in support of BC Hydro's obligation to issue the news release. BC Hydro will distribute the news release.	1 hour from written request by BC Hydro.
Media Interviews	Category: Request from media for an interview. Process: BC Hydro will identify appropriate lead for interview. In the event a spokesperson is required, BC Hydro will determine the spokesperson. Contractor’s Responsibility: To provide an approved communications lead to support the BC Hydro spokesperson as reasonably requested by BC Hydro. All media inquiries are to be forwarded to BC Hydro to coordinate response. The Contractor is not to respond to the media without BC Hydro’s permission.	1 hour from written request by BC Hydro.

Communication Tools	BC Hydro Requirements	Response time
Community Off-site Open House	Category: An open house for the community will be held annually, or on such other schedule as determined by BC Hydro. Process: BC Hydro and the Contractor will profile the Project and its components, including the Work through community open houses. This is an opportunity for the community to see Project evolution through pictures, maps, diagrams, and presentations. This “off-site” open house will allow the community to continue to learn and follow the Project by talking to discipline experts. It may also serve as a recruitment tool for prospective workers on the Project. Contractor’s Responsibility: As required by the Construction Communications Plan. Communications Manager to provide text, graphics and other support materials for the event. The Contractor to provide representatives at the open house, as requested by BC Hydro.	30 Business Days in advance to provide BC Hydro with event support.
Community Liaison Committee	Category: Community Liaison Committees to receive regular updates on the Work and bring forward community issues for discussion. Process: BC Hydro will develop and facilitate the Community Liaison Committees. The Contractor will attend the Community Liaison Committee meetings with BC Hydro, which could include monthly or quarterly meetings. Contractor’s Responsibility: As required by the Construction Communications Plan. Communications Manager to participate in planning and support.	10 Business Days in advance of meeting to provide BC Hydro with information/presentation needs.
General Public Meetings	Category: Meetings to present current Work activity information and identify and minimize Work activity impacts. The types of meetings include Rotary, Chamber of Commerce, City Council, and public groups. Process: BC Hydro will maintain ongoing relationships with the public and attend general public meetings. The Contractor must attend such meetings with BC Hydro. BC Hydro anticipates The Contractor will attend about 6 meetings per year, but dependent on issues, attendance at more meetings may be required as determined by BC Hydro. Contractor’s Responsibility: As required by the Construction Communications Plan. Communications Manager to participate and provide support.	10 Business Days in advance of meeting to provide BC Hydro with information/presentation needs.

Communication Tools	BC Hydro Requirements	Response time
Aboriginal group meetings	Category: Meetings with Aboriginal groups, including Chief and Council meetings and community meetings, to present current Work activity information, bring forward community issues for discussion, and identify and minimize Work activity impacts. Process: BC Hydro will maintain ongoing relationships with the Aboriginal groups. The Contractor must attend such meetings at the request of BC Hydro. BC Hydro anticipates the Contractor will attend about 6 meetings per year, but dependent on issues, attendance at more meetings may be required as determined by BC Hydro. Contractor's Responsibility: Communications Manager to participate and provide support to BC Hydro.	10 Business Days in advance of meeting to provide BC Hydro with information/presentation needs.
Video (HD quality) and High-Quality Photos	Category: Requirement for video footage of the Work and photographs of the Work. Process: The Contractor to take a high-definition video clip of the Work at appropriate weekly/monthly intervals to include all main Turbine and Generator components and subassemblies manufactured and transported to the Site for the first Unit and for all six Units installed. The Contractor also will take an average of 25 to 50 high-quality photographs per month capturing all key elements of the fabrication, testing, transportation and installation of the Units. Contractor's Responsibility: To produce and provide BC Hydro: (i) high-definition video footage of the Work; and (ii) high-quality photographs of the Work. Once the Work is completed, the Contractor will provide BC Hydro with all raw video footage requested by BC Hydro and with a 3- or 4-minute time-lapse video (in high-definition quality) on DVD/CDR, showing the fabrication, testing, transportation and installation of the Units.	Video footage to be provided to BC Hydro within 30 Business Days after: (i) the first Unit is delivered to the Site; (ii) each Unit achieves Substantial Completion; and (iii) on Total Completion of all Units. On a monthly basis, the Contractor is to provide BC Hydro with an electronic copy of the prior month's photographs.
Public Displays	Category: Public displays will be created for the Site C Community Office. Process: BC Hydro will develop public displays that describe the Work. The displays will be updated as needed. Contractor's Responsibility: To provide a contact person to discuss/collaborate on the content and then provide a written response to BC Hydro. BC Hydro will then use/modify the written response to develop the public displays.	5 Business Days from written request by BC Hydro.
Business Liaison	Category: update businesses on status of the Work and provide information on future business opportunities related to the Work. Process: BC Hydro has developed a directory of interested businesses. BC Hydro will continue to conduct information sessions as needed. Contractor's Responsibility: To provide a contact person to discuss/collaborate on updates. Communications Manager to participate in planning and support.	5 Business Days from written request by BC Hydro.

7 COMMUNITY RELATIONS AND PUBLIC CONSULTATION

7.1 Community Relations

The Contractor will provide the supporting role for BC Hydro's community relations program which will include:

(a) supporting BC Hydro in a proactive community relations program to provide the public with regular or scheduled information on the Work, including notification and timing of road closures, and Work updates such as public information bulletins, public displays, advertising, website, Work notices, open houses, milestone announcements and celebrations, news releases and media tours, that BC Hydro considers necessary or desirable in order to conduct and implement the community relations program;

(b) supporting BC Hydro's lead role by providing information for BC Hydro to use in responding to day-to-day inquiries and complaints on issues and concerns arising out of the Work as requested by BC Hydro;

(c) providing a contact to take public inquiries, relay inquiries to BC Hydro and assist BC Hydro in its responses to those inquiries, and in some cases providing responses directly to the public where discussed and agreed to by BC Hydro;

(d) supporting BC Hydro by attending public meetings;

(e) supporting BC Hydro's communications and media relations by providing clear, consistent and accessible Work information, including number of workers, number of apprentices, local workers and local contractors involved in the Work, and to collaborate on local and Aboriginal employment success stories, so that BC Hydro can utilise this in disseminating information on Work activities; and

(f) supporting BC Hydro's communications activities by supplying timely and accurate information to BC Hydro about the Work as requested by BC Hydro.

7.2 Community Liaison Committees

The Contractor will participate in a supporting role, with Community Liaison Committees, as follows:

(a) BC Hydro proposes to establish up to five Community Liaison Committees (e.g., in each of Fort St. John, Hudson's Hope, Taylor, Chetwynd and Peace River Regional District) (each, a "**Community Liaison Committee**"). BC Hydro would work with prospective Community Liaison Committees members to establish terms of reference for the Community Liaison Committees that would include procedures for membership, roles and responsibilities of Community Liaison Committee members, regular reporting, review of mitigation and follow-up programs, and other topics as agreed.

(b) BC Hydro will, with the Contractor's support, at each meeting engage with the Community Liaison Committee and hear the comments and issues raised by the Community Liaison Committee on all matters relating to impacts to the community with respect to the performance of the Work.

(c) The Contractor will consider all comments, issues and matters raised by the Community Liaison Committee at each meeting. Within 15 business days of each meeting with a Community Liaison Committee, the Contractor will prepare and deliver to Hydro's Representative a report, which will:

(i) demonstrate in detail how the Contractor considered the concerns, issues and matters raised by the Community Liaison Committee and how the Contractor proposes to address and remedy each of the concerns, issues and matters raised by the Community Liaison Committee, provided that such proposals will not create additional obligations for the Contractor; and

(ii) if the Contractor proposes not to address or remedy in whole or in part any concern, issue or matter raised by the Community Liaison Committee, provide reasons satisfactory to Hydro's Representative, acting reasonably, why the Contractor proposes not to address or remedy in whole or in part any particular concern, issue or matter raised by the Community Liaison Committee.

7.3 Public Consultation

The Contractor will participate in a supporting role in BC Hydro's public consultation program which will include:

(a) providing a contact to take public inquiries, relay inquiries to BC Hydro and assist BC Hydro in its responses to those inquiries;

(b) providing information for public and stakeholder Site interpretive displays/wayward signage, so that BC Hydro and the Contractor can design the map/diagrams/words to BC Hydro's corporate standards. The Contractor will print/develop the displays and then place at the Site;

(c) attending, with representatives of BC Hydro, public meetings, other small or large group meetings, municipal council and local government presentations, Aboriginal group meetings, and such other meetings as BC Hydro deems necessary or desirable;

(d) providing personnel (i.e., Communications Manager) experienced in making public consultation presentations in a support role;

(e) performing the Work in compliance with the Supporting Role Construction Communications Plan; and

(f) revising and submitting to Hydro's Representative for Review an updated Supporting Role Construction Communication Plan as required to reflect any changes to the Work, and in any event annually.

Compliance with the Supporting Role Construction Communications Plan will not relieve the Contractor of any of its duties, obligations or responsibilities under the Contract to perform the Work in accordance with the requirements of the Contract Documents.

8 MEDIA RELATIONS

The Contractor will participate in a supporting role for the following activities relating to media relations:

(a) as requested by BC Hydro, the Contractor will assist BC Hydro to respond to a media enquiry. This assistance may include providing all information and data regarding the status of the Work, any traffic incidents, emergencies or other incidents, and any other information and data BC Hydro may need to appropriately respond to media inquiries;

(b) provide media opportunities/Site tours for milestone and unique Work events, such as commencement of Unit installation, runner installation, spiral staircase testing, rotor installation and stator winding. By extension, to assist and allow MLA, Minister and City Council Site tours as required; and

(c) providing a contact to take media inquiries, relay inquiries to BC Hydro and assist BC Hydro in its responses to those inquiries and in some cases providing responses directly to the media where discussed and agreed to by BC Hydro.

9 TRAFFIC MANAGEMENT COMMUNICATIONS

9.1 Supporting Role Traffic Management Communications

(a) Within 90 days after the Contractor's mobilization to the Site, the Contractor will prepare and submit to Hydro's Representative for Review a supporting role traffic management plan as part of the Supporting Role Construction Communications Plan that clearly describes how the Contractor will:

(i) implement the requirements of this Schedule 9 [Communications Rolls] related to traffic matters during the performance of the Work; and

(ii) communicate to Hydro's Representative about all matters relating to traffic flow, including, specifically, providing timely notice of Work related delays, closures, detours and any traffic incidents and/or emergencies.

(b) The Contractor will:

(i) minimize traffic disruption and maximize traffic predictability;

(ii) prepare clear, consistent and accessible Work and traffic information for Hydro's Representative;

(iii) communicate Work and traffic information to Hydro's Representative in a timely manner;

(iv) support BC Hydro's communications, community relations and media relations activities by supplying timely and accurate information to Hydro's Representative about the Work; and

(v) perform the Work in compliance with the supporting role traffic management plan.

Compliance with the supporting role traffic management plan will not relieve the Contractor of any of its duties, obligations or responsibilities under the Contract to perform the Work in accordance with the requirements of the Contract Documents.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 10

SAFETY

TABLE OF CONTENTS

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 10

SAFETY

1 INTERPRETATION

1.1 Definitions

In this Schedule 10 [Safety], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Construction Safety Officer**" has the meaning set out in Section 2.5 of this Schedule 10 [Safety];

"**Contractor's Work Area**" means the area where the Contractor will perform the Work as defined by the Contract Documents;

"**CSMP**" means the Site C Clean Energy Project Construction Safety Management Plan dated June 5, 2015, a copy of which has been provided to the Contractor by BC Hydro prior to the Effective Date;

"**CSSMP**" means the Contractor Site Safety Management Plan referred to in BC Hydro's CSMP. The CSSMP can be considered equivalent and interchangeable with the term "SSMP", which is required from all contractors prior to starting work, for detailing and controlling site hazards during construction activities;

"**Emergency Response Plan**" has the meaning set out in Section 5.1 of this Schedule 10 [Safety];

"**Hazardous Material**" means substances defined in Part 5 of the OSHR and WHMIS legislation;

"**Multiple Employer Workplace**" has the meaning set out in Section 118 of the *Workers Compensation Act* (British Columbia) and in WorkSafeBC Regulation Part 20.3 (2) "a work location has overlapping or adjoining work activities of 2 or more employers that create a hazard to workers";

"**Notice of Failure to Comply**" has the meaning set out in Section 5.5(a) of this Schedule 10 [Safety];

"**Occupational Health & Safety Management Program**" or "**OHSMP**" has meaning set out in Part 3.3 of the Occupational Health and Safety Regulation (BC);

"**OHSR**" means the *Occupational Health and Safety Regulation* (British Columbia);

"**Prime Contractor**" has the meaning set out in Section 118 of the *Workers Compensation Act* (British Columbia);

"**Qualified**" has the meaning ascribed to it in Part 1 of the OHSR;

"**Qualified Site Safety Coordinator**" has the meaning set out in Section 2.4 of this Schedule 10 [Safety];

"**Safe Work Procedures**" has the meaning set out in Section 3.2 of this Schedule 10 [Safety];

"**Safety Area**" has the meaning set out in Section 2.1 of this Schedule 10 [Safety];

"**Safety Audits and Inspections**" has the meaning set out in Section 7.1 of this Schedule 10 [Safety];

"**Safety Laws**" has the meaning set out in Section 3.1(a) of this Schedule 10 [Safety];

"**Safety Minimum Requirements**" or "**SMR**" has the meaning set out in Section 3.1(b) of this Schedule 10 [Safety];

"**Site Safety Management Plan**" or "**SSMP**" has meaning set out in Section 3.1 of this Schedule 10 [Safety];

"**Work Area"** means any area at the Site in which work will be performed for the construction of the Project;

"**WorkSafeBC**" means the Workers Compensation Board of British Columbia; and

"**WPP**" has the meaning set out in Section 3.6 of this Schedule 10 [Safety].

2 GENERAL OCCUPATIONAL HEALTH AND SAFETY REQUIREMENTS

2.1 Safety Areas

For the purposes of safety, BC Hydro may divide the Site into a number of areas (each a "**Safety Area**") and designate a specific contractor as the Prime Contractor for each Safety Area. A Safety Area may be comprised of the Contractor's Work Area, Others' work areas, an area of ancillary use such as a storage area or laydown area and roads and access lands. Any Safety Area may be a Multiple Employer Workplace such that more than one contractor may be required to use, perform work in or pass through the Safety Area.

The drawings attached at Appendix 10-2 [Safety Area Drawings] describe designated Safety Areas at the Site that will be in effect during the time periods as specified on the drawings. The Contractor will perform the Work in accordance with the safety requirements as required by the applicable Prime Contractor for the Safety Area in which the Work is being performed, and will fulfill all obligations and requirements of a contractor working under a Prime Contractor as required by Safety Laws. If the Contractor needs to pass through other Safety Areas, the Contractor will follow all safety instructions of the Prime Contractor for those Safety Areas.

2.2 General Duties of the Contractor

The Contractor will:

(a) ensure the health and safety of all workers working for the Contractor, and any other workers present at the workplace at which that the Contractor's Work is being carried out;

(b) comply with the *Workers Compensation Act* (British Columbia), the OHSR and any applicable orders;

(c) remedy any workplace conditions that are hazardous to the health or safety of the Contractor's workers;

(d) ensure that the Contractor's workers are made aware of all known or reasonably foreseeable health or safety hazards to which they are likely to be exposed by their work, comply with the *Workers Compensation Act* (British Columbia), the OHSR and any applicable orders, and are made aware of their rights and duties under the *Workers Compensation Act* (British Columbia) and the OHSR;

(e) provide to the Contractor's workers the information, instruction, training and supervision necessary to ensure the health and safety of those workers in carrying out their work and to ensure the health and safety of other workers at the workplace;

(f) maintain the workplace in a manner that ensures the health and safety of persons at or near the workplace. At all times have full regard for the safety of all persons on the Safety Area (whether such persons are present on the Safety Area lawfully or not) and will keep the Safety Area in a manner and in an orderly state that ensures the safety of such persons and that is appropriate to the avoidance of danger in the Safety Area of a Prime Contractor; and

(g) prior to leaving the area at the conclusion of work in the Contractor's Safety Area, the Contractor will take all practical measures to ensure the Safety Area is free of all hazards created by the work and all safeguards are in place to protect the health and safety of persons entering the Safety Area.

In the event that it is not possible to implement all of the safeguards required to eliminate the hazards, the Contractor will communicate this information to the Prime Contractor.

2.3 Contractor's Duties to the Prime Contractor

The Contractor will:

(a) take all steps or measures necessary, through such arrangements as are appropriate, to comply with the directions of the Prime Contractor;

(b) coordinate the activities of all of the Contractor's workers in the Safety Area so that the activities of the Contractor's workers do not pose any risk to the workers of another employer;

(c) comply with applicable components of an operating plan that may be agreed to between the Prime Contractor and a third-party regarding rail operations within the Safety Area;

(d) establish and maintain a system or process that will ensure compliance with the Safety Laws by the Contractor, the Contractor's workers and any of the Contractor's subcontractors in respect of the Safety Area; and

(e) identify and document to the Prime Contractor any work activities at the workplace where there is a known or reasonably foreseeable risk to workers.

2.4 Qualified Site Safety Coordinator

Prior to the commencement of any construction within the Safety Area, the Contractor will appoint a Qualified person (the "**Qualified Site Safety Coordinator**") to coordinate the Contractor's health and safety activities for the Safety Area with respect to the work and deliver to Hydro's Representative written notice of the designation of the Qualified Site Safety Coordinator. The duties of the Qualified Site Safety Coordinator will be:

(a) establishing and maintaining working relationships with WorkSafeBC and BC Hydro;

(b) prior to the commencement any Construction prepare and deliver under the Review Procedure a schedule of safety activities demonstrating implementation of the Contractor's Site Safety Management Plan;

(c) identifying and documenting all new hazards that arise during the performance of the Work for the Contractor's and Subcontractor's workers;

(d) identifying and documenting any activities at the workplace that could create a known or reasonably foreseeable risk to workers and informing the Prime Contractor of the activities and the hazards;

(e) preparing or causing to be prepared a set of written construction procedures designed to protect the health and safety of workers at the Safety Area;

(f) conducting documented site safety inspections at a frequency that prevents the development of unsafe conditions or procedures in the Safety Area; and

(g) advising the Prime Contractor of any accidents or incidents that occur in the Safety Area including those that must be reported to WorkSafeBC.

2.5 Construction Safety Officers

The Contractor will appoint a sufficient number of Qualified construction safety officers (each a "**Construction Safety Officer**"), having responsibility for the identification and control of potential safety Hazards for the work, in accordance with applicable Safety Laws. The Contractor will ensure that during the performance of all construction activities on the Safety Area, at least one Construction Safety Officer is at the Safety Area and available for every 200 construction workers. A Construction Safety Officer will demonstrate the requisite degree of training and competency to act in that capacity, as required by WorkSafeBC.

3 SITE SAFETY MANAGEMENT PLAN

3.1 Preparation and Submission

Within 60 days after the Effective Date, and in any event, at least 20 days before commencing any Work at the Site, the Contractor will prepare and submit the Contractor's Site Safety Management Plan ("**Site Safety Management Plan**" or "**SSMP**") to the Prime Contractor's representative for review. The SSMP will be prepared by a Qualified Person who will certify that the SSMP:

(a) has been prepared in accordance with the requirements of *Workers Compensation Act* (British Columbia) and OSHR and all applicable Laws and the Safety Regulations (the "**Safety Laws**");

(b) meets the minimum standards of health and safety for each specified component of the Work, as determined by the applicable safety policies or standards (the "**Safety Minimum Requirements**" or "**SMR**");

(c) is in compliance with the Safety Standards and Regulations described in item 3 of Appendix 2-1 [BC Hydro's Policies and Procedures];

(d) is in compliance with Good Industry Practice and Appendix 10-1 [Safety Minimum Requirements];

(e) addresses overall management of occupational safety, health and wellness and addresses mitigation of any risks due to occupational health and safety hazards associated with the Project, the Contractor's Work Area and the performance of the Work. The SSMP will define the safety purpose, responsibilities, strategies and plans that direct the Contractor, its employees, its Subcontractors and its Subcontractors' employees with a key focus made to those components of the Work, including cooperation with Other Contractors, BC Hydro and other persons at the Site;

(f) addresses the development of emergency response plan in communication with the Prime Contractor;

(g) contains the 'Life Saving Rules' as described in Section 3.3 of this Schedule 10 [Safety];

(h) includes a comprehensive physical and operational security program; and

(i) includes the Safe Work Procedures as required by Section 3.2 of this of this Schedule 10 [Safety].

3.2 Safe Work Procedures

Prior to commencing any activities at the Site and as part of the SSMP, the Contractor will develop and submit a set of written instructions identifying the health and safety hazards associated with the performance of each type of activity associated with the performance of the Work ("**Safe Work Procedures**") to the Prime Contractor's representative for review as to completeness. The Contractor will engage a Qualified Person knowledgeable in the applicable WorkSafeBC Regulation and work procedures to prepare each set of Safe Work Procedures. Each set of Safe Work Procedures will:

(a) address all Site specific safety hazards and work procedures necessary to address those hazards for the safe performance of the specific type of Work activity;

(b) be prepared in accordance with the requirements of the CSMP and the Contractor's OSH Program;

(c) include safe work procedures and exposure control plans applicable to the Site and the performance of the specific type of Work activity;

(d) include reference to hot work precautions including a permitting system;

(e) be prepared in accordance with WorkSafeBC requirements;

(f) be consistent with Appendix 10-1 [Safety Minimum Requirements]; and

(g) specifically identify the applicable procedures in the event of an accident or safety violation.

The Contractor will review and amend the Safe Work Procedures as necessary to reflect changes to work procedures. The Contractor will submit the amendments to the Safe Work Procedures to the Prime Contractor's representative for review as to completeness.

The Contractor will implement and comply with the Safe Work Procedures, and require all Subcontractors to comply with the Safe Work Procedures, prepared and as may be amended from time to time in accordance with the requirements of this Schedule 10 [Safety].

3.3 Life Saving Rules

The Contractor will ensure compliance with the following lifesaving rules by all the Contractor's workers and subcontractors on the Safety Area as part of the Site Safety Management Plan:

(a) maintain your Limits of Approach;

(b) ensure there is a Safety Protection Guarantee or Lock out in place and check that it is appropriate for your work;

(c) test for hazardous energy;

(d) ensure that Worker Protection Grounding/Bonding is applied;

(e) protect yourself from falling when working at height;

(f) maintain a safe atmosphere in a confined space and ensure you can be rescued;

(g) prevent harmful exposure to known carcinogens, toxins and bio-hazards;

(h) do not work while under the influence of alcohol or drugs; and

(i) adjust your driving to the weather and road conditions.

3.4 Amendment of SSMP

The Contractor will review and amend the SSMP when hazards change to ensure that the SSMP at all times complies with the requirements set out in Section 3.1 of this Schedule 10 [Safety]. The Contractor will submit the amendments to the SSMP to the Prime Contractor's representative for review.

3.5 Compliance to SSMP

The Contractor will implement and comply with the SSMP, and require all Subcontractors to comply with the SSMP, prepared and as may be amended from time to time in accordance with the requirements of this Schedule 10 [Safety].

3.6 Safety Requirement for Work Connected to the Electrical Grid

Before any station equipment can be connected to the electrical grid and at such time that BC Hydro's representative advises, the Contractor will ensure all workers are trained to the level of knowledge set out in and comply with BC Hydro's Safety Practice Regulations (SPR), Work Protection Practices ("**WPP**"), and lockout procedures. The Contractor will train or cause to be trained all persons engaged in the performance of the Work to a minimum of Category B under WPP before the equipment is connected to the grid and from connection time forward all persons working on the equipment must maintain WPP certification to the level required by the work being done. Equipment that has been deemed to be connected to the electrical grid includes equipment that, while not explicitly connected to the electrical grid, can affect the operation of the electrical grid.

3.7 Isolation

If a Contractor requires a change to the equipment isolation and lockout procedures to accommodate the performance of the Work on equipment that has been deemed to be connected to the electrical grid, the Contractor will submit a lockout procedure change request to the Prime Contractor's representative a minimum of three days in advance of the required change. BC Hydro will perform the requested switching and isolation at no charge to the Contractor. Notwithstanding the foregoing, BC Hydro will not be responsible for any costs associated with any delays or interruptions of the Work arising from changes to isolation of equipment requested by the Prime Contractor.

4 WORKSAFEBC

4.1 WorkSafeBC Requirements

Within 60 days after the Effective Date but, in any event, before commencing any Work at the Site, and at any time on written request from Hydro's Representative, the Contractor will deliver to BC Hydro a statement from WorkSafeBC that each Subcontractor is registered and paying its premiums as required.

4.2 Indemnity for WCB Non-Compliance

If the Contractor or anyone employed by or through the Contractor in the performance of any Work does not comply with the requirements of the *Workers Compensation Act* (British Columbia), including payment and deduction and remittance of any and all contributions, premiums, fees, assessments and charges required to be made thereunder, the Contractor will indemnify BC Hydro from any cost, loss, liability or obligation which BC Hydro may incur as a result.

4.3 Failure to Comply with WorkSafeBC Requirements

If at any time the Work or portion of the Work is stopped because the Contractor, or any Subcontractor fails or refuses to comply with an order issued pursuant to the *Workers Compensation Act* (British Columbia), then such failure or refusal will be deemed to be a default to which the provisions of Section 13.1 of Schedule 2 [Design and Construction Protocols] will apply.

5 SAFETY REQUIREMEMENTS

5.1 Emergency Response Plan

The Contractor will prepare an emergency response plan (the "**Emergency Response Plan**") which:

(a) outlines the warning systems for evacuation that will be in place;

(b) provides the Contractor's (including all Subcontractors) emergency response protocol and procedures for safely managing potential emergency situations within the Safety Area; and

(c) defines the detailed safe, effective and timely evacuation procedures in the event of an emergency at the Site.

The Contractor will submit the Emergency Response Plan to the Prime Contractor's representative for review as to completeness.

5.2 Amendment of Emergency Response Plan

The Contractor will review and amend the Emergency Response Plan as required during the performance of the Work so that it at all times covers the Work being performed. The Contractor will submit the amendments to the Emergency Response Plan to the Prime Contractor's representative for review as to completeness.

5.3 Compliance to Emergency Response Plan

The Contractor will implement and comply with the Emergency Response Plan, and require all Subcontractors to comply with the Emergency Response Plan, prepared and as may be amended from time to time in accordance with the requirements of this Schedule 10 [Safety].

5.4 Safety Training

The Contractor will, with respect to the performance of the Work, and will ensure that subcontractors with respect to their work, develop, implement, monitor and update any and all training programs required to train their employees in the hazards of the site and Work and the safe and proper performance of the Work. A safety training program will:

(a) comply with all requirements of WorkSafeBC;

(b) be delivered by Qualified persons;

(c) include orientation of all workers;

(d) identify and address both general and task specific hazards;

(e) address the rights, obligations and duties of all persons engaged in the performance of the Work with respect to occupational health and safety;

(f) address the potential consequences of non-compliance with the Safety Management Plan;

(g) be tailored to the tasks, duties and responsibilities of each person engaged in the performance of the Work;

(h) include mechanisms for participants to evaluate and provide feedback with respect to the safety training sessions;

(i) be modified as and when required to respond to participant evaluations and feedback;

(j) be provided free of charge to all persons engaged in the performance of the Work during normal working hours; and

(k) include such tests as may be necessary to ensure that participants understand the material covered in the safety training sessions.

The Contractor will maintain list or database of all personnel with required and completed training, available at reasonable intervals for examination by others.

5.5 Failure to Comply

If the Prime Contractor determines in its reasonable discretion that any employer or an employer's worker performing work within the Safety Area is creating an unsafe or harmful condition or is doing or failing to do something that constitutes an unsafe or harmful act, or has failed to comply with the *Workers Compensation Act* (British Columbia), the OHSR, BC Hydro Safety Standards and Regulations or the Prime Contractor's health and safety program, and that on written notice from the Prime Contractor to the employer responsible for such of such condition, act or failure that the employer has failed or refused to take action to correct the condition, act or failure, including any condition, act or failure of a worker, then:

(a) the Prime Contractor may issue a written notice ("**Notice of Failure to Comply**") to the applicable employer stipulating in reasonable detail the basis for the issuance of the Notice of Failure to Comply, with a copy to Hydro's Representative;

(b) on receipt of a Notice of Failure to Comply BC Hydro may, in reliance on the Notice of Failure to Comply, take whatever action it deems necessary to reduce or eliminate risk to workers;

(c) on rectification of the condition, act or failure set out in a Notice of Failure to Comply issued by the Prime Contractor, the Prime Contractor will withdraw the Notice of Failure to Comply by endorsing on a copy thereof confirmation of the rectification, and the Prime Contractor will deliver a copy of the endorsed Notice of Failure to Comply to the applicable employer and to Hydro's Representative, and in reliance on such receipt BC Hydro may take steps to permit the resumption of work; and

(d) BC Hydro will be deemed to have relied on the terms of and the reasons set out in the Notice of Failure to Comply, and a subsequently endorsed Notice that the condition has been rectified, notwithstanding any subsequent investigation or inquiry of the matter by BC Hydro, which BC Hydro may but will not be obligated to undertake, and the Prime Contractor will indemnify and hold harmless BC Hydro in connection with any and all Claims arising in connection with the issuance of any Notice of Failure to Comply by the Prime Contractor, or the subsequently endorsed Notice, and any acts or omissions of BC Hydro in reliance on such Notices.

6 SAFETY MEETINGS

6.1 Compliance, Participation, Attendance and Documentation

The Contractor will provide all documents, attend all meetings and conduct activities as required by the OSHR. The Contractor will cause its representative and its Subcontractors' senior site representative to attend all safety meetings.

6.2 General Meetings

The Contractor's Site Safety Coordinator will regularly attend any Site meetings, including:

(a) Joint Health and Safety Committee meetings required under the *Workers Compensation Act* (British Columbia); and

(b) Site safety coordination meetings.

7 AUDITS AND INSPECTIONS

7.1 Access to Work Area, Personnel and Records

The Contractor will allow BC Hydro and its agents' unrestricted access to carry out safety inspections and audits of Site Work, worksite conditions and all pertinent health and safety performance records to determine adherence to safety and health objectives ("**Safety Audits and Inspections**"). BC Hydro and its agents' personnel may carry out Safety Audits and Inspections without prior warning or notice to the Contractor. The Contractor will, during Safety Audits and Inspections, provide evidence of, or establish demonstrated compliance with, Safety Laws, the Site Safety Management Plans (SSMP) and Good Industry Practice.

7.2 Workplace Safety Audits

The Contractor will conduct workplace safety audits in accordance with Good Industry Practice at least once each month during the period between the Effective Date and the Total Completion Date.

Workplace safety audits will be conducted by the Contractor's Site Safety Coordinator. Workplace safety audits will measure the effectiveness of the Contractor's occupational health and safety systems and determine the Contractor's compliance with the OHSMP, the applicable SSMP's, Safe Work Procedures and Safety Regulations.

The Contractor will review all workplace safety audit findings with the Prime Contractor's representative responsible for the Work Area being audited and will determine and implement corrective action for all identified nonconformities.

On or before the last day of each month, the Contractor will prepare and submit to the Prime Contractor's representative, for information only, a completed audit report.

The Contractor will promptly remedy all unsafe conditions and procedures and provide a report back to the Prime Contractor's representative confirming that the applicable issue has been remedied.

7.3 Response to Safety Deficiencies

If, in the opinion of BC Hydro, the Contractor's Work or operations pose an undue hazard, BC Hydro may shut down the Work until such time as the conditions are corrected. BC Hydro may verbally order the Contractor's Representative to shut down the work effective immediately, and deliver notice in writing of the order to the Prime Contractor's representative within 48 hours after giving the verbal order. The

Contractor will not be entitled to any compensation or payment from BC Hydro for any costs the Contractor incurs by reason of such shutdown or the implementation of corrective safety measures.

On or before the last day of each month the Contractor will prepare and submit to Hydro's Representative a statistical report, in the form provided by Hydro's Representative, of all safety deficiencies. The Contractor will maintain such reports in accordance with Schedule 15 [Records]. The Contractor will document the implementation of all corrective actions and will, on a monthly basis, provide proof of the implementation of all corrective actions to BC Hydro.

7.4 Annual Audit

The Contractor will cause an independent third party, acceptable to BC Hydro, to conduct an audit of the Contractor's OHSMP to the BC Construction Safety Association's standard, not less than once each calendar year during the duration of the Contract, in order to assess the Contractor's compliance with, and implementation of, the OHSMP, as required by the Safety Laws and this Schedule 10 [Safety].

The Contractor will submit the independent auditor's report to BC Hydro within one week of the anniversary of the completion of the previous annual audit in accordance with the Review Procedure, and in any event within 14 days after receipt.

8 ACCIDENTS AND INCIDENTS

8.1 Accident and Incident Reporting

The Contractor will:

(a) immediately notify WorkSafeBC, the Prime Contractor and BC Hydro of any incident if the incident involves serious injury or death, public safety, a public near-miss incident, a major structural failure or collapse, a major release of Hazardous Material, or any other circumstance which is required to be reported pursuant to Safety Laws. For the purposes of this Section 8.1(a), the Contractor will use the incident report form set out in Appendix 10-3 [Contractor Safety Incident Report Form], or such other form as Hydro's Representative may from time to time require;

(b) where an incident investigation report is required pursuant to the *Workers Compensation Act* (British Columbia), prepare and submit a report to WorkSafeBC, and concurrently deliver a copy of such report to the Prime Contractor and BC Hydro; and

(c) follow and adhere to BC Hydro's Incident Management System requirements.

9 PUBLIC SAFETY

9.1 Public Safety Management Plan

The Contractor will collaborate with the Prime Contractor to develop a Public Safety Management Plan in accordance with Section 5.3 of the CSMP and submit the Public Safety Management Plan to the Prime Contractor's representative for review as to completeness. The Contractor will implement and comply with the Public Safety Management Plan, and require all Subcontractors to comply with the Public Safety Management Plan, prepared in accordance with the requirements of this Schedule 10 [Safety].

10 WORKER HEALTH AND SAFETY MANAGEMENT PLAN

10.1 Worker Health and Safety Management Plan

The Contractor will develop a Worker Health and Safety Management Plan in accordance with Section 5.5 of the CSMP. For the purposes of this Contract, the Worker Health and Safety Management Plan will be considered to be the Site Safety Management Plan.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS

APPENDIX 10-1

SAFETY MINIMUM REQUIREMENTS

OPERATIONAL FIELD SUPPORT PLANNING AND REVIEW

Project Short Name:	Site C Clean Energy Project		
Project Description:	Installation of turbines and generators		
Project Phase:			
Occupational Health & Safety Specialist:	Natalee Williams	Date Created: Nov 11 2014	

Project Information

Level of Risk for this Project

☒ **High** ☐ **Moderate** ☐ **Low**

BCH Safety Region:	Peace River Region Northeastern BC	Business Group:		Facility of Asset:	
Construction Start Date:		Site Location/ Identification Description(s):	Located on the Peace River approximately 15 kms east of Fort St John BC and downstream of the GMS and Peace Canyon Generating Stations.		
Construction End Date:					

Project Description for Safety Management Purposes:

This project requires the preparation for and installation of the turbines and generators for the six 183 MW generating units within the project scope of the Site C Clean Energy Project (Site C), a third dam and hydroelectric generating station under development on the Peace River in northeast B.C.

Background and Instructions for Use

About Contractor OH&S Programs

All contracting organizations are required to have an OH&S program as defined in the Occupational Health and Safety Regulation of British Columbia (OHSR) including all seven essential elements outlined in OHSR Section 3.3. The OH&S program is typically reviewed as part of the BC Hydro procurement process and may be reviewed by the

Prime Contractor for completeness.

What is a BC Hydro "Safety Minimum Requirements" (SMR) document?

A "Safety Minimum Requirements" or "SMR" document (this document) is part of BC Hydro's Project Safety Planning System. The SMR is intended to consistently and clearly outline the base expectations of the owner for any project work. Most importantly, this is the guide for contractors to be empowered to efficiently build an effective site safety management plan (SSMP)

About Contractor Safety Management Plans (SSMP) –

All contracting organizations are required to have a site-specific safety management plan (SSMP) that covers all personnel at site. There is no such thing as a generic safety plan – each safety management plan must address the work, hazards and specific conditions of the work site.

The required depth and scope of the SSMP is guided by:

- The risk and complexity of the project including contemplated work, work methods and work environment
- Applicable safety regulations as well as BC Hydro requirements.

The Prime Contractor will review your SSMP prior to commencing work to ensure that it provides reasonable evidence to the Prime Contractor that the SSMP is complete. BC Hydro expects that the SSMP will be adhered to and be a living document that is updated as needed when changes to contemplated work, work methods or work environments occur.

Disclaimer

The information presented in this document is intended to provide information on safety management requirements only for the specific project described. This is not a definitive guide to government legislation or BC Hydro policies. This information does not relieve persons, organizations or other entities from their responsibilities under applicable legislation or BC Hydro policies. BC Hydro does not guarantee the accuracy of, and does not assume liability for, the information presented. Errors and omissions may occur. All information is subject to change without notification. Paper copies of this document are not controlled – users of this document are responsible to ensure that they are relying upon the correct information and to inquire about any updates that may be released.

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Foundational Requirements for Safety Management

Foundational Requirement 1	**OH&S Program Required for all Contractors**

All contracting organizations must have an OH&S program that has been reviewed by BC Hydro or the Prime Contractor prior to work commencing. The OH&S program must be available at the work site and a copy must be on file with BC Hydro. Out-of-province contractors must ensure that they are able to provide evidence that they are able to meet regulatory requirements for the Province of British Columbia. In some cases, "less formal" OH&S programs may be acceptable; it is the contractor's responsibility to verify this.

At a minimum, the OH&S program must provide for the following (see OHSR Section 3.3 (BC) or WorkSafeBC):

1. An OHS policy for your organization. 2. Regular inspection of premises, machinery, tools, equipment, and work practices. 3. Written instructions (safe work procedures) to guide workers in the safe performance of their jobs. 4. Regularly scheduled management meetings. 5. Investigation of incidents, injuries, and diseases. 6. The keeping of safety Records and statistics. 7. Instruction and supervision of workers.
"No OH&S Program, No Work"

Foundational Requirement 2	**Site-Specific Safety Management Plan (SSMP) Required for all Sites**
All contracting organizations must have a Site-Specific Safety Management Plan (SSMP) that has been reviewed by BC Hydro or the Prime Contractor prior to work commencing. There is no such thing as a generic SSMP – each SSMP must address the work, hazards and specific conditions of the work site. The SSMP must be available at the work site and have been clearly communicated to all persons at site.	
"No Site-Specific Safety Management Plan, No Work"	

Required Elements of a Site-Specific Safety Management Plan

Element 1	**Safety Communications and Record Requirements**
The contractor's SSMP will include: • The **name and contact information** of the person-in-charge of the project. • The **name and contact information** of the person-in-charge of the project on site. • The **name and contact information** of the person responsible for safety on the project. • Copies of all **forms** utilized for safety communications such as safety orientations, tailboards, meetings and other safety activities. The contractor SSMP must provide written evidence of a means to maintain all current and historical records at site.	

<table>
<tr><td>Element 2</td><td>Compliance with BC Hydro Standards</td></tr>
<tr><td colspan="2">The contractor SSMP will include <u>all</u> relevant BC Hydro Life Saving Rules

Safety Practices Regulations, and Safety Publications that are <u>relevant</u> to the work, hazards and specific conditions of the work site. This information is available for contractors at:
https://extranet.bchydro.com/sites/safety/default.aspx
If you do not have an existing password, please contact ExtranetUserRequests@bchydro.com
If you do not have access to the extranet site you may use this alternative web page</td></tr>
<tr><td>Element 3</td><td>Hazard Identification and Risk Assessment</td></tr>
<tr><td colspan="2">The contractor SSMP will include their own list of <u>all</u> hazards, risks and planned mitigations related to the contemplated work, work methods and work environments. Information on the hazards related to this project and known by the owner is included in Appendix A.</td></tr>
<tr><td>Element 4</td><td>Occupational Health and Industrial Hygiene</td></tr>
<tr><td colspan="2">The contractor SMP will include provisions for developing exposure control plans for <u>all</u> identified Occupational Health and Industrial hygiene hazards such as silica, H2S and lead or asbestos. Exposure control plans must be submitted to BC Hydro and or the Prime Contractor for review 10 days prior to starting work.</td></tr>
<tr><td>Element 5</td><td>First-Aid, Emergency Response and Rescue Response</td></tr>
<tr><td colspan="2">The contractor SSMP will include <u>relevant</u> response plans for first-aid, emergencies and rescue as are required given the contemplated work, hazards and specific conditions of the work site. A First Aid Assessment form is available at WorkSafeBC website http://www2.worksafebc.com/PDFs/firstaid/First_aid_assessment_worksheet.pdf .</td></tr>
<tr><td>Element 6</td><td>Safe Work Procedures</td></tr>
<tr><td colspan="2">The contractor SSMP will include safe work procedures for <u>all</u> work related to the power system and for all high-hazard or non-routine work as identified in the contractor hazard identification and risk assessment such as work within WPP boundaries, confined space entry, abrasive blasting, work from heights, lead abatement, work with silica or other work. Safe work procedures must be submitted to BC Hydro and or the Prime Contractor for review 10 days prior to this work starting.</td></tr>
<tr><td>Element 7</td><td>Training and Competence</td></tr>
<tr><td colspan="2">The contractor SSMP will include a portfolio of training records for all personnel including name, job title/trade and evidence of completed and current training. Copies of training records or certificates must be available for review on site but not included in the SSMP.</td></tr>
<tr><td>Element 8</td><td>Personal Protective Equipment (PPE)</td></tr>
<tr><td colspan="2">The contractor SSMP will clearly identify the PPE required to perform the work and mitigate hazards and specific conditions of the work site.</td></tr>
</table>

Element 9	**Inspections**
The contractor SSMP will include the relevant **inspection activities** given the equipment, contemplated work, hazards and specific conditions of the work site. The activities must be aligned with expectation in the submitted contractor OH&S program.	

Element 10	**Near Miss Reporting**
The contractor SSMP will include provisions for: • Reporting and investigation of all incidents • Reporting all incidents without delay to the Prime Contractor representative.	

Element 11	**Subcontractor Management**
The contractor SSMP will include all relevant **safety information** for the work being performed by subcontractors. Considerations may include safe work procedures for the work performed by subcontractors and training records for subcontractor personnel.	

Project Specific Safety Requirements

The following specific safety requirements must be followed and included in SSMP if specified below.

Specific Safety Requirement #1	**Training**
WPP	
Once construction of equipment reaches a point where the BC Hydro Representative considers it necessary,(as outlined in 3.6 above) workers must receive a minimum WPP System Component Category A&B training. To register for training or to inquire about training, please contact the relevant BC Hydro representative.	
Site Orientation Contractor SSMP will state that all personnel will attend and participate in the Prime Contractor Safety Orientation before commencing work. In addition, the contractor is required to provide all workers with a Contractor New Worker orientation to communicate hazards specific to the scope and location of the work being performed. Orientation records must be maintained and be made readily available.	

