SECTION 34 21 25

DC SWITCHGEAR

PART 1 - GENERAL

1.01 SECTION INCLUDES

A. General requirements

B. Operating requirements

C. Ratings

D. Housing

E. Structure

F. Circuit breakers

G. Power buses and bus connections

H. Equipment protection

I. Instrumentation

J. 125 V dc control power

K. 120 V ac control power

L. Cable terminations

N. Negative enclosure

O. DC switchgear accessories

P. Factory testing

1.02 MEASUREMENT AND PAYMENT

A. Separate measurement and payment will not be made for work required under this Section. All costs in connection with the work specified herein will be considered to be included with the related item of work in the Bid Schedule of the Bid Form, or incidental to the Work of this Contract.

1.03 REFERENCES

A. American National Standards Institute (ANSI):

1. ANSI C37.16 Low Voltage Power Circuit Breakers and AC Circuit Protectors – Preferred Ratings, Related Requirements and Application Recommendations

B. Institute of Electrical and Electronics Engineers (IEEE):

1. IEEE C37.14 Standard for Low-Voltage DC Power Circuit breakers Used in Enclosures

2. IEEE C.37.20.1 Standard for Metal-Enclosed Low-Voltage Power Circuit Breaker Switchgear

3. IEEE C.37.23 Standard for Metal Enclosed Bus and Calculating Losses in Isolating Phase Bus

C. National Electrical Manufacturers Association (NEMA):

1. NEMA BU1 Busways

2. NEMA CC1 Power Connections

3. NEMA ICS1 General Standards for Industrial Controls and Systems

4. NEMA ICS2 Industrial Control Devices, Controllers and Assemblies

5. NEMA ICS6 Enclosures for Industrial Controls and Systems

6. NEMA SG3 Low Voltage Power Circuit Breakers

D. National Fire Protection Agency (NFPA):

1. NFPA 101 Life Safety Code

1.04 SUBMITTALS

A. General: Refer to Section 01 33 00, Submittal Procedures and Section 01 33 23, Shop Drawings, Product Data, and Samples for submittal requirements and procedures.

B. Submit the following:

1. Detailed design drawings

2. Product data.

1.05 QUALITY ASSURANCE AND SUPPLIER QUALIFICATIONS

A. Electrical components, devices, and accessories shall be listed and labeled in conformance with NFPA 70, Article 100. Electrical components, devices, and accessories shall comply with NECA's Standard of Installation.

B. The manufacturer of the dc switchgear assembly shall have a minimum of 5 years of successful and proven design and manufacturing experience in the transit industry, providing equipment similar to the one to be furnished under this Contract.

C. The 1200 V dc circuit breaker shall be a standard product of the respective manufacturer, and have at least 5 years of successful record of use in mass transit, or similar industrial applications.

1.06 DELIVERY, STORAGE AND HANDLING

A. Equipment shall be weatherproofed for shipment. Connection openings shall be closed to prevent entrance of foreign material during shipment and storage.

B. Equipment shall be handled and stored in conformance with manufacturer's instructions. One copy of these instructions shall be included with the equipment at time of shipment.

1.07 WARRANTY

A. A warranty for the dc switchgear components shall be provided and signed by the manufacturer and installer agreeing to correct system deficiencies and replace components that fail in materials or workmanship. The warranty shall be for the period between installation and the start of revenue service, and 2 years from the date of system in revenue service.

PART 2 - PRODUCTS

2.01 GENERAL

A. System Description: The dc switchgear shall be suitable for installation and operation installed in traction power substations and gap breaker stations to provide dc power distribution, selective fault protection and contact rail isolation capabilities, as follows:

1. In typical traction power substations with two transformer-rectifier units, a double-ended 1200 V dc switchgear assembly shall receive power from the two traction rectifiers, and distribute it to the contact rails through a sectionalizing scheme as indicated.

2. In gap breaker stations the dc switchgear shall be used to provide sectionalizing flexibility and selective contact rail system isolation capability, such as at crossovers and turnouts.

B. The dc switchgear shall be designed and fabricated in accordance with IEEE C37.14, ANSI C37.16, and IEEE C37.20.1.

C. The switchgear assemblies shall be of the metal-enclosed indoor type, and shall include circuit breakers, positive buses, bus connections, protective relaying, negative enclosure, and other equipment and devices as indicated.

