1 General

.1 System Requirements

.a Energy efficient fixtures shall be utilized. LED lighting shall be baseline on new construction and renovation projects. Alternatives to LED shall be reviewed by the owner during the design development phase of design. 0 to 10v dimmers shall be provided except in utility spaces.

.b Building lighting controls shall tie into the Building Management System so that lights may be scheduled and turned on or off for each lighting zone independently (floor and or suite level contactors) and for the entire building.

.c Localized individual space control should generally utilize occupancy sensors and can be used in individual offices, conference rooms, lounges and toilets, or as required by code.

.d Where future expansion is planned in the initial design of a facility the Engineer shall provide adequate additional capacity and connection points in the electrical design. The additional capacity shall be clearly noted in the equipment schedules.

.e All points for future connections shall be clearly shown and labeled on the drawings with the capacity (Kw, etc.) that is available at each connection point.

.f **Provide ten (10) ¾" spare conduits for all recessed panel boards to stub out above lay-in ceiling. Label spares and note where spare terminates.**

.g Provide lightning and surge suppression on all security, intercom, Building Automation System (BAS), MATV, and fire alarm systems.

.h Phase loss protection shall be provided at motors and equipment >1 HP not served by VFD's.

.i Provide conduit and pull string from demand meters (electrical, gas, and water) to main Mechanical Room and Electrical Room or closest point of access to BAS network.

.j Provide dedicated and protected 120V power to all HVAC control panels.

.k A network jack shall be located at each DDC panel, UPS system, and Electrical Room. Coordinate location of DDC controls panels with HVAC designer as required and provide quantity of network jacks needed at all locations indicated.

.l Label each outlet showing panel, and circuit number. Exterior receptacles shall have the label installed on the inside of the weather-proof enclosure; floor boxes shall have the labels installed inside the floor box and not on the cover.

.m Label each switch showing panel, and circuit number.

.n Junction boxes and conduit shall be color coded as indicated in the Wake County Conduit and Box Color Chart (Exhibit A) in Division 26. Raceways shall be provided with factory applied color surface.

.o Provide separate panels for lighting, plug, and mechanical loads, (controls) for integration of submetering as required by the owner. This requirement for projects less than 5000 square feet to be discussed with the owner as to applicability.

.p Raceways shall be UL listed and provided for all conductors, including but not limited to lighting, power, grounding, control, fire alarm, and communications.

.q Where applicable (Fire stations, EMS, etc.) provide "Supervisory Control and Data Acquisition Systems" (SCADA) at remote equipment sites for supervision and control, alarm management, energy management, and data collection. SCADA shall be cellular, and IP based. See SCADA specification in Division 26 – Exhibit B

.r All public safety facilities, detention, and other 24/7 operational facilities shall be equipped with emergency generators to serve 100% of building load.

.s Lighting serving mechanical, electrical rooms, and elevator machine rooms shall be manually switched.

.t Disconnect switches shall be installed at a height not to exceed 6'-2" AFF. Disconnect heights shall be consistent throughout facility

.2 Codes & Standards

.a Comply with applicable provisions of the most recent "North Carolina Building Code: Electrical Code".

.b Comply with NFPA Codes and Standards.

.c Comply with all applicable NEIS standards.

.d Comply with OSHA electrical standards and workmanship.

.e Comply with applicable requirements of NEMA Standards.

.f Comply with the 2022 or latest edition of the Wake County "Energy Design and Management Guidelines."

.g Comply with Illuminating Engineering Society (IES) for interior and exterior lighting.

.h All products specified and installed shall bear the label of UL or other North Carolina recognized third party testing agency. (https://www.ncosfm.gov/third-party-testing-agencies/open)

.i Reference "Illuminating Engineering Society Handbook" for space lighting illumination levels.

.j Design and installation shall be compliant with the requirements of the "local authority having jurisdiction."

.k Reference Division 25 Building Automation, Division 27 Communication/Data/Public Address, and Division 28 Electronic Security.

2 Products

.1 Equipment Selection

.a The selection of all Electrical systems shall be approved by Wake County at the schematic design phase.

.b . **Conduit:**

1. Minimum conduit size shall be 3/4", 1" for data.
2. Conduit types shall be galvanized rigid steel, IMC, or EMT.
    a. Interior Conduit shall be pre-colored EMT (see Conduit Color Code Chart – Exhibit A)
    b. Exterior Conduit shall be galvanized rigid conduit. Conduit color is not required for exterior galvanized rigid conduit.
3. Flexible conduit can be used for equipment connections but must be **limited to a maximum of 4 feet**
    a. Flexible Liquid-tight metallic conduit should be used in damp or wet locations such as mechanical rooms with pumps or exterior locations.
    b. Flexible Metallic Conduit can be used in interior dry locations.
4. **The use of MC Cable shall not be permitted. Exceptions may be granted where cable is factory provided, i.e. light fixtures, etc. and is limited to 6'-0.**
5. Exposed raceways or conduits are unacceptable in finished spaces.
6. Exterior conduits serving lights, equipment, signs, etc. shall be galvanized rigid.
7. The use of wire mold shall not be permitted.
8. Insulated throat connectors shall be used on all conduit terminations
9. Fittings shall be all steel. EMT couplings shall be compression. Set screw and crimp type fittings shall not be permitted.
10. Roof penetrations shall use weather heads.
11. All conduit and raceways shall be neatly installed parallel to or at right angles to beams, walls, and floors of the building.
12. Installation of conduit shall not be installed in concrete columns, beams, or slabs.

13. PVC may be used under slab or on site if encased in concrete and is a minimum of 1". Provide 90-degree rigid metal elbows transitioning to above the slab. Rigid conduits are preferred.
14. **Refer to the conduit color requirement as indicated in the Wake County Conduit and Box Color Chart (Exhibit A).**

.c Panel boards:

1. All panel boards shall have factory furnished copper bus with bolt-in breakers.
2. Provide main breakers in all panel boards including sub panels that are served from another panel board.
3. Circuit breakers shall be molded case (MCCB), bolt-on type thermal magnetic trip, with common trip handle for all poles.
4. Lighting panel boards shall only contain lighting circuits. All other loads such as receptacles, plug-loads, equipment, etc. shall be served from separate panel boards. Projects under 5000 square feet may be exempted from this requirement.
5. **All panel boards shall be selected for 25% minimum spare electrical and physical capacity above the anticipated demand load.**
6. Typed directories shall be provided in all panel boards indicating room names and number to match final signage used at the site and as required by the National Electric Code.
7. Provide phenolic labels on each panel board, transformer, and main distribution panel identifying the electrical equipment and, on each panel, transformer, main distribution panel identifying each piece of equipment being served.
8. An electrical panel arc-flash study should be provided on new and renovation projects over 5000 square feet. Arc-flash labels shall be provided on electrical panels.

