Television and Radio Transmitting Towers

This report provides a brief description of the different types of transmitting towers, and discusses government regulations, design considerations, additions and modifications, construction considerations, lightning protection, inspection and maintenance, fire protection, and physical security of transmitting towers.

Television- and radio-transmitting towers are among the tallest and most fragile structures built, with some up to 2,000 ft (609.60 m) in height. Since the early 1930s, there have been hundreds of documented tower failures that have resulted in total or partial collapses. Losses can be due to wind loadings, ice formation, earthquakes, lightning, floods, collapses during erection, vandalism, and insulator and structural failures. Other losses can occur when aircrafts collide with them. Structural failures are most often related to poor maintenance or overloaded structures.

Lives and property are at risk when a tower fails; the risk is greater in urban areas. In addition, there will also be loss of business income if the tower is unusable and transmission is interrupted for an extended period of time. It is important, therefore, to assure that towers are adequately designed, constructed, inspected, maintained, and equipped with the proper devices so that they function safely and efficiently.

The towers considered in this report are open frame, trussed towers composed of metal members. They are used to support antennas for FM radio and television transmissions, as well as microwave dishes and reflectors. In other cases, the towers function as antennas for transmitting AM radio signals and must be insulated from the ground for their proper operation.

Types of Towers

Towers can be of two general types: guyed and self-supporting. The decision of which type of tower to use depends on, among other factors, the following:

- The purpose of the tower (e.g., transmission for AM, FM, or TV);
- The height of the tower;
- The size of the property on which it is to be built; and
- The loads to which it will be subjected.

Guyed Towers

A guyed tower depends entirely on its guy wires to hold it vertical and keep it stable. The correct design of the guy wires is extremely important since the guy wire's ability to produce a resisting horizontal load varies inversely with its slope. It is good practice to place guy anchors at a far enough distance from the tower base so that a reasonably flat slope results. Guy wires with

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steeper slopes are undesirable because they produce greater downward vertical load and increased deflections on the tower. For towers with one set of guy wires, an angle of forty-five degrees is commonly used. For taller towers with multiple sets of guy wires, a somewhat steeper angle is used for the top set. This allows the attachment of several guy wires to one anchor and does not result in too shallow a slope for the lowest set. Guyed towers are usually used where sufficient land is available.

The guy wires used in larger towers are most often galvanized bridge strands that are composed of high strength steel. They are manufactured so that any potential elongation due to loads is minimized. Prestressing the wires is sometimes done to reduce elongation.

Guyed towers can be square or triangular in cross section and are commonly constructed of either angular, tubular, or solid circular members. Most members used in guyed towers are generally lighter than, or not as strong as, those used in self-supporting towers. Two methods of attaching towers to their foundations are generally used: pivoted supports and fixed supports.

Where a guyed tower utilizes a pivoted support, its members taper to a point at its base to which a ball and socket joint or similar connection is installed. If the foundation should settle unevenly (called differential settlement), the tower can usually rotate about the pivoted support to minimize disrupting its vertical alignment.

Where a guyed tower utilizes fixed supports, each of the three or four legs is usually bolted to the foundation. It is similar to a standard guyed tower, but its members do not taper to a point at its base.

Self-Supporting Towers

This type of tower does not generally exceed 900 ft (274.32 m) in height. They are used particularly where space is limited (i.e., small lots or building tops). It is usually square in cross section, but can also be triangular, and is generally constructed of larger, stronger members than guyed towers. While the legs are normally in compression, certain wind loadings can cause tension in most of the members on the windward side of the tower. The tower's legs should be sufficiently spread apart to provide the structure with adequate stability, and its supports are usually fixed or pivoted.

Federal Government Regulations

FCC and FAA

Prospective owners of telecommunications facilities are required to file information regarding their proposal with the Federal Communications Commission (FCC) and the Federal Aviation Administration (FAA). The information aids these agencies in determining if the proposed facility poses any potential hazards for air navigation. Specifications for marking and lighting the structure, if required, are stated in the license that is issued by the FCC. The FCC's responsibility continues with the inspection and enforcement of the specifications, while the FAA receives the notifications of certain failures of obstruction lighting.

When a broadcaster submits an application to the FCC for a license for a new station, for the modification of an existing station, or for the renewal of a license, the broadcaster is required to certify compliance with the FCC's regulations governing human exposure to radiofrequency (RF) radiation. These regulations apply to the exposure of both the general public and workers employed by the station, either for running the broadcasts or for maintenance reasons. The regulations have been adopted as a preventive and precautionary measure.

