The Pennsylvania Society of Professional Engineers
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Pittsburgh, PA

TOWER DESIGNS, STRUCTURAL UPGRADES, AND MAINTENANCE USING ANSI/TIA-222-G

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Session Objective

The objective of this session is to introduce ANSI/TIA-222, revision G, "Structural Standard for Antenna Supporting Structures and Antennas," the design standard for communication structures and antennas

About The Presenter

- ✓ Brian Reese, President of Reese Tower Services
- ✓ 19 years experience in the tower business; involved in the design & production of 5,000 steel poles and the field modification/repair/inspection of thousands of poles and tower structures
- ✓ Former Chairman of TIA TR-14 222 structural tower standard committee
- ✓ Chairman of ASCE's Athletic Field Lighting Structures Standard Committee
- ✓ Registered PE in forty-four (44) states
- ✓ Certified Weld Inspector (CWI)

Wireless Communications in the U.S.

Statistics per the CTIA:

- ✓ **Over 355 million wireless subscribers in the U.S.**
- ✓ **Nearly 90% of households use wireless service (44% wireless only)**
- ✓ **45 million Americans use mobile phones as their primary internet access device**
- ✓ **1 out of 10 use smartphones only to access the internet**

Wireless Demand

- ✓ U.S. mobile data use doubled from 2012 to 2013 and will increase about 650% by 2018
- ✓ About 56% of all mobile data is now data-intensive video, and that will increase by 600% by 2018
- ✓ U.S. carriers invested a 10 year record high of more than $33 billion in capitol expenditures in 2013, and more than $260 billion in the last 10 years
- ✓ U.S. wireless industry is valued at nearly $196 billion, which is larger than publishing, agriculture, hotels & lodging, air transportation, and motor vehicle manufacturing segments

Tower Infrastructure

With the explosive demand for wireless technology in the last twenty years, the use of communications towers has exploded

- ✓ **Almost 300,000 cell sites in U.S. today**
- ✓ **Elevated structures, or towers, are required to support the communications antennas**

The infrastructure to support this demand is one of the last great infrastructure build-outs in the U.S.

Tower Infrastructure

There are three main types of antenna support structures for the communications industry:

- ✓ **Self-Support Towers**
- ✓ **Guyed Towers**
- ✓ **Monopoles**

Self-Support Towers

- ✓ SST structures can vary to 500 ft in height
- ✓ Tapered, free-standing and 3 or 4-sided, typically in 20 ft sections
- ✓ Steel tower legs are solid round, hollow tube, or lattice-leg style
- ✓ Steel bracing members are either angle or round members
- ✓ Bracing configurations are typically X-braced or K-down style
- ✓ Typical finish is galvanizing and paint over galvanizing
- ✓ Designed for multiple carriers or ‘tenants’ and other communications requirements

Guyed Towers

- ✓ Guyed towers can be some of the largest structures in the world at heights to 2000 ft
- ✓ The structures are guyed with cables and are 3 or 4-sided
- ✓ Steel tower legs are solid round, hollow tube, or angle
- ✓ Steel bracing members are either angle or round members
- ✓ Typical finish is galvanizing and paint over galvanizing
- ✓ Designed for multiple carriers or ‘tenants’, broadcast, and other communications requirements

