Canadian Coast Guard
Maritime and Civil Infrastructure

24.40m SELF-SUPPORTED TOWER DESIGN, SUPPLY, AND CONSTRUCTION
MOUNT GIL TOWER
BRITISH COLUMBIA

CANADIAN COAST GUARD
MARITIME AND CIVIL INFRASTRUCTURE
WESTERN REGION

CONTRACT F1705-180002

DATE: FEBRUARY 2018

SPECIFICATIONS:

DRAWINGS:

Part 1 General

1.1 MINIMUM STANDARDS

.1 Perform Work in accordance with the latest edition of the National Building Code of Canada (NBCC) and any other code of provincial, federal, or local application. In the case of any conflict or discrepancy, the more stringent requirements shall apply.

.2 Meet or exceed requirements of:

- .1 Contract documents.
- .2 Specified standards, codes, and reference documents.

1.2 WORK COVERED BY CONTRACT DOCUMENTS

.1 Work of this Contract comprises design, materials, and installation of a 24.40m (80ft) tall self-supported communications tower at the Canadian Coast Guard (CCG) site on Mount Gil. Work includes, but not limited to, the following:

- .1 Design, supply, and installation of a new tower foundation.
- .2 Design, supply, and installation of a new 24.40m (80ft) self-supported tower with work platform.
- .3 Design, supply, and installation of antenna mounts.
- .4 Design, supply, and installation of a new grounding system.

1.3 WORK LOCATION

.1 Work is to be completed at the CCG peripheral Marine Communications and Traffic Services (MCTS) Radio Site on Mount Gil located on the north coast of BC. Appendix A: Site Location / Photos gives site location details and includes some photos of the existing site. Site coordinates are 53° 15’ 46” N - 129° 11’ 42” W.

- .1 The site is accessed via helicopter. The Contractor is responsible for providing all transportation services of materials, equipment and crew to and from the site before and during construction. This also includes any trips required during tendering.
- .2 Before tender closing, Contractors should familiarize themselves with the location, scope of work, site restrictions, and temporary measures required for completing the work as specified.

1.4 WORK BY OTHERS

.1 CCG performs regular maintenance at this site. The Contractor must co-operate with other Contractors in carrying out their respective works and follow instructions from CCG as required.

1.5 CONTRACTOR USE OF PREMISES

.1 Limit use of premises for Work to allow:

- .1 Work by other contractors.
- .2 Co-ordinate use of premises under direction of CCG.

1.6 SUBMITTALS

.1 Mandatory submittals and schedule for submission are detailed below and in Appendix B Summary of Submittals. The following identifies general requirements only. The relevant Sections must be consulted for a complete listing of mandatory content. This summary is not an exhaustive list of all submissions required for the duration of the project, as additional submissions may be required after award.

- .1 Design Package
  - .1 Deadline: 28 days following contract award.
  - .2 Submission to include:
    - .1 Tower drawings stamped and sealed by a qualified Professional Engineer registered in the Province of British Columbia (Section 13 36 13)
    - .2 Foundation design drawings stamped and sealed by a qualified Professional Engineer registered in the Province of British Columbia (Section 03 30 00).
    - .3 Grounding design drawings (Section 26 05 27).
    - .4 Drawings to conform to all requirements outlined in relevant Sections.
- .2 Fabrication Plan
  - .1 Deadline: 28 days following contract award.
  - .2 Submission to include:
    - .1 Tower supply company qualifications to include:
      - .1 Canadian Welding Bureau (CWB) Certification;
      - .2 Proof of 5 previous tower design/fabricate contracts of a similar construction and remote site/helicopter use complexity.
    - .2 Fabrication shop drawings.
    - .3 Schedule indicating:
      - .1 Start and completion dates of fabrication;
      - .2 Delivery of tower to site.
- .3 Construction Plan
  - .1 Deadline: 56 days following contract award.
  - .2 Construction Plan to be of sufficient detail to demonstrate that the Contractor has considered all the challenges of the project and is prepared to undertake the Work in a competent and professional manner in accordance with all legislation.
  - .3 Submission to include:
    - .1 Contractor qualifications including:
      - .1 Core Project member contact information (Site Foreman, and Project Manager).
      - .2 Complete listing of all Subcontractors.
      - .3 Project Health and Safety Plan (Section 01 35 29).
      - .4 Environmental Protection Plan (Section 01 35 43).

.5 Concrete Construction Plan (Section 03 30 00).

.6 Tower Erection Plan (Section 13 36 13).

.7 Grounding Plan (Section 26 05 27).

.4 Supplemental Material

.1 Deadline: 21 days following acceptance of completed Works.

.2 Submission to include:

.1 Project as-built drawings (Section 01 33 00).

.2 Rock anchor pull-test results (Section 01 45 00).

.3 Concrete tests results (Section 01 45 00).

1.7 EXISTING SERVICES

.1 The Work site location does not provide any utilities or services for Contractor use.

.2 Contractor to pay for and provide temporary: water supply, sanitary facilities, and electrical power supply in accordance with governing regulations and ordinances.

.1 Sanitary facilities to be in good repair and adequately secured to prevent spills or contamination from reaching the site.

.3 Take care to safeguard any existing structures and/or equipment. Upon completion of Work, all rejected materials, materials declared surplus by CCG, and debris to be removed from the site.

1.8 DOCUMENTS REQUIRED

.1 Maintain at job site, one copy each document as follows:

.1 Health and Safety Plan and Other Safety Related Documents (Section 01 35 29).

.2 Environmental Protection Plan (Section 01 35 43).

.3 Other documents as specified.

1.9 FEES, PERMITS, AND CERTIFICATES

.1 Contractor to pay fees, obtain certificates and permits, and provide information to authorities having jurisdiction where required.

.1 Contractor to provide copies to CCG of any documentation submitted to other authorities related to the Work.

.2 Contractor to furnish certificates and permits when requested.

Part 2 Products

2.1 NOT USED

.1 Not used.

Part 3 Execution

3.1 WORK COMPLETION DEADLINES

.1 All work to be completed by October 31, 2018

END OF SECTION

Part 1 General

1.1 ACCESS AND EGRESS

.1 Design, construct and maintain temporary "access to" and "egress from" work areas, including foundations, storage areas, ramps or ladders, and helipad, independent of finished surfaces and in accordance with relevant municipal, provincial and other regulations.

1.2 HELICOPTER OPERATIONS

.1 Helicopters and helicopter cranes used for external load lifting during construction, maintenance and demolition activities shall comply with any and all applicable regulations of the Canadian Aviation Regulations (CAR), SOR/96-433 for helicopter external sling load operations.

.2 Every practical precaution shall be taken to provide for the protection of the employees from flying objects in the rotor downwash. All loose gear, equipment and materials within 100 feet of the load lifting area and setting the load, and all other areas susceptible to rotor downwash, shall be secured or removed.

.3 Maintain constant, reliable communication between the pilot and a competent rigger. Signal systems between aircrew and ground personal shall be checked and understood in advance of hoisting the load. This applies to either radio or hand signal systems.

.4 Train the construction crew in advance of any helicopter external sling operations.

1.3 USE OF SITE AND FACILITIES

.1 Execute work with least possible interference or disturbance to normal use of premises. Make arrangements with Canadian Coast Guard (CCG) to facilitate work as stated.

.2 Where Work involves connecting to existing services, give CCG 5 working days of notice for necessary interruption of mechanical or electrical services throughout the course of Work. Keep duration of interruptions to a minimum.

.3 The existing CCG equipment building can be used as a temporary tool and equipment storage area and an emergency shelter.

.4 The existing CCG equipment building must be kept clean at all times. All waste materials are to be removed promptly from site.

.5 The Contractor will be accompanied on site at all times with 1 CCG representative. Provide helicopter transport for CCG representative with work crews.

Part 2 Products

2.1 NOT USED

.1 Not used.

Part 3 Execution

3.1 NOT USED

.1 Not used.

END OF SECTION

Part 1 General

1.1 ADMINISTRATIVE

.1 Submit to Canadian Coast Guard (CCG) submittals listed for review. Submit promptly and in orderly sequence to not cause delay in Work. Failure to submit in ample time is not considered sufficient reason for extension of Contract Time and no claim for extension by reason of such default will be allowed.

.2 Do not proceed with Work affected by submittal until review is complete.

.3 The CCG Representative will review the submittal within 7 calendar days following submission and will notify the Contractor of the status of its general conformance. Changes may be required if not in conformance to CCG specifications and it is the Contractors responsibility to ensure there are no resulting delays to the agreed deadlines.

.4 Present drawings, product data, samples and mock-ups in SI Metric units.

.5 Where items or information is not produced in SI Metric units converted values are acceptable.

.6 Review submittals prior to submission to CCG. This review represents that necessary requirements have been determined and verified, or will be, and that each submittal has been checked and co-ordinated with requirements of Work and Contract Documents.

.7 Notify CCG, in writing at time of submission, identifying deviations from requirements of Contract Documents stating reasons for deviations.

.8 Contractor's responsibility for errors and omissions in submission is not relieved by CCG’s review of submittals.

.9 Contractor's responsibility for deviations in submission from requirements of Contract Documents is not relieved by CCG’s review, unless CCG gives written acceptance of specific deviations.

1.2 SHOP DRAWINGS

.1 The term "shop drawings" means drawings, diagrams, illustrations, schedules, performance charts, brochures and other data which are to be provided by Contractor to illustrate details of a portion of Work.

.2 Submit drawings stamped and signed by professional engineer registered or licensed in British Columbia, Canada.

.3 Indicate materials, methods of construction and attachment or anchorage, erection diagrams, connections, explanatory notes and other information necessary for completion of Work. Where articles or equipment attach or connect to other articles or equipment, indicate that such items have been co-ordinated, regardless of Section under which adjacent items will be supplied and installed. Indicate cross references to design drawings and specifications.

.4 Allow 7 calendar days, or as otherwise stipulated in the specifications, for CCG to review of each submission.

.5 Adjustments made on shop drawings by CCG are not intended to change Contract Price. If adjustments affect value of Work, state such in writing to CCG and await authorization prior to proceeding with Work.

.6 Make changes in shop drawings as CCG may require, consistent with Contract Documents. When resubmitting, notify CCG in writing of revisions other than those requested.

.7 Accompany submissions with transmittal letter containing:

- .1 Date.
- .2 Project title and number.
- .3 Contractor's name and address.
- .4 Identification and quantity of each shop drawing, product data and sample.
- .5 Other pertinent data.

.8 Submissions include:

- .1 Date and revision dates.
- .2 Project title and number.
- .3 Name and address of:
  - .1 Subcontractor.
  - .2 Supplier.
  - .3 Manufacturer.
- .4 Details of appropriate portions of Work as applicable:
  - .1 Fabrication.
  - .2 Layout, showing dimensions, including identified field dimensions, and clearances.
  - .3 Setting or erection details.
  - .4 Capacities.
  - .5 Performance characteristics.
  - .6 Standards.
  - .7 Operating weight.
  - .8 Wiring diagrams.
  - .9 Single line and schematic diagrams.
  - .10 Relationship to adjacent work.

.9 After CCG’s review, distribute copies.

.10 Submit electronic copies of shop drawings for each requirement requested in specification Sections and as CCG may reasonably request.

.11 Submit 3 copies of product data sheets or brochures for requirements requested in specification Sections and as requested by CCG where shop drawings will not be prepared due to standardized manufacture of product.

.12 Submit electronic copies of test reports for requirements requested in specification Sections and as requested by CCG.

.1 Report signed by authorized official of testing laboratory that material, product or system identical to material, product or system to be provided has been tested in accord with specified requirements.

.2 Testing must have been within 3 years of date of contract award for project.

.13 Submit electronic copies of certificates for requirements requested in specification Sections and as requested by CCG.

.1 Statements printed on manufacturer's letterhead and signed by responsible officials of manufacturer of product, system or material attesting that product, system or material meets specification requirements.

.2 Certificates must be dated after award of project contract complete with project name.

.14 Submit electronic copies of Manufacturer's Field Reports for requirements requested in specification Sections and as requested by CCG.

.15 Documentation of the testing and verification actions taken by manufacturer's representative to confirm compliance with manufacturer's standards or instructions.

.16 Submit electronic copies of Operation and Maintenance Data for requirements requested in specification Sections and as requested by CCG.

.17 Delete information not applicable to project.

.18 Supplement standard information to provide details applicable to project.

.19 If upon review by CCG, no errors or omissions are discovered or if only minor corrections are made, copies will be returned and fabrication and installation of Work may proceed. If shop drawings are rejected, noted copy will be returned and resubmission of corrected shop drawings, through same procedure indicated above, must be performed before fabrication and installation of Work may proceed.

.20 The review of shop drawings by CCG is for sole purpose of ascertaining conformance with general concept.

.1 This review shall not mean that CCG approves detail design inherent in shop drawings, responsibility for which shall remain with Contractor submitting same, and such review shall not relieve Contractor of responsibility for errors or omissions in shop drawings or of responsibility for meeting requirements of construction and Contract Documents.

.2 Without restricting generality of foregoing, Contractor is responsible for dimensions to be confirmed and correlated at job site, for information that pertains solely to fabrication processes or to techniques of construction and installation and for co-ordination of Work of sub-trades.

1.3 DESIGN DRAWINGS AND PLANS

.1 Submit drawings stamped and signed by a professional engineer registered or licensed in British Columbia, Canada. The Tower Design Engineer and the Foundation Design Engineer are to have at least 5 years of experience in tower design to CSA S37.

.2 Allow 7 calendar days, or as otherwise stipulated in the specifications, for CCG to review of each submission.

.3 Any changes to engineering plans must be approved by CCG. Changes are to be highlighted on engineering plans and an As-Built set of engineering plans are to be submitted at the conclusion of the project.

.4 Indicate materials, connections, explanatory notes and other information necessary for completion of Work.

.5 Accompany submissions with transmittal letter containing:

- .1 Date.
- .2 Project title and number.
- .3 Other pertinent data.

.6 Submissions include:

- .1 Date and revision dates.
- .2 Project title and number.
- .3 Name and address of:
  - .1 Subcontractor.
  - .2 Supplier.
  - .3 Manufacturer.
- .4 Details of appropriate portions of Work as applicable:
  - .1 All details required by specifications and information specified in CSA S37-13.
  - .2 Reference design standards.
  - .3 All design loads for specified load conditions.
  - .4 All analysis, calculations, and reactions for foundations and tower. A capacity profile of tower giving designed % load capacity for tower legs, diagonals, and foundations.
  - .5 Leg diameters for each section, types of connections, and typical details.
  - .6 Details of ice guards, attachments of antennas, anti-climb devices, and transmission line placement.
  - .7 Details of the grounding system and cable requirements.
  - .8 Any other information deemed relevant by the Engineer of Record.

.7 Submit electronic and 2 printed copies of drawings for each requirement requested in specification Sections and as CCG may reasonably request.

1.4 PHOTOGRAPHIC DOCUMENTATION

.1 Submit electronic digital photography in jpg format, standard resolution at completion of Work or as directed by CCG.

.2 Name photo files in the format of: SiteName_item_date.jpeg.

.3 Take photographs of work completed clearly showing location of installed equipment. Photographs of the tower and mounting brackets to be taken further back to clearly indicate as much information as possible which will help for future additions.

1.5 AS-BUILT DRAWINGS

.1 Submit As-builts, including digital photographs and scanned redline drawings, within 21 days following completion of Work to CCG in CD format.

.2 As-built CD to be labelled for easy identification including:

- .1 Date.
- .2 Project title and number.
- .3 Contractor's name.
- .4 Other pertinent data.

.3 Submissions include:

- .1 1 page report summarizing Work completed or not completed.
- .2 Redlined drawings containing:
  - .1 Any changes or variations from the original design drawings clearly identified in red markings.
  - .2 Antenna type and model specified when there is a change in the scope of work.
- .3 Construction photographs clearly showing completion of Work and any changes of variations from the original design documents corresponding to redlined drawings.
- .4 Drawings of new hardware (if applicable).
- .5 1 page signed and stamped letter from the Tower Design Engineer stating that Work relevant to their design has been completed to their satisfaction and in accordance with their design.
- .6 1 page signed and stamped letter from the Foundation Design Engineer stating that Work relevant to their design has been completed to their satisfaction and in accordance with their design.
- .7 Any other information deemed relevant by the Engineer of Record.

Part 2 Products

2.1 NOT USED

.1 Not used.

Part 3 Execution

3.1 NOT USED

.1 Not used.

END OF SECTION

Part 1 General

1.1 REFERENCE STANDARDS

.1 Canada Labour Code, Part 2, Canada Occupational Safety and Health Regulations

.2 Province of British Columbia

- .1 Workers Compensation Act, RSBC 1996.
- .2 WorkSafeBC Occupational Health and Safety Regulation.

1.2 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit in accordance with Section 01 33 00- Submittal Procedures.

.2 Submit site-specific Health and Safety Plan: Within 56 days following contract award. Health and Safety Plan must include:

- .1 Results of site specific safety hazard assessment.
- .2 Listing of all activities specific to the project and their Health and Safety risks or hazards.
- .3 Detailed descriptions of how the activities are to be carried out as well as methods for mitigating hazards and risks.
- .4 Listing of personnel responsible for Health and Safety measures, and Emergency procedures.
- .5 Proof of training for all employees working at heights and proof of rescue training for at least one employee working on site.

.3 Canadian Coast Guard (CCG) will review Contractor's site-specific Health and Safety Plan and provide comments to Contractor within 7 calendar days.

.4 CCG’s review of Contractor's final Health and Safety plan should not be construed as approval and does not reduce the Contractor's overall responsibility for construction Health and Safety.

1.3 GENERAL REQUIREMENTS

.1 Develop written site-specific Health and Safety Plan based on hazard assessment prior to beginning site Work and continue to implement, maintain, and enforce plan until final demobilization from site. Health and Safety Plan must address project specifications.

.2 CCG may respond in writing, where deficiencies or concerns are noted and may request re-submission with correction of deficiencies or concerns.

1.4 RESPONSIBILITY

.1 Be responsible for health and safety of persons on site, safety of property on site and for protection of persons adjacent to site and environment to extent that they may be affected by conduct of Work.

.2 Comply with and enforce compliance by employees with safety requirements of Contract Documents, applicable federal, provincial, territorial and local statutes, regulations, and ordinances, and with site-specific Health and Safety Plan.

1.5 COMPLIANCE REQUIREMENTS

.1 Comply with Workers Compensation Act, B.C.

.2 Comply with WorkSafeBC Occupational Health and Safety Regulation.

.3 Comply with Canada Labour Code, Canada Occupational Safety and Health Regulations.

1.6 UNFORSEEN HAZARDS

.1 When unforeseen or peculiar safety-related factor, hazard, or condition occur during performance of Work, follow procedures in place for Employee's Right to Refuse Work in accordance with Acts and Regulations of Province having jurisdiction and advise CCG verbally and in writing.

1.7 HEALTH AND SAFETY CO-ORDINATOR

.1 Employ and assign to Work, competent and authorized representative as Health and Safety Co-ordinator. Health and Safety Co-ordinator must:

  .1 Have site-related working experience specific to activities of the Work.