Specific Safety Requirement # 2	**Work Involving "Boats", or "Swift Water"**

An acceptable contractor SSMP for this project must:
 	
• Comply with BC Hydro's OSH Standard 408-Operation of Boats
• Contain a **Standard or Rule** that for any work that may be done in and around rivers, lakes, reservoirs or other bodies of water, under the following conditions:
    ▪ working in river environments classified as low to high risk;
    ▪ construction project
    ▪ working from boats or barges	

- working in small team unsupervised;

- **Contain assurance that appropriate rescue training is provided to rescuers.**
- **Contain detailed information** on your company's specific safe work procedures that comply with relevant regulatory requirements to ensure safe working conditions where work will be in or around swift currents and/or in water and/or from boats.
- **Contain detailed information** on your company's specific safe work procedures that comply with relevant regulatory requirements to ensure safe working conditions where work methods may include snorkelling and/or other underwater work.

Specific Safety Requirement # 3	**Motor Vehicle Safety**

Worker transport vehicles owned and operated by the Contractor are responsible for all aspects of safety of the vehicle including condition, maintenance, operation, and use. Requirements apply under provisions such as Part 17 (Worker transportation) of the WorkSafeBC Regulation, and those under the **Motor Vehicle Act**.

Specific Safety Requirement # 4	**Public Safety Requirements**

BC Hydro and the Independent Parties performing work on BC Hydro Facilities must identify hazards that influence the public created by their operations. Assessing the risk of these hazards, and where applicable, implementing control measures will eliminate any risk to the public. Documenting, tracking, and maintaining any required control measures and reporting and investigating public safety incidents must be recorded and submitted to the BC Hydro and or Prime Contractor representative.

Workers must report unsafe conditions or practices to the Prime Contractor Site Representative responsible for corrective action.

Definition of a public incident means; any event involving BC Hydro property or personnel where there was an injury (public injury) or the potential for injury (public near miss) to the public.

SSMP Requirement- The following will be completed to ensure public safety:

- Hazard Identification
- Public Hazards, Control measures and safety devices procedures
- Regular Inspection and Maintenance
- Signs
- Interaction with Public Procedures

Specific Safety Requirement # 5	**Working Alone or in Isolation Requirements**

Prior to Contractor starting their work assignments, a working alone or in Isolation procedure must be submitted to BC Hydro and or the Prime Contractor for review.

Hazard identification must be completed identifying all hazards and the measure to eliminate the hazards and minimize the risk to the workers. The Contractor must minimize the risk from the hazard to the lowest level practicable using engineering controls, administrative controls or a combination of engineering and administrative controls.

Provincial and Federal Safety Authorities will be consulted to verify regulations and guidelines for Working Alone or in Isolation.

Specific Safety Requirement # 6	**Wildlife**

The requirements of an active and effective wildlife awareness program and to provide information on common animals and insects that may be encountered must be conducted.

Caution is necessary when travelling through wildlife habitats. Attacks upon humans in the wilderness are not common, but still present a risk. Insects are usually not dangerous if common sense precautions about exposure are taken.

The WorkSafeBC Occupational Health and Safety Regulation requires the development of effective written procedures in addition to education and training for workers who may be exposed to safety risks including bears, or other wildlife, and insects. An assessment of risk must be made for every place of work where some level of risk could reasonably be expected from wildlife.

As required by WorkSafeBC regulations, training of all employees who are exposed to the potential of encounters with bears, other wildlife and insects will be conducted. Training must be presented to all participants.

BC Hydro policy on weapons and firearms is explained in Corporate Policy – Security

Specific Safety Requirement # 7	**Winter Field Work**

Section 7.34(a) of the *WSBC Regulation* requires that a cold stress assessment be conducted if a worker is or may be exposed to conditions which could cause cold stress or injury, or could cause a worker's core body temperature to fall below 36°C (96.8°F), or fall below the "little danger" levels in the ACGIH table (see OHS Guidelines G7.33-2 and G7.33-3). Part of the cold stress assessment for hazardous exposure will include the potential for unplanned exposure.

Education and Training

This element will contain initial and ongoing training and education that will be provided to all workers who work in areas where there is a reasonable likelihood of exposure to conditions that could cause cold stress. The training and education material provided to workers who have not previously worked in a cold stress environment will include the following information:

Recognition of the signs and symptoms of impending hypothermia or excessive cooling of the body even when shivering does not occur

- Recognition of impending frostbite
- Proper re-warming procedures and appropriate first aid treatment
- Proper use of clothing
- Proper eating and drinking practices
- Safe work practices appropriate to the work that is to be performed

For those workers exposed to cold-stress environments, provide refresher training and education to ensure that workers remain knowledgeable about the above-mentioned items. It is recommended that continuing education be provided at least annually.

Specific Safety Requirement # 8	**Work Involving "Helicopters and Fixed Wing Aircrafts"**

- Must comply with BC Hydro's OSH Standard 407-Helicopter and Fixed-wing Aircraft Safety.
- BC Hydro contractors, who use helicopters, must choose helicopter vendors that meet or exceed the BC Hydro Helicopter policy and standards. This means that the contractor chosen helicopter vendors must have a signed helicopter safety management system which demonstrates:

- Policy on safe use of helicopters,
- Standard Operating Procedures,
- Pilot qualification in terms of flying hours, including utility wire environment experience where appropriate for the contract work,

- **SSMP must specify detailed information** on your company's specific safe work procedures that comply with relevant regulatory requirements to ensure safe working conditions where work will involve the use of helicopters or fixed wing aircraft.

Specific Safety Requirement # 9	**Hot Work**

The contractor SSMP must include the provision for participation in a Hot Work Permit program. Hot work permits will be administered to all contractors for implementation and will include:

i. Authorization from the Prime Contractor before hot work commences

ii. Dedicated and trained Fire Watch

iii. Precautions for the prevention of fire

iv. Mandatory checks after hot work has ceased

Specific Safety Requirement # 10	**Mobile Equipment / Cranes / Drill Rigs**

The contractor SSMP must include the following provisions

Equipment inspection daily prior to use and all findings documented in the equipment log books. Operators manuals must be in equipment or readily available at site. All workers will be wearing high vis clothing when working in proximity to mobile equipment. Fire extinguishers with up to date inspection tags must be on board. Rentals must have recent inspections and if applicable, up-to-date yearly NDT and dielectric testing.

Crane Operators must be certified by British Columbia Association for Crane Safety (BCACS) or Fulford Harbour Group (FHG) or the Industry Training Association (ITA). Crane operator's certification must be available on site at all times.

Specific Safety Requirement # 11	**PPE**

The contractor SSMP must include provision for Mandatory PPE for this work site. Minimum standards must include head protection, foot protection, high visibility clothing, and eye protection.

Specific Safety Requirement # 12	**Site Safety Coordination**

Ensure the following accountabilities are carried out by the Site Safety Coordinator for the safety area1. Establish a means of informing workers who the Site Safety Coordinator is and how to contact that individual.

2. Review the scope of work of all employers on site that might adjoin or overlap. These areas must be discussed with all employers on a multiple-employer workplace so that the hazards can be explained to affected workers.

3. Review all employers' site-specific work procedures before they begin work. 4. Conduct and document timely site safety co-ordination meetings to co-ordinate safe work activities.

5. Conduct regular site inspections, along with the employer safety representative, to identify work areas

where more than one employer is working. 6. Accompany the WorkSafeBC officer, along with the appropriate employer safety representative, on-site inspections. The results of the inspection must be posted in accordance with WorkSafeBC requirements. 7. Inform all employer safety representatives of the hazards and risks that arise at the work-site as work is in progress. 8. Transfer accountabilities and records to a successor if required.	
Specific Safety Requirement # 13	**Hazardous Materials / WHMIS**
If WHIMS controlled products are used in the workplace Prime Contractors, and Subcontractors must establish and maintain an effective WHMIS program, as part of the overall workplace health and safety program, the program will address the following: Applicable WHMIS Requirements including education and training is reviewed at least annually or more frequently if required by a change in work conditions or available hazard information. General WHMIS education, as it pertains to the workplace, must be provided to all workers. If there is a possibility of excessive exposure of lungs or skin to the use of strong solvents contractor must prepare a chemical exposure control plan that involves safe work procedures to control and prevent workers being exposed to this specific solvents and that will include adequate mechanical ventilation by the use of exhaust or other means of mechanical ventilation as prescribed in their respective site specific ECP. **MSDS must be available for all WHMIS controlled products brought onto the worksite.**	
Specific Safety Requirement # 14	**Concrete Cutting, Coring & Drilling**
Contractors will ensure that appropriate practices and Site Specific Safety Work Procedures including silica exposure control procedures are developed prior to work commencing.	

ATTACHMENT 1 – Owner Identified Hazards

This hazard identification process was completed considering BC Hydro’s existing knowledge of the work site. The contractor process must include verification of hazards identified by BC Hydro as well as any additional hazards based on their work methods or any other changes plus any control measures/safeguards/barriers planned or implemented to address them.

#	Hazard Type	Hazard Description
1.	**Travel to work-site**	• Public roadway from town of Fort St John with commercial and passenger vehicle traffic • Pedestrian traffic • School zones on route
2.	**Mobile equipment**	• Adjacent work by others may create mobile equipment hazards • Road maintenance work involves mobile equipment on right of ways and access routes • Steep slope areas
3.	**Power lines**	• Potential for electrical and overhead hazards
4.	**Height hazards**	• Work on steep slopes may require fall protection system • Work at heights must be conducted as per the regulatory requirements
5.	**Working over and/or near water**	• Worksite is located downstream of two generating stations on the Peace River • Swift water and frigid water temperature conditions exist • River water levels fluctuate due to upstream generating stations • Ice flows present on the river in the winter and early spring months • Spring run-off may contribute debris to be present on the river
6.	**Slips/Trips/Falls**	• Uneven terrain • Icy and slippery conditions present during fall and winter months • Large diameter boreholes present on site from previous work • All boreholes may not be correctly represented on site maps • Steep slopes
7.	**Wildfire**	• Fire hazards in the region vary but exist during spring & summer months – local authorities may limit work activities during extreme conditions • Precautions must be taken with any work activities or equipment that may create sparks as well as workers smoking on site • Contractor must ensure they follow all requirements of the Wildfire Act and Regulations
8.	**Communications issues**	• Potential for radio interference • Cell phone range on site is intermittent, sporadic or non-existent dependent on location • Inadequate communication of adjacent work may cause potential hazards
9.	**Emergency/Rescue**	• Potential for emergency response to be restricted due to road conditions • Prime contractor must ensure effective rescue exists for all work performed at this site • Emergency helicopter evacuation for an injured worker may be required

#	Hazard Type	Hazard Description
10.	**Site access and egress**	• Rain and snow cause extreme slippery conditions on service roads accessing areas on site • Site roads and access routes are narrow and winding restricting visibility for oncoming traffic and other roadway hazards • Steep grades on narrow roadways exist • Wildlife and domestic rangeland animals cause potential for vehicle incident • Passenger and commercial vehicle traffic present
11.	**Wildlife**	• Bears, cougars, wolves, coyotes, deer, elk and moose are local to the Site • Insects such as wasps, bees, spiders and hornets are known to inhabit the area • Insects present including black flies, mosquitoes and ticks present depending on season
12.	**Lighting**	• Limited daylight hours during late fall and winter seasons
13.	**Noise**	• Adjacent work and or equipment may create potential for noise hazards
14.	**Silica**	• Potential for crystalline silica dust exposure due to composition of sand and rock on site • Silica hazard dependent on contractor or adjacent work processes involving concrete placement or finishing • Must comply with BC Hydro's OSH Standard 318-Crstalline Silica
15.	**H2S and other hazardous gases**	• Oil and gas pipelines run through the site and potential for inadvertent release of hazardous gases exist
16.	**Weather**	• Freezing rain and snow during fall and winter months • Lightning and electrical storms occur in the region • Hot and dry conditions during summer months • Fog may limit visibility • Increased freezing temperatures with wind chill
17.	**Heat and cold stress**	• Potential for frost bite and or hypothermia during winter season • Hot weather during summer months may contribute to hyperthermia and heat stroke
18.	**Drinking water**	• Potable water may not be available at all areas of the project dependent on stage of development
19.	**General hygiene**	• Wash car facilities must be provided as per regulatory requirements
20.	**Public vehicle traffic**	• Potential for public using boats on the river • Potential for recreational vehicles to be on site roads and right of ways
21.	**Public interaction**	• Potential for aggressive behavior from public due to nature of project • Potential for hunters, hikers and other recreational land users to be in area
22.	**Avalanche hazards**	• Snow and ice build-up on the steep slopes at the work site may provide potential for avalanche hazards
23.	**Mud and rock slide hazards**	• Mud and rock slides from the steep slopes along the road have potential to occur due to weather conditions and slope stability
24.	**Danger trees**	• Woodland conditions may cause potential for danger trees to exist at or near access routes

#	Hazard Type	Hazard Description
25.	**Biological hazards**	• Giant Hogweed has been identified in the region and contains toxic sap that can cause severe burns • Poison ivy, thistle and other vegetation can cause skin irritation
26.	**Violence/Harassmen t in the workplace**	• Large multi-employer work site allows for potential for violence or harassment in the workplace • Public may also pose threat due to the nature of the project
27.	**Work alone or in isolation**	• Large and geographically diverse project site • Potential for inadequate communication due to radio interference or failure
28.	**Congestion**	• Large multi-employer work site may lead to overlap in work areas • Adjacent work by others may affect Contractor workers
29.	**Engulfment**	• Existing Dams are upstream of project, potential for engulfment if the WAC Bennett, and/or Peace Canyon dams fail or overflow
30.	**Typical construction hazards**	• Mobile equipment, cranes, civil construction, temporary electrical systems, formwork, scaffolding, manual handling and labour, excavations, confined spaces, work at heights, silica exposure, welding, noise are examples
31.	**Railway lines**	• Railway lines run through the worksite and there is a Siding (Septimus Siding) located within the site boundaries

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS

APPENDIX 10-2

SAFETY AREA DRAWINGS

The following Safety Area maps are attached to this Appendix 10-2 [Safety Area Drawings]:

(a) 1016-C14-A7735-1 R6 [Safety Areas Q1/Q2 2016 to Q4 - 2017];

(b) 1016-C14-A7750-1 R5 [Safety Areas Q4 - 2017 to Q4 - 2018];

(c) 1016-C14-A7750-2 R5 [Safety Areas Q4 - 2018 to Q3 - 2022]; and

(d) 1016-C14-A7750-3 R5 [Safety Areas Q3 - 2022 to Q4 - 2023].

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS

APPENDIX 10-3

CONTRACTOR SAFETY INCIDENT FORM

(see attached)

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

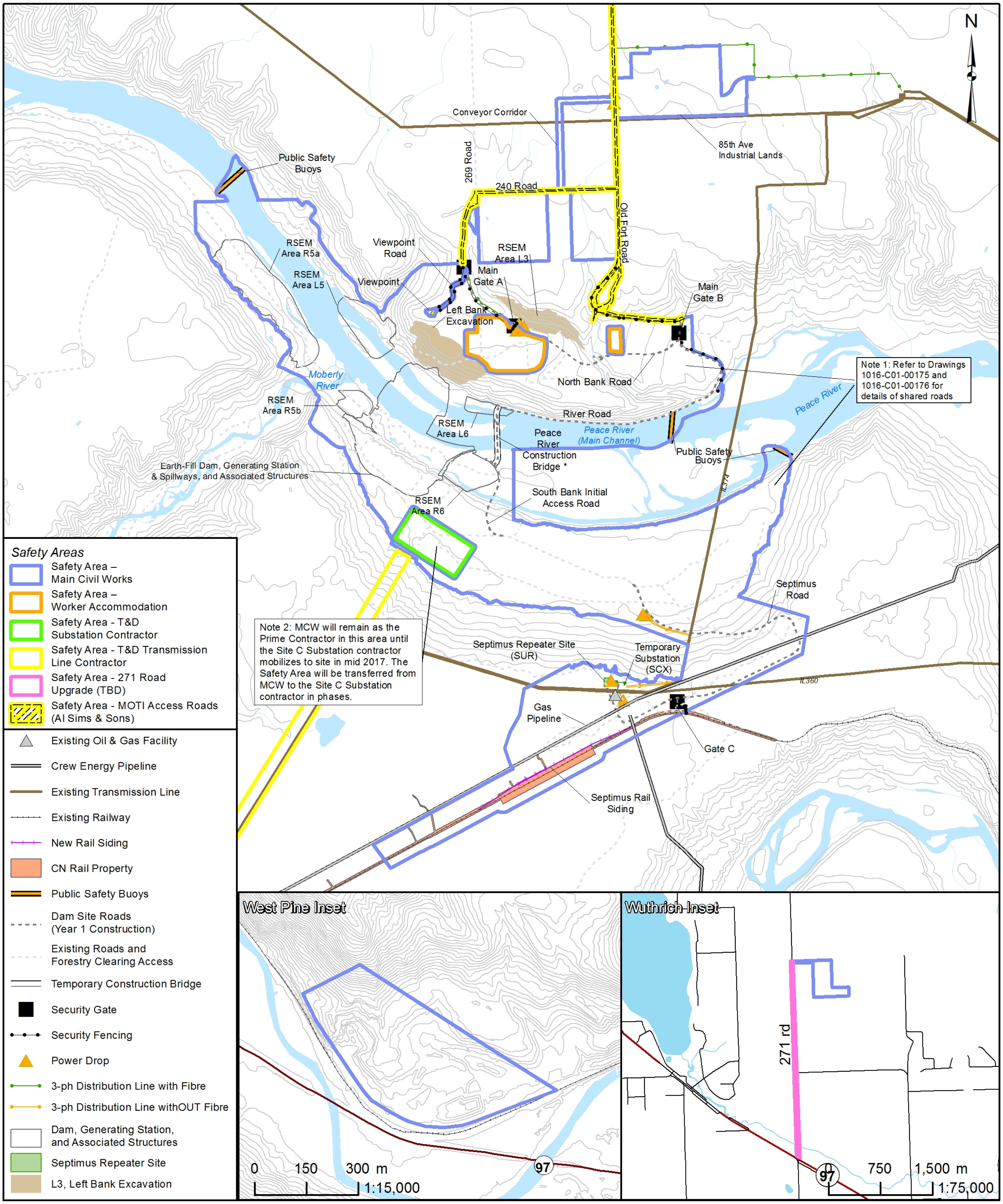
APPENDIX 10-4

BANNED OR REGULATED PRODUCTS

Product Category	Chemical of Concern	Status
Chlorinated Solvent	• Chloroethene • Dichloromethane (Methylene Chloride) • Tetrachloroethane • Tetrachloroethylene (Perchloroethylene or Perc) • Tetrachloromethane (Carbon Tetrachloride) • Trichloroethane (1,1,1-Trichloroethane or 1,1,2-Trichloroethane) • Trichloroethylene (Triclene, Trilene, Triklone, Trichlor, TCE, Trilex) • Trichloromethane (Chloroform)	Banned
CFC	• Trichlorofluoromethane (CFC 11, R 11, Freon 11) • Dichlorodifluoromethane (CFC 12, R 12, Freon 12, CEFOIN12, Dymel 12 • Trichlorotrifluoroethane (CFC 113, R 113, Genetron 113) • Dichlorotetrafluoroethane (CFC 114) • Chloropentafluoroethane (CFC 115)	Banned
HCFC	• Chlorodifluoromethane (R 22, HCFC 22, Genetron 22) • 1,1-Dichloro-1-fluoroethane (HCFC 141b) • 1-Chloro-1,1-difluoroethane (HCFC 142b) • 1,1 –Dichloro-2,2,3,3-pentafluoropropane (HCFC 225ca) • Dichloropentafluoropropane (HCFC 225cb)	Banned
HCFC 123	• 2,2-Dichloro-1,1,1-trifluoroethane (R 123, HCFC 123, Genetron 123)	Banned
Halon	• Bromochlorodifluoromethane (Halon 1211) • Bromotrifluoromethane (Halon 1301) • Dibromotetrafluoroethane (Halon 2402)	Banned
Wood Preservatives	• Creosote • Pentachlorophenol	Banned

Permissible Wood Preservatives	• Copper Naphthenate • Copper Chromated Arsenate (CCA) • Disodium Octaborate Tetrahydrate or Borates • Copper 8 Quinolinolate • Ammonical Copper Zinc Arsenate (ACZA) • Ammonical Copper Quat (ACQ) • Copper Azole • Copper Citrate	Banned, without the prior written approval of Hydro's Representative
Pesticides / Herbicides	• All pesticides and herbicides	Banned, without the prior written approval of Hydro's Representative

If, as a condition of any written approval permitting the Contractor to use any permissible wood preservatives, pesticides or herbicides identified in the above table, Hydro's Representative identifies any relevant BC Hydro policies, procedures and guidelines the Contractor is required to comply with for the use of such products, then the Contractor will comply with such policies, procedures and guidelines.



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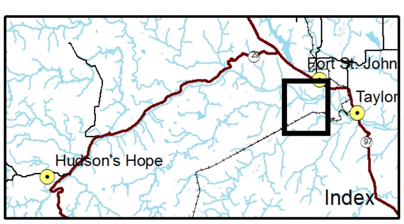

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. BC Hydro does not own or have rights to all the lands within the depicted areas, as of the date of this map.
5. The information on this map is based on the current project schedule and is subject to change.
6. Existing infrastrucutre is only shown where there is an overlap or interaction with work areas.

BC Hydro

Safety Areas
Q1/Q2 2016 to Q4 - 2017
Dam Site Area and Off-Site
Construction Material Sources

DATE	February 9, 2016	1016-C14-A7735-1	R 6

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Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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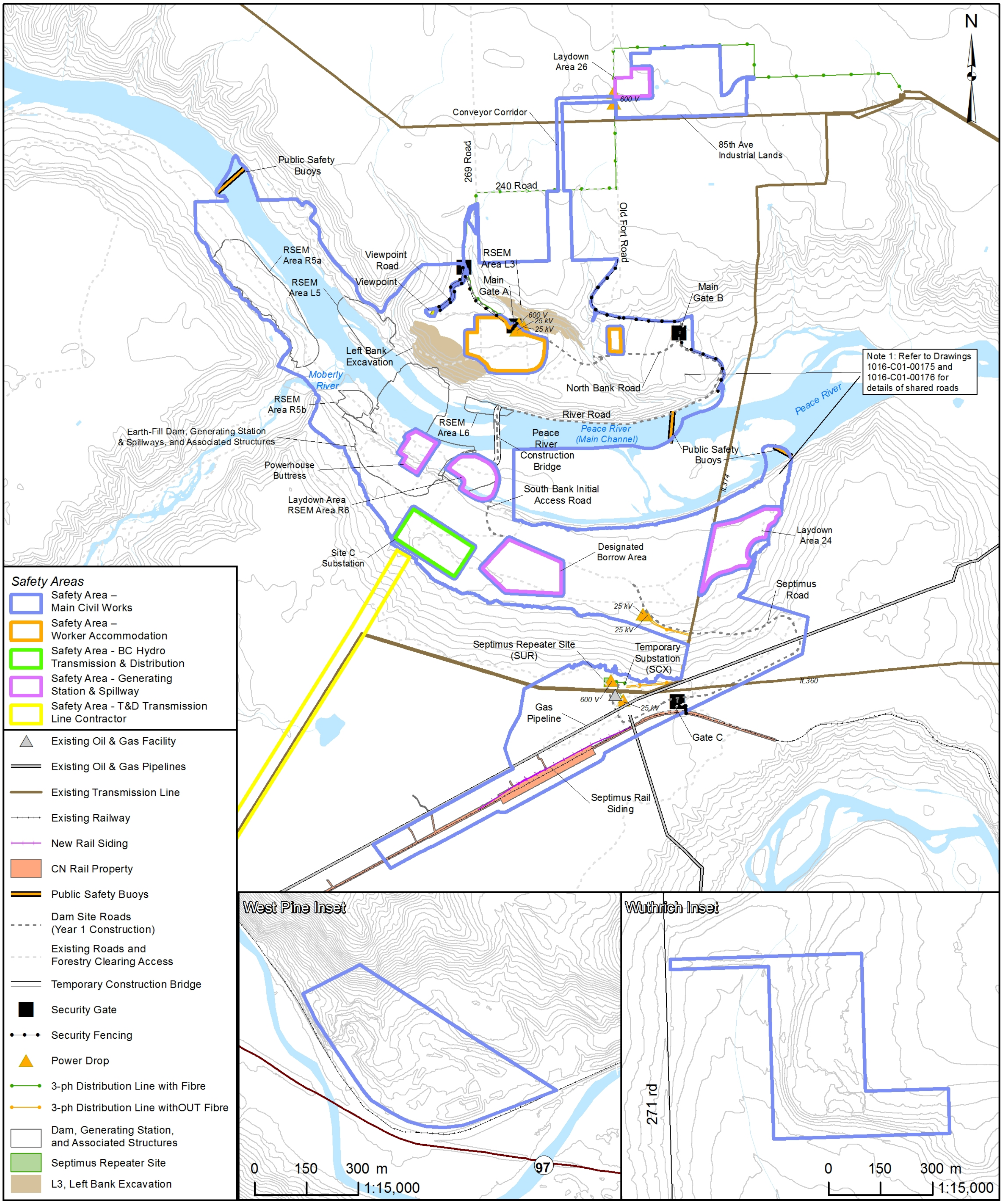

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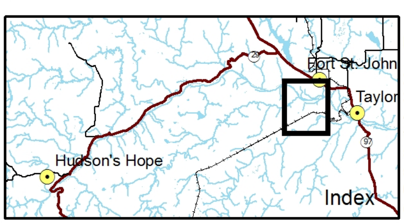

Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. BC Hydro does not own or have rights to all the lands within the depicted areas, as of the date of this map.
5. The information on this map is based on the current project schedule and is subject to change.
6. Existing infrastrucutre is only shown where there is an overlap or interaction with work areas.

BC Hydro

Safety Areas
Q4 - 2017 to Q4 - 2018
Dam Site Area and Off-Site
Construction Material Sources

DATE	February 9, 2016	1016-C14-A7750-1	R 5

Path: X:\ArcGIS\Projects\Field_Work_Coordination\Prime_Safety_Areas\Dam_Site_Prime_Contractor_Areas_Q4-2017_1016_C14_A7750-1.mxd

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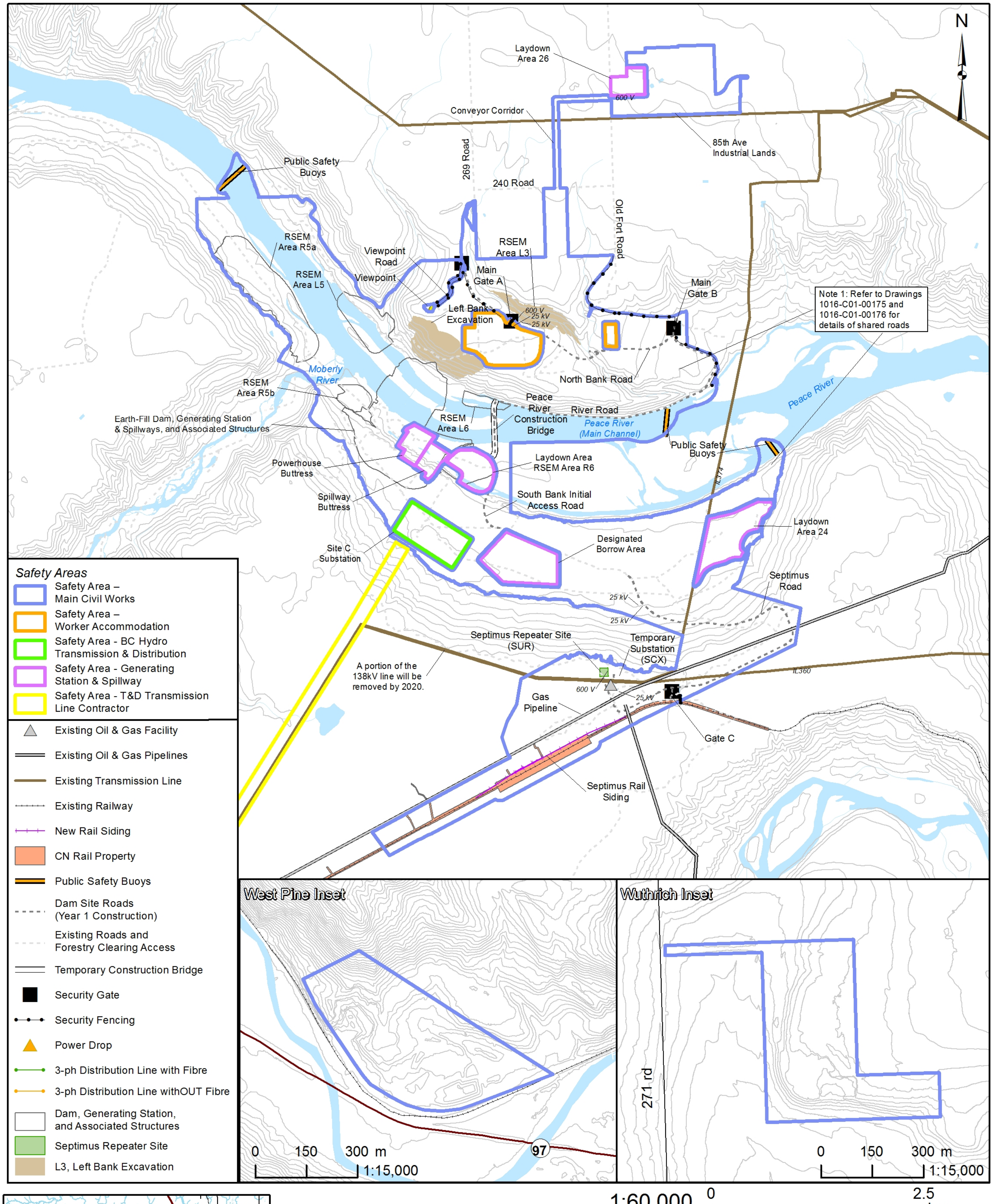
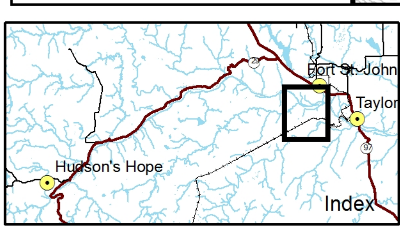
Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.





Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. BC Hydro does not own or have rights to all the lands within the depicted areas, as of the date of this map.
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6. Existing infrastrucutre is only shown where there is an overlap or interaction with work areas.

BC Hydro

Safety Areas
Q4 - 2018 to Q3 - 2022
Dam Site Area and Off-Site
Construction Material Sources

DATE	February 9, 2016	1016-C14-A7750-2	R 5

Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

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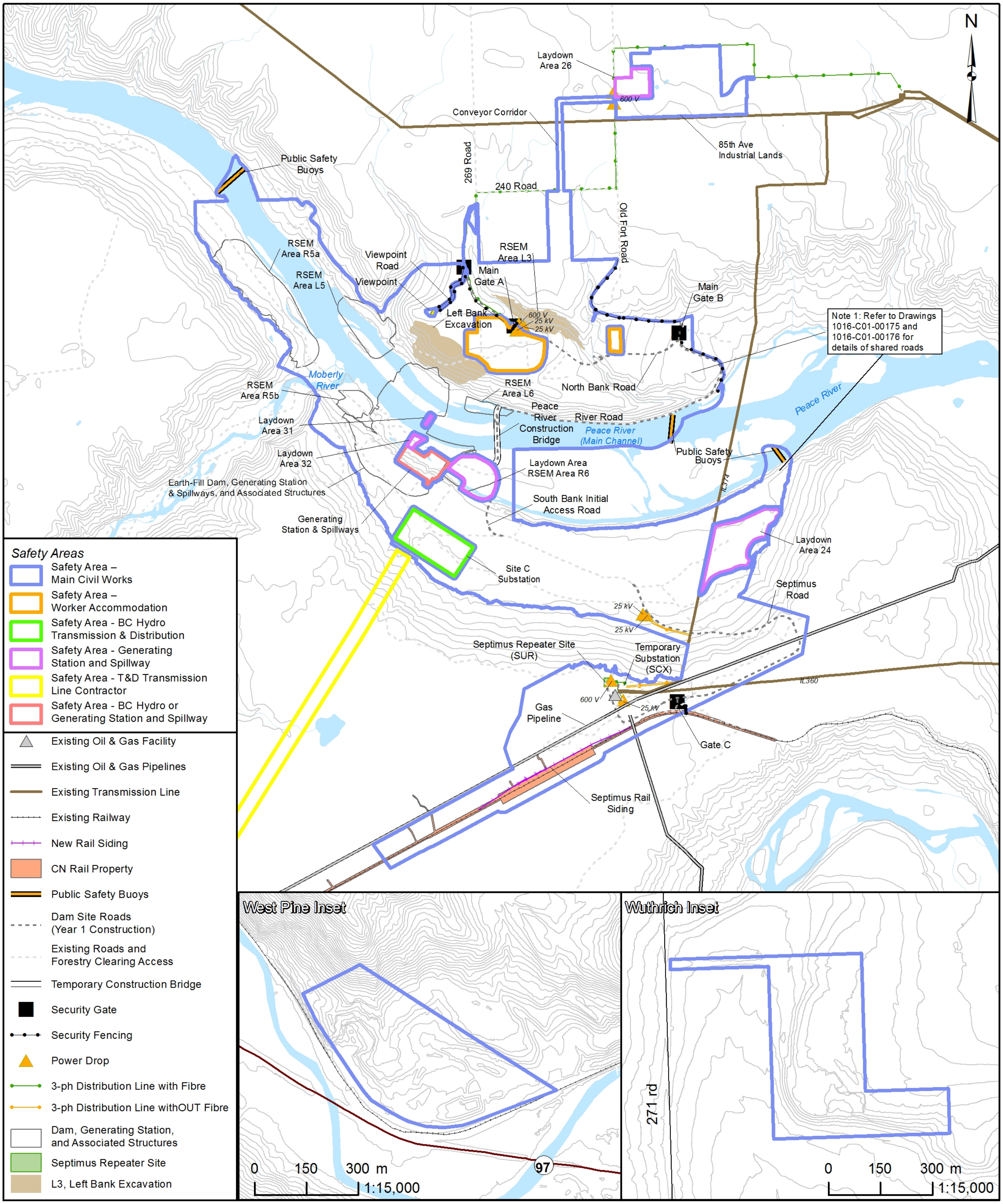

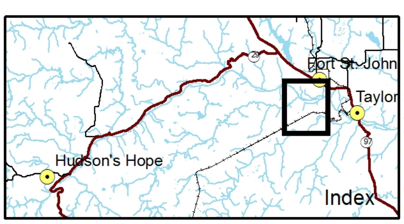

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Map Notes:
1. Datum: NAD83
2. Projection: UTM Zone 10N
3. Base Data: Province of B.C.
4. BC Hydro does not own or have rights to all the lands within the depicted areas, as of the date of this map.
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6. Existing infrastrucutre is only shown where there is an overlap or interaction with work areas.

BC Hydro

Safety Areas
Q3 - 2022 to Q4 - 2023
Dam Site Area and Off-Site
Construction Material Sources

DATE	February 9, 2016	1016-C14-A7750-3	R 5

Path: X:\ArcGIS\Projects\Field_Work_Coordination\Prime_Safety_Areas\Dam_Site_Prime_Contractor_Areas_Q3-2022_1016_C14_A7750-3.mxd

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Construction of the Site C Clean Energy Project is subject to required regulatory and permitting approvals.

CONTRACTOR SAFETY INCIDENT REPORT FORM

BC hydro FOR GENERATIONS

1. **Contractor**: In the event of any injury (or near-miss incident) to a worker during the contracted work on the BC Hydro job site, as soon as practicable, notify Hydro's Representative of the incident, and submit an incident report.
   1. Complete this incident report form or your own safety incident report as long as it contains the same information.
   2. Forward the completed incident report to Hydro's Representative in electronic or paper copy.
2. **Hydro's Representative:** Use this incident report form completed by the Contractor's Representative to assist you with initiating and completing a BC Hydro Contractor Injury/Illness or near miss Incident report in BC Hydro SAP Incident Management System (IMS).

Note: Independent Contractors are responsible for incident reporting and investigations and as outlined by WorkSafeBC as per the Worker's Compensation Act Part 3 Division 10.

Incident Date:	Incident Time: Click here to enter text. AM ☐ PM ☐

Incident Information

Incident Location (Address/City): Click here to enter text.		
Brief Incident Description: Click here to enter text.		
Immediate Corrective Actions Taken (if needed):Click here to enter text.		
Description of Injuries and Immediate Treatment Received (including Left or Right side of body): Click here to enter text.		
Treatment Administered By? (e.g. First Aid Attendant/Doctor/etc.) Click here to enter text.		
Did Worker Have Lost Time Beyond Day of Injury?	Yes ☐	No ☐
Was There an Electrical Contact? If YES, please check all that apply	Yes ☐ WITH: Person ☐	No ☐ Vehicle ☐

Contractor Information

Contractor Company Name:	Click here to enter text.	
Name of Contractor's Representative:	Click here to enter text.	
Address:	Click here to enter text.	
Telephone#:	Click here to enter text.	
Hydro's Representative Contract #:	Click here to enter text.	BC Hydro Project #: Click here to enter text.
Are You Prime On Site?	Yes ☐ No ☐	
Hydro's Representative Name	Click here to enter text.	
E-Mail Address:	Click here to enter text.	
Telephone#:	Click here to enter text.	

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 11

PRICES AND PAYMENT

TABLE OF CONTENTS

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 11

PRICES AND PAYMENT

1 INTERPRETATION

1.1 Definitions

In this Schedule 11 [Prices and Payment], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Advance Payment**" has the meaning set out in Section 5.2 of this Schedule 11 [Prices and Payment];

"**Advance Payment Letter of Credit**" has the meaning set out in Section 5.2 of this Schedule 11 [Prices and Payment];

"**Advance Payment Request**" has the meaning set out in Section 5.2 of this Schedule 11 [Prices and Payment];

"**Completion Milestone**" has the meaning set out in Section 9.5 of this Schedule 11 [Prices and Payment];

"**Contractor Duties**" has the meaning set out in Section 6.4 of this Schedule 11 [Prices and Payment];

"**Contractor Taxes**" has the meaning set out in Section 6.4 of this Schedule 11 [Prices and Payment];

"**Contractor's Actual Daily Guest Night Use**" has the meaning set out in Section 5.20(a)(ii) of this Schedule 11 [Prices and Payment];

"**Contractor's Aggregate Guest Night Use**" has the meaning set out in Section 5.20(a)(iii) of this Schedule 11 [Prices and Payment];

"**Contractor's Guest Night Entitlement**" has the meaning set out in Section 5.20(a)(i) of this Schedule 11 [Prices and Payment];

"**Contractor's Guest Night Overage**" has the meaning set out in Section 5.20(c) of this Schedule 11 [Prices and Payment];

"**CTHEA**" has the meaning set out in Section 5.21(c)(i)(A)(I) of this Schedule 11 [Prices and Payment];

"**Deposit Application**" has the meaning set out in Section 4.2 of this Schedule 11 [Prices and Payment];

"**Draft Tube Temporary Enclosure Installed**" means the Installation Work described in Section 4.33 of Appendix 6-3 [Turbine Specifications];

"**Excitation System Technical Data and Information Form**" or "**Exciter TDIF**" means the form set out under Section 5.0 of Appendix 11-6 [Technical Data and Information Forms];

"**General Technical Data and Information Form**" or "**General TDIF**" means the form set out under Section 1.0 of Appendix 11-6 [Technical Data and Information Forms];

"**Generator Technical Data and Information Form**" or "**Generator TDIF**" means the form set out under Section 4.0 of Appendix 11-6 [Technical Data and Information Forms];

“**Governor System Technical Data and Information Form**” or “**Governor TDIF**” means the form set out under Section 3.0 of Appendix 11-6 [Technical Data and Information Forms];

“**Installation Work**” means, for the purposes of this Schedule 11 [Prices and Payment], the Installation Work and the Testing and Commissioning Work;

“**Letter of Credit**” has the meaning set out in Section 3.2(a) of this Schedule 11 [Prices and Payment];

“**Liquidated Damages**” means the amount of damages the parties have agreed will be paid by one party to the other upon the occurrence of a defined event;

“**Low-End Range Performance Bonus**” or “**LEPB**” has the meaning set out in Section 8.1 of this Schedule 11 [Prices and Payment];

“**Milestone**” has the meaning set out in Section 5.3(a) of this Schedule 11 [Prices and Payment];

“**Milestone Payment**” has the meaning set out in Section 5.3 of this Schedule 11 [Prices and Payment];

“**Non-Installation Work**” means, for the purposes of this Schedule 11 [Prices and Payment], the Supply and Delivery Work;

“**Progress Payment Estimate**” has the meaning set out in Section 5.4(a) of this Schedule 11 [Prices and Payment];

“**Single Unit Substantial Completion**” has the meaning set out in Section 5.12(a) of this Schedule 11 [Prices and Payment];

“**Single Unit Total Completion**” has the meaning set out in Section 5.16(a) of this Schedule 11 [Prices and Payment];

“**Spare Parts Payment**” has the meaning set out in Table Note 3 of Appendix 11-7 [Equipment Spare Parts Lists];

“**SPNA**” has the meaning set out in Section 5.21(a) of this Schedule 11 [Prices and Payment];

“**Substantial Completion**” has the meaning set out in Section 5.11 of this Schedule 11 [Prices and Payment];

“**Technical Data and Information Forms**” means the General TDIF, Turbine TDIF, Governor TDIF, Generator TDIF and Exciter TDIF;

“**Third Party Guarantee**” has the meaning set out in Section 3.2(d) of this Schedule 11 [Prices and Payment];

“**Total Completion**” has the meaning set out in Section 5.15 of this Schedule 11 [Prices and Payment];

“**Turbine Technical Data and Information Form**” or “**Turbine TDIF**” means the form set out under Section 2.0 of Appendix 11-6 [Technical Data and Information Forms]; and

“**Unit Assembly Complete**” means the stage of the Work when all of the Equipment associated with a Unit, including all of the associated hardware, software, lubricants and/or auxiliary components required for operation, has been assembled and installed in accordance with the requirements of the Contract Documents, has been inspected and accepted by BC Hydro, and is ready for Commissioning.

2 GENERAL

2.1 Complete Prices

The prices listed in Appendix 11-1 [Payment Schedule], including unit prices, lump sum prices and other forms of pricing, represent the complete price to BC Hydro, excluding only GST, for the performance of the Work. Notwithstanding the generality of the above, the prices listed in Appendix 11-1 [Prices and Payment] (including unit prices, lump sum prices, or other forms of pricing) will be deemed to include sufficient amounts to cover:

(a) the costs of all labour, equipment and materials included in or required for the complete performance of the Work, including all items which, while not specifically listed in Appendix 11-1 [Prices and Payment], are included in the Work expressly in the Contract Documents or by necessary inference in the interpretation of the Contract Documents;

(b) all costs associated with all performance security, including any overhead costs, whether head office or on-site overhead costs, with respect to the performance security;

(c) all insurance costs and overhead costs, including head office and on-site overhead costs, and all amounts for the Contractor's profit; and

(d) all costs required for compliance with all Laws and Permits applicable to the performance of the Work.

For certainty, there will be no escalation of any prices listed in Appendix 11-1 [Payment Schedule] except as otherwise expressly set out in the Contract Documents.

