1.1 **GENERAL**

1.2 **Coordination Requirements**
   .1 SFU Facilities

1.3 **Description**
   .1 SFU requirements for Unit Substation.

2.1 **MATERIAL AND DESIGN REQUIREMENTS**

2.2 **General Requirements**
   .1 The unit substation assembly shall be CSA approved 15 KV rated and be a completely unitized assembly of components as described in the next section.
   
   .2 Outdoor oil filled padmount unit substations may be acceptable to SFU but designs shall be applied on a case by case basis and only in coordination with SFU Facilities.
   
   .3 Switchgear located in sprinklered rooms, or rooms where the likelihood of water ingress could occur from above, shall have drip hoods installed on all cubicles. Openings for ventilation shall have suitable sprinkler protection. Where multiple cubicles are joined to form a single unit, individual drip hoods shall form a single continuous water barrier by means of factory provided upturned flanges or approved caulking methods.
   
   .4 Unit Substation Components shall consist of:
      .1 15 KV switchgear.
      .2 Main feeder and standby feeder cable entrance sections.
      .3 Drawout, 15KV vacuum circuit breakers and protection relay.
      .4 Cast coil transformer, (aluminum shall not be specified).
      .5 Unit substation ball connectors for grounding.
      .6 Metering.
      .7 Secondary Distribution (if applicable).

   .5 Characteristics of the unit substation shall be:
      .1 Primary voltage
         .1 12,480 volts.

      .2 Secondary voltage
         .1 277/480 volts.

   .6 Transformer KV Rating
      .1 KVA rating as required.
      .2 Fan cooling to provide 50% additional capacity.

   .7 High voltage equipment shall be rated.
      .1 3 phase 60 hertz.
      .2 95 KV BIL.
      .3 300 MVA interrupting capacity at 12.5 KV.

   .8 Primary service connections shall be nominal 3 phase 3 wire 12.5 KV.

   .9 Secondary voltage shall be 277/480 volts 3 phase, 4 wire.
.10 Maximum allowable Arc Flash Hazard/Risk Category within any part of the unit substation between primary cable entrances and main secondary bus shall not exceed level 2 (8 cal/cm²).

.11 All equipment shall be housed in factory assembled enclosed cubicles. Adjacent cubicles shall be separated by metal barriers.

.12 Where it is necessary to construct the components in separate enclosures these, when mounted and bolted together, shall present a unified appearance as to height, form and color.

.13 All exterior surfaces shall be free from projections. Cubicle construction shall be rigid with formed metal corner posts and with all metal edges returned.

.14 Access to all individual components must be readily obtainable. Doors shall be maximum 1200 mm wide with a minimum 90 degree opening. All panels on which relays, meters, or instruments are mounted shall have a barred compartment with hinged door. All hinges shall be concealed.

.15 Cubicles shall have heavy duty locks with common key or inter-lock.

.16 Access doors shall have two vault-type handles with padlocking feature or be secured with bolt(s) where required. This will allow easy infrared scanning.

.17 IR windows are to be specified.

.18 Interlocking shall be to Canadian Electrical Code and SFU Facilities requirement.

.19 Inside of cubicles shall be painted white or ASA 61 grey. Exterior shall be ASA 61 grey, two coats of high gloss enamel.

.20 All power connections shall be rigid bussing adequately supported for available fault currents. All equipment shall be wired at manufacturer’s plant and required field connections wired to accessible load terminals. Grounding ball studs shall be affixed to bus at each cable entrance compartment and on the high voltage common bus.

.21 All ground conductors including equipment ground shall be copper.

.22 A flat copper bonding strip of 0.50 sq. in. (1.3 sq. cm) minimum cross sectional area shall extend the length of the unit substation and be extended to all non-current carrying metal parts of the unit substation and the neutral grounding bus. Grounding ball studs shall be located for easy access during maintenance and shall be located within easy access of all door openings.