  .2 Have working knowledge of occupational safety and health regulations.

  .3 Be responsible for completing Contractor's Health and Safety Training Sessions and ensuring that personnel not successfully completing required training are not permitted to enter site to perform Work.

  .4 Be responsible for implementing, enforcing daily and monitoring site-specific Contractor's Health and Safety Plan.

  .5 Be on site during execution of Work.

1.8 CORRECTION OF NON-COMPLIANCE

.1 Immediately address health and safety non-compliance issues identified by authority having jurisdiction or by CCG.

.2 CCG may stop Work if non-compliance of health and safety regulations is not corrected.

1.9 WORK STOPPAGE

.1 Give precedence to safety and health of public and site personnel and protection of environment over cost and schedule considerations for Work.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION

Part 1 General

1.1 REFERENCE STANDARDS

.1 Canadian Environmental Protection Act (CEPA)

.2 Canadian Environmental Assessment Act, 2012 (CEAA)

1.2 DEFINITIONS

.1 Environmental Pollution and Damage: presence of chemical, physical, biological elements or agents which adversely affect human health and welfare; unfavourably alter ecological balances of importance to human life; affect other species of importance to humans; or degrade environment aesthetically, culturally and/or historically.

.2 Environmental Protection: prevention/control of pollution and habitat or environment disruption during construction.

1.3 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit Environmental Protection Plan: Within 56 days following contract award and before commencing construction activities or delivery of materials to site.

.3 Environmental Protection Plan must include comprehensive overview of known or potential environmental issues to be addressed during construction.

.4 Address topics at level of detail commensurate with environmental issue and required construction tasks.

.5 Include in Environmental Protection Plan:

   .1 Name of person responsible for ensuring adherence to Environmental Protection Plan.

   .2 Name and qualifications of person responsible for manifesting hazardous waste to be removed from site.

   .3 Name and qualifications of person responsible for training site personnel.

   .4 Drawings indicating locations of proposed temporary excavations or embankments for material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on site.

   .5 Work area plan showing proposed activity in each portion of area and identifying areas of limited use or non-use.

      .1 Plan to include measures for marking limits of use areas and methods for protection of features to be preserved within authorized work areas. Plan to indicate staging, refueling, and cleaning areas.

   .6 Spill Control Plan to include procedures, instructions, and reports to be used in event of unforeseen spill of regulated substance.

   .7 Non-Hazardous solid waste disposal plan identifying methods and locations for solid waste disposal including clearing debris.

.8 Contaminant Prevention Plan identifying potentially hazardous substances to be used on job site; intended actions to prevent introduction of such materials into air, water, or ground; and detailing provisions for compliance with Federal, Provincial, and Municipal laws and regulations for storage and handling of these materials.

.9 Waste Water Management Plan identifying methods and procedures for management and discharge of waste waters which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, disinfection water, hydrostatic test water, and water used in flushing of lines.

.10 Historical, archaeological, cultural resources biological resources and wetlands plan that defines procedures for identifying and protecting historical, archaeological, cultural resources, biological resources and wetlands.

.11 Equipment to be used on site identifying age and spill containment procedures.

1.4 FIRES

.1 Fires and burning of rubbish on site is not permitted.

1.5 DRAINAGE

.1 Provide temporary drainage and pumping required to keep excavations and site free from water.

.2 Ensure pumped water into waterways is free of suspended materials.

.3 Control disposal or runoff of water containing suspended materials or other harmful substances in accordance with local authority requirements.

1.6 SITE CLEARING AND PLANT PROTECTION

.1 Protect trees and plants on site and adjacent properties as indicated.

.2 Only clear vegetation that interferes with construction.

.3 Minimize stripping of topsoil and vegetation.

.4 Restrict tree removal to areas designated by CCG.

1.7 POLLUTION CONTROL

.1 Maintain temporary erosion and pollution control features installed under this Contract.

.2 Provide methods, means, and facilities to prevent the contamination of soil, water, and atmosphere from the discharge of pollutants produced by construction operations.

.3 Vehicles, machinery, and equipment shall be in good repair, equipped with emission controls as applicable and operated within regulatory requirements.

.4 Avoid unnecessary idling of vehicles or heavy machinery.

.5 Cover or wet down dry materials and rubbish to prevent blowing dust and debris.

1.8 NOTIFICATION

.1 CCG will notify Contractor in writing of observed noncompliance with Federal, Provincial or Municipal environmental laws or regulations, permits, and other elements of Contractor's Environmental Protection plan.

.2 Contractor: after receipt of such notice, inform CCG of proposed corrective action and take such action for approval by CCG.

.3 CCG will issue stop order of work until satisfactory corrective action has been taken.

.4 No time extensions granted or equitable adjustments allowed to Contractor for such suspensions.

Part 2 Products

2.1 NOT USED

.1 Not Used.

Part 3 Execution

3.1 CLEANING

.1 Progress Cleaning: Leave Work area clean at end of each day.

.2 Do not bury rubbish and waste materials on site.

.3 Final Cleaning: upon completion remove surplus materials, rubbish, tools and equipment.

.4 Waste Management: separate waste materials for recycling or reuse from materials for disposal.

  .1 Remove recycling containers and bins from site and dispose of materials at appropriate facility.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

.1 Section 03 30 00 – Concrete Work

.2 Section 13 36 13 - Steel Towers

1.2 INSPECTION

.1 Allow Canadian Coast Guard (CCG) access to Work. If part of Work is in preparation at locations other than Place of Work, allow access to such Work whenever it is in progress.

.2 Give timely notice requesting inspection if Work is designated for special tests, inspections or approvals by CCG instructions, or law of Place of Work.

.3 If Contractor covers or permits to be covered Work that has been designated for special tests, inspections or approvals before such is made, uncover such Work, have inspections or tests satisfactorily completed and make good such Work.

.4 CCG will order part of Work to be examined if Work is suspected to be not in accordance with Contract Documents. If, upon examination such work is found not in accordance with Contract Documents, correct such Work and pay cost of examination and correction. If such Work is found in accordance with Contract Documents, CCG shall pay cost of examination and replacement.

.5 The below list identifies key milestones where the Canadian Coast Guard will require an opportunity to take samples/inspect:

- .1 Tower fabrication: CCG will inspect the tower and associated components after the fabrication work is complete and prior to site installation.
- .2 Rock anchor installation: CCG will be on site while Contractor performs rock anchor pull-tests and verify size and quantity of anchors prior to concrete or surrounding grout installation. The Contractor is to provide documented results of the pull-test to CCG.
- .3 Reinforcing steel installation: CCG will inspect rebar for concrete foundations prior to placing concrete, or, at CCG’s discretion, request photographic documentation to be reviewed prior to concrete pour.
- .4 Concrete formwork: CCG will inspect formwork prior to placing concrete.
- .5 Concrete testing: The Contractor is to arrange an independent testing agency to test concrete for air content, slump, and compressive strength during the concrete pour. The Contractor is to arrange, coordinate, and supply transport to and from the work site for the testing agency representative on the day of the pour. The testing to include at minimum 6 cylinders (one 7 day, two 28 day, and three extras). Documented results of this test is to be submitted to CCG.
- .6 Final completion: CCG will conduct a final inspection upon completion.

1.3 INDEPENDENT INSPECTION AGENCIES

.1 Work done by the Independent Inspection/Testing Agencies services for purpose of inspecting and/or testing portions of Work will be paid by CCG.

.2 Employment of inspection/testing agencies does not relax responsibility to perform Work in accordance with Contract Documents.

.3 If defects are revealed during inspection and/or testing, the appointed agency will request additional inspection and/or testing to ascertain full degree of defect. Corrected defects and irregularities are at no cost to CCG and must be borne by the Contractor. The Contracts must pay costs for retesting and re-inspection by testing agency.

1.4 ACCESS TO WORK

.1 Allow inspection/testing agencies access to Work, off site manufacturing and fabrication plants.

.2 Co-operate to provide reasonable facilities for such access.

1.5 PROCEDURES

.1 Notify appropriate agency and CCG in advance of requirement for tests, in order that attendance arrangements can be made.

.2 Submit samples and/or materials required for testing, as specifically requested in specifications. Submit with reasonable promptness and in orderly sequence to not cause delays in Work.

.3 Provide labour and facilities to obtain and handle samples and materials on site. Provide sufficient space to store and cure test samples.

.4 Provide access to site if the site is of remote nature whereby the Contractor is responsible for providing access to the site.

.5 All work to be completed in compliance with the Specifications before requesting the visit for inspection. If the Work is not completed or deemed non-compliant, the Contractor shall be responsible for all costs incurred for subsequent inspections.

1.6 REJECTED WORK

.1 Remove defective Work, whether result of poor workmanship, use of defective products or damage and whether incorporated in Work or not, which has been rejected by CCG as failing to conform to Contract Documents. Replace or re-execute in accordance with Contract Documents.

1.7 TESTS AND MIX DESIGNS

.1 Furnish test results and mix designs as requested.

1.8 MILL TESTS

.1 Submit mill test certificates as required of specification Sections or as otherwise requested by CCG.

Part 2 Products

2.1 NOT USED

.1 Not used.

Part 3 Execution

3.1 NOT USED

.1 Not used.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

.1 Section 03 30 00 - Cast-In-Place Concrete

1.2 REFERENCE STANDARDS

.1 CSA-A23.1/A23.2, Concrete Materials and Methods of Concrete Construction/Test Methods and Standard Practices for Concrete.

.2 CAN/CSA-A23.3, Design of Concrete Structures.

.3 CSA-G30.18, Carbon Steel Bars for Concrete Reinforcement.

.4 CSA-G40.20/G40.21, General Requirements for Rolled or Welded Structural Quality Steel/Structural Quality Steel.

.5 CSA W186, Welding of Reinforcing Bars in Reinforced Concrete Construction.

.6 National Building Code of Canada

1.3 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store and handle materials in a manner which prevents contamination or damage.

.2 Clean all loose scaly rust, dirt, oil, paint, or other coatings that may be detrimental from reinforcement prior to being placed.

Part 2 Products

2.1 MATERIALS

.1 All reinforcement steel to be of size and grade as per the engineered design drawings.

2.2 FABRICATION

.1 Fabricate reinforcing steel in accordance with CSA-A23.1/A23.2.

.2 Obtain Engineer of Record’s written approval for locations of reinforcement splices other than those shown on placing drawings.

.3 Upon approval of Engineer of Record, weld reinforcement in accordance with CSA W186.

.4 Ship bundles of bar reinforcement, clearly identified in accordance with bar bending details and lists.

2.3 SOURCE QUALITY CONTROL

.1 Upon request, provide CCG with certified copy of mill test report of reinforcing steel, showing physical and chemical analysis.

.2 Upon request, inform CCG of proposed source of material to be supplied.

Part 3 Execution

3.1 FIELD BENDING

.1 Do not field bend or field weld reinforcement except where indicated or authorized by the Engineer of Record.

.2 When field bending is authorized, bend without heat, applying slow and steady pressure.

.3 Replace bars, which develop cracks or splits.

3.2 PLACING REINFORCEMENT

.1 Place reinforcing steel as indicated on engineered design drawings.

.2 Ensure cover to reinforcement is maintained during concrete pour.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

.1 Section 03 20 00 - Concrete Reinforcement.

1.2 REFERENCE STANDARDS

.1 Work under this section to be in compliance will all listed references. In the case of conflict or discrepancy, the more stringent shall apply:

- .1 CSA A23.1, Concrete Materials and Methods of Concrete Construction;
- .2 CSA A23.2, Methods of Test and Standard Practices for Concrete;
- .3 CSA A23.3, Design of Concrete Structures;
- .4 CSA S269.3 Concrete Formwork;
- .5 National Building Code of Canada;
- .6 ACI Specification 306 Cold Weather Concreting (if applicable).

1.3 SCOPE OF WORK

.1 Work in this section includes the design of:

- .1 Reinforced concrete tower foundation including anchorage to bedrock;

.2 Work in this section includes the supply of all labour, material, and equipment necessary to complete the following activities:

- .1 Construction of the tower foundation;

1.4 PERFORMANCE REQUIREMENTS

.1 The Work shall be designed to perform as reasonably expected for a life of 50 years.

1.5 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit in accordance with Section 01 33 00- Submittal Procedures.

.2 Submit Foundation Design Drawings: Within 28 days following contract award and before commencing construction activities or delivery of materials to site. Submission to include:

- .1 Drawings showing locations, plans and section views of the foundations;
- .2 Drawings showing reinforcement steel, anchorage steel and bonding to bedrock and required anchorage pull-test results;
- .3 Other information listed in Section 01 33 00 – Submittal Procedures.

.3 Submit Concrete Construction Plan: Within 56 days following contract award and as part of the Construction Plan in accordance with Section 01 11 00 – Summary of Work, and before commencing construction activities or delivery of materials to site. Submission to include:

- .1 High level summary of mix properties and admixtures to demonstrate compliance with CCG criteria and Foundation Design Drawings;

.2 Concrete placing plan identifying the location of the source of ready mix concrete, the transport and placement plan and any other relevant information required to demonstrate a plan for placing the concrete in the required amount of time;

.3 Finishing procedures;

.4 Curing methods and schedule;

.5 Clean-up procedures;

.6 Procedures to place and cure concrete in hot or cold temperatures where reasonably anticipated during the construction period.

.4 Provide testing results reports for review by CCG and Foundation Engineer and do not proceed without written approval when deviations from mix design or parameters are found.

.5 Concrete hauling time: provide for review by Foundation Engineer.

1.6 QUALITY ASSURANCE

.1 Quality Assurance: in accordance with Section 01 45 00 - Quality Control.

.2 Concrete cylinders to be broken to determine foundation strength prior to tower erection.

1.7 DESIGN REQUIREMENTS

.1 Foundation Engineer: design a suitable foundation for the tower in consideration as per:

.1 The loading provided by the Tower Engineer and in the Specifications;

.2 Any other loads that could be reasonably anticipated to affect the foundation; and

.3 The specific site soil conditions provided in Appendix E – Geotechnical Assessment Report.

.2 Foundation to be designed by a qualified Professional Engineer registered in British Columbia with a minimum of 5 years’ experience in tower foundation design.

Part 2 Products

2.1 PERFORMANCE CRITERIA

.1 Quality Control Plan: ensure concrete supplier meets performance criteria of concrete as established by Foundation Engineer and provide verification of compliance as described in PART 1 - QUALITY ASSURANCE.

2.2 MIXES

.1 Concrete mix to be determined by Contractor and shall meet specifications on Foundation Design Drawings.

.2 The use of calcium chloride as an admixture is not permitted.

Part 3 Execution

3.1 PREPARATION

.1 Allow for CCG to review rock anchors, reinforcing steel and formwork prior to placing concrete.

.2 Obtain CCG's written approval before placing concrete.

.3 Place, finish, and cure concrete in accordance with the Contractor's submitted Concrete Construction Plan and the Foundation Design Drawings.

.4 Place concrete reinforcing in accordance with Section 03 20 00 - Concrete Reinforcing.

.5 During concreting operations:

- .1 Development of cold joints is not allowed unless otherwise approved in writing by CCG.
- .2 Ensure concrete delivery and handling facilitates placing with minimum of re-handling, and without damage to existing structure or Work.

.6 Ensure reinforcement and inserts are not disturbed during concrete placement.

3.2 INSTALLATION/APPLICATION

.1 Do cast-in-place concrete work to CSA A23.1/A23.2.

.2 Finishing and curing:

- .1 Finish concrete to CSA A23.1/A23.2 making all adjustments necessary to account for climatic conditions anticipated during the curing period.
- .2 Provide a lightly brushed non-skid surface on exposed concrete surfaces, unless otherwise specified in the submitted design.
- .3 Finish concrete so as to slope gently away from the center of the slab. No water shall pond on the finished surface.
- .4 Provide appropriate chamfers at all exposed concrete edges.

.3 Provide samples as required for the performance of quality assurance testing.

3.3 FIELD QUALITY CONTROL

.1 Arrange for concrete testing in accordance with Section 01 45 00 – Quality Control and submit report.

.2 Inspection and testing of concrete and concrete materials will be carried out by testing laboratory designated by CCG in accordance with Section 01 45 00 – Quality Control.

.3 Allow for CCG to monitor any concrete pour and provide minimum 3 working days' notice prior to placement of any concrete.

3.4 CLEANING

.1 Clean in accordance with Section 01 35 43 – Environmental Procedures.

END OF SECTION

Part 1 General

1.1 REFERENCE STANDARDS

.1 Work under this section to be in compliance will all listed references. In the case of conflict or discrepancy, the more stringent shall apply:

- .1 CSA S37-13, Antenna, Towers, and Antenna Supporting Structures;
- .2 CSA G40.20, General Requirements for Rolled or Welded Structural Quality Steel;
- .3 CSA G40.21, Structural Quality Steel;
- .4 CSA W47.1, Certification of Companies for Fusion Welding of Steel Structures;
- .5 CSA W59, Welded Steel Construction (Metal-Arc Welding);
- .6 ASTM A123 / A123M, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products;
- .7 Canada Labour Code Part II;
- .8 Health and Welfare Canada Limits of Exposure to Radio-Frequency Fields Frequencies from 3kHz – 300GHz, Safety Code 6;
- .9 WorkSafeBC Occupational Health and Safety Regulation;
- .10 National Building Code of Canada;
- .11 TC CAR Standard 621.19, Standards Obstruction Markings;
- .12 SSPC-SP 1, Solvent Cleaning;
- .13 SSPC-SP 7/NACE No. 4, Brush-Off Blast Cleaning.

1.2 SCOPE OF WORK

.1 Work in this section includes the supply of all labour, material, and equipment necessary to complete the following activities:

- .1 Design, supply, and installation of a new 24.40m (80ft) tall self-supported tower;
- .2 Supply and install of a Trylon Cougar Rail fall arrest system or CCG approved equivalent; and
- .3 Design, supply and installation of antenna mounts for antennas identified in Appendix F: Antenna Layout Drawing excluding antennas noted as “future.”

1.3 PERFORMANCE REQUIREMENTS

.1 The Work shall be designed to perform as reasonably expected for a life of 50 years.

1.4 GUARANTEE

.1 The Contractor shall guarantee that all material and workmanship used in the fabrication and construction of this tower is in accordance with all applicable specifications listed in the Section.

.2 For a period of one year from the date of the installation, the Contractor shall replace, free of charge, all defective component. A failure of 10% or more of a particular item shall be interpreted as failure in all similar units. All these items shall be replaced by units of a superior design at no cost to CCG.

1.5 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit Tower Design Drawings: Within 28 days following contract award and before commencing construction activities or delivery of materials to site. Submission to include:

- .1 Drawings indicating:
  - .1 Plan and section views of the tower; and
  - .2 Other requirements identified in this section.
- .2 Other information listed in Section 01 33 00 – Submittal Procedures.

.3 Submit Tower Fabrication Plan: Within 56 days following contract award and in accordance with Section 01 11 00 - Summary of Work. Contractor to obtain written approval from CCG prior to beginning fabrication.