2.2 Costs of Labour

The prices listed in Appendix 11-1 [Payment Schedule] will be deemed to include all costs of labour required for the performance of the Work including the cost of:

(a) compliance with the requirements of the Contract Documents;

(b) all assessments payable with respect to labour as required by any statutory scheme such as Workers' Compensation, unemployment insurance, holiday pay, insurance, CPP and all employee benefits and compliance with all applicable Laws regarding trade or other qualifications of employees performing the Work; and

(c) payment of appropriate wages for labour included in or required for the Work.

3 PERFORMANCE SECURITY

3.1 Delivery of Performance Security

Unless expressly specified otherwise in the Contract Documents, within ten Business Days of the Effective Date, or by such later date as Hydro's Representative may agree to in writing, but in any event prior to the commencement of the Work, in addition to and not in substitution for any security that the Contractor is required to provide to BC Hydro under the Contract for the performance of the Work, and, unless otherwise agreed to in writing by Hydro's Representative, the Contractor will deliver to BC Hydro the performance security specified in Section 3.2 of this Schedule 11 [Prices and Payment].

3.2 Performance Security

Performance Security for Installation Work and Non-Installation Work:

(a) Letter of Credit:

The Contractor will deliver to BC Hydro a letter of credit (the "**Letter of Credit**") in an amount equal to [redacted] of the sum of the Contractor's price for the Installation Work as specified in Appendix 11-1 [Payment Schedule] and the Contractor's price for the Non-Installation Work as specified in Appendix 11-1 [Payment Schedule]. The Letter of Credit will be held by BC Hydro as security for:

(i) the Contractor's performance of all of the Contractor's obligations under the Contract, including:

(A) the Installation Work and the Non-Installation Work, including the payment of Liquidated Damages, if any, as specified in the Contract;

(B) the warranty obligations in respect of the Installation Work and the Non-Installation Work as described in Section 24 of Schedule 2 [Design and Construction Protocols]; and

(C) any obligations under the Contract with respect to the Installation Work and the Non-Installation Work commencing on the fifth anniversary after Total Completion.

(ii) the Contractor's payment obligations with respect to equipment, labour, materials and services under the Contract for:

(A) the Installation Work and the Non-Installation Work; and

(B) the warranty obligations in respect of the Installation Work and the Non-Installation Work described in Section 24 of Schedule 2 [Design and Construction Protocols].

On the first anniversary after Total Completion, the Letter of Credit will be reduced to an amount equal to [redacted] of the sum of the Contractor's price for the Installation Work as specified in Appendix 11-1 [Payment Schedule] and the Contractor's price for the Non-Installation Work as specified in Appendix 11-1 [Payment Schedule].

On the fifth anniversary after Total Completion, the Letter of Credit will be further reduced to an amount equal to [redacted].

(b) *Letter of Credit Form*: Unless otherwise agreed to in writing by BC Hydro, the Letter of Credit will be irrevocable, unconditional and in the form and contain the content as set out in Appendix 11-2 [Form of Letter of Credit].

The Letter of Credit will be issued or confirmed by a branch in Vancouver, British Columbia of a domestic Canadian financial institution having a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or DBRS A (low). If the issuing financial institution is not a domestic Canadian financial institution, the sovereign country's debt rating will be no less than Standard & Poor's AA, Moody's Aa2 or DBRS AA and the financial institution must have a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or DBRS A (low). BC Hydro, at its discretion, may accept a sovereign debt rating of Standard & Poor's AA-, Moody's Aa3 or DBRS AA (low) if the issuing bank has a rating of not less than Standard & Poor's A, Moody A2 or DBRS A. If such credit rating agencies publish differing credit ratings for the same financial institution, the lowest credit rating of any of the credit rating agencies will apply for the purposes of this paragraph.

(c) *Letter of Credit Term:* The Letter of Credit will be maintained by the Contractor, and will remain in full force and effect for the benefit of BC Hydro, until the earlier of:

(i) two years from the date on which the Contract is terminated; or

(ii) eight years from Total Completion.

(d) Third Party Guarantee:

The Contractor will deliver to BC Hydro a third party Guarantee (the "**Third Party Guarantee**") executed by an entity acceptable to BC Hydro, in amount equal to [redacted] of the sum of the Contractor's price for the Installation Work as specified in Appendix 11-1 [Payment Schedule] and the Contractor's price for the Non-Installation Work as specified in Appendix 11-1 [Payment Schedule]. The Third Party Guarantee will be held by BC Hydro as security for:

(i) the Contractor's performance of all of the Contractor's obligations under the Contract, including:

(A) the Installation Work and the Non-Installation Work, including the payment of Liquidated Damages, if any, as specified in the Contract;

(B) the warranty obligations in respect of the Installation Work and the Non-Installation Work as described in Section 24 of Schedule 2 [Design and Construction Protocols]; and

(C) any obligations under the Contract with respect to the Installation Work and the Non-Installation Work commencing on the fifth anniversary after Total Completion (as described in Section 5.15 of this Schedule 11 [Prices and Payment]).

(ii) the Contractor's payment obligations with respect to equipment, labour, materials and services under the Contract for:

(A) the Installation Work and the Non-Installation Work; and

(B) the warranty obligations in respect of the Installation and the Non-Installation Work as described in Section 24 of Schedule 2 [Design and Construction Protocols].

On the first anniversary after Total Completion (as described in Section 5.15 of this Schedule 11 [Prices and Payment]), the Third Party Guarantee will be reduced to an amount equal to [redacted] of the sum of the Contractor's price for the Installation Work as specified in Appendix 11-1 [Payment Schedule] and the Contractor's price for the Non-Installation Work as specified in Appendix 11-1 [Payment Schedule].

(e) *Third Party Guarantee Form*: Unless otherwise agreed to by BC Hydro in writing, the Third Party Guarantee will be in the form and contain the content as set out in Appendix 11-3 [Form of Guarantee].

(f) *Third Party Guarantee Term*: The Third Party Guarantee will be maintained by the Contractor, and will remain in full force and effect for the benefit of BC Hydro, until the earlier of:

(i) two years from the date on which the Contract is terminated; or

(ii) eight years from Total Completion.

3.3 Performance Security – BC Hydro's Rights

Upon the occurrence of any of the events specified in Section 13.1 or 13.2 of Schedule 2 [Design and Construction Protocols], or if the Contractor breaches any term of the Contract or fails to perform any obligation under the Contract (including failing to pay any amount owing to BC Hydro under the Contract or failing to provide the required performance security as set out in Section 3.2 of this Schedule 11 [Prices and Payment]), or if the Contractor fails to replace or have re-issued any performance security such that at all times all performance security is issued by an entity meeting the minimum required credit ratings, or if any issuer of a performance security or any guarantor under the Third Party Guarantee becomes unacceptable to BC Hydro, acting reasonably, BC Hydro will have the immediate and absolute right to pursue its remedies under any and all of the performance securities described in Section 3.2 of this Schedule 11 [Prices and Payment]. For greater certainty, BC Hydro will be entitled to pursue its remedies under any of the performance securities described in Section 3.2 of this Schedule 11 [Prices and Payment] simultaneously, as long as there is no double recovery, and will not be required to exhaust its recourse under any one performance security under Section 3.2 of this Schedule 11 [Prices and Payment] before pursuing its remedies under another performance security under Section 3.2 of this Schedule 11 [Prices and Payment], or any other remedy available to it under the Contract or at law.

3.4 Renewal of Letter of Credit

If, in accordance with the terms of the Letter of Credit, the issuing bank gives notice to BC Hydro of its determination not to extend the Letter of Credit and the Contractor fails to provide BC Hydro with acceptable replacement security at least 60 days prior to the expiration date of the Letter of Credit, BC Hydro will have the immediate and absolute right to draw upon the Letter of Credit for the full amount thereof, in which case BC Hydro will hold the proceeds thereof as a cash deposit (without interest) to be drawn on and applied in the same manner as the Letter of Credit. Any unused amount of such cash deposit will be returned to the Contractor at the time prescribed in Section 3.6 for the return of any unused performance security.

3.5 No Limitation on BC Hydro's Remedies

The performance security given by the Contractor to BC Hydro pursuant to Section 3.2 of this Schedule 11 [Prices and Payment] will not in any way limit BC Hydro's other remedies under the Contract or applicable Laws.

3.6 Return of Performance Security

BC Hydro will return to the Contractor any unused performance security held by it under Section 3 of this Schedule 11 [Prices and Payment] after such performance security ceases to be of any force and effect in accordance with Section 3 of this Schedule 11 [Prices and Payment], or at such earlier time as BC Hydro may, in its sole discretion, consider appropriate.

3.7 Change in Performance Security Amounts

At any time and from time to time BC Hydro may, in its sole discretion, require the Contractor to lower the amount of a performance security. If BC Hydro requires the Contractor to lower the amount of a performance security under this Section 3.7, the Contractor will, prior to lowering the amount of that performance security, provide to Hydro's Representative within a reasonable time an estimate of the savings expected to be realized in connection with such lower amount. All cost savings realized by lowering the amount of a performance security will be passed on to BC Hydro by way of a reduction to the Contract Price, implemented by a Change Order, with valuation calculated on the basis of actual savings realized in connection with lowering the amount of that performance security.

4 PAYMENT FORMS

4.1 Breakdown of Contract Price

The Contractor will submit to Hydro's Representative, at least 14 days before the first application for payment, a schedule of values of the various parts of the performance of the Work based on the attached Appendix 11-1 [Payment Schedule], aggregating the total amount of the Contract Price. The schedule of values will be prepared in such form and supported by such evidence as to its correctness as Hydro's Representative may reasonably direct, and, when approved by Hydro's Representative, will be used as the basis for all applications from the Contractor for payment.

4.2 Direct Deposit Application Form

Within ten days of the Effective Date, or such later date as Hydro's Representative may agree to in writing, the Contractor will provide to Hydro's Representative, a completed direct deposit application form in the form provided by Hydro's Representative (the "**Deposit Application**"). The following will apply to the information contained in the Deposit Application:

(a) BC Hydro is entitled to rely on such information without further enquiry or investigation;

(b) BC Hydro reserves the right (but does not have the obligation), in its sole discretion, to require the Contractor's Representative to provide evidence as to the accuracy of such information; and

(c) the Contractor will, at no cost to BC Hydro, promptly provide such evidence to Hydro's Representative.

If, at any time, the Contractor needs to change any information contained in its completed Deposit Application, the Contractor's Representative must submit to Hydro's Representative a revised Deposit Application.

5 PAYMENT

5.1 Participation Payments

All "RFP Participation Payments", as defined under the RFP, paid by BC Hydro to the Contractor pursuant to the RFP are deemed to be payment on account of amounts owed by BC Hydro to the Contractor under the Contract, and accordingly have been deducted from the "Proposal Price", as defined in the RFP, submitted by the Contractor pursuant to the RFP.

5.2 Advance Payment and Advance Payment Security

The Contractor may from time to time request BC Hydro to make one or more interest-free advance payments (each such payment an "**Advance Payment**") on account of design, off-site manufacturing, mobilization to the Site and such other matters as BC Hydro may decide in its sole discretion (each such request an "**Advance Payment Request**"), provided that:

(a) Advance Payment Requests are made in accordance with the Advance Payment timing and amounts set out in [redacted], unless otherwise agreed in writing by Hydro's Representative; and

(b) the aggregate amount of all Advance Payments outstanding at any time will not exceed [redacted] of the Contract Price.

The Contractor will submit an Advance Payment Request not less than 60 days prior to the requested payment date and will include in the Advance Payment Request the amount of the Advance Payment and the period of time that the Contractor anticipates the Advance Payment will remain outstanding.

If an Advance Payment Request is approved by BC Hydro, in its sole discretion, including with respect to any conditions of such approval, then the Contractor will provide to BC Hydro a letter of credit (an "**Advance Payment Letter of Credit**") in the amount equal to [redacted] of the Advance Payment amount.

BC Hydro will within 30 days of receiving an Advance Payment Letter of Credit in respect of an approved Advance Payment Request make the applicable Advance Payment.

The Advance Payment Letter of Credit will be held by BC Hydro as security against the Contractor's obligations under the Contract to perform the work for which the Advance Payment was made and the Contractor's obligations to repay the Advance Payment, as set out in this Section 5.2.

Without limiting BC Hydro's rights under Section 5.9 of this Schedule 11 [Prices and Payment], the Contractor may from time to time reduce the outstanding amount of any Advance Payment:

(c) to the extent that BC Hydro is required to make any payment to the Contractor under Section 5.7 of this Schedule 11 [Prices and Payment], by providing written directions to Hydro's Representative to first apply such payment to that outstanding Advance Payment; or

(d) by repaying to BC Hydro all or any part of that outstanding Advance Payment.

If the outstanding amount of an Advance Payment is reduced in accordance with this Section 5.2, then the Advance Payment Letter of Credit in respect of that Advance Payment will be reduced by the same amount as the reduction of the outstanding amount of that Advance Payment.

BC Hydro may accept an advance payment bond in substitution for an Advance Payment Letter of Credit, such advance payment bond to be in the form and on the terms and conditions and in the amount required by BC Hydro, in its sole discretion.

Letter of Credit Form: Unless otherwise agreed to in writing by BC Hydro, any Advance Payment Letter of Credit will be irrevocable, unconditional and in the form and contain the content as set out in Appendix 11-2 [Form of Letter of Credit].

The Advance Payment Letter of Credit will be issued or confirmed by a branch in Vancouver, British Columbia of a domestic Canadian financial institution having a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or DBRS A (low). If the issuing financial institution is not a domestic Canadian financial institution, the sovereign country's debt rating will be no less than Standard & Poor's AA, Moody's Aa2 or DBRS AA and the financial institution must have a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or DBRS A (low). BC Hydro, at its discretion, may accept a sovereign debt rating of Standard & Poor's AA-, Moody's Aa3 or DBRS AA (low) if the issuing bank has a rating of not less than Standard & Poor's A, Moody A2 or DBRS A. If such credit rating agencies publish differing credit ratings for the same financial institution, the lowest credit rating of any of the credit rating agencies will apply for the purposes of this Section 5.2.

Letter of Credit Term: The Advance Payment Letter of Credit will be maintained by the Contractor, and will remain in full force and effect for the benefit of BC Hydro until BC Hydro has made payment on invoices received from the Contractor for Progress Payments equal to the total amount of the Advance Payments made by BC Hydro under this Section 5.2. However, BC Hydro may, in its sole discretion, agree to decrease the amount of an Advance Payment Letter of Credit before such time.

5.3 Milestones

Upon the later of:

(a) the completion of a milestone as set out in Table Appendix 11-1 B of Appendix 11-1 [Payment Schedule] (each a "**Milestone**"); or

(b) the date set out in Table Appendix 11-1 B of Appendix 11-1 [Payment Schedule] for that Milestone,

the Contractor will be entitled to payment of the amount corresponding to such Milestone (each such amount a "**Milestone Payment**") in accordance with the provisions of Section 5 of this Schedule 11 [Prices and Payment].

5.4 Application for Payment

The Contractor will make applications for payment as follows:

(a) when eligible for payment as described under Section 5.3 of this Schedule 11 [Prices and Payment], the Contractor's Representative will submit to Hydro's Representative a payment estimate (the "**Progress Payment Estimate**") in the form provided by Hydro's Representative with:

  (i) all supporting documents as expressly required by the Contract Documents;

  (ii) a copy of the most recent monthly updated Work Program and Schedule prepared in accordance with Schedule 4 [Work Program and Schedule]; and

  (iii) other documents required by Hydro's Representative, acting reasonably;

(b) within seven Business Days after receipt of such material, Hydro's Representative will, in consultation with the Contractor's Representative, review the Progress Payment Estimate and either:

  (i) if Hydro's Representative agrees with the amount claimed by the Contractor on a Progress Payment Estimate, then Hydro's Representative will return the Progress Payment Estimate to the Contractor's Representative with a written notice confirming such agreement; or

  (ii) if Hydro's Representative disagrees with any amount claimed by the Contractor on a Progress Payment Estimate, then Hydro's Representative will return the Progress Payment Estimate to the Contractor's Representative with a written notice setting out:

    (A) the amount, if any, Hydro's Representative agrees is payable; and

    (B) the reasons for the disagreement and, if available, the amount disputed; and

(c) within ten Business Days after receipt of the Progress Payment Estimate under Section 5.4(b)(i) or Section 5.4(b)(ii) of this Schedule 11 [Prices and Payment], as the case may be, the

Contractor's Representative will submit to BC Hydro an original invoice in the amount that Hydro's Representative has indicated under Section 5.4(b) of this Schedule 11 [Prices and Payment] is payable dated the date the Progress Payment Estimate was returned by Hydro's Representative under Section 5.4(b) of this Schedule 11 [Prices and Payment], with a copy of the invoice to Hydro's Representative. The original invoice will be submitted by email to BCH-InvoicesforPayment@absu.accenture.com, or by hard copy to BC Hydro Accounts Payable, 6911 Southpoint Drive, Burnaby, BC V3N 4X8, both in accordance with any additional invoicing instructions provided by Hydro's Representative.

The Contractor will show as separate entries on any invoice or Progress Payment Estimate, as the case may be, submitted for payment, the GST payable by BC Hydro and collectable by the Contractor on that portion of Work invoiced or for which a Progress Payment Estimate has been issued. The Contractor will provide to BC Hydro on all invoices and Progress Payment Estimates the Contractor's GST registration number and all other information as may be required pursuant to the *Excise Tax Act* (Canada).

5.5 Materials on Site

Unless otherwise specifically set out in this Schedule 11 [Prices and Payment] or any other Contract Document or otherwise agreed in writing by Hydro's Representative, the Contractor will not be entitled to apply for payment for material delivered to the Site but not yet incorporated into the completed Work.

5.6 Application for Payment Not a Waiver

The Contractor's application for payment under Section 5 of this Schedule 11 [Prices and Payment] will be without prejudice to the Contractor's rights to Dispute under Section 16 of Schedule 2 [Design and Construction Protocols].

5.7 Payment

Payment will be made to the Contractor as follows:

(a) BC Hydro will pay the Contractor the amount of each invoice prepared and submitted in accordance with Section 5.4(c) of this Schedule 11 [Prices and Payment], including the GST as a separate item in addition to the Contract Price, less any holdbacks, 30 days after receipt of the invoice; and

(b) all amounts due and owing as determined in accordance with Section 5.7(a) of this Schedule 11 [Prices and Payment] will be paid:

 (i) if the Contractor is a Canadian entity, by direct deposit using an electronic funds transfer to the account the Contractor has designated in its then current Deposit Application; or

 (ii) in any other case, either by wire transfer to the account the Contractor has designated in its then current Deposit Application or by cheque or bank draft, in BC Hydro's sole discretion.

Any fees charged by the receiving institution related to accepting or processing an electronic funds transfer or a wire transfer will be the responsibility of the Contractor.

5.8 Payment Not a Waiver

No payment made to the Contractor by BC Hydro will at any time constitute approval or acceptance of any performed Work under the Contract, nor be considered a waiver by BC Hydro of any of the terms of the Contract, nor relieve the Contractor of any of its duties, obligations or responsibilities under the Contract to perform the Work in accordance with the requirements of the Contract Documents.

5.9 Right of Set-off

BC Hydro may set off, as against any amounts due to the Contractor, any amount owing or claimed to be owing from the Contractor to BC Hydro, including Liquidated Damages and other amounts as payable under the Contract.

5.10 Application for Substantial Completion

When the Contractor judges that the Work is sufficiently complete (including with respect to all six Units), the Contractor may apply to Hydro's Representative for a certificate of Substantial Completion. The application will be in writing and will include the following:

(a) a comprehensive list of all items to be completed or corrected, including an estimated cost to complete or correct each item, and a schedule for completion and correction of all such items through to Total Completion, prepared in consultation with Hydro's Representative;

(b) all manufacturer's inspections, certifications, guarantees and warranties specified in the Contract or otherwise applicable to the performed Work;

(c) evidence that all required Permits, except for Project Related Permits, and approvals from testing or inspection agencies, if any, have been obtained;

(d) evidence from the Workers' Compensation Board of British Columbia that the Contractor is in good standing; and

(e) a statement as to the status of amounts owing to first tier Subcontractors and as to any unresolved claims made by Subcontractors against the Contractor or another Subcontractor.

5.11 Substantial Completion

"**Substantial Completion**" means the stage in the progress of the Work, as certified by Hydro's Representative in accordance with this Section 5.11, when:

(a) the Work (including all six Units):

  (i) achieves full Commercial Operation; or

  (ii) is sufficiently complete in accordance with the requirements of the Contract Documents that BC Hydro can use the Work for its intended purpose,

  whichever occurs first;

(b) the Work is capable of completion or correction at a cost of not more than [redacted];

(c) any other conditions specified in the Contract Documents to be satisfied on or before Substantial Completion, including the submission of all information and documents required by Section 5.10 of this Schedule 11 [Prices and Payment], have been satisfied, or waived in writing by BC Hydro; and

(d) Hydro's Representative has issued the certificate of Substantial Completion.

Hydro's Representative will, no later than 14 days after the receipt of an application under Section 5.10 of this Schedule 11 [Prices and Payment], inspect the Work to verify the validity and accuracy of the application. Hydro's Representative will, no later than a further seven days after the inspection, notify the Contractor in writing of approval, or the reasons for refusal, of the application. If the application is refused, then the Contractor will address the reasons for refusal and may re-apply for a certificate of Substantial Completion pursuant to Section 5.10 of this Schedule 11 [Prices and Payment]. The provisions of this Section 5.11 will apply to any such subsequent application.

When Hydro's Representative, acting reasonably, determines that the requirements for Substantial Completion have been achieved (other than the issuance of the certificate of Substantial Completion), Hydro's Representative will issue a certificate of Substantial Completion that includes the date of Substantial Completion. Concurrently with the issuance of such certificate, Hydro's Representative will prepare a written list of items of the Work to be completed or corrected that were apparent to Hydro's Representative in the inspection of the Work. The issuance of such list will not relieve the Contractor of any of its duties, obligations or responsibilities under the Contract to perform the Work, complete the performance of the Work and correct all defects and deficiencies in the Work, all in accordance with the requirements of the Contract Documents.

5.12 Single Unit Substantial Completion

Notwithstanding Sections 5.10 and 5.11 of this Schedule 11 [Prices and Payment], the Contractor may apply for substantial completion with respect to the individual Units as follows:

(a) "**Single Unit Substantial Completion**" means the stage in the progress of the Work when the Unit:

    (i) is put into Commercial Operation under Section 5.4 of Schedule 2 [Design and Construction Protocols]; or

    (ii) is sufficiently complete in accordance with the requirements of the Contract Documents so that BC Hydro could put it into Commercial Operation as certified by Hydro's Representative,

    whichever occurs first;

(b) the Contractor will include the information required under Section 5.10 of this Schedule 11 [Prices and Payment], as applicable to the individual Unit;

(c) Hydro's Representative will, no later than 14 days after the receipt of an application under Section 5.12 of this Schedule 11 [Prices and Payment], inspect the Unit and the related Work to verify the validity and accuracy of the application. Hydro's Representative will, no later than a further seven days after the inspection, notify the Contractor in writing of approval, or the reasons for refusal, of the application. If the application is refused, then the Contractor will address the reasons for refusal and may re-apply for a certificate of Single Unit Substantial Completion pursuant to Section 5.12 of this Schedule 11 [Prices and Payment]. The provisions of Section 5.12 of this Schedule 11 [Prices and Payment] will apply to any such subsequent application;

(d) when Hydro's Representative, acting reasonably, determines that the requirements for Single Unit Substantial Completion have been achieved for the Unit (other than the issuance of the certificate of Substantial Completion), Hydro's Representative will issue a certificate of Single Unit Substantial Completion that includes the date of the Single Unit Substantial Completion. Concurrently with the issuance of such certificate, Hydro's Representative will prepare a written list of items of the Work to be completed or corrected that were apparent to Hydro's Representative in the inspection of the Work. The issuance of such list will not relieve the Contractor of any of its duties, obligations or responsibilities under the Contract to perform the Work, complete the performance of the Work and correct all defects and deficiencies in the Work, all in accordance with the requirements of the Contract Documents; and

(e) without limiting BC Hydro's right to retain a holdback for deficiencies as described in Section 5.13 of this Schedule 11 [Prices and Payment] or to set off against any amount owing or claimed to be owing from the Contractor to BC Hydro as described in the Contract Documents, upon issuance of a Single Unit Substantial Completion certificate the Contractor may, if applicable, apply for a release of the portion of the letter of credit, that corresponds to the Work covered by the Single Unit Substantial Completion certificate, and upon such application BC Hydro will, if applicable, release such portion of the letter of credit.

5.13 Deficiencies Holdback

BC Hydro may retain, out of the amount due and owing to the Contractor on each Single Unit Substantial Completion and on Substantial Completion, an amount equal to two times the value of the estimated cost to complete or correct the items set out in the list provided pursuant to Section 5.10(a) or Section 5.12(b), as applicable, of this Schedule 11 [Prices and Payment]. If the total amount due and owing to the Contractor upon Single Unit Substantial Completion, or Substantial Completion as applicable, is less than two times the value of the estimated cost to complete or correct the items set out in the list provided pursuant to Section 5.10(a) or Section 5.12(b), as applicable, of this Schedule 11 [Prices and Payment], then such difference will be immediately due and owing by the Contractor to BC Hydro upon receipt of an invoice from BC Hydro for such difference. The amount retained by BC Hydro will be treated as a reduction in the amount payable to the Contractor including a corresponding decrease in the amount of GST payable to the Contractor.

If the Contractor completes or corrects an item set out in the list provided pursuant to Section 5.10(a) or Section 5.12(b), as applicable, of this Schedule 11 [Prices and Payment], then BC Hydro will release to the Contractor the amount held back by BC Hydro under Section 5.13 of this Schedule 11 [Prices and Payment] on account of that item.

If the Contractor fails to complete or correct an item set out in the list provided pursuant to Section 5.10(a) or Section 5.12(b), as applicable, of this Schedule 11 [Prices and Payment], then:

(a) that item will be deemed to be a defect and the provisions of Section 24.7 of Schedule 2 [Design and Construction Protocols] will apply; and

(b) if BC Hydro carries out the work to complete or correct that item as contemplated under Section 24.7(a) of Schedule 2 [Design and Construction Protocols], then:

  (i) BC Hydro may deduct the costs incurred by BC Hydro, including the costs of Others, any administrative costs, the cost of BC Hydro's own forces and resources and the cost to BC Hydro of Hydro's Representative, to complete or correct that item against the amount held back by BC Hydro under Section 5.13 of this Schedule 11 [Prices and Payment] on account of that item;

  (ii) if the amount held back by BC Hydro under Section 5.13 of this Schedule 11 [Prices and Payment] on account of that item is greater than the costs incurred by BC Hydro to complete or correct that item, then BC Hydro will release to the Contractor the balance of the amount held back on account of that item; and

  (iii) if the amount held back by BC Hydro under Section 5.13 of this Schedule 11 [Prices and Payment] on account of that item is less than the costs incurred by BC Hydro to complete or correct that item, then the difference will be immediately due and owing by the Contractor upon receipt of an invoice from BC Hydro.

5.14 Application for Total Completion

When the Contractor judges that all deficiencies have been corrected and that the performance of the Work is fully complete (including with respect to all six Units) except for Contractor's warranty obligations, the Contractor may apply to Hydro's Representative for a certificate of Total Completion. The application will be in writing and will include the following:

(a) evidence that all deficiencies have been corrected and approved by Hydro's Representative;

(b) evidence from the Workers' Compensation Board of British Columbia that the Contractor is in good standing; and

(c) a statement as to the status of amounts owing to first tier Subcontractors and as to any unresolved claims made by Subcontractors against the Contractor or another Subcontractor.

5.15 Total Completion

Hydro's Representative will, as soon as practicable after receipt of an application under Section 5.14 of this Schedule 11 [Prices and Payment], inspect the Work (including all six Units) to verify the validity of the application and, when all Work is complete in accordance with the requirements of the Contract Documents except for the Contractor's warranty obligations ("**Total Completion**"), issue the certificate of Total Completion with respect to all six Units.

5.16 Single Unit Total Completion

Notwithstanding Sections 5.14 and 5.15 of this Schedule 11 [Prices and Payment], the Contractor may apply for total completion with respect to the individual Units as follows:

(a) "**Single Unit Total Completion**" means the stage in the progress of the Work when the Unit is totally complete in accordance with the requirements of the Contract Documents;

(b) the Contractor will include the information required under Section 5.13 of this Schedule 11 [Prices and Payment], as applicable to the individual Unit; and

(c) Hydro's Representative will, as soon as practicable after receipt of an application under Section 5.16 of this Schedule 11 [Prices and Payment], inspect the Unit and the related Work to verify the validity of the application and, when all Work is complete for that Unit in accordance with the requirements of the Contract Documents except for the Contractor's warranty obligations, issue the certificate of Single Unit Total Completion for that Unit.

5.17 Limitation of Certificates

Neither Hydro's Representative nor BC Hydro, by issuing any certificate, including any certificate of Substantial Completion or a certificate of Total Completion, guarantees, or otherwise becomes liable or responsible in any way for, the completeness or correctness of the Work, and no certificate will make Hydro's Representative or BC Hydro in any way responsible or liable for the performance of the Work or relieve the Contractor of its warranty obligations under the Contract.

5.18 Waiver of Claims

As of the dates of the Contractor's application for Substantial Completion and Total Completion, the Contractor expressly waives and releases the Indemnified Parties from any and all Claims which, as of the date of the applicable application, the Contractor has or reasonably ought to have known the Contractor has against the Indemnified Parties, or any one of them, with respect to the performance of the Work or with respect to the Contract, including those that may arise from the negligence of or breach of the Contract by an Indemnified Party, or any other representative of BC Hydro, except for Claims set out in writing and delivered to Hydro's Representative prior to the delivery by the Contractor of the applicable application and still unsettled.

5.19 Provisional Sums

If BC Hydro has included a provisional sum in this Schedule 11 [Prices and Payment], then BC Hydro will pay any such sum or portion of such sum only pursuant to a Change Order.

5.20 Worker Guest Night Use Overage Adjustment

The Contract Price will be adjusted on account of the Contractor's aggregate number of Guest nights that the Contractor uses to achieve Total Completion of the Work as follows:

(a) for the purposes of Section 5.20 of this Schedule 11 [Prices and Payment]:

(i) "**Contractor's Guest Night Entitlement**" means [redacted], calculated based on the number of Guests specified in [redacted];

(ii) "**Contractor's Actual Daily Guest Night Use**" means for each day during the performance of the Work the greater of:

(A) the Contractor's Daily 72 Hour Confirmation, or

(B) the actual number of Guest nights; and

(iii) "**Contractor's Aggregate Guest Night Use**" means the aggregate, at any time, of all the Contractor's Actual Daily Guest Night Use for all days commencing from the Effective Date;

(b) if the Contractor's Aggregate Guest Night Use is less than or equal to the Contractor's Guest Night Entitlement then there will be no adjustment to the Contract Price; and

(c) if at any time the Contractor's Aggregate Guest Night Use is more than the Contractor's Guest Night Entitlement, then thereafter the Contract Price will be reduced, without duplication, by an amount (the "**Contractor's Guest Night Overage**") calculated as follows:

Contractor's Guest Night Overage =

[Contractor's Aggregate Guest Night Use – Contractor's Guest Night Entitlement] x [[redacted] (as may be adjusted for escalation – see below)],

and in such event the Contractor's Guest Night Overage, as of the end of a month, for additional Guest nights used in that month, in excess of the Contractor's Guest Night Entitlement will be included in the next occurring Progress Payment Estimates and deducted from amounts owing by BC Hydro to the Contractor. GST will be payable on any Contractor's Guest Night Overage.

The Guest night rate of [redacted] is the rate as of the Effective Date, and will be subject to escalation for BC Consumer Price Index (CPI) as follows:

$$Guest\ night\ Rate = \text{[redacted]} * \frac{BCCPI_{Year}}{BCCPI_{2015}}$$

5.21 Labour Cost Escalation

The Contract Price will be adjusted on account of labour cost escalation as follows:

(a) the Contractor is one of three 'Proponent' signatories to a collective agreement entitled 'Special Project Needs Agreement' dated for reference June 3, 2015 between:

(i) Construction Labour Relations Association of BC on behalf of: Alstom Renewable Power Canada Inc., Andritz Hydro Canada and Voith Hydro Inc.; and

(ii) the Bargaining Council of British Columbia Building Trade Unions

(the "**SPNA**");

(b) the SPNA identifies:

(i) hourly wage rates and benefits (provided by hourly employer contributions) for the various craft trades that the Contractor intends to employ for the performance of the Installation Work; and

(ii) additional miscellaneous costs for all employer travel and transportation costs, rest breaks, testing and/or qualification costs necessary to obtain certification and all personal protective equipment, which the Contractor is obligated to pay and incurs the cost for, for those employees covered by the SPNA in respect to the employment of the various craft trades identified in Section 5.21(b)(i) of this Schedule 11 [Prices and Payment]. For certainty, no costs other than as listed in this Section 5.21(b)(ii) are included in such additional miscellaneous costs.

For the purposes of Section 5.21 of this Schedule 11 [Prices and Payment] craft trades will be deemed to include apprentices for the applicable craft trade; and

(c) with respect to each application for payment of a Milestone Payment where the associated Milestone is for Installation Work as set out in Appendix 11-1 [Payment Schedule]:

(i) the Contractor will include the actual number of hours worked by each craft tradesperson in the performance of that Milestone and the escalation of straight time hourly wage rates and benefits (provided by hourly employer contributions) described in Section 5.21(b)(i) of this Schedule 11 [Prices and Payment] will be as follows:

(A) the amount of the applicable Milestone Payment will be adjusted (increased or decreased) on account of the increase or decrease in the straight time hourly wage rates and benefits (provided by hourly employer contributions) payable by the Contractor pursuant to the SPNA, calculated as follows:

(I) for each craft trade determine the escalation adjustment as follows:

Craft Trade Hourly Escalation Adjustment ("**CTHEA**") =

(straight time hourly wage rate and benefits (provided by hourly employer contributions) for that craft trade payable by the Contractor pursuant to the SPNA for the applicable Installation Work, but excluding "those more advantageous provisions", if any, that the Contractor has agreed to pay under section 3.07 of the SPNA) minus

(straight time hourly wage rate and benefits (provided by hourly employer contributions) for that craft trade payable by the Contractor pursuant to the SPNA as of the "Closing Time" as defined in the RFP),

which for certainty may be positive or negative depending on whether the straight time hourly wage rate and benefits (provided by hourly employer contributions) increase or decrease between the "Closing Time" as defined in the RFP and the time when the straight time hourly wage rates and benefits (provided by hourly employer contributions) are payable by the Contractor for the applicable Installation Work;

(II) for each craft trade the escalation adjustment will be:

(CTHEA) x (the actual number of hours worked by that craft trade in the performance of that Milestone); and

(III) the total adjustment to the Milestone Payment on account of labour escalation of straight time hourly wage rates and benefits (provided by hourly employer contributions) described in Section 5.21(b)(i) of this Schedule 11 [Price and Payment] will be the aggregate of the escalation adjustments as determined under Section 5.21(c)(i)(A)(II) for all applicable craft trades that performed Installation Work covered by that Milestone;

(ii) the Contractor will include a description and an amount of the aggregate additional miscellaneous costs incurred in the performance of that Milestone and the escalation of additional miscellaneous costs described in Section 5.21(a)(ii) of this Schedule 11 [Prices and Payment] will be as follows:

(A) the amount of the applicable Milestone Payment will be adjusted (increased or decreased) on account of the aggregate increase or decrease in the additional miscellaneous costs payable by the Contractor pursuant to the SPNA, calculated as follows:

Additional Miscellaneous Costs Adjustment =

(aggregate of the additional miscellaneous costs payable by the Contractor pursuant to the SPNA for the applicable Installation Work)

minus

(aggregate additional miscellaneous costs payable by the Contractor pursuant to the SPNA as of the "Closing Time" as defined in the RFP),

which for certainty may be positive or negative depending on whether the aggregate additional miscellaneous costs increase or decrease between the "Closing Time" as defined in the RFP and the time when the aggregate additional miscellaneous costs are payable by the Contractor for the applicable Installation Work; and

(iii) if any of the collective agreements are under negotiation and not finalized as of the time of such calculation, then the calculation will be delayed until such collective agreements are finalized.

6 TAXES

6.1 Tax Included in Contract Price

The Contract Price (and any part of the Contract Price) paid or payable by BC Hydro to the Contractor includes all applicable taxes, PST, duties, levies and charges (excluding only GST) payable in respect of the performance of the Work (or any part of the Work) assessed by any and all Governmental Authorities for Work performed by the Contractor, its Subcontractors, their employees or other Persons engaged by or through them in connection with the Work, and includes all customs duties with respect to all imported equipment and materials.

6.2 GST

GST will be identified as a separate line item on all invoices, and will be payable by BC Hydro to the Contractor as a separate item in addition to the Contract Price.

6.3 Input Tax Credits

Each party will provide to the other party at all times when any GST is required to be paid, such documents and particulars relating to the supply as may be required by either BC Hydro or the Contractor, as the case may be, to substantiate a claim for any input tax credits as may be permitted pursuant to the *Excise Tax Act* (Canada) in respect of GST.

6.4 Payment of Taxes

Except as may be specifically and expressly set out in the Contract Documents, the Contract Price (and any part of the Contract Price) paid or payable by BC Hydro to the Contractor includes all applicable taxes, PST, levies and charges (excluding only GST) payable or assessed on any of the Contractor, Subcontractors, or their employees or other Persons engaged by or through them by any and all Governmental Authorities in connection with the performance of the Work ("**Contractor Taxes**"), and includes all customs duties with respect to all imported equipment and materials regardless of whether such equipment is held in the name of the Contractor, a Subcontractor or BC Hydro at the time of import ("**Contractor Duties**"). The Contractor is solely responsible to incur and bear the Contractor Taxes and Contractor Duties on inputs relating to the Work.

6.5 Tax Indemnity

The Contractor will indemnify and hold harmless the Indemnified Parties, or any one of them, from and against any liability and costs incurred by them in respect of any Contractor Taxes or Contractor Duties, or any other related charges, including any related interest, fines, or penalties and any related reporting obligations and costs incurred as a consequence of such. The Contractor will be registered with all Governmental Authorities in accordance with Laws and will comply with all of its obligations to pay any such Contractor Taxes and Contractor Duties.

Notwithstanding any other provision in the Contract, BC Hydro may, in its sole discretion, withhold from any monies owed to the Contractor, whether such monies are owed under and pursuant to the Contract or otherwise, such amounts as are payable by the Contractor in respect of Contractor Taxes or Contractor Duties for which BC Hydro becomes or may become liable.

6.6 Non-Resident

The Contractor represents and warrants that it is not a non-resident of Canada for purposes of the *Income Tax Act* (Canada). In the event that the Contractor becomes a non-resident of Canada for purposes of the *Income Tax Act* (Canada), the Contractor will provide Hydro's Representative with written notice of such circumstance.

If the Contractor:

(a) becomes a "non-resident person" (as defined in the *Income Tax Act* (Canada));

(b) provides or performs any part of the Work in Canada; and

(c) has not received and provided Hydro's Representative with a copy of a waiver letter from the Canada Revenue Agency,

then BC Hydro may deduct and withhold 15% of the value of the Work performed in Canada, or such other amount as may be specified by the Canada Revenue Agency from time to time, and remit such amount according to Laws. If the Canada Revenue Agency assesses BC Hydro for a failure to deduct non-resident withholding tax, then the Contractor will indemnify the Indemnified Parties against all taxes, penalties, interest and costs resulting from such failure.

If the Contractor hires employees or Subcontractors who are not residents of Canada to perform any portion of the Work, the Contractor will, as part of the Work, be responsible for all income tax compliance and other expenditures relating to non-resident workers.

6.7 Tax Exemptions, Refunds and Compliance

The Contractor will, where applicable, use all commercially reasonable efforts to obtain for the benefit of BC Hydro all available exemptions, deductions, rebates, remissions and refunds for all Contractor Taxes and Contractor Duties, including any other related charges, including any related interest, fines or penalties, and upon receipt of any amount in respect of any such exemption, deduction, rebate, remission or refund, the Contractor will promptly pay such amount to BC Hydro.

The Contractor will show as separate entries on any invoice submitted for payment, each of the GST and, if applicable, the PST, in each case, payable by BC Hydro and collectable by the Contractor on that portion of the Work invoiced or for which a monthly estimate has been provided.

The Contractor will self-assess the PST payable on all taxable equipment and materials that are brought into British Columbia for incorporation into the Work unless an exemption applies (such as the PST exemption for production machinery and equipment). The Contractor will use the landed cost of the equipment or materials in British Columbia as the tax base for the self-assessment.

If the Contractor is required to collect PST from BC Hydro, the Contractor must be registered to do so in the Province of British Columbia.

If the Contractor is required to collect GST from BC Hydro, the Contractor must be registered for GST under the *Excise Tax Act* (Canada) and must provide to BC Hydro on all invoices the Contractor's Canadian federal GST registration number and all other information as may be required pursuant to the *Excise Tax Act* (Canada).

6.8 Tax Change

Where, at any time after the Effective Date:

(a) the rate of any applicable Canadian federal or British Columbia sales tax, excise tax, or duty has been varied;

(b) the application of any Canadian federal or British Columbia sales tax, excise tax, or duty has been changed; or

(c) a new Canadian federal or British Columbia sales tax, excise tax, or duty has been levied,

that causes an increase or decrease to the expenditure for property and services with respect to the Work, either party may before the certificate of Substantial Completion is issued give written notice to the other party that such event is a Change to which Schedule 12 [Changes] applies. The party seeking a Change will provide a detailed analysis of the estimated expenditure on property and services as at the Effective Date, and this estimate will be used to calculate the increase or decrease in expenditure if there is a Change as contemplated in this Section 6.8.

6.9 PST Exemption

The Equipment installed by the Contractor in the Powerhouse that will be used by BC Hydro primarily and directly in the production of electricity is eligible for the PST exemption for production machinery and equipment. For reference, a listing of some qualifying production machinery and equipment is provided in Table Appendix 11-4 B in Appendix 11-4 [PST]. BC Hydro will provide the Contractor with a PST certificate of exemption or other declaration as required to claim the PST exemption on qualifying Equipment and materials only.

6.10 Termination and Modification Payments and Bulk Transactions

If Section 182 of the *Excise Tax Act* (Canada) applies to a termination or modification payment made by BC Hydro under this Contract, the Contractor will remit the applicable GST included in the amount payable on its next GST return for the period the payment is made.

If termination of this Contract qualifies as a “bulk transaction” as contemplated in Section 187 of the *Provincial Sales Tax Act* (British Columbia), the Contractor will request a certificate as required under Subsection 187(3) of the *Provincial Sales Tax Act* (British Columbia) in a timely manner and provide a copy of the certificate to BC Hydro.

6.11 Tax Consequences

For greater certainty: (i) BC Hydro is not responsible or liable for any adverse tax consequences (including additional or increased Contractor Taxes) to Contractor or any Contractor personnel (including a Key Individual) as a result of the personnel performing services for a prolonged period at the Site, which is a location that is different from the personnel’s country of residence; and (ii) the desire to avoid those kinds of adverse tax consequences are not a justification for removal of a Key Individual from, or permission for a Key Individual to cease performance of the Work.