.d Lighting:

1. Discuss light ideas and control strategies with Wake County prior to design of lighting systems.
2. Site Parking Lighting shall be designed and provided by local utility and shown on the site plan at the Design Development Submittal.
3. Provide additional exterior building lighting as needed to insure all exterior entrances and first floor windows are illuminated. Coordinate with Security Designers.
4. Light Fixtures:
   - **a.** Interior Lighting:
     - **i.** Interior lighting should be 3500K. Any exceptions should be justified and approved by the County in writing.
     - **ii.** All fixture types selected should be available from 3 different manufacturers so that future replacement continues the design intent visually.
     - **iii.** Office, Conference, Hallway areas should use direct/indirect LED troffers
     - **iv.** Mechanical and utilitarian areas should use surface mount strip fixtures with diffusers or flat panel LED fixtures.
     - **v.** Pendants shall be architectural Linear LEDs.
     - **vi.** Ornamental or decorative fixtures should be selected to ensure long-term operation. Fixtures that use non-enclosed medium base LED lamps are preferred.
   - **b.** Exterior Lighting:
     - **i.** Exterior lighting should be 4000K. Any exception should be justified and approved by the County in writing.

ii. All fixture types selected should be available from 3 different manufacturers so that replacement continues the design intent visually.

c. Provide minimum five (5) year warranty.

5. In ground light fixtures shall not be used.
6. Site, flag pole and sign lighting to be reviewed by Wake County of a project basis.
7. Limit the total number of various types of lamps.
8. Use wall mounted light fixtures to light stairwells.
9. Engineer to furnish a copy of lighting calculations to the owner to review prior to 100% CD submittal. Provide cut sheets and photometrics of site lighting design.
10. Vandal-resistant materials or metal guards shall be used for fixtures within reach of floors and all outdoor locations.
11. Photocell and BAS control shall be provided for exterior lighting control where BAS control is utilized. Where BAS is not available, control via photocell or timeclock.
12. Light selections and cut sheets to be submitted to Wake County at DD and CD submittal phase.
13. Lighting attic stock shall be discussed on a per project basis.

.e Building Distribution Wire and Cable

1. Conductors for general power wiring shall be single conductor insulated wire, conductor: copper: insulated voltage rating: 600 volts, insulation type: THHN/THWN or other where code mandates.
2. Aluminum wiring is prohibited.
3. Minimum wire #12 gauge. Stranded copper wire should be used. Feeder wiring on final run from junction box to receptacles, light switches, or other devices as allowed by owner should be solid copper.

.f Junction & Floor Boxes

1. Minimum outlet box size: 4” square x 1-1/2” deep.
2. Inaccessible Ceiling Areas: Install outlets and junction boxes no more than 6 inches from ceiling access panel.
3. Metal junction boxes only. Steel interior, stainless steel exterior. Exceptions only as approved by owner.

.g Wiring Devices

1. Heavy-duty general use devices.
2. Device body: Gray plastic unless otherwise permitted by owner.
3. Device color: Gray
4. Cover Plate: Brushed stainless steel.
5. Devices supported by all emergency or standby generation systems. ~~or UPS~~ shall be red unless it is a fully generated building. UPS systems devices shall be orange.

.h Generators

1. When generator back-up will be provided, an above ground double-wall belly tank will be specified.
2. All tanks shall have a minimum of 48 hours of fuel capacity unless otherwise required by code.
3. Generators shall be diesel.
4. Generator Status shall be monitored by SCADA system.
5. Transfer switch to be automatic.
6. All emergency generation and UPS conduit distributions systems shall be color code green per the Wake County Conduit and Box Color Chart – Exhibit A. The exception is where the

entire building is on emergency backup power then only the UPS conduit distribution system needs to be green.

.i Supervisory Control and Data Acquisition (SCADA)

1. See Supervisory Control and Data Acquisition Systems Supplement in Division 26 – Exhibit B. Fire and EMS stations should include cellular connectivity for SCADA communications
2. Automatic transfer switch shall be utilized.
3. Designer should request the latest details for adaptation and incorporation into the project manual.

.j Grounding

1. Bond the metal underground water pipe, metal frame of the building, and rod electrode with an un-spliced insulated copper grounding electrode conductor.
2. Provide separate, insulated copper within each feeder and branch circuit raceway. Terminate each end on suitable lugs, bus, or bushing.
3. Bond metal coping of building exterior to grounding system.
4. Provide ground bar for MDF and IDF data closets to building ground.

.k Enclosed Disconnects

1. Fusible heavy duty load interrupter enclosed knife switch with externally operable handle interlocked to prevent opening front cover with switch in ON position except by operating a permissive release device. Handle lockable in OFF position.
2. Interior and dry locations: NEMA type 1 enclosures 1, exterior locations: NEMA type 4XSS enclosures.
3. Exterior locations shall be stainless steel.

.l Variable Frequency Drives

1. Refer to Division 23.2.1.j for requirements.
2. Coordinate with HVAC designer locations where required.

.m Dry Type Transformers

1. Use of energy savings or K-rated isolation type transformers shall be evaluated based on specific application and loading. Consideration to be given to quiet operating transformers.
2. Factory-assembled and tested, air cooled units for 60 Hz service.
3. Surpasses NEMA TP-1, Class I efficiency by 25 percent.
4. Wall mounted units shall have brackets fabricated by the manufacturer.
5. Floor mounted units shall have concrete bases and be anchored. Add spacer so conduit stubs into bottom.
6. Provide copper coils.
7. Transformers 100 KVA and over shall be isolated in an individual room and have a separate cooling/ventilation system.

.n Lighting Relay Panels

1. Lighting relay panels shall only be used where integrated into an audio-visual package. Motorized breakers are not acceptable.

.o Lighting Control System:

1. Lighting controls shall be accomplished using mechanical held lighting contactors with two-wire control module. Control of this contactor should be through the building management system (BMS). This includes all lighting with the exception of emergency lighting.
2. Offices and conference rooms shall have local occupancy controls via wall or ceiling mounted sensors.
3. Enclosure shall be NEMA 1, NEMA 3R, or NEMA 4 dependent of location.
4. Motorized breakers are not allowed.

.p 800 MgHz Towers:

1. Comply with "Understanding TIA-222 – Revision G" – Exhibit C

.q Transient Voltage Surge Suppression (TVSS)

1. Provide TVSS for main electrical switchgear and branch panel boards serving computers and electronic loads and all life safety panels as required by the NEC.

.r EV Charging Station

~~1.~~ Where EV charging is planned for the building, a separate utility service should be installed for EV charging.

