SECTION 26 33 00 – DIRECT CURRENT EQUIPMENT

1.01 SUMMARY:

A. **Scope**:

1. [A17]Scope of work shall be in accordance with Paragraph 1.01 D. of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), as required, for direct current electrical power distribution in the Works, as well as in Agua Clara Substation. The Sections listed in Table 26 33 00-1 shall be read in conjunction with this Section of the Employer's Requirements. [A17]

2. DC equipment shall include, but not be limited to, the following:

   a. -48 VDC power systems for voice and data communication equipment.

   b. + 125 VDC power systems for long distance power distribution within both locks complexes

   c. +125 VDC power system for Agua Clara Substation.

   d. +125 to +24 volt DC-DC Converters for local control power used by process control systems and other special systems.

   e. Backup 120/240 AC to +24 VDC power supplies for process control systems and other systems.

   f. Diodes, or bridge rectifiers, used as failover devices by combining redundant or backup sources of the same voltage level.

   g. Ground fault detectors for +125 VDC power systems.

   h. Inverters for critical AC loads in main control buildings.

B. **Related Sections**:

Table 26 33 00-1: [A8]Related Sections[A8]			
1.	Section 01 81 26	-	Communications, Control, Safety, and Security Systems.
2.	Section 01 86 13	-	Plant – Mechanical Systems and Equipment (ref. air conditioning equipment, eye washes, fire extinguishing systems, and plumbing).
3.	Section 09 69 00	-	Raised Access Flooring.
4.	Section 09 96 00	-	Corrosion Control Coatings.
5.	Section 26 05 26	-	Grounding and Bonding for Electrical Systems.
6.	Section 26 05 43	-	Underground Ducts and Raceways for Electrical Systems.
7.	Section 26 05 53	-	Identification for Electrical Systems.

Table 26 33 00-1: [A8]Related Sections[A8]			
8.	Section 26 20 00	-	Electrical Low Voltage Distribution Work.
9.	Section 26 22 00	-	Dry Type Transformers.
10.	Section 26 32 13.13	-	Diesel-Engine Driven Generator Sets.
11.	Section 26 43 13	-	Transient Voltage Surge Suppressors.
12.	Section 27 11 16	-	Cabinets, Racks, Frames, and Enclosures.
13.	Section 28 13 00	-	Access Control Systems.
14.	Section 28 16 00	-	Intrusion Detection Systems.
15.	Section 28 16 43	-	Perimeter Security Systems.
16.	Section 28 16 46	-	Vehicular Control Systems.
17.	Section 28 23 00	-	Closed Circuit Video Systems.
18.	Section 33 81 26	-	Outside Plant Pathways for Underground Communications.
19.	Section 33 82 00	-	Cabling for Underground Communications Outside Plant.
20.	Section 40 91 00	-	Primary Process Measurement Devices.
21.	Section 40 95 13.19	-	Process Control Hardware for Electrical Distribution Control Systems.
22.	Section 48 19 16	-	Inverters.

1.02 REFERENCE:

A. **Applicable Publications**: Refer to Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), [A8]Paragraph 1.02.[A8]

1.03 REQUIREMENTS:

A. **General Requirements**:

1. **General**:

a. All applicable requirements of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), [A8]Paragraph 1.03[A8] shall apply to all systems specified herein.

b. For improved ease of maintenance throughout the new locks complexes, the Main Control Building shall be the single location for batteries, and power derived from +125 VDC systems shall be distributed as needed.

c. All room incoming power that is used for electronic systems (DC or AC) shall be protected by a suitable local TVSS which shall condition the power voltage within design levels. All power output circuits that are used for electronic systems (DC or AC) shall include over-voltage and overload protection.

d. -48 and +125 VDC power systems shall be completely isolated and independent from each other. Each system's availability shall be 99.999% or better.

e. Components shall be sized as required for the corresponding loads (including spare capacity), required backup time, and recharge time.

f. All active electronic devices shall be solid-state.

g. Equipment shall be designed for heavy-duty industrial service.

h. The systems shall continuously monitor the operation status.

i. All modules or devices shall have a cooling system, shall be hot-swappable and easily replaceable without the use of special tools.