7 FINAL ACCOUNTING AND PAYMENT

7.1 Summary of Payments

After the certificate of Total Completion has been issued, Hydro’s Representative will prepare a summary of all payments due to the Contractor, setting off the total of all:

(a) payments already made by BC Hydro to the Contractor under the Contract;

(b) amounts payable and claimed to be payable by the Contractor to BC Hydro under the Contract, including amounts owing or claimed to be owing from the Contractor to BC Hydro;

(c) amounts payable by the Contractor to BC Hydro in respect of any other matters under the Contract in respect of which the cost is to be borne by the Contractor; and

(d) amounts paid by BC Hydro on behalf of the Contractor or a Subcontractor to a third party.

7.2 Certification

Where satisfied that the Work has been properly performed under the Contract, Hydro's Representative will certify in the summary prepared under Section 7.1 of this Schedule 11 [Prices and Payment] the amount owed by one party to the other and will provide a copy of the summary to the Contractor.

7.3 Payment Due

The party owing any amount certified in the summary in Section 7.2 of this Schedule 11 [Prices and Payment] as payable will pay that amount to the other party within 30 Days:

(a) in the case of BC Hydro, after certification of the summary; and

(b) in the case of the Contractor, after receipt of an invoice from BC Hydro for such amount.

8 LOW-END RANGE PERFORMANCE BONUS

8.1 Low-End Range Performance Bonus

BC Hydro will pay a performance bonus (the "**Low-End Range Performance Bonus**" or "**LEPB**") to the Contractor for Additional Prototype Low-End Operating Range as set out below. The LEPB applies to all Units collectively and will be based on the Generator power output for the one Unit that has the highest Prototype Minimum Turbine Output (i.e. the smallest resultant Additional Prototype Low-End Operating Range).

The LEPB will be calculated as follows:

(a) $AR_L = P_{ref} - P_{min} - P_{mu}$

where:

AR_L = Additional Prototype Low-End Operating Range;

P_{ref} = Generator power output of the Unit in kW (as would be measured at the Generator terminals) as stated in Section 2.4(e) of the Turbine TDIF with Turbine operating at the Reference Minimum Turbine Output;

P_{min} = Generator power output of the Unit in kW (as measured at the Generator terminals during the site acceptance and commissioning tests) with the Turbine operating at the highest Prototype Minimum Turbine Output; and

P_{mu} = Power measurement uncertainty. For the purposes of this Section 8.1(a), an uncertainty allowance of 300 kW will be applied to the measured Generator power output;

(b) the LEPB, if payable, will be a single payment covering all six Units calculated as follows:

$$LEPB = AR_L \times r_L$$

where:

r_L = [redacted]/kW ([redacted]/kW/Unit x 6 Units); and

(c) notwithstanding any other provision of Section 8.1 of this Schedule 11 [Prices and Payment], the maximum amount payable for the LEPB is [redacted] in $CAD (in the aggregate, for all six Units).

9 LIQUIDATED DAMAGES

9.1 Liquidated Damages for Defined Events

The parties confirm and agree that the amount of each specified Liquidated Damages as described in Section 9 of this Schedule 11 [Prices and Payment] and in Appendix 4-8 [Interface Requirements] represents a genuine and reasonable pre-estimate of the damages that will be incurred by the party suffering the damages upon the occurrence of the defined event, and each such amount is not a penalty.

9.2 No Duplicate Recovery

Notwithstanding any other provision of this Contract, neither party will be entitled to recover compensation or make a Claim under this Contract or any other agreement in relation to the Work in respect of any damages it has incurred to the extent that the claiming party has already been compensated in respect of that loss.

The parties agree that Liquidated Damages up to the aggregate limits set out in Section 9.16 or Section 9.17, as applicable, with respect to the associated defined event, will be the claiming party's sole remedy with respect to damages incurred as a result of the occurrence of that event.

9.3 Cure Period

Notwithstanding any other provision of this Contract, no Liquidated Damages will be payable pursuant to Sections 9.7 through 9.14 of this Schedule 11 [Prices and Payment] for a period of one year (or such longer period of time as BC Hydro may determine in its sole and absolute discretion) after the date on which such Liquidated Damages would have been payable but for this Section 9.3. If, after such one year period, the circumstances described in Sections 9.7 through 9.14 of this Schedule 11 [Prices and Payment] continue to exist, then Liquidated Damages will be payable by the Contractor in accordance with the applicable provisions.

Notwithstanding the one year cure period, the Contractor will, immediately upon becoming aware of a circumstance that may give rise to the payment of Liquidated Damages, take all necessary action to correct such circumstance.

9.4 Interface Milestones

The parties will pay the Liquidated Damages as described in Appendix 4-8 [Interface Requirements] upon the occurrence of the defined events set out in Appendix 4-8 [Interface Requirements].

9.5 Completion Milestone Liquidated Damages

If the Contractor fails to achieve a completion milestone as described in Appendix 11-5 [Completion Milestone Damages] (each a "**Completion Milestone**") on or before the date specified for the achievement of that Completion Milestone, as such date may be adjusted in accordance with the Contract Documents, the Contractor will pay BC Hydro Liquidated Damages equal to the amount per day (or portion of a day) as indicated in Appendix 11-5 [Completion Milestone Damages] until that Completion Milestone is achieved.

The following will apply to Liquidated Damages with respect to Completion Milestones:

(a) Multiple Applicable Liquidated Damages for Completion Milestones: If at any time the Contractor has failed to achieve more than one Completion Milestone for a particular Unit, then for the period during which multiple Liquidated Damages are applicable, the Liquidated Damages payable will be the highest applicable daily Liquidated Damage for that Unit as set out in Appendix 11-5 [Completion Milestone Damages] for each day of such period.

(b) Waiver of Completion Milestone Damages: Notwithstanding any Liquidated Damages payable for failure to achieve a Completion Milestone(s) with respect to a single Unit, if the Substantial Completion date for that Unit is achieved as described in the Schedule 4 [Work Program and Schedule], as may be adjusted in accordance with the Contract Documents, then any such Liquidated Damages will be waived by BC Hydro and, if applicable, credited back to the Contractor. For certainty, this Section 9.5(b) does not apply to any Liquidated Damages to which BC Hydro may be entitled under Appendix 4-8 [Interface Requirements].

9.6 Technical Data and Information Forms

The Equipment will fully comply with the information contained in the Technical Data and Information Forms.

9.7 Liquidated Damages for Failure to Achieve Power Outputs for Operating Condition A

For each Unit that is capable of continuous operation at Operating Condition A in accordance with the procedure specified in Appendix 6-2 [General Technical Specifications (SPGT)], the determination of whether a Unit fails to achieve power outputs for Operating Condition A will be determined from the Generator Losses. Where the Generator Losses exceed those losses stated in Section 4.3(b) of the Generator TDIF, coincident with the Turbine power output for Operating Condition A, the Contractor will pay BC Hydro Liquidated Damages for each such Unit calculated as follows:

$$LDP_C = (L_C - L_{CF} - L_{tu}) \times V_C$$

where:

LDP_C = Liquidated Damages for Generator power output not achieved at Operating Condition A for a Unit;

L_C = Generator Losses in kW coincident with the Turbine power output indicated in Section 2.4(e)(v) of the Turbine TDIF for Operating Condition A;

L_{CF} = Generator losses in kW for Operating Condition A as set out in Section 4.3(b) of the Generator TDIF;

L_{tu} = Generator Losses Test Uncertainties as stated in Section 4.3(d) of the Generator TDIF; and

V_C = [redacted]/kW = the value for Generator power output not achieved at Operating Condition A for a Unit.

No bonus or other additional compensation will be paid by BC Hydro to the Contractor for Generator Losses in kW that are less than as stated in Section 4.3(b) of the Generator TDIF for the Turbine operating at Operating Condition A.

9.8 Liquidated Damages for Failure to Achieve Power Outputs for Operation Condition B

For any Unit that fails during the site acceptance and commissioning tests, as specified in Appendix 6-2 [General Technical Specifications (SPGT)], to operate continuously at the Generator power output coincident with the Turbine operating at the Turbine maximum power output for Operating Condition B, the Contractor will pay BC Hydro Liquidated Damages for each such Unit calculated as follows:

$$LDP_H = (P_{HF} – P_H – P_{mu}) \times V_H$$

where:

LDP_H = Liquidated Damages for Generator power output not achieved at Operating Condition B for a Unit;

P_{HF} = Generator power output in kW as stated in Section 2.3(a) of the Turbine TDIF;

P_H = Measured Generator power output in kW coincident with the Turbine operating at the highest power output for Operating Condition B;

P_{mu} = Power measurement uncertainty. For the purposes of this Section 9.8, an uncertainty allowance of 300 kW per Unit will be applied to the measured Generator power output; and

V_H = [redacted]/kW = the value for Generator power output not achieved at Operating Condition B for a Unit.

No bonus or other additional compensation will be paid by BC Hydro to the Contractor for a Generator power output in kW for the Turbine operating at Operating Condition B that is greater than as stated in the Turbine TDIF.

9.9 Liquidated Damages for Failure to Achieve Guaranteed Plant Annual Energy

The Contractor will pay BC Hydro Liquidated Damages if the achieved Plant Annual Energy during testing and commissioning is less than the Guaranteed Plant Annual Energy as stated in Section 2.1(a) of the Turbine TDIF.

The achieved Plant Annual Energy will be calculated using the Plant Annual Energy Calculation methodology with the Generator losses in Section 4.3 of the Generator TDIF updated with the Generator Losses measured during the site acceptance and commissioning tests.

If any prototype Turbine has one or more zones within the Normal Turbine Operating Range that fail to meet the requirements of Schedule 6 [Specifications and Drawings], then at BC Hydro's sole discretion, acting reasonably, the annual operating hours may be reduced proportionally to reflect the achievable operating zones and hours and the achieved Plant Annual Energy will be recalculated accordingly.

If, for any reason, modifications to the prototype Turbine are required, and such modifications are not represented in the Turbine Model Test results, then the Contractor will as part of the Work perform additional performance testing (such as a prototype Turbine index test that compares the relative Turbine efficiency before and after the modifications, or additional Turbine model testing) to determine whether the prototype Turbine efficiency is negatively impacted by such modifications. If the prototype Turbine efficiency is lower than as stated in Table 2.19 – Guaranteed Plant Annual Energy Calculation of

Appendix 11-6 [Technical Data and Information Forms] because of the modifications described in this paragraph, then the Turbine efficiency value used in the Plant Annual Energy Calculation for the nearest applicable Weighting Regime(s) will be adjusted and the achieved Plant Annual Energy will be recalculated.

Liquidated Damages will be assessed on any shortfall in achieved Plant Annual Energy below the Guaranteed Plant Annual Energy calculated as follows:

$$LD_E = (EP_2 – EP_1) \times VP_E$$

where:

LD_E = Liquidated Damages for Plant Annual Energy not achieved;

EP_2 = the guaranteed Plant Annual Energy;

EP_1 = the achieved Plant Annual Energy; and

VP_E = the value for Plant Annual Energy not achieved will be assessed at [redacted] per GWh.

Liquidated Damages for Plant Annual Energy not achieved will be rounded down to the nearest increment of [redacted].

No bonus will be paid for any achieved Plant Annual Energy in excess of the Guaranteed Plant Annual Energy.

9.10 Liquidated Damages for Failure to Achieve Core Buckling Performance

For each Unit where the Generator fails to meet the requirements of Section 2.5.4(f) of Appendix 6-5 [Generator Specifications (SPG)] the Contractor will pay BC Hydro Liquidated Damages calculated as follows:

(a) Step 1 – Determine the significance factor.

Obtain the significance factor from Table 9.10(a) using measurements of the core at the time of the assessment.

Table 9.10(a) – Significance Factor

	Significance Factor – SF_{core}		
Circumferential Length[1]	> 10 m	5 m to 10 m	< 5 m
Magnitude[2]			
5 mm to 9 mm	1	2	2
>9 mm to 12 mm	2	3	3
>12 mm	3	4	4

(b) Step 2 – Determine core stability factor.

Using the significance factor from Step 1 obtain the core stability factor from Table 9.10(b) based on the stability of the core at the time of the assessment.

Table 9.10(b) – Core Stability Factor

	Core Stability Factor – CSF_{core}	
	Core is Not Stable[3]	Core is Stable[3]
SF_{core}		
1	50%	25%
2	65%	40%
3	80%	55%
4	100%	75%

(c) Step 3 – Determine amount of Liquidated Damages.

Using the values obtained for the significance factor and the core stability factor obtained in Steps 1 and 2 above calculate the Liquidated Damages as follows:

Liquidated Damages per Generator = C_{core} x CSF_{core}

where:

Cost Core (C_{core}) = [redacted] per Generator.

Notes:

1 The core wave circumferential length is the circumferential distance on the inside diameter of the core from the point of maximum deviation from a level reference plane to the nearest adjacent reversal in the wave.

2 Core wave magnitude is equivalent to the deviation from level as defined in CEATI Report No. T052700-0329 Part I. However, BC Hydro, in its sole and absolute discretion, may decide to adjust the measured deviation from level to account for any deviations that existed prior to the winding installation but after the core full flux test described in Section 4.5.2 of Appendix 6-5 [Generator Specifications (SPG)]. The datum for this adjustment would be based on elevation measurements at the mid-point of the core.

3 A core will be deemed stable if the rate of increase in magnitude of a core wave is less than 1 mm in 4 years.

9.11 Liquidated Damages for Failure to Achieve Generator Stator Winding and Generator Rotor Winding

For each Generator where the Generator stator or rotor winding fails to meet the requirements of Section 5.4 of Appendix 6-5 [Generator Specifications (SPG)], then the Contractor will pay Liquidated Damages in the amount of [redacted].

9.12 Liquidated Damages for Failure to Achieve Cavitation Warranty

For each Turbine where the Turbine exceeds the Actual Permitted Thresholds for cavitation in the last completed Actual Warranty Assessment Periods in accordance with Section 4.4 of Appendix 6-3 [Turbine Specifications (SPT)], then the Contractor will pay to BC Hydro Liquidated Damages in the amount of [redacted].

9.13 Liquidated Damages for Failure to Achieve Wicket Gate Leakage

For each Turbine where the Turbine Wicket Gate Leakage, as measured during the site acceptance and commissioning tests, is greater than the Wicket Gate Leakage stated in Section 2.12(l) of the Turbine TDIF, then the Contractor will pay BC Hydro Liquidated Damages in the amount of [redacted] per L/s.

9.14 Liquidated Damages for Failure to Achieve Cooling Water Usage

For each Generator where the cooling water flow rate of the Generator air coolers as measured during the site acceptance and commissioning tests is greater than the cooling water flow rate stated in Section 4.7(a) of the Generator TDIF, then the Contractor will pay BC Hydro Liquidated Damages in the amount of [redacted] per L/s.

9.15 Rounding of Liquidated Damages Amount

In each instance where Liquidated Damages are payable by the Contractor pursuant to Section 9.7, 9.8 and 9.10 through Section 9.14 of this Schedule 11 [Prices and Payment], that Liquidated Damage amount will be rounded down to the nearest increment of [redacted].

9.16 Aggregate Limits for Interface Milestone Liquidated Damages and Completion Milestone Liquidated Damages

The aggregate Liquidated Damages payable by the Contractor pursuant to:

(a) Section 9.4 of this Schedule 11 [Prices and Payment] and Appendix 4-8 [Interface Requirements]; plus

(b) the first paragraph of Section 9.5 of this Schedule 11 [Prices and Payment], subject to Section 9.5(a) and Section 9.5(b) of this Schedule 11[Prices and Payment],

will not exceed with respect to all six Units, [redacted] of the Contract Price.

9.17 Aggregate Limits for Performance Liquidated Damages

The aggregate Liquidated Damages payable by the Contractor pursuant to Sections 9.7 through 9.14 of this Schedule 11 [Prices and Payment] will not exceed with respect to all six Units, [redacted] of the Contract Price.

9.18 Schedule 11 Liquidated Damages Aggregate Limit

The aggregate Liquidated Damages payable by the Contractor pursuant to this Schedule 11 [Prices and Payment] plus Appendix 4-8 [Interface Requirements] will not exceed [redacted] of the Contract Price.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-1

PAYMENT SCHEDULE

<u>Note:</u> Attached to this Appendix 11-1 is an Excel spreadsheet entitled “Appendix 11-1 Payment Schedule” that the parties agree contains the correct Contract prices and which are deemed to be read as part of this Appendix 11-1 (and which will be subject to adjustment for currency fluctuation as provided by Section 12.1 of the Agreement).

<u>Table Appendix 11-1 A: Contract Price Breakdown, by Milestone</u>

				Milestone Payment Amount in $CAD						
Milestone Number	**Milestone**	**Payment Unit**	**PST Status**	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Total**
Design										
1	Group A Submittals complete	Lump Sum for all six Units	PST Exempt			[redacted]				[redacted]
2	Group B Submittals complete	Lump Sum for all six Units	PST Exempt			[redacted]				[redacted]
3	Group C Submittals complete	Lump Sum for all six Units	PST Exempt			[redacted]				[redacted]
4	Group D, E, F Submittals and Group H, I, J preliminary Submittals complete	Lump Sum for all six Units	PST Exempt			[redacted]				[redacted]

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD						
				Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
5	Group M and L Submittals complete	Lump Sum for all six Units	PST Exempt			[redacted]				[redacted]
6	Manuals and Issued for Record Drawings Submittals complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7	Final Drawings and Explanatory Documents Submittals complete	Lump sum for all six Units	PST Exempt			[redacted]				[redacted]
			Design Sub-Total							[redacted]
Supply										
	Turbine									
8	1st Stage Concrete anchors, draft tube pier nose cap, draft tube elbow access door	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
9	Draft tube elbow, draft tube cone, draft tube platform, draft tube temporary closure piece, discharge ring	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
10	Spiral case, stay ring, bulkheads, flexible coupling, closure section, penstock spool piece, turbine pit liner	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
11	Bottom ring, headcover, turbine pit walkway and guard rails, turbine pit hoist, turbine pit door	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
12	Runner, main shaft	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
13	Shaft seal, turbine guide bearing, wicket gate operating mechanism, wicket gates, servomotors	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
14	Air admission system, synchronous condense system	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
15	Piping, cooling water system, penstock drain valve	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
16	Turbine terminal panel, instrumentation, lighting, conduit, receptacles	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
17	Tooling and lifting devices	Lump Sum for all six Units	Taxable	[redacted]						[redacted]
	Generator									
18	Stator frame, stator sole plates, stator core	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
19	Stator winding, including circuit rings, winding connections, main and neutral terminals	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
20	Rotor hub, rotor spider, rotor rim, rotor field poles, field winding, field bus, pole interconnections	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
21	Generator lower bracket, generator thrust and guide bearing, high-pressure oil injection system, generator brakes, brake dust collection system, rotor jacking system	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22	Piping, cooling and ventilation system, fire protection system	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
23	Brushgear	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
24	Upper bracket, brushgear housing, generator covers, generator enclosure doors and miscellaneous steelwork	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
25	Generator terminal cabinets, instrumentation, lighting, conduit, receptacles, heaters	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD						
				Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
26	Tooling and lifting devices	Lump Sum for all six Units	Taxable	[redacted]						[redacted]
	Exciter									
27	Exciter, including control system, excitation transformer, cabling, connection to generator isophase buswork, protection and monitoring systems, HMI and software	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Governor									
28	Governor, including control cabinet, hydraulic power unit, air make-up compressor, speed signal generator, motor control center, HMI and software	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			Supply Sub-Total							[redacted]
			Design and Supply Sub-Total							[redacted]
Installation										
29	Draft tube elbows and anchors installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
30	Draft tube cone and anchors installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
31	Stay ring and spiral case installation complete; ready for hydrostatic test	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
32	Spiral case spool piece, flexible coupling and closure piece installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
33	Generator stator assembly and installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD						
				Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
34	Generator rotor assembly and installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
35	Exciter installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
36	Governor installation complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
37	Unit Assembly Complete	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
			Installation Sub-Total	[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	[redacted]
Testing and Commissioning										
38	Single Unit Substantial Completion	Lump Sum per Unit	PST Exempt	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
39	Remaining Testing and Commissioning complete	Lump Sum for all six Units	PST Exempt	[redacted]						[redacted]
			Testing and Commissioning Sub-Total							[redacted]
			Installation and Testing and Commissioning Sub-Total							[redacted]
Committed Spare Parts										
40	Committed Spares	Lump Sum for all six Units	PST Exempt	[redacted]						[redacted]
			Committed Spare Parts Sub-Total							[redacted]
Optional Spare Parts										
41	Optional Spares	Unit Prices	PST Exempt	Refer to Appendix 11-7 [Equipment Spare Parts Lists] for unit prices						
Optional Items										
42	Runner Modal Test in Water complete	Lump Sum for all six Units	PST Exempt	[redacted] (fixed price) (exercisable within 24 months after the Effective Date)						

				Milestone Payment Amount in $CAD						
Milestone Number	**Milestone**	**Payment Unit**	**PST Status**	**Unit 1**	**Unit 2**	**Unit 3**	**Unit 4**	**Unit 5**	**Unit 6**	**Total**
43A	Alternative Excitation System Cooling System (Option 1 configuration is a straight line rectifier and control panel group with central cooling (separated from the Excitation System transformer))	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (not including costs for the changes to the cooling water system) (exercisable within 12 months after the Effective Date)						
43B	Alternative Excitation System Cooling System (Option 2 configuration adds the Excitation System transformer heat load to Option 1; either for the straight line or back-to-back rectifier an control panel group)	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (not including costs for the changes to the cooling water system) (exercisable within 12 months after the Effective Date)						
44A	Change the configuration of the Excitation System from a configuration where the rectifier and the control panels are arranged in a straight line of panels (i.e. 1 panel deep and 6 panels long) and with an Excitation System transformer that is physically separate from the rectifier and control panels (requiring a cable connection between them) to: - a configuration where the rectifier and control panels are arranged back-to-back (i.e. 2 panels deep and 3 panels long) and/or - a configuration where the Excitation System transformer is located immediately adjacent to the rectifier panels (and utilizes a direct bus connection that passes through the side of the rectifier panel enclosure and the Excitation System transformer enclosure).	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 12 months after the Effective Date)						

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
44B	Adapt the upper bracket and top covers and change the configuration and length of the Generator neutral leads to fit the octagonal shape of the Generator enclosure.	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 2 months after the Effective Date)						
44C	Not used									
44D	Provide the Generator stator frame with 72 additional (108 total) round openings (225 mm diameter) including covers and hardware. These openings to be located left, middle and right of each frame shelf.	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 6 months after the Effective Date)						
44E	Change the design of the generator thrust block to a design where shrinking or keying to the shaft are not required and where the turbine shaft and generator rotor are independently bolted to the thrust block such that the rotor can be removed without impacting the shaft to thrust block connection.	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 2 months after the Effective Date)						
44F	Change the Governor System distributing valve from a Vortex distributing valve to an to a L&S distributing valve	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 4 months after the Effective Date)						
44G	Update several engineering reports to accommodate the change in the tailwater level (TWL) that has been lowered by 0.2m but remove the vertical access hatch in the spiral case	No cost	PST Exempt	[redacted] (exercisable within 3 months after the Effective Date)	[redacted] (exercisable within 3 months after the Effective Date)	[redacted] (exercisable within 3 months after the Effective Date)	[redacted] (exercisable within 3 months after the Effective Date)	[redacted] (exercisable within 3 months after the Effective Date)	[redacted] (exercisable within 3 months after the Effective Date)	
44H	At the interface point to the penstock, remove the bracing on the penstock side of the interface point and perform the required paint repairs in this location (assume there is only one brace per unit)	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 12 months after the Effective Date)						

Milestone Number	Milestone	Payment Unit	PST Status	Milestone Payment Amount in $CAD Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
44I	Provide concrete Generator top covers that are completely enclosed by steel plates (including seal welding of all seams to keep the concrete dust in).	Lump Sum for all six Units	PST Exempt	[redacted] (fixed price) (exercisable within 3 months after the Effective Date)						
44J	Substitute the Generator top covers provided as part of the base design with Generator top covers that are similar in design to the Revelstoke U05 Generator top covers.	Lump Sum for all six Units	PST Exempt	Not to exceed [redacted] (exercisable within 3 months after the Effective Date)						
44K	Not used									
Deduction Amounts										
45	Compensation for Labour Agreement Cost Participation Payment	Lump Sum	PST Exempt	[redacted]						[redacted]
46	Compensation for Conducting Model Testing	Lump Sum	PST Exempt	[redacted]						[redacted]
Deduction Amounts Sub-Total										[redacted]
Provisional Sum										
47	Provisional Sum (to be paid in accordance with Section 5.19 of Schedule 11 [Prices and Payment])	Provisional Sum	PST Exempt	[redacted]						[redacted]
Provisional Sum Sub-Total										[redacted]
Design and Supply Sub-Total (Non-Installation Work)[1]										[redacted]
Installation and Testing and Commissioning Sub-Total (Installation Work)[2]										[redacted]
Committed Spare Parts Sub-Total										[redacted]

[1] For the purposes of this Schedule 11 [Prices and Payment], "Design and Supply Sub-Total" will be the Contractor's price for the Non-Installation Work.

[2] For the purposes of this Schedule 11 [Prices and Payment], "Installation and Testing and Commissioning Sub-Total" will be the Contractor's price for the Installation Work.

				Milestone Payment Amount in $CAD						
Milestone Number	Milestone	Payment Unit	PST Status	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Total
Sub Total Before Deduction Amounts										[redacted]
Deduction Amounts Sub-Total										[redacted]
Contract Price										[redacted]
GST										[redacted]
Provisional Sum Sub-Total										[redacted]

Table Appendix 11-1 B: Milestone Dates, by Unit

Milestone Number	Milestone	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Design[1]							
1	Group A Submittals complete	[redacted]					
2	Group B Submittals complete	[redacted]					
3	Group C Submittals complete	[redacted]					
4	Group D, E, F Submittals and Group H, I, J preliminary Submittals complete	[redacted]					
5	Group M and L Submittals complete	[redacted]					
6	Manuals and Record Issue drawings Submittals complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
7	Final Drawings and Explanatory Documents Submittals complete	[redacted]					
Supply[2]							
	Turbine						
8	1st Stage Concrete anchors, draft tube pier nose cap, draft tube elbow access door supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
9	Draft tube elbow, draft tube cone, draft tube platform, draft tube temporary closure piece, discharge ring supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10	Spiral case, stay ring, bulkheads, flexible coupling, closure section, penstock spool piece, turbine pit liner supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
11	Bottom ring, headcover, turbine pit walkway and guard rails, turbine pit hoist, turbine pit door supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12	Runner, main shaft supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
13	Shaft seal, turbine guide bearing, wicket gate operating mechanism, wicket gates, servomotors supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
14	Air admission system, synchronous condense system supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
15	Piping, cooling water system, penstock drain valve supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
16	Turbine terminal panel, instrumentation, lighting, conduit, receptacles supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
17	Tooling and lifting devices supply complete	[redacted]					
	Generator						
18	Stator frame, stator sole plates, stator core supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
19	Stator winding, including circuit rings, winding connections, main and neutral terminals supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
20	Rotor hub, rotor spider, rotor rim, rotor field poles, field winding, field bus, pole interconnections supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
21	Generator lower bracket, generator thrust and guide bearing, high-pressure oil injection system, generator brakes, brake dust collection system, rotor jacking system supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
22	Piping, cooling and ventilation system, fire protection system supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
23	Brushgear supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
24	Upper bracket, brushgear housing, generator covers, generator enclosure doors and miscellaneous steelwork supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
25	Generator terminal cabinets, instrumentation, lighting, conduit, receptacles, heaters supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
26	Tooling and lifting devices supply complete	[redacted]					
	Exciter						
27	Exciter, including control system, excitation transformer, cabling, connection to generator isophase buswork, protection and monitoring systems, HMI and software supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Governor						
28	Governor, including control cabinet, hydraulic power unit, air make-up compressor, speed signal generator, motor control center, HMI and software supply complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Installation[3]							
29	Draft tube elbows and anchors installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
30	Draft tube cone and anchors installation complete	3[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
31	Stay ring and spiral case installation complete; ready for hydrostatic test	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
32	Spiral case spool piece, flexible coupling and closure piece installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
33	Generator stator assembly and installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
34	Generator rotor assembly and installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Milestone Number	Milestone	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
35	Exciter installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
36	Governor installation complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
37	Unit Assembly Complete	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Testing and Commissioning							
38	Single Unit Substantial Completion[4]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
39	Remaining Testing and Commissioning complete[5]	[redacted]					
Committed Spare Parts							
40	Committed Spares[6]	[redacted]					
Optional Spare Parts							
41	Optional Spares	[redacted]					
Optional Items							
42	Runner Modal Test in Water complete	[redacted]					
43	Alternate Excitation System Cooling System	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Notes:

1 A design Milestone is complete when all calculations, reports, drawings and supporting information associated with that Milestone have been submitted by the Contractor to BC Hydro in accordance with the requirements of the Contract Documents and have been endorsed “Accepted” or deemed to have been endorsed “Accepted” by Hydro’s Representative in accordance with Schedule 5 [Submittals Procedure].

[2] A supply Milestone is complete when the equipment described in the description of that milestone event, including all of the associated anchors, fittings, hardware and auxiliary components required for handling, assembly and installation, has been factory assembled and/or tested and delivered to the designated storage or laydown area at the Site in accordance with the requirements of the Contract Documents and has been inspected and accepted by BC Hydro.

[3] An installation Milestone is complete when the equipment described in the description of that milestone event, including all of the associated hardware, software, lubricants and/or auxiliary components required for operation, has been assembled and installed in accordance with the requirements of Contract Documents and has been inspected and accepted by BC Hydro.

[4] Milestone 38, with respect to an individual Unit, is complete when all of the testing and commissioning activities as required by the Contract Documents have been completed by the Contractor, the results accepted by BC Hydro, and the Unit is ready for Commercial Operation.

[5] Milestone 39 is complete when the following tests have been completed by the Contractor, in accordance with the Contract Documents, and the results accepted by BC Hydro: Generator Loss Measurement, Generator Three-Phase Sudden Short Circuit Test, Runner Strain Gauge Measurement and Runaway Test.

[6] Milestone 40 is complete when all of the spare parts identified as “Committed Spares” in Table Appendix 11-7 A have been delivered to Site and have been deemed by Hydro’s Representative to meet the requirements for spare parts in accordance with Appendix 6-2 [General Technical Specifications (SPGT)].

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-2

FORM OF LETTER OF CREDIT

[*Issuing Bank Name & Address*]	**Date of Issue**: [*Date*]
	Irrevocable Standby Letter of Credit
	No. [*Number*]
Applicant:	**Beneficiary:**
[*Customer Name and Address*]	British Columbia Hydro and Power Authority
	[*Address*]
	Amount:
	[*Currency and Amount both in letters and numbers*]

At the request of and for the account of the Applicant, we, [*Bank Name*], hereby establish in favour of the Beneficiary our irrevocable standby Letter Of Credit No. [*Number*] (hereinafter called the "**Letter of Credit**") for an amount not exceeding [*Currency and Amount both in letters and numbers*].

We, [*Bank Name and Address*], hereby unconditionally and irrevocably undertake and bind ourselves, and our successors and assigns, to pay British Columbia Hydro and Power Authority ("**you**") immediately, the sum, which you claim upon receipt of the following documents:

(1) your written demand specifying the amount claimed, the number of this Letter of Credit, and the date of issue of this Letter of Credit; and

(2) this original Letter of Credit, including any amendments, must be presented with your demand for payment for endorsement purposes.

This Letter of Credit may be presented for payment at the above issuing address or at [*alternate Vancouver (B.C.) branch location if letter of credit is not issued in Vancouver*].

It is understood that we are obligated under this Letter of Credit for the payment of monies only and we hereby agree that we shall honour your demand for payment, on or before the expiry date or any future expiry date, without enquiring whether you have a right as between yourself and the Applicant to make such demand and without recognizing any claim of the Applicant.

Partial drawings and multiple presentations are allowed. The amount of this Letter of Credit shall be automatically reduced by the amount of any drawing paid hereunder.

This Letter of Credit takes effect from the Date of Issue set forth above, and shall remain valid until [*Date*]. However, it is a condition of this Letter of Credit that it will be automatically extended without notice for a further one year period from the present or any future expiry date unless at least ninety (90) days prior to such expiry date we notify you in writing at your address and the Site C Department or Personnel at the address below by courier or registered mail that we elect not to consider this Letter of Credit to be extended for any additional period. If we give you notice of our election not to extend for an additional period, you shall be entitled to immediately demand payment of the full amount of this Letter of Credit.

Site C Department or Personnel:
[*insert address*]

This Letter of Credit is subject to the International Standby Practices 1998 ("**ISP98**"). All matters not covered by ISP98 will be governed by the laws applicable in the Province of British Columbia. The parties hereby irrevocably attorn to the exclusive jurisdiction of the courts of British Columbia. The number of this Letter of Credit must be quoted on all documents required hereby.

____________________________	________________________________
Authorized Signing Officer	Authorized Signing Officer
[Bank Name]	[Bank Name]

Letter of Credit Requirements
(wording contained in this box does not form part of the issued LoC)

(a) issued or confirmed by a branch of a domestic Canadian financial institution having a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or Dominion Bond Rating Service A (low). If the issuing financial institution is not a domestic Canadian financial institution, the sovereign country's debt rating will be no less than Standard & Poor's AA, Moody's Aa2 or DBRS AA and the financial institution must have a minimum credit rating not less than Standard & Poor's A-, Moody's A3 or DBRS A (low). BC Hydro, at its discretion, may accept a sovereign debt rating of Standard & Poor's AA-, Moody's Aa3 or DBRS AA (low) if the issuing bank has a rating of not less than Standard & Poor's A, Moody's A2 or DBRS A. If such credit rating agencies publish differing credit ratings for the same financial institution, the lowest credit rating of any of the credit rating agencies shall apply for purposes of this section;

(b) available for presentation in Vancouver (B.C.) Canada; and

(c) for a term of not less than one year and providing that it is renewed automatically, unless the issuing or confirming financial institution advises otherwise as specified in the letter of credit.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-3

FORM OF GUARANTEE

THIS GUARANTEE is made as of the _______ day of _________, 20__.

BETWEEN:

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY, having its head office at 333 Dunsmuir Street, Vancouver, B.C., V6B 5R3, Canada

(the "**Beneficiary**")

AND:

[ ]

(the "**Guarantor**")

WHEREAS:

(A) The Beneficiary and [ ] ("**Contractor**") entered into a contract entitled "BC Hydro Site C Clean Energy Project Supply and Installation of Turbines and Generators Contract, (BC Hydro Reference #_____________)" (the "**Contract**").

(B) At the request of the Beneficiary, and as a condition of the Contract, the Guarantor has agreed to guarantee the punctual and complete performance of any and all of the present and future obligations and liabilities of Contractor under or arising out of the Contract, including, without limitation, Contractor's obligations to pay Liquidated Damages (as defined in the Contract) as specified in the Contract (the "**Guaranteed Obligations**").

THEREFORE IN CONSIDERATION OF THE PAYMENT of ten ($10.00) dollars by the Beneficiary to the Guarantor and other good and valuable consideration (the receipt and sufficiency of which is hereby acknowledged and agreed), including the Beneficiary entering into the Contract with Contractor, the parties agree as follows:

(1) The Guarantor absolutely, irrevocably and unconditionally guarantees to the Beneficiary the punctual and complete performance and observance of all of the Guaranteed Obligations whenever, however or wherever incurred. If at any time Contractor defaults in the performance of any of the Guaranteed Obligations in accordance with the Contract, the Guarantor shall, immediately upon the Beneficiary's written demand, remedy the default, including perform (or procure the performance of) Contractor's Guaranteed Obligations and pay any and all sums, including, without limitation, Liquidated Damages, that may be payable under the Contract in consequence of the non-performance by Contractor of such Guaranteed Obligations.

(2) Subject to clause (6) below, the Guarantor agrees to pay the Beneficiary, forthwith upon demand, all reasonable out of pocket costs and expenses, including, without limitation, legal fees on a solicitor and client basis, incurred by or on behalf of the Beneficiary to realize the benefit of any of its rights:

(a) against the Contractor (but solely to the extent the Contractor would have been responsible for such costs and expenses under the Contract); and

(b) against the Guarantor,

in respect of the Guaranteed Obligations.

(3) Any obligation of the Guarantor hereunder that is not paid when due will bear interest at a rate that is equal to the annual rate of interest declared by the Bank of Montreal from time to time as the rate of interest charged to its most creditworthy commercial borrowers for loans in Canadian dollars payable on demand and commonly referred to as its “prime rate”, plus [redacted], from the date it becomes due to the date of payment, due and payable on demand.

(4) This Guarantee is a continuing guarantee and shall apply to all of the Guaranteed Obligations and remain in place until the earlier of: 1) two years from the date on which the Contract is terminated; or 2) eight years from Total Completion as described in Section 5.15 of Schedule 11 [Prices and Payment] of the Contract.

(5) The Beneficiary shall not be bound to seek or exhaust its recourse against Contractor or any other persons or to realize on any security (including, without limitation, any letters of credit it may hold in respect of the Guaranteed Obligations) before being entitled to exercise its rights under this Guarantee. However, the Beneficiary shall not be entitled to enforce its rights and claims under this Guarantee with respect to a Guaranteed Obligation to the extent such Guaranteed Obligation has already been satisfied through other security held by the Beneficiary in respect of such Guaranteed Obligation.

(6) Subject to clauses (3) and (12), nothing herein shall be construed as imposing greater obligations and liabilities on the Guarantor than are imposed on Contractor under the Contract. The Guarantor shall be entitled to all defences, limitations and exclusions available to Contractor under the Contract. In no event shall the Guarantor’s aggregate liability under this Guarantee exceed an amount equal to [redacted] of the sum of the Contractor’s price for the Installation Work as specified in Appendix 11-1 [Payment Schedule] of the Contract and the Contractor’s price for the Non-Installation Work as specified in Appendix 11-1 [Payment Schedule] of the Contract.

(7) This Guarantee shall extend to any variation of or amendment to the Contract and to any agreement supplemental thereto agreed between the Beneficiary and Contractor.

(8) The Beneficiary may, at its election, exercise or decline to exercise any right or remedy it may have against Contractor or any other person liable on or in respect of the Guaranteed Obligations, or any security held from Contractor or any other person in respect of the Guaranteed Obligations, without affecting or impairing the liability of the Guarantor, and the Guarantor hereby waives any defence arising out of the absence, impairment or loss of any such security or right of reimbursement, contribution or subrogation.

(9) The Beneficiary will have the right, in its discretion, to proceed directly against the Guarantor for any and all remedies provided by law, equity or in the Contract whether by legal proceedings or otherwise, to have the Guarantor fulfil the Guaranteed Obligations.

(10) Until the Guaranteed Obligations have been fully and completely performed, and subject to fulfilment of the requirements of this Guarantee, the Guarantor will not be released or discharged from its obligations hereunder by any matter or thing whatsoever that would otherwise release or discharge a guarantor. Without limiting the generality of the foregoing, the Guarantor expressly agrees that none of the following circumstances or actions, whether taken by or occurring in respect of Contractor, the Beneficiary, the Guarantor or any other person or entity, will in any way release, affect or impair the obligations and liabilities of the Guarantor hereunder:

(a) voluntary or involuntary liquidation, dissolution, consolidation or merger (or the sale or other disposition of all or part of a party or its assets);

(b) bankruptcy, receivership, insolvency, assignment for the benefit of creditors, reorganization, arrangement, composition or readjustment of debt, or other similar proceeding affecting a party or any of its assets;

(c) the invalidity or unenforceability of the Contract or any security, bond, third party guarantees, or other assurances intended to be granted or provided by Contractor or any other party to the Beneficiary or any other party under the Contract;

(d) the failure of the Beneficiary or any other party to take, protect or preserve any rights, security or similar assurance in relation to the Contract, from Contractor or any other party, or the loss, diminution or unenforceability or impossibility to realize or abstention from realization of any such right, security or similar assurance, whether or not caused or resulting from any act or omission of the Beneficiary or any person acting for the Beneficiary;

(e) any other occurrence or circumstance whatsoever, whether similar or dissimilar to the foregoing, any other circumstance that might otherwise constitute any legal or equitable defence or discharge of the obligations and/or liabilities of Contractor or the Guarantor or that might otherwise limit recourse against the Guarantor; and

(f) if, with or without the Guarantor’s knowledge or consent, any one or more of the following occur:

(1) any modifications of the Contract, made by agreement of Contractor and the Beneficiary;

(2) any waivers by the Beneficiary or Contractor of any terms, provisions, conditions or obligations under the Contract;

(3) any assignment or the making of any assignment of the Contract as may be permitted under the Contract;

(4) any failure by the Beneficiary to enforce any provision of the Contract against Contractor; or

(5) any other granting of extensions or time, renewals, indulgences, waivers, releases or discharges, or the making of any compromises or transactions or arrangements, regarding the Contract.

(11) Until the Guaranteed Obligations have been fully and completely performed, the Guarantor shall not be subrogated in any manner to any right of the Beneficiary.

(12) If the Guarantor or any other person is required by law to make any deduction or withholding on account of any tax or other amount from any sum paid or payable by the Guarantor under this Guarantee, the sum payable by the Guarantor in respect of which the relevant deduction, withholding or payment is required shall (except, in the case of any such payment, to the extent that its amount is not ascertainable when that sum is paid) be increased to the extent necessary to ensure that, after the making of that deduction, withholding or payment, the Beneficiary receives on the due date and retains (free from any liability in respect of any such deduction, withholding or payment) a net sum equal to what it would have received and so retained had no such deduction, withholding or payment been required or made.

(13) Neither the Guarantor’s obligations under this guarantee nor any right or remedy for the enforcement thereof will be impaired, stayed, modified, changed or released in any manner whatsoever by any order, stay, modification, release or limitation in regard to Contractor or the

Guarantor resulting from the operation or effect of any provision of the *Bankruptcy and Insolvency Act* (Canada), the *Companies' Creditors Arrangement Act* (Canada), the *Winding-up and Restructuring Act* (Canada) or other statute, code or laws of any jurisdiction relating to debtor relief or relating to the release of the obligations of the Guarantor hereunder, or from the decision of any court or authority interpreting any of the same, and the Guarantor will be obligated under this guarantee as if no such order, stay, modification, release or limitation had occurred.

(14) This Guarantee constitutes the entire agreement of the Guarantor with the Beneficiary relating to the subject matter hereof and supersedes all prior contracts or agreements, whether oral or written. There are no representations, agreements, arrangements or undertakings, oral or written, between the Guarantor and the Beneficiary relating to the subject matter of this Guarantee which are not fully expressed herein.

(15) No amendment to this Guarantee will be valid or binding unless set forth in writing and duly executed by each of the Beneficiary and the Guarantor. No waiver of any breach by the Guarantor of any provision of this Guarantee will be effective or binding unless made in writing and signed by the Beneficiary and, unless otherwise provided, will be limited to the specific breach waived.

(16) This Guarantee is in addition to and not in substitution for any other undertakings, securities and guarantees held or which may be held by or for the benefit of the Beneficiary, including without limitation any performance bonds, letters of credit, financial holdbacks under the Contract, and guarantees from any other parties.

(17) The Guarantor shall promptly and with all due diligence perform its obligations under this Guarantee.