.s Solar PV Systems

1. All new buildings should be considered for solar PV installation.
2. At a minimum all buildings shall be solar PV ready.
   a. Space should be planned and set aside for inverters and reserved for PV throughout construction.
   b. Interconnection point shall be determined during design and provision for installation should be provided, i.e. spare breakers, lugs for line side tap, etc.
   c. Roof penetrations and conduit sized for full solar PV shall be installed through roof and weatherproofed.
3. Solar PV system shall be consistent and compatible with existing monitoring system the County operates.
4. Include building power consumption monitoring with the PV system
5. Racking System:
   a. Low-sloped roofs shall use a ballasted, all metal racking system
   b. Standing seam metal roofs shall use seam clamp metal racking (S-5 clamp)
6. Inverters:
   a. Inverters are preferred to be installed on the interior of the facility.
   b. Where the inverters must be installed on the exterior of a facility, protection from direct sun, exposure, rain, dust, and debris is required.
   c. Multi-module inverters are not allowed. Multiple inverters must be combined on the AC side with conduit and panelboards.
   d. DC-optimized system must be provided with attic stock (5%, or minimum of 3)
   e. Provide minimum 20-year warranty.
7. Module Requirements:
   a. Mono-Si modules
   b. Must have a minimum 12-year product warranty and 25-year production warranty.
   c. Modules must be provided with attic stock (5% or minimum of 3)

.t UPS System

1. UPS shall be fully isolated double conversion type.
2. Rack mounted UPS for Telecom and Security shall be provided. (One for telecom and one for security)
3. UPS must be compatible with the County's existing monitoring system.

3 Execution

.1 Design Requirements

.a The electrical contractor shall provide all power wiring to each piece of mechanical equipment. The mechanical contactor shall furnish all starters and disconnects to turn over to the electrical contractor. Mechanical contractor is to make final connection to each piece of mechanical equipment.

.b Engraved laminated labels shall be provided on **all** electrical equipment, panels, main distribution panels, and transformers.

.c Equipment name plates (metal preferred) with raised or depressed images for permanent attachment shall list the following:

1. Manufacturer, product name, model number, and serial number.
2. Capacity, operating and power characteristics, and essential data
3. Labels of tested compliances.

.2 Testing

.a Contractor to submit the following to the Designer and County:

1. A copy of all electrical exit and emergency battery testing
2. Generator capacity load tests. Test at 50, 75, and 100 percent.
3. Fire alarm certification.
4. SCADA Testing
5. Generator load test as required (tested at 100% of generator capacity load).
6. Megger testing for feeders 100 amperes and larger.
7. Ground fault testing of circuit breakers as required by the NEC.

.b A copy of all certification tests shall be available for the Fire Marshall at final inspection for issuing the Certificate of Occupancy.

.c A copy of a letter certifying that an operating test of the complete electrical system has been completed Minimum tests include the control and distribution equipment, phase rotation, circuit breakers, and wiring.

Exhibit A: Conduit and Box Color Chart; Exhibit B: SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS VERSION 1.2 specification; and Exhibit C: Understanding TIA-222-Revison G are included in this document below.

Exhibit A

Wake County Conduit and Box Color Chart

System	Junction Box & Cover	Conduit Color	Raceway Labels	Comments
120/208 V equipment	Galvanized	Galvanized		
277/480 V equipment	Black	Galvanized		
Emergency Systems	Green	Green		
Telephone Systems	Orange	Orange		
Data Systems	Brown	Orange		
Paging	White	Orange		
Fire Alarm Systems	Bright Red	Red	White	
TV Systems	Purple	Orange		
Audio Visual	Blue	Galvanized		
HVAC Controls	Galvanized	Blue		
Communications – ES	Galvanized	Yellow	Orange	Intercom System
Security Control – ES	Galvanized	Yellow	Green	Card Reader System
Video Surveillance – ES	Galvanized	Yellow	Blue	Camera System
Network	Galvanized	Yellow	Yellow	Backbone that connects the security closets
Nurse Call System	Galvanized	Orange		Label box covers “Nurse Call System”

EXHIBIT B

SECTION 269999 – SUPERVISORY CONTROL AND DATA ACQUISITION SYSTEMS VERSION 1.2

PART 1 – GENERAL

1.1 SECTION INCLUDES

A. MOSCAD Remote Terminal Unit (RTU) equipment.

B. DEMARC equipment.

C. Input/Output Sensors.

1.2 RELATED DRAWINGS

A. Drawings and general provision of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.

1.3 SUMMARY

A. This Section includes equipment for monitoring and controlling remote systems and components, including generators, lift stations and pumping stations.

1.4 RELATED SECTIONS

A. Section 263600-Transfer Switches.

B. Section 263213-Engine Generators.

1.5 SYSTEM DESCRIPTION

A. Supervisory Control and Data Acquisition (SCADA) Contractor shall provide:

1. A fully assembled and operational MOSCAD RTU and DEMARC Control Panel.
2. All wiring, conduit, panels, for all SCADA controls and data acquisition.
3. All final electrical connections.
4. Contractor shall be responsible for all electrical work associated with the SCADA system and as called for on the Drawings.

    a. Perform all wiring in accordance with all local and national codes.
    b. Install all line voltage wiring, concealed or exposed, in accordance with Division 16.
    c. Contractor shall provide 120 volt, 20 amp circuits and circuit breakers from normal and/or emergency power panel for SCADA systems.
    d. All low voltage electrical control wiring through the building shall be installed in accordance with Division 16.

B. General Product Description:

1. The supervisory control and data acquisition system (SCADA) shall provide control and data acquisition to remote equipment sites. The functions including equipment supervision and control, alarm management, energy management, and data collection. The Supervisory Control and Data Acquisition system shall be fully compatible and shall be fully integrated with the existing Wake County owned 800 MHz system presently owned and operated by Wake County. MOSCAD-L or MOSCAD-M are not acceptable.
2. The supervisory control and data acquisition system shall consist of the following: Motorola MOSCAD RTU, DEMARC Panel and all required accessories.

1.6 SUBMITTALS

A. General: Submit each item in this Article according to the Conditions of the Contract and Division 1 Specification Sections. A minimum of 7 complete sets of documents are required. Submit 3 copies of all submittals to owner at time of submittal to architect.

B. Manufacturer's Product Data for each and all types of products specified. Include manufacturer's technical Product Data for each device furnished, indicating dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, installation instructions, and startup instructions.

C. Shop Drawings from manufacturer detailing equipment assemblies and indicating dimensions, weights, loadings, required clearances, method of field assembly, components, and location and size of each field connection.

D. Certificate for Motorola Certified MOSCAD Solution Provider and certificate for Wonderware Certified System Integrator from preferred vendor (prime or subcontractor).

1.7 PROJECT RECORD DOCUMENTS

A. Submit under provision of Division 1.

B. Accurately record actual location of components, including but not limited to, panels and sensors.

C. Revise shop drawings to reflect actual installation.

D. Provide hard copy and electronic files.

1.8 OPERATION AND MAINTENANCE DATA

A. Submit under provision of Division 1.

B. Maintenance instruction and spare parts list for each type of device.

C. Interconnection wiring diagrams with identified and numbered system components and devices.

D. Inspection period, cleaning methods, cleaning materials recommended, and calibration tolerances.

E. Calibration records and list of set points.

1.9 QUALIFICATIONS & QUALITY ASSURANCE

A. Materials and equipment shall be the catalogued products of manufacturers regularly engaged in production and installation of SCADA systems and shall be manufacturer's latest standard design that complies with the specification requirements.