2.02 OPERATING REQUIREMENTS

A. Dc circuit breakers shall be provided with both local and remote control and status monitoring.

B. Unless otherwise indicated, the dc circuit breakers shall be normally closed, supplying continuous power to the contact rails.

C. DC feeder breakers in traction power substations and gap breaker stations shall also be controlled by the emergency and transfer-tripping system (ETTS).

2.03 RATINGS

A. Unless otherwise indicated, the dc switchgear assemblies shall be in accordance with IEEE C37.20.1, and shall have the following minimum ratings:

1.	Rated Maximum Operating Voltage	1200 V dc
2.	Rated Main Bus Continuous Current	8000 A
3.	Rated Feeder Bus Continuous Current	4000 A

B. DC circuit breakers shall comply with ANSI C37.16 (Table 12) and IEEE C37.14, and shall have the following minimum ratings:

1.	Rated Breaker Continuous Current	As indicated
2.	Rated Control Voltage	125 V dc
3.	Short-Circuit Current Ratings	135 ka peak 80 ka steady state per ANSI C37.16
4.	DC withstand voltage, one minute	6.8 kV
5.	Rated Maximum Voltage	1200 V dc

2.04 HOUSING

A. The switchgear shall be indoor type conforming to the applicable sections of IEEE C37.20.1.

B. The switchgear assemblies shall be housed in a prefabricated modular dc switchgear house, specified in Section 34 21 05, Prefabricated AC and DC Equipment Houses.

2.05 STRUCTURE

A. The switchgear assemblies shall be of the metal-enclosed type, and shall form a line-up of freestanding cubicles. Each cubicle shall consist of compartments to house the circuit breakers, busbar, cables, relays and devices, as required. Each freestanding cubicle enclosure shall be insulated from adjacent cubicles with glastic insulation sheets, and provided with removable links so that under normal operation they are electrically connected. The connection shall be designed such that when enclosure GROUNDED or ALIVE condition is detected, the connecting links by their selective manual removal will allow isolation of the problem enclosure.

B. Each cubicle shall be of a rigid, self-supporting and self-contained electrically welded or bolted steel structure enclosing all sides and top, except openings for specific purposes. The structure shall support equipment under normal and short-circuit conditions.

C. All panels comprising the switchgear enclosure, including the doors, shall be constructed of sheet steel, of thickness not less than No. 11 gauge.

D. Compartments shall be isolated from one another by barriers of not less than No. 11 gauge sheet steel. All other covers, barriers, and panels shall be of sheet steel having thickness not less than No. 14 gauge.

E. Each cubicle shall have front-hinged doors with or without rear hinged doors. Front door mounted on the breaker assembly is acceptable, provided it meets all safety and specifications requirements. Rear hinged doors, if provided, shall have provisions for locking and shall be removable without tools. In addition, each compartment shall have a separate hinged door so that servicing one compartment will not expose circuits in adjacent compartments:

1. The doors shall support flush and semi-flush mounted devices and not distort from a plane surface in any position with all devices mounted. Doors shall be supported by means of concealed hinges, and structural reinforcing shall be used as needed to prevent sagging.

2. Each hinged door shall have a handle and a mechanical three-point vibration-proof latch for holding it in a closed position.

3. Each cubicle door shall be provided with a stop to hold the door in the open position, so that devices mounted on this door will not touch the devices mounted on adjacent doors.

4. Front door of each circuit breaker compartment shall interlock with the circuit breaker controls, so that door opening trips the breaker.

5. At the traction power substations, a key-interlock shall be provided between the main circuit breaker and the corresponding negative return disconnect switch in the rectifier, so that the disconnect switch can be operated only when the main breaker is in the disconnected position.

F. The circuit breaker compartment shall be designed so that the removable element (circuit breaker proper) may be drawn in and out of its housing on guide ways, and make connections to the positive bus and auxiliary circuits by means of self-aligning, self-

coupling primary and secondary disconnecting devices. Secondary disconnecting devices by means of plug connectors are acceptable provided each connector has a different pin arrangement. Cables used with the connectors shall be harnessed properly to prevent any damage due to the movement of the breaker assembly.

