SECTION 26 13 00 – MEDIUM VOLTAGE SWITCHGEAR

1.01 SUMMARY:

A. **Basic Function**: [A17]The medium voltage switchgears are an essential part of the 12 kV distribution system of the new set of locks complex. Medium voltage switchgears will receive the electrical power from the incoming feeders and distribute it to the new set of locks. The medium voltage system shall maintain the N+2 redundant as described on Section 01 81 29 (*Electrical and Lighting System*). Each switchgear shall have two buses connected by a tie breaker, and each bus connected to a distribution loop. The two loops are totally independent and they will be identified as north loop and south loop. The bus tie breakers will make it possible to connect part or all locks loads into one loop. [A17]

B. **Scope of Work**: Each medium voltage switchgear shall have protection equipment for the incoming and outgoing feeders. Metering, protection relay scheme and instruments shall be provided as required. The switchgears shall be located in an [A17]electrical room, [A17] with an underground cable gallery, in accordance with Section 01 81 36.13 (*O&M Building and Facilities – Space Programming*).

1.02 [A16]REFERENCES:[A16]

A. **American National Standards Institute (ANSI) Standards**:

C37.06.1-00	Guides for High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis Designated “Definite Purpose for Fast Transient Recovery Voltage Rise Times.
C37.55-02	Metal-Clad Switchgear Assemblies Conformance Test Procedures

B. **International Electrotechnical Commission Standards**:

IEC 61000-4-30 -- 08	Testing and Measurement Techniques – Power Quality Measurement Methods

C. **Institute of Electrical and Electronics Engineers (IEEE) Standards**:

48-03	Test Procedures and Requirements for Alternating-Current Cable Terminations 2.5 kV through 765 kV
C2-07	National Electrical Safety Code (NESC)
C37.04-06	Rating Structure for AC High Voltage Circuit Breakers
C37.09-07	Test Procedure for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis
C37.010-05	Application Guide for AC High-Voltage Circuit Breakers Rated on a Symmetrical Current Basis

C37.011-05	Application Guide for Transient Recovery Voltage for AC High-Voltage Circuit Breakers
C37.20.2-05	Metal-Clad Switchgear
C37.21-05	Control Switchboards
C37.90-05	Relays and Relay Systems Associated with Electric Power Apparatus
C37.90.1-02	Surge Withstand Capabilities (SWC) Tests for Relays and Relay Systems Associated with Electric Power Apparatus
C37.100-01	Definitions for Power Switchgear
C57.12.91-01	Test Code for Dry-Type Distribution and Power Transformer
C57.13-03	Requirements for Instrument Transformers
[A5]C37.20.7	Guide for Testing Medium-Voltage Metal-Enclosed Switchgear for internal Arcing Faults [A5]

D. **National Electrical Manufacturers Association (NEMA) Publications**:

SG 2-93	High Voltage Fuses
SG 4–05	Alternating-Current High-Voltage Circuit Breakers
SG 5-95	Power Switchgear Assemblies

E. **National Fire Protection Association (NFPA) Publications**:

70-08	National Electrical Code

F. **Underwriters Laboratories Inc. (UL) Safety Standards**:

467-04	Grounding and Bonding Equipment

G. **Autoridad del Canal de Panama Publications**:

Manual de Seguridad en Operaciones de Alto Voltaje (2005)

1.03 REQUIREMENTS:

A. **General**: Operational flexibility is a fundamental requirement. Redundant loop concept shall be maintained for the medium voltage system, as expressed on Section 01 81 29

(*Electrical and Lighting System*). Shall be more than one simultaneous failure in the electrical system to cause an electrical outage to any equipment. Even in the situation exposed before, the operator shall be able to isolate the problem and reestablish power to the equipment from an alternate source (N+2 redundancy concept). [A5]The Switchgear shall be [A17]Arc-resistant switchgear designed and built to provide maximum safety in the event of an internal arcing fault. [A17] [A16]Arc Resistant construction is required at front, back and sides of the equipment.[A16] The design shall provide protection based on the minimum protection results from the Arc-Flash study required in Section 26 05 73 (*Short Circuit and Load Flow Coordination Study*). [A5]

B. **Safety**: Equipment and Installation shall meet the requirements of the IEEE C2, [A5]IEEE C37.20.7, [A5] NFPA 70 and ACP "Manual de Seguridad en Operaciones de Alto Voltaje (2005)".

C. **Medium Voltage Switchgear**: Each switchgear bus bars shall be sized to carry at its 50% capacity the maximum new set of [A17]locks demand load (in other words, shall be sized for 100% spare capacity). There will be different switchgear arrangements as shown on drawings 5802-400 and 5803-400. Conductor bus bars shall be electrical grade copper having the specified continuous current rating as limited by ANSI Standards to temperature rise and documented by design tests.