OSHA [5]

The Occupational Safety and Health Administration (OSHA) is involved in many facets of broadcast operation, but this section relates only to requirements affecting transmitting towers.

Many towers are equipped with permanently installed steps, rungs, or fixed ladders to facilitate the climbing of these structures. The OSHA requirement only applies to fixed ladders on towers. [5]

Design Considerations

Modern codes and standards require that a transmitting tower be designed to resist dead and live wind and earthquake loads. Loads, forces, and stresses that result from temperature changes, movements due to differential settlements, or any combination of these should also be considered. Older towers should be carefully checked to assure that no significant changes in design criteria have been required, since their original design and erection, that would increase the possibility of failure.

Dead and Live Loads

Dead loads consist of the weights of the members of a tower and any equipment that is permanently attached to it, including any attached signs. AM transmitting towers support only their lighting equipment. The FM transmitting tower supports its transmission line, antenna, and lighting equipment. The microwave tower must support microwave dishes, reflectors, and lighting equipment. The TV transmitting tower is the most complicated, having to support its transmission line, antenna, and microwave facilities. In addition to the above, many larger towers of all types may be required to support deicer circuits, deicer control circuits, elevators, telephone circuits, power circuits, anti-climbing devices, and climbing and working facilities. Some towers are used to transmit multiple signals, such as AM, FM, and TV signals, increasing the associated dead loads.

Ice is considered a live load. Snow and rain are also considered live loads, but have no application to towers unless they are equipped with large platforms or similar installations where the precipitation can accumulate.

Wind Loads

Wind loads have been responsible for the vast majority of tower failures. The stresses produced in the members of a tower by load combinations, that include wind loads, are usually the most critical and control the structural design. Therefore, it is important that the effects of wind be carefully considered during the design phase.

Wind loads, sometimes referred to as “wind pressures,” are most commonly expressed in units of pounds per square foot (psf) (kgs/m2). They develop as air at some velocity (wind) moves past the members of a tower and its appurtenances, such as guy wires, antenna assemblies, transmission lines, reflectors, conduits, lighting, signs, anti-climbing devices, and climbing and working facilities.

The magnitude of the wind pressure that is developed on a body will depend, among other factors, on the geometrical shape of its cross section. For a constant wind speed, the more a body is streamlined, the less wind pressure will be developed on it. Therefore, a tower that is built of members with flat or angular cross sections will develop larger wind pressures than a similar tower built of members with circular cross sections. The total load in pounds (lbs) (kgs) on a member or appurtenance of a tower can be obtained by multiplying the wind pressure by the normal projected area of the member or appurtenance. The total wind load (lbs) acting on a section of a tower can be obtained by simply adding the total wind loads (lbs) on the members and appurtenances in that section.

The magnitude of the wind pressure that is developed will also depend on the speed of the wind. It follows that, in the design of a tower, the variation of the wind speed is important, as well as the maximum wind speed to which it might be subjected. The Basic Wind Speed is often exceeded for a few seconds during gusts. To account for this phenomenon in design, the Basic Wind Speed can be multiplied by a "gust factor" that can vary with the height above ground.

In addition to the variation of wind speeds with respect to geographical location, they also vary with respect to the height above ground, usually increasing with higher elevations. Engineers generally accept that the wind speed will increase by some n^{th} power of the height above ground (i.e., hn where h is the height above ground). The factor "n" can vary depending on the type of terrain where the tower is to be built (for example, urban areas, flat, open country, or mountainous).

Towers are virtually never designed to resist the wind loads produced by tornadoes, even though no section of the country can be considered entirely free from them. It is generally felt that the probability of a tower being in the narrow path of the maximum wind velocity of a tornado is small, even in those regions of the country with the greatest tornado frequency. Further, to design towers for the full force of a tornado, which can amount to several hundred pounds per square foot, is uneconomical. Even if so designed, there is no guarantee that an extremely strong structure will survive a direct hit.

Wind loads produced by hurricanes should always be considered in the design of a tower. Since hurricanes, unlike tornadoes, have wide paths of travel and can be anticipated in certain well defined regions of the country, their associated wind loads should be included in the design of towers in these regions. Hurricane wind speeds, while not as great as tornado, have been recorded in excess of 155 mph (249.45 k m/h).