B. Install system using competent workmen who are fully trained in the installation of SCADA equipment.

C. Motorola MOSCAD equipment and related programming will be executed by a firm which is both a Motorola Certified MOSCAD Solution Provider and Wonderware Certified System Integrator.

D. **Contractor MUST obtain a translation file from Wireless Communications that will allow the new SCADA system to communicate with the County's existing head-in equipment.**

1.10 INPUT/OUTPUT SUMMARY

A. **Refer to Sheet E603 for list of points.**

PART 2 – PRODUCTS

2.1 ACCEPTABLE MANUFACTURERS

A. **Motorola.**

B. **No others will be accepted. In addition, in order to provide a complete and working system the component manufacturers listed in this specification MUST be provided with no substitutions.**

2.2 MOSCAD RTU

A. General:

1. The remote terminal unit (RTU) shall be an intelligent, modular unit capable of both data acquisition and local data processing. It shall monitor and control local equipment in a stand alone mode as well as being an intelligent node in a distributed processing system. It shall be microprocessor based and allow reconfiguration and optimization to occur via software only. To facilitate installation, maintenance and future expansion, all Input/Output (I/O) modules shall connect to the basic processor module via a passive motherboard on the RTU rack. A PC-compatible computer running a single, comprehensive standard application development and diagnostic software package shall be used for program development and downloading (directly to the RTU).

   Each RTU must be supplied with the number and type of I/O points as indicated elsewhere in the plans and specifications. Future expansion shall be possible by simply plugging in additional I/O modules to the I/O bus. Each RTU shall be supplied with the following minimum configuration:

   a. Mother Board
   b. Power Supply
   c. I/O Bus
   d. Battery
   e. Enclosure
   f. I/O Modules as required
   g. CPU Processor Module
   h. Communications Interface

B. Communications:

1. General: The RTU shall support the establishment of a sophisticated data communication network for SCADA applications utilizing 800 MHz radio links, smart zone compatible and flash port upgradeable. Radio links shall include conventional trunked radio.

2. Data Protocol: Data communications shall utilize a secure, smart protocol designed in accordance with the Open System Interconnection (OSI) model as defined by the International Organization for Standardization (ISO). The protocol should allow flexible, efficient communications for transmission of data, complete programs, databases or other parameters. Complete configuration and diagnostic programs shall be transferable from/to the Central site (full data upload/download capability). Complete RTU/system debugging shall be allowed without visiting each remote site. The protocol shall support a complex hierarchical system structures of multiple host computers and sub-master stations. Its detail structure, however shall be transparent to the system user and allow him to concentrate upon the application.

C. Communications Methods:

1. In addition to the simplistic master/slave polling configuration, the RTU shall operate in a number of more efficient contention formats required by point to multipoint networks. The RTU must support quiescent operation and initiate data transmissions under the following conditions:

   a. Report by Exception – Automatically transmit upon defined exception condition(s); analog, digital or any combination.
   b. Timed Transmission – Automatically transmit data on programmed time interval.

D. Special Communication Requirements:

1. In addition to the communication methods above, the RTU must also support the following special modes:

   a. Trunked Radio Interface: Each RTU shall be able to use a trunked radio communication system.

E. Radio Communication Channels:

1. The RTU shall operate on 800 MHz trunking. Each RTU shall monitor the communication channel(s) to prevent transmission during a busy period. Channel priority assignments shall be available (both network and individually) to handle avalanche conditions. The RTUs are fixed equipment that transmit digital information over radio frequencies.

F. Hardware Modules:

1. Basic Processor Module: The basic processor module (CPU) of the RTU shall be a real time process controller and support:

   a. Bus communication with I/O modules
   b. System memory allocation
   c. System parameter/logic programming
   d. Communication port control

2. The Central Processing Unit (CPU) shall be a high speed (16MHz clock rate), 32 bit CMOS microprocessor, Motorola 68302 or equivalent. This VLSI design must incorporate a separate co-processor (embedded RISC Chip) to handle all external communication tasks so as to not affect base CPU performance.

3. The CPU shall be equipped with a minimum of 704 kbyte on-board memory of different types.

   EPROM - for system programs

RAM - for data and parameters

FLASH (EEPROM) - for application programs

Total RTU memory must be expandable to a minimum of 2.5 Mbyte. Provision must be available to add a numerical co-processor (Motorola 68882 or equivalent) with true double precision floating point capabilities along with additional memory and support for trigonometric and transcendental functions.

4. The CPU module must incorporate a real-time clock (RTC) with lithium battery backup for both RTC and module RAM. Large scale CMOS gate array technology must be used for minimum component count and maximum performance and reliability. CPU features include:

   a. Watch-dog timer (WDT)
   b. Symbolic debugging support
   c. Diagnostic LED indication
   d. Power monitor for clean program start/stop

5. The CPU module must include at least the three built-in communication ports as listed below:

   a. Port 1: RS-232 or RS-485, software controlled, full DCE/DTE operation to 9600 bps.
   b. Port 2: RS-232, full DCE/DTE, 9600bps, transient protected.
   c. Port 3: Configurable (Plug-In) communication module for radio, wireline, trunked radio, and dial-up wire line, 600-9600 bps, dependent upon media.

6. Support shall be available for additional serial channels, second radio, wireline or other external communications.

G. Input/Output Modules:

1. Support shall be available for additional serial channels, second radio, wireline or other.
2. The RTU shall address variable I/O requirements by the addition of appropriate expansion modules. Each module shall communicate with the CPU module via a high speed (> 1 Mbps) data bus. Up to 44 modules shall be supported by a single CPU module; dual CPU configurations shall optionally be available. Each expansion module may be plugged into an empty slot on the I/O bus.
3. All modules, regardless of type (unless specifically noted), must share the following features:

   a. Input Protection: dc/dc converter with 2.5kv optical isolation per IEEE SWC 472/587.
   b. Output Protection: 1 kv between contacts, 1.5kv between contact and coil per IEEE SWC 472 CMOS Gate Array: all logic, bus and LED interface contained in one gate array on each module to minimize components and increase reliability.

   c. Diagnostics: Loopback test, system clock, WDT, 20 diagnostic LED indicators of status and module failure modes.
   d. Terminal Boards: Removable, Phoenix type up to 14 AWG (2.5 sq. mm) or DIN connector.

4. Module Identification: Check hardware I/O versus application specification.

5. Digital Input Module – Type 1

   a. Capacity: 16 dry contacts, all isolated inputs; 2 high speed counters (up to 10 Khz).
   b. Counters: All base inputs may be defined as low speed counters, 50-500Hz.
   c. Interrupt-Handling: Change of State (COS) reporting to 1 ms in interrupt mode.
   d. Input filtering 1-32 ms, software controlled.