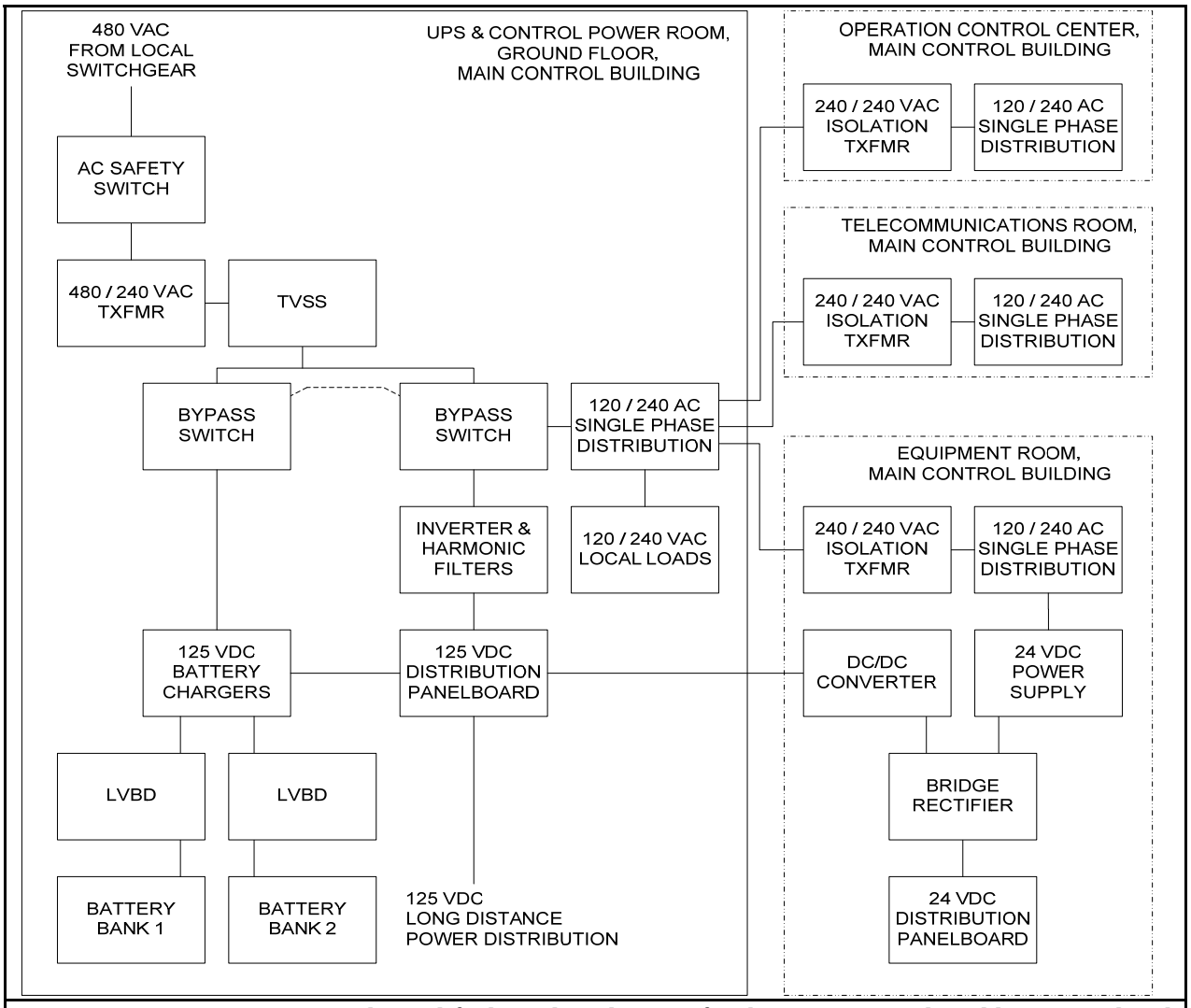

Figure No. 26 33 00-1: Typical simplified one-line diagram for the Main Control Building control and equipment room power source.

j. DC power systems shall have AC input overcurrent, undervoltage, and overload protection.

k. Figure Nos. 26 33 00-1, 26 33 00-2, and 26 33 00-3 show design guidelines for DC power systems.

2. **-48 VDC Systems**:

a. These systems shall be dedicated for telecommunications equipment.

b. -48 VDC systems shall include, but not be limited to, the following: battery chargers, batteries, DC distribution panelboards, and LVBDs.

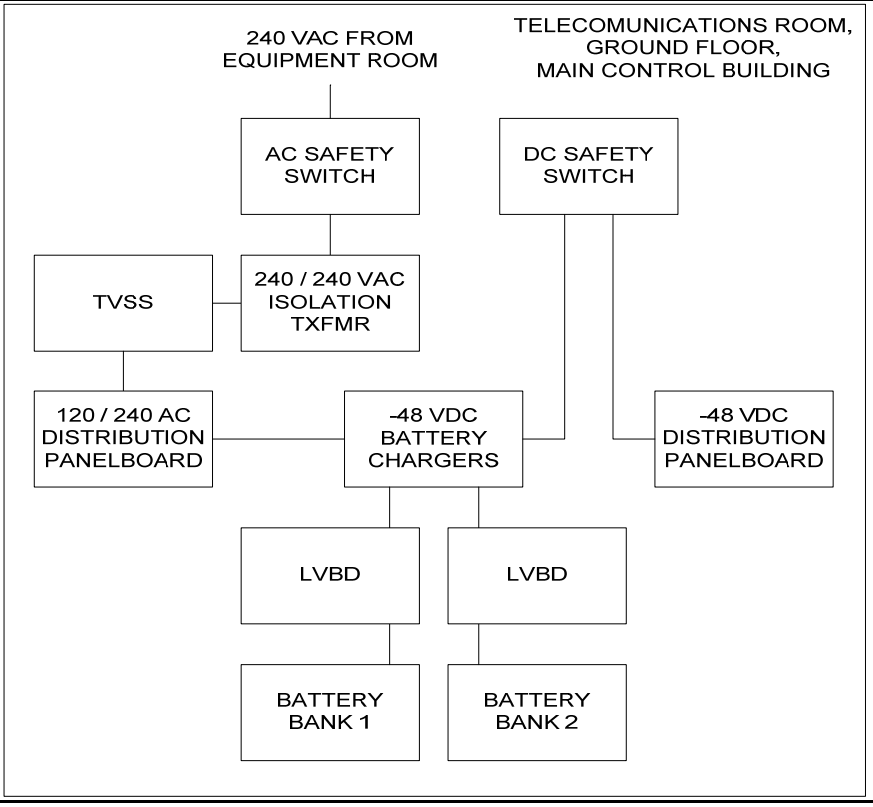

Figure No. 26 33 00-2: Typical simplified one-line diagram of -48 VDC power systems for telecommunications equipment.