Ice Formation

Although ice formation has been considered directly responsible for significantly fewer tower failures than wind, it should nevertheless be considered in the design. While its occurrence is not as frequent as high winds, an ice storm or freezing rain can have disastrous results. When ice forms on the members and appurtenances of a tower, not only is the total gravity load (dead plus live load) increased, but the loads on projected areas of the members and appurtenances are increased. As indicated in the preceding section on wind loads, this will have the effect of producing larger total wind loads for the same wind pressure.

Towers can vary in their susceptibility to damage from ice formation. Under similar ice-forming conditions, a self-supporting tower, with fewer, but heavier, structural members than a guyed tower, which is usually built of a number of lighter, more closely spaced members, is subject to a smaller percentage increase in load. The weight of ice that can form on a guyed tower may substantially exceed the dead weight of the tower.

Where icing conditions are frequent and severe, consideration should be given to the installation of deicing equipment. Deicing equipment is typically installed only on antennas and is used to minimize the standing wave ratio of the radiated signal from the antenna. Many types of deicing systems have been tried on the larger towers in ice-prone areas, but cost-benefit results have been disappointing. The current, most dependable and widely used method of dealing with the accumulation of ice and its related loading is designing the tower to support the additional load.

Ice falling from towers can be hazardous and cause injuries or death to persons, as well as considerable damage to property (i.e., vehicles, buildings, antennas, transmission lines, and other equipment) and sections of the tower below. Where this is possible, protective measures should be taken. The installation of ice shields is recommended over transmission lines and other sensitive equipment. Consideration should be given to the protection of the transmitter building, or it should be constructed to resist damage from falling ice. The installation of protective canopies should also be considered for the protection of other property, automobiles, and people. Consideration should also be given to the fact that wind can deflect falling ice.

Earthquake Loads

Many areas in the United States, while not considered active seismically, are susceptible to earthquakes. No reliable method of predicting the time and place of a destructive earthquake, either in a highly seismic or relatively non-seismic area, is available.

In some regions of the country, earthquake loads must be considered in the design of a tower, particularly on the west coast. Usually, earthquake loads are considered to act horizontally on a structure and vary with, among other factors, the mass of the structure. For this reason, the less massive guyed towers are very often preferable in these regions. More sophisticated design techniques will incorporate features to equalize vertical, as well as horizontal, ground motions.

Codes and Standards

Most municipalities have their own building codes or are subject to statewide, countrywide, or other jurisdictional building codes. Commonly, these codes are based either in part or entirely on one of the three nationally recognized model building codes, which are referenced below. As such, the owner of a proposed tower usually will not be issued a building permit unless the design and construction conform to the provisions of the municipal building code or is granted a variance accepting other criteria. If the construction of a tower is proposed in a jurisdiction where there is no building code, a model building code containing such provisions can be used as guidance. In addition, nationally recognized standards are available for use in the design and construction of towers. Having knowledge of which code or standard was used in the design and construction of a tower can be very useful to risk management personnel in evaluating the tower.

The four nationally recognized model building codes are:

- Structural Standard for Antenna Supporting Structures and Antennas published by the Telecommunications Industry Association (TIA) [11]
- The Uniform Building Code published by the International Conference of Building Officials (ICBO) [8]
- The BOCA National Building Code published by Building Officials and Code Administrators International, Inc. (BOCA) [4]
- The Standard Building Code published by Southern Building Code Congress International, Inc. (SBCCI) [10]

Tower Additions and Modifications

It is not advisable to make any modifications or to secure any additional equipment to a tower unless its structural capacity is known to be sufficient. When additions to a tower are being considered, an effort should be made to determine the tower's structural capacity. If possible, the manufacturer should be contacted for information. Many manufacturers now have computer programs that model their towers mathematically. Proposed modifications or additions can be quickly and easily analyzed with the aid of a computer to determine their effect on the tower.

An older tower, designed before computers were widely used, will probably not have a program prepared for it. Sometimes, a general purpose structural computer program, can be used successfully for calculating static and dynamic loading effects on the tower. Otherwise, owners would be well advised to have a program written for their tower(s). Expenses are well worth the cost, especially for larger and more expensive structures. At any time thereafter, additions or modifications can be inexpensively investigated.

If the manufacturer of a tower is not known or has gone out of business, determining the tower's structural capacity may be more difficult. Unless another manufacturer has taken over the operation of the defunct business and obtained its files, a qualified professional tower consultant should be contacted.

