APPENDIX B: TECHNICAL SPECIFICATION

B.1 CUSTOMS AND BORDER PROTECTION (CBP) STANDARDS

The CBP has adopted (b) (7)(E) [redacted] to serve as its standard for the grounding of communications structures and equipment. This document is sometimes referred to as the (b) (7)(E) [redacted] and is available from (b) (7)(E) [redacted]

In the event that certain grounding practices, methods or standards are in conflict with the standards adopted by the CBP, then the most stringent shall prevail.

B.2 OTHER GOVERNMENT AND INDUSTRIAL STANDARDS

The following is a list of government and industrial grounding standards listed in the order of governing precedence:

a. National Fire Protection Association (NFPA) 780
b. National Electrical Code 70
c. Institute of Electrical and Electronics Engineers Emerald Book - Powering and Grounding Sensitive Electronics Equipment
d. Institute of Electric and Electronic Engineers/ American National Standards Institute (IEEE/ANSI) C62.41-199, C62.45-1992, c62.1 and C62.11
e. Underwriters Laboratories UL 1449, UL 1283, UL 489 and UL198

Practices, methods and/or standards contained in these documents can be used to complement or supplement the standards adopted by the state or CBP.

B.3 UNDESIRABLE METHODS AND MATERIALS

B.3.1 Ufer Grounds

Ufer or concrete-encased grounding systems are prohibited for use by CBP, especially as part of the tower or building foundation, for use on new construction of communications facilities.

B.3.2 Aluminum

Aluminum conductors are prohibited for use on new construction of communications facilities.

B.3.3 Chemical Grounds

Methods of acquiring lower ground resistance by adding ionized salts (soil doping) and other chemicals are unacceptable for new construction of communications facilities. The preferred method of lowering the ground resistance is addition of ground rods and ground radials. In hardship circumstances, with CBP's advance approval the contractor may use electrolytic ground rods as described in (b) (7)(E) [redacted]

B.3.4 External Grounding Design and Installation

The external grounding system shall be designed, furnished and installed in accordance with (b) (7)(E) [redacted].

B.3.5 Grounding

An earth electrode system shall be installed for each communications facility. For each site, the earth electrode system shall consist of a buried external site ground system of #2 American Wire Gauge (AWG) ANSI or coarser, bare, solid, tinned or untinned copper conductor connected to copper or copper clad steel ground rods as required to obtain the overall grounding resistance goals. (b) (7)(E) [redacted] section 4.4.1.

B.3.6 Ground Resistance

The integrated, common, single-point ground system shall have a grounding (earthing) electrode system resistance design goal as low as practical and not over 10 ohms; CBP's preference is for a design goal of 5 ohms or less.

B.3.7 Grounding for Building, Architectural, and Structural Steel

All building, architectural, and structural steel shall be electrically grounded and connected into a single electrically-conductive unit. Acceptable grounding connection methods include clamps, bolting, exothermic welds and welding. (b) (7)(E) [redacted]
The building structural steel system shall be connected to the grounded conductor of the incoming Alternating Current (AC) supply system at the service entrance, and to the main cold-water piping and sewer systems, if the building is provided with water or sewer service and continuous metallic piping is used.

B.3.8 Site Ground System

Each facility shall be provided with an interconnected buried ground system for all structures. These structures include but are not limited to the following: building, sheds, towers, fuel tanks, generators, generator supports, fences and other structures.
This ground system shall be connected to the building's (or any other structure's) structural steel system and to any electrical and metallic piping systems that cross it. Connection shall occur at the nearest point to the intersection between the ground system and the item being connected. The system shall be continuously connected into one electrical system. The ground system shall be buried at a minimum distance of 36 inches from shelter foundations and 24 inches from tower foundations, and shall be buried at a minimum depth of 30 inches or below the frost line, which ever is greater. In hard rock locations, the 30 inches deep grounding wire installation requirement is waived.

B.3.9 Ground Test Well

A buried ground test well shall be furnished and placed at an exterior site location near the cable entry panel of the shelter.