Guyed Towers

Name	Height (ft)	Height (m)	Year	Structural type	Main use	Country	Town	Remarks	Coordinates
Burj Khalifa	2,275	688	2008	Skyscraper	Office, hotel, residential	United Arab Emirates	Dubai	tallest structure in the world	25°11′50.0″N, 55°16′26.6″E (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=25_11_50.0_N_55_16_26.6_E_)
Warsaw Radio Mast	2,118	645.4	1974	Guyed mast	LF-transmission	Poland	Gąbin-Konstantynów, Masovian Voivodeship	insulated; collapsed on August 8, 1991 during guy wire exchange	52°22′14″N, 19°48′23″E (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=52_22_14_N_19_48_23_E_)
KVLY/KTHI TV Mast	2,063	628.8	1963	Guyed mast	UHF/VHF-transmission	U.S.	Blanchard, North Dakota	World's tallest mast	47°20′32″N, 97°17′20″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=47_20_32_N_97_17_20_W_)
KXJB-TV mast	2,060	627.8	1998	Guyed mast	UHF/VHF-transmission	U.S.	Galesburg, North Dakota	rebuilt after collapses on February 14, 1968 and on April 6, 1997	47°16′45″N, 97°20′27″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=47_16_45_N_97_20_27_W_)
KXTV/KOVR Tower	2,049	624.5	2000	Guyed mast	UHF/VHF-transmission	U.S.	Walnut Grove, California	Tallest structure in California	38°14′24″N, 121°30′07″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=38_14_24_N_121_30_07_W_{{{9}}})
Canton Tower	2,001	610	2010	Concrete tower	Observation, TV transmission	People's Republic of China	Guangzhou	tallest structure in China	23°06′32.55″N 113°19′9.29″E
Petronius Platform	2,001	610	2000	Offshore platform	Oil drilling	Gulf of Mexico	Petronius field	Located appr. 210 km (130 mi) southeast of New Orleans	
KATV Tower	2,000	609.6	1965?1967?	Guyed mast	UHF/VHF-transmission	U.S.	Redfield, Arkansas	It is the tallest structure in Arkansas	34°28′24.0″N, 92°12′11″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=34_28_24.0_N_92_12_11_W_)
KCAU TV Tower	2,000	609.6	1965	Guyed mast	UHF/VHF-transmission	U.S.	Sioux City, Iowa	Tallest structure in Iowa (equal)[3]	42°35′11.0″N, 96°13′57″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=42_35_11.0_N_96_13_57_W_)
WECT TV6 Tower	2,000	609.6	1969	Guyed mast	UHF/VHF-transmission	U.S.	Colly Township, North Carolina	Tallest structure in N Carolina	34°34′44.0″N, 78°26′12″W (http://tools.wikimedia.de/~magnus/geo/geohack.php?pagename=List_of_tallest_structures_in_the_world&params=34_34_44.0_N_78_26_12_W_)

reference Wikipedia - excerpted


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Monopoles

- ✓ Freestanding structures varying in height to 250 ft
- ✓ Constructed of steel, concrete, or wood
- ✓ Polygonal tubular steel poles are pressed and welded with high strength steel plate and assembled via slip joint overlapping connections in the field
- ✓ Round poles consist of pipe and flanged sections
- ✓ Typical finish for a pole structure is hot-dip galvanized
- ✓ Designed for multiple carriers or ‘tenants’ and other communications requirements
- ✓ Can be concealed – ‘disguised’


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What is the Design Standard for Communications Structures?

ANSI/TIA-222, revision G, "*Structural Standard for Antenna Supporting Structures and Antennas*," governs the design and analysis of communication structures and antennas

- ✓ **From SST to GT and monopoles, the Standard provides recognized literature for antenna supporting structures and antennas pertaining to minimum load requirements and design criteria**
- ✓ **The Standard can also be used for the design of structural modifications and addresses maintenance requirements for tower structures**

What is ANSI/TIA?

Founded in 1918 and headquartered in Washington, D.C., the American National Standards Institute (ANSI) coordinates the development and use of voluntary consensus standards in the U.S. and represents the needs and views of U.S. stakeholders in standardization forums around the world

The Telecommunications Industry Association (TIA) was formed in 1988 and is based in Arlington, VA. The TIA is the leading trade association for the information and communications technology industry.