If it is suspected or known that additions or modifications have been made to a tower, every effort should be made to determine whether or not they were designed by a qualified professional engineer.

Construction Considerations

The erection procedures and sequences used during the construction of a transmitting tower should be planned well in advance. The retention of a reputable, qualified, and experienced tower erection contractor is very important to minimize the possibility of a loss. During the planning stage, careful consideration should be given to the stresses to which individual members and sections of the tower are subjected as the construction progresses. Failure to do so may result in subjecting such members or sections of the tower to erection stresses that are in excess of the maximum stresses anticipated in the completed structure. This can cause damage to, or actual collapse of, a partially completed tower. These considerations are especially important for guyed towers that depend on the guy wires for their stability.

The greatest and most unpredictable hazard during the construction of a tower can be the weather. Efforts should be made to obtain as accurate a weather forecast as possible so that a competent construction supervisor can anticipate any potentially dangerous conditions that might arise and take suitable precautionary measures. For example, wind loads on a partially constructed tower can subject certain members or sections to stresses exceeding those that they were designed to resist when the tower was completed. Again, damage or actual collapse of a partially completed tower is possible unless provisions are made for some form of temporary bracing.

The guy wires of a guyed tower should be installed in a sequence such that the alignment of the tower is maintained at all times. All guys at a particular elevation should be tensioned simultaneously and in such a manner that the loads they produce on the structure are equal. The task of equalizing the loads during a strong wind becomes next to impossible, and therefore, the procedure should not be attempted under these conditions. In one method, calibrated instruments are used to indicate the forces produced in guy wires during tensioning. In another method, the guy wires are marked with reference points so that the elongation that occurs during the tensioning can be determined. The elongation can then be converted to force units by means of charts or calibration curves for the particular wire. A suitable means of communication is essential between the crews adjusting the tension in several guys simultaneously, so that they willbe able to effectively coordinate their efforts.

Foundations and guy anchors constructed of concrete should be permitted to cure properly before any loads are applied to them (see Construction Management Reports CM-40-00 to CM-40-14, Concrete Series for further information). [1]

Lightning Protection

Since a tower is usually of much greater height than any of the surrounding structures, it is particularly susceptible to lightning and should always be provided with protection. While the superstructure (tower itself) is not usually damaged by lightning, the foundations, insulators, or transmitting equipment can be damaged if not properly protected. The following are suggested recommendations:

AM Towers

The superstructure of AM broadcasting towers serves as the antenna and is insulated from electrical ground. These towers must be equipped with a lightning arrestor that will permit a satisfactory path to ground for lightning and, at the same time, to not ground the antenna so that it will function properly. Usually, the lightning arrestor will consist of two good conductors of electricity, commonly spherical in shape, the surfaces of which are positioned to form an air (spark) gap between them.

One sphere is connected to the antenna and the other to a suitable ground. The gap is wide enough so that the difference in potential produced by the AM transmission is not great enough to cause a spark to jump across it and ground the antenna. However, the gap is also narrow enough that in the event the antenna is struck by a bolt of lightning powerful enough to do damage, its associated potential will be large enough to cause a spark to jump across the gap and harmlessly ground the lightning.

On some installations the spark gap will be used alone, while on others it will be used in conjunction with a resistor that drains off accumulations of static charges. On guyed towers with one pivoted support, a spark gap should be installed at the support. On guyed towers with fixed supports, and in the instances where self-supporting towers are used as AM antennas, each tower leg should be provided with protection from lightning either by installing a spark gap at each support or by using one spark gap that is electrically wired to each leg.

FM, TV, and Microwave Towers

Towers that serve only as supporting structures for FM and TV antennas or microwave dishes and reflectors are not insulated from ground. In fact, they should be well grounded to provide the appropriate lightning protection. The pivot support or each leg of fixed-support guyed towers and each leg of self-supporting towers should be connected to a suitable ground.

Antennas that are installed on supporting towers also should be protected from lightning. This can be accomplished at one of three possible locations: [11]

- Where the antenna is attached to a well grounded superstructure;
- At grade at the transmission line; or
- Through the transmitting equipment in the station's building.

Lighting

The specific lighting required on a tower is stated in the license that is issued to the broadcaster by the FCC. The general requirements can be found in the FCC Rules and Regulations. [6] Structures 200 ft (60.96 m) or more in height are required to be equipped with lights. Structures less than 200 ft (60.96 m) in height are required to be equipped with lights when located near an airport.