G. All breaker compartment surfaces, or portions thereof, exposed to arcs or ionized gases shall be lined with flame-resistant, insulating barrier material.

H. Bus compartments shall be of rigid framework and shall include, but not be limited to, positive bus work, splice plates, cable terminal connectors, and bus and cable supports.

I. For cleaning and inspection, removable cover plates with lifting handles for all bus compartment openings shall be furnished to provide access to the bus and cable connections with cables in place. Plates shall be less than 18 by 24 inches in size, have no sharp edges, and weigh less than 20 lbs each.

J. The switchgear enclosure, if required by test design, shall contain louvers as defined by ANSI C37.20.1 to provide ventilation and air-cooling of the components. If ventilation is required, intake openings shall be located not less than six inches above the floor where they do not allow entry of debris or dirt. Adequate provisions shall be made for release of gases from the breaker cubicles by stacks, chimneys, louvered vent openings, and shall be arranged in such a way that hot gases or other materials cannot be discharged in a manner hazardous to personnel, or detrimental to equipment.

K. All items requiring inspection and maintenance shall be accessible from the front or rear of the switchgear lineup, and be located at a level below 72 inches from the floor.

2.06 CIRCUIT BREAKERS

A. General:

1. The switchgear assemblies shall include air type dc circuit breakers.

2. The circuit breaker shall be metal-enclosed, single-pole, high-speed type rated as specified herein, and in accordance with IEEE C37.14 and ANSI C37.16. The main switching and interrupting element of the circuit breaker shall be of the removable type, mounted on a wheeled truck together with its operating mechanism, controls, and closing and tripping devices.

3. The circuit breaker control circuits and its operating mechanism shall be rated for power supply from a 125 V dc source.

4. The transient voltage surge introduced by the circuit breakers during interruption shall not exceed the one-minute dc withstand voltage rating of the switchgear.

5. The circuit breaker shall have a cold cathode arc chute for the main contacts, consisting of arc chambers and splitter plates for confining and extinguishing electrical arcs.

6. The circuit breaker shall be equipped with a blowout device or like-acting feature to help extinguish low-current arcs, as defined and tested in accordance with IEEE C37.14.

7. Contact surfaces of the moving and stationary contact members of the main contacts shall be silver, non-welding silver alloy or equivalent with the characteristics of high conductivity and necessary arc-resistant properties.

8. Removable circuit breaker elements of the same type and rating shall be physically and electrically interchangeable. Removable breaker elements not of the same type or ratings shall not be interchangeable.

B. Breaker Positions: The removable element of the circuit breaker shall have three positions inside the cubicle, referred to as CONNECTED, TEST, and DISCONNECTED positions. A fully interlocked, manually operated racking mechanism shall be furnished to move the mobile breaker assembly to and from the CONNECTED and TEST/DISCONNECTED positions:

1. In the CONNECTED position, both the primary and secondary disconnecting devices shall be in full contact.

2. In the TEST position, the primary disconnecting devices shall be open and separated by sufficient clearance to prevent arcing, with access to the stationary contacts blocked by safety shutters. The secondary disconnecting devices shall be in full contact, however.

3. In the DISCONNECTED position, both primary and secondary disconnecting devices shall be completely disconnected.

4. If an umbilical cord is used, there shall be interlocks to prevent removing the breaker from the cubicle while the secondary is connected.

5. The circuit breaker shall be held securely in place in the housing when the removable element is in the CONNECTED or TEST positions.

6. If the circuit breaker test position is considered, the disconnect position when the secondary connection is removed there must a interlock which will insure the secondary is connected prior to moving the breaker into the connected position.

C. Breaker Controls:

1. A test switch shall be provided on the front of each circuit breaker, which shall allow electrical closing with the breaker only in the TEST position, and electrical tripping with the breaker either in the TEST or CONNECTED position.

2. Manual local control of the breaker while in the CONNECTED position shall be from the control switch installed on the control and annunciator (C02) panel of the traction power facility.

3. Each breaker shall be provided with backup mechanical means for tripping the circuit breaker when in the TEST and CONNECTED positions. This function shall be available with the breaker's compartment door closed.