(18) All notices or other communications in connection with this Guarantee shall be served:

(a) Upon the Beneficiary, at 333 Dunsmuir Street, Vancouver, British Columbia, V6B 5R3. Attention: [______________]; and Attention: [______________] at **[insert Site C Address]**; and

(b) Upon the Guarantor, at [______________] Attention: [______________].

Notice given by personal delivery or mail shall be effective upon actual receipt. Notice given by facsimile transmission shall be effective upon actual receipt if received during the recipient's normal business hours, or at the beginning of the recipient's next business day after receipt if not received during the recipient's normal business hours. All Notices by facsimile transmission shall be confirmed promptly after transmission in writing by certified or registered mail or personal delivery.

(19) The Beneficiary and the Guarantor may change their respective nominated addresses for service of communications to another address but only by prior written notice to each other. All such communications must be in writing.

(20) This Guarantee shall enure to the benefit of and be binding upon the parties and their respective heirs, legal representatives, successors and permitted assigns (as permitted under the Contract, the "**Permitted Assigns**"). Other than an assignment to a Permitted Assign, neither party may assign this Guarantee without the express written consent of the other party.

(21) Whenever possible, each provision of this Guarantee shall be interpreted in such manner as to be effective, enforceable and valid under British Columbia law, and Canadian law to the extent applicable, but if any provision of this Guarantee shall be found to be illegal, ineffective, invalid or unenforceable under such law, it shall be deemed severed from this Guarantee to the extent of

such illegality, ineffectiveness, invalidity or unenforceability without effect on any of the remaining provisions of this Guarantee.

(22) This Guarantee shall be governed by and construed in accordance with the laws of the Province of British Columbia and the laws of Canada applicable in British Columbia.

(23) Any dispute arising from, connected with, or relating to this Guarantee will be resolved by the courts of British Columbia sitting in the City of Vancouver, and the Guarantor hereby irrevocably submits and attorns to the original and exclusive jurisdiction of the courts of British Columbia sitting in the City of Vancouver for those purposes.

(24) The Guarantor represents and warrants that:

(a) it is duly organized and validly existing under the laws of its jurisdiction of organization;

(b) it has the power, authority and legal right to execute and deliver, and to perform its obligations under, this Guarantee, and has taken all necessary action to authorize its execution, delivery and performance of this Guarantee, and this Guarantee has been duly executed by it;

(c) this Guarantee constitutes a legal, valid and binding obligation of the Guarantor;

(d) the execution, delivery and performance of this Guarantee will not violate or result in default under any applicable law, rule or regulation or any judgement, order, decree, agreement, instrument or undertaking applicable to the Guarantor;

(e) it is related to Contractor and directly or indirectly derives a benefit from the Beneficiary entering into the Contract with Contractor;[3]

(f) it has the financial equity and the ability and capacity as described in (a) and (b) above to carry out its obligations under this Guarantee.

(25) The Beneficiary may at any time during the term of this Guarantee request, by written notice, reasonable financial assurances of the Guarantor's continued ability to carry out its obligations under this Guarantee and the Guarantor shall provide such reasonable assurances to the Beneficiary in writing within ten (10) Days of the Beneficiary's notice.

[3] If the Guarantor is not an affiliate of the Contractor, clause (e) will be deleted from the Guarantee before it is delivered.

IN WITNESS WHEREOF the Guarantor has executed this Guarantee as of the day and year first above written.

[GUARANTOR]

By: ________________________________
(Signature)

____
(Print Name)

Title: ________________________________

Date: ________________________________

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-4

PST

Table Appendix 11-4 A

Production Machinery and Equipment PST Exemption (PME)

Exclusions (not a complete list)

Item	PME	Components
1.	No PST Exemption	Bases and foundations Buildings Equipment that is located away from the generation facility Equipment used to heat, ventilate and cool the powerhouse – HVAC Gantry cranes Gates/security Overhead cranes Walkways and catwalks Tooling and lifting devices

Table Appendix 11-4 B

Production Machinery and Equipment PST Exemption (PME)

Qualifying PME used at the Powerhouse primarily and directly in the production of electricity for sale by BC Hydro (not a complete list)

Item	PME	Components
1.	Turbine	Air admission system (all components) Air head Air piping Embedded casings (spiral case) Francis turbine (all components) Head cover Head cover drainage pump Instrumentation Kaplan (all components) Operating ring Operating ring bushings Operating ring locks Pelton (all components) Piping (air & water) Shaft Shaft seal cooling water piping Shaft seals

Item	PME	Components
		Shear pins Shift ring Synchronous condense equipment (all components) Stationary ring seals Stay ring Turbine seals Unwatering systems (see Auxiliary Equipment) Wicket gate arms Wicket gate bushings (lower, upper middle) Wicket gate thrust collars Wicket gates
2.	Generator	Air-water coolers Bearing cooling systems Bearing oil systems Bearings Brakes (including brake pads) Cooling water system (piping, instrumentation & controls) Covers Current transformers (main, neutral, split phase) Deluge ring Fire protection system Guide bearing Instrumentation Lift pump Lower bracket Neutral cubicle Partial discharge monitoring system Partial discharge System Resistance Temperature Detector (RTD) cabinet Rotor (all components) Sole plates Stator (all components) Thrust bearing Upper bracket

Item	PME	Components
3.	Governor, HPU, Servomotors	Controls High pressure gas compressors High pressure oil and gas tanks High pressure oil pumps High pressure piping (oil and air) Instrumentation Jockey pump Oil sump Servo-motor connecting rods Servo-motor connecting rod bushings Servo-motor leakage pump Servo-motor locks Servo-motors
4.	Excitation System	Automatic voltage regulator Brush rigging Brushgear (with the exception of the brushes) Collector (slip ring) brush holders Collector ring (slip ring) Cooling and ventilation system Exciter brush holders Exciter leads Exciter transformer Field bus Field leads Rotary exciter (and all sub components) Static exciter (and all sub components)
5	Protection & Control, And Switchgear	Air gap monitoring system Alarm panels Bus work Capacitors Circuit breakers Current transformers DC batteries DC battery charger Disconnects Enclosures, DIN rail, terminal blocks, and other misc. equipment Gas insulated switchgear (GIS) Instrumentation Insulators Isolated phase bus Line Traps (if used for P&C) Load breaking resistors Metal clad switchgear Metering equipment Networking equipment (plant LAN) OI (Operational Information) equipment

Item	PME	Components
		PLC's (Power Line Carrier) and associated equipment Reactors Relays Surge arresters Unit Control Board (UCB) Vibration monitoring systems Voltage transformers Water contamination detector Wire and cabling
6.	Auxiliary Equipment	Draft tube drainage system (pumps, piping & controls) Draft tube gate lifting device Draft tube gates Equipment heaters Hydraulic cylinders Hydraulic hoists Motors & motor control centers (MCCs) Piping (air systems) Piping (oil systems) Piping (water cooling systems) Screens (cooling systems) Station service panels (only panels used for production equipment) Station service transformers Stationary air compressors, dryer and air Thermal insulation & linings Unwatering systems Valves (cooling systems)

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-5

COMPLETION MILESTONE DAMAGES

Completion Milestone	2022 In-Service			
	Milestone Date	Liquidated Damages / day (or portion of a day)		
		1–30 day delay	31-120 day delay	Delay > 120 days
Units 1 to 6 **Draft Tube Temporary Closure Installed**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 1 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 1 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 2 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 2 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 3 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 3 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 4 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 4 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 5 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 5 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 6 – **Unit Assembly Complete**	[redacted]	[redacted]	[redacted]	[redacted]
Unit 6 **Single Unit Substantial Completion**	[redacted]	[redacted]	[redacted]	[redacted]

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-6

TECHNICAL DATA AND INFORMATION FORMS

1.0 GENERAL TECHNICAL DATA AND INFORMATION FORM

			Value	Units
1.1	**Mechanical Design Information**			
(a)	Speed			
	(i)	Rated speed	[redacted]	rpm
	(ii)	Runaway speed	[redacted]	rpm
	(iii)	Shaft critical speed	[redacted]	rpm
(b)	Unit Inertia			
	(i)	Unit Moment of Inertia, J_{GT} (Generator + Turbine)	[redacted]	kg•m^2
	(ii)	Unit Inertia Constant, H_{GT} (Generator + Turbine)	[redacted]	MW•s/ MVA
1.2	**Cooling Water System**			
(a)	Spiral case supply pipe diameter at first valve		[redacted]	in
(b)	Raw water interface pipe diameter		[redacted]	in
(c)	Basket strainer make and model		[redacted]	
(d)	Shut off control valve diameter		[redacted]	in
(e)	Shut off control valve make and model		[redacted]	
(f)	Shut off control valve actuator make and model		[redacted]	
(g)	Return line diameter at interface		[redacted]	in
(h)	Maximum total cooling water flow at the Maximum Cooling Water Supply Temperature (assuming zero flow in raw water header)		[redacted]	L/s
(i)	Pressure drop from the spiral case to the return line interface at the above design flow		[redacted]	kPa
1.3	**Station Service Compressed Air Requirements**			
(a)	Maximum simultaneous air flow at 690 kPa (excluding synchronous condenser air depression requirements)		[redacted]	L/min
1.4	**Shaft Coupling**			
(a)	Bolt tensioning method for turbine shaft to runner		[redacted]	
(b)	Bolt tensioning method for turbine shaft to rotor/thrust block		[redacted]	

		Value	Units

1.5 Hoists/Cranes

(a) Turbine pit hoist capacity — [redacted] tonnes

(b) Heaviest component that turbine pit hoist will lift — [redacted]

(c) Mass of the heaviest component to be lifted in the penstock coupling chamber during site erection (penstock coupling chamber crane to be provided by Others) — ____

(d) Description, capacity, and the heaviest component to be lifted, for all other hoists/cranes to be provided

[redacted]

1.6 Lifting Devices

(a) Description, capacity, and the heaviest component to be lifted, for all lifting devices with ratings over 25 tonnes

[redacted];

Rotor lifting device, 565 tonnes, complete rotor with poles, rim and

[redacted]

1.7 Key Powerhouse and Equipment Dimensions and Values

		Value	Units
(a)	Turbine Center Line Elevation (TCL EL)	[redacted]	m
(b)	Draft tube base elevation (DTB EL)	[redacted]	m
(c)	Main floor elevation (MFL EL)	[redacted]	m
(d)	Draft tube gate sill elevation (DGS EL)	[redacted]	m
(e)	Turbine Bay Length & service bay length (TBL)	[redacted]	m
(f)	Offset between Turbine centerline and draft tube centerline (TDO)	[redacted]	m
(g)	Offset between penstock centerline and Turbine centerline (TPO)	[redacted]	m
(h)	Turbine Bay Width (TBW)	[redacted]	m
(i)	Turbine Centerline to end of spiral case inlet at the coupling (TE)	[redacted]	m
(j)	Generator centerline elevation (GCL EL)	[redacted]	m

		Value	Units
(k)	Maximum extent of Generator enclosure (X Direction & Y Direction) (GA)	[redacted]	m
(l)	Height of Generator enclosure (GB)	[redacted]	m

2.0 TURBINE TECHNICAL DATA AND INFORMATION FORM

Line items in the Turbine TDIF that are shown in a box are the critical TDIF values (refer to Section 12.2 of the Agreement).

		Value	Units
2.1	**Plant Annual Energy**		
(a)	Guaranteed Plant Annual Energy (as calculated using the Plant Annual Energy Calculation set out under with the Independent Laboratory Turbine Model test result) – see Table 2.19 in this Appendix 11-6 [Technical Data and Information Forms]:	[redacted]	GW-h
2.2	**Generator Power Output for Operating Condition A**		
(a)	The Generator power output measured at the Generator terminals with the Generator operating at: 0.95 power factor (over-excited), rated voltage, rated frequency, and Generator Rated Operating Conditions, and with the Turbine operating at the Turbine discharge and the NSHE for Operating Condition A will not be less than:	[redacted]	kW
2.3	**Generator Power Output for Operating Condition B**		
(a)	The Generator power output measured at the Generator terminals with the Generator operating at: 0.95 power factor (over-excited), rated voltage, rated frequency, and Generator Rated Operating Conditions, and with the Turbine operating at the Turbine discharge and the NSHE for Operating Condition B will not be less than:	[redacted]	kW
2.4	**Turbine Performance Parameters**		
(a)	Turbine Rated Output	[redacted]	kW
(b)	Minimum NSHE (Calculated with minimum penstock diameter of 9.8 m and using definition of “(d) Other Operating Conditions, (i) Low Head, High Flow” (refer to Appendix 6-3 [Turbine Specifications (SPT)], SPT 3.2.2))	[redacted]	m^2/s^2
(c)	Maximum NSHE (Calculated with maximum penstock diameter of 10.5 m and using definition of “(d) Other Operating Conditions, (iv) High Head, Low Flow” (refer to Appendix 6-3 [Turbine Specifications (SPT)], SPT 3.2.2))	[redacted]	m^2/s^2
(d)	Rotational speed	[redacted]	r/min

(e) Operating Conditions[1] (filled in by BC Hydro using data from the Independent Lab)	Operating Condition A	Operating Condition B	Reference Minimum Turbine Output[2]	
(i) NSHE	[redacted]	[redacted]	[redacted]	m^2/s^2
(ii) Wicket gate position	[redacted]	[redacted]	[redacted]	°
(iii) Turbine discharge	[redacted]	[redacted]	[redacted]	m^3/s
(iv) Scaled up Turbine efficiency	[redacted]	[redacted]	[redacted]	%
(v) Turbine power	[redacted]	[redacted]	[redacted]	kW

			Value	Units
	(vi)	Unit power, at the Generator terminals at 0.95 power factor	[redacted] [redacted] [redacted]	kW

Note:

(1) Determined using the tailwater levels indicated in SPT3.1.4, and intake losses associated with a penstock diameter of 10.2 m.

(2) A Turbine operating at the discharge associated with the Reference Minimum Turbine Output and the reservoir, tailwater and power factor as defined for Operating Condition C.

				Value	Units
(f)	Maximum runaway speed of Prototype turbine:			[redacted]	r/min
(g)	Conditions under which maximum runaway speed of the Prototype turbine occurs:				
	(i)	NSHE		[redacted]	m^2/s^2
	(ii)	Turbine Discharge		[redacted]	m^3/s
(h)	Axial hydraulic thrust of Prototype turbine				
	(i)	Maximum hydraulic downthrust at steady-state operating regimes:		[redacted]	kN
	(ii)	Conditions under which maximum thrust occurs:			
		(A)	Turbine power	[redacted]	kW
		(B)	NSHE	[redacted]	m^2/s^2
	(iii)	Maximum hydraulic upthrust at steady-state operating regimes:		[redacted]	kN
	(iv)	Conditions under which maximum thrust occurs:			
		(A)	Turbine power	[redacted]	kW
		(B)	NSHE	[redacted]	m^2/s^2
	(v)	Maximum downthrust at transient conditions:		[redacted]	kN
		(A)	(transient conditions to be specified)	[redacted]	
	(vi)	Maximum upthrust at transient conditions:		[redacted]	kN
		(A)	(transient conditions to be specified)	[redacted]	
(i)	Spiral Case Design Pressure (equal to or greater than)			[redacted]	kPa
(j)	Maximum total indicated shaft runout of Prototype turbine referenced to turbine guide bearing as specified in SPT4.3.2, for the full operating range of NSHE's:				
	(i)	Operating Zone 1		[redacted]	mm
	(ii)	Operating Zone 2		[redacted]	mm
	(iii)	Operating Zone 3		[redacted]	mm
(k)	Moment of inertia, J_T of runner and shaft			[redacted]	kg•m²

		Value	Units
2.5	**Spiral Case, Flexible Coupling Section, Closure Section, Penstock Spool Piece, and Draft Tube**		
(a)	Plate thickness at:		
	(i) Spiral case inlet	[redacted]	mm
	(ii) Closure section	[redacted]	mm
	(iii) Flexible coupling section	[redacted]	mm
	(iv) Penstock Spool Piece	[redacted]	mm
	(v) Draft Tube steel liner	[redacted]	mm
2.6	**Stay Ring**		
(a)	Outside diameter of stay ring	[redacted]	mm
(b)	Number of stay vanes	[redacted]	
(c)	Number of sections	[redacted]	
2.7	**Turbine Pit Liner**		
(a)	Pit diameter	[redacted]	mm
2.8	**Main Shaft**		
(a)	Minimum shaft outside diameter	[redacted]	mm
(b)	Shaft inside diameter	[redacted]	mm
(c)	Shaft length face to face of flanges (not to exceed)	[redacted]	mm
(d)	Mass of shaft complete with coupling bolts and nuts, nut guard and shaft sleeve or runner plate	[redacted]	kg
(e)	Height of shaft/runner lifting device from device flange to center of pin (not to exceed)	[redacted]	mm
2.9	**Shaft Seal**		
(a)	Stainless steel shaft seal wear face finish	[redacted]	µm
(b)	Cooling water flow rate for main shaft water seal		
	(i) design rate of flow in generation or synchronous condense mode:		
	(A) Maximum	[redacted]	L/s
	(B) Minimum	[redacted]	L/s
	(ii) when Turbine is not running:		
	(A) Minimum	[redacted]	L/s

				Value	Units
	(iii)	required pressure differential between seal pressure and pressure outside the seal:			
		(A)	Maximum	[redacted]	kPa
		(B)	Minimum	[redacted]	kPa
	(iv)	Seal Water Filtration System			
		(A)	Filtration system provided?	[redacted]	Y/N
		(B)	Filtration level	[redacted]	µm
		(C)	Design pressure rating of filtration unit	[redacted]	kPa
		(D)	Maximum flow capacity of filtration system	[redacted]	L/s
2.10	**Guide Bearing**				
(a)	Shaft journal:				
	(i)	diameter		[redacted]	mm
	(ii)	length		[redacted]	mm
	(iii)	surface finish		[redacted]	µm
(b)	Centreline elevation			[redacted]	m
(c)	Radial clearance			[redacted]	mm
(d)	Number of pads			[redacted]	
(e)	Babbitt material			[redacted]	
(f)	Babbitt temperature:				
	(i)	design, at Maximum Cooling Water Supply Temperature		[redacted]	°C
	(ii)	maximum allowable temperature for continuous operation (not to exceed) Note: guide bearing sensors located 20 mm below Babbitt surface, 50% in circumferential direction and 50% in height.		[redacted]	°C
(g)	Maximum cooling water flow rate:				
	(i)	at Minimum Cooling Water Supply Temperature		[redacted]	L/s
	(ii)	at Maximum Cooling Water Supply Temperature		[redacted]	L/s
(h)	Pressure drop across cooling coils at maximum flow rate			[redacted]	kPa
(i)	Cooler tube material			[redacted]	
(j)	Cooler fin material			[redacted]	

		Value	Units
(k)	Quantity of bearing oil	[redacted]	L
(l)	Oil temperature at Maximum Cooling Water Supply Temperature:		
	(i) design	[redacted]	°C
	(ii) maximum allowable temperature for continuous operation (not to exceed) Note: temperature based on average of all oil bath RTDs.	[redacted]	°C
2.11	**Runner**		
(a)	Runner diameter at throat	[redacted]	mm
(b)	Runner outlet diameter at bottom of runner band	[redacted]	mm
(c)	Runner height	[redacted]	mm
(d)	Maximum runner diameter	[redacted]	mm
(e)	Distance from centreline of distributor to the runner outlet	[redacted]	mm
(f)	Number of blades	[redacted]	
(g)	Finish of prototype hydraulic surfaces		
	(i) Spiral case (not to exceed, as installed)	[redacted]	µm
	(ii) Stay vane channels (not to exceed, as installed)	[redacted]	µm
	(iii) Wicket gate channels (not to exceed, as installed)	[redacted]	µm
	(iv) Runner blade, crown, and band (inner surfaces) (not to exceed, as installed)	[redacted]	µm
	(v) Runner band and crown (outer surfaces) (not to exceed, as installed)	[redacted]	µm
	(vi) Draft tube (not to exceed, as installed)	[redacted]	µm
	(vii) Stationary parts (headcover, discharge ring/bottom ring) facing the runner outer surfaces (not to exceed, as installed)	[redacted]	µm
(h)	Mass of assembled runner and cone	[redacted]	kg
	(i) Mass of crown	[redacted]	kg
	(ii) Mass of band	[redacted]	kg
	(iii) Mass of one blade	[redacted]	kg

		Value	Units
(i)	Base material	[redacted]	
(j)	Weld material	[redacted]	
2.12	**Wicket Gates**		
(a)	Wicket gate circle diameter	[redacted]	mm
(b)	Wicket gate height	[redacted]	mm
(c)	Number of wicket gates	[redacted]	
(d)	Wicket gate end clearance (dewatered)		
	(i) top	[redacted]	mm
	(ii) bottom	[redacted]	mm
(e)	Wicket gate end seal material	[redacted]	
(f)	Maximum wicket gate movement	[redacted]	°
(g)	Wicket gate upthrust bearing mechanism required?	[redacted]	Y/N
	(i) If yes, design clearance in bearing	[redacted]	mm
(h)	The speed-no-load position of the wicket gates from the fully closed position	[redacted]	°
(i)	Wicket Gate stem diameters		
	(i) upper	[redacted]	mm
	(ii) intermediate	[redacted]	mm
	(iii) lower	[redacted]	mm
(j)	Mass of one wicket gate	[redacted]	kg
(k)	Wicket gate material	[redacted]	
(l)	Wicket Gate Leakage for one Turbine	[redacted]	L/s
2.13	**Servomotors for Wicket Gates**		
(a)	Number of cylinders	[redacted]	
(b)	Cylinder bore diameter	[redacted]	mm
(c)	Piston rod diameter	[redacted]	mm
(d)	Piston ring material	[redacted]	

		Value	Units
(e)	Length of travel from 0% to 100% stroke	[redacted]	mm
(f)	Stroke at speed-no-load position	[redacted]	mm
(g)	Total net volume of piston displacement on pressure side		
	(i) opening	[redacted]	mm^3
	(ii) closing	[redacted]	mm^3
(h)	Governor capacity required	[redacted]	J
(i)	Cushioning		
	(i) time (closing)	[redacted]	s
	(ii) stroke	[redacted]	mm
(j)	Mass of a complete servomotor (heaviest one)	[redacted]	kg
2.14	**<u>Governing Characteristics</u>**		
(a)	Wicket gate time settings as defined in SPGOV6.9		
	(i) opening	[redacted]	s
	(ii) closing	[redacted]	s
(b)	Maximum transient pressure at turbine inlet and in spiral case and speed rise on load rejection for the most adverse combination of NSHE and power output corresponding to the gate closing time in Item (a)(ii) above		
	(i) maximum pressure at turbine inlet	[redacted]	kPa
	(ii) maximum pressure in spiral case	[redacted]	kPa
	(iii) speed rise	[redacted]	%
2.15	**<u>Synchronous Condenser System</u>**		
(a)	Cooling water for runner seals		
	(i) crown seal design rate of flow		
	(A) at Maximum Cooling Water Supply Temperature	[redacted]	L/s
	(B) at Minimum Cooling Water Supply Temperature	[redacted]	L/s
	(ii) band seal design rate of flow		
	(A) at Maximum Cooling Water Supply Temperature	[redacted]	L/s
	(B) at Minimum Cooling Water Supply Temperature	[redacted]	L/s
	(iii) filtration level	[redacted]	µm

		Value	Units
(b)	Time required for water depression at 620 kPa starting air pressure in the air tanks		
	(i) to just below the runner	[redacted]	s
	(ii) to final water level	[redacted]	s
(c)	Volume of compressed air required for initial full water depression, with the compressed air starting at a pressure of 620 kPa	[redacted]	m^3
(d)	Residual pressure in air system after full water depression, with the compressed air starting at a pressure of 620 kPa	[redacted]	kPa
(e)	Residual pressure in air system after full water depression, with the compressed air starting at a pressure of 690 kPa	[redacted]	kPa
(f)	Rate of compressed air make-up at a minimum pressure of 620 kPa required to maintain a depressed water level	[redacted]	L/s
(g)	Distance below bottom of runner to water surface after initial air depression	[redacted]	mm
(h)	Acceptable water level increase before initiating a maintenance air depression cycle	[redacted]	mm
(i)	Internal diameter of depression air piping at interface point	[redacted]	in
(j)	Internal diameter of exhaust air piping at interface point	[redacted]	in
(k)	Total air receiver volume required to meet the requirements of SPT4.28 (not to exceed)	[redacted]	m^3
2.16	**Air Admission System**		
(a)	Internal diameter of air admission piping at interface point	[redacted]	in
(b)	Expected maximum air flow (standard conditions)	[redacted]	m^3/s
2.17	**Penstock Drain**		
(a)	Large penstock drain diameter	[redacted]	mm
(b)	Small penstock drain diameter	[redacted]	mm
2.18	**Miscellaneous Masses**		
(a)	Fully assembled headcover	[redacted]	kg
(b)	Fully assembled operating ring	[redacted]	kg

2.19 Guaranteed Plant Annual Energy Calculation

Table 2.19 – Guaranteed Plant Annual Energy Calculation (Filled in by BC Hydro after the Independent Turbine Model Tests)

Constants and operating conditions to be used in performance calculations:

Reservoir Level (H_{res})	$461.7\ m$	Local gravitational acceleration (g)	$9.8149\ {}^{m}/_{s^2}$	Gross Head ($H_g = H_{res} - H_{tr}$)	$51.2\ m$
Tailwater Level (H_{tr})	$410.5m$	Density of water (p)	$1000\ {}^{kg}/_{m^3}$	Frequency (f)	60 Hz

Weighting Regime	Turbine Discharge	Head Losses	Net Head	NSHE	Scaled up Prototype Turbine Efficiency	Turbine Output	Generator Losses[1,2,3]	Generator Output	Operating Hours (annual, 6 units)	Energy (annual, 6 units)
	$\left({}^{m^3}/_{s}\right)$	(m)	(m)	$\left({}^{m^2}/_{s^2}\right)$	$(\%)$	(kW)	(kW)	(kW)	(h)	(GWh)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
		$(k+ko)\cdot(1)^2$	$H_g-(2)$	$(3)\cdot g$		$\frac{(1)\cdot(4)\cdot(5)\cdot p}{10^3}$		$(6)-(7)$		$\frac{(8)\cdot(9)}{10^6}$
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Synchronous Condenser Operation[4]						[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
									Guaranteed Plant Annual Energy (GWh):	[redacted]

Notes:

1. Generator losses for this calculation are for the Generator operating at a power factor of 0.95.
2. Generator losses for this calculation are to include Generator thrust bearing losses, including hydraulic thrust from the Turbine, Generator guide bearing losses, and Turbine guide bearing losses.
3. For this Table 2.19, the Generator losses to be entered into this column by BC Hydro will be the Generator losses without any test uncertainties applied.
4. Synchronous condenser operation losses are for the Generator operating under-excited with a reactive power output in kVAr measured at the Generator terminals equal to [redacted] of the Generator Rated Output (kVA) excluding Turbine runner windage losses.

3.0 GOVERNOR SYSTEM TECHNICAL DATA AND INFORMATION FORM

			Value	Units
3.1	**Manufacturer Information**			
(a)	Manufacturer		____________	
(b)	Make and Model		____________	
3.2	**Motor Starters**			
(a)	High-pressure oil pump motor starters – main pumps			
	(i)	Manufacturer	[redacted]	
	(ii)	Model	[redacted]	
	(iii)	NEMA size	[redacted]	
	(iv)	Rated voltage (3 phase)	[redacted]	V
	(v)	Overload relay manufacturer	[redacted]	
	(vi)	Overload relay model	[redacted]	
(b)	High-pressure oil pump motor starter – jockey pump			
	(i)	Manufacturer	[redacted]	
	(ii)	Model	[redacted]	
	(iii)	NEMA size	[redacted]	
	(iv)	Rated voltage (3 phase)	[redacted]	V
	(v)	Overload relay manufacturer	[redacted]	
	(vi)	Overload relay model	[redacted]	
(c)	Air compressor motor starters			
	(i)	Manufacturer	[redacted]	
	(ii)	Model	[redacted]	
	(iii)	NEMA size	[redacted]	
	(iv)	Rated voltage (3 phase)	[redacted]	V
	(v)	Overload relay manufacturer	[redacted]	
	(vi)	Overload relay model	[redacted]	

	Value	Units

3.3 Governor Control Cabinet

(a) Governor PLC

(i) Manufacturer [redacted]

(ii) Model [redacted]

(iii) Configuration tool software model [redacted]

(iv) Configuration tool software version number [redacted]

(v) Communications Links: protocol and physical layer

(A) protocol [redacted]

(B) physical layer [redacted]

(b) Governor HMI

(i) Manufacturer [redacted]

(ii) Model [redacted]

(iii) Configuration tool software model [redacted]

(iv) Configuration tool software version number [redacted]

3.4 Instrumentation

(a) Speed sensing systems

(i) Generator VT Speed Sensing System and Running Bus Speed Sensing System

(A) Signal conditioner manufacturer [redacted]

(B) Signal conditioner model [redacted]

(C) High-speed counter PLC module manufacturer [redacted]

(D) High-speed counter PLC module model [redacted]

(ii) Toothed-wheel sensing system

(A) ZVPU Probe manufacturer [redacted]

(B) ZVPU Probe model [redacted]

			Value	Units
	(C)	ZVPU Probe signal conditioner manufacturer	[redacted]	
	(D)	ZVPU Probe signal conditioner model	[redacted]	
	(E)	High-speed counter PLC module manufacturer	[redacted]	
	(F)	High-speed counter PLC module model	[redacted]	
(b)	Wicket Gate position transducers			
	(i)	Manufacturer	[redacted]	
	(ii)	Model	[redacted]	
(c)	Governor MW transducer			
	(i)	Manufacturer	[redacted]	
	(ii)	Model	[redacted]	
(d)	Accumulator pressure sensing devices			
	(i)	Pressure switches manufacturer	[redacted]	
	(ii)	Pressure switches model	[redacted]	
	(iii)	Pressure transducers manufacturer	[redacted]	
	(iv)	Pressure transducers model	[redacted]	
(e)	Accumulator oil level sensing devices			
	(i)	Magnetic float transducer manufacturer	[redacted]	
	(ii)	Magnetic float transducer model	[redacted]	
	(iii)	Guided wave radar level transducer manufacturer	[redacted]	
	(iv)	Guided wave radar level transducer model	[redacted]	
	(v)	Magnetic semaphore indicators manufacturer	[redacted]	
	(vi)	Magnetic semaphore indicators model	[redacted]	
(f)	Oil sump instrumentation			
	(i)	Oil level transducer manufacturer	[redacted]	
	(ii)	Oil level transducer model	[redacted]	
	(iii)	Oil level sight glass manufacturer	[redacted]	
	(iv)	Oil level sight glass model	[redacted]	

			Value	Units
	(v)	Oil temperature transducer manufacturer	[redacted]	
	(vi)	Oil temperature transducer model	[redacted]	

3.5 Governor Hydraulic System

			Value	Units
(a)	Governor high-pressure oil system			
	(i)	Nominal (maximum) operating pressure	[redacted]	kPa
	(ii)	Design pressure	[redacted]	kPa
	(iii)	Minimum operating pressure (when trip initiated)		kPa
	(iv)	Minimum operating pressure (when float valve closes)	[redacted]	kPa
	(v)	Normal minimum oil pressure (lead pump cut-in pressure)	[redacted]	kPa
	(vi)	Normal maximum oil pressure (lead pump cut-out pressure)	[redacted]	kPa
(b)	Oil volumes			
	(i)	Servomotors (total)	[redacted]	L
	(ii)	Accumulator tank(s) – at normal (maximum) operating level	[redacted]	L
	(iii)	Sump tank – at normal operating level	[redacted]	L
	(iv)	Pressure piping	[redacted]	L
	(v)	Total volume of oil in governor oil system	[redacted]	L
(c)	Accumulator tank			
	(i)	Number of accumulator tanks	[redacted]	
	(ii)	Inside diameter	[redacted]	mm
	(iii)	Inside height	[redacted]	mm
	(iv)	Maximum overall height	[redacted]	mm
	(v)	Total volume (each tank)	[redacted]	L
	(vi)	Oil level (inside) at normal operating conditions	[redacted]	mm
	(vii)	Shape of access hatch	[redacted]	
	(viii)	Size of access hatch [redacted] mm high by	[redacted]	mm wide
	(ix)	Mass (empty, but fully assembled – each tank)	[redacted]	kg
	(x)	Description of system if more than one tank		

[redacted]

			Value	Units
(d)	Sump tank			
	(i)	Length	[redacted]	mm
	(ii)	Width	[redacted]	mm
	(iii)	Height	[redacted]	mm
	(iv)	Total volume	[redacted]	L
	(v)	Oil level (inside) at normal operating conditions	[redacted]	mm
	(vi)	Mass (empty, but fully assembled)	[redacted]	kg
(e)	Oil piping			
	(i)	Servomotor pressure piping diameter	[redacted]	
	(ii)	Accumulator tank pressure piping diameter	[redacted]	
	(iii)	Maximum oil velocity in the pressure piping system	[redacted]	m/s
(f)	Distributing valve			
	(i)	Supplier	[redacted]	
	(ii)	Model	[redacted]	
	(iii)	Maximum flow rate valve is capable of		L/s
	(iv)	Maximum flow rate required to operate servomotors	[redacted]	L/s
	(v)	Pressure drop across valve at maximum flow rate required to operate servomotors	[redacted]	kPa
	(vi)	Frequency response	[redacted]	Hz
(g)	Pilot valve			
	(i)	Name of supplier	[redacted]	
	(ii)	Model		
	(iii)	Maximum flow rate valve is capable of	[redacted]	L/s @ 10 bars
	(iv)	Frequency response	[redacted]	Hz
(h)	Oil pumps			
	(i)	Main pumps		
		(A) Make	[redacted]	

			Value	Units
		(B) Type/model	[redacted]	
		(C) Flow	[redacted]	L/s
	(ii)	Main pump motors		
		(A) Output power (mechanical, per pump)	[redacted]	kW
		(B) Rated voltage and number of phases	[redacted] V, [redacted]	
		(C) Service factor	[redacted]	
		(D) Power factor	[redacted]	
		(E) Speed	[redacted]	rpm
	(iii)	Jockey pump		
		(A) Make	[redacted]	
		(B) Type/Model		
		(C) Flow	[redacted]	L/s
	(iv)	Jockey pump motor		
		(A) Output power (mechanical)	[redacted]	kW
		(B) Rated voltage and number of phases	[redacted] V, [redacted]	
		(C) Service factor	[redacted]	
		(D) Power factor	[redacted]	
		(E) Speed	[redacted]	rpm
(i)	Cooling water for HPU, if required			
	(i)	Flow at maximum water temperature	[redacted]	L/s
	(ii)	Flow at minimum water temperature	[redacted]	L/s
	(iii)	Minimum supply pressure	[redacted]	kPa
	(iv)	Pressure drop between the inlet and outlet	[redacted]	kPa
(j)	Filtration levels			
	(i)	Pilot oil	[redacted]	
	(ii)	Kidney loop	[redacted]	
	(iii)	Compressed air	[redacted]	
	(iv)	Sump venting	[redacted]	

			Value	Units
(k)	Compressed air system			
	(i)	Nominal operating pressure	[redacted]	kPa
	(ii)	Design pressure	[redacted]	kPa
	(iii)	Number of air compressors	[redacted]	
	(iv)	Compressor(s) make	[redacted]	
	(v)	Compressor type/model	[redacted]	
	(vi)	Compressor capacity (each) at nominal operating pressure	[redacted]	L/min
	(vii)	Number of compressor receivers	[redacted]	
	(viii)	Volume of compressor receivers (each)	[redacted]	L
	(ix)	Volume of make-up air receivers (each)	[redacted]	L
	(x)	Motor power	[redacted]	kW
	(xi)	Rated voltage and number of phases	[redacted] V, [redacted]	
	(xii)	Service factor	[redacted]	
	(xiii)	Power factor	[redacted]	
	(xiv)	Speed	[redacted]	rpm
(l)	Miscellaneous operating data			
	(i)	Estimated steady-state oil consumption	[redacted]	L/min
	(ii)	Governor oil temperature		
		(A) Target range	[redacted] °C to [redacted]	°C
		(B) Maximum allowable	[redacted]	°C

4.0 GENERATOR TECHNICAL DATA AND INFORMATION FORM

Line items in the Generator TDIF that are shown in a box are the critical TDIF values (refer to Section 12.2 of the Agreement).

			Value	Units
4.1	**Generator Information**			
(a)	Rated Output at Generator Rated Operating Conditions			
	(i)	Generator Rated Output	[redacted]	kVA
	(ii)	Rated power	[redacted]	kW
	(iii)	Reactive power capability over-excited)	[redacted]	kVAr
	(iv)	Rated power factor	[redacted]	pf
	(v)	Rated voltage	[redacted]	kV
	(vi)	Rated frequency	[redacted]	Hz
	(vii)	Number of phases	[redacted]	
	(viii)	Rated armature current	[redacted]	A
	(ix)	Rated Field Current	[redacted]	A±10%
	(x)	Number of poles	[redacted]	
(b)	Rated Operating Conditions			
	(i)	Maximum cold air temperature	[redacted]	°C
	(ii)	Regulated Cold Air Temperature	[redacted]	°C
	(iii)	Stator winding temperature rise	[redacted]	°C
	(iv)	Stator circuit-ring and end-winding surface temperature rise	[redacted]	°C
	(v)	Rotor and field bus temperature rise	[redacted]	°C
4.2	**Calculated Electrical Characteristics**			
(a)	Synchronous Reactances (calculated)			
	(i)	Direct axis, saturated, $X_{d,\ sat}$	[redacted]	pu
	(ii)	Direct axis, unsaturated, $X_{d,\ unsat}$	[redacted]	pu
	(iii)	Quadrature axis, unsaturated $X_{q,\ unsat}$	[redacted]	pu
(b)	Transient Reactances (calculated)			
	(i)	Direct axis, saturated (rated-voltage), $X'_{d,\ sat}$	[redacted]	pu
	(ii)	Direct axis, unsaturated (rated-current), $X'_{d,\ unsat}$	[redacted]	pu
	(iii)	Quadrature axis, unsaturated $X'_{q,\ unsat}$	[redacted]	pu

			Value	Units
(c)	Sub-transient Reactances (calculated)			
	(i)	Direct axis, saturated, X_d'', $_{sat}$	[redacted]	pu
	(ii)	Direct axis, unsaturated, X_d'', $_{unsat}$	[redacted]	pu
(d)	Ratio of quadrature to direct axis reactance, X_q''/X_d''		[redacted]	pu
(e)	Negative sequence reactance, X_2		[redacted]	pu
(f)	Zero sequence reactance, X_0		[redacted]	pu
(g)	Short circuit ratio, SCR		[redacted]	
(h)	Resistances[4] (calculated @ 95°C)			
	(i)	Stator winding per phase, R_A	[redacted]	mohm
	(ii)	Field winding, R_F	[redacted]	mohm
	(iii)	Negative sequence resistance, R_2	[redacted]	mohm
(i)	Time Constants			
	(i)	Direct axis transient open circuit (T'_{do})	[redacted]	s
	(ii)	Direct axis sub-transient open circuit (T''_{do})	[redacted]	s
	(iii)	Quadrature axis transient open circuit (T'_{qo})	[redacted]	s
	(iv)	Quadrature axis sub-transient open circuit (T''_{qo})	[redacted]	s
	(v)	Direct axis transient short circuit (T'_d)	[redacted]	s
	(vi)	Armature short circuit (T_a)	[redacted]	s
	(vii)	Deviation factor of the open circuit terminal voltage	[redacted]	
(j)	Telephone Interference Factor			
	(i)	Balanced	[redacted]	
	(ii)	Residual	[redacted]	
(k)	Zero sequence capacitance per phase		[redacted]	microF
(l)	Field Characteristics			
	(i)	Field voltage on the airgap line at 1.00 pu terminal voltage (at 100°C)	[redacted]	V
	(ii)	Field current on the airgap line at 1.00 pu terminal voltage	[redacted]	A±10%
	(iii)	Field current at 1.00 pu terminal voltage open circuit	[redacted]	A±10%
	(iv)	Field current at 1.00 pu phase current on short circuit line	[redacted]	A±10%

[4] The resistance will be stated at the "reference temperature for use in determining I^2R losses" specified in IEEE C50.12.

			Value	Units
	(v)	Field current at Generator Rated Output and Generator Rated Operating Conditions	[redacted]	A±10%
	(vi)	Field voltage at Generator Rated Output and Generator Rated Operating Conditions	[redacted]	V
	(vii)	Field temperature at Generator Rated Output and Generator Rated Operating Conditions	[redacted]	°C
	(viii)	Field current at Generator Rated Operating Conditions, rated kVA and speed, 1.05 pu terminal voltage, and the minimum overexcited power factor	[redacted]	A±10%
	(ix)	Field current at Generator Rated Operating Conditions, rated kVA and speed, 1.10 pu terminal voltage, and at the minimum overexcited power factor	[redacted]	A±10%
	(x)	Field current at Generator Rated Output, Generator Rated Operating Conditions, and 105% of design average airgap	[redacted]	A
(m)	Synchronous Condenser Operation			
	(i)	Power required to operate the Generator as a synchronous condenser operating under-excited with a reactive power output in kVAr measured at the Generator terminals equal to 50% of the Generator Rated Output (kVA) excluding Turbine runner windage losses (with test uncertainties applied).	[redacted]	kW

4.3 Generator Losses

(a) Generator Losses for Specified Generator Outputs

Table 4.3(a) – Generator Losses[1] for Specified Generator Outputs

	Generator Rated Output (%)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(z)	Generator Output (kW)	[redacted]			[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power Factor	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Fixed Losses (kW)								
(a)	Core	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(b)	Field I^2R (open circuit, rated voltage)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(c)	Windage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(d)	Friction – Generator guide bearing(s)[2]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(e)	Friction – Turbine guide bearing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(f)	Friction – thrust bearing[3]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(g)	Subtotal (sum a to f)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Variable Losses (kW)								
(h)	Armature I^2R[(4)]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(i)	Field I^2R (loaded, increase over no load)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	Stray load	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(k)	Friction – hydraulic thrust[5]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(l)	Subtotal (sum h to k)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	**Total Losses (kW)** (g + l)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Efficiency (%) ((z / (z + j) x 100)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Notes:
1. With the temperature of the air leaving the Generator air coolers regulated to the Regulated Cold Air Temperature.
2. Standalone guide bearing if applicable.
3. Standalone thrust bearing or combined thrust/guide bearing as applicable, and includes mass of all rotating components for the Turbine and Generator.
4. For the reference temperature refer to Section 4.2(h) of this Appendix 11-6 [Technical Data and Information Forms].
5. Incremental losses due to hydraulic thrust.