ANSI/TIA-222-G Standard

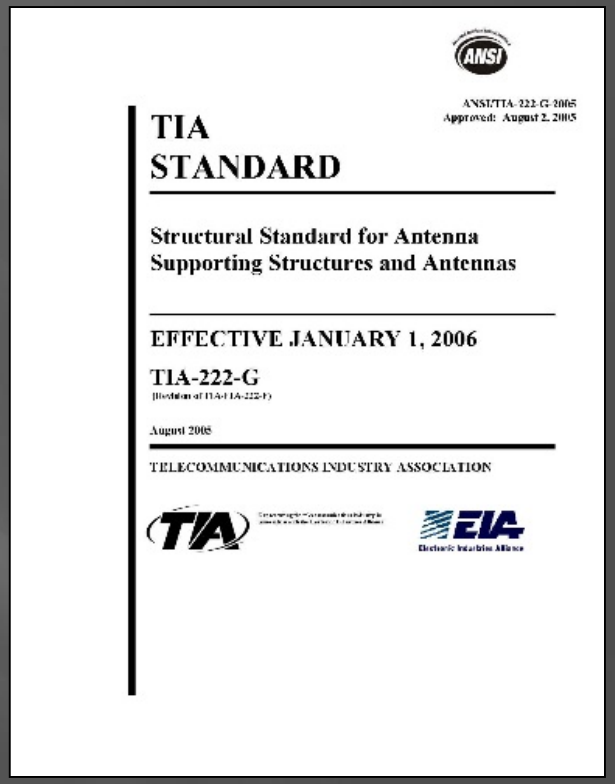
TIA engineering committee TR-14 is the formulating committee and responsible for the ANSI/TIA-222 Standard

- ✓ **The committee consists of volunteer engineers and industry personnel from tower manufacturers, consulting firms, construction firms, software developers, equipment manufacturers, tower owners, and wireless carriers**
- ✓ **First issued in 1959, the 222 Standard is reaffirmed or revised every 5 years**

ANSI/TIA-222-G Standard

222-G was effective January 1st, 2006. G was a revision to ANSI/TIA/EIA-F from 1996. The G revision was 10 years in development.

- ✓ TIA-222-G-1 is an addendum to G published in 2007
- ✓ TIA-222-G-2 is the 2nd addendum to G published in 2009
- ✓ TIA-222-G-3 is the 3rd addendum to G published in 2014
- ✓ TIA-222-G-4 is the 4th addendum to G published in 2014


ANSI/TIA-222-G-2005
Approved: August 2, 2005

TIA STANDARD

Structural Standard for Antenna Supporting Structures and Antennas

EFFECTIVE JANUARY 1, 2006

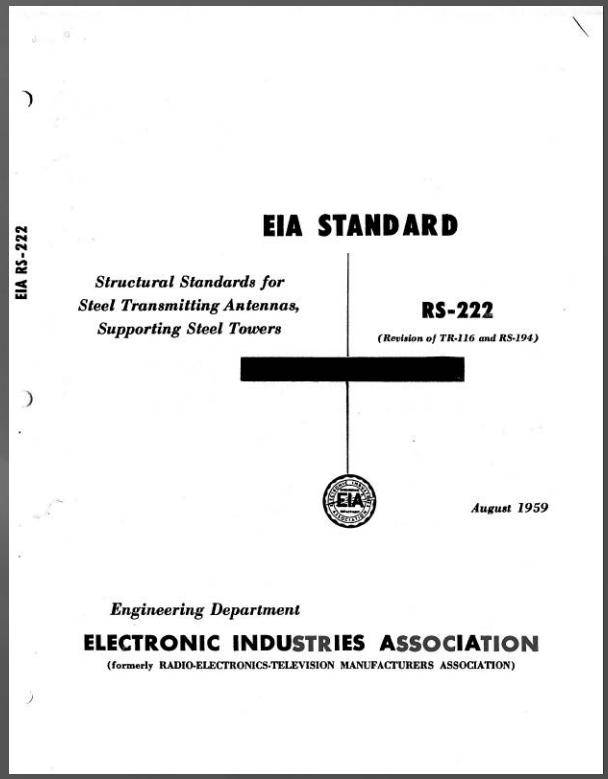
TIA-222-G

August 2005

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

222 Tower Standard History

- ✓ *1959* **EIA RS-222 (first edition)**
- ✓ *1966* **RS-222-A**
- ✓ *1972* **RS-222-B**
- ✓ *1976* **RS-222-C**
- ✓ *1987* **EIA-222-D**
- ✓ *1991* **TIA/EIA-222-E**
- ✓ *1996* **TIA/EIA-222-F**
- ✓ *2006* **TIA-222-G**
- ✓ *2016/2017?* **TIA-222-H**