6. Digital Output Module

    a. Capacity: 16 electrically energized relay contacts.

7. Analog Input Module

    a. Capacity: 8 floating, isolated inputs.
    b. Type: 4-20Ma.
    c. Resolution: 13 bits including sign.
    d. Accuracy/Linearity: ±0.05% full scale/±1 LSB.
    e. Calibration: Automatic, software controlled (no potentiometer).

8. Analog Output Module

    a. Capacity: 4 optically isolated outputs.
    b. Type: 0-5 V or 4-20Ma performance dependent upon power supply.
    c. Resolution: 12 bits including sign.
    d. Accuracy: ±0.1% full scale.

9. Mixed Input/Output Module

    a. Capacity: 8 isolated dry contracts digital inputs, 4 electrically-energized relay contacts, 2 analog inputs.
    b. Type: 4-20Ma.
    c. Resolution: 12 bits including sign.
    d. Accuracy/Linearity: ±0.05% full scale/±1 LSB.
    e. Calibration: Automatic, software controlled (no potentiometer).

H. Construction:

1. The RTU shall be totally modular in design and construction, allowing specific configuration merely by plugging in the appropriate CPU and I/O modules. All modules and their assembly shall be accomplished without screws or fasteners of any type. All connections shall utilize a “snap-in” action and a tool shall be supplied to aid easy connector removal. The RTU shall be available in several sizes to fit different application requirements including 3, 6, 8 and 16 module assemblies. Basic RTU models shall consist of a mounting plate and motherboard, a CPU module (occupies 1 slot) and a power supply/charger.

2. All elements must use CMOS components and LSI circuitry. No jumpers, DIP switches, or adjustable potentiometers shall be allowed. Extensive use of SMD (surface mount device) is required.
3. Front access to all controls, indicators, lithium battery and external cables shall be provided. Motherboard connection to I/O modules shall be direct; no daisy chain or multiple ribbon cable connections allowed.
4. All I/O modules shall be equipped with a front cover door to serve as: module latch release, wiring identification label and terminal board protection. Space shall be available to direct and route external wires from outside the RTU that are connected to the I/O modules.

I. Enclosures:

1. The RTU shall be wall mounted NEMA 4X, stainless steel.

J. Environmental:

1. The RTU must operate over an ambient temperature range of -30 to +60 degrees C with relative humidity <95% @ 50 degrees C. It must meet or exceed EIA standards RS-204B and RS-152B.

2. The RTU shall meet or exceed the SWC standards as defined in IEEE C37.90A for all inputs and outputs. In the appropriated enclosure, the RTU shall meet all qualifications for UL 611, paragraph 26.
3. The RTU shall operate from 115/230 VAC, ±15%, 50/60 Hz primary power. A battery and charging circuit shall be included to provide 4 hour standby operation (for defined RTU capacity and use). Larger capacity batteries shall be available to extend operating time.

K. Application Software & Related Programming:

1. Operating System: The software shall be based upon a multi-tasking executive system optimized for real-time environments, Motorola's Object Oriented MTE or equivalent.
2. Application Software: The RTU shall be programmed with a high level, multiple process ladder diagram language which includes Boolean and arithmetic functions as well as specialized function blocks such as proportional, integral, derivative (PID) control and American Gas Association (AGA) flow calculations. The ladder diagrams shall be used for process definitions as well as symbolic monitoring and debugging.
3. Motorola MOSCAD hardware must be programmed and configured with the appropriate RTU software application program by Motorola 'Certified MOSCAD Solution Provider / Wonderware Certified System Integrator firm.
4. The MOSCAD engineer will program/download the application program to be executed in the RTU utilizing Programming ToolBox. This includes but is not limited to downloading the site configuration, application program and network configuration.

2.3 DEMARC PANEL

A. Enclosure shall be AM Products, series JIC size junction box, Stainless steel.

B. DIN Rail shall be Automation Direct, Rail #DN-R3551.

C. Terminal blocks shall be Automation Direct # DN-T10, gray, DN-T10-BLK, black, DN-T10-GRN, green.

D. Loop power supply shall be Automation Direct #PS24075D.

2.4 INPUT/OUTPUT SENSORS

A. AC current transducer shall be an American Aerospace Controls, Inc., series 100 SX, 4 to 20 mA, 2 wire operation.

B. Room temperature transmitter shall be Kele Model ST-T91E, 1000 OHM platinum room temperature transmitter.

C. AC voltage transducer shall be an American Aerospace Controls, Inc., series VX, 4 to 20 mA loop powered.

D. Monitoring system battery voltage system shall be Engineering Concepts Unlimited, Inc., Model ECU-VLD2-12 for 12 volt system or Model ECU-VLD2-24 for 24 volt system.

E. Electronic engine speed sensor shall be Thomson Technology Model FSR 230.

F. Single station level switch shall be Gems sensor.

G. Relay shall be cube electro-mechanical type with LED. The relay shall be rated for ampere and voltage as required for the application.

H. Relay sockets shall be compatible with cube relay.

2.5 ANTENNA

A. Antenna shall be Celwave Model PD10108-1, frequency 806-896 Mgz.

B. The coax between the antenna and the RTU shall be in accordance with manufacturer's recommendations.

2.6 RACEWAY

A. EMT: Electrical metallic tubing; ANSI C80.3, zinc-coated steel, with compression fittings.

B. FMC: Flexible metal conduit; zinc-coated steel.

C. LTMC: Liquid-tight flexible metal conduit; zinc-coated steel with sunlight-resistant and mineral-oil-resistant plastic jacket.

2.7 WIRES, CABLES, AND CONNECTIONS

A. Conductor, minimum No. 14, Solid or stranded copper.

B. Insulation: Thermoplastic, rated 600 V, 75 deg C minimum, Type THHN.

C. Wire Connectors and Splices: Units of size, ampacity rating, material, type, and class suitable for service indicated.

PART 3 – EXECUTION

A. EXAMINATION

Verify that field end devices and wiring are installed before proceeding with installation.

3.2 INSTALLATION

A. Install equipment as indicated to comply with manufacturer's written instructions.

B. Verify location of sensor and panels with plans before installation.

C. Install labels and nameplates to identify components.

D. Install electrical work in accordance with Division 16. Electrical material and installation shall be in accordance with appropriate requirements of Division 16.