.23 All control fuses mounted in substation shall have downstream long life LED indicating lights, with nameplates, to indicate circuits are energized. Supply one set of spare fuses for all fuses locations.

.24 Provide wiring terminal box with terminal block for all outgoing control circuits and spare contacts. Terminal block shall be located where access is possible without de-energizing.

.25 Corrosion resistant approved warning signs shall be securely mounted on the outside of the unit substation cubicles.

.26 All operating control and indicating equipment shall be clearly labeled with laminoid labels.
Provide engraved brass nameplates for each section and general nameplates directed by Engineer.

.27 All high voltage vaults must have floor drains and containment curbs.

.28 Approved manufacturers of unit substations are as follows:
   1. Eaton.
   2. Electric Power Equipment.
   3. Schneider Electric.
   4. Unit Electrical Engineering (UEE).
   5. Prime Engineering.

2.3 Performance Standards

.1 Unit substation assembly installation shall comply with:
   1. CSA C22.2 No. 31, current edition and CSA labeled.
   2. BC Hydro “Requirements for Primary Substations Supplied at 12.0 KV and 25.0 KV”.
   4. BC Electrical Regulations and Bulletins.
   5. SFU Facilities Standards.

2.4 Submittals

.1 Shop drawings shall include:
   1. All major electrical equipment.
   2. High voltage switch.
   3. Unit substation
      1. High voltage breaker.
      2. 12 KV switchgear.
      3. Transformer cubicle.
      4. Protection and control.
   5. Co-ordination study and curves.
   7. High voltage cable.
   8. High voltage terminations.
  10. Distribution centre.
  11. Revenue metering.
  12. Seismic restraints.

.2 Submit the following test reports associated with the unit substation:
   1. Production Tests - manufacturer’s standard product test as requested in Section 26 08 00 Commissioning of Electrical Systems.
   2. Unit Substation Test - manufacturer’s factory test on supplied unit substation as specified in Section 26 08 00 Commissioning of Electrical Systems.
   3. Site Commissioning - test report on site commission as specified in Section 26 08 00 Commissioning of Electrical Systems.
   4. Factory Transformer Test Report – test report of no-load and load losses, winding resistance tests and impedance test. Refer to Section 26 12 00 Medium-Voltage Transformers, sentence 2.4.4, for required loss limits for various size transformers.

.3 Station Ground Resistance
.1 Submit ground resistance test as outlined in *Section 26 08 00 Commissioning of Electrical Systems*.

.4 Cable Testing
   .1 Submit conductor and cable test reports as outlined in *Section 26 05 05 High Voltage Cables 2.12 Testing*.

.5 Voltage Calibration
   .1 Submit voltage calibration report as outlined in *Section 26 08 00 Commissioning of Electrical Systems*.

.6 Seismic Certification
   .1 Submit certification of compliance with seismic requirements as specified in *Section 26 05 48 Vibration and Seismic Controls for Electrical Systems*.

.7 Final Inspection Certificate
   .1 Submit a copy of the final provincial electrical inspection certificate.

.8 Operating & Maintenance Manuals
   .1 Operating and maintenance manuals shall be submitted.

.9 Project Record Documents
   .1 Project record documents shall be submitted as specified and as per CCDC standards.

.10 Shop drawings shall be submitted for review prior to construction. Shop drawings shall be AutoCAD or PDF with minimum 600 dpi resolution. Hard copies shall be on AO (841 mm x 1189 mm) sized drawings. Supply digital files with Shop Drawing submittal.

.11 Refer to SFU Standard Details for reference details on shop drawing requirements.

.12 Before assembly of the unit substation, submit the following information in digital format:
   .1 Electrical one-line diagram.
   .2 Protective device co-ordination graph.
   .3 Layout plan with dimensions.
   .4 Reviewed and approved equipment cubicle drawing, including circuit breaker control wiring diagrams and key interlock scheme.
   .5 Shop drawing information.