.4 Submit Tower Erection Plan: Within 56 days following contract award and as part of the Construction Plan in accordance with Section 01 11 00 – Summary of Work, and before commencing construction activities or delivery of materials to site. Submission to include:

- .1 Procedures and methods to be employed to:
  - .1 Place new tower on new foundation;
  - .2 Monitor that turn of nut has been completed;
  - .3 Remedy any damage to the coating system incurred during erection.
- .2 CCG reserves the right to request additional documentation verifying the suitability

.5 Provide testing results reports for review by CCG and Foundation Engineer and do not proceed without written approval when deviations from mix design or parameters are found.

1.6 QUALITY ASSURANCE

.1 Quality Assurance: in accordance with Section 01 45 00 - Quality Control.

1.7 DESIGN REQUIREMENTS

.1 Design a tower in accordance with CSA S37-13 to support all equipment indicated on Appendix F: Antenna Layout Drawing. The tower must be capable of supporting all initial and future antenna loading requirements.

.2 Design all tower accessories including: new mounts for all equipment and climbing facility with a fall arrest assembly.

.3 Tower to be designed by a qualified Professional Engineer registered in British Columbia with a minimum of 5 years' experience in tower design to CSA S37.

.4 Tower to be designed to resist: all loads specified in CSA S37-13, maximum loads caused by all immediate and future equipment installed on the tower, and site specific wind pressure supplied in Appendix C – Site Specific Wind Pressure Report.

.5 Unless otherwise specified, determine loading in accordance with CSA S37-13, latest edition, reliability Class I.

.6 Tower to be designed for a minimum radial ice load of +25mm (Class II).

.7 The operational requirement for maximum twist is 0.05 degrees.

.8 The operational requirement for maximum tilt is 0.5 degrees.

.9 Each tower section must be in 3.05m lengths.

.10 Provide concrete foundations such that all steel not encased in concrete is above finished grade.

.11 Tower to be designed to support a High Gain X-Band SWG Antenna (Antenna #1) with the following allowances:

  .1 Antenna Specifications:

    .1 Weight: 400kg

    .2 Dimensions: H x L x W: 1100mm x 6560mm x 1280mm for the complete unit.

    .3 Lateral force: 6200N

    .4 Turning Unit Base Torque: 730N*m

.12 Tower to be designed and include a work platform with the following specifications:

    .1 DL: Self weight of the platform

    .2 LL: 4.8 kPa Live Load

    .3 Minimum dimensions: H x L x W: 1500mm x 4500mm x 4500mm

    .4 Materials: Galvanized Steel frame construction with guardrails all around the perimeter.

    .5 Platform to meet applicable regulations and fit for use for CCG workers performing maintenance activities on the High Gain X-Band SWG Antenna (Antenna #1). Such regulations include, but not limited to, WorkSafeBC Occupational Health and Safety Regulation as it relates to guardrails and the latest edition of the National Building Code of Canada for the design and fabrication standard of the platform.

.13 Anchorage steel below grade that is not encased in concrete shall be galvanized and further corrosion protection shall be provided.

Part 2 Products

2.1 GENERAL

.1 Structural steel to be grade 300W or better.

.2 All mounts, mount hardware, and line hangers shall be heavy-duty hot-dip galvanized.

.3 All tower and anchor hardware, where possible, including turnbuckles, thimbles and shackles shall be Crosby products or approved equivalent, manufactured from AISI 1035 steel, heat treated, and shall be hot-dip galvanized.

.4 Bolts shall be hot-dip galvanized with hexagonal heads and be supplied with hexagonal nuts. The unthreaded part of the bolt shall be long enough for full bearing of the adjoining parts and enough washers shall be placed on each bolt under the nut to prevent the nut from reaching the end of the bolt threads when tightened.

Part 3 Execution

3.1 FABRICATION

.1 Provide to CCG a copy of Canadian Welding Bureau (CWB) certification for the tower fabricating company and for each worker assigned to the project.

.2 Designate each tower segment with a number that is easily read after galvanizing. Stamp the mark into each piece in such a manner, or in such a place, as will not injure or reduce the strength of the piece. The marks on like pieces shall be in the same relative position on each piece. The markings on each piece shall correspond with the shown on the erection drawings.

.3 Fabricate all members in accordance with the Engineered Drawings and the referenced codes and standards.

.4 All like parts to be interchangeable. All like parts to have the same number.

.5 In any bending or reworking of any material, methods employed shall ensure that the physical properties of the material are not impaired.

.6 Provide electrical continuity between all tower sections.

3.2 CLIMBING APPARATUS

.1 The tower shall be equipped with a climbing apparatus complete with a fall arrest rail, in compliance with CSA S37-13.

.2 Provide an unobstructed and continuous climbing path and maintain the required climbing clearance radius as per CSA S37-13.

.3 Climbing apparatus configuration shall comply with CSA S37-13 and the Canada Labour Code. Rungs are to be horizontal, have adequate clearance, and line up vertically.

3.3 FALL ARREST SYSTEM

.1 The Contractor shall supply and install a Trylon Cougar Fall Arrest Rail, or CCG Representative approved equivalent, to meet CSA S37-13 requirements and CSA Z259.2.4-15.

.2 The fall arrest rail shall be free from obstructions for the complete height of the tower.

.3 The fall arrest rail shall be supported at spans not more than 1 m, or to meet the manufacturer's instructions.

.4 The fall arrest rail shall run up the tower or ladder in a manner to facilitate climbing. The fall arrest rail shall be straight and true to prevent trolley binding.

.5 The extension of the fall arrest rail beyond the top of the tower must be structurally supported for the entire height.

.6 Proper manufactured stop hardware is to be installed at the top of the fall arrest rail to prevent accidental dislodging of the trolley from the rail.

3.4 GALVANIZING

.1 All materials, structural steel, pipe and fittings, including bolts, nuts and washers shall be hot-dip galvanized to the requirement of CSA S37-13 and CSA-G164 and as otherwise specified therein.

.2 All materials shall be completely fabricated before galvanizing (except the tapping of nuts).

.3 Before galvanizing, the steel shall be thoroughly cleaned of all paint, grease, rust, scale or other materials that will interfere with proper binding of the zinc with the steel.

.4 Tests for thickness and uniformity of coating shall be made as considered necessary by CCG. Tests shall be conducted in full accordance with the requirements of CSA S37-13. If required, contractor shall pay for testing, all costs to be included in the tender price.

.5 The Contractor shall touch up in the field all steel members of the tower where the galvanized finish has been scraped or chipped during erection using zinc-enriched paint.

.6 Steel members that have a slightly damaged finish shall be given three coats of zinc-enriched paint applied according to the manufacturer's printed instructions.

.7 Contractor shall warranty all galvanizing work for a period of not less than 3 years.

3.5 HANDLING OF MATERIAL AND TRANSPORTATION

.1 The tower and parts are to be built so they may be safely transported to the site from the manufacturer's premises.

.2 Materials shall be handled and stored in the plant and on the job site in such a manner that no damage shall be done to the materials of any existing building or structure.

.3 Special care shall be taken to ensure that galvanizing is not damaged during handling and erection of materials.

.4 Storage of materials on the site will be the responsibility of the Contractor. CCG will designate site storage and construction layout areas after Contractor has submitted their Construction Plan.

3.6 INSTALLATION

.1 Obtain written authorization from CCG prior to site mobilization.

.2 The precise tower location and orientation will be laid out by CCG.

.3 The contractor shall give Coast Guard a written notice TWO WEEKS prior to the commencement of the standing of the tower.

.4 The tower shall be erected in a manner that will not bend, scrape, distort, or injure the component parts of the galvanizing.

.5 Every failure of the tower sections to join together properly shall be reported to CCG.

.6 Upon completion of erection, the tower shall be inspected by the Contractor for damage. Any damaged or missing items, including nuts, bolts, etc., shall be replaced. The tightness of all bolts shall be rechecked at this time.

.7 The Contractor shall be responsible to ensure that no members of the tower are over stressed during erection.

.8 Any members damaged during erection shall be replaced at the Contractor's cost.

.9 The Contractor shall be responsible for any damages done to the work of others, or to adjoining structures and property during erection.

3.7 FIELD QUALITY CONTROL

.1 Allow for CCG to monitor any tower field erection to confirm submitted plans are being followed.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

.1 Section 13 36 13 – Steel Towers

1.2 REFERENCE STANDARDS

.1 Work under this section to be in compliance with all listed references. In the case of conflict or discrepancy, the more stringent shall apply:

.1 67-013-000-ES-EQ-001, Lightning and Grounding Protection for MCTS Sites

.2 CSA C22.1, Canadian Electrical Code.

.3 CSA S37-13, Antennas, Towers, and Antenna-Supporting Structures.

.4 National Building Code of Canada.

.5 Canada Labour Code Part II.

.6 WorkSafeBC Occupational Health and Safety Act and Regulation.

1.3 SCOPE OF WORK

.1 Work in this section includes the supply of all design, labour, material, and equipment necessary to provide a grounding system comprising: copper-clad steel ground rods and tinned copper ground cable complete with exothermic ground rod connections.

.2 The grounding system is to be provided for all applicable Sections.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

.1 Provide submittals in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit Grounding Design Drawings: Within 28 days following contract award and before commencing construction activities or delivery of materials to site. Submission to include:

.1 Drawings indicating plan and section views of the grounding system, as well as all other requirements identified in this Section.

.2 Other information listed in Section 01 33 00 – Submittal Procedures.

.3 Submit Grounding Plan: Within 56 days following contract award and as part of the Construction Plan in accordance with Section 0 11 00 – Summary of Work, and before commencing construction activities or delivery of materials to site. Submission to include procedures and methods to be used during construction.

.4 Submit As-Built Drawings: Within 21 days following acceptance of Works.

1.5 QUALITY ASSURANCE

.1 Quality assurance: in accordance with Section 01 45 00 – Quality Control.

1.6 DESIGN REQUIREMENTS

.1 Provide grounding work in accordance with the Canadian Coast Guard (CCG) Standard: Lightning and Grounding Protection for MCTS Sites 67-013-000-ES-EQ-001. Any deviation from this standard shall be made known to CCG.

Part 2 Products

2.1 NOT USED

.1 Not used.

Part 3 Execution

3.1 GENERAL

.1 Ensure other site infrastructure and grounding systems are not disturbed by excavation and backfill activities.

.2 Obtain CCG’s written approval before installing grounding system.

3.2 FIELD QUALITY CONTROL

.1 Allow for CCG to monitor any grounding construction to confirm submitted plans are being followed.

END OF SECTION

Part 1 General

1.1 RELATED REQUIREMENTS

.1 Section 13 36 13 – Steel Towers

.2 Section 26 05 27 – Grounding

1.2 REFERENCE STANDARDS

.1 Work under this section to be in compliance will all listed references. In the case of conflict or discrepancy, the more stringent shall apply:

- .1 CSA S37-13, Antenna, Towers, and Antenna Supporting Structures;
- .2 Canada Labour Code Part II;
- .3 WorkSafeBC Occupational Health and Safety Regulation.

1.3 SCOPE OF WORK

.1 Work in this section consist of the excavation of soil for new tower and waveguide bridge foundations and grounding.

1.4 ACTION AND INFORMATIONAL SUBMITTALS

.1 Submit in accordance with Section 01 33 00 - Submittal Procedures.

.2 Submit Construction Plan in accordance with Section 01 11 00 – Summary of Work.

1.5 QUALITY ASSURANCE

.1 Quality Assurance: in accordance with Section 01 45 00 - Quality Control.

1.6 EXISTING CONDITIONS

.1 Examine geotechnical report supplied in Appendix E.

Part 2 Products

2.1 NOT USED

.1 Not Used.

Part 3 Execution

3.1 SITE PREPARATION/PROTECTION

.1 Unless otherwise indicated or located in an area to be occupied by new construction, protect existing compacted gravel storage area from loose soils excavated from nearby areas.

.2 Only clear vegetation that interferes with construction.

.3 Minimize stripping of topsoil and vegetation.

.4 Obtain CCG approval prior to any tree removal.

3.2 EXCAVATION/BACKFILL

.1 Excavation and backfill for foundations and anchors to be undertaken as per Engineering Plans submitted by Contractor

.2 In areas where topsoil is present, strip 152mm topsoil and stockpile. Upon completion of backfilling, spread topsoil evenly over affected areas.

3.3 RESTORATION

.1 Upon completion of Work, remove waste materials and debris.

.2 Replace topsoil.

.3 Clean and reinstate areas affected by Work.

END OF SECTION

Figure 1 - Site Location

Figure 2 - Site Photo

Figure 3 - Site Photo

Figure 4 - Existing Tower and Building

SUBMISSION DESCRIPTION	SECTION(S)	REQUIRED DATE
Design Package	01 11 00 – 1.6.1.1	28 days after award
Tower and waveguide bridge design drawings		
Foundation design drawings		
Grounding design drawings		
Fabrication Plan	01 11 00 – 1.6.1.2	28 days after award
Tower company qualifications		
Tower shop drawings		
Tower fabrication schedule		
Construction Plan	01 11 00 – 1.6.1.3	56 days after award
Contractor qualifications		
Health and safety program		
Environmental protection plan		
Concrete construction plan		
Erection plan		
Grounding plan		
Supplemental Material	01 11 00 – 1.6.1.4	21 days after acceptance of Work
As-built drawings		
Rock anchor pull-test results		
Concrete tests results		

ENVIRONMENT CANADA SITE SPECIFIC WIND PRESSURE REPORT

See following pages.

Mt. Gil, BC 24.4m Tower

Site-Specific 10-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

Site Information:

Name: Mt. Gil, BC
Latitude: 53° 15' 45" N
Longitude: 129° 11' 48" W
Tower Height (m): 24.4
Elevation MSL (m): 827

Results:

Note: Following direction from the S37 Committee, Qe can no longer be provided.

Q_{nbc} (Pa):	430	$Q_{nbc} = 430(Z/10)^{0.2}$	V_{nbc} = 57.69 mph
Icing:	As per CAN/CSA S37-13		
Q_{Min} (Pa)	250	$Q_{Min} = 250(Z/10)^{0.2}$	V_{Min} = 43.99 mph

Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919 \{[0.6000\, e^{(-0.0020\, z)} + 1.0000\, \ln(z/0.8000) / \ln(z/0.8000)]\, 45.32\}^2\ (z/10)^{0.319}$$

Profile Formula General Form:

$$Q_h = 0.12919 \{[a_1\, e^{(-a2\, z)} + a_3\, \ln(z/z_h) / \ln(z/z_{01})]\, v_{01}\}^2\ (z/10)^{0.319}$$

Site Values of Coefficients:

$$a_1 = 0.6000,\ a_2 = 0.0020,\ a_3 = 1.0000,\ z_h = 0.8000,\ z_{01} = 0.8000,\ v_{01} = 45.32\ mph$$

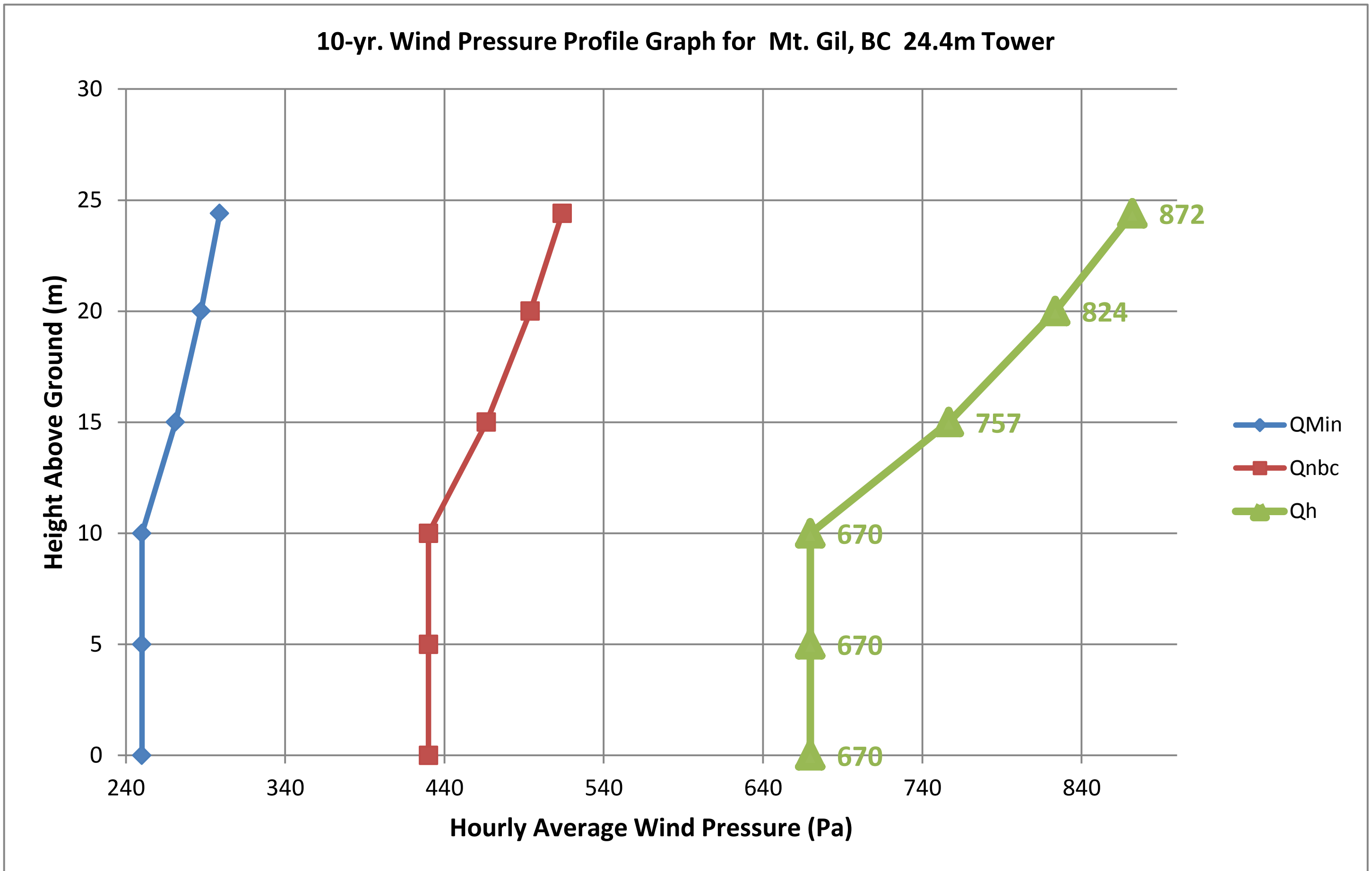
Definitions

Tower Height: Height of the tower from ground level at the base of the tower to the top of the structure.
Q_{nbc}: Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the Q_{nbc} value is profiled with the $^2/_{10}$ power law.
Q_{Min}: Minimum reference wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the $^2/_{10}$ power law as per Section 5.4.1 of S37-13.

Wind Pressure Formula: Formula for the design wind pressure as a function of height. (Ref.: S37-13, 5.3.1)
Height (Z): the vertical distance (m) above ground level at the base of the tower.

Note: No wind pressure value less than 90% of the value at 10 m should be used for heights less than 10 m a.g.l.