E. Coordinate the direction of the antenna with Wake County General Services Administration's Representative.

F. Coax must be supported in accordance with the manufacturer's recommendations.

3.3 MANUFACTURER'S FIELD SERVICES

A. Prepare and start systems under provisions of Division 1.

B. Start-up systems. Allow sufficient time for start-up prior to placing systems in permanent operation.

3.4 COMMISSIONING

A. Test and adjust safeties and communications.

B. Replace damaged or malfunctioning components and equipment.

C. Start, test, and adjust systems.

D. Demonstrate compliance with requirements.

3.5 DEMONSTRATION

A. Demonstrate a complete and fully operational system to Owner.

END OF SECTION 269999

EXHIBIT C

UNDERSTANDING TIA-222 - REVISION G

UNDERSTANDING TIA-222 - REVISION G

What is Rev G?
Rev G is the latest revision of the TIA-222 Standard "Structural Standards for Antenna Supporting Structures and Antennas". The previous version of the Standard was Rev F. Rev G is based on a 3-second gust wind speed and Rev F is based on a fastest-mile wind speed. The wind speeds are not directly comparable and it is very important to define the basis of a wind speed when specifying wind loading requirements. For a given location, the 3-second gust wind speed represents the peak gust wind speed whereas the fastest-mile wind speed represents the average wind speed over the time required for one mile of wind to pass the site.

Rev G presents additional factors to be considered in the design of new structures and for the modification of existing structures. These factors are briefly discussed below. The reliability requirements of a structure can now be accounted for by assigning a classification to a structure (Class I, II or III). The wind speed can also be adjusted based on the type of terrain surrounding the site (Exposure B, C or D) and if the site is located on a hill, ridge or escarpment (Topographic Category 1-5).

Many tower profiles in this catalog now include antenna loading capacities for both Exposure B and Exposure C terrain conditions located on relatively flat sites (Topographic Category 1). Antenna loading capacities in accordance with Rev F are also provided for many tower profiles in the catalog. Please refer to the design notes in the catalog for each tower model series for further explanations. The Class of structure is stated in the design notes. Conditions other than stated may require a different tower profile than illustrated in this catalog. Quotes may be obtained for a specific application by contacting your ROHN representative.

Classification of Structures
Allows for the adjustment of wind, ice and earthquake loading to match the reliability requirements for a specific application. Three reliability classes have been established based on the type of service provided and on the structure's potential hazard to human life and property. Wind, ice and earthquake loading progressively increase from Class I to Class III structures.

Class I: Structures used for services where a delay in returning the service would be acceptable and the structure represents a low hazard to human life and/or property. Example services would be: residential wireless and conventional 2-way radio communications; television, radio and scanner reception; wireless cable, amateur and CB radio communications. Structures of this classification are exempt from ice and earthquake loading.

Class II: Structures used for services that may be provided by other means or structures that represent a significant hazard to human life and/or property. Example services would be: commercial wireless communications; television and radio broadcasting; cellular, PCS, CATV and microwave communications.

Class III: Structures specifically designed for essential communications or structures that represent a substantial hazard to human life and/or property. Examples of essential communications would be: civil or national defense; emergency, rescue or disaster operations; military and navigational facilities.

What is EPA?
EPA stands for Effective Projected Area. It is a standard way to define the "size" of an antenna regarding wind loading. Many antenna manufacturers provide data sheets that specify the EPA of their antennas. The TIA standard also defines a method to calculate the EPA of an antenna based on the size and type of the antenna components.

Generally, the EPA of an antenna, mount or accessory is equal to the summation of the projected areas of its components times appropriate drag factors defined in the TIA Standard. The EPA values listed in this catalog for standard tower designs represents the maximum EPA that may be supported unless otherwise indicated.

UNDERSTANDING TIA-222 - REVISION G

What is Exposure?
Exposure categories are used to adjust wind loading based on the type of terrain surrounding a site. Reduced wind loads are associated with rougher terrains that tend to slow the wind down. Three exposure categories have been defined based on terrain roughness. Wind loading is increased as the exposure designation changes from Exposure B (roughest terrain) to Exposure D (smoothest terrain).

Exposure B: Urban, suburban or wooded areas. The wind load at ground level is reduced compared to Exposure C. This reduction diminishes with height, making the overall wind reduction less significant for taller structures. In order to qualify for the wind load reduction, the rough terrain must extend in all directions from the site at least twenty times the height of the structure, but not less than one-half mile.

Exposure C: Flat, open country and grasslands.

Exposure D: Flat, unobstructed shorelines exposed to wind flowing over open water, smooth mud flats, salt flats and other similar terrain. The wind load at ground level is increased compared to Exposure C.

Topographic Categories
Topographic categories are used to determine increases in wind loading for sites located on hills and other elevated locations (other than buildings). The shape and relative height (topography) of an elevated site determines the increase in wind load. Although many elevated sites have their own unique features, the intent is to idealize these sites into one of the standard topography categories described below.

The height of an elevated site above the surrounding terrain must be specified in order to determine the increase in wind loading. Height should not be confused with the elevation of the site. As described below, elevations of the site and the surrounding terrain must be used to determine the relative height of a site. For structures supported on buildings, it is only necessary to specify the height of the building and the surrounding exposure category.

Category 1: Flat or rolling terrain with no abrupt changes in general topography. No increase in wind loading is required for this category.

Category 2: Sites separated from a lower elevation by a gently sloping terrain (escarpment). Wind loads at the crest are 2.0 times the wind loads for a flat site and diminish with height depending on the height of the escarpment.

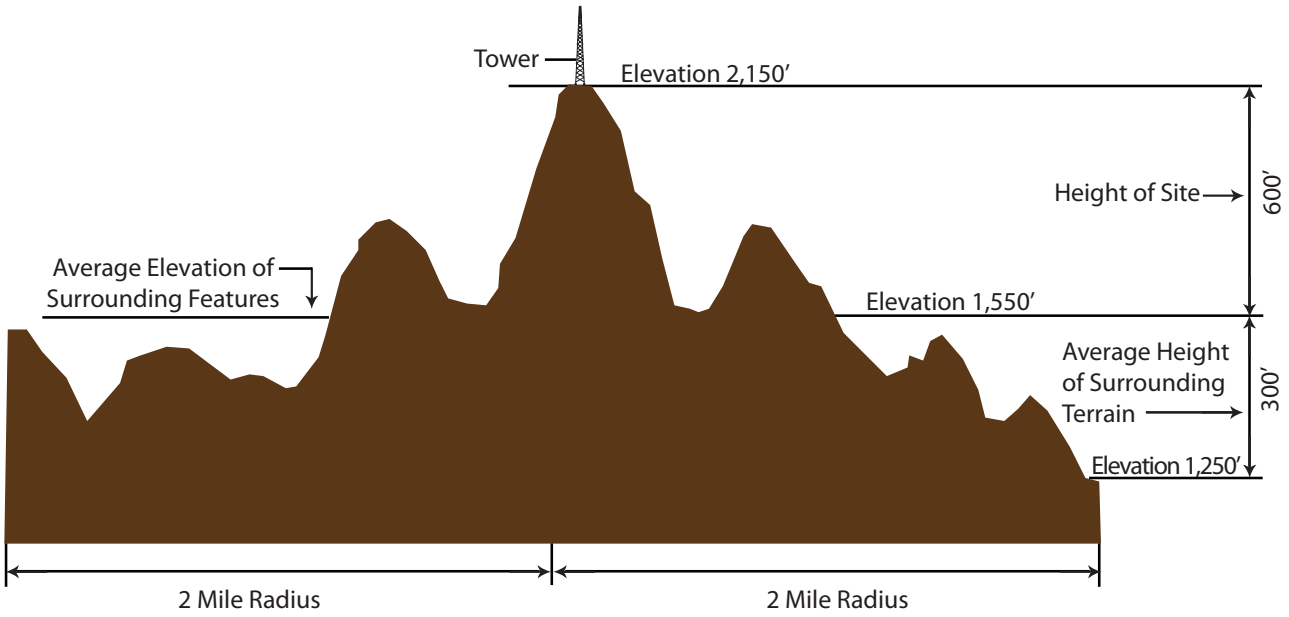
Height for an escarpment is the difference in elevation between the upper and lower levels. Increased wind loads do not apply for structures located in the lower half of the sloping terrain or located beyond 16 times the escarpment's height from the crest.