3. **+125 VDC Systems**:

a. +125 VDC Systems shall be used for delivering power to remote locations from a single centralized location. At remote locations, this power shall be converted into nominal +24 VDC.

b. +125 VDC systems shall include, but not be limited to, the following: battery chargers, batteries, DC-DC converters, DC distribution panelboards, bridge rectifiers, and LVBDs.

4. **+24 VDC Systems**:

   a. [A19]Nominal +24 VDC output shall be provided for all process control systems (PCSs) at equipment room of main control building and remote machinery rooms, derived from +125 VDC power systems using DC/DC converters and 120 VAC using power supplies. [A19]

   b. Nominal +24 VDC output shall be provided to FM200 based fire extinguishing systems of Section 01 86 13 (*Plant - Mechanical Systems and Equipment*).

   c. Using +125 VDC power to derive nominal +24 VDC provides a wide input voltage range for a robust +24 VDC regulation. All control power shall be designed using nominal +24 VDC voltage level for added safety for maintenance personnel.

   d. +24 VDC systems shall include, but not be limited to, the following: DC-DC converters (125-to-24) as main sources, distribution panelboards, and power supplies operable on 120 VAC as redundant sources.

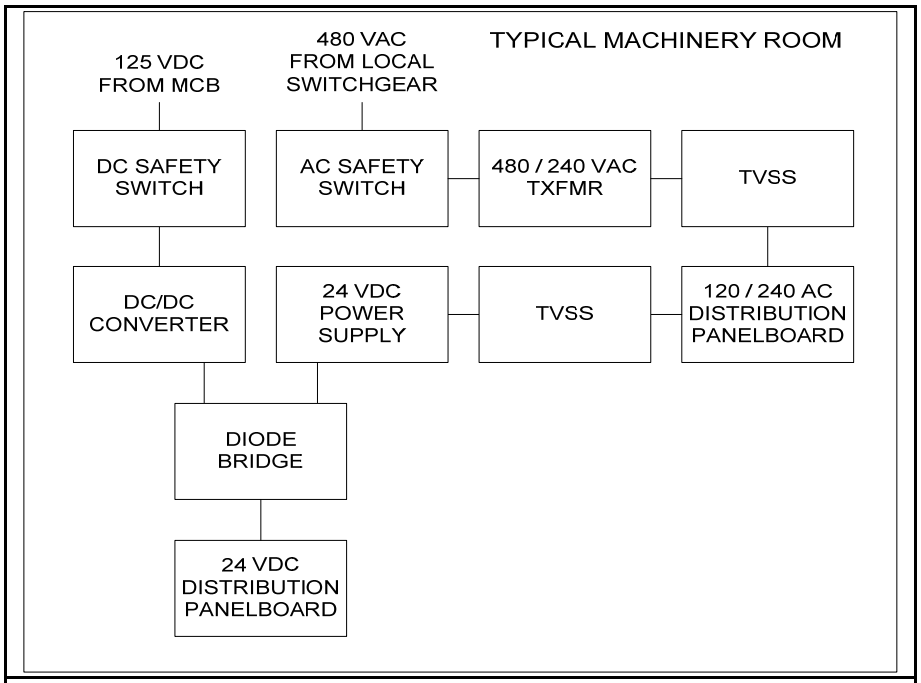

Figure No. 26 33 00-3: Typical simplified one-line diagram of +24 VDC power systems for machinery rooms.

5. **Cable Pulling Tension Calculations**: Shall be done for +125 VDC outside plant cables in accordance with the guidelines of Section 33 82 00 (*Cabling for Underground Communications Outside Plant*).

6. **Interoperability and Coordination**:

a. [A19]DC equipment and inverters shall be coordinated and compatible with equipment being furnished. [A19]

7. [A5]**Uninterruptible Power Supply (UPS) Systems**:

a. a. UPS systems shall include, but not be limited to, the following: 125 VDC battery banks, LVBDs, and chargers, as well as bypass switches (automatic and manual), distribution panelboards (AC and DC), and inverters.

b. b. Unless otherwise specified, use of a UPS as a single component is unacceptable. Each new lock complex shall have at least one redundant inverter for AC loads in main control buildings (including HMI) in accordance with Section 48 19 16 (*Inverters*), connected to battery banks and battery chargers of this Section. [A5]

8. **Grounding**

a. **+125 VDC Systems**: Shall be isolated from ground.

b. **-48 VDC Systems**: Shall have positive pole grounded.

c. **+24 VDC Systems**: Shall be isolated from ground.

d. **UPS Systems** (+125 VDC systems with inverters): The loads shall be grounded to the same ground point as the UPS, and the ground wiring shall be for the exclusive use of the UPS and AC loads.

B. **Spaces**:

1. **Battery Rooms**:

a. Battery rooms shall be air conditioned, sized as required, and isolated from equipment rooms unless otherwise specified. The Contractor shall avoid circulation of hydrogen fumes throughout the facilities' air conditioning systems. Furthermore, battery rooms shall have a hydrogen monitor in accordance with Section 40 91 00 (*Primary Process Measurement Devices*.).

b. Battery rooms for -48 and +125 VDC systems shall not interconnect at all.

c. Battery rooms shall have automatic exhaust fan(s), chemical resistant floor, an eye wash and shower per Section 01 86 13 (*Plant – Mechanical Systems and Equipment*), and a contention pool with capacity of 1.2 times the liquid volume stored in batteries or larger. These rooms shall not have suspended ceilings and windows.

d. Battery rooms for -48 VDC systems shall be in ground floor of Main Control Buildings, sized as required (with a minimum of 20 m^2), and be connected to the adjacent telecommunications equipment room.

e. Battery rooms for +125 VDC systems shall be in ground floor of Main Control Buildings and Agua Clara Substation, sized as required (with a minimum of 20 m^2), with a door connecting to adjacent electrical equipment room, and no door connecting to -48 VDC battery room.