These wind pressures were evaluated using a version of the methods described by Taylor and Lee (1984) "Simple Guidelines for Estimating Wind Speed Variations Due to Small Scale Topographic Features", Climatological Bulletin 18 2, using the Boyd (1969) analysis of thirty year return period wind speeds (which is also used for the National Building Code of Canada), modified by a technique described by Wieringa (1980) "Representativeness of Wind Observations at Airports" Bulletin of the American Meteorological Society, 61 9, as input data. The uncertainty in NBCC regionally representative reference wind pressures is about [+15%,-15%].



Q_{nbc} Profile: Regionally representative reference wind profiled with the $^2/_{10}$ power law.
Q_{Min} Profile: Minimum site-specific wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the $^2/_{10}$ power law.
Q_h Profile: The site-specific wind pressure profile directly from the Taylor and Lee (1984) simple guidelines.

Explanatory notes regarding the new report format and changes to calculation methods.

1. The most significant change from the previous versions of the reports is that the exponent used in the Q_h equation is no longer fixed at 0.2. The exponent now varies continuously from 0.2 for open terrain to 0.32 for closed terrain.
2. A new Q_{min} profile has been added to the graphs and it represents the minimum acceptable reference wind pressure profile. It starts with the minimum 10-metre reference wind pressure of 320 Pa for a 50-year return period as per section 5.4.1 of S37-13 and then uses the same $^2/_{10}$ power law formulation as the Q_{NBC} profile to generate the curve. The corresponding 10-metre reference wind pressures for the 10-year and 30-year return periods are 250 Pa and 300 Pa respectively.
3. Q_h will always be plotted even when they are less than Q_{Min}. This will allow designers to see how Q_h varies over the height of the tower. Also, in rough terrain and for taller towers, the Q_h profile might cross the Q_{Min} profile.
4. The coefficients for the Q_h equation will now always be given regardless of the Q_{NBC} or Q_{Min} values.
5. The wind speeds will be given for each of the 4 equations (Q_h, Q_{NBC}, or Q_{Min}) too.

Site-Specific 30-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

Site Information:

Name: Mt. Gil, BC
Latitude: 53° 15' 45" N
Longitude: 129° 11' 48" W
Tower Height (m): 24.4
Elevation MSL (m): 827

Results:

Note: **Following direction from the S37 Committee, Qe can no longer be provided.**

Q_{nbc} (Pa):	520	$Q_{nbc} = 520(Z/10)^{0.2}$	V_{nbc} = 63.44 mph
Icing:	As per CAN/CSA S37-13		
Q_{Min} (Pa)	300	$Q_{Min} = 300(Z/10)^{0.2}$	V_{Min} = 48.19 mph

Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919\,\{[0.6000\,e^{(-0.0020\,z)} + 1.0000\,\ln(z/0.8000) / \ln(z/0.8000)]\,49.60\}^2\,(z/10)^{0.319}$$

Profile Formula General Form:

$$Q_h = 0.12919\,\{[a_1\,e^{(-a2\,z)} + a_3\,\ln(z/z_h) / \ln(z/z_{01})]\,v_{01}\}^2\,(z/10)^{0.319}$$

Site Values of Coefficients:

$$a_1 = 0.6000,\; a_2 = 0.0020,\; a_3 = 1.0000,\; z_h = 0.8000,\; z_{01} = 0.8000,\; v_{01} = 49.60 \text{ mph}$$

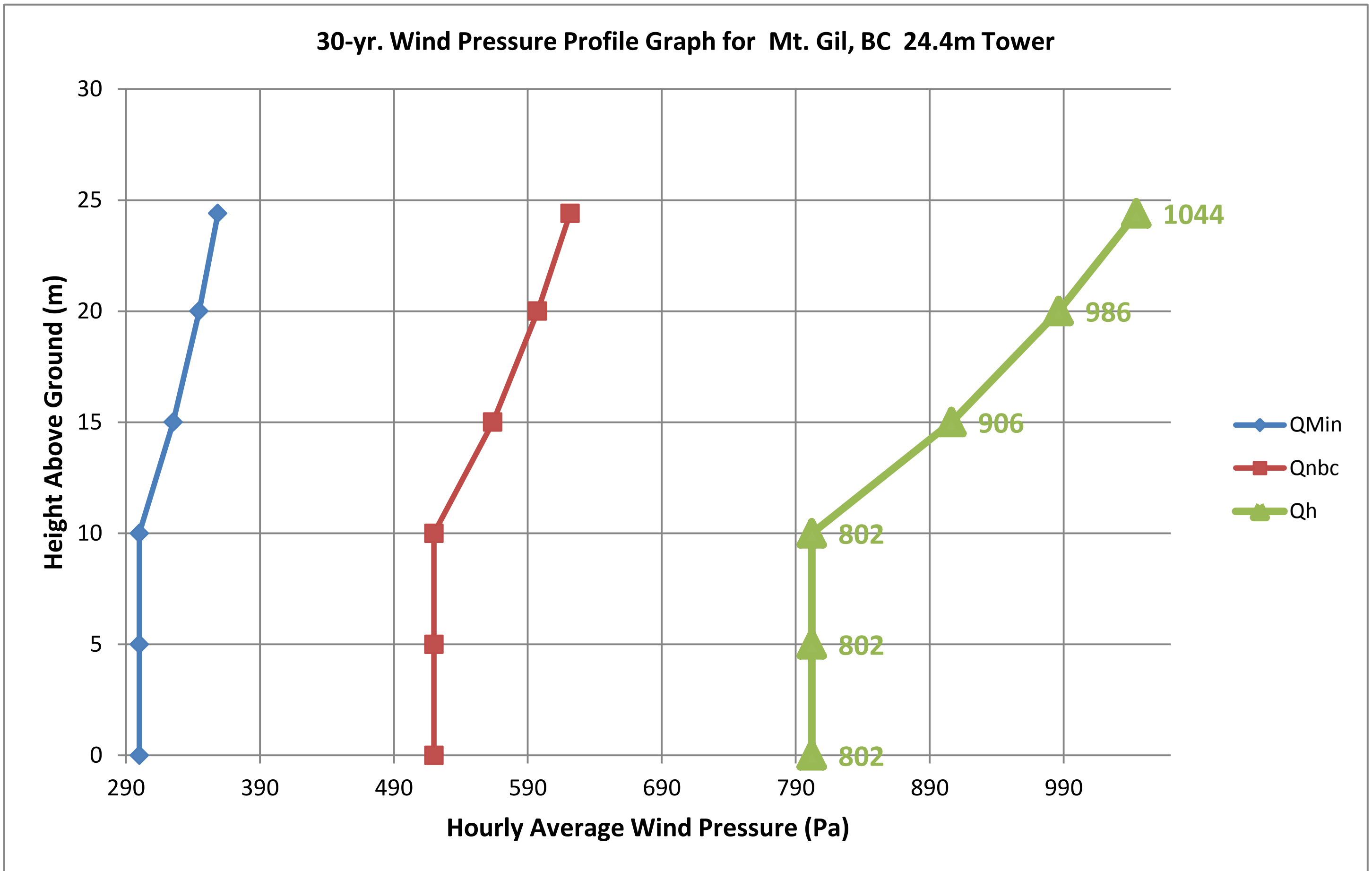
<u>Definitions</u>

Tower Height: Height of the tower from ground level at the base of the tower to the top of the structure.
Q_{nbc}: Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the Q_{nbc} value is profiled with the $^2/_{10}$ power law.
Q_{Min}: Minimum reference wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the $^2/_{10}$ power law as per Section 5.4.1 of S37-13.

Wind Pressure Formula: Formula for the design wind pressure as a function of height. (Ref.: S37-13, 5.3.1)
Height (Z): the vertical distance (m) above ground level at the base of the tower.

Note: No wind pressure value less than 90% of the value at 10 m should be used for heights less than 10 m a.g.l.

These wind pressures were evaluated using a version of the methods described by Taylor and Lee (1984) "Simple Guidelines for Estimating Wind Speed Variations Due to Small Scale Topographic Features", Climatological Bulletin 18 2, using the Boyd (1969) analysis of thirty year return period wind speeds (which is also used for the National Building Code of Canada), modified by a technique described by Wieringa (1980) "Representativeness of Wind Observations at Airports" Bulletin of the American Meteorological Society, 61 9, as input data. The uncertainty in NBCC regionally representative reference wind pressures is about [+15%,-15%].



Q_{nbc} Profile: Regionally representative reference wind profiled with the $^{2}/_{10}$ power law.
Q_{Min} Profile: Minimum site-specific wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the $^{2}/_{10}$ power law.
Q_h.Profile: The site-specific wind pressure profile directly from the Taylor and Lee (1984) simple guidelines.

Explanatory notes regarding the new report format and changes to calculation methods.

1. The most significant change from the previous versions of the reports is that the exponent used in the Q_h equation is no longer fixed at 0.2. The exponent now varies continuously from 0.2 for open terrain to 0.32 for closed terrain.
2. A new Q_{min} profile has been added to the graphs and it represents the minimum acceptable reference wind pressure profile. It starts with the minimum 10-metre reference wind pressure of 320 Pa for a 50-year return period as per section 5.4.1 of S37-13 and then uses the same $^{2}/_{10}$ power law formulation as the Q_{NBC} profile to generate the curve. The corresponding 10-metre reference wind pressures for the 10-year and 30-year return periods are 250 Pa and 300 Pa respectively.
3. Q_h will always be plotted even when they are less than Q_{Min}. This will allow designers to see how Q_h varies over the height of the tower. Also, in rough terrain and for taller towers, the Q_h profile might cross the Q_{Min} profile.
4. The coefficients for the Q_h equation will now always be given regardless of the Q_{NBC} or Q_{Min} values.
5. The wind speeds will be given for each of the 4 equations (Q_h, Q_{NBC}, or Q_{Min}) too.

Mt. Gil, BC 24.4m Tower

Site-Specific 50-yr. Wind Pressure Report (V2.1 2016-01-04 Format)

Site Information:

Name: Mt. Gil, BC
Latitude: 53° 15' 45" N
Longitude: 129° 11' 48" W
Tower Height (m): 24.4
Elevation MSL (m): 827

Results:

Note: **Following direction from the S37 Committee, Qe can no longer be provided.**

Q_{nbc} (Pa):	560	$Q_{nbc} = 560(Z/10)^{0.2}$	V_{nbc} = 65.84 mph
Icing:	As per CAN/CSA S37-13		
Q_{Min} (Pa)	320	$Q_{Min} = 320(Z/10)^{0.2}$	V_{Min} = 49.77 mph

Wind Pressure Formula (for z in metres and result in Pa):

$$Q_h = 0.12919 \{[0.6000\, e^{(-0.0020 z)} + 1.0000 \ln(z/0.8000) / \ln(z/0.8000)]\, 51.56\}^2 (z/10)^{0.319}$$

Profile Formula General Form:

$$Q_h = 0.12919 \{[a_1\, e^{(-a2\, z)} + a_3 \ln(z/z_h) / \ln(z/z_{01})]\, v_{01}\}^2 (z/10)^{0.319}$$

Site Values of Coefficients:

$a_1 = 0.6000$, $a_2 = 0.0020$, $a_3 = 1.0000$, $z_h = 0.8000$, $z_{01} = 0.8000$, $v_{01} = 51.56$ mph

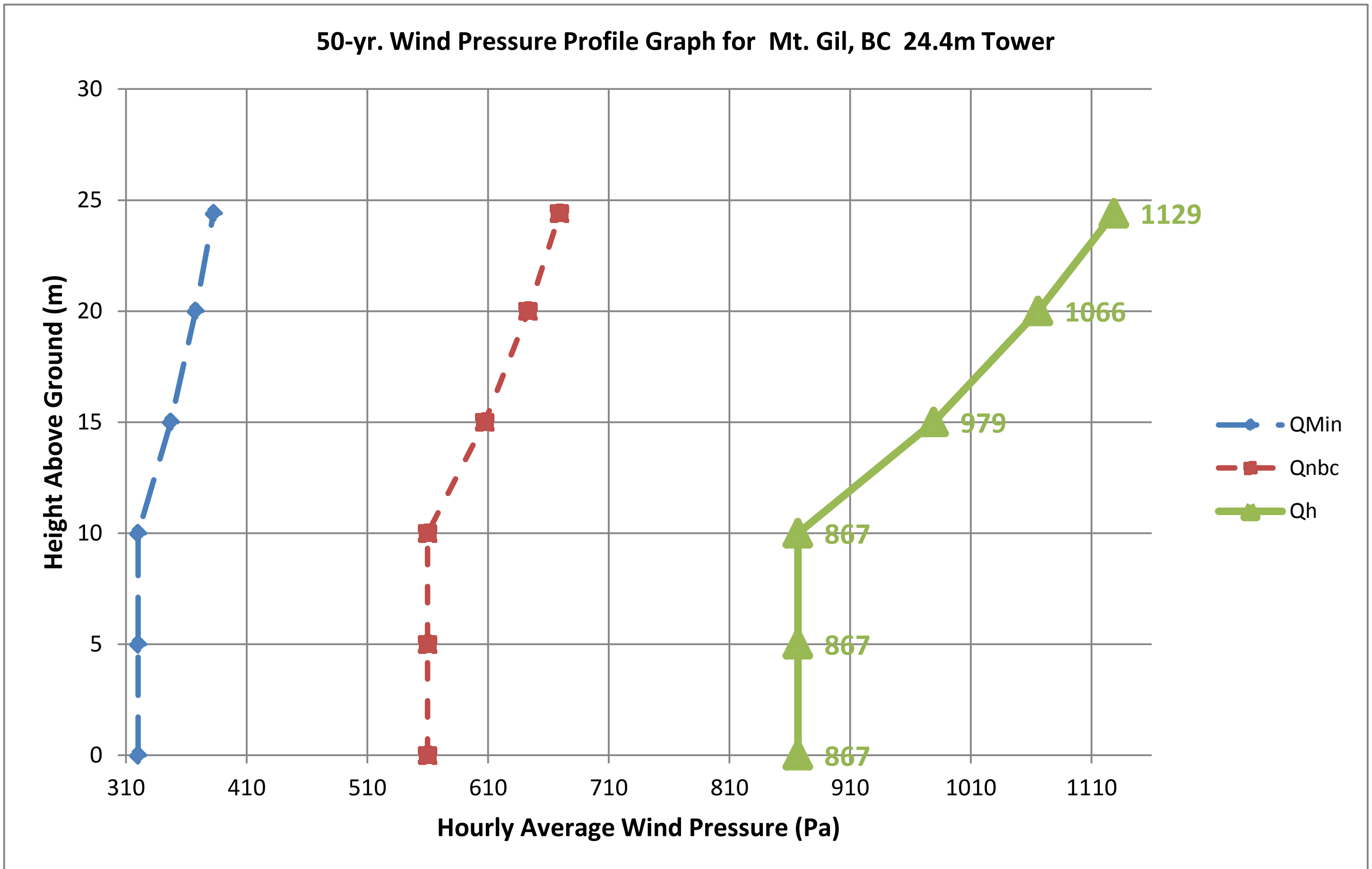
Definitions

Tower Height: Height of the tower from ground level at the base of the tower to the top of the structure.
Q_{nbc}: Regionally representative reference wind pressure at 10 m in the format of the National Building Code of Canada and the Q_{nbc} value is profiled with the $^2/_{10}$ power law.
Q_{Min}: Minimum reference wind pressure (320 Pa, 300 Pa, and 250 Pa for the 50-year, 30-year, and 10-year return periods respectively) profiled with the $^2/_{10}$ power law as per Section 5.4.1 of S37-13.

Wind Pressure Formula: Formula for the design wind pressure as a function of height. (Ref.: S37-13, 5.3.1)
Height (Z): the vertical distance (m) above ground level at the base of the tower.

Note: No wind pressure value less than 90% of the value at 10 m should be used for heights less than 10 m a.g.l.

These wind pressures were evaluated using a version of the methods described by Taylor and Lee (1984) "Simple Guidelines for Estimating Wind Speed Variations Due to Small Scale Topographic Features", Climatological Bulletin 18 2, using the Boyd (1969) analysis of thirty year return period wind speeds (which is also used for the National Building Code of Canada), modified by a technique described by Wieringa (1980) "Representativeness of Wind Observations at Airports" Bulletin of the American Meteorological Society, 61 9, as input data. The uncertainty in NBCC regionally representative reference wind pressures is about [+15%,-15%].



Q_{nbc} Profile: Regionally representative reference wind profiled with the $^{2}/_{10}$ power law.
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Explanatory notes regarding the new report format and changes to calculation methods.

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4. The coefficients for the Q_h equation will now always be given regardless of the Q_{NBC} or Q_{Min} values.
5. The wind speeds will be given for each of the 4 equations (Q_h, Q_{NBC}, or Q_{Min}) too.

SIMPSON GEOTECHNICAL ASSESMENT REPORT

NOTE: Geotechnical information for the new tower is not shown here. The following report is to be used for bidding purposes only. Following contract award a new geotechnical report will be provided at no later than May 1, 2018.

See following pages.

6.0 MOUNT GIL

Mount Gil radio site is located on Gil Island at the crest of Mount Gil at an elevation of 844 m. Gil Island is located off the north coast of British Columbia south of the mouth of Douglas Channel and west of the north end of Princess Royal Island. The site is about 140 km southeast of Prince Rupert. The peak is part of the Eberts Range within the Kitimat Ranges of the Coast Mountains. The radio site is fully exposed to south-westerly Hecate Straight weather systems and fully exposed to winter outflow winds of Douglas Channel.

Mount Gil has a 9.1 m high Trylon KDSS tower. The tower was originally constructed as a 6.1 m tower in 1981 and then was extended and a radome installed on top in 1992. The proposed 2005 modifications would see the tower extended to 15.2 m with the radome on top. For preliminary analyses, a factor of 1.35 was applied to the 1992 uplift and overturning moments used to analyse Klemtu Mountain, a 12.2 m tower.

I reviewed foundation conditions on January 13, 2005. Weather conditions at the time were high overcast with blowing snow, occasional fog and gusting wind and a temperature of about -10°C. The foundations were covered with about 200 mm of snow. We used shovels and brooms to expose the soil at the base of the grout pads, and rock hammers and picks to remove hard frozen, peaty soil to expose the bedrock. During the review I noted rock and overburden conditions adjacent to the foundations, general rock conditions where they were not snow-covered and took pictures of the site. I did not collect joint orientation measurements at this site as they were not exposed.

The tower legs are welded to steel plates 0.2 m wide by 0.31 m long set on a grout pad, with both through-bolted into bedrock. Photos K1711-Mount Gil-01 and 02 show the base of the tower and a detail of the northeast grout pad. The grout pads appear in sound condition though the grout is not neat to bedrock. We exposed the south and east grout pads and bedrock and both showed that at least the outside margin of the grout pad is on soil. We could not fully excavate to beneath the steel base plate and chose to stop breaking back the grout pad about 75 mm from the edge of the plate at the east leg. Stick up of the grout pads is nominal and based on the two exposed pads, the base of the steel plate is about from 75 mm to 125 mm above the bedrock surface.