Category 3: Sites located at the top or within the upper half of a hill. Wind loads at the top of a hill are 2.3 times the wind loads for a flat site and diminish with height depending on the relative height of the hill.

Height for a hill is the difference in elevation between the top and bottom of the hill. For sites surrounded by other hills, height is the difference in the hill elevation at the site and the average elevation of the surrounding hills (within a 2-mile radius). In other words, height is the projection of the hill exposed to wind. When there are other hills surrounding the site, increased wind loads do not apply unless the height of the hill at the tower site is at least 2 times the average height of the surrounding hills. (Refer to sketch above.)

Topographic Categories continued on next page.

UNDERSTANDING TIA-222 - REVISION G



H = 2,150′ - 1,550′ = 600′

Wind speed-up must be considered when H exceeds
2 times the average height of surrounding features.

Category 4: Sites located on a ridge. Wind loads at the top of a ridge are 3 times the wind loads for a flat site and diminish with height depending on the height of the ridge.

Height for a ridge is the difference between the top and bottom elevations of the ridge.

Category 5: This category is reserved for sites where site-specific investigations are performed to determine wind loading. A site-specific investigation may result in either higher or lower wind loads compared to using one of the standard topographic categories.

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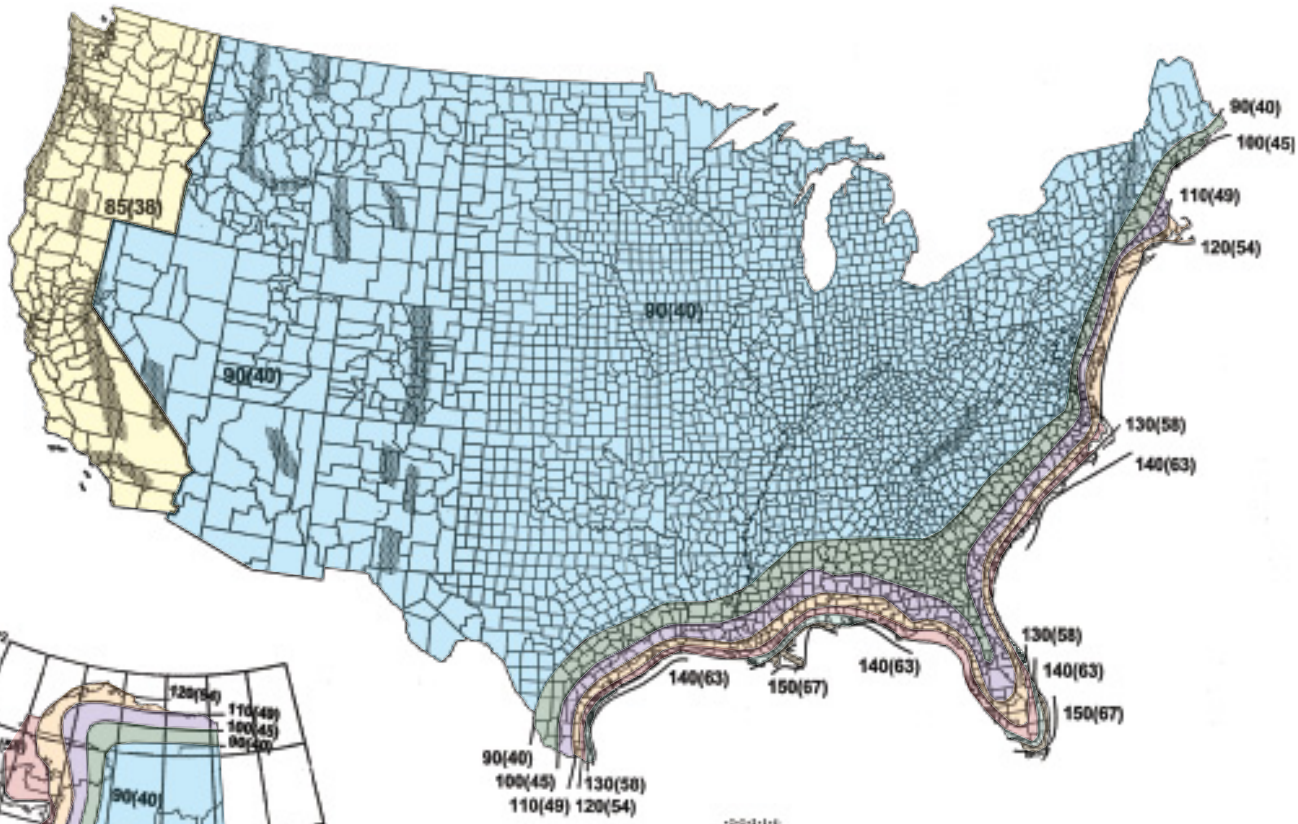
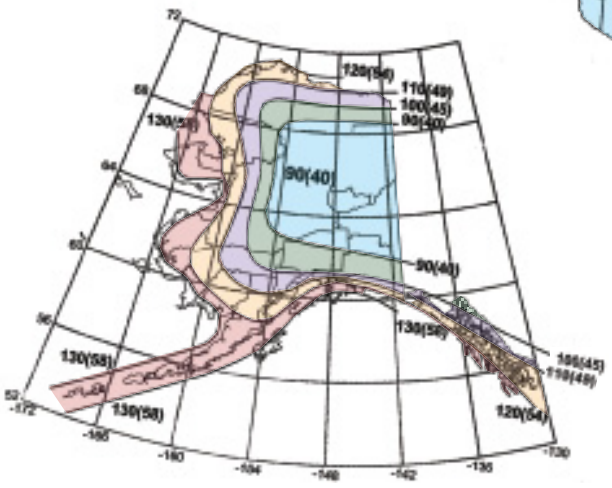
REV G 3-SECOND BASIC WIND SPEED MAP





Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(66)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:

1. Values are 3-second gust wind speeds in miles per hour (m/s) at 33 ft. (10 m) above ground for Exposure C terrain.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside last contour must use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions must be examined for unusual wind conditions.