4. Remote control of all circuit breakers shall be provided through the SCADA system:

   a. Controls of all circuit breakers shall be designed so that the breaker can be:

      1) Tripped by remote command at all times, and

      2) Closed by remote command only when the LOCAL-REMOTE selector switch is in the REMOTE position.

   b. The interface between breaker controls and the SCADA system shall be at the interface terminal cabinet as indicated.

5. A minimum of eight electrically separate reversible auxiliary breaker contacts shall be provided as spares, in addition to those required for the circuit breaker control circuit.

6. All auxiliary breaker contacts shall be operated by the breaker mechanism in both the CONNECTED and TEST positions. All spare auxiliary contacts shall be wired to terminal blocks and properly labeled.

7. A closed circuit breaker shall remain closed and not trip in the event of a loss of the 125 V dc control power.

8. The circuit breaker shall be furnished with a minimum four-digit operation counter to record tripping operations, with no provisions for resetting the counter to zero.

D. Operating Mechanism:

1. Each circuit breaker shall be operated by means of either a solenoid (magnetic or electric), or a motor-operated, stored-energy mechanism; and shall have a latch for positive quick-make and quick-break operations with currents up to the short-time current rating of the breaker. The operating mechanism shall ensure full contact pressure until time of opening. The circuit breaker shall have mechanically held closed mechanism only and shall not open if 125V dc control power is removed.

2. Each circuit breaker shall have either a shunt-tripping device for tripping the breaker by an 125VOC electrical control signal.

3. All breakers shall be electrically and mechanically trip-free, and shall have control circuits connected in a manner to make the mechanism anti-pumping.

4. Means shall be provided to manually close the circuit breakers in the event of emergency or for testing purposes.

5. The circuit breakers shall be electrically operated in normal circumstances, using the 125 V dc control power system of the traction power facility. The operating mechanism shall successfully close the breaker over a voltage range of 100 to 140 V dc, and trip the breaker over a voltage range of 70 to 140 V dc.

6. Solenoid-type closing mechanisms, if used, shall be so connected that control voltage is removed from the closing coil after a preset time. In the event the breaker does not

close, or the control circuit is not opened, a trip sequence shall be initiated to open the closing control circuit and restore all closing sequence relays to their normal status.

E. Withdrawal Mechanism:

1. Each switchgear cubicle shall have a cranking device for moving the removable circuit breaker element to the CONNECTED, TEST, or DISCONNECTED positions with the door closed. If charging motor is used, a switch shall be provided to disconnect the charging motor circuit during cranking.

2. Guideways shall be provided to ensure proper alignment of the circuit breaker during insertion or withdrawal. Breaker insertion and withdrawal shall be effortless, and shall be within the capabilities of an average person.

3. The wheels of the breaker assembly shall be durable plastic or provided with rubber rims to prevent indenting or scratching the floor surface when the breaker assembly is withdrawn from the cubicle, or is moved around the substation house.

F. Electrical and Mechanical Interlocks: All circuit breakers shall be furnished at a minimum with the following electrical and mechanical interlocks.

1. Positive acting mechanical interlocks shall be provided on each unit to:

   a. Prevent a closed circuit breaker from being moved in or out of the CONNECTED position,

   b. Discharge the stored energy springs prior to circuit breaker removal, and

   c. Prevent a closed circuit breaker from being moved from the TEST to the CONNECTED position.

2. Positive stops shall be provided to prevent over-travel of the circuit breaker, when it is being moved into the CONNECTED or TEST positions.

3. A visual indicator shall be provided to show when the circuit breaker is in the TEST or in the CONNECTED position.

4. Electrical closing of the circuit breaker within the compartment shall be prevented except when the removable element is locked in place for the CONNECTED or TEST positions.

5. Interlocks shall be provided to prevent the circuit breaker from being racked into the CONNECTED position, if the front door of the cubicle is still open; and to prevent the door from being opened, if the circuit breaker is in the CONNECTED position.

6. An interlock shall be provided to prevent the circuit breaker from closing, if the springs are not fully charged.

G. Disconnecting Devices:

1. Each circuit breaker shall be equipped with primary and secondary disconnecting devices and associated contacts, to make or break the power and control circuits,

respectively, depending on the position of the breaker's removable element. The disconnecting devices shall be designed and mounted so as to maintain correct alignment between their stationary and moving parts during insertion and withdrawal of the removable breaker element.