The test well will be used for:

a. Periodic soil resistively and ground system resistance checks.
b. Connection node for future expansion of the ground system.
c. The well shall:
   i. Rise no less than two inches and no more than four inches above grade.
   ii. Be no less than six inches in width.
   iii. Be protected inside a weatherproof non-corrosive metal or plastic-type conduit or pipe.
   iv. Be capped with a screw-type top.
   v. Be furnished with a weatherproof identification sign.
   vi. Be placed at a location coordinated with CBP and protected from vehicular traffic.

B.3.10 Tower Grounding

The antenna tower shall be connected to the site ground system. The preferred attachment method for grounding conductors to the tower is by an exothermic weld treated with cold galvanizing spray attached near the base of each tower leg.

All grounding cables and wires attached to the tower, transmission lines, ice bridges and other exterior appurtenances shall be installed leading in a constantly descending manner with no sharp bends or loops. This tower ground shall be connected to the site ground system.

B.3.11 Guy Wire Grounding

A ground rod shall be installed at each guy anchor. This guy wire ground shall be connected to the site ground. A single ground cable shall be clamped to each guy wire above the anchor plate. This cable shall be installed in a constantly descending direction with no sharp bends or loops.

B.3.12 Fence Grounding

A ground rod shall be installed at intervals for each (b) (7)(E) [redacted]. This ground rod shall be installed from the closest fence post to the site ground. The fence shall be electrically connected so that it forms a single electrical unit.

Exothermic welds shall be used to connect each fence post to its associated ground rod and to the site ground system. All gates shall be connected to grounded components using exothermic welds and stranded copper wire.

All exothermic welds on fence posts shall be treated with cold galvanizing spray.

B.3.13 Grounding for Commercial Power Service

The commercial power service and any generators shall connect the AC power grounds and neutrals to the site ground. This connection to the site ground shall be adjacent to the master ground bar (MGB).

All AC power metal equipment parts, such as enclosures, raceways or conduits, and equipment grounding conductors, and all earth grounding electrodes shall be connected into a continuous electrically conductive system.

B.3.14 Grounding for Telephone Services

The commercial telephone service ground shall be connected to the site ground. This connection to the site ground system shall be adjacent to the MGB.

All telephone equipment's metal parts, such as enclosures, raceways or conduits, and equipment grounding conductors, and all earth grounding electrodes shall be connected into a continuous electrically conductive system.

B.3.15 Transmission Lines

The outer conductor of all coaxial transmission lines and waveguides shall be bonded to the tower at:

a. Its highest practical point on the tower
b. Midpoints along the length of the transmission lines and waveguides in accordance with requirements specifications.
c. The lowest point on the tower via the tower ground bar (TGB)
d. To the cable entry panel ground at the point of entrance to the building.

A common ground point consisting of a copper grounding bar shall be provided to ground the transmission lines at the entrance to the building. This ground bar shall be bonded to the nearest external ground point on the site ground system with a minimum of two 6" copper straps. These straps shall be connected to the internal building ground bar.

This can be achieved by use of internal and an external ground bar connected with copper straps or a commercially available transmission line entrance assembly.

B.3.16 Other Grounding

All other metallic items at each communications site shall be grounded. These include but are not limited to the following items: metal hatches and doors, metal downspouts, roofing and siding, all metal fuel-storage tanks, telephones, electrical and other utility equipment, generators and supports, solar photovoltaic panel supporting structures, and exterior and interior cable trays and ice shields.

B.3.17 Internal Building Grounding

The internal building grounding system shall be designed, furnished and installed in accordance with (b) (7)(E) [redacted] and as further detailed below.

B.3.18 Master Ground Bar (MGB)

A connection to the site ground system shall enter the building at a single point and terminate at a master ground bar. At a minimum, the ground bar shall be in accordance with the (b) (7)(E) [redacted].

The MGB shall be installed adjacent to the AC ground system, and shall consist of a single copper bar with attachment points for internal building grounding. The copper bar shall be connected to the external ground system by exothermic welds, brazing, or welding.

All internal equipment shall be connected to this master ground bar. This includes the telephone system, the electrical system, and RF systems. The CBP prefers adjacent Commercial Power entrance and Cable Entry Panel shelter configurations.

B.3.19 Internal Perimeter Ground Bus (IPGB).