The bedrock surface is covered with peaty soil from about 100 to 200 mm thick over the area of the site. The bedrock is sound, hard and fresh beneath a mildly weathered surface. Vigorous chipping with a rock hammer removed flakes to 12 mm. Due to the toughness of the frozen peat, we did not have sufficient time to prove the continuity of the rock surface to the west tower leg.

6.1 CSA S37-01 Factors

A. BCGS mapping indicates that the bedrock of the area is dioritic intrusive rocks of Early Cretaceous age McCauly Island Plutonic Suite. Exposed rock at the site appeared to be granodiorite to quartz diorite with a 1 to 3 mm thick, weathered surface layer. The rock is generally sound, hard and fresh.

B. The rock is covered by organic-rich soil to about 0.2 m outside the area of the footing and was hard frozen at the time of review.

C. The rock has an estimated relative density of 2.72. Use a bulk relative density of 26 kN/m^3 for calculating volume weights.

D. Bearing resistance is dependent on jointing and fragment size. Based on a joint spacing of 0.4 to 1.0 m and the tight, unweathered nature of the joints, we recommend an allowable bearing pressure of 4 MPa.

E. The intact rock shear strength is estimated to be greater than 15 MPa. Bulk shear strength should be governed by forces acting on and across joint surfaces using a friction angle of 32°.

F. A water table at this site is not expected due to the lack of catchment area, elevation and jointing.

G. The recommended foundation type is grout pads or concrete pedestals anchored to bedrock using appropriately-sized, Grade 517/75, galvanized Dywidag Threadbar bolts to resist uplift forces.

H. The recommended bond strength for this site is 2 MPa. Use either a two-part plastic resin or a cementitious grout.

I. Based on blocks and slabs 400 mm, or more, thick, the estimated RQD for this location is 100%.

6.2 Existing Foundation

The existing foundations consist of two #8 Dywidag rock bolts having 2.44 m (8') embedment into bedrock at each leg. The bolt hole diameter was specified as 37.5 mm (1.5") and is used to determine bond capacity. The potential mass of anchoring rock contained by the bolts was estimated using a 90° cone and considered acceptable for this site. The volume of rock to resist uplift at each leg is about 14.5 m^3 presuming that the joints are tight, rough, and an effective anchor cone of 90° is achieved.

Based on the foregoing values, and using #8, Grade 517/75 Dywidag bars with a penetration of 2.4 m into bedrock to estimate foundation values, the allowable capacities at each foundation are:

- available volume/weight to resist uplift 375 kN (85 kips)
- available strength #8, Grade 517/75 bolt 237 kN (53 kips)
  2 bolts at 237 kN each = 474 kN (106 kips)
- available bond strength for 2.4 m long bolt 558 kN (125 kips)
  2 bolts at 558 kN each = 1116 kN (250 kips)

The governing case appears to be the available weight of rock to resist uplift at the current embedment of 2.4 m. Assuming that the 2005 uplift forces are in the range of 135% of the 1992 Klemtu, Mount Gil will need about 495 kN (111 kips) uplift resistance. Additional uplift resistance can be gained by using longer bolts.

6.3 Recommended Foundation Modifications

If additional capacity is required, use the values given in Section 6.1, Items C, G and H, to determine the additional foundation elements. Install bolts into holes of at least the minimum diameter recommended by the manufacturer for a given size. Follow the general recommendations in Section 9.

Installing additional bolts outside of the existing pedestals, in the manner of the 1992 modifications is straightforward due to the relatively flat ground. If this method is used, break back the grout pads overlying soil to the edge of the steel plate or to expose a grout-to-bedrock contact. Remove all soil from the footprint of the new overcast block, scrub the rock surface with a wire brush to remove all organic material, weathered rock and soil particles. Flush the surface clean with water immediately before casting the new block. If soil extends beneath the grout pad directly below the plate, use a wire brush to remove the soil that can be reached. Place new grout around the circumference of the existing grout pad and work the grout into the crevice between the bedrock and the grout beneath the plate. Make the new grout at least 150 mm wider than the existing grout pad, and match the thickness of the un-broken grout pad. Finish the surface of the new grout to shed water away from the footing.

The use of a cantilevered "spider" hold-down similar to that proposed by WesTower for Upper Barry may be a suitable means of transferring load to the bedrock at this site.

Photo K1711-Mount Gil-01: View southwest to tower. Note regular surface of snow and low grout pads that footings are set on. Slope across site here is very gently dipping to northwest and is relatively flat. Topsoil in excavations was 75 to 125 mm thickness.

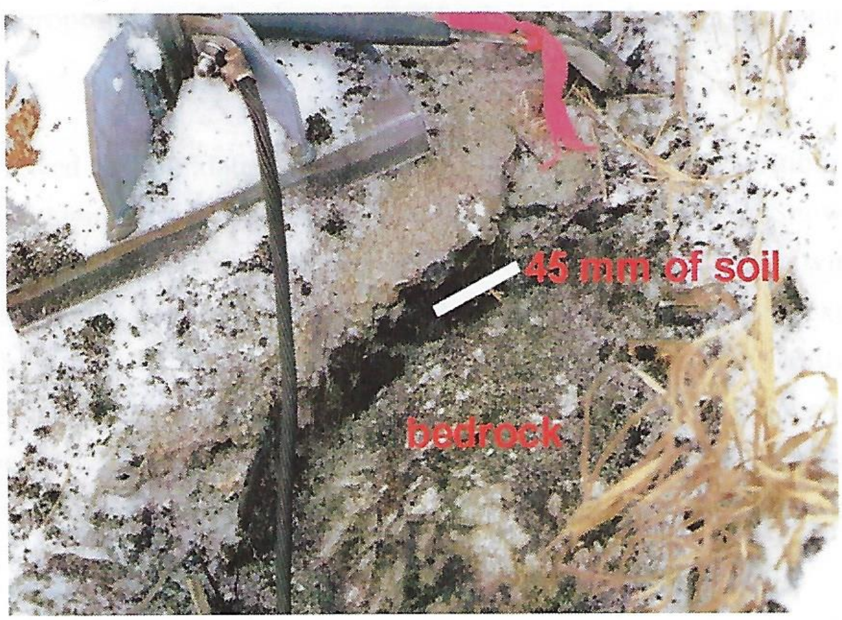

Photo K1711-Mount Gil-02: The foundations consist of steel plates set on grout pads with two Dywidag bolts penetrating rock 2.44 m. Bolts size are #8 Dywidag and length is 2.44 m according to the 1992 assessment. Note peaty soil between grout pad and bedrock. Soil thickness, if any, directly beneath the steel pad and grout is unknown.

CANADIAN COAST GUARD GROUNDING STANDARD

See following pages.

Fisheries and Oceans Canada | Pêches et Océans Canada
Canadian Coast Guard | Garde côtière canadienne

67-013-000-ES-EQ-001

Lightning and Grounding Protection for MCTS Sites

Canadian Coast Guard

Standard

Canada

Published under the Authority of:

Integrated Technical Services Directorate
Fisheries and Oceans Canada
Canadian Coast Guard
Ottawa, Ontario

K1A 0E6

67-013-000-ES-EQ-001
LIGHTNING AND GROUNDING PROTECTION FOR MCTS SITES

FIRST EDITION – MARCH 2010

EKME# 2122925-v1

Document template :	English
Print Format:	Double Sided
Last revision:	Sept 01, 2004
Compatibility:	Word 97 & 2002 (XP)

Available on CCG Intranet site at:
http://ccg-gcc.ncr.dfo-mpo.gc.ca

Disponible en français : **Protection contre la foudre et mise à la terre des sites des MCTM**

Printed on recycled paper

Document Control

Record of Amendments

#	Date	Description	Initials
1	March 2010	First Edition	R.M.

Approvals

Office of Primary Interest (OPI)	Rocco Maso	Approved:	
		Date:	June 24, 2010
Manager, Integrated Technical Services – Civil & Marine Aids	Stephanie Verbit	Approved:	
		Date:	July 15, 2010
Director, Integrated Technical Services, Engineering Services	Gilles Gareau	Approved:	
		Date:	July 20, 2010
Director General, Integrated Technical Services	Robert Wight	Approved:	
		Date:	July 28, 2010

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Document Management

1. Authority

This document is issued by the Director General, Integrated Technical Services, CCG's National Technical Authority under delegation from the Deputy Minister, Fisheries and Oceans and the Commissioner of the Canadian Coast Guard.

2. Responsibility

a) The Director of Engineering Services is responsible for:

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b) The OPI is responsible for:

- i) the validity and accuracy of the content;
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- iii) the update as needed;
- iv) the periodical revision; and
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All inquiries regarding this document, including suggestions for revision and requests for interpretation shall be addressed to:

Position Title: **LCM for Towers**
Address: Canadian Cost Guard, Integrated Technical Services
200 Kent St, 7th Floor
Ottawa, Ontario, K1A 0E6

All requests should:

- vi) be clear and concise; and
- vii) reference the specific Chapter, Section, Figure or Table.

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Foreword

1. Purpose

The purpose of these Lightning Protection and Grounding Standards is to ensure that Canadian Coast Guard (CCG) Maritime Communication and Traffic Services (MCTS) communication towers and sites comply with all applicable Canadian Acts and Codes including the Lightning Rod Act and Canadian Electrical Code.

These Standards apply the legal requirements of the referenced Act and Code, the requirements of various Canadian Standards Association (CSA) Standards (and others), and apply the best practices developed by the CCG and industry to CCG's operation and maintenance of MCTS communication towers and sites, see Annex D for a list of reference documents. Because the Act, Code, and CSA Standards may be revised at any time, it is an ongoing requirement to refer to them for currency and any changes that may be required to these Standards.

CCG is responsible for a variety of services for Canada's coastal regions, the Great Lakes and some inland waterways. A number of these services require the transmission of radio signals that are transmitted from communication towers and because of their height and metallic structure, are prone to being struck by lightning. To ensure the safety of staff on site and to prevent damage to critical communication equipment, good grounding is essential for good lightning protection.

Canada’s many topographical and geological formations, combined with the extreme climatic conditions found in the Arctic, require a comprehensive and site-specific approach to grounding. The detailed assessment of how many ground rods have to be used, the number and configuration of ground radials employed, and the calculations of how well the surrounding soil can absorb and dissipate lightning induced charges is largely a function of the geological formation and its soil resistivity. The site engineer developing a communication site is best able to design the appropriate grounding systems for the protection of the communication tower, the equipment building, equipment racks, and electronics.

Accordingly, this Standard deals primarily with standards that are applicable to the design and construction of new communication towers and sites. This Standard also covers the cause of lightning, the theory of lightning protection and grounding before addressing lightning protection and grounding standards for CCG MCTS communication towers and sites.

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Chapter 1 BACKGROUND AND DEFINITIONS

1.1 LIGHTNING

1.1.1 Theory of Lightning

When the lower atmosphere and the earth's surface are highly charged, a lightning strike occurs to restore the equilibrium. The voltage potential in a lightning strike can be as high as 100,000,000 volts with an average current charge of 30,000 amperes. Normally the earth's surface has a negative charge. During a thunderstorm, clouds in the lower atmosphere become negatively charged as the warm air moves upwards and the upper layers of the clouds become positively charged. The strong negative charge of the lower atmosphere/clouds repels the negative charge of the ground below even further, causing more positive charges to travel up to the earth's surface. When the difference in potential is high enough, the positive charges of the earth's surface recombine with the negative charges from the lower atmosphere/clouds via a lightning strike. The extremely hot air in the lightning path explodes, causing shockwaves that expand rapidly into compression waves that we hear as thunder.

As the electric field becomes very strong, the air around the clouds breaks down and ionizes, turning it to plasma. This in turn creates a highly conductive environment and allows the incremental formation of *step leaders* to find the best conductive path to recombine with the positive charges on the ground. Once the step leader has mapped out a conductive path, the lightning strike occurs to restore the in-balance.

When the negative charges in the clouds of the lower atmosphere have become strong enough to enable the ground's surface to become positive, some of those positive charges try to travel upward to meet the negative charged clouds. Since at this point the air is still non-conductive, the positive charges have to use conductive mediums to shorten the gap. Communication towers made of steel enable positive charges to travel upwards in an effort to get closer to the negatively charged clouds in the lower atmosphere and thereby shorten the distance. These moving charges are called *streamers* and they in turn try to attract the *step leaders*, negative charges building the downward path for the eventual lightning strike when the equilibrium is restored.

Damage caused to a Canadian Coast Guard tower site in Estavan by a direct lightning strike. (see Fig 1-1 & Fig 1-2)

Figure 1-1 - Lightning strike on tower causing part of foundation to break apart

Figure 1-2 - Lightning strike traveling down transmission line, into communication

Figure 1-1 and 1-2

1.2 LIGHTNING PROTECTION

1.2.1 Theory of Lightning Protection

Lightning protection is achieved by providing a controlled conductive path for the lightning strike to discharge its energy to ground. A lightning rod, a tower itself or anything conductive that is elevated above its surrounding area is, because of its height and conductivity, more likely to be used as part of the discharge path of a lightning strike. Good lightning protection and the prevention of damage to equipment installed on towers or in equipment rooms is achieved by ensuring that the incoming strike can bypass the equipment via the various grounding systems (see para 2.3.2) and discharge its energy quickly and effectively into the ground and surrounding area.

1.3 GROUNDING

1.3.1 Basic Principles of Grounding

The purpose of electrical grounding is to shunt fault currents associated with a power system or faulty electrical equipment to ground, whereas grounding for lightning protection deals with lightning induced energy and its discharge path into ground. Both grounding systems should be tied together into what is commonly referred to as single point ground.

Good grounding for lightning protection is the provision of a non-corrosive, highly conductive path for lightning induced energy to dissipate and be absorbed into the ground to prevent injury to personnel and protect equipment.

Lightning strikes have a very short duration and the induced energy is a high frequency pulse. All discharge paths have inductance and resistance, causing voltage drops to develop that can damage equipment, harm people and destroy communication sites. Keeping the ground conductors as straight as possible and using conductors with a large surface area reduces the inductance and allows the lightning induced energy to discharge quickly.

Some of the lightning induced energy will also travel inside AC lines, transmission lines, CAT5 cable, data and audio lines attached to the tower. In order to protect the connected electrical and electronic equipment inside the equipment room from power surges, voltage spikes, and other high transient voltages, surge protectors are installed. These sense the higher voltage level, switch and shunt it to ground thereby protecting the equipment.

Single Point Grounding is a grounding method to ensure that all system related electrical and electronic equipment, waveguides, transmission lines, cable trays and if desired, all other metallic surfaces of an equipment shelter or environment is connected to the same grounding point through individual and direct connections to one single grounding bar.

It is imperative that the building's perimeter ground be part of the tower grounding system that also connects to the internal building Master Ground Bar (MGB) where the AC service entrance ground is also attached. All equipment chassis are grounded to this single point master ground as are all other ground connectors from any other electrical or electronic devices inside the room.

This ensures that the same ground potential is maintained during and after the lightning strike, preventing ground currents from developing.

1.3.2 Site Grounding Systems

Several types of Grounding Systems are applicable to MCTS sites as follows:

- Lightning/Tower Ground;
- Power Ground;
- Building Perimeter Ground;
- Equipment Ground.

1.3.2.1 Lightning/Tower Ground

A lightning or tower ground is a grounding system of cables and ground rods typically laid out in a radial pattern that shunts the lightning induced energy away from equipment and people for quick dissipation of charges. In most cases, the charges are dissipated into the ground (see para 3.1).

1.3.2.2 Power Ground

The site power supply alternating current (AC) return (neutral) is used for the electrical ground and ties all electrical systems to the electrical ground. This ground is often very inductive to high frequency pulses.

1.3.2.3 Building Perimeter Ground

A building perimeter ground, or ring ground, is a buried cable encircling the equipment shelter(s) connected to ground rods as required. The building perimeter ground is also connected to the shelter's structural steel, the MGB, the tower grounding system, any nearby pipes that it crosses any fence posts and other metallic surfaces on site to achieve a single point ground for the site (see para 3.3).

1.3.2.4 Equipment Ground

During a lightning strike, the ground reference level can increase because of the momentary inductance that the site's grounding system experiences, developing a voltage rise commonly called ground potential rise (GPR). This ground reference can be different from the ground reference other equipment on site is subjected to if connected through wires from a remote source or a poorly grounded electrical system. Interconnected equipment experiencing two or more different ground potentials can be damaged because of the currents that are developed. If the difference in the GPR is high enough, it can lead to fire, cause an explosion of back-up batteries, or equipment failure (see para 3.3).

1.4 CONNECTIONS

There are 4 ways of connecting grounding cables or wires to each other or to other metallic surfaces:

- Exothermic;
- Bolt-on;
- Clamping and crimping;
- Silver soldering.

1.4.1 Exothermic

The preferred way of interconnecting dissimilar metals for best conductivity and corrosion resistance is by cad-welding, thermit connections (exothermic bonding), or brazing. This creates a solid homogenous bond that can then be coated with a moisture resistant compound. Toxic fumes are created when zinc is vapourized and care should be taken not to inhale those fumes during bonding. All other types of connections are much inferior but can be used if exothermic bonding is not possible.

1.4.2 Bolt-on

Provides a stronger mechanical connection than clamping/crimping and is typically used to attach the eye of the cable grounding kit to the tower's grounding bar. All exterior grounding connections, especially clamped, crimped and bolted should use a moisture repelling compound to prevent water from migrating into the connection, causing oxidization.

1.4.3 Clamping and crimping

Most cable grounding kits are fitted with crimped or clamped terminal eyes that attach to the tower or to cable grounding bars on towers. This is an acceptable practice for attaching lighter gauged grounding straps or wires. Clamping or compression fitted connections should be avoided whenever possible for all major connections of stranded grounding cables of AWG#2 or larger, especially if buried below grade. Galvanized steel also causes a chemical reaction to copper or brass over time, especially when moisture is present. This can be mitigated by the use of stainless steel clamps when connecting to copper grounding cables.

1.4.4 Silver soldering

Thin stranded copper wire typically used for the ground plane of isolated towers makes for a good corrosion resistant connection. Silver soldering this connection creates an even strong mechanical connection that otherwise might melt from the heat conducted through a direct lightning strike.

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Chapter 2 STANDARDS

2.1 LIGHTNING PROTECTION OF TOWERS

This is normally achieved via ground rods and ground plates. Typically copper clad steel rods between 8 -12 feet in length with an O/D of between ¾ inch and 1 inch are preferred. Grounding plates are hot-dipped galvanized steel plates intended for direct burial, and can dissipate twice as many charges as an 8 feet ground rod if installed in a highly conductive environment that allows for quick dissipation of electric charges. If possible, ground rods are installed vertically into the ground to come into contact with the water table or permanently moist soil below.

2.1.1 Guyed Towers

Three AWG#4/0 stranded copper cables shall be attached to the tower base at 120 degree spacing, CAD-welded to the ring conductor around the base of the tower and buried. A AWG#4/0 stranded copper cable shall run from the buried ring conductor to the equipment building and then around the shelter, forming a complete and closed perimeter loop. Care shall be taken to avoid cable bends of 8” (20 cm) or less.