Conventional Systems

The conventional lighting system usually consists of two 620 or 700 watt lamps housed within a red globe located at the top of the tower. These are sometimes referred to as "beacons." The lamps are required to blink at a rate of not less than 12 flashes per minute nor more than 40 flashes per minute. A number of 116 or 125 watt lamps, also housed within red globes, are installed as sidelights along the height of the tower. These are also referred to as "obstruction lights" and burn continuously when lighting is required. On tall towers, in addition to being installed at the top, beacons are sometimes used in conjunction with the sidelights. The FCC Rules and Regulations state the detailed requirements for conventional lighting. Conventional lighting may be continuously energized or be automatically activated by photocell devices capable of sensing when the north sky light intensity falls below approximately 35 to 58-foot candles.

High Intensity System

A lighting system consisting of high intensity flashing white lights, also referred to as "strobe lighting," may be used as an alternate to the conventional system. These lights are required to flash at the rate of 40 pulses per minute with the following intensities: at night, 4,000 candelas; at twilight, 20,000 candelas; and during the day, 200,000 candelas.

The high intensity system is initially more expensive than the combination of the conventional lights and marking. However, towers with the high intensity lighting system usually cost less to maintain, especially in the case of galvanized towers where, most often, repainting even for protective purposes is not necessary. These high intensity lighting systems are relatively new, though, and some maintenance complications can exist. For example, while the conventional system can usually be maintained quite simply by a worker who could replace a lamp when it burns out, the more complex circuitry of the high intensity system would require a climber/technician to do the maintenance. Generally, the FAA does not encourage the installation of high intensity lighting systems on towers less than 500 ft (152.4 m) in height.

The flashing of high intensity lamps can be very annoying to the general public living near the tower. There are cases where the community surrounding the site of a proposed structure equipped with such lighting objected so strenuously that the FCC did not approve the construction. Prejob planning and public relations need to be addressed before designing high intensity systems.

Tower Marking (Painting)

The specific requirements for each individual tower are stated in the station's license. The general requirements for the marking of towers are stated in the FCC Rules and Regulations. [6]

Banding Specification

All towers that use conventional lighting systems must be marked with alternating bands of orange and white paint of equal width. The FCC Rules and Regulations specify the following colors: aviation surface orange and white. For towers up to 700 ft (213.36 m) in height, the width of the color bands should be approximately one-seventh the height of the structure but not less than 1-1/2 ft (0.46 m) or larger than 100 ft (30.48 m). On towers greater than 700 ft (213.36 m) in height, the color bands are required to be no greater than 100 ft (30.48 m) in width. Two additional color bands are to be provided for each 200 ft (60.96 m) of height in excess of 700 ft (213.36 m). For towers of all heights, the top and bottom color bands are to be of aviation surface orange color. The result of the above is that for towers of all heights:

- There will always be an odd number of color bands;
- Aviation surface orange color will appear at the top and bottom of the tower; and
- The color bands will be not less than 1-1/2 ft (0.46 m) nor more than 100 ft (30.48 m) in width.

Inspection and Maintenance

To assure that a well designed and constructed tower remains in a safe operating condition, it is important that it be inspected at regular intervals and any necessary maintenance work be performed. Inspection and maintenance work should be performed by qualified firms who specialize in this field. The frequency of the inspections will depend on the climatic conditions to which the tower is subjected. Generally, inspections are recommended at least once each year. Additional inspections should be scheduled following severe storms. If the tower is located in a section of the country where the windy seasons occur at regular intervals, it is recommended that the inspections have corresponding intervals.

Risk management personnel should obtain the maintenance and inspection reports for a tower, where possible, to aid in determining how well the tower has been maintained. It is very unlikely that a properly designed, constructed, and maintained tower will experience any significant losses. The inspection and maintenance records will also reflect management's attitude.

Structural and Mechanical

The first step in any inspection of a tower entails climbing of the structure from bottom to top by a qualified climber/inspector or tower consultant. Observations should be made for evidence of wear, stress, or corrosion on the following:

- Superstructure (tower itself), including any associated hardware;
- Guy wires and guy points, including any associated hardware;
- Foundations and guy anchors; and
- Antenna mounts

Superstructure

The tower itself should be checked for linearity (straightness) and alignment (verticality). A surveyor's transit is used for this purpose. Indications of misalignment are excessive sag in guy wires, excessive vibration of members, or considerable sway in high winds. The individual members of the tower should also be inspected for straightness. Bent members are an indication that something is wrong. All joint connections should be checked for tightness along with any clamping devices. Most towers have bolted connections with a means of locking the nuts of the fastening system securely in place. Broken or cracked welds should also be noted and repaired.