EIA RS-222

EIA STANDARD

Structural Standards for Steel Transmitting Antennas, Supporting Steel Towers

RS-222

(Revision of TR-116 and RS-194)

August 1959

Engineering Department

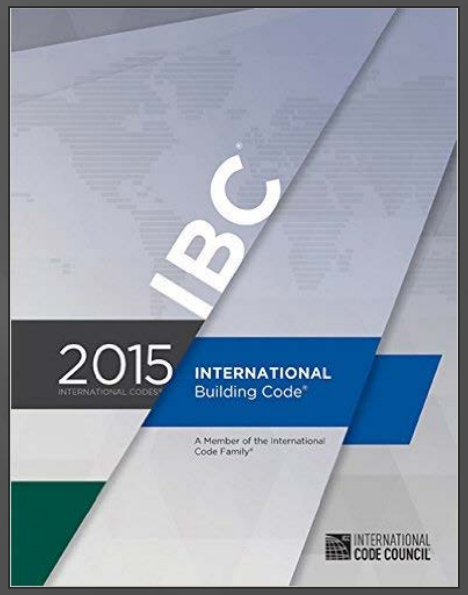
ELECTRONIC INDUSTRIES ASSOCIATION

(formerly RADIO-ELECTRONICS-TELEVISION MANUFACTURERS ASSOCIATION)

ANSI/TIA-222-G Standard

The information contained in the Standard was obtained from available sources and represents, in the judgment of the committee, the accepted industry minimum structural standards for the design of antenna supporting structures and antennas

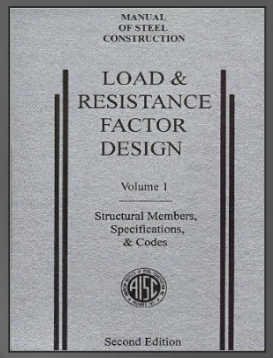
- ✓ **The committee's intent was to create an internationally recognized and acceptable standard that can be implemented beyond the North American market**
- ✓ **The G version is presently incorporated by reference in the International Building Code (IBC), which means that by default it becomes the most widely recognized tower standard of most countries, states and municipalities for their building codes**

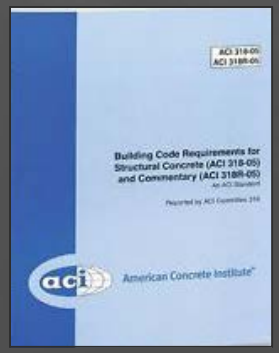


ANSI/TIA-222-G Standard - Loading

Minimum loading requirements in 222-G were derived from the following:

- ✓ **ASCE 7-02, "*Minimum Design Loads for Buildings and Other Structures*"**
- ✓ **AISC-LRFD-99, "*Load and Resistance Factor Design Specification for Structural Steel Buildings*"**
- ✓ **ACI 318-05, "*Building Code Requirements for Structural Concrete*"**





ANSI/TIA-222-G Standard - Loading

Loading Requirements - Five Loading Cases

- ✓ $1.2\ D + 1.0\ D_g + 1.6\ W_o$
- ✓ $0.9\ D + 1.0\ D_g + 1.6\ W_o$
- ✓ $1.2\ D + 1.0\ D_g + 1.0\ D_i + 1.0\ W_i + 1.0\ T_i$
- ✓ $1.2\ D + 1.0\ D_g + 1.0\ E$
- ✓ $0.9\ D + 1.0\ D_g + 1.0\ E$