### 2.5 Drawing Requirements

.1 AutoCAD Drawings Shall Include:
   .1 Equipment layout and overall dimensions.
   .2 Equipment specifications.
   .3 One line diagram.
   .4 Relating information including relay specs; time-current graphs; wiring diagrams, and tripping system.
   .5 Seismic support and restraints.
   .6 Metering information.
   .7 Terminal block wiring and labeling.
   .8 Labels.

.2 Electrical One-Line Diagram
   .1 The electrical one-line diagram shall show the connection of all the service entrance equipment. It shall contain the proposed service entrance relay settings.
.3 **Protective Device Co-ordination Graph**
   .1 A standard size 4 ½ x 5 cycle log-log graph shall be used for the co-ordination study. It is mandatory that the service entrance protective device setting be compatible and co-ordinate with SFU Facilities protective equipment. The manufacturer shall provide the required co-ordination study. Refer to **Section 26 05 04 Protective Device Coordination and Arc Flash Analysis**.

.4 **Equipment Drawing - Unit Substation**
   .1 The unit substation shop drawings shall be submitted for review prior to assembly.
   .2 The drawings shall show fully dimensioned equipment assembly details and the wiring diagram of the circuit breaker control scheme.

2.6 **Metering Requirements**
   .1 Metering shall be supplied at the project’s cost and installed by the manufacturer.
   .2 All substations’ meters are to be connected via MODBUS to SFU’s SCADA system. 48V DC power is required for this metering.

2.7 **Testing & Commissioning**
   .1 Factory tests shall be performed as specified in **Section 26 08 00 Commissioning of Electrical Systems**. Provide written report of test results prior to shipment of unit substation.
   .2 Provide written report of test results prior to energization of unit substation.
   .3 Unit substation, when fully assembled, shall be made available for inspection in the factory by the Engineer.
      .1 Unit substation to have factory test and site and commissioning as outlined in the Specification.

2.8 **Cubical Specifications**
   .1 **Cable Entrance and Withdrawable Breaker Cubicles**
      .1 Shall house incoming cable terminations with provision for stress cones and cable supports.
      .2 Shall include grounding ball studs on all buses.
      .3 Shall house Capacitive Voltage Transformers (CVT).
      .4 Shall house Current Transformers (CT).
      .5 Shall house electrically operated withdrawable vacuum circuit breakers.
      .6 Shall house electrical operating controls for breaker racking mechanism behind lockable door.
      .7 Shall house electrical operating controls for breaker open/close override behind lockable door.
      .8 Shall include IR viewing windows.
      .9 Doors shall have provisions for heavy duty padlock.
   .2 **Transformer Cubicle**
      .1 Shall house cast coil transformer. Aluminum transformers shall not be allowed.
      .2 Ventilation louvers and fan cooling shall provide adequate cooling and ventilation.
      .3 Access doors shall be interlocked with main breaker.
      .4 May house metering equipment if not located in secondary distribution.
      .5 Transformer mounting shall meet seismic requirements.
2.9 **Stress Cones**

.1 Stress cones shall be Raychem "Hot Shrink" or 3M "Cold Shrink" termination kit for 4/0 XLPE 25 KV rated.

2.10 **15kV Cable Entrance**

.1 All components with the 15kV cable entrance section shall be fully accessible after substation installation.

.2 The cable entrance section shall house the 15kV Current Transformers (CT) and Capacitive Voltage Transformers (CVT).

.3 Grounding ball studs shall be installed on all incoming feeder connections and shall be positioned to allow access after the equipment is installed.

.4 Cable support blocks shall be installed such that they do not interfere with cable terminations or cause undue mechanical stress to cable or connections. Supports blocks shall be constructed of electrically insulating material rated for the application. Support blocks shall utilize a clamping method to secure cables. Cable ties are not permitted.

2.11 **Primary Bussing**

.1 15 KV primary copper bussing, minimum 600 Amp capacity.