REV G WIND SPEEDS

The TIA-222-G Standard is based on the wind map published in the ASCE 7-02 Standard, "Minimum Design Loads for Buildings and Other Standards". The ASCE 7 standard is published by the American Society of Civil Engineers (ASCE) and represents the latest research and data available for wind speeds in the United States.

Subsequent to the release of the TIA-222-G Standard, ASCE has published 2 revisions to the ASCE-7 Standard. The first revision was published in 2005 and is designated as ASCE 7-05. There were no changes to the wind map. The second revision was published in 2010 and is designated as ASCE 7-10. There are changes to the wind map in this version.

The previous versions of ASCE 7 used a 50-year return wind speed map and relied on additional design factors to increase wind loads according to the reliability requirements of a structure. This resulted in structures being able to survive wind speeds of much higher return periods. The new wind maps in ASCE 7 -10 now include these design factors and now represent a much higher return period wind speed. A wind map is provided for each classification of structure. No additional factors have to be considered based on the classification of a structure when these wind speeds are used to calculate wind loads. The new maps can be thought of as "Factored" wind speeds, or in other words, wind speeds for which permanent deformation may occur in a structure, but the structure does not collapse.

The new ASCE 7-10 factored wind speeds can be easily converted for use with the TIA-222-G Standard using the following conversion table. If the conversion is not made, the design factors for determining wind loads will be "doubled up" resulting in much higher wind loads than intended. Eventually the TIA Standard and other similar structural standards will be upgraded to reflect the new ASCE 7-10 wind maps. Conversions for fastest-mile wind speeds used in Rev F and ASCE 7-93 are also included in the table.

Design Wind Speed Conversions, MPH

Rev F ASCE 7-93 (fastest-mile)	Rev G ASCE 7-02 & ASCE 7-05 (3-second gust)	Factored ASCE 7-10 (3-second gust)
71	85	110
76	90	115
85	100	126
90	105	133
95	110	139
104	120	152
114	130	164
123	140	177
128	145	183
133	150	190
152	170	215

Examples to determine appropriate Rev G design criteria:

1. Desire a 95 mph Rev F fastest-mile design. Use a 110 mph Rev G design.
2. Desire a 115 mph ASCE 7-10 design. Use a 90 mph Rev G design.

REV G GROUNDING REQUIREMENT FOR STRUCTURES

Rev G made significant changes regarding the grounding requirements for structures. A prescriptive approach to grounding was used in Rev F where providing specific grounding leads and ground rods were considered adequate to protect a structure. Rev G adopted a performance specification approach that requires providing a grounding system that will result in a maximum 10 ohm resistance to earth. Rev G also requires minimum ground lead and ground rod sizes that are greater than the Rev F prescriptive requirements.

Another change is that Rev G does not require specific grounding materials. Rev F required the use of galvanized ground rods with tinned copper leads. Rev G only requires that the leads and connections be compatible with the ground rods from a corrosion standpoint (i.e. minimize difference between metals connected).

Rev G does provide default grounding arrangements for various types of structures that are intended to meet the 10 ohm requirement for a wide variety of soil conditions. In accordance with Rev G, the actual resistance of a default grounding system must be verified based on site conditions. Additional ground rods or special grounding systems may be required.

It should be noted that the TIA-222 grounding requirements are meant to protect the structure and foundation from high fault currents. Other grounding requirements are often needed for the protection of antennas, radio equipment and other appurtenances.

REV G STANDARD FOUNDATIONS

Rev G has taken a different approach from Rev F regarding standard foundations and the term "Normal Soil" has been eliminated. A new term "Presumptive Soil" has been introduced. Rev G provides for two different types of presumptive soil, sand and clay. Generally the strength of Rev G presumptive soil is lower than the strength of Rev F normal soil.

The intent is to provide default design parameters that can be used to design foundations when a geotechnical report is not available for a site. In accordance with Rev G, clay is to be considered the default presumptive soil unless more information is known about a site. The values for clay presumptive soil have therefore been used for the generation of the standard foundations contained in this catalog.

It should be noted that in accordance with Rev G, actual site conditions must be investigated prior to the installation of a foundation that was designed using presumptive soil parameters. Modifications to the standard foundations contained in this catalog may be required. It should also be noted that Rev G requires a geotechnical investigation for all Class III structures.

One common cause for changes to a standard foundation is due to frost depth. The frost depth for Rev G presumptive soil is considered to be 3.5 feet. The standard foundations in this catalog are based on this frost depth. Special foundations may be required for sites in locations where frost depths exceed 3.5 feet and the local soil conditions are susceptible to frost heave.

Presumptive soil also assumes that the water table is below the foundation depth. For this condition, there is no concern for buoyant conditions that can significantly reduce the uplift capacity of a foundation. The standard foundations in this catalog are based on dry soil conditions and do not consider buoyant conditions. Special foundations may be required for sites where the water table may rise above the base elevation of the foundation.

In accordance with Rev G, presumptive soils are also considered to be non-corrosive. When local soil conditions are corrosive, anchors or direct embedded poles that are in direct soil contact may require corrosion protection in addition to hot dip galvanizing. Rev G provides guidance on various alternatives to consider in these situations.

Presumptive soils are also considered to be non-expansive. Locations known to have expansive soil require special considerations for foundation design. Modifications to the standard foundations in this catalog may be required in these cases.

REV G CLIMBING FACILITIES

Rev G has made significant additions addressing climber safety. Two classifications of climbers have been defined. An Authorized Climber (also called a Basic Climber) is an individual trained in climbing but may not have had previous climbing experience. These climbers are intended to be limited to climbing fixed access routes equipped with safety climb devices. A Competent Climber (also called a Skilled Climber) is a professional who is capable of climbing on structural members.

Rev G provides requirements for climbing facilities by defining two classes of climbing facilities, Class A and Class B. Class B requirements are similar to Rev F requirements and are intended for structures to be climbed by professional Competent Climbers. Class A requirements are more restrictive in comparison to Rev F and are intended for structures expected to be climbed by lesser qualified (Basic) climbers. In accordance with Rev G, Class B is considered to be the default climbing facility requirement for structures unless otherwise specified. Towers can be quoted to accomodate Class A climbing facilities when specified. All ROHN standard structures are intended to be climbed by Competent Climbers only.

Safety climb systems are now mandatory in accordance with Rev G for structures exceeding 10 feet in height that are intended to be climbed. Some structures are intended to be maintained by bucket trucks or other methods that do not involve climbing the structure. Safety climb systems, when required, must be ordered separately for all ROHN standard structures in this catalog.