2. Each circuit breaker's primary disconnecting devices shall comprise of heavy-duty self-aligning, silver-plated copper disconnect fingers that engage with the load-side stationary parts of the contacts. Access to the stationary part of the primary disconnecting devices shall be prevented when the circuit breaker is in the CONNECTED, TEST and DISCONNECTED positions. To achieve this, shutters shall be provided to automatically cover the stationary contacts when the breaker is withdrawn to the TEST or DISCONNECTED positions.

3. The secondary disconnecting devices shall have silver-plated copper contacts and shall be of a design that automatically or manually connects or disconnects the control circuits of the circuit breaker, when the latter is inserted into or removed from its compartment. The secondary disconnecting devices shall be without tendency of misalignment, and shall not be prone to warping or loss of contact pressure due to repeated withdrawals of the breaker from its cubicle or during accidental knocks during routine maintenance.

H. Breaker Status Indications:

1. OPEN and CLOSED status of the breakers shall be shown by green and red LED indication lights, respectively. The indication lights shall be mounted on the front door of the circuit breaker cubicle, and on the control and annunciator panel, as indicated.

2. The red 'BREAKER CLOSED' lights shall be connected so as to monitor the continuity of a shunt trip circuit.

3. An amber LED light shall be provided to indicate if the breaker is in the CONNECTED position. The amber light shall be located together with the red and green lights mounted on the front door of the breaker cubicle.

4. A mechanical status indicator, visible when the door is closed, shall be provided as a backup indication of the OPEN or CLOSED status of the circuit breaker.

5. A mechanical flag/position indicator shall be provided to show whether the circuit breaker is in the CONNECTED, TEST or DISCONNECTED position. The position indicator shall be visible when the circuit breaker compartment door is closed.

6. If a spring charging mechanism is utilized it shall be monitored with a white light on the front door panel, to indicate that the closing mechanism is charged. Additional auxiliary contacts shall be provided for possible future remote indication.

2.07 POWER BUSES AND BUS CONNECTIONS

A. Buses and bus connections shall be as specified in the applicable portions of Section 34 21 50, Common Materials and Methods for Traction Power.

B. The dc buses shall be made of bare copper and have sufficient cross section to carry the continuous rated current of the associated circuit breakers as specified, without exceeding the allowable temperature rise indicated in ANSI C37.20.1.

C. The buses shall be supported by non-tracking, non-hygroscopic insulators and insulated supports and bushings, of sufficient strength and bracing to withstand without damage or permanent distortion the forces produced by the rated short-circuit currents of the circuit breakers.

2.08 EQUIPMENT PROTECTION

A. Relaying, metering and indicating devices for the dc switchgear shall be provided as specified in Section 34 20 10, Emergency and Transfer Trip System (To be developed), Section 34 21 11, Multi-Function Protection Relay Equipment, Section 34 21 50, Common Materials and Methods for Traction Power, as specified herein, and as indicated.

B. Overcurrent Trip Device (Device 176): Each dc feeder circuit breaker shall be provided with a direct-acting, instantaneous forward overcurrent trip device. The trip device shall be adjustable between 100 and 400 percent of the circuit breaker continuous current rating, and shall be furnished with an auxiliary contact to initiate operation of the backup transfer trip circuit.

C. Multi-Function Protection Relay (MPR): DC feeder circuit breakers shall be equipped with electronic multi-function protection relays providing instantaneous overcurrent, rate-of-rise, timed overcurrent, and long term overcurrent protective functions, as specified in Section 34 21 11, Multi-Function Protection Relay Equipment.

D. Load Measuring and Automatic Re-Closing System: The MPR shall also provide load measuring and automatic breaker re-closing capability, designed to prevent feeder breakers from (re)closing on a short-circuit fault in the contact rail system. Features and logic sequence for the load-measuring and auto-reclosing system shall be as specified in Section 34 21 11, Multi-Function Protection Relay Equipment. The Contractor shall design, furnish and install all components of the load-measuring and auto-reclosing system, including hardware such as dc contactors, load-measuring resistors and wiring, as required to provide a complete and functional system.