2.12 **15kV Withdrawable Circuit Breakers**

.1 15kV, 3 pole, 600 Amp group operated vacuum circuit breaker with magnetic actuator.

.2 Each vacuum interrupter shall be mounted in molded epoxy housing with a minimum pole spacing of 210 mm. Vacuum interrupters shall be designed and rated as “sealed for life”.

.3 The breaker shall be operated by an electrically operated magnetic actuator controlled by position sensors and by electronic module. The energy required for operation shall be provided by integrated capacitors capable of storing sufficient energy for a complete operating cycle: open – close – open.

.4 The breaker shall have local control buttons for open and close with an emergency mechanical opening operation and shall include a position indicator.

.5 Rated interrupting capacity shall be minimum 300 MVA and 16kA RMS symmetrical at 15kV. Rated current 630 Amps. Rated duty cycle: open - 0.3 sec. - close/open - 15 sec. - close/open.

.6 Number of operations at rated current = 30,000. Number of operations under short circuit = 100.

.7 Rated impulse withstand of 95 KV BIL.

.8 Breaker shall be type tested in accordance with ANSI Standard C57 and/or IEC 62271-100, CEI 17-1 file 1375.

.9 Breaker shall be withdrawable type via motorized operator and manual racking lever.

.10 Electric operators shall be 24 or 48V DC type compatible with unit substation control voltage and be powered directly from the DC Battery System.
The breaker shall have position sensors to prevent racking out while breaker is in the closed position.

The breaker shall have an integrated lockable hasp for the provision of personal lockout with mechanical and electric interlock to prevent the breaker from being able to be racked in.

The breaker shall be able to be fully racked in and out with the doors closed.

The breaker door shall be able to be closed after applying personal padlocks to the breaker.

All doors shall have provisions for padlocks.

A window shall be provided to permit viewing of the breaker in both the open, closed and racked out position.

Approved manufacturers are:

1. ABB
2. Eaton
3. Schneider Electric

2.13 15kV Breaker Trip

Tripping power shall be obtained from the DC battery system.

The operating voltage for breaker trip shall be either 24 or 48 V DC.

Auxiliary trip coils shall be DC operated and independent of availability of AC current.

In addition, provide a shunt trip for over temperature and ground fault trip. Power to be from the DC battery system. Provide LED lamps for monitoring of shunt trip.

Provide one set of NO and NC auxiliary contacts to indicate whether breaker is open or closed wired to a terminal block located in an outlet box at the top of the cubicle.

2.14 Relay Current Transformers and Zone of Protection

Current Transformers (CT) shall be installed within the switchgear to create a complete protection zone. The zone of protection shall include cable terminations for both incoming feeders, HV circuit breakers, main transformer and main secondary bus and distribution board.

Provide window style, 600V, relay accuracy C100 CT’s, ratio XX:5, in each 15kV cable entrance section. CT window shall be sized to allow for cable to pass through without interference to cable or its termination. CT’s shall be permanently and securely mounted in switchgear cable entrance section.

Provide window style, 600V, relay accuracy C100 CT’s, ratio XXX:5 in the low voltage section. Locate CT’s as close as possible to the secondary connections of the transformer to maximize the protection zone area. CT’s shall be permanently and securely mounted in switchgear.

The Arc Flash Hazard category within any area covered by the Zone of Protection shall not exceed level 2 (8 cal/cm^2).
2.15 Protection Relay

.1 Overcurrent and short circuit protection shall be provided by a single Schweitzer Engineering Laboratories (SEL) 700GT+ series relay.

.2 The SEL relay shall also provide protection for primary and secondary ground faults.

.3 Protection shall be of the circuit closing type with programmable current range from 0.1 to 96.0 amps.

.4 CT inputs shall be rated for 5 amp CT secondary.

.5 The SEL relay shall be powered directly from the DC Battery System.

.6 The SEL relay shall be surface mounted on the switchgear.