C. **Equipment and Materials**:

1. **General**:

a. DC power systems and components shall be monitored from the corresponding EDCS in accordance with Section 40 95 13.19 (*Process Control Hardware for Electrical Distribution Control Systems*).

2. **AC Panel boards**: Shall be in accordance with Section 26 20 00 (*Electrical Low Voltage Distribution Work*).

3. **Anti-Corrosion Compound**: Shall be suitable for covering the contact areas of all battery electrical connections.

4. **Batteries**:

a. Units shall be rechargeable, sealed (not vented), low maintenance, of robust construction adequate for heavy-duty industrial service and for telecommunications and electrical equipment.

b. Batteries and their components shall be acid resistant, corrosion proof, and fire retardant.

c. Batteries shall be IEC 60896-21 compliant and have the characteristics or better of Table 26 33 00-2 (Battery Characteristics).

d. Battery cells shall be stackable vertically for high density and to save space.

e. Batteries shall not require special ventilation (other than local air conditioning) nor aggregating water, shall not emit hydrogen or other explosive gases, and shall not require periodic equalization. Batteries shall only require periodic visual inspections, verification of flotation voltage, cell voltage and connection torque.

f. Batteries shall tolerate high rates of charge following a discharge, and shall recharge to a minimum of 80% in tour hours after having discharged to 50%.

g. [A19]Each battery bank shall operate normally in flotation condition, and shall only supply power during the time between the loss of commercial

power and the start of a local emergency generator (if applicable) or the reestablishment of commercial power (without exceeding the corresponding backup time). [A19]

h. Hydrogen accumulation resulting in closed battery rooms shall be such that it can easily be maintained at non-dangerous levels.

i. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted either.

j. Each cell of the battery shall be provided with a pressure regulation valve. The porosity of the container shall be such as not to allow any gases to escape except from the regulation valve.

k. All inter cell connectors shall be protected with heat shrinkable sleeves made of silicon or better material.

Table 26 33 00-2: [A8]Battery Characteristics[A8]

Physical and Chemical Characteristics		
Construction		Absorbed electrolyte type, with recombination
Electrolyte		High purity sulfuric acid, diluted in pure water (not gel type)
Enclosure	Oxygen Index	28 or larger
	Material	Polypropylene with high impact resistance, preferably one single piece.
	Fire Retardance	Limiting Oxygen Index (LOI) of 28% or larger, in accordance with UL 94.
Marking in Each Cell		[A19]Ah capacity, cell number, manufacturer name and model, polarity of each pole, serial number, type, and voltage.[A19]
Plates		With width and quantity of lead as required for specified useful life.
Oxygen-Hydrogen Re-combination		≥99% efficiency to minimize water loss.
Pressure Valve	Min.-Max. Range	Between 2 and 9 psi.
	Type	VRLA.
	Safety	In accordance with Telcordia GR-4228-CORE.
	Venting	Somewhere between 5 and 9 psi as recommended by the manufacturer, with auto-recloser, unidirectional, in accordance with UL 924.
Separators		Micro-porous matrix or fiberglass mesh with electrolyte, high performance AGM type suitable for deep discharges.
Size		Small enough to pass through a Standard door.
Type		Lead-calcium
Electrical Characteristics		
Capacity	In time	≥80% of nominal capacity at end of useful life.
	[A19]Nominal (Ah)[A19]	Meeting the specified nominal current at 8 hours.
Discharge Cycles Supported (one or the	Light	1,000 (t ≤ 15 minutes).
	Deep	150 at 80% and 100 at 100%.

Table 26 33 00-2: [A8]Battery Characteristics[A8]		
other, or a combination) along the useful life		
Internal Discharge		Not to exceed 1.5% per week nor 3% per month (both at 25°C).
Nominal Current at 1.75 volt per cell	Each site	[A19]100% or required Ah in 2 battery banks, with no less than 50% per bank.[A19]
Number of Cells per Group		Not to exceed six individual cells (12 V).
Poles or Terminals		Corrosion resistant, and designed for maximum conductivity and to facilitate firm connections between cells.
Voltage per cell	Final discharge at 8 hours	1.75 VCC
	Nominal	2.00 VCC
	Flotation (typical)	2.25 VCC
	Maximum	2.42 VCC

5. **Battery Chargers**:

a. Chargers shall be designed to equalize and float charge separate -48 VDC and +125 VDC battery banks automatically, and to have a soft-start when turned on so that output current is gradually increased without overloading.

b. Battery chargers shall have a constant voltage characteristic throughout the range (from zero to full load) at the floating value of the voltage so as to keep the battery fully charged but without harmful overcharge.

c. The units shall have load limiters with drooping characteristic. Any overload or short circuit in DC system shall not damage the chargers. The chargers shall not trip on overload or external short circuit conditions.

d. Battery chargers shall be provided with a switching device to isolate the battery banks from the charger for maintenance.

e. Units shall have the following or better characteristics:

Table 26 33 00-3: [A8]Battery Charger Characteristics[A8]		
Alarms		AC input failure (with form "C" contact), charger failure, fan failure, high/low battery voltage, and trip breaker.
Circuit Breakers		AC input and DC output.
Controls		Equalize/float mode selector, and power switch.
Efficiency	At 25% load	80%
	At 50% load	87%
	At 75% load	88%
	At 100% load	89%

Table 26 33 00-3: [A8]Battery Charger Characteristics[A8]		
Indicator Lights		Equalize/float and power on.
Input	Voltage	120 or 120/240 VAC, 60 Hz.
	Variation	±5% for voltage level, and ± 3 Hz for frequency.
Meters		Output voltage and current, and temperature.
Outputs	Controls	Manual switch for DC output.
	Current	As required in accordance with reviewed calculations.
	Noise	≤30 mV when connected to batteries.
	Regulation	±0.5% from setpoint from 0 to 100% load with specified input variations.
Remote Monitoring		IP-based intelligent monitoring system.

f. The housing of the chargers shall be constructed of rustproof metal and treated with a protective coating.

6. **Battery Racks**:

a. Battery racks shall be rigid structures of welded steel designed to avoid twists that may result from stress. These shall have all necessary hardware, the dimensions and strength required for the battery banks to be furnished.

b. Metal racks shall be protected against corrosion with factory-applied acid resistant coatings, complying with Section 09 96 00 (*Corrosion Control Coatings*).

c. Battery racks shall have cell spacers made of antistatic foam or better material.

d. Each battery rack shall allow cells to be installed with front access (see Figure 26 33 00-3) and shall facilitate the replacement of individual cells without having to disconnect most other cells or disassemble the rack.

e. Units shall have clamps or other suitable devices to protect cells and minimize damages in case of minor quakes.

f. Battery racks shall include transparent plastic covers to protect battery poles and connections against accidental hits or short circuits.

7. **Bypass Switches**: Units shall do the following:

a. Automatic bypass to normal input source in the case of a DC power failure. All transfers to and from bypass shall be make-before-break transitions for continuity of power to the load.

b. Allow bypassing to normal input source for maintenance or repair.

c. Hard or soft-key locking to prevent unauthorized operation.

8. **Circuit Breakers**: Shall be in accordance with Section 26 20 00 (*Electrical Low Voltage Distribution Work*), with quantity, spares, and capacity as required.

9. **Conductors for Battery Banks**: Battery banks shall include all required conductors for interconnecting cells in the front side. Conductors shall be dimensioned to allow discharge at the maximum published rate, and so that the voltage drop between adjacent cells does not exceed 30 mV at the three hour rate for 1.75 volts per cell.

10. **Connectors**: Shall meet the requirements of UL 486A and be of the best commercial quality recommended by the battery manufacturer.

11. **DC-DC Converters**:

a. Units shall include condition monitoring of analog outputs for temperature, output current, and output voltage. These outputs shall be wired to the room's I/O Concentrator, and viewed on the MDS HMI.

b. Units shall be electronic switch-mode converters with the following or better characteristics:

Table 26 33 00-4: [A8]DC-DC Converter Characteristics[A8]

Input Voltage	Nominal	+125 VDC
	Range	Variable between 35 and 140 VDC
Conversion	Efficiency	90%
Output	Power Rating (Watts)	As required for PLCs, MCCs, switchgear, and all other +24 VDC loads
	Protection	Overload, overvoltage, and short circuit.
	Regulation	±1% line and load
	Voltage	+24 VDC nominal

12. **DC Panel boards**: -48 and +125 VDC panel boards shall be in accordance with Section 26 20 00 (*Electrical Low Voltage Distribution Work*).

13. **Diodes or Bridge Rectifiers**: Shall be suitable for isolating and combining different DC power sources of the same voltage level, and shall have ampacity as required.

14. **Ground Fault Detectors (GFDs)**:

a. Units shall be capable of monitoring DC ground leakage current on +125 VDC power systems.

b. Units shall have a normally open alarm contact.

15. **Insulators**: All live parts shall have insulating covers to protect people from accidental discharges and equipment from possible short circuits.

16. **Inverters**: Shall be in accordance with Section 48 19 16 (*Inverters*).

17. **Isolation Transformers**: Shall be in accordance with Section 26 22 00 (*Dry Type Transformers*), coordinated with +125 VDC power supplies, and sized as required.

18. **Low Voltage Battery Disconnects (LVBDs)**: Shall be coordinated with batteries, chargers, and inverters to protect batteries in case of dangerously low voltage, and to bypass inverters.

19. **Power Distribution Cables**: Shall be in accordance with Section 26 20 00 (*Electrical Low Voltage Distribution Work*).

20. **Power Supplies**:

    a. Power supplies shall be power factor corrected switching type, fully automatic, rugged, and designed for industrial control applications without the need for batteries.

    b. Units shall include condition monitoring of analog outputs for temperature, output current, and output voltage. These outputs shall be wired to the room's I/O Concentrator, and viewed on the MDS HMI.

    c. Power supplies shall output regulated constant potential, adjustable output level, and be UL 508 compliant.

    d. Units shall have the following or better characteristics:

Table 26 33 00-5: [A8]Power Supply Characteristics[A8]

Input	Surge Withstand Capability	In accordance with IEEE C37.90
	Voltage	Variable input 85 ~ 240 VAC or better input range
Conversion	Efficiency	85%
Output	Power Rating (Watts)	As per load requirements
	Protection	Overload and reverse polarity
	Regulation	$\pm$1% line and load
	Ripple and Noise	$\leq$ 100 mV
	Voltage	+24 VDC

21. **Spare Parts**: Shall be furnished as recommended by the designer/integrator and systems manufacturer.