At least 2 separate grounding cables, AWG#4/0 shall be CAD-welded to the buried tower ground ring conductor, each running in an outward direction away from the tower and away from the equipment building a distance of 60 feet (18 m) or more (see Fig 2-1). Copper clad 10 feet long ground rods shall be bonded to the radials every 20 feet (6 m) or as required by soil resistance measurements.

Figure 2-1 shows the base section of a 300 ft guyed communication tower grounded by a single AWG #2 bare stranded copper cables. This is not adequate. This single, light gauge ground cable exhibits high inductance during a lightning pulse that might cause too much energy to be shunted through the transmission lines into the communication room. The high energy pulse could damage or destroy communication equipment which might lead to fire. Instead, the tower base should be grounded with 3 stranded, copper ground cables, AWG #4/0 or with 3 copper straps bonded to the tower base ground ring to reduce the inductance to acceptable levels. The tower base ground ring should be buried below grade by 4 feet where possible. The tower base ground ring is bonded to the perimeter building ground and radials running outwards and away from the tower with ground rods every 20 feet (6 m) or as determined by the site engineer.

Figure 2-1

Guy anchors shall be grounded separately. Two different methods can be employed to offset the effects that the pH of acidic rainwater (pH between 5.5 and 6 typically) has on copper. Acidic water frees ions of copper that wash onto the galvanized guy cables below, breaking down its zinc coating causing the guys to rust.

1) A continuous, tinned stranded AWG#2/0 copper cable shall be attached to the top guy cable above the preformed guy grips with stainless steel clamps or galvanized clamps and attached the same way to each guy cable below (see Fig 2-2). It shall then be buried and bonded to a copper clad 10 feet ground rod below. From there, 2 buried radials shall branch out and away from the anchor with 10 feet ground rods attached every 20 feet (6 m) or as governed by soil resistance (see Fig 2-3).

2) A hot-dipped galvanized guy strand or better shall be attached to the top guy cable above the preformed guy grips with stainless steel clamps or galvanized clamps and attached the same way to each guy cable below. It shall then be connected to an AWG#2/0 stranded copper cable that is buried and attached to a copper clad 10 feet (3.05 m) ground rod below. From there, 2 buried radials branch out and away from the anchor with 10 feet (3.05 m) ground rods attached every 20 feet (6.0 m) or as governed by soil resistance measurements.

Figure 2-2 Individual grounding of guy cables near anchors above the preformed guy grips using stainless steel ice breakers.

Figure 2-3 Ice breakers are mounted above preformed guy grips, preventing ice from pushing down on guy cable out from guy grip. This also provides a corrosion resistant bond of the stranded copper ground cable via stainless steel plates to the hot-dipped galvanized guy cables.

Figures 2-2 and 2-3

2.1.2 Free-Standing or Self-Supporting Towers

Each tower leg of a free-standing tower shall be exothermically bonded to the buried grounding ring around the tower's base with AWG#4/0 stranded copper cable. The tower grounding ring shall also be connected to the building perimeter ground with AWG#4/0 stranded copper cable to form a complete loop. Care shall be taken to avoid cable bends of 8" (20cm) or less.

Three radial ground cables of AWG#4/0 stranded copper cable shall be bonded to the tower ground ring and run in an outward direction away from the tower and away from the equipment building the distance of 60 feet (18 m) or more. Copper clad 10 feet long ground rods shall be bonded to the radials every 20 feet (6 m) or as determined through soil resistance measurements.

The same grounding principle holds true for 4-sided or cylindrical towers, however, one additional radial with ground rods shall be attached to the tower's grounding ring. Except for the ground connection to the building perimeter ground, all other ground radials should point away from the equipment building. This ensures that the same volume of soil does not get saturated from ground rods dissipating electrons from ground rods opposite to each other.

The buried perimeter ground cable shall be interconnected near each corner of the building and at 20 ft (6 m) intervals to a 10 ft copper clad 3/4” ground rod. An additional ground rod is installed and connected to the perimeter ground near the utility entry point and the bulkhead panel, completing the single point ground system.

2.1.3 Isolated Towers (AM Towers)

All towers that act as antennas shall be isolated from ground by placing them on top of insulators. Guyed AM towers shall also have their guy cables isolated from ground. This is accomplished by incorporating insulators into the guy strands. Most insulated towers operate in the Medium Frequency range (MF) between 300 KHZ to 3MHZ with the commercial broadcasting AM band between 540 KHZ to 1,600 KHZ. The transmitted carrier is amplitude modulated (AM).

In order to operate efficiently, all AM towers have to use an extensive radial ground system to contain and propagate the electric field. This RF ground is a grid network of buried copper radials of AWG#1 to AWG#2/0, going outwards from the tower in all directions to a distance of at least the height of the tower. This buried RF ground, if sufficiently complemented with vertically installed ground rods, is the best ground for lightning protection since it will dissipate the energy induced by a lightning strike away from the tower quickly over a large area.

Special provisions have to be made for lightning protection because AM towers are isolated from ground. A spark-gap arrestor across the insulator between the base of the tower and the ground provides this safeguard. The lightning strike induced voltage will travel down the tower, jump across the approximate ½ inch (1.3 cm) gap of the spark-gap arrestor (see Fig 2-4) and dissipates into the radial ground grid typical of AM towers provided it is connected to sufficient ground rods for fast charge dissipation. The size of the gap in the spark-gap arrestor is a function of the effective radiated power (ERP) of the tower and the anticipated energy of a typical lightning strike in that area.

Figure 2-4 shows part of the base section of an old 220 feet (67 m) isolated tower sitting on top of the insulator. The spark gap arrestor has to have its contact balls positioned horizontally to prevent water from shortening the gap.

Figure 2-5 shows isolated guys.

Figures 2-4 and 2-5

Another device that is also employed with isolated towers is a static drain choke/static drain resistor (see Fig 2-5). Thunderstorms are not the only source of a charge build-up on an isolated tower. Cold dry winds, dust storms and snowstorms can also cause a build up of static charges on towers that can damage electronic equipment if not properly dealt with. The static drain choke appears as a high impedance at the operating frequency of radiating towers and bleeds off static charges before they build up. At power line frequencies or DC, it provides a short circuit to ground. A static drain resistor operates on a similar principle except that it always exhibits high resistance at DC or RF and thereby slowly bleeds off any charges before they can build up. Static drain chokes or drain resistors are employed in addition to spark gap arrestors.

Tower lights on AM towers also require special considerations. In this case, the AC fed from the equipment building to the tower is coupled through a large toroidal transformer where the primary winding is isolated from the secondary windings without physical contact through inductive coupling alone. This transformer is located outside, near the base of the tower and the distance between the secondary and primary winding is much larger than the gap of the spark-gap arrestor nearby, ensuring that most of the high energy pulse of a lightning strike will initially be shunted to ground through the spark gap arrestor.

2.1.4 Cantilever or Roof-Top Mounted Towers

These towers, (including masts and antennas) are mounted on the roof of an existing building, typically against the side of the mechanical or elevator penthouse.

The tower/mast shall be connected to bare stranded copper cable, AWG# 2/0 or greater, and be connected to the structural steel of the building where the MGB shall also be attached.

The tower or mast ground cable can also be connected to an existing roof-top grounding system, bonded to a drain pipe that is at ground potential or, if the building has attachment points to concrete encased rebar, connected to the rebar using the "Ufer" grounding method.

The tower can also be grounded by running bare stranded copper cable, AWG#4/0 from the tower to the side of the building, down the exterior wall of the building into the ground below and bonded to several 10 feet (3 m) ground rods spaced at least 20 feet (6 m) apart from each other and if possible, tied into the existing perimeter ground of the building.

Wide copper bands are better conductors because of their low inductance and are the preferred choice where possible. The trade-offs are higher installation cost of copper bands over stranded copper cables and a more unsightly appearance when installed against the outside of a building.

2.2 LIGHTNING PROTECTION OF TOWER MOUNTED EQUIPMENT

2.2.1 Antennas

Most antennas used by the CCG are at ground potential. Antennas shall be mounted with stainless steel, hot-dipped galvanized or aluminum brackets to the tower. If the tower is painted, the paint shall be removed carefully to the zinc finish where the brackets make contact with the tower leg or structural member. This will help to prevent damage to the antenna and its transmission line in case of a lightning strike by maintaining the same ground potential as the tower.

2.2.2 Transmission Lines, Waveguides, and Cable Trays

Size specific transmission line grounding kits are available from manufacturers and shall be used near where the antenna is mounted, every 200 feet (60 m) of a downward run, near the base of the tower, just before the bulkhead panel or cable entry port, and at any point where the cable's bending radius nears or exceeds 70 degrees.

A Tower Ground Bus Bar (TGB) shall be fastened to the tower just below the area where the transmission lines start their horizontal run across the waveguide bridge, cable tray, or messenger cable to the equipment building. The TGB shall be fastened securely to the tower providing good electrical connection and shall be bonded by CAD-welding to the tower's ground ring with an AWG#2/0 stranded copper cable. The grounding leads of all transmission line grounding kits shall also be secured to the TGB (see Fig 2-6).

Figure 2-6 TGBs are installed near the cable bridge entrance where the transmission lines leave the tower for their horizontal run across the cable bridge into the communication room.

Figure 2-7 The TGB has to be mounted below the cable grounding kits to ensure that the discharge path of a potential lightning strike will be downwards to the TGB where all cable grounding straps are tight together.

Figures 2-6 and 2-7

Waveguide bridges or cable trays shall be electrically isolated from the tower and shall be bonded to the perimeter ground using AWG# 4/0 stranded copper cable that is exothermically connected to each support mast. An outdoor ground bar shall be installed near the cable entry point, either attached to the building or isolated from the waveguide bridge or cable tray. This external ground bar shall be connected with an AWG#2 stranded copper cable to the perimeter ground system. (see Fig 2-7)

The bulkhead panel is a copper plate that acts as the feed-through entrance panel for the transmission lines into the equipment room. The transmission lines are terminated against the panel with their corresponding surge arrestors attached and from there connect to the transceivers via flexible jumpers. Surge arresters may also be mounted inside the equipment room as long as the grounding straps or cables attached to the surge protectors are less than 24 inch (60 cm) in length and are connected to the MGB. The bulkhead panel shall connect to the perimeter ground with 2 x 3 inch (5 x 7cm) wide copper bands or alternatively with at least 2 lengths of AWG#2/0 stranded copper cable.

Andrews' wall feed-through panels or individual cable entry ports may also be used in conjunction with Harger Entrance Panel Kit or equivalent, to provide proper grounding points to the outside perimeter ground, coaxial cable shields and surge suppressors (see Fig 2-8).

Figure 2-8 shows transmission lines entering the communication shelter through individual Andrews's cable entrance ports. The cable grounding kits are attached to the transmission lines just before they enter into the building and the grounding straps are attached to the outside portion of the Harger Entrance Panel that in turn is grounded through an AWG#4/0 stranded copper cable to the perimeter ground.

Figure 2-8

2.2.3 Tower Lights

All AC cables on towers shall run inside metal conduits or steel-armoured TECK cables. The conduit or TECK cable shall be firmly connected to the structural steel of the tower where the lights are connected, at least every 200 feet (60 m) on a downward run and via flash-guard or similar surge protection near the base of the tower (see Fig 2-9 to 2-11). The AC power line energizing tower lights shall also be protected using metal oxide varistors (MOV) or silicon avalanche diodes (SAD), or other surge protective devices (SPD). All SPDs shall be installed within the equipment room for maximum effectiveness.

Figures 2-9, 2-10 and 2-11

2.2.4 Tower Mounted Electronics

Amplifiers. The AC feed cables that power electronic and amplifiers mounted on a tower are to be connected to the structural steel of the tower identically as specified for tower lights above.

The DC supply voltage required for the operation of a tower mounted amplifier is delivered through the transmission line via DC injection from inside the communication room. Special surge protectors shall be installed on the bulkhead entrance panel or within 24 inch (60 cm) of the MGB or the Harger Entrance panel allowing for DC injection.

Low Power Amplifiers. Low power amplifiers receive their DC supply and operating voltage through the power-over-ethernet (POE) CAT5 cable that also allows bi-directional data transfer.

Special surge arrestors can be installed between the POE injector and the CAT5 cable going up the tower.

2.3 LIGHTNING PROTECTION AND GROUNDING OF BUILDING AND SITES

2.3.1 Building Perimeter Ground

A building perimeter ground shall be a AWG# 4/0 bare, stranded copper cable, that runs buried to a depth of between 12 to 24 inch (30 to 60 cm) around the equipment building and shall be exothermically connected to ¾ inch O/D of 10 feet copper clad ground rods at every corner and every 20 feet (6 m) or as determined by soil resistive measurements. It interconnects via stranded AWG#1/0 to fence posts and other metallic surfaces and it also interconnects to any nearby pipes it crosses. The perimeter ground or ring ground is also connected to the lightning ground of the tower, the structural steel of the building and the MGB (see Fig 2-12). All grounding conductors, rods or radials achieve the highest efficiency when placed in moist soil.

The building perimeter ground shall also be connected to the bulkhead panel by 2x3 inch copper bands or alternatively by 2 runs of bare AWG#2/0 stranded copper cable.

The building perimeter ground shall also be connected to the MGB by bare AWG#2/0 stranded copper cable. It shall not be in contact with any other metal surface or object.

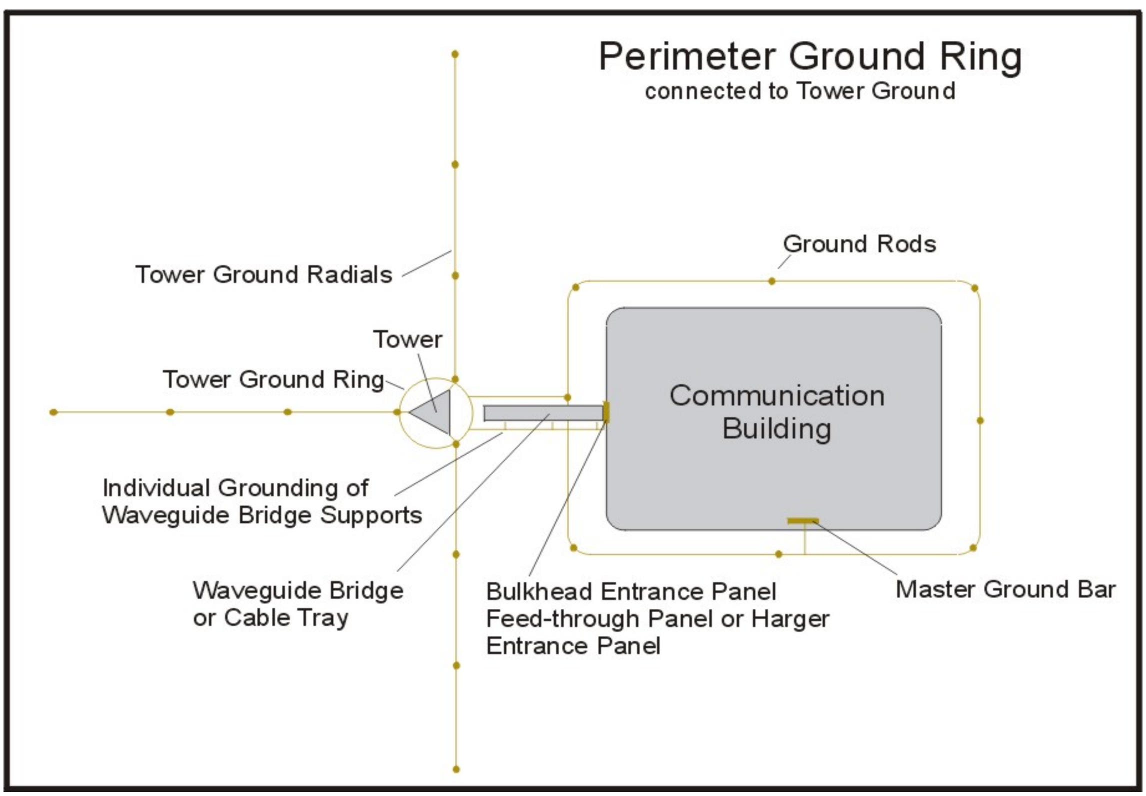

Figure 2-12

2.3.2 Equipment Room Ground

A bulkhead panel shall be installed where the transmission lines enter the building and it shall be bonded to the building's perimeter ground by 2x3 inch copper bands, or alternatively, by 2 runs of bare AWG#2/0 stranded copper cable (see Fig 2-13). If this cannot be done, or is impractical, a separate grounding system with ground rods is to be installed and bonded via copper straps to the bulkhead panel.

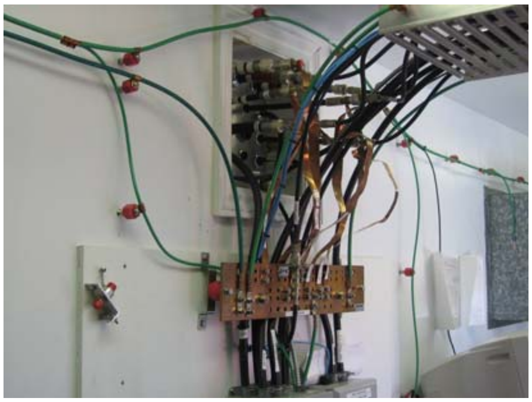

Figure 2-13

Fig 2-13 shows a Bulkhead Panel with surge suppressors mounted against incoming transmission lines. The Master Ground Bar is mounted below and is connected to the perimeter ground. Copper straps attached to the MGB and to the surge suppressors ensure a low inductance discharge path to the outside ground system.

A Master Ground Bar (MGB), a rigid copper bar with multiple attachment points for individual grounding cables to interconnect equipment, racks, shelves, etc in the communications room, shall be installed. In most cases, the MGB is installed against a wall about 12 inches above the floor near the bulkhead panel or AC service entrance and acts as the single reference ground for all ground connections inside the building. The MGB shall be connected to the building perimeter ground by bare AWG#2/0 stranded copper cable. It shall not be in contact with any other metal surface or object.

All equipment inside the equipment room shall be connected to the MGB.

In order to protect electronic equipment from transient voltage spikes and residual energy caused by lightning strikes, transmission lines shall be terminated on bulkhead panel mounted surge protectors or lightning suppressers. The fast response time of surge protectors aid in shortening the center conductor to ground, thereby preventing costly damage to the antenna input/output stage of the transceiver.

Surge suppressers may also be mounted closer to the transceivers inside the equipment room as long as they are connected with green, insulated AWG#6 stranded copper conductors not exceeding a length of 24 inches (60 cm) to the MGB.

Figure 2-14 shows incoming transmission lines being terminated against surge suppressors that are grounded with wide copper bands to the inside part of the Harger Entrance Panel Kit. The brass plate is connected via two threaded rods that run inside PVC conduits through the wall to the outside ground bar that provides cable grounding kit termination. The outside ground plate is connected to the perimeter ground.