D. **Protection system**: See Section 26 05 73 (*Short Circuit and Load Flow Coordination Study*). Data information on each event shall be available remotely by communication means.

E. **Generator Transfer Scheme**: In black-out condition (no voltage sensed on incoming lines) the generator system shall act as an emergency system, the [A11]generator(s)[A11] shall start, the incoming lines shall open and the load shall be transferred to the [A11]generator(s).[A11] The load transfer shall not last more than 2 seconds after generator voltage is sensed. When the utility electrical system is reestablished the back-to-normal procedure shall be initiated. The back-to-normal will be a decision from the Power Dispatching (PD) office. The transfer back-to-normal shall be made without an outage. Another sequence shall be programmed in order to connect the [A11]generator(s)[A11] to locks system without an outage in case of line maintenance.

F. **Corrosion resistance**: Coatings for corrosion resistance shall comply with Section 09 96 00 (*Corrosion Control Coatings*).

G. **Appearance**: The switchgear exterior shall be finished in ANSI 61 light gray color.

H. **Marking**: Internal equipment wiring marking shall be as per Section 26 05 53 (*Identification for Electrical Systems*).

1.04 DESIGN CRITERIA /SYSTEM DESCRIPTION AND PERFORMANCE:

A. **General**: Medium voltage switchgears for the 12 kV distribution system for the new set of [A17]locks [A17] shall be based on minimum redundant requirements shown on drawings 5802-400 and 5803-400. General characteristics of the switchgear shall be as follows:

General	
Switchgear enclosure type	Metal-clad type, indoor
Switchgear access	Front and rear swing doors
Bus bars	Copper bars fully insulated
Connections	Silver plated joints and cover by reusable insulating boots
Earth system	Copper
Electrical	
Operating voltage	12kV
Rated voltage	15kV
Basic impulse level BIL	95kV
Rated current and short circuit capacity	To be calculated by [A5]Contractor[A5]
[A5]Arc-Flash Resistance	To be calculated by the Contractor[A5]
Frequency	60Hz
Control voltage	125VDC
Space heaters	120VAC
Breakers type	Vacuum, draw-out type
Current transformers (CT)	
Incoming and generator feeders cubicles	Four sets, bushing type
Load and transformer feeders cubicles	Three sets, bushing type
Bus Tie cubicles	Two sets, one CT per bushing
Voltage transformers (VT)	
Bus VTs	Two sets of removable drawer type, one set per bus
Incoming feeder VT	One VT on incoming line for synchronization
Generator feeder VT	One VT on generator line for synchronization
Incoming feeders protection	
Bus differential	87B
Synchronism check/dead bus	25/27
Under-voltage	27
Overcurrent	50,51, 50N & 51N
Reverse power	32
Synchrocloser relay	to send a close breaker signal in phase with the system utility

Incoming feeders protection	
*Synchro-scope and synchro-switch	Scheme for manual synchronization
Loop feeders protection	
Bus differential	87B
Line differential	87L
Overcurrent	50,51, 50N & 51N
Load feeders protection	
Overcurrent	50,51, 50N & 51N
Bus differential	87B
Transformer protection	
Overcurrent	50,51, 50N & 51N
Transformer differential	87T
Transformer lockout relay	86T
Bus differential	87B
Generator protection	
Overcurrent	50,51, 50N & 51N
Synchronism check/dead bus	25/27
Bus differential	87B
Synchrocloser relay	to send a close breaker signal in phase with the system utility
Automatic synchronizer relay	For automatic matching of voltage and frequency
*Synchro-scope and synchro-switch	Scheme for manual synchronization
Bus Tie Protection	
Synchronism check/dead bus	25/27
Bus lockout relay	86B
Bus differential	87B
Metering	
All feeders cubicles	Multifunction digital meters

* Can be only one synchro-scope meter if there is only one removable handle for synchro-switches.

B. **Standard Compliance**: Switchgear and equipment shall be designed, manufactured, assembled, and tested in accordance with ANSI C37.06.1 and C37.55, IEEE 48, C37.04, C37.09, C37.010, C37.011, C37.20.2, [A5]C37.20.7,[A5] C37.90, C37.100; IEEE 48; and NEMA SG-2, SG-4, and SG-5.

C. **Circuit Breakers**: Circuit breakers shall be of the same type and rating, and be completely interchangeable. The breaker shall be self-aligning and shall be held rigidly in the operating position by the draw-out mechanism without the necessity of adding locking bars or bolts. The breaker compartments shall be furnished with a mechanism to move the breaker between the operating and disconnect positions:

1. 5-cycle maximum interrupting time
2. Mechanically stored-energy operating mechanism.
3. Manual charging provision of the mechanism
4. Padlocking provisions for the draw-out mechanism in the disconnected position.
5. Breaker on-off control shall be done locally and from the Electrical Distribution Control System (EDCS).
6. Breaker status indication shall be shown locally and status data shown at the Electrical Distribution Control System (EDCS).