2.16 Capacitive Voltage Transformers

.1 Three (3) Capacitive Voltage Transformers (CVT) shall be installed in each 15kV cable entrance section.

.2 CVT’s shall be mounted on the line side of each 15kV breaker and used exclusively for the purposes of synchronization check only as required in 2.16.

.3 CVT’s shall have a voltage rating of at least 22kV to permit high potential cable testing.

2.17 12kV Feeder Synchronization Check

.1 Provide synchronization check to confirm correct phase relationship between both normal and alternate 12kV feeders.

.2 The synchronization check shall be incorporated into a single SEL 700G relay, as part of 2.14, and be capable of accepting the voltage outputs from the capacitive voltage transformers (CVT) for the purposes of synchronization comparison only.

.3 The device shall monitor each of the three phases of each feeder to ensure correct phase relationship.

.4 The device shall electrically lock out the operating controls for both 15kV breakers to prevent paralleling in the event of incorrect phasing.

.5 The device shall electrically lock out the operating control for any breaker attempting to close on a dead bus.

.6 The device shall illuminate a pilot light in the event of an “out of synch” condition.

.7 The device shall not interfere with the open operation of any breaker.

.8 The device shall be powered directly from the DC Battery System.

2.18 Breaker Remote Operation

.1 Both the normal and alternate breakers shall normally be operated remotely via control cabinet located in an area outside of the arc flash protection boundary.

.2 The control cabinet shall house a single operating switch to transfer from one feeder to the other.
.3 The control cabinet shall house operating controls to open and close individual 15kV breakers.

.4 The control cabinet shall house pilot lamps to indicate breaker position for both 15kV feeders.

.5 A time delay shall be incorporated of up to 15 seconds before the first action for the purposes of transferring between feeders or closing an individual breaker. This time delay will allow sufficient time for anyone that may still be within an arc flash protection zone to safely exit the area before the breakers operate. There shall be no time delay associated with opening an individual breaker.

.6 Control wiring between the unit substation and the control cabinet may be via individual control wires, fibre optic cables or a combination of both.

.7 All breaker operations shall be supplied from the DC Battery System.

.8 The control cabinet shall have a hinged cover with provision for a heavy duty padlock.

.9 The control cabinet controls shall look similar to that in SFU Standard Drawing E1-6.

2.19 Location of Auxiliary and Control Equipment

.1 All components used for protection and control shall be housed in a separately barriered compartment from any high voltage equipment. This also applies to all auxiliary components including terminals, relays and pilot lamps.

.2 Provide a 27mm conduit extending from the barriered control section of each feeder to a junction box on top of the substation equipment to allow for connection to external devices or monitoring equipment.

2.20 DC Battery System

.1 Provide 24 or 48 volt DC battery system complete with heavy duty charger. Batteries shall have sufficient storage capacity to fully operate the circuit breakers (open – close – open), pilot lights and protection and control system in the event of a power failure.

.2 Batteries shall store sufficient energy to ably maintain, monitor and control for up to 24 hours.

.3 The DC charger shall be fed directly from the substation at 120 volts.

.4 The DC charger shall have output relays with Form C dry contacts for the following conditions:
   .1 AC power loss
   .2 Charger failure
   .3 DC power loss

.5 The DC charger shall have an internal audible alarm that will annunciate during any of the above abnormal conditions.

.6 The DC Battery System may be located in a separately barriered section of the switchgear or stand-alone outside of the switchgear. The system shall be designed such that any component of the system can be readily and safely accessed without shutting down the substation.
2.21 Main Secondary Breaker

.1 A main secondary, 600 or 208 volt, is not preferred.

.2 In lieu of a secondary main breaker, provide current transformers (CT) to perform necessary overload, short circuit protection and Arc Flash Hazard Category reduction as outlined in Section 26 11 13 Primary Unit Substations, 2.1.8.

.3 A main secondary may only be provided for the purposes of derating downstream buses or as approved by SFU Facilities.

***END OF SECTION***