Guy Wires and Guy Points

Most often, especially in larger towers, the guy wires are manufactured from galvanized bridge strand, and experience has shown that the life of these wires is very long. Components such as these have been in service for more than 50 years with no signs of distress, even without a protective treatment. However, if signs of rust appear on these wires, tower manufacturers have various types of coatings available to protect them. It is more essential to inspect and treat guy wires that are not galvanized.

Most tall towers use stranded cable for the guys. Consequently, the cables are not perfectly round in cross section. Under certain conditions, wind striking the cables can create an aerodynamic instability and cause the cables to vibrate. This condition can be created in both high and low wind conditions. Ice or snow accumulated on the cables can also induce aerodynamic instability and cause vibration. There are two basic types of aerodynamic instability. Vortex shedding of the wind off the cables can create a high frequency vibration in the cables. When this occurs, vortex shedding vibrations can be felt on, and usually heard, in the tower and cables. Aerodynamic shedding of wind on the cables can create a large amplitude, low frequency oscillation called "galloping." To induce this condition, high winds do not need to be present. Unchecked galloping of the cables can be severe enough to put stresses on the tower great enough todestroy it. Both conditions are usually compensated for through design. Some towers will have high frequency dampers installed. Low frequency galloping is usually controlled by tying the cables off at some point. If the tower cables use high or low frequency dampers they should be checked for serviceability.

Proper tension in a guy wire is extremely important. One of the best methods for obtaining an indication of proper guy tension forces is to check the tower's linearity and alignment with the vertical using a transit. If the tower is straight and plumb, it is almost a certainty that the guy tension forces are correct. The initial tensions are set at the time of construction fairly precisely. The resetting of the guys is not an easy procedure and, in the event it is necessary, it is recommended that the procedure be performed by a qualified tower consultant.

Finally, the guy wires should be checked for evidence of wear, such as broken or frayed strands. The tightness of any guy wire clamps and connections to the tower and guy points should be assured; cable sockets should be checked for damage.

Foundations and Guy Anchors

The condition of the concrete [1] used for the foundations and the guy anchors is an important consideration, but unfortunately, the greater portion of these components is underground and cannot be easily inspected. It is, therefore, very important that foundations and guy anchors be properly designed and constructed initially. The condition of the portions that are exposed and accessible should, however, be checked. Observations should be made to determine whether there has been any differential settlement of the foundations and guy anchors. A surveyor's transit or level can be used to accomplish this. The tension in the guy wires could cause lateral shifting of the guy anchors and this should also be noted. Shifted anchors and differential settlements of foundations can cause misalignment or induce settlement stresses in the superstructure.

Antenna Mounts

Potential problems with antenna mounts are similar to those encountered with the superstructure. The inspector should be on the lookout for cracked or broken welds on the base plate and guide flanges at the tower junction. Any bolts, clamping devices, and other hardware should be checked for tightness and corrosion.

Ladders, Platforms, and Elevators

Fixed ladders, rungs, steps, and platforms should be inspected for corrosion, the condition of their paint, tightness of bolts, and cracked or broken welds. [5] The condition of any special safety devices should also be observed and tested according to the manufacturer's recommendation.

Tall towers are very often equipped with elevators, the general condition of which should be carefully inspected to assure safe operation. It is recommended that the elevator's cable be checked along its entire length for frays, broken strands, and other signs of wear, along with its cable clips, fittings, and sockets. The cab should ascend and descend smoothly without binding or experiencing any other difficulty. The mechanical safety locking mechanism that "freezes" the cab in place in the event of a cable break must be free to operate properly. All levers, pivot points, shafts, or other components should be kept clear of paint and free of corrosion and generally be able to operate freely. State or local agencies sometimes perform a drop test and issue a certificate if the elevator complies with the particular specification being used. Also, local jurisdictions sometimes adopt their own inspection requirements. The elevatorcontrol system should be checked to assure that it is fully operable. When the tower is equipped with a communication system, its proper operation is essential for both safe and efficient work on the tower.