ANSI/TIA-222-G Standard - Loading

Loading Requirements – Wind & Ice

- ✓ **Wind speed measured as 3-sec. gust per ASCE 7**
- ✓ **Tables with wind speeds by county**
- ✓ **Exposure categories and importance factors**
- ✓ **Topographic effects and categories**
- ✓ **Ice load by county and a function of height; wind speed with ice varies**

ANSI/TIA-222-G Standard - Loading

Loading Requirements – Wind

- ✓ **Wind on the structure**
- ✓ **Wind on guys**
- ✓ **Wind on appurtenances**
- ✓ **Wind on antenna mounts**
- ✓ **Shielding limitations**
- ✓ **EPA of transmission line clusters**

ANSI/TIA-222-G Standard - Loading

Loading Requirements – Ice

- ✓ **Ice function of height**
- ✓ **Specified by county**
- ✓ **Projected area of ice**
- ✓ **Calculating ice weight**
- ✓ **Mountainous terrains and gorges shall be examined for unusual wind, wind on ice, and ice conditions**

ANSI/TIA-222-G Standard - Loading

Loading Requirements - Seismic

- ✓ **While seismic typically does not govern tower design, seismic analysis required for IBC**
- ✓ **Towers require special considerations of their response characteristics in regions of high seismicity**
- ✓ **The provisions of 222-G provide design criteria to insure sufficient strength and stability to resist seismic ground motions**
- ✓ **Analysis shall be made in accordance with one of the following procedure methods - equivalent lateral force, equivalent modal analysis, modal analysis, or time-history analysis**

ANSI/TIA-222-G Standard - Analysis

Analysis of Structures

- ✓ **SST - elastic 3D truss model or an elastic 3D frame-truss model**
- ✓ **GT - elastic 3D beam-column, 3D truss, or elastic 3D frame-truss model**
- ✓ **Poles - elastic 3D beam-column model producing moments, shears, and axial forces**
- ✓ **Displacement effects - P-delta effects must be considered (SST exception clause)**
- ✓ **Application of wind forces to lattice structures & wind loading patterns for towers**

ANSI/TIA-222-G Standard - Design

Design Methodology

- ✓ **Load & resistance factor design - 222-F was ASD**
- ✓ **Bracing design**
- ✓ **Compression members**
- ✓ **Tension members**
- ✓ **Tubular pole structures (monopoles)**

ANSI/TIA-222-G Standard - Design

Design Methodology - Connections

- ✓ **Bolts**
- ✓ **Nut-locking devices**
- ✓ **Pre-tensioned bolts**
- ✓ **Edge distances**
- ✓ **Bearing type connections**
- ✓ **Connection resistance**
- ✓ **Design strengths; tensile, bearing, and shear**
- ✓ **Combined shear and torsion**
- ✓ **Anchor rods**

ANSI/TIA-222-G Standard - Manufacturing

Manufacturing

- ✓ **Pre-qualified structural steel listing**
- ✓ **Non pre-qualified steel – carbon equivalent shall not exceed 0.65**
- ✓ **Charpy impact values required (ASTM A370)**
- ✓ **Material test reports required**
- ✓ **Fabrication and tolerances**
- ✓ **Corrosion control – hot dip galvanizing preferred**

ANSI/TIA-222-G Standard – Other Materials

Other Structural Materials

- ✓ **Other materials other than steel are permissible**
- ✓ **Other materials (concrete, aluminum, wood) shall conform to current limit states design**
- ✓ **Design strength – appropriate resistance factors shall be established**