E. Track Potential Detection (Dev 127): Each dc feeder circuit breaker shall be provided with an undervoltage detection (Dev 127), which shall be implemented as a function of the MPR. The undervoltage condition, used to indicate a de-energized contact rail section, shall be annunciated remotely from the MPR as indicated.

F. Directional Current Relay (Device 132): DC circuit breakers in gap breaker stations and main dc circuit breakers in traction power substations shall be provided with directional current relays. The input signal to the directional current relay shall be from an isolation transducer, which in turn shall be connected to a current shunt, as indicated:

1. For traction power substation or gap breaker station dc feeder breakers, the directional current relay shall be implemented as a function of the MPR. The directional current setting shall be settable to operate for faults on both line and load sides of the circuit breaker. Combined with the MPR overcurrent functions and circuit breaker trip release (Dev. 176) this relay shall be used to provide directional fault detection for initiating

the backup transfer trip circuit, as indicated. The directional current relay shall be adjustable between 25 and 100 percent of the circuit breaker continuous current rating.

2. In traction power substations, the dc main breaker directional current relay shall be used to detect short-circuits or positive bus to ground faults in the traction rectifier, and prevent back-feeding the fault from the contact rail system by tripping the main breaker upon detection of reverse current flow. The relay's current setting shall be as low as practically possible.

G. Enclosure Alive/Grounded Relaying (Device 164A/164G): The dc switchgear and rectifier cubicles shall be insulated from each other, and each shall be connected to the station ground through a high-resistance ground relay (Device 164A/164G) as indicated. The relay shall detect any part of the enclosure that may become grounded, or energized in the event of a fault between the enclosure and any of the current carrying components. Each relay shall be self-monitoring to ensure the integrity of its functions and shall be provided with a mechanical target to indicate alarmed and reset positions:

1. The Dev. 164 enclosure alive/grounded relay shall be provided with contacts to initiate local and remote alarms when the enclosure comes into contact with either ground or the negative side of the 1000 V dc system.

2. The Dev. 164 enclosure alive/grounded relay shall be provided with contacts to initiate local and remote alarms and tripping of the substation lockout relay when the positive side of the 1000 V dc system 125 V DC or 120 V AC control comes into contact with any part of the enclosure.

3. A local indication for structure GROUNDED or ALIVE shall be provided for each enclosure. The indication shall consist of colored indicating lights with mounting arrangement of the indicating lights to be submitted for approval. The indications shall be as follows:

   a. Amber light to indicate grounded structure.

   b. Red light to indicate alive or hot structure.

4. Test switches shall be provided to simulate GROUNDED and ALIVE conditions.

H. Emergency and Transfer Trip System (ETTS): The dc feeder circuit breakers shall be incorporated in an integrated emergency tripping and transfer tripping system based on fiber-optic communications between traction power facilities, as described in Section 34 20 10, Emergency and Transfer Trip System (To be developed), and as indicated.

2.09 INSTRUMENTATION

A. Instruments for measuring currents and voltages at the 1000-volt potential shall receive their inputs from isolating transducers, which shall be furnished and mounted within the bus compartment of the switchgear assemblies.

B. Proper insulation for meters and instruments shall be provided to assure safe operation for maintenance personnel. Wiring and terminal blocks in the dc switchgear that are exposed to the 1000 V dc potential shall have 2 kV insulation, and shall be equipped with warning signs

and tags. Wires with 2 kV insulation shall be as specified in Section 34 22 23, Traction Power Cables. All connections to 1000 V potential shall be fused.

C. Isolation transducers associated with MPR's shall be powered from the associated MPR controller, using any appropriate control voltage. The power supply to the isolation transducers operating on circuit breakers without MPR units shall be 125 V dc.

D. Instruments and isolation transducers shall be as specified in Section 34 21 50, Common Materials and Methods for Traction Power.

2.10 125 V DC CONTROL POWER

A. The 125-volt dc station battery system shall be used for all closing and tripping functions of the circuit breakers, and for energizing control and protection devices in the dc switchgear. The 125-volt dc battery system shall conform to the requirements of Section 34 21 40, DC Control Power Systems.