(b) Generator Losses for Specified Turbine Discharges

Table 4.3(b) – Generator Losses[1,2] for Specified Turbine Discharges (Filled in by BC Hydro using data from the Independent Lab)

	Turbine Weighting Regime	A	B	C	D	E	F	G	H	I	J	K	L	Operating Condition A	S/C[7]
	Turbine Discharge (m^3/s)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Fixed Losses (kW)														
(a)	Core	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(b)	Field I^2R (open circuit, rated voltage)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(c)	Windage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(d)	Friction - Generator guide bearing(s)[3]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(e)	Friction - Turbine guide bearing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(f)	Friction – thrust bearing[4]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(g)	Subtotal (sum a to f)	[redacted]												[redacted]	[redacted]
	Variable Losses (kW)														
(h)	Armature $I^2R^{(5)}$	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(i)	Field I^2R (loaded, increase over no load)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	Stray load	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(k)	Friction - hydraulic thrust[6]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(l)	Subtotal (sum h to k)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]				[redacted]	[redacted]
(j)	**Total Losses (kW)** (g + l)	[redacted]												[redacted]	[redacted]

Notes:

1 With the temperature of the air leaving the Generator air coolers regulated to the Regulated Cold Air Temperature.
2 The Generator losses entered into this Table 4.3(b) will be the Generator losses without any test uncertainties applied.
3 Standalone guide bearing if applicable.
4 Standalone thrust bearing or combined thrust/guide bearing as applicable and includes mass of all rotating components for the Turbine and Generator.
5 For the reference temperature refer to Section 4.2(h) of this Appendix 11-6 [Technical Data and Information Forms].
6 Incremental losses due to hydraulic thrust.
7 Synchronous condenser operation - Losses are for the Generator operating under-excited with a reactive power output in kVAr measured at the Generator terminals equal to [redacted] of the Generator Rated Output (kVA) excluding Turbine runner windage losses.

(c) Generator Losses Test Uncertainties for Specified Generator Outputs

Table 4.3(c) – Generator Losses Test Uncertainties[1] for Specified Generator Outputs

	Generator Rated Output (%)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Power Factor	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Fixed Loss Uncertainties (kW)								
(a)	Core	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(b)	Field I^2R (open circuit, rated voltage)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(c)	Windage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(d)	Friction – Generator guide bearing(s)[2]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(e)	Friction – Turbine guide bearing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(f)	Friction – thrust bearing[3]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(g)	Subtotal (sum a to f)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Variable Loss Uncertainties (kW)								
(h)	Armature I^2R[(4)]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(i)	Field I^2R (loaded, increase over no load)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	Stray load	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(k)	Friction – hydraulic thrust[5]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(l)	Subtotal (sum h to k)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	**Total Uncertainties (kW)** (g + l)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Notes:
1 With the temperature of the air leaving the Generator air coolers regulated to the Regulated Cold Air Temperature.
2 Standalone guide bearing if applicable.
3 Standalone thrust bearing or combined thrust/guide bearing as applicable and includes mass of all rotating components for the Turbine and Generator.
4 For the reference temperature refer to Section 4.2(h) of this Appendix 11-6 [Technical Data and Information Forms].
5 Incremental losses due to hydraulic thrust.

(d) Generator Losses Test Uncertainties for Specified Turbine Discharges

Table 4.3(d) – Generator Losses Test Uncertainties[1] for Specified Turbine Discharges

	Turbine Weighting Regime	A	B	C	D	E	F	G	H	I	J	K	L	Operating Condition A	S/C[6]
	Turbine Discharge (m^3/s)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Fixed Loss Uncertainties (kW)														
(a)	Core	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(b)	Field I^2R (open circuit, rated voltage)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(c)	Windage	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(d)	Friction – Generator guide bearing(s)[2]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(e)	Friction – Turbine guide bearing	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(f)	Friction – thrust bearing[3]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(g)	Subtotal (sum a to f)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Variable Loss Uncertainties (kW)														
(h)	Armature I^2R[(4)]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(i)	Field I^2R (loaded, increase over no load)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	Stray load	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(k)	Friction – hydraulic thrust[5]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(l)	Subtotal (sum h to k)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
(j)	**Total Uncertainties (kW)** (g + l)	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Notes:

1 With the temperature of the air leaving the Generator air coolers regulated to the Regulated Cold Air Temperature.
2 Standalone guide bearing if applicable.
3 Standalone thrust bearing or combined thrust/guide bearing as applicable and includes mass of all rotating components for the Turbine and Generator.
4 For the reference temperature refer to Section 4.2(h) of this Appendix 11-6 [Technical Data and Information Forms].
5 Incremental losses due to hydraulic thrust.
6 Synchronous condenser operation - Losses are for the Generator operating under-excited with a reactive power output in kVAr measured at the Generator terminals equal to [redacted] of the Generator Rated Output (kVA) excluding Turbine runner windage losses.

			Value	Units
4.4	**Mechanical Design Information**			
(a)	Inertia Constant (Flywheel Effect)			
	(i)	Moment of Inertia, J_G (Generator only)	[redacted]	kg•m^2
	(ii)	Inertia Constant, H_G (Generator only)	[redacted]	MW•s/ MVA
(b)	Airgap			
	(i)	Nominal airgap	[redacted]	mm
	(ii)	Nominal airgap as a function of rotor diameter	[redacted]	%
	(iii)	Measured average airgap tolerance (Generator Rated Output and Generator Rated Operating Conditions)		mm
	(iv)	Airgap variation due to maximum rotor unbalance	[redacted]	mm
(c)	Dimensions			
	(i)	Stator bore diameter	[redacted]	mm
	(ii)	Stator bore height (including air ducts)	[redacted]	mm
	(iii)	Stator outside diameter	[redacted]	mm
	(iv)	Rotor rim diameter (ID)		mm
	(v)	Rotor rim diameter (OD)	[redacted]	mm
	(vi)	Rotor diameter (to pole face) (in operation)	[redacted]	mm
	(vii)	Pole body width (tangential, including pole shoe and excluding coil)	[redacted]	mm
	(i)	Pole body shoe width		mm
	(ii)	Pole body height (axial, including pole shoe and excluding coil)	[redacted]	mm
	(iii)	Pole depth (radial, rim to pole face)	[redacted]	mm
	(iv)	Number of different (unique) Generator field pole coils	[redacted]	
(d)	Masses			
	(i)	Stator frame (including sole plates and core clamping/attachment system)	[redacted]	kg
	(ii)	Stator core	[redacted]	kg
	(iii)	Stator winding	[redacted]	kg
	(iv)	Fully wound stator	[redacted]	kg
	(v)	Rotor pole coil (one)	[redacted]	kg
	(vi)	Rotor pole (complete) (one)	[redacted]	kg

		Value	Units
(vii)	Rotor rim (including clamping plates, bolts and keys)	[redacted]	kg
(viii)	Rotor spider and hub (including brake ring)	[redacted]	kg
(ix)	Rotor (complete) (including poles, rim and spider/hub)	[redacted]	kg
(x)	Rotating parts (for Generator only) (including thrust runner, connections, stub shaft, hub, spider, rim, poles, and slip rings)	[redacted]	kg
(xi)	Upper bracket	[redacted]	kg
(xii)	Lower bracket (including sole plates)	[redacted]	kg
(xiii)	Complete Generator (including lower combined bearing, covers, air guides and accessories)	[redacted]	kg
(xiv)	Heaviest crane lift for assembly or disassembly (including lifting devices), not to exceed	[redacted]	kg
(xv)	Component(s) included in the heaviest crane lift for assembly or disassembly	[redacted]	

4.5 Generator Temperatures

(a) The temperatures in the table below will be stated for operation at Generator Rated Output with the cooling water at the minimum and maximum operating temperatures.

(b)	Temperatures at the specified Cooling Water Supply Temperature	Minimum Operating Temperature	Maximum Operating Temperature	
(i)	Stator winding	[redacted]	[redacted]	°C
(ii)	Stator circuit-ring and end-winding surface temperature	[redacted]	[redacted]	°C
(iii)	Stator circuit-ring and end-winding copper temperature (calculated)	[redacted]	[redacted]	°C
(iv)	Stator core - yoke	[redacted]	[redacted]	°C
(v)	Stator core – finger	[redacted]	[redacted]	°C
(vi)	Rotor winding and field bus	[redacted]	[redacted]	°C
(vii)	Rotor amortisseur winding	[redacted]	[redacted]	°C

4.6 Generator Air Coolers

(a) The data for the Generator air coolers will be stated with heat recovery system inactive (all Generator air coolers functioning but with no heat being removed by the heat recovery system)

(b) Number of Generator air coolers [redacted] --

		Value	Units

		Percentage of Generator Rated Output			
		[redacted]	[redacted]	[redacted]	
(c)	Cooling water flow rate through air coolers				
(i)	at Minimum Cooling Water Supply Temperature				
	* Minimum flow to keep water velocity within acceptable range	[redacted]	[redacted]	[redacted]	L/s
(ii)	at 6 °C cooling water supply temperature	[redacted]	[redacted]	[redacted]	L/s
(iii)	at 12 °C cooling water supply temperature	[redacted]	[redacted]	[redacted]	L/s
(iv)	at Maximum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	L/s
(d)	Temperature of air entering air coolers at maximum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	°C
(e)	Temperature rise of cooling water in air coolers				
(i)	at Minimum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	°C
(ii)	at Maximum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	°C
(f)	Temperature drop of Generator cooling air passing through the coolers				
(i)	at Minimum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	°C
(ii)	at Maximum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	°C
(g)	Pressure drop of cooling water through Generator air coolers at Generator Rated Output				
(i)	at Minimum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	kPa
(ii)	at Maximum Cooling Water Supply Temperature	[redacted]	[redacted]	[redacted]	kPa

(h) If the heat recovery coolers and the Generator air coolers are not independent, and the heat recovery coolers serve the dual purpose of cooling and heat recovery and cooling functions, then provide an explanation for what restrictions, if any, would be imposed on Unit operation if the heat recovery coolers were not functional.

[redacted]

	Value	Units

4.7 Cooling Water Flow Rate

(a)	Cooling water flow rate for the Generator air coolers of one Unit operating at the Generator Rated Output at Generator Rated Operating Conditions with a penstock water temperature of 6 degrees C and the Generator heat recovery system inactive (all Generator air coolers fully functioning but with no heat being removed from the Generator by the heat recovery system).	[redacted]	L/s

4.8 Generator Heat Recovery System Heat Exchangers

(a) Heat Recovery System Water

Provide values under the following conditions:

- Water temperature entering heat recovery system heat exchangers = 25°C; and
- Heat removed by the heat recovery system heat exchangers = 500 kW.

		Percent of Generator Rated Output		
		[redacted]	[redacted]	
(i)	Flow rate through heat recovery system heat exchangers * Heat recovery at 50% of generator rated output is 332 kW.	[redacted]	[redacted]	L/s
(ii)	Water temperature leaving the heat recovery system heat exchangers * Heat recovery at 50% of generator rated output is 332 kW.	[redacted]	[redacted]	°C
(iii)	Pressure drop for the heat exchangers and piping (inside Generator Enclosure)	[redacted]	[redacted]	kPa

4.9 Cooling Water Regulating Valve

(a)	Regulating valve diameter	[redacted]	in
(b)	Regulating valve make and model	[redacted]	
(c)	Regulating valve actuator make and model	[redacted]	

4.10 Brake System

(a) Stopping time to bring the Unit to rest

(i)	From 50% rated speed	[redacted]	min
(ii)	From 15% rated speed	[redacted]	min

			Value	Units
	(iii)	From 10% rated speed		
		* Due to turbine water leakage, brakes are applied for a minimum speed of 12.5% of rated speed.	[redacted]	min
(b)	Volume of compressed air at 690 kPa required for one Generator brake application		[redacted]	m^3
(c)	Volume of Generator brake air receiver		[redacted]	m^3
(d)	Make-up air required when brakes continuously applied (at specified pressure) (i.e., to account for leakage)			L/min
(e)	Minimum allowable pressure without reduction in brake capability		[redacted]	kPa
(f)	Number of brake cylinders			
4.11	**Brake Dust Collection System**			
(a)	Number of dust collectors		[redacted]	--
(b)	For each motor			
	(i)	output power (mechanical)	[redacted]	kW
	(ii)	rated voltage	[redacted]	V
	(iii)	number of phases	[redacted]	--
	(iv)	service factor	[redacted]	%
	(v)	power factor	[redacted]	--
	(vi)	speed	[redacted]	rpm
	(vii)	insulation class	[redacted]	--
4.12	**Bearing – Thrust and Guide**			
(a)	Thrust Bearing Details			
	(i)	Design capacity (steady state)	[redacted]	MN
	(ii)	Design capacity (maximum)		NM
	(iii)	Average pressure on babbitt at design capacity	[redacted]	MPa
	(iv)	Inside diameter of thrust runner	[redacted]	mm
	(v)	Outside diameter of thrust runner	[redacted]	mm
	(vi)	Thrust runner surface finish		µm
	(vii)	Number of thrust pads	[redacted]	
	(viii)	Babbitt material	[redacted]	

			Value	Units
	(ix)	Babbitt temperature with cooling water at Maximum Cooling Water Supply Temperature:		
		(A) design at Generator Rated Output	[redacted]	°C
		(B) maximum at runaway speed	[redacted]	°C
		(C) maximum temperature that Unit can operate continuously (not to exceed) Note: thrust bearing sensors located 20 mm below the babbitt surface, 50% in the circumferential direction and 55% to 75% in the radial direction (from ID)	[redacted]	°C
	(x)	Time the Unit can be operated with cooling water at Maximum Cooling Water Supply Temperature:		
		(A) at 10 rpm without cooling water and with lift pump operating	[redacted]	min
		(B) at 10 rpm with cooling water and with lift pump operating	[redacted]	min
		(C) at Generator Rated Output without cooling water	[redacted]	min
		(D) at runaway speed with cooling water at Maximum Cooling Water Supply Temperature	[redacted]	min
	(xi)	Lowest speed Unit can be operated at continuously without lift pump	[redacted]	rpm
	(xii)	Distance that rotor must be jacked to remove thrust bearing pads	[redacted]	mm
(b)	Guide Bearing Details			
	(i)	Thrust block journal		
		(A) diameter	[redacted]	mm
		(B) length	[redacted]	mm
		(C) width		mm
		(D) surface finish	[redacted]	µm
	(ii)	Centreline elevation	[redacted]	m
	(iii)	Radial clearance	[redacted]	mm
	(iv)	Number of pads	[redacted]	--
	(v)	Babbitt material	[redacted]	
	(vi)	Babbitt temperature at Generator Rated Output at Maximum Cooling Water Supply Temperature:		
		(A) design at Generator Rated Output	[redacted]	°C

			Value	Units
	(B)	maximum temperature that Unit can operate continuously (not to exceed)		
		Note: guide bearing sensors located 20 mm below the babbitt surface, 50% in the circumferential direction and 50% in height.	[redacted]	°C

(c) Additional Information for Upper Guide Bearing

(i) Description of electrical isolation

[redacted]

(d) Cooling System

			Value	Units
(i)	Cooler tube material		[redacted]	
(ii)	Cooler fin material		[redacted]	
(iii)	Cooler design pressure		[redacted]	kPa
(iv)	Cooling water flow rate at Generator Rated Output:			
	(A)	at Minimum Cooling Water Supply Temperature	[redacted]	L/s
	(B)	at 6° C cooling water supply temperature	[redacted]	L/s
	(C)	at Maximum Cooling Water Supply Temperature	[redacted]	L/s
(v)	Pressure drop across cooling coils at maximum flow rate		[redacted]	kPa
(vi)	Power dissipated at Generator Rated Output		[redacted]	kW
(vii)	Power dissipated at runaway speed		[redacted]	kW

(e) Oil Reservoir

			Value	Units
(i)	Oil quantity		[redacted]	L
(ii)	Oil temperature with cooling water at Maximum Cooling Water Supply Temperature:			
	(A)	design at Generator Rated Output	[redacted]	°C
	(B)	maximum at runaway speed	[redacted]	°C
	(C)	maximum temperature that Unit can operate continuously (not to exceed)		
		Note: temperature based on average of all oil bath RTDs.	[redacted]	°C

4.13 Bearing High-Pressure Oil Injection System (Lift Pump)

(a) Pump make/model [redacted]

			Value	Units
(b)	Pump flow rate		[redacted]	L/min
(c)	Expected steady-state operating pressure		[redacted]	kPa
(d)	Maximum start-up pressure		[redacted]	kPa
(e)	Lift pump motor			
	(i)	rated output	[redacted]	kW
	(ii)	rated voltage	[redacted]	V
	(iii)	number of phases	[redacted]	--
	(iv)	service factor	[redacted]	pu
	(v)	rated speed	[redacted]	rpm
	(vi)	insulation class	[redacted]	--
(f)	Minimum acceptable rotational speed of Unit during acceleration for pump operation to stop (with bearing either cold, i.e. at ambient temperature, or at normal operating temperature, whichever is the limiting case)		[redacted]	rpm
(g)	Minimum acceptable rotational speed of Unit during deceleration for pump operation to start (with bearing temperature at the maximum allowable operating value)		[redacted]	rpm
(h)	If failure of the lift pump occurs during a Unit starting or stopping sequence, will the bearing design permit, without damage:			
	(i)	either sequence to be completed without detrimental effects (with the bearing babbitt at the maximum allowable temperature)	[redacted] ☒	[redacted] ☐
	(ii)	a starting sequence to be initiated or completed provided the babbitt temperature determined by embedded detector in thrust pad, is less than a specified temperature	[redacted] ☒	[redacted] ☐
		(A) Specified thrust bearing pad babbitt temperature for above condition	[redacted]	°C
	(iii)	a stopping sequence to be completed regardless of the bearing babbitt temperature value (with the brakes applied at normal speed)	[redacted] ☒	[redacted] ☐

4.14 Rotor Jacking System Oil Pump

			Value	Units
(a)	Oil pressure of portable jacking system oil pump		[redacted]	kPa
(b)	Portable jacking system oil pump			
	(i)	rated output	[redacted]	kW
	(ii)	rated voltage	[redacted]	V
	(iii)	number of phases	[redacted]	--
	(iv)	service factor	[redacted]	pu

			Value	Units
	(v)	rated speed	[redacted]	rpm
	(vi)	insulation class	[redacted]	--
4.15	**Fire Protection System**			
(a)	Water pressure required		[redacted]	kPa
(b)	Water flow rate required		[redacted]	L/s
(c)	Air pressure required (if any)		[redacted]	kPa
(d)	Air pressure flow rate required (if any)		[redacted]	
4.16	**Protection Information**			
(a)	Current Transformers			
	(i)	CSA accuracy class (for the protection CTs)	[redacted]	--
	(ii)	Ratio	[redacted]	A
	(iii)	Rated primary current	[redacted]	A
	(iv)	Voltage class	[redacted]	kV
	(v)	Mechanical short-time rating (crest)	[redacted]	kA/s
	(vi)	Thermal short-time rating (rms symmetrical)	[redacted]	kA/s
	(vii)	Secondary resistance	[redacted]	ohms
	(viii)	Core area	[redacted]	mm^2
	(ix)	Core length	[redacted]	mm
	(x)	Number of secondary turns	[redacted]	--
	(xi)	Flux density of saturation (saturation point being defined as where a 10% increase i.e. voltage produces a 50% increase in excitation current)	[redacted]	T
(b)	Current Unbalance Protection			
	(i)	Expected current unbalance under normal operation	[redacted]	A
	(ii)	Current unbalance transformer ratio	[redacted]	--
4.17	**Other Data**			
(a)	Stator Frame			
	(i)	Number of shelves including top and bottom shelves	[redacted]	--
(b)	Keybars			
	(i)	Number	[redacted]	--

			Value	Units
	(ii)	Circularity tolerance	[redacted]	±mm
	(iii)	Verticality tolerance	[redacted]	±mm
(c)	Core Studs			
	(i)	Number	[redacted]	--
	(ii)	Diameter	[redacted]	mm
	(iii)	Material	[redacted]	--
	(iv)	Yield strength	[redacted]	MPa
	(v)	Nominal clamping pressure of the stator core	[redacted]	MPa
(d)	Laminations			
	(i)	Slot width (tangential) (punched)	[redacted]	mm
	(ii)	Slot depth (radial) (punched)	[redacted]	mm
	(iii)	Number of packets (in axial height)	[redacted]	
	(iv)	Packet height (axial)	[redacted]	mm
	(v)	Lamination material type and grade	[redacted]	--
(e)	Clamping Finger Material			
	(i)	Type	[redacted]	--
	(ii)	Grade	[redacted]	--
	(iii)	Yield strength	[redacted]	MPa
(f)	Air Duct Spacer Material			
	(i)	Type	[redacted]	
	(ii)	Grade	[redacted]	
(g)	Air Ducts			
	(i)	Number in core length	[redacted]	--
	(ii)	Thickness	[redacted]	mm

			Value	Units
(h)	Magnetic Flux Density (at Generator Rated Output)			
	(i)	Teeth	[redacted]	T
	(ii)	Yoke	[redacted]	T
	(iii)	Back	[redacted]	T
(i)	Flux Test			
	(i)	Maximum power	[redacted]	kVA
	(ii)	Voltage	[redacted]	V
(j)	Stator Winding Details			
	(i)	Circuits per phase	[redacted]	--
	(ii)	Number of slots	[redacted]	--
	(iii)	Pitch	[redacted]	--
	(iv)	Insulation class	[redacted]	--
(k)	Strand Copper			
	(i)	Number of strands	[redacted]	--
	(ii)	Strand width (tangential, in slot section)	[redacted]	mm
	(iii)	Strand depth (radial, in slot section)	[redacted]	mm
	(iv)	Degrees of Roebel transposition in slot portion	[redacted]	o
(l)	Ground Insulation			
	(i)	Insulation type	[redacted]	
	(ii)	Insulation thickness	[redacted]	mm
	(iii)	Voltage stress level	[redacted]	kV/mm
(m)	Stator Bar			
	(i)	Bar overall width (tangential, in slot section)	[redacted]	mm
	(ii)	Bar overall depth (radial, in slot section)	[redacted]	mm
	(iii)	Bar overall length (axial end-to-end)	[redacted]	mm
(n)	Bar Dimensional Tolerances (between bar and slot)			
	(i)	Maximum width (tangential)	[redacted]	mm
	(ii)	Minimum width (tangential)	[redacted]	mm
	(iii)	Maximum depth (radial)	[redacted]	mm
	(iv)	Minimum depth (radial)	[redacted]	mm

			Value	Units
	(v)	Mean side clearance of bar in slot	[redacted]	mm
(o)	Stator End-Turns and Circuit Rings			
	(i)	End-turn spacing (T-spacing)	[redacted]	mm
	(ii)	End-turn connection end span tolerances (tangential)	[redacted]	mm
	(iii)	End-turn connection end drop tolerances (radial)	[redacted]	mm
	(iv)	End-turn spacing between front and back bars at slot exit	[redacted]	mm
	(v)	End-turn maximum temperature differential surface temperature to copper temperature	[redacted]	ºC
	(vi)	Circuit ring maximum temperature differential surface temperature to copper temperature	[redacted]	ºC
(p)	Bar Surface Contact Resistance			
	(i)	Mean surface contact resistance to ground	[redacted]	kohm
	(ii)	Deviation from mean	[redacted]	kohm
(q)	Toothed-Wheel Speed Sensing System			
	(i)	Location of toothed wheel system	[redacted]	

5.0 EXCITATION SYSTEM TECHNICAL DATA AND INFORMATION FORM

		Value	Units
5.1	**Manufacturer Information**		
(a)	Manufacturer	[redacted]	
(b)	Make and Model	[redacted]	
5.2	**Excitation System**		
(a)	Excitation System Rated Current:		
(i)	with all bridges in service (voltage obtained by multiplication with the field resistance R (110°C) = 107.17 mΩ)	[redacted] Adc at [redacted]	V
(ii)	with one bridge out of service	[redacted] Adc at [redacted]	V
(b)	Maximum 30 second output rating, immediately preceded by continuous operation at Excitation System Rated Current, and immediately followed by continuous operation at Excitation System Rated Current:		
(i)	All bridges in service (Excitation System 30 Second Rating):	[redacted] Adc at [redacted]	V
(ii)	One bridge out of service:	[redacted] Adc at [redacted]	V
(c)	Excitation System ambient temperature rating	[redacted]	°C
(d)	Ceiling Voltage while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	Vdc
(i)	Expressed in per unit, where 1 pu is equal to the Generator field voltage at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	pu
(ii)	Expressed in per unit, where 1 pu is equal to the air-gap field voltage as defined in IEEE Std.421.1:	[redacted]	pu
(e)	Response time (time to reach 95% of Ceiling Voltage while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	msec
(f)	Maximum negative field forcing voltage while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	Vdc
(i)	Expressed in per unit, where 1 pu is equal to the Generator field voltage at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	pu
(ii)	Expressed in per unit, where 1 pu is equal to the air-gap field voltage as defined in IEEE Std.421.1:	[redacted]	pu

	Value	Units
(g) Setpoint adjustment ranges:		
(i) Automatic voltage regulation mode: Generator terminal voltage setpoint adjustment range (where 1 pu is equal to rated Generator terminal voltage):	[redacted] pu to [redacted]	pu
(ii) Manual field current regulation mode: Field current setpoint adjustment range (where 1 pu is equal to Excitation System Rated Current):	[redacted] pu to [redacted]	pu
(iii) Manual field voltage regulation mode: Setpoint adjustment range (where 1 pu is equal to Generator rated field voltage):	[redacted] pu to [redacted]	pu
(h) Minimum ac supply voltage required for the Excitation System to supply rated Generator field current at rated Generator field voltage:	[redacted]	kV
(i) Ceiling voltage at the minimum ac supply voltage above:	[redacted]	Vdc
(A) = [redacted] pu (where 1 pu is equal to the Generator field voltage at Generator Rated Output)		
(B) = [redacted] pu (where 1 pu is equal to the air-gap field voltage as defined in IEEE Std.421.1		
(i) Minimum Generator terminal voltage error required to drive the Excitation System to Ceiling Voltage while supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions:	[redacted]	pu
(j) Current required by the Excitation System while configured in open-loop operation and supplying the Generator operating at 120% of rated Generator terminal voltage during an open circuit saturation test:		
(i) with a Generator Rated Voltage supply connected to the Exciter transformer:	[redacted]	A_{rms} at Generator Rated Voltage
(ii) with a 600V supply connected to the Power Rectifier:	[redacted]	A_{rms} at 600V
(k) Excitation System auxiliary equipment power required while the Excitation System is supplying the Generator operating at Generator Rated Output and Rated Operating Conditions:	[redacted]	kW
(l) Excitation System total heat rejected while the Excitation System is supplying the Generator operating at Generator Rated Output and Rated Operating Conditions:	[redacted]	kW
(m) Excitation System losses while it is supplying the Generator operating at Generator Rated Output and Rated Operating Conditions:		
(i) Exciter Transformer losses	[redacted]	kW
(ii) Power Rectifier losses	[redacted]	kW
(iii) Other losses (snubbers, auxiliary equipment, buswork, etc.)	[redacted]	kW

				Value	Units
	(iv)	Total losses		[redacted]	kW
(n)	Maximum audible noise level while the Excitation System is supplying the Generator operating at Generator Rated Output and Rated Operating Conditions, measured at:				
	(i)	1 m from the Exciter Transformer		[redacted]	dBA
	(ii)	1 m from the Power Rectifier		[redacted]	dBA
(o)	Exciter Software and communications:				
	(i)	ExcPCE/ExcRCE:			
		(A)	Configuration tool software model	[redacted]	
		(B)	Configuration tool software version number		
		(C)	Communications link protocol and physical layer:		
			(I) Protocol	[redacted]	
			(II) Physical	[redacted]	
	(ii)	Exciter HMI:			
		(A)	Configuration tool software model	[redacted]	
		(B)	Configuration tool software version number		
		(C)	Communications link protocol and physical layer:		
			(I) Protocol	[redacted]	
			(II) Physical	[redacted]	
(p)	Excitation System total mass (not including Excitation Transformer)			[redacted]	kg
(q)	Excitation System Design Life				years

	Value	Units

5.3 Power Rectifier

(a) Power Rectifier dimensions

		Value	Units
	(i) overall height	[redacted]	mm
	(ii) overall width	[redacted]	mm
	(iii) overall length	[redacted]	mm
(b)	Power Rectifier mass	[redacted]	kg
(c)	Number of SCR bridges used	[redacted]	

(d) Number of SCRs/bridge:

[redacted] consisting of [redacted] in series, [redacted] in parallel

(e) Maximum continuous output rating of each bridge:

(i) all bridges in service

(A) [redacted] V, [redacted] Adc at Tj = [redacted] °C

(f) Cooling:

		Value	Units
(i)	All bridges in service:	☒ [redacted]	☐ [redacted]
(ii)	One bridge out of service:	☒ [redacted]	☐ [redacted]
(iii)	Fans (if any):	[redacted]	
	(A) Number:	[redacted]	
	(B) Total Flow:	[redacted]	m^3/s
	(C) Motors:	☒ [redacted]	☐ [redacted]
	(I)	[redacted]	Vac
	(II)	[redacted]	VA

(g) Silicon Controlled Rectifiers (SCRs):

		Value	Units
(i)	SCR Manufacturer:	[redacted]	
(ii)	SCR Type:	[redacted]	
(iii)	Rated maximum operating junction temperature (Tjm):	[redacted]	°C

(iv) Repetitive forward blocking voltage: [redacted] Vdc at Tjm = [redacted]

(v) Repetitive reverse blocking voltage: [redacted] Vdc at Tjm = [redacted]

(vi) Non-repetitive reverse blocking voltage: [redacted] V_{peak} at Tjm = [redacted]

			Value	Units
(h)	Maximum SCR junction temperature rise above ambient while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions:			
	(i)	with all bridges in service	[redacted]	°C
	(ii)	with one bridge out of service	[redacted]	°C
(i)	Total SCR losses with all bridges in service while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions		[redacted]	kW
(j)	Surge arresters:			
	(i)	breakover voltage	[redacted]	Vdc
	(ii)	energy rating	[redacted]	kW

5.4 Exciter Transformer

			Value	Units
(a)	Ratings			
	(i)	Primary voltage	[redacted]	kV
	(ii)	Secondary voltage	[redacted]	V
	(iii)	Basic impulse level (BIL) of primary insulation	[redacted]	kV
	(iv)	Voltage class of secondary	[redacted]	V
	(v)	Type of cooling	[redacted]	
	(vi)	Number of phases ☒ [redacted]	☐ [redacted]	
	(vii)	Frequency	[redacted]	Hz
	(viii)	Insulation system class	[redacted]	
	(ix)	kVA rating for rated winding temperature rise	[redacted]	kVA
	(x)	Winding temperature rise	[redacted]	°C
	(xi)	Taps (if provided)	[redacted]	%
	(xii)	K-factor	[redacted]	
	(xiii)	High-Voltage current transformer class	[redacted]	
(b)	Losses in accordance with CSA C9 M			
	(i)	No load losses	[redacted]	kW
	(ii)	Total losses while the Excitation System is supplying the Generator operating at Generator Rated Output and Generator Rated Operating Conditions	[redacted]	kW

				Value	Units
(c)	Efficiencies at 1.0 power factor				
	(i)	¼ load		[redacted]	%
	(ii)	½ load		[redacted]	%
	(iii)	Full load		[redacted]	%
(d)	Excitation current at				
	(i)	Rated primary voltage		[redacted]	%
	(ii)	110% of rated primary voltage		[redacted]	%
(e)	Impedance and fault current				
	(i)	Impedance		[redacted]	%
	(ii)	Maximum secondary symmetrical fault current assuming an infinite source:		[redacted]	kA_{rms}
(f)	Physical characteristics				
	(i)	Overall height		[redacted]	mm
	(ii)	Overall width		[redacted]	mm
	(iii)	Overall length		[redacted]	mm
	(iv)	Mass of core and coil		[redacted]	kg
	(v)	Total mass		[redacted]	kg
(g)	Test values for primary winding				
	(i)	Applied test voltage		[redacted]	kV
	(ii)	Induced test voltage		[redacted]	kV
(h)	Terminals and terminal connectors				
	(i)	HV terminal type		[redacted]	
	(ii)	LV phase terminal type		[redacted]	
	(iii)	LV neutral terminal type		[redacted]	

5.5 <u>Field Breaker</u>

(a)	Type			☐ [redacted]	☒ [redacted]
(b)	Manufacturer and type/series			[redacted]	
(c)	Manufacturer's part number				
(d)	Rated maximum interruption voltage	[redacted]	V	☐ [redacted]	☒ [redacted]
(e)	Rated maximum steady-state current	[redacted]	A	☐ [redacted]	☒ [redacted]

				Value	Units
(f)	Rated maximum interrupting current of main contacts		[redacted] A	☐ [redacted]	☒ [redacted]
	(i)	at	[redacted] V	☐ [redacted]	☒ [redacted]
(g)	Closing time of main contacts			[redacted]	msec
(h)	Opening time of main contacts			[redacted]	msec
(i)	Duty cycle			[redacted]	
(j)	Number and type of auxiliary contacts:				
	(i)	Quantity of form A contacts:		[redacted]	
	(ii)	Quantity of form B contacts:		[redacted]	
	(iii)	Quantity of form C contacts:		[redacted]	
(k)	Rated interrupting current of auxiliary contacts		[redacted] A (inductive) at	[redacted]	Vdc
(l)	Charging mechanism			[redacted]	
5.6	**<u>Field Flashing</u>**				
(a)	Field flashing current limiting			[redacted]	type
(b)	Field flashing contact				
	(i)	maximum continuous current rating	[redacted] Adc at	[redacted]	Vdc
	(ii)	maximum interrupting current rating	[redacted] Adc (inductive) at	[redacted]	Vdc
(c)	Series resistor (if applicable)				
	(i)	continuous power rating		[redacted]	kW
	(ii)	30 second power rating		[redacted]	kW
	(iii)	Type		[redacted]	
	(iv)	Resistance adjusting range:	[redacted] ohms to	[redacted]	ohms
5.7	**<u>Field Discharge Equipment</u>**				
(a)	De-excitation equipment				
	(i)	Type (e.g. SCR)		[redacted]	
	(ii)	Discharge capacity		[redacted]	kW
	(iii)	Peak voltage capability		[redacted]	Vdc
(b)	Crowbar circuit equipment				
	(i)	Type (e.g. SCR)		[redacted]	

			Value	Units
	(ii)	Breakover voltage	[redacted]	Vdc
	(iii)	I^2t rating	[redacted] MA^2 for [redacted]	sec
	(iv)	Bi-directional	☒ [redacted]	☐ [redacted]
	(v)	Breakover voltage adjustment range	[redacted] Vdc to [redacted]	Vdc
(c)	Field Discharge Resistor (FDR)			
	(i)	Type	[redacted]	
	(ii)	Energy rating	[redacted]	kW
	(iii)	Number of resistors	[redacted]	
	(iv)	Connection method (parallel or series)	[redacted]	
	(v)	Calculated total field suppression time after a three phase short circuit at the stator terminals	[redacted]	s

5.8 Surge Suppression Devices

		Value	Units
(a)	Type	[redacted]	
(b)	Rating	[redacted]	kV
(c)	Maximum surge voltage	[redacted] kV for [redacted]	s
(d)	Maximum steady state voltage	[redacted]	kV

5.9 AC Bus Duct

		Value	Units
(a)	Manufacturer	[redacted]	
(b)	Manufacturer's model (if applicable)	[redacted]	
(c)	Rated continuous current	[redacted]	A
(d)	Rated voltage	[redacted]	kV

		Value	Units
(e)	Power frequency withstand	[redacted]	kV
(f)	Basic impulse level (BIL)	[redacted]	kV
(g)	Insulation type (e.g. tape, fluidized epoxy, etc.)	[redacted]	

5.10 **DC Bus Duct**

		Value	Units
(a)	Manufacturer	[redacted]	
(b)	Manufacturer’s Model (if applicable)	[redacted]	
(c)	Rated continuous current	[redacted]	A
(d)	Rated voltage	[redacted]	kV
(e)	Power frequency withstand	[redacted]	kV
(f)	Basic impulse level (BIL)	[redacted]	kV
(g)	Insulation type (e.g. tape, fluidized epoxy, etc.)	[redacted]	

6.0 NOT USED

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 11-7

EQUIPMENT SPARE PARTS LISTS

Note: Attached to this Appendix 11-7 is an Excel spreadsheet entitled "Appendix 11-7 Equipment Spare Parts Lists" that the parties agree contains the correct Contract prices and which are deemed to be read as part of this Appendix 11-7 (and which will be subject to adjustment for currency fluctuation as provided by Section 12.1 of the Agreement).

Spare Parts Quantity Key

N Total number of items/components installed on one Unit
M1 One spare part required where there are four or less items/components installed on one Unit
M2 Two spare parts required where there are five to eight items/components installed on one Unit
M3 Three spare parts required where there more than eight items/components installed on one Unit
Y Quantity expected to be needed for the operation of one Unit for one year (but cannot be less than a quantity of one)

Table Notes:

[1] Where not already specified elsewhere in the Contract Documents, the Contractor will provide all spare parts identified as "Committed Spares" in this Appendix 11-7 [Equipment Spare Parts Lists], in the corresponding quantities set out under the column entitled "Total Quantity".

[2] BC Hydro may, at its option, issue one or more Change Orders requiring the Contractor to provide spare parts identified as "Optional Spares" in this Appendix 11-7 [Equipment Spare Parts Lists]. The price to provide one unit of each such spare part will be deemed to be equal to the corresponding Spare Parts Payment for that spare part. For certainty, BC Hydro may pay all or part of a provisional sum identified in this Schedule 11 [Prices and Payment] pursuant to such Change Orders.

[3] For spare parts identified as "Committed Spares" in this Appendix 11-7 [Equipment Spare Parts Lists], these prices (each a "**Spare Parts Payment**") are each for the total quantity specified in the column entitled "Total Quantity".

[4] Valve(s) includes all types of valves such as isolating, regulating, control, pressure relief, solenoid, etc.

[5] BC Hydro may, at its option, order up to four additional complete Excitation Systems.

Interpretations:

1 Unless otherwise expressly stated, each spare part described in a line item will be interpreted as meaning a complete assembly of such part, including all of the sub-components that make up the part, and the spare part will come fully assembled.

2 Where the Contract Documents describe more than one type for a part referred to in a spare part line item, then the quantity required will be interpreted as the quantity required for each type.