22. **Surge Protectors**: +125 VDC distribution lines shall be protected with surge suppressors in accordance with Section 26 43 13 (*Transient Voltage Surge Suppressors*).

D. **Software**: [A19]Shall be intelligent, IP-based, and as required for remote system monitoring by central managing SNMP stations for telecommunication equipment and by HMI software for EDCSs in no less than four sites evenly distributed between Atlantic and Pacific sides. [A19] [A20]SNPM shall be the latest version (v.3 as of December 2008).[A20]

E. **Installation**:

1. **General**:

   a. Devices shall be installed in accordance with the guidelines of Figure Nos. 26 33 00-1 through -3.

2. **AC Panel boards**: Shall be used to distribute AC power from inverter in Main Control Building to critical loads.

3. **Batteries**:

   a. Batteries shall be installed in approved metal structures, as illustrated in Figure 26 33 00-4.

   b. [A19]Each site requiring batteries shall have two battery banks as illustrated in Figure 26 33 00-5, with each bank having at least one half of the required Ah capacity calculated. [A19]

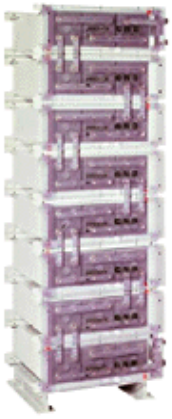

Figure No. 26 33 00-4: Typical Battery Bank Mounting

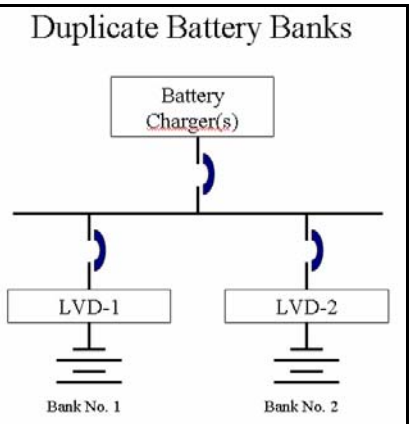

Figure No. 26 33 00-5: Typical Battery Banks with Circuit Breakers

   c. Battery banks with nominal voltage of -48 VDC shall have 24 cells.

   d. Battery banks with nominal voltage of +125 VDC shall have 60 cells.

4. **Battery Chargers**: [A17]All units [A17] shall be rack mounted.

5. **Bridge Rectifiers**:

   a. Rectifiers shall be used in +24 VDC power systems to combine and isolate power sources as illustrated in Figure 26 33 00-6. Using bridge

rectifiers in lieu of diodes provides added fault tolerance because input polarity wiring errors will not affect the power system.

b. Rectifier capacity shall be no less than 30% higher than the maximum expected current in the circuit.

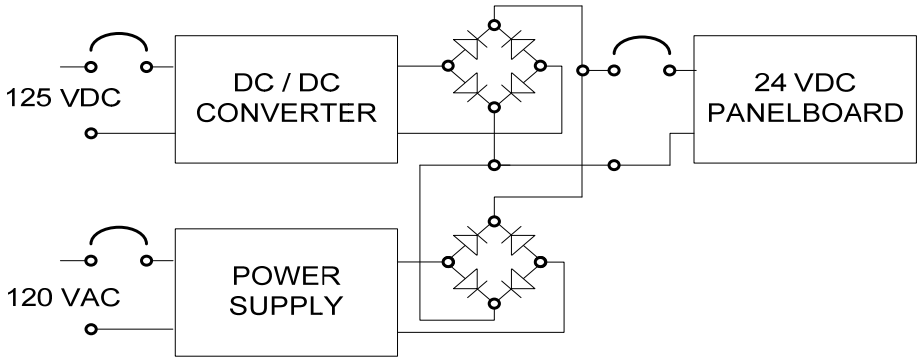

Figure No. 26 33 00-6: **Typical s**implified one-line diagram of +24 VDC power systems for machinery rooms.

6. **Circuit Breakers**: Shall be installed as shown on Figures 26 33 00-5 and -6. All circuit breakers shall include auxiliary contacts which shall be used to indicate circuit breaker status to LMCSs.

7. **DC Panel boards**: -48 and +125 VDC panelboards shall be completely isolated and independent from each other.

8. **DC Power Distribution Cables**:

   a. DC power cables in inside plant shall be installed in cable trays under raised access floor of Section 09 69 00 (*Raised Access Flooring*), and other approved raceways.

   b. DC power cables in locks' outside plant shall be installed in ducts and raceways in accordance with [A17]Section 26 05 43 (*Underground Ducts and Raceways for Electrical Systems*)[A17] along the locks walls in each side. Such cables shall be lubricated in accordance with the guidelines of Section 33 82 00 (*Cabling for Underground Communications Outside Plant*).

9. [A19]**DC-DC Converters and Power Supplies**: Shall be installed in equipment racks mounted in Main Control Building and machinery rooms.[A19] DIN rails are acceptable.

10. **Ground Fault Detectors**: Shall have alarm contact connected to EDCS PLCs.

11. **Isolation Transformers**: Shall be used on the main 120 VAC source at the equipment room of the Main Control Building and the machinery rooms for

electrical noise and harmonics isolation. A step-down transformer or a one to one ratio transformer shall be used as an isolation transformer.