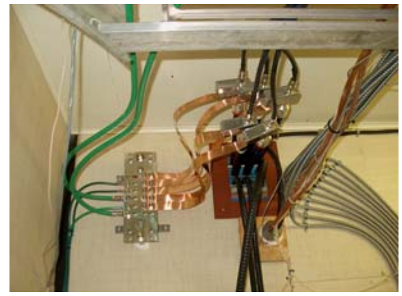

Figure 2-14

Halo Ceiling Ground Ring (see Fig 2-14), a stranded AWG#4/0 copper cable with a black jacket shall be fastened around the room's wall about 6 inches (15 cm) below the ceiling. This cable shall be attached with copper straps to all non-electronic metal surfaces such as windows, doors, vents, etc. that are **not** connected to the single point ground. The function of the halo ground ring is to reduce the effects of the induced magnetic field following a lightning strike.

2.3.3 Incoming Lines; Power, UPS, Telephone, and Data

Ideally, telephone lines shall enter the building near the MGB and shall be grounded to it. If this is not possible, a telephone copper ground bus bar shall be installed near the telephone line entry point. This secondary bus bar shall be connected to the MGB utilizing a single length green insulated AWG#6 stranded copper cable.

Each telephone line shall be protected by a surge arrestor, MOV/SAD, with its ground connected to the MGB or the telephone bus bar.

Each incoming audio or data line shall be protected by a surge arrestor, MOV/SAD, with its ground connected to the MGB, the telephone bus bar.

The primary power neutral shall be connected at the main service disconnect location to the MGB with green insulated AWG#2/0 stranded copper cable.

The chassis of all emergency generators or other AC powered equipment shall be bonded with a green insulated stranded copper cable to the MGB.

The DC output of the un-interrupted power supply (UPS) shall be protected using MOV/SAD or other devices to shunt high surge currents to ground.

2.3.4 Other Site Grounding Requirements

2.3.4.1 Grounding of Chain-Link Fences

Chain-link fences within 30 feet (9 m) of the building perimeter ground shall be connected to the perimeter ground using AWG#2/0 stranded copper cable (see Fig 2-15). Chain-link fences within 30 feet (9 m) of a tower shall be bonded to the radials or perimeter groundings that are interconnected. Fence posts shall be exothermically connected to the peripheral ground every 100 ft (30 m).

Chain-link fences that are more than 30 feet (9 m) away from the building peripheral ground but less than 50 feet (15 m) beyond the perimeter ground shall be bonded using AWG#6 copper wire attached to the reinforcing wire of the chain link fence and to a 10 feet x ¾ inch ground rod every 150 feet (45 m).

Figure 2-15 Chain-link fence around this communication site is not bonded to the external perimeter ground since it is well beyond the 50 feet (15.24 m) distance of the 340 feet communication tower and the adjacent communication building.

Figure 2-15

Chain link fences that encircle a tower and/or an equipment building within 20 feet (6 m) of the structures shall have their gates grounded and bonded to the gatepost using copper braided straps.

Every gatepost shall be grounded directly to a ground rod or, if within 30 feet (9 m) of the building's perimeter ground, bonded to the perimeter ground.

No chain-link or metallic fences shall be on the active ground plane of an AM site. This is a distance of at least the height of the tower away from the base of the tower. Fences around an active AM site are subject to induced RF currents and unless extremely well grounded can cause severe burns. Fences at AM communication sites shall be grounded every 20 feet (6 m) to a ground rod or as specified by the site engineer.

All chain link or metallic fences shall be exothermically bonded to any metallic structure, pipe, conduit or object within 10 feet (3 m) using AWG#2/0 if below grade or AWG#2 if above grade, stranded copper cable.

2.4 LIGHTNING PROTECTION AND GROUNDING OF ELECTRONIC EQUIPMENT

2.4.1 Electronic Equipment inside Equipment Rooms

Proper surge protectors shall be installed on all incoming transmission lines between the outside cable entry point and the antenna connection of the equipment.

All chassis of all electronic equipment inside the same rack or enclosure shall be connected to the rack(s) or the enclosure's own copper grounding bus bar using green, insulated AWG#6 stranded copper conductors.

Figure 2-16 shows equipment racks inside the Canadian Coast Guard's communication building at Cardinal, Ontario. The center rack has a vertical copper ground bus bar that allows attachment provisions for all individual chassis of rack mounted equipment. The bus bar in turn is connected to the MGB.

Copper Ground Bus Bar

Figure 2-16

Each rack's or metal enclosure's copper bus bar shall be connected to the MGB using green, insulated AWG#2 stranded copper conductors (see Fig 2-16).

Metal cable trays or conduits shall be bonded to a continuous length of AWG#2/0 stranded copper cable that is attached to the MGB. The green jacket of this cable shall be cut at intervals to allow bonding to each individual cable tray section.

Good grounding practices ensures that all grounding connections are as short as possible with few bends, that appropriately large copper conductors are used and that each piece of equipment has its own and direct connection to the MGB.

2.5 SPECIAL GROUNDING CONSIDERATIONS

2.5.1 Grounding Towers and Anchors in Rock

A ring of stranded copper cable AWG# 4/0 shall be placed around the base of the tower. Each tower leg shall be bonded to the conductor ring with AWG#4/0 stranded copper cable. Copper ground radials shall be attached to the base grounding ring running outwards in a star-like pattern for at least 60 feet (18 m) and spaced between 20 to 40 degrees apart or as determined by the site engineer to establish the capacitive coupled discharge system. The radials shall be AWG#2/0 and for better charge dispersion, short, flat, 12 inches (30 cm) long copper straps shall be bonded at right angles to each radial at 2 feet (60 cm) increments (see Fig 2-17).

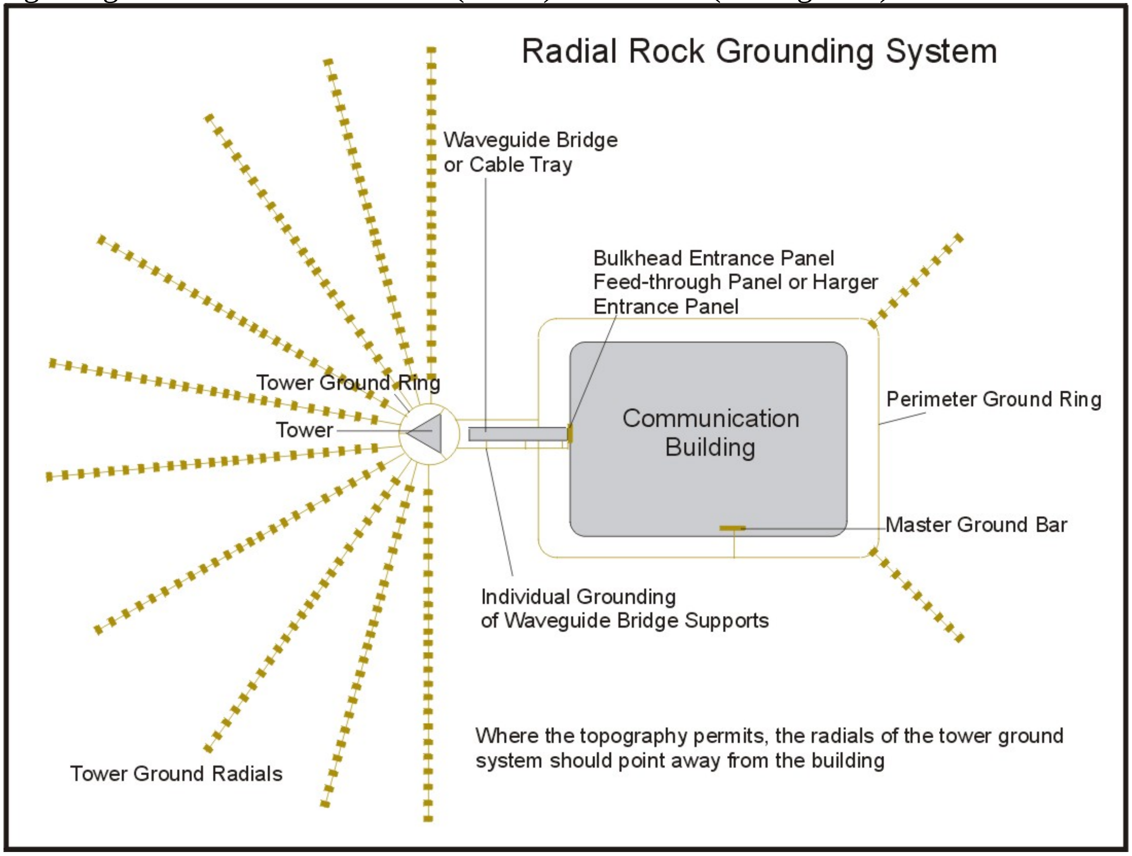

Figure 2-17

The effectiveness of using Bentonite as the filling agent in holes is much disputed. Holes are drilled into the rock some distance apart with a copper grounding rod installed inside. The grounding rods are all connected together and the holes are filled with Bentonite, a form of highly conductive clay that exhibits low pH which helps to minimize the corrosion of copper grounding rods.

Radial grounding can also be improved upon by encasing the radials in Ground Enhancing Materials (GEM) that will bond to the rock.

One continuous AWG#2/0 stranded copper cable shall be attached to the upper guy cable at each anchor and fastened to all guys below using stainless steel clamps so that the ground cables run in an almost vertical downward direction.

The guy ground cable shall be bonded below grade level to a second copper cable so as to create 2 radials that can bypass the anchor in a V-shaped connection and run beyond the anchor for another 60 ft (18 m). The radials shall be AWG#2/0 and for better charge dispersion, short, flat, 12-inch (30 cm) long copper straps shall be bonded at right angles to each radial at 2 feet (60 cm) increments.

2.5.2 Grounding in Permafrost

Permafrost is non-conductive and not unlike grounding on rocky surfaces; fast discharge paths for the lightning induced energy can be difficult to obtain. A surface radial grounding system is often the only way to discharge and dissipate the lightning strike's induced energy.

A ring of stranded copper cable AWG# 4/0 shall be placed around the base of the tower. Each tower leg shall be bonded to this ring with AWG#4/0 cable. Copper ground radials shall be attached to the base grounding ring running outwards in a star-like pattern for at least 60 feet (18 m) and spaced 20 to 40 degrees apart or as determined by the site engineer. The radials should be AWG#2/0 and for better charge dispersion, short, flat, 12 inch (30 cm) copper straps shall be bonded at right angles to each radial at 2 feet (60 cm) increments.

A more effective ground system can be designed if copper bands are used rather than stranded ground conductors.

This "floating" ground shall be bonded to all equipment and metal structures to ensure that the same ground potential is maintained during the lightning strike's discharge.

2.5.3 Grounding in Low-Conductive Soil

When poor soil conditions are suspected, the soil's measurements have to be obtained. A Megger earth tester shall be used to measure the soil's resistivity. Typically, four short copper rods are driven into the ground in a straight-line equal distant from each other. Current is applied to the 2 outermost rods and then measured between the 2 inner rods allowing the soil resistivity to be calculated based on the current flowing through it. In order for the test results to be valid, testing is to be performed under "normal" climatic conditions by personnel familiar with the test equipment and testing procedures.

For communication sites, the resistance of the ground system to ground shall be 5 Ohms or less.

The soil's conductivity can be increased by using Epson salt, Magnesium Sulfate, Copper Sulfate, Rock Salt, or other chemicals. There are chemical ground rods available that also try to retain moisture and then slowly release the saline liquid into the ground increasing its conductivity. Careful consideration should be given regarding the choice of any chemicals used to enhance ground conductivity, since in most cases unwanted side effects are encountered.

12 pounds (5.5 kilograms) of salt should be considered for every 10 feet grounding rod. The salt should be mixed with water so that it can penetrate into the soil below. Magnesium Sulfate is the least damaging to the environment other than specially designed GEMs. Even though salt is readily available, because of its impact on the environment, its corrosive properties and because it has to be replenished at periodic intervals, it is not the best choice.

There is also Ground Enhancing Materials (GEM) available that ensure a more environmentally friendly approach in increasing the soil's conductivity. Some of these general soil enhancement options are listed below with resistivity values.

- **Bentonite:** Conductive clay formed from volcanic ash typical 2.5 ohms per meter. Its moisture content can vary by a large percentage.
- **Carbon-Based Backfill Materials**: 0.1 – 0.5 ohms-per-meter. Its water retention properties are not as good as clay;
- **Clay-Based Backfill Materials (GAF)**: exhibiting high water retention capabilities between 0.2 – 0.8 ohms-per-meter;
- **Conductive Concrete:** 30 – 90 ohms-per-meter. Concrete is affected by ice and corrosion.

Soil resistive values are shown in Annex A.

2.5.4 Grounding in Corrosive Environments

A buffering agent such as Bentonite can be added to and mixed with the soil to help offset the damaging impact a highly corrosive soil might have on a grounding system. In extreme situations, a specially formulated GEM can be used.

Where the air is salty, has a high sulfuric content, or other chemical pollutants that might cause accelerated corrosion, all external grounding connections should be sealed with an anti-corrosion compound and, if possible, sealed air tight to prevent oxidization.

2.5.5 Grounding in Co-locating Environments

The owner of communication site is responsible for the proper grounding of tower and facility. The tenant or co-locator is responsible for the grounding of their own equipment. All incoming transmission lines should connect through a surge protector that is grounded to the bulkhead entrance panel or in its absence, to the internal MGB. Equipment chassis, racks and metal enclosures as well as all data, telephone or audio lines shall be protected and grounded as described in the earlier paragraphs. If the general grounding inside the equipment room appears to be substandard, the site owner shall be requested to address the deficiencies. The installation of a separate grounding system is not an option.

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Chapter 3 INSPECTION AND MAINTENANCE

3.1 NEW INSTALLATIONS

3.1.1 Newly installed lightning protection and grounding systems shall be inspected for the following:

- Check all ground cable connection points of guys and anchors for proper connection and tightness;
- Check all other grounding connections for tightness and anti-corrosion compound (e.g. No-Ox-ID);
- Measure and record ground resistivity (maximum 5 ohms);
- Measure and record bonding resistance (maximum 1 ohm).

3.1.2 The above ground and connection inspection of new installations shall be repeated six months after installation and thereafter in conjunction with the scheduled tower inspections.

3.2 EXISTING INSTALLATIONS

3.2.1 Existing sites shall be inspected in conjunction with the scheduled tower inspection as follows:

- Check all ground cable connection points of guys and anchors for proper connection, tightness, and corrosion. Tighten or replace as required;
- Check all other ground connections for tightness, corrosion and anti-corrosion; compound. Replace as required and re-apply anti-corrosion compound (e.g. No-Ox-ID);
- Measure and record ground resistivity, (maximum 5 ohms), at sites with known poor soil conductivity. For sites with 'normal' soil conditions ground resistivity measurements should be done every five years;
- Measure bonding resistance (maximum 1 ohm).

3.3 CONNECTIVITY MEASUREMENTS

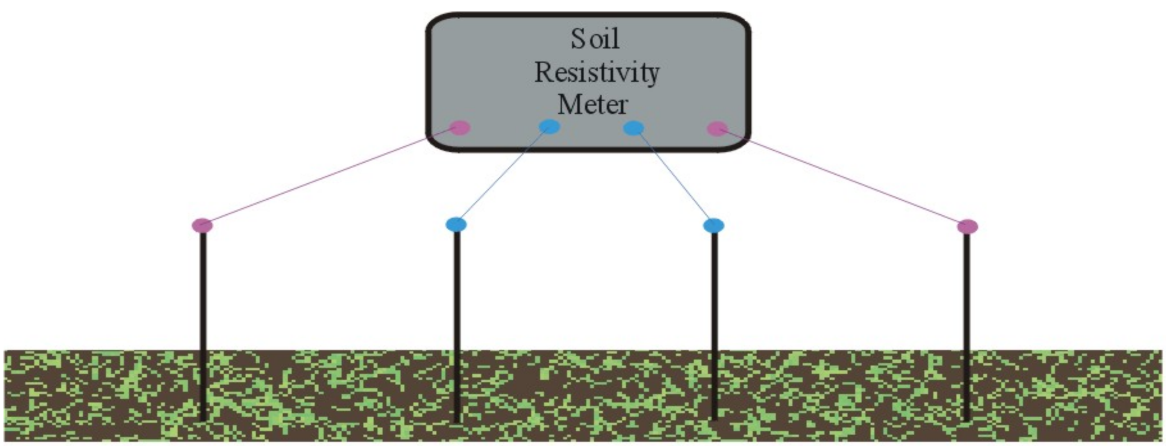
The resistance from each piece of equipment and ground within an equipment room can be checked by using a specially designed clamp-on meter. The resistive value between the MGB and each equipment attachment point should not be greater than 1 ohm.

3.4 TESTING SOIL RESISTIVITY

A periodic testing of the soil's resistivity should be done and, if unusually dry weather conditions prevail, initiated more frequently. The findings of newly conducted soil resistivity measurements should be compared to the original system specification to identify if conductance enhancement material needs to be injected into the soil or if the grounding system has to be upgraded using alternative methods (see Fig 3-1).

The testing of the complete buried ground system with its radials, ground rods and peripheral ground is a complex process that may require excavation to access the copper cables at various locations if corrosion of the grounding system is suspected. The cables may have to be cut at certain locations and replaced if damaged and additional ground rods may have to be installed if the moisture content or conductivity of the soil is reduced. In order to do active ground system measurements, currents have to be induced into the soil at various distances to measure and calculate the performance of the grounding system. This type of measurement and analysis should be done by a qualified technician with experience in measuring soil resistivity and ground systems.

In order to obtain accurate readings of the soil's resistivity, tests have to be conducted at multiple locations at various depths. The most common instrument used to obtain accurate readings is a Soil Resistivity Meter. This measuring equipment typically comes with 4 test leads and test electrodes made from stainless steel. Soil resistivity is measured by injecting current between two test electrodes and measuring the resultant voltage between the second set of electrodes. The results are analyzed, evaluated and recorded.



Voltage is dropped across the 2 outer electrodes and the current is measured between the 2 inner electrodes, establishing the soil's resistivity. Equal spacing between electrodes is important to obtain accurate readings.

Figure 3-1

The Four-Electrode-Method of testing the soil's resistivity as shown above is called the Wenner

4-pin Method. It identifies the average resistivity (ρ) of the soil (electrolyte). The obtained readings are calculated by the test equipment and displayed. In order to avoid erroneous readings caused by polarization of electrodes by DC test currents or because of other fault currents present in the soil, soil resistivity testers employ fast reversing DC measurement technology or use 50 HZ AC line current coupled through isolation transformer or similar technology.

Manufacturers of soil resistivity testers provide detailed information on how their equipment is to be used and how ground resistivity measurements are to be conducted. Additional information on more comprehensive soil resistivity measurement techniques can be found in Motorola's *Standards and Guidelines for Communication Sites R56* under section 4.3 Soil Resistivity Measurements.

Soil Resistive Values in Ω-cm

Soil Composition	Minimum Resistivity	Average Resistivity	Maximum Resistivity
Ashes, cinder, brine, waste	590	2,370	7,000
Clay, shale, gumbo, loam	340	4,060	16,300
Clay, shale, gumbo, loam with portions of sand and gravel	1,020	15,800	135,000
Gravel, sand, stones with little clay or loam	59,000	94,000	458,000

Effect of salt content on the resistivity of sandy loam with a moisture content of 15% by weight at 17°C.