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
Table Appendix 11-7 A – Common Spare Parts[1]						
A 1	M1	power supply, converter, and inverter of each type	Yes			[redacted]
A 2	M2	relay of each type	Yes			[redacted]
A 3	M1	contactor of each type	Yes			[redacted]
A 4	M1	holding coils and main and auxiliary contacts for each type and size of motor starter or contactor used	Yes			[redacted]
A 5	M1	moulded case circuit breaker	Yes			[redacted]
A 6	M1	control and instrument transformer of each type	Yes			[redacted]
A 7	M1	printed circuit board complete with components of each type	Yes			[redacted]
A 8	M1	coil for each type of solenoid valve or mechanism, including all parts required to replace each type of coil	Yes			[redacted]
A 9	M1	pressure transducer of each type	Yes			[redacted]
A 10	M1	pressure switch of each type	Yes			[redacted]
A 11	M1	pressure gauge of each type	Yes			[redacted]
A 12	M1	level transducer of each type	Yes			[redacted]
A 13	M1	level switch of each type	Yes			[redacted]
A 14	M1	flow transducer of each type	Yes			[redacted]
A 15	M1	flow switch of each type	Yes			[redacted]
A 16	M1	displacement transducers of each type	Yes			[redacted]
A 17	M1	limit switches of each type	Yes			[redacted]
A 18	M1	temperature transducer of each type	Yes			[redacted]
A 19	M1	RTD of each type	Yes			[redacted]
A 20	M1	temperature switch of each type	Yes			[redacted]
A 21	M1	temperature gauge of each type	Yes			[redacted]
A 22	M1	thermowell of each type	Yes			[redacted]
A 23	M1	oil contamination monitor detector of each type	Yes			[redacted]
A 24	M1	valve of each type for valves 250 mm (10") and smaller including any seals/gaskets required for installation[3]	Yes			[redacted]
A 25	M1	repair kit for each type of valve over 250 mm (10") including any seals/gaskets required for installation[4]	Yes			[redacted]
A 26	M1	valve actuator and controller of each type	Yes			[redacted]

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
A 27	M1	repair kit for each type of pneumatic actuator	Yes			[redacted]
A 28	1	Generator cooling water flow regulating valve and actuator if not provided in A 24, A 25, A 26 and A 27	Yes			[redacted]
A 29	18 x Y	oil filters or cartridges of all types	Yes			[redacted]
A 30	3 x Y	air filters or cartridges of all types	Yes			[redacted]
A 31	3 x Y	water filters or cartridges of all types	Yes			[redacted]
A 32	1	strainer baskets of each type	Yes			[redacted]
A 33	M1	vibration monitoring system eddy current probe and drivers	Yes			[redacted]
A 34	M2	terminal blocks and accessories of each type	Yes			[redacted]
A 35	M1	oil mist collector assembly	Yes			[redacted]
Table Appendix 11-7 B – Turbine Spare Parts						
		For the Turbine runner seals:				
B 1	1	headcover renewable runner seal ring		Yes		[redacted]
B 2	1	headcover renewable runner inner seal ring, if applicable		Yes		[redacted]
B 3	1	bottom ring renewable runner seal ring		Yes		[redacted]
		For the Turbine shaft seal:				
B 4	1	replaceable seal wear face	Yes			[redacted]
B 5	2 x N	replaceable carbon rings	Yes			[redacted]
B 6	1 x N	packing, gaskets, O-rings and seals	Yes			[redacted]
		For the Turbine guide bearing:				
B 7	1 x N	bearing pads	Yes			[redacted]
B 8	1 x N	bearing pad accessories such as sealing strips, adjustment mechanism wearable components, locking tabs etc. (as applicable to the design)	Yes			[redacted]
B 9	1	bearing cooler of each type	Yes			[redacted]
B 10	1 x N	bearing cover shaft oil seal if subject to wear	Yes			[redacted]
B 11	1 x N	bearing packing, gaskets, O-rings and seals (except for top cover and inspection covers/hatches)	Yes			[redacted]
B 12	3 x N	gaskets, O-rings and seals for top cover and inspection covers/hatches	Yes			[redacted]
		For the Turbine wicket gates:				

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
B 13	2 x N	shear pins	Yes			[redacted]
B 14	6	self-lubricated bushing of each type for the headcover and bottom ring	Yes			[redacted]
B 15	6	operating mechanism self-lubricated bushing of each type for the gate links	Yes			[redacted]
B 16	6	self-lubricated thrust bearing of each type	Yes			[redacted]
B 17	1 x N	stem seals or packing of each type including any seals required for removable housings	Yes			[redacted]
B 18	1 x N	end seal segments of each type	Yes			[redacted]
B 19	4	end seal segment clamp bars and all hardware necessary to install	Yes			[redacted]
		For the Turbine operating ring and servomotors:				
B 20	0.5 x N	Servomotor connecting rod bushing of each type including thrust washer	Yes			[redacted]
B 21	1 x N	Servomotor bushing, piston rings, rod seal, gaskets etc. required to overhaul servomotors	Yes			[redacted]
B 22	1 x N	Servomotor gate lock piston rings, rod seal, gaskets etc. required to overhaul gate lock	Yes			[redacted]
B 23	0.5 x N	operating ring self-lubricated thrust and radial wear strips of each type	Yes			[redacted]
		Other:				
B 24	1	headcover pumped drainage system including pump, motor, strainers, check valves, level instrumentation, etc.	Yes			[redacted]
B 25	1	flexible coupling seal ring including two seal clamp ring segments	Yes			[redacted]
B 26	2 x N	spiral case, draft tube, and draft tube elbow door O-rings	Yes			[redacted]
B 27	1 x N	air admission airhead packing, gaskets, O-rings, seals if applicable and all required electrical isolation	Yes			[redacted]

Table Appendix 11-7 C – Governor System Spare Parts

C 1	1	pump and motor assembly of each type including unloader, coupling, and housing and including any seals/gaskets required for installation	Yes			[redacted]

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
C 2	1	distributing valve including feedback displacement transducer and any seals/gaskets required for installation	Yes			[redacted]
C 3	1	pilot valve including feedback displacement transducer and any seals/gaskets required for installation	Yes			[redacted]
C 4	1	accumulator float valve including any seals/gaskets required for installation	Yes			[redacted]
C 5	1	accumulator sight glass assembly including any seals/gaskets required for installation	Yes			[redacted]
C 6	1	high pressure air compressor and motor assembly	Yes			[redacted]
C 7	1	Governor PLC	Yes			[redacted]
C 8	1	Governor HMI	Yes			[redacted]
C 9	2	Toothed-Wheel speed detector ZVPU Probe, including signal conditioner of each type	Yes			[redacted]
C 10	1	Fully assembled Toothed Wheel Speed Sensing System if the system is installed above the Generator rotor	Yes			[redacted]
Table Appendix 11-7 D – Generator Spare Parts						
		For the Generator stator core:				
D 1	1	laminations, including all different types, to pile one-eighth of one Generator	Yes			[redacted]
D 2	1	pressure plates and pressure fingers for one quarter circumference of one Generator	Yes			[redacted]
D 3	8	clamping studs complete with washers and nuts (and insulation if applicable)	Yes			[redacted]
		For the Generator stator winding:				
D 4	80	front bars	Yes			[redacted]
D 5	20	back bars	Yes			[redacted]
D 6	8	group jumpers of each type and associated hardware	Yes			[redacted]
D 7	80	series connections and associated hardware including end-caps	Yes			[redacted]
D 8	3	circuit ring tap connections of each type or three universal equivalents	Yes			[redacted]

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
D 9	1	circuit-ring section of each type	Yes			[redacted]
D 10	4	circuit-ring supports of each type or four universal equivalents	Yes			[redacted]
D 11	1	support ring section of each type	Yes			[redacted]
D 12	1	depth and side packing required to install 80 front bars and 20 back bars	Yes			[redacted]
D 13	1	wedges required to install 80 front bars	Yes			[redacted]
D 14	1	blocking, lashing, and epoxy sufficient for replacement of 80 front bars and 20 back bars	Yes			[redacted]
D 15	1 x N	flex connectors for the Generator main and neutral lead connections	Yes			[redacted]
		For the Generator rotor:				
D 16	6	pole field windings	Yes			[redacted]
D 17	2	pole field ground insulation kits including all necessary ground insulation components	Yes			[redacted]
D 18	1	field bus assembly for one Generator (field bus from rotor poles to brushgear and brushgear to Excitation System)	Yes			[redacted]
D 19	6 x N	pole keys required for one pole	Yes			[redacted]
D 20	6	inter-polar jumpers of each type (if there are more than one type)	Yes			[redacted]
D 21	2	pole inter-polar baffles (if used)	Yes			[redacted]
		For the Generator bearings:				
D 22	1 x N	thrust bearing pads	Yes			[redacted]
D 23	1 x N	thrust bearing supporting springs (or equivalent)	Yes			[redacted]
D 24	1 x N	thrust bearing pad accessories including check valves, orifices, flexible pipe or tubing connections	Yes			[redacted]
D 25	1 x N	guide bearing pads	Yes			[redacted]
D 26	1 x N	guide bearing pad accessories such as sealing strips, adjustment mechanism wearable components, locking tabs etc. (as applicable to the design)	Yes			[redacted]
D 27	1 x N	guide and/or thrust bearing electrical insulation if applicable	Yes			[redacted]
D 28	1	thrust bearing thrust runner	Yes			[redacted]
D 29	1	guide/thrust bearing cooler of each type	Yes			[redacted]
D 30	1 x N	bearing cover shaft oil seal if subject to wear	Yes			[redacted]

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
D 31	1	thrust bearing lift pump and motor assembly	Yes			[redacted]
D 32	1 x N	bearing packing, gaskets, O-rings and seals (except for top cover and inspection covers/hatches)	Yes			[redacted]
D 33	3 x N	gaskets, O-rings and seals for top cover and inspection covers/hatches	Yes			[redacted]
		For the Generator brakes:				
D 34	2 x N	brake pads	Yes			[redacted]
D 35	1	brake/jack assembly (excluding pad)	Yes			[redacted]
D 36	1	brake solenoid valve assembly (including manual valve and all limit switches)	Yes			[redacted]
D 37	1 x N	seal between brake and brake track for dust collector	Yes			[redacted]
		For the Generator cooling system:				
D 38	1	stator air cooler and heat recovery cooler of each type	Yes			[redacted]
		For the Generator brushgear:				
D 39	2 x N	Brushes	Yes			[redacted]
D 40	1 x N	brush holders	Yes			[redacted]
D 41	1	collector ring assembly fully assembled including both collector rings, insulators, mounting hardware, and all other components required for installation	Yes			[redacted]
		For the Generator instrumentation:				
D 42	1	partial discharge monitoring system coupling capacitor and surge arrestor including Enclosure	Yes			[redacted]
D 43	4	stator winding RTD of each type	Yes			[redacted]
D 44	2	stator core RTD of each type	Yes			[redacted]
D 45	2	stator frame RTD of each type	Yes			[redacted]
D 46	2	air coolers RTD of each type	Yes			[redacted]
D 47	4	airgap monitoring system proximity probe and signal conditioner of each type	Yes			[redacted]
D 48	1	CT of each type	Yes			[redacted]
D 49	1	airgap monitoring system instrument slip-ring	Yes			[redacted]
D 50	1	fire detection system sensor of each type	Yes			[redacted]
D 51	1	fire protection deluge nozzle of each type	Yes			[redacted]

Item Number	Total Quantity	Description	Committed Spares[1]	Optional Spares[2]	Spare Parts Payment[3]	
Table Appendix 11-7 E – Excitation System Spare Parts						
E 1	1	Exciter Transformer	Yes			[redacted]
E 2	1	SCR bridge assembly	Yes			[redacted]
E 3	1	SCR bridge assembly		Yes		[redacted]
E 4	1	fan module (if fans are used for cooling within the Excitation System)	Yes			[redacted]
E 5	1	Field Breaker	Yes			[redacted]
E 6	1	field discharge equipment (including Field Discharge Resistor, de-excitation SCR assembly, and field shorting crowbar SCR assembly)	Yes			[redacted]
E 7	1	field flashing equipment assembly	Yes			[redacted]
E 8	1	ExcPCE equipment assembly, including power supplies, communications devices, main and daughter printed circuit boards or modules, and I/O printed circuit boards or modules	Yes			[redacted]
E 9	1	ExcRCE equipment assembly, including power supplies, communications devices, main and daughter printed circuit boards or modules, and I/O printed circuit boards or modules	Yes			[redacted]
E 10	1 x N	fuses of each type	Yes			[redacted]
E 11	1	field ground detector equipment assembly	Yes			[redacted]
E 12	1	conduction monitoring equipment assembly (if not provided with the spare SCR bridge assembly)	Yes			[redacted]
E 13	1	Exciter HMI	Yes			[redacted]
E 14	1	each type of component used in the Exciter Hardwired Controls	Yes			[redacted]
E 15	1	SEL 351 Exciter Transformer protective relay		Yes		[redacted]
E 16	1[5]	Complete Excitation System		Yes		[redacted]
Committed Spares Sub-Total		[redacted]				
Optional Spares Sub-Total (assume one of each)		[redacted]				

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 12

CHANGES

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 12

CHANGES

1 INTERPRETATION

1.1 Definitions

In this Schedule 12 [Changes], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Change**" means a change, including an addition, deletion, alteration, substitution or otherwise, to the Work, including a change to the Supply and the Delivery Work, the Installation Work or the Testing and Commissioning Work;

"**Change Directive**" has the meaning set out in Section 2.5 of this Schedule 12 [Changes];

"**Change Order**" has the meaning set out in Section 2.4 of this Schedule 12 [Changes];

"**Change Report**" means a written report prepared by the Contractor in response to a Preliminary Change Instruction, containing the information described in Section 3.3 of this Schedule 12 [Changes];

"**Preliminary Change Instruction**" has the meaning set out in Section 3.1 of this Schedule 12 [Changes]; and

"**Small Tool**" means a small tool or equipment item with a replacement value of no more than $1,500.00 per tool or item.

2 CHANGES

2.1 BC Hydro's Right to Require Changes

BC Hydro may require a Change by issuing a written Change Order or a written Change Directive, and except to the extent that a Change Order or Change Directive expressly requires otherwise, the Contractor will comply with all applicable terms of the Contract Documents, including Schedule 2 [Design and Construction Protocols] and Schedule 6 [Specifications and Drawings] in implementing the Change.

2.2 Restrictions on Changes

BC Hydro will not at any time require, and the Contractor may refuse to implement, a Change which:

(a) is not within the general scope of the Work, including the Supply and the Delivery Work, the Installation Work or the Testing and Commissioning Work;

(b) would be contrary to Law;

(c) would render the insurance policies required under this Contract void or voidable and BC Hydro does not agree to replacement security satisfactory to the Contractor acting reasonably;

(d) would cause the revocation of any Permit required by the Contractor to perform its obligations under this Contract, and such Permit would not, using reasonable efforts, be capable of amendment or renewal;

(e) would require a new Permit for the Contractor to perform its obligations under this Contract, which Permit would not, using reasonable efforts by the Contractor or BC Hydro, as applicable, be obtainable; or

(f) would cause the Contractor to be unable to obtain a Permit required by the Contractor to perform its obligations under this Contract, provided that such Permit was previously required but at the time of the Preliminary Change Instruction had not been obtained and such Permit would not, using reasonable efforts by the Contractor or BC Hydro, as applicable, be obtainable.

If the Contractor, acting reasonably, determines that a Change is unacceptable because it contravenes one or more of the above, then the Contractor will promptly deliver written notice to BC Hydro of its objection, with written reasons. If BC Hydro disagrees then it may deliver a Dispute Notice to the Contractor, and the parties will cooperate to have the issue resolved in a timely manner in accordance with Schedule 14 [Dispute Resolution Procedure].

2.3 No Change Without Written Direction

Except as expressly set out otherwise in the Contract Documents, the Contractor will not proceed with any Change prior to the receipt of a written Change Order or Change Directive issued by BC Hydro. No claim for an adjustment to the Contract Price or the time for the performance of the Work may be made without such written direction. The Contractor will not be entitled to, nor will the Contractor rely on, any oral representation (except in an emergency), Site meeting discussion or minutes, or other communication as approval for a Change.

2.4 Change Orders

When the adjustments, if any, to the Contract Price or the time for the performance of the Work or both with respect to a Change are agreed by BC Hydro and the Contractor, Hydro's Representative will issue a written approval (a "**Change Order**") setting out:

(a) a description of the Work covered by the Change;

(b) the price or method of valuation for such Work;

(c) the total adjustment, if any, to the Contract Price (excluding only GST) on account of the Change and, for certainty, will be deemed to include all claims for compensation on account of all related costs, including all direct, indirect or "impact", overhead, and all other costs, and all mark-ups and profits, even if the Change Order does not specifically mention such items; and

(d) the net effect on the time for the performance of the Work on account of the Change and, for certainty, will be deemed to include all effects on the time for the performance of the Work, and if there is no mention in the Change Order of a required adjustment to the time for the performance of the Work, then the Change Order will be interpreted to mean that the Contractor will complete the performance of the Work covered by the Change Order without any adjustment to the time for the performance of the Work.

Hydro's Representative and the Contractor's Representative will sign the Change Order to confirm agreement and, upon receipt of a signed Change Order, the Contractor will proceed with the Change without delay.

2.5 Change Directives

Subject to Section 2.2 of this Schedule 12 [Changes] but notwithstanding any other provision of this Schedule, BC Hydro may at any time issue a written direction (a "**Change Directive**") to the Contractor, signed by Hydro's Representative, directing the Contractor to proceed with a Change as described in the Change Directive, and for certainty BC Hydro may issue a Change Directive:

(a) in the absence of a Preliminary Change Instruction;

(b) at any time following issuance of a Preliminary Change Instruction, if the Contractor fails to provide a Change Report;

(c) if a Change Report or Change Order is not promptly agreed upon by the parties; or

(d) if there is a Dispute in relation to a Preliminary Change Instruction, Change Report or Change Order.

Upon receipt of a Change Directive the Contractor will proceed with the Work, including the Change, without delay, without prejudice to the Contractor's and BC Hydro's rights to claim an adjustment to the Contract Price and the time for the performance of the Work or both as a result of the Change, and the following will apply:

(e) the valuation of the cost of the Change and impact on the Work Program and Schedule will be evaluated in the same manner as described in Section 5 of this Schedule 12 [Changes], calculated as soon as reasonably possible after the delivery of the Change Directive;

(f) pending a final determination as to any adjustments to the Contract Price or the time for the performance of the Work or both for the Change BC Hydro will make a monthly payment to the Contractor of amounts the Contractor substantiates that it incurred on account of the Change and that BC Hydro, acting reasonably, agrees are owing on account of the Change;

(g) if the parties reach agreement on adjustments to the Contract Price or the time for the performance of the Work or both for the Change BC Hydro will issue a signed Change Order confirming the valuation of the Change and the impact on the Work Program and Schedule; and

(h) if within 30 Business Days after the delivery of a Change Directive to the Contractor, or such other time as the parties acting reasonably may agree in writing, the parties have not reached agreement on a Change Order covering all Changes implemented by the Change Directive, then Hydro's Representative will deliver to the Contractor's Representative a draft Change Order acceptable to BC Hydro covering all Changes in the Change Directive, and if the Contractor does not agree to the draft Change Order within 10 Business Days of receipt by the Contractor, or such other time as the parties acting reasonably may agree in writing, then either party may refer the valuation of the cost of the Change and impact on the Work Program and Schedule to be settled in accordance with Schedule 14 [Dispute Resolution Procedure].

3 POTENTIAL CHANGES

3.1 Preliminary Change Instruction

BC Hydro may at any time issue to the Contractor a written instruction (a "**Preliminary Change Instruction**") describing a contemplated Change that BC Hydro is considering. A Preliminary Change Instruction will include sufficient description of the contemplated Change, including any requirements under Section 3.8(b) of this Schedule 12 [Changes], to permit the Contractor to prepare a Change Report.

3.2 Delivery of Change Report

Subject to Section 2.2 of this Schedule 12 [Changes], as soon as practicable and in any event, to the extent reasonably possible, within 15 Business Days after receipt of a Preliminary Change Instruction, or such other period as the parties may agree in writing acting reasonably, the Contractor will, at its cost, prepare and deliver to BC Hydro a Change Report, signed by the Contractor's Representative, for the contemplated Change described in the Preliminary Change Instruction.

3.3 Change Report Contents

A Change Report will include:

(a) a description of the scope of the contemplated Change;

(b) a comparison of the scope of Work as a result of the contemplated Change as compared to the scope prior to the Change;

(c) subject to the Contractor's duties under Section 29.2 of Schedule 2 [Design and Construction Protocols], a description of any adjustments to the Work Program and Schedule which the Contractor will require as a result of the implementation of the contemplated Change (including details of any corresponding adjustments required by any Subcontractor); and

(d) an estimate of all costs, if any, reasonably necessary for and directly associated with the contemplated Change, including the following (which will be shown separately if requested by Hydro's Representative), as applicable:

   (i) the cost of all Design, if any (based on the estimated number of hours reasonably required to perform any such Design);

   (ii) a breakdown of all labour, material and equipment costs (quotations from proposed Subcontractors are not required to be provided unless requested by Hydro's Representative and only if the Change is proposed to be on a time and materials basis);

   (iii) all additional costs of direct management of the Work, including supervision of trade foremen and Site overheads;

   (iv) all costs of Permits required on account of the Change, including any required new Permit(s) or amendment or renewal of an existing Permit(s);

   (v) all costs associated with services provided by third party professional advisors or subcontractors;

   (vi) an estimate of the cost savings, if any, resulting for any reason (including reduction in scope of Work or reduction in the time for the performance of the Work) from the contemplated Change;

   (vii) any proposal(s) as to how the contemplated Change could be accomplished at a lower or zero net cost;

   (viii) a description of the extent to which the contemplated Change would interfere with the Contractor's ability to comply with any of its obligations under the Contract, any Subcontracts and any Permits;

   (ix) the name of the Subcontractor(s) (if any) which the Contractor intends to engage for the purposes of implementing the contemplated Change together with a description of the qualifications of any such Subcontractor(s) so as to demonstrate the ability of such Subcontractor(s) to implement the contemplated Change;

   (x) a description of any further effects (including benefits and impairments) which, the Contractor foresees as being likely to result from the contemplated Change;

(xi) a description of any actions that would be reasonably required by BC Hydro to implement the contemplated Change; and

(xii) a description of the steps the Contractor will take to implement the contemplated Change, in such detail as is reasonable and appropriate in all the circumstances.

The cost or impact on the Work Program and Schedule of the correction of a Defect or Deficiency will not be included in the valuation of a Change.

All of the costs described in this Section 3.3 will be provided in the dollar amounts applicable as of the date of the Change Report. There will be no indexation of any cost amounts unless specifically agreed to by BC Hydro.

3.4 Change Report to Cover all Cost and Time

Any Change Report submitted by the Contractor will, except as expressly set out otherwise in the Change Report, be interpreted to represent the proposed total adjustment to the Contract Price (excluding only GST) and the net effect on the time for the performance of the Work on account of such contemplated Change, and, for certainty, will be deemed to include:

(a) all claims for compensation on account of all related costs, including all direct, indirect or “impact”, overhead, and all other costs, and all mark-ups and profits, even if the Change Report does not specifically mention such items; and

(b) all effects on the time for the performance of the Work, and if there is no mention in the Change Report of a required adjustment to the time for the performance of the Work, then the Change Report will be interpreted to mean that the Contractor will complete the performance of the Work as covered by the Change Report without any adjustment to the time for the performance of the Work.

3.5 Third Party Costs to Prepare Change Report

If the Contractor is unable to prepare a Change Report without the assistance of third party professional advisors or subcontractors, and if the Contractor wishes to be reimbursed for the costs of such third parties pursuant to Section 3.7 of this Schedule 12 [Changes], then the Contractor will only be entitled to make a claim for such costs if the Contractor obtains Hydro’s Representative’s prior written approval to retain such third parties.

3.6 Justification and Supporting Documentation for Contemplated Change Estimates

The cost estimates included in a Change Report will be in sufficient detail to allow evaluation by BC Hydro and will include such supporting information and justification as is necessary to demonstrate that:

(a) the Contractor has used all reasonable efforts, including utilizing competitive quotes or tenders, to minimize the cost of a contemplated Change and maximize potential related cost savings;

(b) the Contractor and Subcontractors have valued the Change as described in Section 5.1 of this Schedule 12 [Changes], and have not included margins or mark-ups not provided for in Section 5.2 of this Schedule 12 [Changes];

(c) the full amount of any and all expenditures that have been reduced or avoided have been fully taken into account; and

(d) the Contractor has mitigated or will mitigate, in accordance with Section 29.2 of Schedule 2 [Design and Construction Protocols], the impact of the contemplated Change, including on the Work Program and Schedule and the direct costs to be incurred.

3.7 Contractor's Costs to Prepare Change Report

If, following receipt of a Change Report:

(a) BC Hydro elects to proceed with the contemplated Change, then all costs incurred by the Contractor to prepare the Change Report will be paid by the Contractor, and the Change Order issued with respect to the contemplated Change will be deemed to be the entire compensation payable by BC Hydro for such Change; or

(b) BC Hydro, for any reason, elects not to proceed with a contemplated Change, then:

(i) if the Contractor retained third parties pursuant to Section 3.5 of this Schedule 12 [Changes], then BC Hydro will pay the Contractor for the reasonable and substantiated direct costs paid to all such third parties who were approved in advance by Hydro's Representative; and

(ii) the Contractor will bear all other costs incurred by the Contractor to prepare the Change Report.

3.8 Agreement on a Change

Following receipt by BC Hydro of a Change Report prepared in accordance with Section 3.3 of this Schedule 12 [Changes]:

(a) as soon as practicable, and in any event within 15 Business Days after BC Hydro receives a Change Report, or such longer period as the parties acting reasonably may agree in writing, BC Hydro will deliver to the Contractor any requests for clarifications or amendments, and on request from Hydro's Representative the parties' Representatives will meet without delay and use all reasonable efforts to reach agreement on the Change Report;

(b) if BC Hydro is required by applicable Law or Governmental Authority to require the Contractor to competitively tender any contract in relation to a contemplated Change, the Contractor will, to BC Hydro's satisfaction acting reasonably, obtain and evaluate competitive tenders for the proposed Change; and

(c) BC Hydro may in writing modify a Preliminary Change Instruction at any time prior to the parties reaching an agreement on the Change Report in which case the Contractor will, as soon as practicable and in any event not more than 10 Business Days after receipt of such modification (or such longer period as the parties acting reasonably may agree in writing), notify BC Hydro of any consequential changes to the Change Report.

If Hydro's Representative accepts the Change Report in response to a contemplated Change, or the parties otherwise agree to proceed with the contemplated Change on terms different from those in the Change Report, then the Change Report or such other agreed to terms will be recorded in a Change Order, signed by the parties and issued pursuant to Section 2.4 of this Schedule 12 [Changes].

3.9 Disagreement on Change Report

If the parties do not agree on a Change Report, then BC Hydro may:

(a) elect not to proceed with the Change described in the Preliminary Change Instruction; or

(b) issue a Change Directive with respect to some or all of the Change described in the Change Report.

4 CLAIM FOR A CHANGE

4.1 Claim for a Change

If the Contractor at any time wishes to claim that a Change has occurred, then:

(a) if the Contractor receives a direction, instruction or decision from Hydro's Representative for which a Change Order or Change Directive was not given, then the Contractor may only claim an adjustment to the Contract Price or an adjustment to the time for the performance of the Work or both as follows:

  (i) prior to proceeding with such direction, instruction or decision, the Contractor will give written notice to Hydro's Representative of its intention to make such a claim with sufficient detail to permit Hydro's Representative to be able to understand the basis for the claim as well as the anticipated impact on the Contract Price, if any, and the time for the performance of the Work, if any; and

  (ii) the Contractor will maintain daily records of the resources used in connection with the claimed Change, including labour, equipment and materials, prepared contemporaneously with the performance of the affected Work, and submit such records, together with the amount claimed for such affected Work, to Hydro's Representative on a rolling two business day basis;

(b) upon receipt of a notice under Section 4.1(a)(i) of this Schedule 12 [Changes] from the Contractor, Hydro's Representative will promptly investigate the conditions giving rise to the claimed Change;

(c) in no event will the Contractor be entitled to, nor will the Contractor make any claim for, an adjustment to the Contract Price or the time for the performance of the Work on account of any circumstance, condition or event that entitles the Contractor to make a claim under Section 4.1 of this Schedule:

  (i) that occurs more than seven days prior to the notice delivered by the Contractor to Hydro's Representative as provided by Section 4.1(a)(i) of this Schedule 12 [Changes]; or

  (ii) notwithstanding Section 4.1(c)(i) of this Schedule 12 [Changes], to the extent BC Hydro is materially prejudiced by any delay in the Contractor complying with its obligations under Section 4.1(a)(i) of this Schedule 12 [Changes]; and

(d) in no event will the Contractor be entitled to, nor will the Contractor make any claim for, an adjustment to the Contract Price on account of any circumstance, condition or event that entitles the Contractor to make a claim under Section 4.1 of this Schedule 12 [Changes] for which the Contractor has not kept, nor made available to Hydro's Representative, the records as required under Section 4.1(a)(ii) of this Schedule 12 [Changes].

If Hydro's Representative refuses the Contractor's request for a Change Order or Change Directive, then such refusal will be subject to settlement in accordance with Schedule 14 [Dispute Resolution Procedure].

5 VALUATION OF CHANGES

5.1 Valuation of Changes

The value and method of valuation of a Change will be determined by one or more of the following methods:

(a) as set out in a Change Report, if any, and accepted in writing by Hydro's Representative, in accordance with this Schedule;

(b) by a lump sum as agreed by the parties covering some or all of the Change;

(c) by unit prices as applicable to the Work covered by the Change; and

(d) to the extent not settled under one or more of Sections 5.1(a), 5.1(b) or 5.1(c) of this Schedule 12 [Changes], by the direct cost (or saving) of implementing the Change, calculated as follows:

   (i) with respect to labour, the total of:

      (A) the reasonable and substantiated wages and salaries, including payroll burden and statutory assessments, paid directly by the Contractor for labour directly and actively engaged in the performance of such Change, including a proper proportion of the time of Site supervisors directly supervising the performance of such Change; plus

      (B) the reasonable and substantiated food, lodging and additional transportation costs for labour and supervisory personnel directly and actively engaged in the performance of such Change, to the extent the Contractor actually pays such costs; plus

   (ii) with respect to materials, the total of the reasonable and substantiated direct costs of all materials reasonably and necessarily used by the Contractor for or incorporated into the Work on account of such Change, including extraordinary freight and shipping costs, if any; plus

   (iii) with respect to equipment (other than Small Tools) the total of the reasonable and substantiated rental charges for such equipment used directly in the performance of such Change, including equipment owned by the Contractor, at the rates established in the most recently published edition of the book entitled "Equipment Rental Rate Guide" and "The Blue Book" as published by the B.C. Road Builders & Heavy Construction Association on the date when such Change is performed, without mark-up. Such rates will be without an operator and the cost of the operator of such equipment may be included in the amount permitted for labour under Section 5.1(d)(i) of this Schedule 12 [Changes]; plus

   (iv) with respect to first tier Subcontractors performing some or all of such Change, BC Hydro will pay the amounts as determined under Sections 5.1(d)(i), 5.1(d)(ii) and 5.1(d)(iii) of this Schedule 12 [Changes] as incurred by such first tier Subcontractors;

   (v) the rates and charges applied will be no greater than the market rates and charges prevailing at the time of the implementation of the Change, paid between arms-length contracting parties;

(vi) unless otherwise agreed by BC Hydro in writing, the Contractor will obtain competitive quotations or tenders for all work, equipment and materials required to implement a Change; and

(vii) the rates and charges, of the Contractor or any Subcontractor, will be determined all without addition of any mark-ups for indirect costs, and the aggregate of mark-ups payable with respect to a Change will be limited to the mark-ups set out in Section 5.2 of this Schedule 12 [Changes].

The final evaluation of a Change will take account of any savings resulting from the Change and accordingly valuation of a Change will be the aggregate of the direct incremental costs minus the aggregate direct cost savings reasonably incurred or resulting from the implementation of the Change. For certainty a Change may have a net cost, or a net saving, or may result in no net cost or saving.

5.2 Mark-Up on Changes

Mark-up on direct costs relating to a Change valued under Section 5.1(d) of this Schedule 12 [Changes] will be payable only as follows:

(a) for the purposes of Section 5.2 of this Schedule 12 [Changes] a mark-up will be deemed to cover all indirect, head office, supervision and management, including without duplication, any costs related to the Contractor's, and any Subcontractors', management and oversight of the Work, Site management, supervision of trade foremen, Site overheads, and other costs and profit associated with the Change;

(b) if the aggregate of the direct incremental costs minus the aggregate direct cost savings of a Change is positive such that there is a net cost for the Change then, in addition to such aggregate net cost, BC Hydro will pay the Contractor a mark-up on such aggregate net cost of 15%; and

(c) if the aggregate of the direct incremental costs minus the aggregate direct cost savings of a Change is negative such that there is a net saving for the Change then the Contractor will pay BC Hydro such net saving without adjustment of such net saving on account of any mark-up.

5.3 Quantity Variation

If, for any reason, including an addition or deletion to the scope of the Work under Section 2 of this Schedule 12 [Changes], the actual quantity of a unit price item varies by more than plus or minus 20% from the estimated quantity for that unit price item as listed in the Contract Documents, or as otherwise agreed to pursuant to the Contract Documents, then either BC Hydro or the Contractor may, by written notice to the other party, request the other party to agree to a revised unit price, to take account of the variation in quantity and prevent either party from obtaining a windfall or suffering a loss as a result of the quantity variation. A party will make a request for a revised unit price as soon as reasonably practicable after it becomes aware of the quantity variation. Upon a request under this Section 5.3 the Contractor's Representative will deliver to Hydro's Representative all documentation reasonably required by Hydro's Representative to evaluate and substantiate the calculation of the applicable unit price(s).

5.4 Adjustments to Time for the Performance of the Work

Subject always to the Contractor's duties under Section 29.2 of Schedule 2 [Design and Construction Protocols], the time for the performance of the Work will be adjusted on account of a Change by the net amount of time reasonably required by the Contractor to accommodate and perform the Change, taking account of any impacts that require more time, and any impacts, that result in time savings, as follows:

(a) as set out in a Change Report, if any, and accepted by Hydro's Representative pursuant to Section 3.8 of this Schedule 12 [Changes];

(b) as otherwise agreed in writing by the parties; or

(c) in the absence of an agreement, in accordance with Schedule 14 [Dispute Resolution Procedure].

6 EMERGENCY

6.1 Emergency

Notwithstanding any other provision in the Contract, Hydro's Representative may, in the event of an emergency, issue oral orders to the Contractor for any Change required by reason of an emergency. The Contractor will proceed with such Change without delay, without prejudice to the Contractor's right to claim an adjustment to the Contract Price or the time for the performance of the Work or both. Hydro's Representative will confirm such orders in the form of a Change Order or Change Directive as soon as practicable.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 13

INSURANCE

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 13

INSURANCE

1 INTERPRETATION

1.1 Definitions

In this Schedule 13 [Insurance], definitions are as set out in Schedule 1 [Definitions and Interpretation].

2 CONTRACTOR PROVIDED INSURANCE COVERAGE

Without limiting any of the Contractor's obligations or liabilities under the Contract and prior to commencing performance of the Work under the Contract, the Contractor will, at its sole cost and expense, obtain and maintain during the performance of the Work policies in respect of the following insurances:

(a) Workers' Compensation coverage for all employees engaged in the performance of the Work in accordance with the *Workers Compensation Act* (British Columbia);

(b) Personal Optional Protection coverage available through the Workers' Compensation Board of British Columbia for all employees engaged in the performance of the Work who are not covered by the *Workers Compensation Act* (British Columbia);

(c) Commercial General Liability Insurance in an amount of [redacted] per occurrence, and annually in the aggregate with respect to Products and Completed Operations Liability. Such coverage to include, but not be limited to, Blanket Contractual Liability, including liability assumed under the Contract, Tortious Liability, Contractual Liability, Contractors Protective Liability, Non Owned Automobile Liability, Attached Equipment Cross Liability, Broad Form Property Damage Liability, Products and Completed Operations Liability, and, when applicable to the Work, Hook Liability, Sudden and Accidental Pollution Liability and Explosion, Collapse and Underground Damage Liability and Forest Fire Fighting Expense Liability, and, in any event, such Commercial General Liability Insurance will provide coverage not less than the insurance required by IBC Form 2100 or its equivalent replacement. The policy will name BC Hydro as additional insured in respect of liability arising out of the Contractor's operations or its employees outside of the Contractor's Work Area, and will contain cross liability and severability of interest clauses, or equivalent wording;

(d) Automobile Liability Insurance for owned, non-owned, leased, operated or licensed automobiles, trucks, trailers, tractors and all-terrain vehicles with limits of [redacted] for accidental injury to or death of one or more Persons or damage to or destruction of property as a result of one accident or occurrence;

(e) Contractor's Equipment / Property Insurance covering loss or damage to, or loss of use of, tools, property and equipment of the Contractor and its Subcontractors, if any, or for which the Contractor and its Subcontractors, if any, are legally liable or responsible, in an amount equal to the full replacement value of the tools, property and equipment (or on such other value basis as Hydro's Representative may approve). The policy will include a waiver of the insurer's rights of subrogation in favour of BC Hydro;

(f) Cargo / Marine Cargo Insurance covering all insurable risks of loss or damage to equipment, parts and materials that comprise or are intended to comprise the Work, including the Equipment. Such coverage to attach at the commencement of loading at the manufacturer's facility and be maintained throughout the course of transport, including while the insured property is in trans-shipment, customs or interim storage, until arrival at and completion of unloading at the Site. Such policy will be in an amount not less than the total replacement cost of the insured property, and the scope of coverage will be not less than that provided by the Institute Cargo Clauses ("All Risks") or equivalent, and will specifically include coverage for war, strikes, riots and civil commotions;

(g) if aircraft or watercraft or both are used in connection with the Work, then the Contractor will carry Aircraft Liability and Watercraft Liability Insurance, as applicable, covering all aircraft and watercraft owned or non-owned and licensed by the Contractor with limits of liability of [redacted] for aircraft liability and [redacted] for watercraft liability, for bodily injury or death of one or more Persons or damage to or destruction of property as a result of one accident or occurrence; and

(h) such additional coverage as may be required by Law or by BC Hydro, or which the Contractor considers necessary.

3 BC HYDRO PROVIDED INSURANCE COVERAGE

Prior to the commencement of the Work at the Site and until the date of issuance of the certificate of Substantial Completion or any other additional period of time as required by the Contract Documents, BC Hydro will obtain and maintain the following insurance coverage:

(a) Project specific “Wrap-up” liability insurance in an amount of not less than [redacted] per occurrence. This policy will have an aggregate limit of [redacted] with respect only to completed operations liability. This policy will also have sub-limits as described in Appendix 13-1 [Wrap-up Liability Insurance Specifications]. The policy will have a per occurrence deductible of up to [redacted]. The policy will name BC Hydro as the insured and will include Others, the Contractor and the Subcontractors, project and construction managers, architects, engineers, and consultants, if any, while engaged in the Work and providing work or services with respect to the Project as additional insured and will contain cross liability and severability of interest clauses, or equivalent wording. The policy will maintain in force and effect an “Extended Completed Operations Liability” endorsement coverage for a period ending not earlier than 24 months after the earlier of (i) the date of issuance of the certificate of Total Completion, and (ii) termination of the Contract. For the purposes of this Schedule 13 [Insurance] “Extended Completed Operations Liability” means what is typically referred to as “Completed Operations Liability” in the insurance industry. BC Hydro's construction wrap-up liability coverage will be primary and non-contributory to the Contractor's Commercial General Liability Insurance for Work at the Site; and

(b) Broad Form “Builder's Risk” insurance, on a replacement cost valuation basis, in an amount deemed appropriate by BC Hydro. The policy will have a per occurrence deductible as described in Appendix 13-2 [Course of Construction Insurance Specifications]. The policy will provide coverage on an “All Risks” basis, including perils of flood and earthquake, will name BC Hydro as the insured, and Others, the Contractor and the Subcontractors as additional insureds, including any person employed directly or indirectly by either or both the Contractor and Subcontractors to perform a part or parts of the Work and any other person employed directly or indirectly to perform work or services with respect to the Project. The policy will contain a waiver of insurer’s rights of subrogation in favour of the Contractor and the Subcontractors.

The documents attached at Appendix 13-1 [Wrap-Up Liability Insurance Specifications] and Appendix 13-2 [Course of Construction Insurance Specifications] contain terms and conditions applicable to the insurances that BC Hydro is required to obtain and maintain pursuant to this Section 3. In the event of a conflict between the terms and conditions contained in:

(c) Appendix 13-1 [Wrap-Up Liability Insurance Specifications] and the provisions of Section 3(a) of this Schedule 13 [Insurance]; and

(d) Appendix 13-2 [Course of Construction Insurance Specifications] and the provisions of Section 3(b) of this Schedule 13 [Insurance],

the terms and conditions of the applicable Appendix will govern.

4 GENERAL INSURANCE PROVISIONS

4.1 Requirements for Contractor Provided Insurance

The insurance provided by the Contractor will be provided in accordance with the following terms and conditions:

(a) the Contractor will provide Hydro's Representative with evidence of compliance with the *Workers Compensation Act* (British Columbia) and coverage under that Act prior to commencement of performance of the Work, and the Contractor will:

    (i) upon request, at any time, from Hydro's Representative, provide such evidence to Hydro's Representative within five days of such request; and

    (ii) immediately notify Hydro's Representative in writing of any change with respect to such compliance or coverage;

(b) certificates of insurance for the policies described in Section 2 of this Schedule 13 [Insurance] will be submitted to Hydro's Representative prior to commencement of performance of the Work;

(c) copies of insurance policies described in Section 2 of this Schedule 13 [Insurance] will be submitted to Hydro's Representative within 14 days upon written request by Hydro's Representative;

(d) all insurance provided by the Contractor will be considered primary, non-contributory and not excess to any insurance carried by BC Hydro, unless expressly stated otherwise in the Contract Documents;

(e) all policies of insurance to be obtained by the Contractor in accordance with this Contract will be issued by financially sound insurers acceptable to BC Hydro, acting reasonably, and, where required by statute, licensed to insure such risk in British Columbia;

(f) all insurance provided by the Contractor will contain endorsements confirming that the policy will not be cancelled, adversely reduced, adversely materially altered or adversely materially amended without the insurer(s) giving at least thirty (30) days prior written notice by registered mail to BC Hydro;

(g) all insurance provided by the Contractor will contain endorsements confirming that, in the event of cancellation for non-payment of premium, the insurer(s) will give at least fifteen (15) days prior written notice by registered mail to BC Hydro;

(h) all insurance, except for automobile liability insurance and workers compensation insurance, provided by the Contractor will:

    (i) include BC Hydro and its directors, officers, employees and agents as additional insureds (but this requirement will not apply to equipment insurance described in Section 2(e) of this Schedule 13 [Insurance]);

    (ii) contain a waiver of subrogation against BC Hydro and its directors, officers, employees and agents; and

(iii) contain a cross liability or severability of interest clause.

4.2 Minimum Amount No Limit on Recovery

All policy limits and types of insurance specified by the Contract to be obtained and maintained by the Contractor are the minimum policy limits and types of insurance that are to be provided. The Contractor will be solely responsible for determining whether the policy limits and types of insurance are adequate and for placing any excess insurance and any additional insurance which it considers necessary to protect and indemnify itself.

Subject to Section 23.1 of Schedule 2 [Design and Construction Protocols], the Contractor will be liable to BC Hydro for all Claims and Claim Costs excluded by, or in excess of the policy limits of, applicable insurance policies.

4.3 BC Hydro's Right to Maintain

If, at any time, any insurance required to be obtained and maintained by the Contractor under the Contract has its policy limits reduced by the applicable insurance provider or the Contractor, from the policy limits required by the Contract, or is no longer in force, then, without limiting BC Hydro's rights in respect of any default that arises as a result of such occurrence, BC Hydro may, at its option, obtain and maintain the applicable insurance or portion of such insurance. In such event, BC Hydro may withhold and set-off the cost of insurance premiums expended for such insurance from any payments due to the Contractor.

4.4 Subcontractor Insurance

Without duplication of insurance coverage provided by BC Hydro, the Contractor will require all first tier Subcontractors to enter into an agreement with the Contractor containing provisions in the same form as those found in Section 2 of this Schedule 13 [Insurance], as applicable to the Work being undertaken by such Subcontractors. The Contractor will provide to Hydro's Representative, upon request, certificates of insurance for the insurance policies the Contractor has obtained from such Subcontractors and a copy of the agreement entered into with such Subcontractors setting out the insurance requirements of such Subcontractors, without reference to commercial terms.

4.5 Deductibles

The Contractor will be responsible for the payment of all deductibles for the insurance policies described in this Schedule 13 [Insurance], except with respect to damage arising out of the negligent acts or omissions of BC Hydro or any Person for whom BC Hydro is in law responsible (other than the Contractor and those engaged by or through the Contractor, including Subcontractors), BC Hydro will pay the proportion of the deductible that represents the proportionate fault of BC Hydro for the loss which gave rise to the damage.

Deductibles for insurance policies required under Section 2 of this Schedule 13 [Insurance] will be no more than [redacted], except as otherwise agreed by BC Hydro in writing.

4.6 Liability of Contractor

Neither the providing of insurance by BC Hydro or the Contractor in accordance with the requirements of this Schedule 13 [Insurance], nor the insolvency, bankruptcy or the failure of any insurance company to pay any claim occurring will be held to relieve the Contractor from any other provisions of the Contract with respect to liability of the Contractor or otherwise.

4.7 Notice of Occurrence

Hydro’s Representative and the Contractor’s Representative will immediately notify, in writing, each other and the relevant insurer of any occurrence or incident likely to give rise to a claim under the policies or insurance coverage referred to in this Schedule 13 [Insurance] whether or not such occurrence or incident arises under the Contract, and of any other matter or thing in respect of which notice should be given by BC Hydro or the Contractor to the relevant insurers. In addition, both BC Hydro and the Contractor will give all such information and assistance as may be reasonably practicable in all the circumstances.

4.8 Claims Cooperation

With respect to any Claim against BC Hydro, whether insured or otherwise, the Contractor will cooperate with BC Hydro, BC Hydro’s insurers, claims adjusters and other representatives to mitigate any impact of any investigations relating to the Claim on BC Hydro’s operations, including the performance of the Work.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 13-1

WRAP-UP LIABILITY INSURANCE SPECIFICATIONS

(see attached)

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 13-2

COURSE OF CONSTRUCTION INSURANCE SPECIFICATIONS

(see attached)

Site C Clean Energy Project
Wrap-up Liability Insurance Specifications

Insured

British Columbia Hydro and Power Authority.

Additional Insured

As set out in Section 3(a) of Schedule 13 [Insurance].

Insured Project

The Site C Clean Energy Project.

Coverage

Comprehensive Wrap-Up General Liability, on occurrence and pay on behalf basis, covering property damage, personal injury and bodily injury arising out of the Insured Project.

Policy Term

As stipulated in Section 3 of Schedule 13 [Insurance]; plus 24 months Extended Completed Operations Coverage, starting at the date of Total Completion.

Limit of Liability

[redacted] each and every Occurrence

[redacted] aggregate with respect to the Completed Operations coverage

Principal Sub-limits

Tenant's Legal Liability	[redacted]
Forest Fire Fighting Expenses Aggregate	[redacted]
Damage to Hired Vehicles	[redacted]
Sudden and Accidental Pollution Aggregate	[redacted]
Employee Benefits Liability Aggregate	[redacted]

Territory

Worldwide including Canada and USA

Deductible

[redacted] per occurrence on property damage only

Principal Extensions

- Broad form Property Damage
- Premises & Operations Liability
- Products & Completed Operations liability
- Sudden & Accidental Pollution liability
- Cross Liability and Severability clause
- Blanket Contractual liability
- Contingent Employer's liability
- Incidental Malpractice liability
- Non-owned Automobile liability and use of attached machinery
- Legal liability for damage to hired Automobiles or non-owned auto
- Hazardous Operations (No XCU exclusion)
- Blanket Additional Insured
- Hoist / Elevator liability
- Blanket Tenant's Legal Liability
- Watercraft Liability
- Voluntary Medical payments
- Intentional Injury to protect persons or property
- Forest Fire Fighting Expenses

Principal Exclusions

- Occupational Disease and Workers Compensation
- Automobile, Aircraft or large Watercraft liability
- Intentional acts
- Broad form Property Damage
- Known Defects
- Lack of Performance
- Professional Services
- War
- Nuclear Liability
- Pollution, except Sudden & Accidental
- Fines & Penalties
- Asbestos
- Fungus

Cancellation

Non-cancellable policy except for non-payment of the premium

Currency

All amounts are in Canadian Dollars unless indicated otherwise

Jurisdiction

This insurance shall be governed and construed in all respects in accordance with the laws of the Province of British Columbia wherever applicable

Site C Clean Energy Project
Course of Construction Insurance Specifications

Insured

British Columbia Hydro and Power Authority

Additional Insured

As set out in Section 3(b) of Schedule 13 [Insurance].