An internal perimeter ground bus system shall be installed to allow low impedance ground connections between the MGB and the ancillary support apparatus, electrical conduits and other metallic items located throughout the shelter

a. The IPGB shall be constructed of green insulated #2 American Wire Gauge (AWG) or coarser stranded copper wire.
b. The IPGB shall be connected to the site ground system at a single point at the MGB.
c. Reference: (b) (7)(E) [redacted].

B.3.20 Connection to Equipment

All stand-alone equipment shall be connected to the internal MGB or RGB if provided. Care shall be taken to minimize the length of the connection to the designated ground bar.

Reference: (b) (7)(E) [redacted] for appropriate bonding methods and (b) (7)(E) for appropriate bonding interconnections and routing.

B.3.21 Connection to Electronic Equipment Racks

All electronic equipment racks, console cabinets, and transmitter cabinets shall be connected to the MGB using #2 AWG stranded copper wire. Reference: (b) (7)(E) [redacted] for appropriate bonding methods and (b) (7)(E) [redacted] for appropriate bonding interconnections and routing.

B.3.22 Roof Mounted Antennas

The steel structure used to support roof-mounted antennas shall be connected to the nearest point on the site ground system.

B.3.23 Grounding Components

B.3.23.1 Ground Rods

a. All ground rods shall be made of copper or copper clad steel and shall be a minimum of 5/8 inch in diameter and eight feet in length.
b. In soils where there is difficulty driving ground rods; 3/4 inch diameter ground rod shall be used.
c. Sections of ground rods may be coupled together using exothermic welds or threaded connectors.
d. Connection from the ground rod to the site ground system conductor shall employ an exothermic weld. Ground rods shall be driven using the proper tool to prevent deformation of the rod.
e. The top of each ground rod shall be driven to the depth of the site ground system.
f. Ground rods shall be driven to a minimum depth of eight feet below the site ground system conductor.
g. In low conductivity soils, ground rods shall be driven as deep as practical to provide a satisfactory ground resistance.
h. Ground rods shall be located a minimum of 36 inches from building foundations, 24 inches from tower foundations and concrete tower piers or concrete footings. Ground rods shall be approximately equally spaced along the site ground system.
i. At sites located on solid rock, or where the subsurface layer is solid rock, where ground rods cannot be installed using conventional methods, a star-shaped ground made up of #2 AWG bare copper conductor shall be installed in place of a ground rod.
j. The number and length of individual conductors in this ground system shall be configured to obtain the grounding resistance goal.
k. The ground system shall be buried as deeply as practical for the soil conditions.

B.3.23.2 Ground Wire

a. Wire for buried ground conductors surrounding buildings (main ground wire) and other structures shall be at a minimum #2AWG solid, bare, tinned or untinned copper.
b. All other grounding wire and connection wire shall consist of bare or green insulated #2 AWG or #6 AWG copper conductors (bonding ground wire) as specified in (b) (7)(E) [redacted]
c. In general, solid wire is to be used in locations where there is no movement between the connections, and stranded wire is to be used where movement is expected.
d. For low impedance signal grounds, copper strap is preferred.

B.3.23.3 Ground Connectors

Exothermic welds shall be used for all ground connections exposed to the elements. In places where exothermic welds are not possible, brazing, silver solder and bolted clamps are acceptable under authorization from the CBP.

Ground connections shall be according to tower manufacturers' guidelines.
All clamps, connectors, bolts, washers, nuts, and other hardware used in the grounding system shall be copper or bronze, except that nuts, bolts, and washers may be stainless steel.

Dissimilar metal mechanical connections shall be made with components specifically designed to reduce the likelihood of galvanic corrosion.

B.3.23.4 Underground Ground Connectors

All buried ground connections shall use exothermic welding techniques except where it presents a specific hazard such as connections to fuel tanks.

All underground metallic structures such as tanks, water lines, sewer lines, and armored cable shall be connected to the grounding system with bare copper cable with a minimum size of #2 AWG.

Appropriate measures shall be taken to prevent corrosion.

B.3.23.5 Rack Mounted Equipment

All electronic equipment racks shall be provided with a single copper bar, with attachment points for grounding electronic equipment.

All equipment shall have a low-impedance connection to the rack ground bar (RGB).

The rack shall be connected to the RGB, and the RGB shall be connected to the MGB in accordance with CBP's standards.

B.3.23.6 Fuel Tanks and Generators

All fuel tanks and generators shall be grounded in accordance with the site specifications.