ANSI/TIA-222-G Standard - Foundations

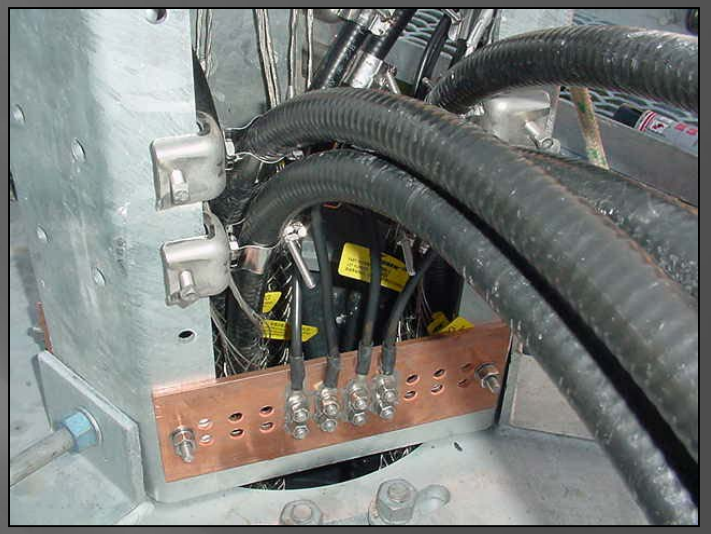
Foundations and Anchorages

- ✓ **Geotechnical reports required depending on structure class**
- ✓ **Presumptive soils parameters are to be used in the absence of a soils report and are defined in Annex F**
- ✓ **Design strength of concrete and steel foundations and anchorages shall be in accordance with ACI 318-05 and AISC-LRFD-99**

ANSI/TIA-222-G Standard - Grounding

Protective Grounding

- ✓ **Grounding protects radio equipment and structure from lightning strikes**
- ✓ **Defines the maximum acceptable electrical resistance of the structural grounding system, and the minimum acceptable materials for the grounding system design**
- ✓ **Grounding materials**



ANSI/TIA-222-G Standard – Obstruction Marking

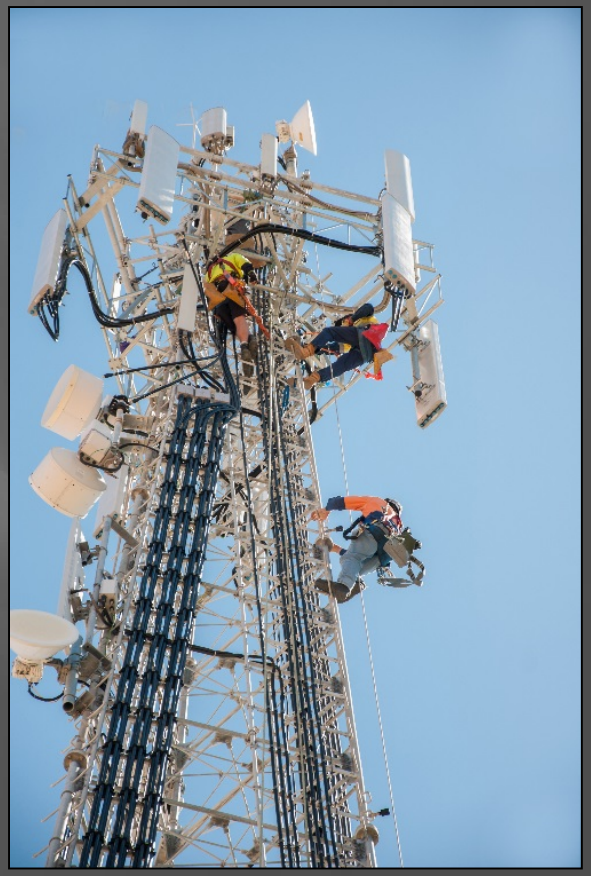
Obstruction Marking

- ✓ **Structures shall be marked in accordance with Federal Communications Commission (FCC), Federal Aviation Authority (FAA), and/or local aviation authority requirements**

ANSI/TIA-222-G Standard – Climbing Facilities

Climbing Facilities

- ✓ **Expanded safety & climbing facilities requirements**
- ✓ **Authorized (basic) climber and competent (skilled) climber – Class A and Class B classifications**
- ✓ **Climbing facility required for structures over 10 ft**
- ✓ **Dimensional requirements**
- ✓ **Signage**