D. **Power Monitoring Device:** Units shall comply with IEC 61000-4-30 Class A equipment, be microprocessor bases, for 3 phase circuits with configurable alarms, for use with current transformers (CTs), potential transformers (PTs) and equipped with a power module as required for operation.

1. Each transformer breaker shall be equipped with a solid-state power monitor with the following features:
   - Voltage: per phase, average and unbalance
   - Current: per phase, average and unbalance
   - Power: real, apparent, reactive and power factor
   - Frequency
   - Energy, 4 quadrant (bi-directional)
   - Voltage Harmonics (up to the 49th or higher)
   - Current Harmonics (up to the 49th or higher)
   - THD for voltage
   - THD for current
   - Power quality as per IEC 61000-4-30
   - Store in memory kW-hours, kVAR-hours, and kW demand (resetable)
   - kW-hour accuracy shall be 0.25% or higher
   - Shall include an interface card to permit communication via Ethernet network for remote monitoring and control
   - Shall have communication and protocol compatibility to the system described on Section 40 95 13.19 *(Process Control Hardware for Electrical Distribution Control Systems Systems (EDCSs))*

- Data from multiple locations shall be synchronized and displayed on the same time
- Shall include built in web server for remote monitoring using standard web browser

E. **Protection relays**: Relays shall conform to applicable portions of IEEE C37.90. Shall be micro-processor based relays specially designed for feeder protection and control, operated from standard relay current and voltage transformers. Relay shall be powered from the 125DC system described in Section 26 33 00 (*Direct Current Equipment*). One or more relays can be installed to provide the protection scheme shown on the general requirement table.

Line differential protection (87L) shall be provided on every loop feeder for quick isolation. Fiber optic differential line differential relays shall be used. Line differential feature in combination with the Bus differential relays (87B) shall provide the highest selectivity and quickest failure isolation for the 12kV distribution system. [A16]Incoming feeders does not require line differential protection.[A16]

Under-voltage (27) feature for incoming feeder is part of the automatic transfer scheme for the generator; the transfer sequence is detailed below.

Additional features shall be provided:

1. Communication and protocol compatibility to the system described on Section 40 70 00 (*Electrical Supervisory Control and Data Acquisition (SCADA*) System)
2. Reserved
3. Local interface display
4. Event recording with sine wave oscillography shall be downloadable from SCADA system

F. **Current and voltage transformers**: All CT leads shall be wired to shorting terminal blocks; all VT leads shall be wired to test blocks. Test blocks shall be mounted on the front cubicle panels corresponding to the location of the instrument transformers.

1. **Station service transformer cubicle**: Each switchgear bus shall be furnished with a fixed, rear mounted, three-phase, dry type, transformer to power the station building, with standard taps; with draw-out primary current limiting fuses, and secondary kirk-key interlocked breaker mounted in the front compartment. The kirk-key interlock is to prevent access to an energized transformer. Transformer tests shall conform to IEEE C57.12.91.

2. **Bus VT Cubicle**: Three draw-out voltage transformers with current limiting fuses. Transformers shall have metering accuracy per IEEE C57.13.

3. **Bushing CT's**: The current transformers CT's on all breaker cubicles shall be installed on each bushing. CTs shall be installed on the corresponding bushings depending on the metering and protection scheme. CT's for metering shall have an accuracy of 0.3 B-0.2 as per IEEE C57.13. CTs for relaying shall be relay accuracy

class C200 or higher. All CT leads shall be connected to a shorting terminal board at the front panel, to facilitate modification of CT's connection.

G. **Accessories**: For each switchgear, the following accessories shall be supplied:

1. One portable breaker lifts
2. Two racking handles, to manually operate the breaker racking mechanism
3. Any special wrench or tool(s) as required for routine maintenance

H. **Generator Transfer Sequences**:

1. **Black-Out Sequence**: It shall be an automatic sequence with provisions for manual operation.
   a. [A11]Generator(s)[A11] shall start automatically
   b. Incoming feeders shall automatically open when generator voltage is sensed
   c. Automatically close the generator [A11]breaker(s)[A11]

2. **Back-to-Normal Sequence**: When the PD considers that the utility system is stable, the PD will send a remote signal to initiate the back-to-normal, and this sequence shall be performed automatically, with provisions for manual operation. Back-to-normal sequence shall include:
   a. Sense line voltage on utility side
   b. Starts synchronization of voltage and frequency (generator controls)
   c. When voltage and frequency are matched then one of the incoming breakers shall close in phase with the utility (by synchrocloser relay)
   d. [A11]Generator(s)[A11] shall reduce gradually the load and when close to 0 kW, generator breaker shall open
   e. After a cooling period the [A11]generator(s)[A11] shall shut-off