B.3.23.7 Dissimilar Metals

Dissimilar metal connections are permissible only when connecting the ground system to other systems and appropriate methods to alleviate galvanic corrosion have been made.

a. All ground systems shall consist of copper components. No aluminum shall be used within any grounding system.

b. Connection to racks and other systems where the connection is to a dissimilar metal shall be made with components specifically designed to reduce the likelihood of galvanic corrosion.
c. All screws and hardware used on racks and other electronic connections shall be constructed from similar metals or from stainless steel.
d. Where interconnection between copper ground system components or bus-work and aluminum equipment cabinets or frames is unavoidable, such connections shall be made by using prepared bimetallic strips or by a tinplate to the copper surface where it contacts aluminum.
e. All dissimilar metal grounding connections (aluminum-tin, copper-zinc galvanizing) in exterior locations shall be painted with waterproof sealing compound (Perma-tex or equal) for at least 2 inches on each side of the dissimilar metal connection.

B.3.24 Surge Protection

All electronic equipment within the new System shall be protected with transient voltage surge suppression (TVSS) systems. This is to assure that there are no equipment faults due to power line fluctuations or lighting events.

Contractor shall also provide TVSS systems for all transmission lines, waveguides and data and telephone lines, or any other electrical conductors that extend off of the premises (such as tower lighting) of the communications facility. These systems shall, to the extent possible, be located at the point of entry into the equipment area or equipment shelter. Contractor shall design an appropriate TVSS system for each application. Documentation shall be provided to demonstrate that the proposed system provides adequate TVSS protection for each application.

The transient voltage surge protection system shall be designed, furnished and installed in accordance with (b) (7)(E) [redacted] and as further detailed below.

These standards are to be used in conjunction with engineering judgment for the design, modification, retrofit, installation and maintenance of communications AC power systems, RF equipment, microwave equipment, and other equipment associated with the new System.

The system designers shall consider site-specific information such as cost, site location, relative lightning risk, and power distribution facilities at existing CBP and local government site communications facilities to be shared by CBP, adjacent communication facilities and other pertinent information to design the optimum AC Power Surge Protection system for each site.

B.3.24.1 Undesirable Methods

To the extent that is possible, TVSS systems shall not rely on components that cease to function after a single TVSS event. The systems shall have adequate front panel notification that the failed component requires replacement.

Systems with sacrificial components shall be designed to withstand multiple TVSS events equivalent to 10 years of typical service without component replacement.

B.3.24.2 TVSS Equipment Location

To the extent possible, all TVSS equipments shall be located as close as possible to the AC mains entrance or the building entrance of telephone or data lines after demark point. TVSS equipment on transmission lines and waveguides shall be incorporated into the transmission line or cable entry panel ground bus.

B.3.25 Physical Conditions

B.3.25.1 Environmental Conditions

Equipment shall function properly under the following environmental conditions:

Temperature:	-30°C to +60°C
Storage:	-30°C to +60°C
Humidity:	5% to 95% non-condensing
Altitude:	up to 15,000 ft. (4,267 meters).

B.3.25.2 Operating Requirements

B.3.25.2.1 Protection Modes

Protection shall be provided for all electrical configuration modes, Line-to-Line, Line-to Neutral, Line-to-Ground and Neutral–to-Ground protection as appropriate for Wye or Delta line configurations.

For telephone company and transmission line TVSS devices, these devices shall be in-line and shall prevent any equipment-damaging TVSS event from entering the building.

B.3.25.3 Transmission Line and Waveguide TVSS

These devices shall be an inline device that presents a Voltage Standing Wave Ratio of no more than 1.1:1 to the RF circuit and an insertion loss of no more that 0.05 decibels.

These devices shall be located within two feet of the tower lighting entry point or wall penetration.

The devices shall be sufficient to protect all downstream equipment from any TVSS event.

B.3.25.4 Tower Lighting Protection

All tower lighting circuits shall have TVSS devices to protect the building equipment from any TVSS event that can enter in the tower lighting circuits.

These devices shall be located within two feet of the tower lighting entry point or wall penetration.

All tower lighting cables shall be run in dedicated conduits to the entry/exit point. They shall not be bundled with other cabling.