12. **Software**: Status monitoring software shall be installed at the following workstations:

a. MDS workstations.

b. Engineering Authorities, including [A8]EAE Atlantic and EAEB Pacific.[A8]

c. For -48 VDC systems only, [A8]Information and Telecommunications Management Authorities, including FAIA (Atlantic) and FAIT (Pacific).[A8]

1.04 DESIGN CRITERIA/SYSTEM PERFORMANCE:

A. **General**:

1. **Problem to be Solved**: DC power systems shall solve the following business needs:

a. Provide a high efficiency, long life source for regulated, reliable, and uninterrupted power to DC loads.

2. **Restrictions to be Considered**: (reserved)

B. **Design Criteria**:

1. **General**:

a. Depending on ACSs, CCVSs, IDSs, and PSSs design, +24 VDC may also be required in accordance with Section 28 13 00 (*Access Control Systems*), 28 23 00 (*Closed Circuit Video Systems*), 28 16 00 (*Intrusion Detection Systems*), and 28 16 43 (*Perimeter Security Systems*), respectively.

b. Depending on vehicular control systems' design, +24 and/or +125 VDC may also be required in accordance with Section 28 16 46 (*Vehicular Control Systems*).

c. [A10]DC power systems shall be designed in accordance with all applicable requirements of ATIS PP.0600311.[A10]

2. **System Sizing Calculations**:

a. DC power system calculations shall be in MS Excel or compatible format, and shall include work-sheets for the following:

1) Detailed list of AC loads, where there are inverter(s).

2) Detailed list of DC loads, including DC-DC converters and other devices.

3) [A19]System calculations, including data on the applicable emergency generators, inverters, batteries, and battery chargers, as well as a summary.[A19]

4) Others as required for load flow coordination, protections, short circuit, and voltage drop.

b. Battery, bridge rectifier, inverter, and power supply size calculations shall include a spare capacity as specified in [A8]Subparagraph 1.03 K.8.a.[A8] of Section 01 81 26 (*Communications, Control, Safety, and Security Systems*).

c. [A19]System calculations shall include, but not be limited to, all information as in the typical spreadsheet shown in Figure 26 33 00-7.[A19]

Direct Current / Uninterruptible Power Supply System Calculations					
By:	Sample Name				
	Simple company name				
Date:	Sample Date				
Site:	Sample site	**Building:**	Sample building		
EMERGENCY GENERATOR(S)					
Make and Model		Sample Make, Sample Model			
Capacity		kW	35		
Fuel			Diesel		
Consumption		gal/hr	2		
Remote Monitoring			Via modem		
Numer of Generators			1		
Tank		gal	80		
Backup Time		hr max	40	with tank full	
INVERTERS					
Make and Model		Sample Make, Sample Model			
Number of Inverters			1		
Output AC Voltage		V	120		
Connected AC Load		A	14.8	From other worksheet	
		VA	1776		
AC Spare	**25%**	VA	444		
Total Inverter Capacity		VA	2220		
Capacity of Each Inverter		VA	2220		
Inverter Efficiency			0.89		
BATTERIES					
Make and Model		Sample Make, Sample Model			
Type		Lead-acid, VRLA			
Number of Cells per Bank			24		
Number of Battery Banks			2		
Battery Inefficiency Factor			1.15	IEEE 485 based margin	
Aging Factor			1.25		
Backup Time		hr	4		
Load:					
Calculated Inverter(s) Load		VA	2494.38202	Includes efficiency and	
Subtotal-Other DC Loads		A	157.42	From other worksheet	
		VA	8311.776		
DC Spare	**25%**	VA	2077.944	Excludes inverters	
Total DC Load		VA	12884.102		
Voltage Levels:			Cell	Bank	
Nominal (Recommended)		V	2.2	52.8	
Start of Discharge		V	2.15	51.6	
Dead Cell		V	1.75	42	
Current Levels:				Bank	
At nominal voltage		A		244.017084	
Start of Discharge (I_1)		A		249.6919	
Dead Cell (I_2)		A		306.764334	
Average of I_1 and I_2 (I_3)		A		278.228117	
Capacity of all Battery Banks in Parallel		A-hr		1599.81167	
Capacity of each Battery Bank		A-hr		799.905836	
BATTERY CHARGERS					
Make and Model		Sample Make, Sample Model			
Modules	**50**	A each		3	
Redundancy				N+1	
Required Recharge Time		hr		12	
Capacity of All Chargers		A		440.081973	
Capacity of Each Charger		A		146.693991	
SUMMARY			Calculated		
Generators	**1**	kW			
Inverters	**1**	VA	2,220		
Battery Banks	**2**	A-hr	1,600		
Chargers	**3**	A	440		
Total Backup Time (Gen		hr max	44		
Required Recharge Time		hr	12		

Figure 26 33 00-7: Typical DC power system calculations spreadsheet

C. **System Performance**:

1. **General**:

a. DC power systems shall be solid state and meet the requirements of NFPA 70 and 110.

2. **Batteries**:

a. Batteries shall store chemical energy and make it available in an electrical form, and shall have a minimum expected life of twenty (20) year under continuous duty.

b. [A16]Battery backup time shall be no less than 4 hours. This is an Employer requirement and should not be confused with the manufacturer´s published battery discharge rating at 8 hours.[A16]

c. Battery bank recharge time shall not exceed 8 hours to fully charged condition.

d. The systems shall have automatic battery testing, and local and remote alarm indication accessible via the Employer's Intranet.