3. [A11]**Generator(s)**[A11] **in Parallel with Utility**: It shall be a semi-automatic or totally manual sequence, depending on operator preferences.
   a. Operator shall start the [A11]generator(s)[A11]
   b. When generator breaker sense voltage, starts synchronization of voltage and frequency (by automatic synchronizer relay or manual provisions)
   c. When voltage and frequency are matched, then generator breaker shall close in phase with the utility (by synchrocloser relay or manually with a synchro-scope/synchro-switch scheme)
   d. Operator shall select the amount of load to be carried by the generator
   e. Shut down shall follow the back-to-normal sequence

4. **Generator(s) design package**: The design shall specify the synchronization and governor controls between generators including the control interconnections with the medium voltage switchgear.

1.05 SUBMITTALS: Documents shall be according to Section 01 33 00 (*Submittal Procedures*)

A. **Before Manufacturing**: Contractor shall submit a complete set of drawings and specifications. Information shall include:

1. Drawings and specifications that show the work to be performed and all design calculations.
2. Programming document that present all activities and provisions that will be taken to maintain the electrical service to each [A17]locks complex.[A17]
3. Submit certified copies of system equipment current applicable approvals issued by UL and/or other national recognized testing laboratory showing compliance with required standards

B. **Before Shipment**: The Contractor shall submit to the Employer's Representative for review the following items:

1. Revised drawings.

2. Shipping sections information.

3. Connection diagrams.

4. Nameplate data.

5. **Factory Test Reports**: Submit certified factory test reports of all factory tests performed by the manufacturer, including tests required by the applicable standards. Results of factory tests performed shall be certified by the manufacturer, or an approved testing laboratory, and submitted following successful completion of the tests.

6. **Installation Manuals and Field Test Procedures**: Submit copies of installation manuals and field test procedures for the medium voltage switchgear and related subsystems. The manufacturer's pass/fail criteria for field tests shall be included.

7. **Field Test Plan**: Submit a proposed field test plan, prior to testing equipment and subsystems. No field test shall be performed until the test plan has been reviewed by the Employer's Representative. The test plan shall consist of the manufacturer recommended field test procedures, including tests to be performed, qualifications of personnel performing the testing, test equipment required, pass fail criteria, and tolerance limits. In addition, field testing shall be in accordance with the applicable requirements of Section 26 90 00 (*Field Testing Electrical Systems*). After completion of field testing, submit Certified Field Test Reports.

C. **After Installation**: The Contractor shall submit the following:

1. **Final Drawings**: Final drawings, including all authorized changes made during the course of manufacture.

2. [A16]**Instruction Books**: Contractor shall deliver the following:[A16]

   a. Complete instruction books covering procedures for installation, maintenance, and operation of the switchgear with copies of all drawings in reduced size format. These shall contain complete descriptions and explanations for the operation of the equipment. [A16]Refer to Section 01 93 00 (*Maintenance Services*).

   b. **Reserved.**[A16]

   c. [A17]Certified copies of the test reports required including commissioning field tests, according to Section 01 91 00 [A17](*Tests On Completion and Tests After Completion*).[A17]

D. **Before Taking Over**: After completion of the modification and commissioning have been completed satisfactorily, Contractor shall deliver the following:

1. **As Built Drawings**: Reproducible tracings showing "as-built" conditions, including all modifications.

2. **Manual and Lists**: Updated operation and maintenance manuals, including complete system description and components, maintenance schedule and procedures, and the list of recommended spare parts. Updating shall include recommendations provided during the training sessions.

[A16]3. **Reserved**[A16]

1.06 QUALITY ASSURANCE:

A. **Manufacturer**: The manufacturer shall be a firm specialized in manufacturing of medium voltage switchgear with minimum ten years documented experience.

B. **Factory Tests**: Standard tests for switchgear assemblies, as described in ANSI C37.55, shall be performed. The manufacturer shall make factory tests at not less than standard ANSI C37.55, [A5]IEEE C37.20.7 [A5] and IEEE C37.90 values and such additional factory tests required by the manufacturer's control organization to insure that this product will maintain its high quality standard of materials and reliability in operation. Tests at each equipment shall include, but not limited to:

1. Dielectric
2. Sequence Test (Control Circuit Continuity)
3. Control Wiring Insulation
4. Functional Check
5. Mechanical Operation Tests
6. Polarity Verification
7. Circuit breakers shall operate over the range of minimum to maximum control voltage.

C. **Field Tests**: The Contractor shall perform the field tests in accordance with the "Field Test Plan".

[A17]D. **Commissioning**: Shall conform to Section 01 91 00 (*Tests On Completion and Tests After Completion*).[A17]

END OF SECTION