Policy Term

The whole period of the Project as stipulated in Section 3 of Schedule 13 [Insurance], including up to 90 days Hot Testing and Commissioning (any one item).

Insured Project

The Site C Clean Energy Project.

Insured Property

Permanent works, materials (including those supplied free to the Project by or on behalf of the Principal, provided the value is included in the Contract Works Sum Insured), temporary works and all other property used for or in connection with the Project (provided the value is included in the Contract Works Sum Insured).

Limit of Insurance

[redacted] per occurrence

[redacted] in aggregate with respect only to loss caused by Earthquake and Flood

Principal Sub-limits

Extra & Expediting Expenses	[redacted]
Debris Removal	[redacted]
Consulting/Auditors' Fees	[redacted]
Fire Fighting Expenses	[redacted]
By-law & Regulations	[redacted]
Valuable Papers	[redacted]

Deductibles

5% of the value of damaged property for Earthquake, subject to a minimum deductible of [redacted]

[redacted] each and every occurrence with respect to all other losses

Principal Extensions (Sub-limits) & Conditions

- LEG 3/06 Defects Clause
- Inland Transit
- Removal of Debris
- Automatic Increase
- Loss of Drawings
- Expediting Expenses/Airfreight
- Fire Fighting Expenses
- Payment of Indemnity
- Reinstatement of the Sum Insured
- Public Authorities
- 72 Hour Loss Period
- Inland Transits, Offsite Storage and Temporary Removal
- Repeat Tests
- Completed Works
- Extra Expense
- Existing Property
- Fuels and Consumables
- Multiple Insureds' Clause
- Munitions of War
- Cessation of Work
- Non-Cancellation
- Loss Minimisation Clause
- Claims Preparation Costs

Principal Exclusions

- Automobiles, Watercraft or Aircraft
- Contractors' Equipment
- Ocean Marine Transit
- Penalties, Fines and Liquidated Damages
- Wear & Tear
- War
- Nuclear Contamination
- Mysterious Disappearance
- Pollution
- Machinery Breakdown except during Testing
- Terrorism

Cancellation

Non-cancellable policy except for non-payment of the premium

Currency

All amounts are in Canadian Dollars

Jurisdiction

This insurance shall be governed and construed in all respects in accordance with the laws of the Province of British Columbia wherever applicable

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 14

DISPUTE RESOLUTION PROCEDURE

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 14

DISPUTE RESOLUTION PROCEDURE

1 INTERPRETATION

1.1 Definitions

In this Schedule 14 [Dispute Resolution Procedure], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**BCICAC**" has the meaning set out in Section 2.11(a) of this Schedule 14 [Dispute Resolution Procedure];

"**Dispute**" means any disagreement, failure to agree or other dispute between BC Hydro and the Contractor arising out of or in connection with this Contract, including in respect of the interpretation, breach, performance, validity or termination of this Contract, whether in the law of contract or any other area of law;

"**Dispute Notice**" has the meaning set out in Section 2.2 of this Schedule 14 [Dispute Resolution Procedure];

"**Dispute Resolution Procedure**" has the meaning set out in Section 2.1 of this Schedule 14 [Dispute Resolution Procedure];

"**Referee**" has the meaning set out in Section 2.6 of this Schedule 14 [Dispute Resolution Procedure];

"**Referee Agreement**" has the meaning set out in Section 2.7(b) of this Schedule 14 [Dispute Resolution Procedure];

"**Referee Notice**" has the meaning set out in Section 2.6 of this Schedule 14 [Dispute Resolution Procedure];

"**Settlement Agreement**" has the meaning set out in Section 2.4 of this Schedule 14 [Dispute Resolution Procedure]; and

"**Settlement Meeting**" has the meaning set out in Section 2.4 of this Schedule 14 [Dispute Resolution Procedure].

2 DISPUTE RESOLUTION PROCEDURE

2.1 Dispute Resolution Procedure

Except as expressly provided otherwise in the Contract Documents, including in this Schedule 14 [Dispute Resolution Procedure], or unless both parties otherwise agree in writing, all Disputes will be resolved in accordance with the procedure set out in Section 2 of this Schedule 14 [Dispute Resolution Procedure] (the "**Dispute Resolution Procedure**"), and for certainty a party will not be entitled to adopt or enforce a procedure to settle a Dispute that varies from the Dispute Resolution Procedure without the express written consent of the other party.

2.2 Commencement of Dispute Resolution Procedure - Dispute Notice

The Dispute Resolution Procedure to settle a Dispute will be invoked and started by the delivery by either party of written notice to the other party (the "**Dispute Notice**") that at a minimum sets out the nature and extent of the Dispute and the remedy or relief sought. A Dispute Notice should include:

(a) a summary of the pertinent facts relating to the Dispute, and include supporting documentation, if any, as may be available;

(b) a statement of the remedy or relief (such as amount of payment or adjustment to the time for the performance of the Work) sought by the disputing party in settlement of the Dispute; and

(c) a summary of the applicable provisions of the Contract Documents relevant to the Dispute, or other grounds on which the disputing party relies, as the basis of the Dispute.

2.3 Reply

Upon receipt of a Dispute Notice, the receiving party may, at its election, deliver a written reply to the disputing party setting out the receiving party's counter-arguments with respect to the Dispute, but for certainty a written reply to a Dispute Notice is not a requirement of the Dispute Resolution Procedure.

2.4 Settlement Meeting

Within 20 days after receipt of the Dispute Notice by the receiving party, or such other time as the parties may agree in writing, the Dispute will, if not already settled by a written agreement signed by both parties (the "**Settlement Agreement**"), be referred to a senior representative(s) of each of the parties who, to the extent reasonably practicable, have not been previously involved in the events leading to the Dispute for a settlement meeting (a "**Settlement Meeting**") to occur within such 20 day period. Representatives of the parties will make good faith efforts to resolve the Dispute by without prejudice negotiations.

2.5 Additional Settlement Meetings

If a Dispute is not settled by a Settlement Agreement after an initial Settlement Meeting held in accordance with Section 2.4 of this Schedule 14 [Dispute Resolution Procedure], then, without extending the time limit set out in Section 2.10 of this Schedule 14 [Dispute Resolution Procedure], BC Hydro may, in its sole discretion, direct in writing that an additional Settlement Meeting or Settlement Meetings be convened at which BC Hydro will be represented by a new representative(s). The Contractor will use reasonable commercial efforts to attend and participate in any additional Settlement Meetings as directed by BC Hydro under this Section 2.5.

BC Hydro will give consideration to a request from the Contractor for an additional Settlement Meeting or Settlement Meetings and for specific BC Hydro representatives to be in attendance at such Settlement Meetings, but BC Hydro will not be obligated to agree to attend an additional Settlement Meeting or Settlement Meetings requested by the Contractor nor to bring the BC Hydro representative as may be requested by the Contractor.

2.6 Referee Notice

If the Dispute is not settled by a Settlement Agreement within the earlier of:

(a) 20 days following the initial Settlement Meeting held in accordance with Section 2.4 of this Schedule 14 [Dispute Resolution Procedure]; or

(b) 40 days after receipt of the Dispute Notice by the receiving party, then, unless both parties agree in writing to a time extension, either party may by notice to the other (a "**Referee Notice**"), request the appointment of a referee (a "**Referee**") as provided under the terms of Section 2.7 of this Schedule 14 [Dispute Resolution Procedure].

2.7 Appointment and Engagement of Referee

The Referee will be appointed and retained by the parties as follows:

(a) unless both parties otherwise agree, the parties will appoint a Referee as follows:

(i) within two Business Days of the delivery of a Referee Notice, each party will submit in writing to the other party, the names of no more than two candidates for Referee from the Site C Referee Panel listed on Appendix 14-1 [Site C Referee Panel] to this Schedule 14 [Dispute Resolution Procedure], each of whom:

(A) is independent of the parties;

(B) is immediately available to perform the role of Referee in respect of the Dispute at hand; and

(C) has not been previously involved with the Dispute;

(ii) if a party has an objection to a candidate, it will give written notice of such objection with reasons to the other party; and

(iii) if for any reason within three Business Days of the delivery of a Referee Notice, a Referee meeting the criteria set out in Section 2.7(a)(i) of this Schedule 14 [Dispute Resolution Procedure] has not been appointed, then either party may request the British Columbia International Commercial Arbitration Centre to promptly appoint the Referee; and

(b) no later than two Business Days after the Referee's appointment, the parties will enter into an agreement with the Referee generally in the form attached to this Schedule 14 [Dispute Resolution Procedure] as Appendix 14-2 [Referee Agreement] (the "**Referee Agreement**"). If a party fails or refuses to enter into the Referee Agreement without lawful excuse, that party will be deemed to have entered into and delivered the Referee Agreement to the other party and the Referee. The Referee's fees and expenses will be shared equally by BC Hydro and the Contractor. BC Hydro will pay the full amount of the Referee's fees and expenses on the day that such fees and expenses are due (including any advances on fees and expenses) in accordance with the Referee Agreement and the Contractor will reimburse BC Hydro for the Contractor's share of all such fees and expenses within five Business Days of receipt of a written demand from BC Hydro, failing which BC Hydro will be entitled to deduct the amount of the Contractor's share of the Referee's fees and expenses from amounts otherwise payable by BC Hydro to the Contractor under the Contract. If BC Hydro fails to pay the Referee, the Contractor will be entitled to pay the sums due to the Referee and to recover such sums from BC Hydro (including by setting off such sums against any amounts due by the Contractor to BC Hydro under the Contract).

2.8 Referee Procedure

The Referee will proceed as follows:

(a) the Referee will conduct an impartial review of the Dispute which is subject to a Dispute Notice in such manner, and according to a procedure, as the Referee may decide, including carrying out site inspections and interviews with any persons identified by the Referee. The parties will comply with all reasonable requests from the Referee for additional information, documents and access to personnel as the Referee may decide is required. Any submission or documentation in respect of the Dispute provided to the Referee by a party will also be provided to the other party;

(b) the Referee will not be required to conduct enquiries in the presence of representatives of either or both parties or to receive submissions from the parties. The Referee may invite submissions from only one party. The Referee may deliver a decision notwithstanding the failure or refusal of a party to cooperate with the Referee or participate in the proceedings as conducted by the Referee;

(c) the Referee may, with the written approval of both parties, retain other professional persons or experts to assist with the review, and will give reasonable consideration to a request by the parties that the Referee retain such other professional persons or experts;

(d) within 10 Business Days of the execution of the Referee Agreement by the Referee and both parties (or the deemed execution of the Referee Agreement as the case may be), or such longer period of time as both parties may agree in writing, acting reasonably, considering any recommendations by the Referee with respect to timing for the delivery of a decision, the Referee will render a brief, written, reasoned and impartial decision on the Dispute, with copies to both parties;

(e) each party acknowledges the value of having the Referee render a timely decision regarding the Dispute. If the Referee is unable to render his decision within the time period described in Section 2.8(d) of this Schedule 14 [Dispute Resolution Procedure], or as extended by the mutual agreement of the parties, then the Referee will within such time provide to the parties such analysis of the Dispute as the Referee is able to complete within that time, together with a description of the remaining work required to arrive at a reasoned decision;

(f) the proceedings under Section 2.8 of this Schedule 14 [Dispute Resolution Procedure], all information, data or documentation disclosed or delivered by either party to the other party under these proceedings, or to the Referee as a result or in connection with his duties as Referee, and the decision of the Referee (and any other information issued by the Referee), will be treated as strictly confidential, and not disclosed to any third party without the prior written consent of the parties, and the parties will jointly instruct the Referee to maintain the strictest confidentiality of the proceedings, evidence and his or her decision (and any analysis and description);

(g) neither party will be entitled to refer to, or enter into evidence, the decision of the Referee, or other information issued by the Referee, or any information that was prepared for the express purpose of submission to, or assistance of, the Referee, or to call on the Referee to provide any evidence, in any subsequent proceeding without the consent of the other party and the Referee; and

(h) nothing contained in Section 2.8 of this Schedule 14 [Dispute Resolution Procedure] will prevent the submission in any subsequent proceedings of any evidence related to the Dispute, provided that neither party will submit in any subsequent proceedings any evidence that came into existence for the express purpose of submission to, or the assistance of, the Referee.

2.9 Referee's Decision Binding But Not Final

The decision of the Referee on the Dispute will have effect as follows:

(a) subject to and without derogating from Section 3.4 of this Schedule 14 [Dispute Resolution Procedure], the decision will, when rendered and delivered to both parties, be immediately binding on both parties, and both parties will forthwith give effect to the decision, and the decision will remain binding unless and until altered or varied by a Settlement Agreement or by proceedings commenced in respect of the Dispute under Section 2.10 of this Schedule 14 [Dispute Resolution Procedure]; and

(b) if, within 30 days of receipt of the decision by both parties:

(i) the decision is not altered or varied by a Settlement Agreement; or

(ii) proceedings have not been commenced in respect of the Dispute under Section 2.10 of this Schedule 14 [Dispute Resolution Procedure],

then the decision will be final and may not be appealed by either party on any grounds.

2.10 Commencement of Proceedings Regarding the Dispute

If:

(a) the Referee's decision on the Dispute is not rendered within the time period described in Section 2.8(d) of this Schedule 14 [Dispute Resolution Procedure]; or

(b) within 90 days after receipt of the Dispute Notice by the receiving party:

(i) the Dispute is not completely settled by a Settlement Agreement; or

(ii) the Referee's decision on the Dispute is not final as described in Section 2.9(b) of this Schedule 14 [Dispute Resolution Procedure],

then upon written notice of either party delivered to the other party, the Dispute will be submitted to arbitration pursuant to Section 2.11 of this Schedule 14 [Dispute Resolution Procedure].

Without limiting Section 2.1 of this Schedule 14 [Dispute Resolution Procedure], in any such arbitration proceedings the scope of issues will not be limited strictly to the terms of the Dispute Notice, but may extend to include other matters in dispute that are related to the Dispute.

2.11 Arbitration

A Dispute submitted to arbitration will be conducted as follows:

(a) the parties will, within ten days of submission, mutually agree upon a single arbitrator who is available and not in a conflict of interest to act as arbitrator in the Dispute. Unless the parties agree otherwise, such arbitrator will be chosen from the panel list of arbitrators maintained by the British Columbia International Commercial Arbitration Centre (the "**BCICAC**");

(b) if the parties cannot agree on an arbitrator within such ten day period, then either party may apply to a judge of the Supreme Court of British Columbia to have a single arbitrator appointed;

(c) the arbitration will be conducted in accordance with the appropriate rules of the BCICAC, and in accordance with the *Arbitration Act* (British Columbia);

(d) the place of the arbitration will be Vancouver, British Columbia and will be conducted in English;

(e) the arbitrator will endeavour to convene a hearing within 90 days of being nominated, and to complete the arbitration and render an award within 150 days of such nomination. The arbitrator may, in his or her discretion, on application of either party or on the motion of the arbitrator, extend either or both of the time periods referred to in this Section 2.11(e), and such discretion may be exercised both before and after any such time period, or extended time period, has expired;

(f) the arbitrator will conduct the arbitration in a cost effective manner and on an expedited basis, having regard for the subject matter of the Dispute;

(g) subject to the arbitrator's ruling on costs:

(i) the cost of the arbitrator and other administrative costs of the arbitration will be shared equally between the parties; and

(ii) each party will bear its own costs incurred in participating in the arbitration;

(h) except as expressly set out otherwise in the Contract Documents, any award by the arbitrator will be final and binding upon the parties and may not be appealed by either party on any grounds;

(i) the award of the arbitrator may be filed in any court of competent jurisdiction, and may be enforced by either party as a final judgment of such court as permitted by Law in the jurisdiction in which enforcement is sought;

(j) the arbitration proceedings, evidence at the arbitration proceedings, and, subject to Section 2.11(i) of this Schedule 14 [Dispute Resolution Procedure], the award of the arbitrator, will be treated as strictly confidential, and not disclosed to any third party without the prior written consent of the parties, and the parties will jointly instruct the arbitrator to maintain the strictest confidentiality of the proceedings, evidence and his or her award;

(k) if a Dispute that is subject to arbitration under Section 2.11 of this Schedule 14 [Dispute Resolution Procedure] is pending concurrently with a related dispute(s) which is subject to separate arbitration(s), then the parties consent to the consolidation of all related arbitration proceedings before one arbitrator if such consolidation of proceedings is feasible. If a Dispute relating to Interface Work is subject to arbitration that is pending concurrently with arbitration proceedings of a Claim by an Interface Contractor relating to the same Interface Work then the parties will be deemed to have consented to the consolidation of proceedings. The Contractor will, upon request of BC Hydro, participate as a direct party in any arbitration arising in connection with this Contract or the Project, as if the Contractor were a direct party to the issue in dispute and as if the Contractor was subject to the relevant arbitration rules of procedure; and

(l) the Contractor will include provisions within its agreements with first tier Subcontractors, and require its first tier Subcontractors to include provisions in such first tier Subcontractor's agreements with other Subcontractors, a dispute resolution provision substantially similar to Section 2.11 of this Schedule 14 [Dispute Resolution Procedure]. The Contractor will cause (including specifying in applicable agreements) its first tier Subcontractors and other Subcontractors to participate, upon the request of BC Hydro, in any arbitration arising in connection with the Work or this Contract, as if the first tier Subcontractor or other Subcontractor were a direct party to the issue in dispute and as if the first tier Subcontractor or other Subcontractor was subject to the relevant arbitration rules of procedure.

3 GENERAL

3.1 Disclosure of Referee Decision and Arbitrator Award

Notwithstanding anything to the contrary in the Contract, the Contractor acknowledges and agrees that BC Hydro may disclose an award of a Referee or an arbitrator to any Governmental Authority which requires or requests the award. BC Hydro will use commercially reasonable efforts to cause such

Governmental Authority to maintain the confidentiality of such award, but does not guarantee that such Governmental Authority will agree to maintain the award in confidence.

3.2 Other Remedies

Nothing contained in this Schedule 14 [Dispute Resolution Procedure] will preclude a party from initiating a proceeding in a court of competent jurisdiction for the purpose of obtaining an emergency or provisional remedy to protect its rights as necessary in the circumstances, including obtaining temporary and preliminary injunctive relief and other orders, whether before or after the Dispute Resolution Procedure has been initiated by delivery of a Dispute Notice.

3.3 Strict Compliance with Time Limits

The parties acknowledge that timely resolution of Disputes is mutually beneficial and the time limits set out in this Schedule 14 [Dispute Resolution Procedure], or as otherwise agreed by the parties, will therefore be strictly complied with and enforced.

3.4 Interim Direction

Notwithstanding a Dispute, or the commencement of a Dispute Resolution Procedure, BC Hydro and the Contractor will in good faith carry out their respective obligations under the Contract without delay concurrently with a Dispute Resolution Procedure or other process or steps as agreed to settle the Dispute. Prior to the final resolution of the Dispute, BC Hydro may in its discretion by written notice to the Contractor direct the Contractor to proceed with the Work in respect of the matter in Dispute and the Contractor will comply with and implement such direction without delay. If a binding determination is made in respect of such Dispute to the effect that BC Hydro's direction, in whole or in part, required the Contractor to do anything that was otherwise beyond the Contractor's obligations under this Contract then the direction, to the extent it changed the Contractor's obligations under this Contract, will be deemed to be a Change pursuant to Schedule 12 [Changes]. Nothing in this Schedule 14 [Dispute Resolution Procedure] will limit BC Hydro's right to require a Change. For certainty, BC Hydro will not be entitled to give a direction to require the Contractor to do anything that constitutes a Change which is not permitted in accordance with Section 2.2(a) to Section 2.2(f) of Schedule 12 [Changes].

3.5 Dentons

The Contractor expressly consents to Dentons representing BC Hydro for all matters in relation to this Contract and the Project, including any matter that is adverse to the Contractor, despite any information of the Contractor that may have been disclosed to Dentons or BC Hydro and any solicitor-client relationship that the Contractor may have had, or may have, with Dentons in relation to matters other than this Contract or the Project.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 14-1

SITE C REFEREE PANEL

[None as of the Effective Date.]

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 14-2

REFEREE AGREEMENT

AMONG:

[Name and address of Referee] (the "**Referee**")

AND:

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY, 333 Dunsmuir Street, Vancouver, British Columbia, V6B 5R3 ("**BC Hydro**")

AND:

[Name and address of Contractor] (the "**Contractor**")

We write to confirm your appointment as a Referee under the Supply and Installation of Turbines and Generators Agreement dated ▼ between BC Hydro and the Contractor (the "**Turbines and Generators Agreement**"). The terms of your appointment are as contained in Section 2 of Schedule 14 [Dispute Resolution Procedure] to the Turbines and Generator Agreement.

We confirm our agreement for you to review the Dispute(s) described in the Dispute Notice in accordance with the provisions of the Turbines and Generator Agreement, and to perform the functions of a Referee as described in Section 2 of Schedule 14 [Dispute Resolution Procedure] to the Turbines and Generator Agreement. A copy of the Turbines and Generator Agreement and related materials will be forwarded to you shortly.

BC Hydro and the Contractor agree, jointly and severally, to release and save you harmless from any liability arising from your actions, made in good faith, in carrying out your duties as described in Schedule 14 [Dispute Resolution Procedure] to the Turbines and Generator Agreement or as may be described in this letter.

We confirm that your daily/hourly rate for fees is $_______________. In addition to your invoiced fees, BC Hydro will pay any and all reasonable disbursements incurred in providing your services.

Please submit your invoices on a monthly basis directly to ________________ **[Insert name of BC Hydro's Representative]** ("**Hydro's Representative**"). BC Hydro will make payment within 30 calendar days of receipt.

[Signature page to the Referee Agreement follows]

Please confirm your agreement to the terms as set out in this letter by signing a copy of the enclosed letter and returning it to Hydro's Representative.

Yours truly,

______________________________	______________________________
Authorized Signatory of BC Hydro	Date
______________________________	______________________________
Authorized Signatory of the Contractor	Date
______________________________	______________________________
Referee	Date

[Signature page to the Referee Agreement]

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 15

RECORDS

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 15

RECORDS

1 GENERAL REQUIREMENTS

1.1 Retention of Records

The Contractor will retain and maintain all the records and reports (including superseded records and reports) referred to in Section 2 of this Schedule 15 [Records] as follows:

(a) in accordance with the Contract Documents, including Schedule 2 [Design and Construction Protocols], Schedule 5 [Submittals Procedure], Schedule 7 [Environmental Obligations], Schedule 8 [Quality Management], Schedule 10 [Safety] and this Schedule 15 [Records];

(b) in an accurate, complete, legible, readily identifiable, readily retrievable and organized manner, complete with computer generated and searchable meta-data;

(c) in a form that is capable of audit;

(d) in accordance with the requirements of Good Industry Practice, including APEGBC standards, and all applicable Laws;

(e) in accordance with the Contractor's normal business practices to which BC Hydro has no objection;

(f) in accordance with International Financial Reporting Standards, as applicable; and

(g) in sufficient detail, in appropriate categories, consistent with the record classification requirements described in Appendix 15-1 [Record Classification Requirements], and generally in such a manner to enable each party to comply with its obligations and exercise its rights under this Contract.

1.2 Destruction of Records and Delivery to BC Hydro

Prior to destroying or disposing of any records or reports required to be maintained under Section 2 of this Schedule 15 [Records], the Contractor will give BC Hydro not less than 60 days' notice of the Contractor's intention to destroy or dispose of records or reports, together with details of the records or reports to be destroyed or disposed of. If within such 60-day period BC Hydro gives notice to the Contractor that BC Hydro wishes to receive any of the records or reports, then the Contractor will, at its own cost and expense, deliver up such records or reports to BC Hydro in the manner and at the location or locations as BC Hydro specifies, acting reasonably.

If, from time-to-time, BC Hydro agrees to accept the long term retention of certain records or reports using electronic storage media (which must include secure back up facilities), the Contractor will make or supply, or have made or supplied, drawings and other documents in such agreed upon form.

2 NATURE OF RECORDS

2.1 Required Records and Retention Periods

Subject to, and without limiting, the requirements of the Contract Documents, the Contractor will retain, and will, where necessary, obtain from its Subcontractors and retain, the following:

(a) the Contract Documents, agreements with Subcontractors, including all amendments to such agreements for a period of ten years after termination of the Contract;

(b) the “Record” drawings, plans, records and other Work documentation described in Schedule 2 [Design and Constructions Protocols] and Schedule 6 [Specifications and Drawings] for a period of ten years after termination of the Contract;

(c) all documents relating to all Permits, including applications, refusals and appeals, for a period of ten years after the expiry date of the relevant Permit;

(d) all electronically and manually recorded information, notices, reports (including test reports, results and certificates) and other documents relating to the Work, the Site and any other such documents described in Schedule 2 [Design and Construction Protocols] or in Schedule 6 [Specifications and Drawings], for a period of ten years after termination of the Contract;

(e) all records relating to any inspections of the Work conducted under applicable Laws or by or for any Governmental Authority, for a period of ten years after the termination of the Contract;

(f) all orders or other requirements issued to the Contractor by any Governmental Authority for a period of ten years after such order or requirement has been satisfied by the Contractor;

(g) all electronically or manually recorded reports and information related to quality management and other records described in Schedule 8 [Quality Management] for a period of ten years after creation;

(h) all electronically or manually recorded reports and information related to safety and security management, including the date and time of any incidents and any other records described in Schedule 10 [Safety], for a period of ten years after creation of such reports and information;

(i) all electronically or manually recorded reports and information related to environmental protection, including the date and time of any environmental incidents and any other records described in Schedule 7 [Environmental Obligations], for a period of twenty years after creation;

(j) all electronically or manually recorded reports and information related to environmental management, including the date and time of any environmental incidents and any other records described in Schedule 7 [Environmental Obligations], for a period of 20 years after each such event;

(k) all electronically or manually recorded information and documents related to external relations, including public, stakeholder, government agency and first nations, for a period of ten years after termination of the Contract;

(l) all electronically or manually recorded reports and information related to environmental remediation and waste disposal, including the date and time of any incidents, for a period of 20 years after creation of such reports and information;

(m) invoices and payments, including relevant calculations, for a period of ten years after the end of the fiscal year within which they were created;

(n) all documents relating to events of Force Majeure and the consequences of such events for a period of ten years after the relevant event occurred, or in the case of a matter in Dispute, for a period of ten years after a determination has been made with respect to such Dispute;

(o) all notices delivered to or received from Hydro's Representative for a period of ten years after receipt;

(p) all documents relating to a referral to the Dispute Resolution Procedure for a period of ten years after a determination has been made with respect to such referral;

(q) all documents submitted in connection with any Change, for a period of ten years after creation of such documents;

(r) all records required by Law (including in relation to health, safety, environmental and waste management matters) to be maintained by the Contractor with respect to the Work, for a period of ten years after creation of such records, or such other retention period determined by Law, whichever is longer;

(s) all documents relating to insurance and insurance claims for a period of ten years after the relevant claim is settled;

(t) records of all internal and external meetings, including any minutes, presentation materials and other documents produced for, or in respect of, such meetings, for a period of ten years after termination of the Contract;

(u) all other records, notices or certificates required to be produced or maintained by the Contractor pursuant to the express terms of the Contract, for a period of ten years after termination of the Contract; and

(v) with respect to all other records, documents, reports and drawings, of any kind whatsoever for which there is no specified retention period set out in the Contract Documents, not less than ten years from the date of creation.

3 RIGHT OF ACCESS TO RECORDS AND AUDITS

BC Hydro and its employees, agents and other representatives may at any time, at BC Hydro’s expense, conduct an audit, examination or investigation of all the records and reports (including superseded records and reports) referred to in this Schedule 15 [Records], with the exception of the information specifically described under Sections 20.3(a), (b) and (c) of Schedule 2 [Design and Construction Protocols], and the Contractor will make available its facilities, records and reports and provide reasonable assistance, including providing copies, in the conduct of, and without limiting Schedule 12 [Changes] implement any recommendations from BC Hydro arising from, the audit, examination or investigation.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

APPENDIX 15-1

RECORD CLASSIFICATION REQUIREMENTS

For record and report retention purposes, the Contractor will classify and assign the applicable record retention class or classes, as described in the following table, to each record and report referred to in Section 2.1 of this Schedule 15 [Records].

Record Retention Class	**Description**
TG-001	Contract Documents, agreements with Subcontractors, including all amendments to such agreements
TG-002	Drawings, plans, records and other Work documentation
TG-003	Permits, including applications, refusals and appeals
TG-004	Notices, reports (including test reports, results and certificates) and other documents relating to the Work
TG-005	Records relating to any inspections
TG-006	Orders or other requirements issued to the Contractor by any Governmental Authority
TG-007	Reports and information related to quality management
TG-008	Reports and information related to safety and security management including incidents and events
TG-009	Reports and information related to environmental protection including incidents and events
TG-010	Reports and information related to environmental management including incidents and events
TG-011	Documents related to external relations, including public, stakeholder, government agency and first nations
TG-012	Information related to environmental remediation and waste disposal,
TG-013	Invoices and payments, including relevant calculations
TG-014	Documents relating to events of Force Majeure and the consequences of such events

Record Retention Class	Description
TG-015	Documents relating to events of Force Majeure and the consequences of such events in the case of a matter in Dispute
TG-016	Notices delivered to or received from Hydro's Representative
TG-017	Documents relating to a referral to the Dispute Resolution Procedure
TG-018	Documents submitted in connection with any Change
TG-019	Records required by Law to be maintained by the Contractor with respect to the Work
TG-020	Documents relating to insurance and insurance claims
TG-021	Records of all internal and external meetings, including any minutes, presentation materials and other documents produced for, or in respect of, such meetings
TG-022	All other records, notices or certificates required to be produced or maintained pursuant to the express terms of the contract
TG-023	All other records, documents, reports, drawings, of any kind whatsoever for which there is no specified retention period

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 16

ABORIGINAL INCLUSION AND REPORTING REQUIREMENTS

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 16

ABORIGINAL INCLUSION AND REPORTING REQUIREMENTS

1 INTERPRETATION

1.1 Definitions

In this Schedule 16 [Aboriginal Inclusion and Reporting Requirements], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Aboriginal**" means Indian (as defined in the *Indian Act* (Canada)), Metis or Inuit;

"**Aboriginal Business**" means:

(a) a sole proprietorship, wholly owned by an Aboriginal person;

(b) a corporation with at least 51% of the equity, including common or voting shares, directly owned by one or more Aboriginal Businesses or Aboriginal persons;

(c) a partnership or joint venture (between two or more Aboriginal Businesses or between one or more Aboriginal Business(es) and one or more non-Aboriginal Business(es)) with at least 51% of the ownership rights, including any voting rights, directly owned by one or more Aboriginal Businesses or Aboriginal persons; or

(d) any other business with a substantial amount of ownership rights held by one or more Aboriginal Businesses or Aboriginal persons, as determined by BC Hydro, acting reasonably;

"**Aboriginal Inclusion Performance Report**" has the meaning set out in Section 2.3 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements];

"**Aboriginal Inclusion Plan**" has the meaning set out in Section 2.2 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements]; and

"**Local Aboriginal Groups**" include:

(e) Blueberry River First Nations;

(f) Doig River First Nation;

(g) Halfway River First Nation;

(h) McLeod Lake Indian Band;

(i) Prophet River First Nation;

(j) Saulteau First Nations; and

(k) West Moberly First Nations.

2 COMMITMENTS

2.1 Commitments

The Contractor acknowledges that BC Hydro has commitments with respect to Aboriginal groups regarding business, employment and other opportunities relating to the Project, and that BC Hydro is looking to the Contractor to satisfy some of these commitments. Accordingly, the Contractor will use reasonable commercial efforts to achieve the following in the performance of the Work:

(a) provision of business opportunities for Aboriginal Businesses;

(b) provision of employment opportunities for Aboriginal persons; and

(c) provision of training opportunities for Aboriginal persons.

2.2 Aboriginal Inclusion Plan

The Contractor will prepare and sign a written plan (the "**Aboriginal Inclusion Plan**") that sets out the approach by which the commitments as described in Section 2.1 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements] for contracting of Aboriginal Businesses and the employment and training of Aboriginal persons can be achieved in the performance of the Work. The Aboriginal Inclusion Plan will, at a minimum:

(a) identify specific scopes of the Work which the Contractor and BC Hydro agree have reasonable potential to provide contracting of Aboriginal Businesses and the employment and training of Aboriginal persons in the performance of the Work; and

(b) identify targets (such as number of employees or dollar value of Work) for contracting with Aboriginal Businesses and employing and training targets for Aboriginal persons in the performance of the Work.

Prior to commencing any Work at the Site the Contractor will submit the Aboriginal Inclusion Plan to BC Hydro for Review.

The Contractor will update and sign the Aboriginal Inclusion Plan quarterly, after submission to BC Hydro for Review.

2.3 Reporting

The Contractor will prior to the 15th day of a calendar month prepare monthly a report (the "**Aboriginal Inclusion Performance Report**") of the actual following amounts as of the end of the previous calendar month:

(a) the number and value of contracts with Aboriginal Businesses relating to the performance of the Work that were awarded in the previous calendar month, and cumulative with respect to all Work performed to the end of the previous calendar month and, for each such contract:

  (i) the type of contract (e.g., "dam site perimeter security");

  (ii) the company to which the contract was awarded;

  (iii) the total value of the contract; and

(iv) the amount paid on the contract, as supported by invoices, as of the end of the previous calendar month and cumulative with respect to all Work performed under the contract to the end of the previous calendar month;

(b) the number of Aboriginal persons, and number of hours, employed in the performance of the Work in the previous calendar month, and cumulative with respect to all Work performed to the end of the previous calendar month; and

(c) the number of Aboriginal persons, and number of hours, who have received training, and the type of training received in the previous calendar month, and cumulative with respect to all Work performed to the end of the previous calendar month,

together with variances from the targets as set out in the Aboriginal Inclusion Plan, as may be updated under Section 2.2 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements]. All information in the Aboriginal Inclusion Performance Report will be separated to identify the specific Aboriginal groups, including Local Aboriginal Groups, that have been involved in the reporting period.

Without limiting any other requirement of this Section 2.3, the Contractor will, in preparing its Aboriginal Inclusion Performance Report, use the electronic form provided by BC Hydro, or such other form as Hydro's Representative may from time to time require.

2.4 Contractor Briefings

No less than once every three months the Contractor's senior Site management and BC Hydro's senior Site management will meet to discuss ways for the Contractor to achieve the commitments as set out in Section 2.1 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements], which collaboration will at a minimum include:

(a) a review of the existing skills and experience of identified Aboriginal Businesses who have expressed interest in contracting and Aboriginal persons who have expressed an interest in being employed in the performance of the Work or who potentially might be interested;

(b) a review of the Contractor's Work plan for the next 12 months to identify potential and practical contracting of Aboriginal Businesses and the employment and training of Aboriginal persons;

(c) a review and update of the Aboriginal Inclusion Plan as described in Section 2.2 of this Schedule 16 [Aboriginal Inclusion and Reporting Requirements]; and

(d) a review of the Aboriginal Inclusion Performance Report.

The Contractor will, as may be requested by BC Hydro, participate in committees that include Aboriginal group representatives established to monitor opportunities for Aboriginal Businesses and Aboriginal persons in the performance of the Work. The Contractor will also, at the request of BC Hydro, participate in meetings and workshops with Aboriginal groups and Aboriginal Businesses, to exchange information related to opportunities for Aboriginal persons and Aboriginal Businesses in the performance of the Work.

SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 17

PRIVACY PROTECTION

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SUPPLY AND INSTALLATION OF TURBINES AND GENERATORS CONTRACT

SCHEDULE 17

PRIVACY PROTECTION

1 INTERPRETATION

1.1 Definitions

In this Schedule 17 [Privacy Protection], in addition to the definitions set out in Schedule 1 [Definitions and Interpretation]:

"**Orders**" has the meaning set out in Section 4.1(d) of this Schedule 17 [Privacy Protection].

2 PURPOSE

2.1 Purpose

The purpose of this Schedule 17 [Privacy Protection] is to:

(a) enable BC Hydro to comply with its statutory obligations under FOIPPA with respect to Personal Information that is within BC Hydro's control and in the Contractor's custody; and

(b) assist the Contractor, as a service provider to BC Hydro, to comply with its statutory obligations under FOIPPA.

3 COLLECTION OF PERSONAL INFORMATION

3.1 Collection

Unless the Contract Documents otherwise specify or BC Hydro otherwise authorizes or directs in writing:

(a) the Contractor may only collect or create Personal Information that is necessary for the performance of the Contractor's obligations, or the exercise of the Contractor's rights, under the Contract;

(b) the Contractor must collect Personal Information directly from the individual the information is about or from another source other than that individual with the written consent of the individual, or the individuals lawful representative; and

(c) the Contractor must advise an individual from whom the Contractor collects Personal Information:

(i) the purpose for collecting it;

(ii) the legal authority for collecting it; and

(iii) the title, business address and business telephone number of the person designated by BC Hydro to answer questions concerning the Contractor's collection of Personal Information.

3.2 Accuracy of Personal Information

The Contractor must make every reasonable effort to ensure the accuracy and completeness of any Personal Information to be used by the Contractor or BC Hydro to make a decision that directly affects an individual the information is about.

3.3 Requests for Access to Personal Information

If the Contractor receives a request, from a person other than BC Hydro, for access to Personal Information, the Contractor must promptly advise the person to make the request to BC Hydro unless the Contract Documents expressly require the Contractor to provide such access, and, if BC Hydro has advised the Contractor of the name or title and contact information of an official of BC Hydro to whom such requests are to be made, the Contractor must also promptly provide that official's name or title and contact information to the person making the request.

3.4 Correction of Personal Information

(a) Within seven days of receiving a written direction from BC Hydro to correct or annotate any Personal Information, the Contractor must correct or annotate the information in accordance with the direction.

(b) When issuing a written direction under Section 3.4(a) of this Schedule 17 [Privacy Protection], BC Hydro must advise the Contractor of the date the correction request to which the direction relates was received by BC Hydro in order that the Contractor may comply with Section 3.4(c) of this Schedule 17 [Privacy Protection].

(c) Within seven days of correcting or annotating any Personal Information under Section 3.4(a) of this Schedule 17 [Privacy Protection], the Contractor must provide the corrected or annotated information to any party to whom, within one year prior to the date the correction request was made to BC Hydro, the Contractor disclosed the information being corrected or annotated.

(d) If the Contractor receives a request for correction of Personal Information from a person other than BC Hydro, the individual whose Personal Information has been requested, or that individual's lawful representative, the Contractor must promptly advise the person to make the request to BC Hydro and, if BC Hydro has advised the Contractor of the name or title and contact information of an official of BC Hydro to whom such requests are to be made, the Contractor must also promptly provide that official's name or title and contact information to the person making the request.

3.5 Protection of Personal Information

The Contractor must protect Personal Information by making reasonable security arrangements against such risks as unauthorized access, collection, use, disclosure or disposal, including any expressly set out in the Contract Documents.

3.6 Storage and Access to Personal Information

Unless BC Hydro otherwise authorizes or directs in writing, the Contractor must not store Personal Information outside Canada or permit access to Personal Information from outside Canada.

3.7 Retention of Personal Information

Unless the Contract Documents otherwise specify, the Contractor must retain Personal Information until authorized or directed by BC Hydro in writing to dispose of it or deliver it as specified in the authorization or direction.

3.8 Use of Personal Information

Unless BC Hydro otherwise authorizes or directs in writing, the Contractor may only use Personal Information if that use is for the performance of the Contractor's obligations, or the exercise of the Contractor's rights, under the Contract, and for clarity in accordance with Section 3.6 of this Schedule 17 [Privacy Protection].

3.9 Disclosure of Personal Information

The Contractor must not disclose Personal Information inside or outside Canada to any person other than BC Hydro unless the disclosure is to an entity that can legitimately compel disclosure under the laws of British Columbia or the disclosure is directed or authorized by BC Hydro or the disclosure is requested or authorized by the individual whose Personal Information is at issue or that individual's lawful representative. BC Hydro will not unreasonably withhold its authorization under this Section 3.9.

3.10 Inspection of Personal Information

In addition to any other rights of inspection BC Hydro may have under the Contract Documents or under statute, BC Hydro may, at any reasonable time and on reasonable notice to the Contractor, enter on the Contractor's premises to inspect any Personal Information in the possession of the Contractor or any of the Contractor's information management policies or practices relevant to its management of Personal Information or its compliance with this Schedule 17 [Privacy Protection] and the Contractor must permit, and provide reasonable assistance in respect to, any such inspection.

4 COMPLIANCE WITH THE ACT AND AUTHORIZATIONS

4.1 Service Provider

(a) The Contractor understands and acknowledges that it is a service provider of a public body as defined in FOIPPA.

(b) The Contractor acknowledges that it is familiar with the requirements of FOIPPA governing Personal Information that are applicable to it as a service provider.

(c) The Contractor must in relation to Personal Information comply with:

  (i) the requirements of FOIPPA applicable to the Contractor as a service provider, including any applicable order of the Information and Privacy Commissioner under FOIPPA; and

  (ii) any direction given by BC Hydro under this Schedule 17 [Privacy Protection].

(d) The Contractor expressly acknowledges and agrees that it is subject to the laws of British Columbia and Canada and is likely as such not subject to any orders, directives, rulings, requirements, judgments, injunctions, awards or decrees, decisions or other requirements for the disclosure of Personal Information issued by a Governmental Authority outside Canada ("**Orders**"). The Contractor will immediately inform BC Hydro if it receives any Orders or any other directives or requests or foreign demands for disclosure.

(e) The Contractor will immediately inform BC Hydro if it becomes subject to the laws or jurisdiction of the United States, which require the disclosure of Personal Information contrary to the provisions of this Schedule 17 [Privacy Protection], for any reason (whether or not there are any Orders for disclosure) and will inform BC Hydro of the circumstances giving rise to same.

4.2 Notice of Non-Compliance

If for any reason the Contractor does not comply, or anticipates that it will be unable to comply, with a provision in this Schedule 17 [Privacy Protection] in any respect, the Contractor must promptly notify BC Hydro of the particulars of the non-compliance or anticipated non-compliance and what steps it proposes to take to address, or prevent recurrence of, the non-compliance or anticipated non-compliance.

4.3 Interpretation

(a) Any reference to "the Contractor" in this Schedule 17 [Privacy Protection] includes any "associate" as defined in FOIPPA and the Contractor must ensure that all such persons comply with this Schedule 17 [Privacy Protection].

(b) The obligations of the Contractor in this Schedule 17 [Privacy Protection] will survive the termination of the Contract.

(c) If a provision of the Contract Documents (including any authorization or direction given by BC Hydro under this Schedule 17 [Privacy Protection]) conflicts with a requirement of FOIPPA or an applicable order of the Information and Privacy Commissioner under FOIPPA, the conflicting provision of the Contract Documents (or authorization or direction) will be inoperative to the extent of the conflict.

(d) The Contractor will comply with this Schedule 17 [Privacy Protection] notwithstanding any conflicting provisions of the Contract Documents or the law of any jurisdiction outside Canada.