3. **Battery Chargers**:

a. Battery chargers shall compensate for AC voltage variations, filter DC output, be coordinated with LVBD units, and meet the applicable requirements of CSA C22.2.

b. Chargers shall be designed for heavy-duty industrial service, and shall put energy into battery banks of rechargeable cells by forcing an electric current through these.

c. -48 VDC battery chargers shall recharge -48 VDC battery banks while simultaneously providing power to the connected communication systems.

d. [A16]+125 VDC battery chargers shall recharge 125 VDC battery banks while simultaneously providing power to connected inverters.[A16]

e. Battery chargers shall be capable of supplying power to full connected load (including inverters and other DC loads) without a battery connected.

f. Redundancy shall be N+1, or better.

4. **DC Power Systems**:

a. DC power systems shall be protected against under-voltage, over-voltage, voltage fluctuation, and over-current conditions.

b. DC power systems shall have local and remote indicators to provide status information for AC power, DC power, battery and battery charger.

c. DC power systems shall have local and remote alarms for warning and shutdown failures.

d. DC power systems shall be provided with monitoring and control circuits to protect the battery system from damage due to excessive discharge.

5. **Ground Isolation**: +125 VDC power supplies shall be isolated from ground on the 120 VAC side.

6. **Power Supplies**: Shall be capable of handling the full load of +24 VDC fed equipment in machinery rooms (ref. Figure 26 33 00-5).

7. **UPS Systems**:

a. UPS systems shall be solid-state and designed to provide regulated and conditioned sinusoidal power to loads.

b. UPSs shall provide uninterruptible power during all modes of operation.

c. The UPS shall be protected against under-voltage, over-voltage, voltage fluctuation and over-current conditions.

d. UPSs shall have built-in protection against permanent self-damage and connected load for all predicable types of functions.

e. The loads shall be automatically transferred to the bypass line uninterrupted for an internal UPS malfunction.

f. UPSs shall have a local and remote indicator to provide status information of operation modes, protective devices, and faults. UPSs shall also have local and remote alarms for warning and shutdown failures. These indications shall also be available at the MDS HMI.

g. The UPS shall operate as a fully automatic system, at least, in the following modes:

1) **Normal Mode**: During normal operation, DC power is supplied by +125 VDC batteries. The UPS shall monitor battery status to avoid possible damage if the batteries are exhausted. Should this happen, the UPS shall automatically transfer load to normal AC power, and the transfer shall be uninterrupted.

2) **Maintenance Bypass/Test Mode**: A key-locked maintenance bypass switch shall be provided to isolate the UPS inverter output. This mode shall allow UPS to be tested or repaired

without affecting load operation neither interruption of power to the load.

1.05 SUBMITTALS:

A. **Design**: The following shall be in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), [A8]Subparagraph 1.05 D.[A8]:

1. Battery data, including:

a. Certificates, including but not limited to the following:

1) ICC-UBC and/or Telcordia GR-63-CORE certification for seismic region IV adequacy.

2) NEBS level 3 certification.

b. Graphics, including but not limited to the following:

1) Charge characteristics (A load and V cells-vs-time).

2) [A19]Discharge characteristics (S family curves with Ah per positive vs A per positive).[A19]

c. MSDSs.

d. Number of partial discharges (including 15 minute and 60%) and deep discharges (80% and 100%) that the offered batteries can withstand along their useful life.

e. Overall dimensions and weight.

f. Storage requirements prior to entry in service.

g. Warranty details, including formula or prorated depreciation.

2. Calculations, including –

a. Battery, battery charger, and inverter sizing.

b. Battery liquid and battery room contention pool volumes.

c. Cable pulling tension calculations for 125 VDC outside plant.

d. [A19]125V DC voltage drop.[A19]

e. Panel-board loads.

f. Power supply sizing.

g. System availability.

h. [A19]DC short circuit in accordance with the recommendations of ANSI and IEC, including maximum current, rate of rise, and time constant.

i. DC load flow. [A19]

3. CPM diagram, with monthly updates.

4. Descriptive literature, including information for batteries, battery racks, conductors, connectors, corrosion protection compound, and insulators.

5. Drawings, including connection diagrams and assembly drawings specific to the items being furnished.

6. [A19]Protection methods for corrosion, ESD, fungus/humidity, lightning/surge, power distortion and harmonics, radio-frequency interference/electromagnetic interference (RFI/EMI), thermal, and vibration.[A19]

7. Quality assurance and control plans.

8. Specifications.

9. SWOT analysis.

B. **Re-submittals Just Prior to Purchasing Materials**: All items in A. above that have changed from original submittal shall be resubmitted in a Design Conference in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), Paragraph 1.05.

C. **Upon FQCT**:

1. QC test reports.

D. **Upon Receipt of Shipped Items in Panama**:

1. Instruction manuals for administration, installation, maintenance, and operation.

2. Packing lists.

E. **60 Days Prior to Start of Training Services or Earlier**:

1. Training services description.

F. **Prior to Issuance of Taking Over Certificate**:

1. As-built drawings.

2. FFIT report

3. List of recommended spare parts

1.06 QUALITY ASSURANCE: Shall include the following in accordance with Section 01 81 26 (*Communications, Control, Safety, and Security Systems*), [A8]Paragraph 1.06[A8]:

A. Factory Quality Control Tests (FQCT).

B. Training services for no less than eight (8) Employer collaborators.

C. Final Field Inspection Tests (FFIT), in accordance with IEC 60896-22.

D. Spare parts.

E. Technical Support

F. Warranty

END OF SECTION