Salt added in % by weight	Resistivity in Ω-cm
0	10,700
0.1	1,800
1.0	460
5	190
10	130
20	100

Effect of temperature on the resistivity of sandy loam with a moisture content of 20% by weight and with salt weighing 5% of moisture.

Temperature in Degrees C	Resistivity in Ω-cm
20	110
10	142
0	190
-5	312
-13	1440

Effect of moisture content by weight.

% Weight	Top Soil	Sandy Loam
0	>1,000,000,000	>1,000,000,000
2.5	250,000	150,000
5	165,000	43,000
10	53,000	18,500
15	19,000	10,500
20	12,000	6,300
30	6,400	4,200

Data obtained from http://www.dranetz-bmi.com/pdf/groundtesting.pdf. “Understanding Ground Resistance Testing Soil Resistivity”.

Annex A SOIL RESISTIVE VALUES

Soil Resistive Values in Ω-cm

Soil Composition	Minimum Resistivity	Average Resistivity	Maximum Resistivity
Ashes, cinder, brine, waste	590	2,370	7,000
Clay, shale, gumbo, loam	340	4,060	16,300
Clay, shale, gumbo, loam with portions of sand and gravel	1,020	15,800	135,000
Gravel, sand, stones with little clay or loam	59,000	94,000	458,000

Effect of salt content on the resistivity of sandy loam with a moisture content of 15% by weight at 17°C.

Salt added in % by weight	Resistivity in Ω-cm
0	10,700
0.1	1,800
1.0	460
5	190
10	130
20	100

Effect of temperature on the resistivity of sandy loam with a moisture content of 20% by weight and with salt weighing 5% of moisture.

Temperature in Degrees C	Resistivity in Ω-cm
20	110
10	142
0	190
-5	312
-13	1440

Effect of moisture content by weight.

% Weight	Top Soil	Sandy Loam
0	>1,000,000,000	>1,000,000,000
2.5	250,000	150,000
5	165,000	43,000
10	53,000	18,500
15	19,000	10,500
20	12,000	6,300
30	6,400	4,200

Data obtained from http://www.dranetz-bmi.com/pdf/groundtesting.pdf. “Understanding Ground Resistance Testing Soil Resistivity”.

Annex B GROUND ENHANCING MATERIALS (GEM)

ERICO's Ground Enhancing Material (GEM) is a superior conductive material that improves grounding effectiveness, especially in areas of poor conductivity such as rocky ground, areas of moisture variation, and sandy soils.

B.1 FEATURES

- l Effective-typical resistivity 12-18 Ohm cms (20 times lower than bentonite clay)
- Once in its "set" form, maintains constant resistance for the "life" of the ground system
- Performs in all soil conditions even during dry spells
- Permanent - does not dissolve, decompose or leach out with time
- Easily installed in dry form or slurry
- Meets (USA) Environmental Protection Authority requirements for landfill
- Can be installed using Trench or Ground Rod Backfill methods

B.2 APPLICATIONS

GEM is ideal for areas with poor conductivity such as rocky ground, mountain tops, sandy soil and areas of moisture variation.

B.3 MORE INFORMATION

B.3.1 GEM Calculator

Download the latest version of ERICO's GEM Software Calculator (http://www.erico.com/static.asp?id=27). Available in four languages (English, French, German and Spanish), the calculator estimates the amount of GEM required for an installation and converts Metric and Imperial measurement units.

B.3.2 How to Specify

- Ground enhancement material in its set form shall have a resistivity of not more than 20 ohm-cm
- Ground enhancement material must be permanent and maintenance-free (no recharging with salts or chemicals which may be corrosive) and maintain its earth resistance with time.

- It must set up firmly and not dissolve or decompose or otherwise pollute the soil or the local water table.
- The ground enhancement material shall be suitable for installation in a slurry form
- The ground enhancement material shall not depend on the continuous presence of water to maintain its conductivity

B.4 GROUND ENHANCING MATERIAL (GEM) INSTALLATION METHODS

B.4.1 Trench Installation

Estimated linear feet of ground conductor covering with each bag of GEM

Trench Width	Total Thickness of GEM			
	2.5cm (1")	5.1cm (2")	7.6cm (3")	10. 2cm (4")
10cm (4")	4.3m (14.0’)	2.1m (7.0’)	1.4m (4.7’)	1.1m (3.5’)
15cm (6")	2.8m (9.3’)	1.4m (4.7’)	0.9m (3.1’)	0.7m (2.3’)
20cm (8")	2.1m (7.0’)	1.1m (3.5’)	0.7m (2.3’)	0.5m (1.8’)
25cm (10")	1.7m 5.6’)	0.9m (2.8’)	0.6m (1.9’)	0.4m (1.4’)
30 cm (12")	1.4m (4.7’)	0.7m (2.3’)	0.5m (1.6’)	0.4m (1.2’)

A 11.1 kg bag of GEM will cover 2.1m (7 linear feet) of conductor length for a 10.2cm - (4-inch) wide, 5.1cm (2-inch) thick covering 2.5cm (1 inch) below and 2.1cm (1 inch) above the conductor), based on 1017 kg /m3 (63.5 lb/cu ft).

B.4.1.1 Method

1) Dig a trench at least 10.2 cm (4 inches) wide x 76.2 cm (30 inches) deep or below the frost line, whichever is deeper. Spread out enough GEM to uniformly cover bottom of trench - about 2.5cm (1 inch) deep.

2) Place copper tape / earth grid conductor on top of GEM.

3) Spread another 3 cm (1 inch) deep layer of GEM around and on top of the conductor so as to completely cover conductor.

4) Carefully cover the GEM with soil to a depth of about 10 cm (4 inches), making sure not to expose the conductor. Tamp down the soil, then fill in the trench.

5) Please note that this is a guide to installation only. Full instructions will be supplied at time of product purchase.

B.4.2 Ground Rod Backfill Installation

Estimated bags of GEM for backfilling around ground rods
to a density of 1442 kg/m3 (90 lb/cu ft)

Diameter of hole	**Depth of hole (feet) ***						
	1.8m (6')	**2.1m (7')**	**2.4m (8')**	**2.7m (9')**	**5.2m (17')**	**5.8m (19')**	**6.1m (20')**
7.5cm (3")	2	2	2	2	4	4	4
10.0cm (4")	2	3	3	3	6	7	7
12.5cm (5")	3	4	4	5	9	10	10
15.0cm (6")	5	5	6	7	13	14	15
17.5cm (7")	6	7	8	9	17	19	20
20.0cm (8")	8	9	11	12	22	25	26
22.5cm (9")	10	12	13	15	28	31	32
25.0cm (10")	12	14	16	18	34	38	40

* 2.44m (8 foot) minimum rod length required to be in contact with the soil (or GEM). As per NEC 250-83c.

B.4.2.1 Method

1) Auger a 7.6cm (3 inch) or large diameter hole to a depth of 15.0cm (6 inches) less than the length of the ground rod.

2) Place ground rod into augured hole and drive it using the steel head and hammer approx 30 cms (one foot) into bottom of the hole. The top of the ground rod will be approximately 15.2cm (6 inches) below the level of the grade. At this time, make any connections to ground rod using CADWELD® connections.

3) Pour the appropriate amount of GEM (see below) around the ground rod. To ensure the GEM material completely fills the hole, tamp around the ground rod with a pole.

4) Fill remainder of augured hole with soil removed during auguring. For various augured-hole diameters and depths, see the table above.

Note: *Excess standing water must be removed the hole.*

Note: *When premixing GEM in a slurry form, use a standard cement mixer or hard-mix in a mixing box, wheelbarrow, etc. Use 5.5 to 7.5 litres (1.5 to 2 gallons) of clean water per bag of GEM.*

Note: *This is a guide to installation only. Full instructions will be supplied at time of product purchase.*

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Annex C TERMS AND DEFINITIONS

Bentonite	A ground enhancing material (GEM) of clay with high conductivity.
Bonding	A process of mechanically connecting two or more metal parts together for the purpose of reducing electrical resistance and facilitating the discharge of lightning or electrical fault currents to ground.
Brazing	The joining of two or more metal pieces together with a heated liquefied filler metal whose melting temperature is lower than that of the metals being joined.
Bulkhead panel	A copper panel/plate designed for the attachment of incoming transmission lines.
Cable tray	A support structure for cables and transmission lines.
Effective Radiated Power (ERP)	The actual Radio Frequency power radiated by an antenna.
Exothermic welding	The fusing of two or more metal pieces with a mixture of copper oxide and granular aluminium through a momentary heating process to achieve a molecular bond.
Ground Enhancing Material (GEM)	Conductive and non-acidic material added to the ground/soil to improve its conductivity for the dissipation of lightning induced energy.
Grounding	The process of establishing a connection/path to ground, often referred to as a discharge system, for the dissipation of lightning induced energy or fault currents into the ground.
Ground Potential Rise (GPR)	The voltage rise caused when the ground reference level increases because of the momentary inductance that a grounding system experiences during a lightning strike.
Ground rod	A steel electrode, copper clad or galvanized driven into the ground for the dissipation of the energy induced by a lightning strike.
Inductance	The electrical resistance to alternating current or pulses.

Master Ground Bar (MGB)	A solid copper or brass plate that is used as the single distribution point for ground cables used inside an equipment room.
Metal Oxide Varistor (MOV)	A surge suppressor, often used for higher voltages, which conducts when a pre-set voltage level is exceeded.
Perimeter ground	A grounding system consisting of a buried cable and ground rods that form a closed loop around a building, trailer, or shelter.
Radials	Straight runs of buried copper cable from the base of a tower, or structure, typically with ground rods attached at specified intervals.
Silicon Avalanche Diode (SAD)	A solid state surge suppressor that conducts when a pre-set voltage level is exceeded.
Silver soldering	The joining two or more metal parts with silver as the filler agent. This provides a stronger mechanical connection over regular lead based soldering having a much higher heat resistance.
Spark gap arrestor	A passive, mechanical devise that only allows current to conduct at a pre-set high voltage by arcing across its contacts.
Surge suppressor	A device that shunts transient currents above a pre-set level to ground.
Thermite bonding	The fusing of two or more metal pieces with a mixture of iron oxide powder and granular aluminium through a momentary heating process to achieve a molecular bond.
Toroidal transformer	A transformer with primary windings on a round ring with secondary windings on another ring that is looped through the center of the primary winding ring without making physical contact.
Tower Ground Bar (TGB)	A solid copper or brass bar attached to a tower for the connection of cable grounding straps.
Ufer grounding	A grounding method that uses the rebar and steel embedded in concrete as grounding electrodes for lightning charge dispersion.
Waveguide bridge	A platform, usually made of galvanized steel, that supports transmission lines and other cables

Annex D TEST

- CAN/CSA-C22.2 No. 0.4-04
- CAN/CSA-S37-01
- Canadian Electrical Code
- Canadian Electrical Safety Code
- CCG Tower/Remote Site Groundings General Drawings And Engineering Standards, Newfoundland
- Designing For A Low Resistant Earth Interface (Grounding) by Roy B. Carpenter, Jr. and Roy B. Lanzoni
- General Site Grounding Specification, Canadian Coast Guard, Rev 5, Central & Artic, December 12, 2002
- Grounding Standard for the National Oceanic and Atmospheric Administration, National Environmental Satellite, Data and Information Service, Standard No. S24.809, Revision of December 22, 2000
- Grounding/Bonding & Lightning Protection For A Typical Cell Site, Rogers Wireless, Issue 3, October 29, 2004
- Installation Methods For Protecting Solid State Broadcast Transmitters against Damage From Lightning And AC Power Surges by John F. Schneider
- Lightning Protection and Grounding Solutions for Communication Sites, Polyphaser by Ken Rand, January 2000
- Lightning Rod Act, Chapter 257, revised Statutes, 1989 and amended 1995-96, c. 8, s. 19
- Motorola's Standards And Guidelines For Communication Sites R56
- Practice For Lightning & Grounding Protection For Telecommunication Sites – Canadian Coast Guard, Maritime, June 19, 2003
- Site Protection Through Proper Grounding, Bonding and Design Practices by Paul Simonds, 2006
- Telecommunications Grounding Standard, MNS-GND001-01, Issue 2.1 of March 5, 2007

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Annex E TEST 2

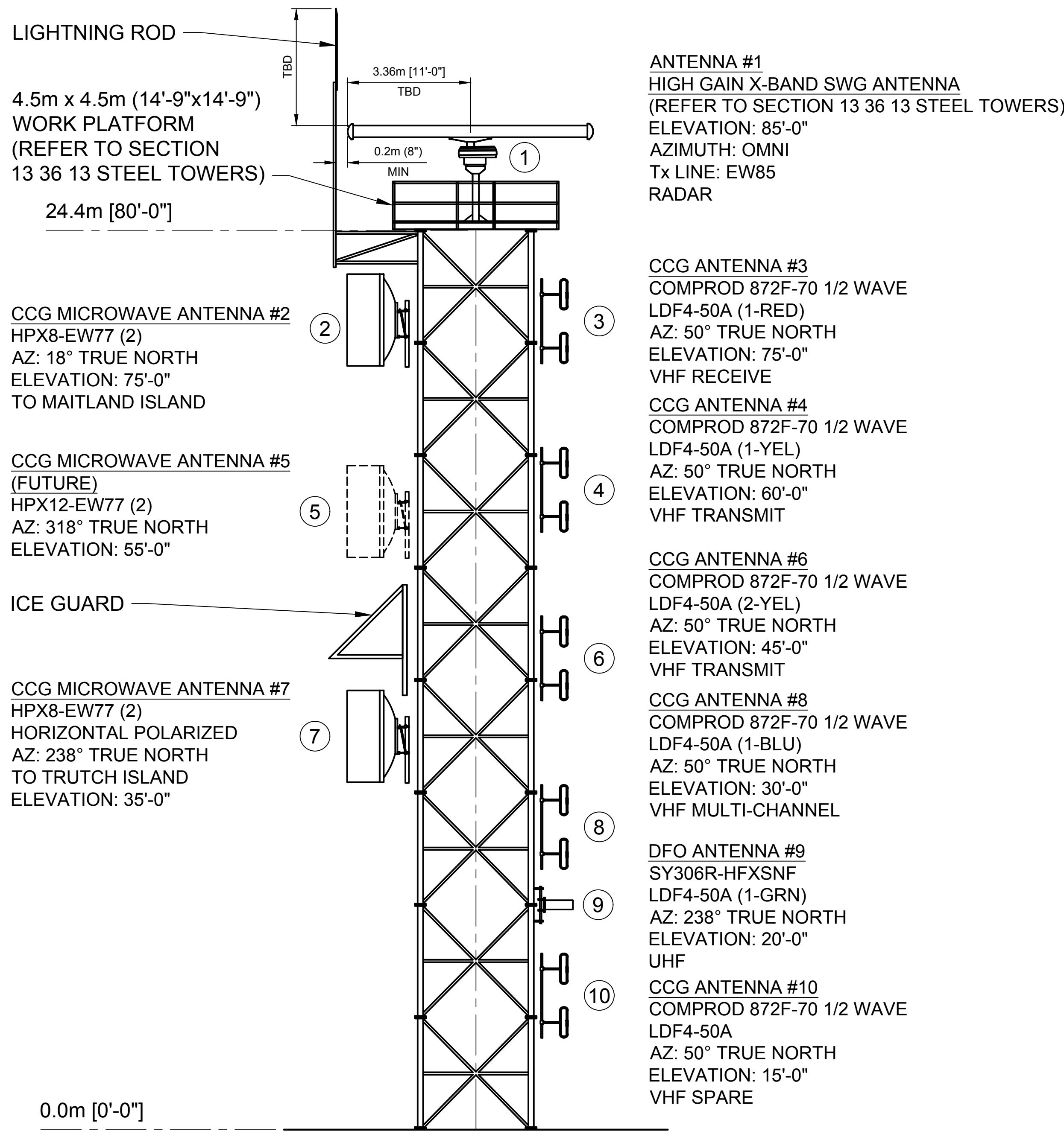
The Canadian Electrical Safety Code defines in **Section 10** under **Grounding and Bonding** the various rules, options and requirements that apply to meet code compliance. For supplementary information and details not in this standard, consult the Canadian Electrical Safety Code for more information.

Section 10 – Grounding and Bonding also details and defines the following:

- Artificial Grounding Electrodes
- Equipment Bonding
- Equipment Bonding Conductors
- Grounding and Bonding Conductors
- Grounding Electrodes
- Lightning Arresters
- Lightning Rods
- Methods of Grounding
- Neutral Grounding Device
- Neutral Grounding Device Conductors
- Neutral Grounding Device Warning Signs
- Spacing and Bonding of Electrical, Communication, and Community Antenna Distribution Grounding Systems
- System Grounding Conductors

ANTENNA LAYOUT DRAWING

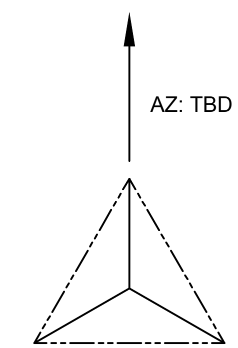
See following page.



ELEVATION

TOWER SPECIFICATIONS

Site:	**MOUNT GIL**
Latitude-NAD83	53° 15' 46" N
Longitude-NAD83	129° 11' 42" W
Design Standard:	CSA S37-13
Design Wind:	Refer to Environment Canada Wind Analysis
Design Ice:	25mm (Class II)
Reliability:	Class I
Serviceability:	1.0
Tower Twist & Tilt	SEE SPECIFICATIONS
Tower Type:	SELF SUPPORT - Triangular in cross section
Tower Height:	24.38m (80'-0")
Tower Section Height:	3.0m (10'-0")
Paint:	N/A
Ice Guard:	1 LOCATION
Safety Climb:	Climb Ladder c/w Trylon Cougar Rail
Anticlimb:	N/A
Lightning Protection:	Lightning Rod to provide 45° protection for top antenna
Tx Brackets:	Tx Brackets on either side of ladder rail or tower face
Antenna Mounts:	Required for All initial antennas.



PLAN VIEW

Fisheries and Oceans Canada — Pêches et Océans Canada
Canadian Coast Guard — Garde côtière Canadienne

designed - conception	date	checked - vérifié	date
-	-	AC/JM	2018-01-31
drawn - dessiné	date	approved - approuvé	date
TDK	2018-01-31	CRH	2018-01-31
CCG ref. no. - no. réf. GCC		scale - échelle	
-		1:175	

rev	description	by / par	Date
1	FOR REVIEW	TDK	2018-01-31

Asset - Actif: MOUNT GIL — VHF PERIPHERAL RADIO STATION

Drawing - Dessin: ANTENNA LAYOUT

drawing no. - no. dessin: WM-606-1000 | sheet-feuille: 01/01 | rev: 0

ANSI B

File / Fichier: WM-606-1000 MOUNT GILL - ANTENNA TOWER LAYOUT.DWG - Printed / Imprimé: 2018/02/13 1:58