B. Control power cables supplying 125-volt dc power to the switchgear shall be No.10 AWG or larger, shall have minimum 600-volt rated insulation, shall be run in a protective raceway the full length of each switchgear assembly, and shall be tapped at each cubicle served via terminal blocks.

C. Two separate control power circuits shall be furnished in the dc switchgear assembly, one used for circuit breaker control and operation, the other for power supply to relays and transducers.

D. Control power circuits, including branches, shall be protected by molded-case, thermal-magnetic circuit breakers.

2.11 120 V AC CONTROL POWER

A. A 120 V ac, 60 Hz control power shall be supplied via No. 2 AWG or larger 2-wire cable with minimum 600-V insulation, for use by devices such as heaters, fans, lights, and receptacles.

B. The ac control power cable shall:

1. Extend for the full length of each switchgear assembly,

2. Be terminated on a terminal block for connection to an external power supply, and

3. Be tapped to the circuit breakers, protecting the circuits for heaters, fans, lights and receptacles. Lighting circuits shall be independent of other circuits.

2.12 CABLE TERMINATIONS

A. Provisions shall be made in the dc circuit breaker cubicles to accommodate the required number of 2.4 kV rated, 750 kcmil sized copper cables for each termination as indicated.

B. Ample space and contact surface shall be provided for pulling and terminating the cables.

C. Cable connectors for the 750 kcmil power cables shall be NEMA 2-hole type.

D. Low voltage terminations shall be as indicated in Section 34 21 50, Common Materials and Methods for Traction Power.

2.13 NEGATIVE ENCLOSURE

A. The negative enclosure shall be an indoor type, and shall be built in coordination with and as part of the dc switchgear assemblies. The enclosure shall have minimum dimensions as required for ease of installation of the specified number of 750 kcmil power cables terminated at the negative bus.

B. The negative enclosure shall include the negative bus, bus connections, bus supports, 5 kV rated connectors, and termination hardware for the 750 kcmil power cables.

2.14 DC SWITCHGEAR ACCESSORIES.

A. The Contractor shall provide switchgear maintenance accessories at each traction power facility, including but not limited to the following:

1. Handling device for removing, replacing and transporting the dc circuit breakers for one-man operation, if required.

2. Removable lever for opening and closing the circuit breakers.

3. One set of test plugs for drawout relays and instruments.

4. One set of wrenches for the primary disconnecting devices of the circuit breaker, if required.

5. One set of fuse tongs or hook sticks, depending on requirements.

6. Wall mounting test cabinet for operating, testing, and inspecting the circuit breakers when removed from their compartments.

7. One set of test jumpers for connecting breaker units to the test cabinet.

8. At a minimum, 12-foot long multi-conductor test cable with a secondary disconnect connector on both ends, to permit operating a circuit breaker when withdrawn from its compartment. This cable will be required to connect the control circuits of the withdrawn breaker and to operate the breaker without use of the test cabinet.

2.15 FACTORY TESTING

A. General: Factory testing for the dc switchgear, including testing plan, procedures and documentation shall be in accordance with Section 01 45 24, Testing Program Requirements.

B. Design Tests: The following design tests shall be performed on one dc circuit breaker and one dc switchgear assembly:

1. All applicable tests identified as Design Tests in IEEE C37.14 shall be performed on one dc circuit breaker.

2. All applicable tests identified as Design Tests in IEEE C37.20.1 shall be performed on one dc switchgear assembly.

3. Mechanical endurance test: withdraw and insert one completely assembled dc circuit breaker from and to its cubicle 20 times within 90 minutes and inspect the breaker assembly for any misalignment. Report and repair any defects incurred as a result of this test.

4. Load measuring and auto-reclosing functions: confirm the proper operation of the circuit breaker with the complete load measuring and auto-reclosing system, including MPR-based logic, contactor and circuit breaker control circuits.

C. Production Tests: the following production tests shall be performed on all dc circuit breakers and dc switchgear assemblies:

1. All applicable tests identified as production tests in IEEE C37.14 shall be performed on all dc circuit breakers.

2. All applicable tests identified as production tests in IEEE C37.20.1 shall be performed on all dc switchgear assemblies.

3. Load measuring and auto-reclosing functions.

END OF SECTION 34 21 25