ANSI/TIA-222-G Standard - Maintenance

Maintenance and Condition Assessment

- ✓ **Infrastructure continues to age in the U.S.**
- ✓ **Corrosion costs hundred of billions of dollars**
- ✓ **Fatigue a hidden enemy**
- ✓ **The structural integrity of many structures is continuously under attack by the elements, corrosion, and fatigue**

ANSI/TIA-222-G Standard - Maintenance

Maintenance and Condition Assessment Recommended Intervals

- ✓ **Three (3) year intervals for GT and five (5) year intervals for SST and monopoles**
- ✓ **After severe wind and /or ice storms or other extreme conditions**
- ✓ **Shorter inspection intervals may be required for Class III structures and structures in coastal regions, in corrosive environments, and in areas subject to frequent vandalism**

ANSI/TIA-222-G Standard - Maintenance

Maintenance and condition assessment checklist; Annex J details condition assessment areas:

- ✓ Structure
- ✓ Finish
- ✓ Lighting
- ✓ Grounding
- ✓ Antennas and lines
- ✓ Other appurtenances
- ✓ Insulators
- ✓ Guys
- ✓ Foundations
- ✓ Tower alignment

ANSI/TIA-222-G Standard - Upgrades

Structural Upgrades

- ✓ **As the public has rejected new tower structure sites, demand has increased for utilizing existing structures**
- ✓ **Existing structures not designed for the capacity required**
- ✓ **Co-location is multiple carriers sharing a structure**
- ✓ **Reinforcement designs per ANSI/TIA-222-G Standard**

ANSI/TIA-222-G Standard - Upgrades

Structural Upgrades

- ✓ **SST upgrades – legs, bracing, base plates, anchors, foundations**
- ✓ **GT upgrades – legs, bracing, guy replacements, anchor modification, foundations**
- ✓ **Monopole upgrades – shaft, base plate, anchors, foundations**
- ✓ **Designs include member replacements, augmentation, welding, blind-bolts**


48"
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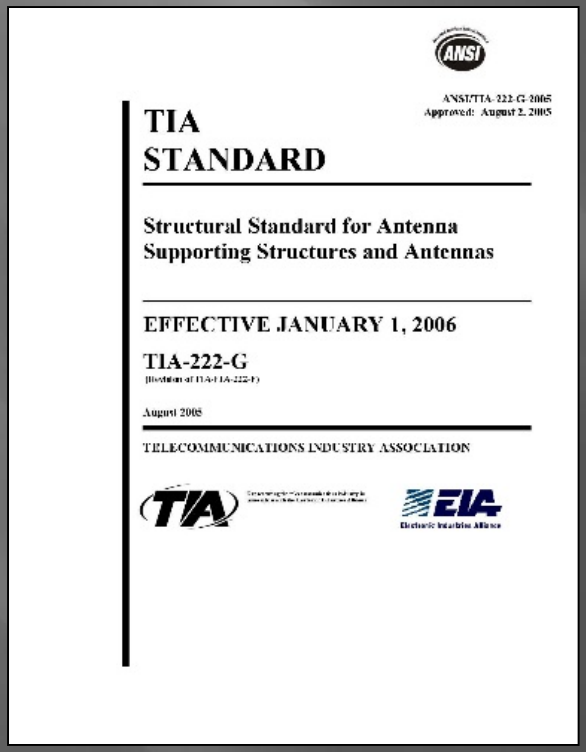
ANSI/TIA-222-G Standard

purchase 222-G @ www.ihs.com



ANSI/TIA-222-G-2005
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EFFECTIVE JANUARY 1, 2006

TIA-222-G

August 2005

TELECOMMUNICATIONS INDUSTRY ASSOCIATION

ANSI/TIA-222-G Standard Quiz

1. *Does ANSI/TIA-222 revision G use fastest mile wind speed or 3-second gust?*

2. *Is ANSI/TIA-222 revision G based on LRFD or ASD?*

3. *How many loading cases are required by ANSI/TIA-222 revision G?*

THANK YOU!