Lighting System

A tower's lighting system usually requires more frequent maintenance than any of its other components. The FCC Rules and Regulations require that tower lights be observed daily unless an automatic device is used to indicate any lighting failure. Rules require that an entry be made in a station's operating log concerning any lighting failures.

When a tower light burns out, it should promptly be reported to the nearest FAA office or flight service station if it is a top light of any kind or if it is a flashing sidelight. Steps should then be immediately taken to restore the proper operation of the lighting system. Any other lighting that malfunctions need not be reported, but is to be repaired "as soon as possible" as required by the FCC.

While bulbs are being replaced, signs of deterioration or damage to the globes, sockets, or wiring should be noted. Towers that are located in areas of the country where hunting with firearms is common, are subject to a unique type of vandalism; some hunters use components of the tower for target practice. Damage is inflicted upon the red globes, light sockets, conduits, wires, and other components of the tower. General corrosion and aging also take their toll on the lighting system components.

The FCC Rules and Regulations state that the entire lighting system of a tower is to be inspected every three months. [6] It is recommended that, among other components, the following should be checked: flashers, lighting chokes or transformers for AM transmitters, photocell switches, alarms, and remote control switches. Any corrections, modifications, or adjustments must be recorded in the station's log.

Painting

The licensee is required to maintain the color bands in good condition according to the stated specification. Experience has shown that the shortest paint life occurs near the ocean or where a tower is located in close proximity to industrial operations that emit corrosive or caustic mists, vapors, or dusts. In these situations, repainting is suggested every two years or less. A repainting interval of six years is noted for a galvanized tower in a dry moderate climate. For galvanized towers, painting is primarily for marking rather than protective purposes. A typical average time interval between paint jobs is considered to be four years. During any tower inspection, evidence of cracking or peeling paint or any corrosion should be noted and repaired.

Tower Equipment

All FM, TV, and microwave antenna-supporting towers and many AM towers support some type of equipment. Usually, a variety of transmission lines, antennas, reflectors, microwave dishes, and other similar units are attached to a tower. Often a continuous support is designed for the transmission line leading to the tower along with associated cat walks, ladders, and railings. All previous suggestions for inspections and maintenance apply to such equipment and should be checked at the same time as the tower.

Lightning Protection System

Weep holes in base insulators and guy point insulators need to be periodically checked. They should be kept clean and clear to allow rainwater, moisture from condensation, and other sources to drain freely. Water that freezes in the insulator can cause it to crack and thereby destroy its insulating properties and interfere with the transmission of signals.

The condition of the surfaces of the spheres forming the spark gap, that serves as part of the lightning arrestor, also needs to be checked. If the gap becomes partially or entirely shorted with some type of foreign substance, the efficient operation of the antenna can be disturbed. If the surfaces forming the gap become sufficiently corroded or deteriorated so that their function is impaired, there can be serious damage to the transmitting equipment, foundations, or insulators if the tower is struck during a storm.

Surrounding Land

The site on which a tower is built is often sizable and, as good general practice, should also be properly maintained. In the case of AM transmitting towers, plant and grass growth around the base or any guy points could affect the operation of the antenna system. The area should be mowed and cleared at least four times a year and preferably more often. While FM, TV, and microwave antenna-supporting towers are not similarly affected, the areas around their bases and any guy points should also be kept mowed to allow for inspection and to minimize damage should brush fire occur. The areas around transmission line supports should also be maintained and mowed.

Fire Protection

The cost of replacing a transmitter building and its related equipment can be exceedingly high. The risk of fire is always present. Since many towers are located in isolated, rural areas, an adequate water supply for fire suppression may not always be available. The proper extinguishing equipment or systems should be available in accordance with the recognized codes and standards. If the tower and transmitter building are bordered by forests, grass areas, or other combustible vegetation, it is recommended that an adequate fire break be maintained.

Physical Security

There is an electrical shock hazard present at the base of AM transmitting towers. The superstructure itself serves as the antenna and is insulated from electrical ground at the supports and any guy anchors. The FCC Rules and Regulations require that the tuning house of such a station be kept locked and that fencing be provided around the tower and any guy points. Although there may not be a shock hazard associated with a TV, FM, or microwave antennasupporting tower, there is the "curiosity problem" where unauthorized people climb the tower and its associated equipment. Since injuries are always a possibility, it is recommended that a suitable fence be installed around the base and guy points of all towers that are accessible to unauthorized personnel. Chain link fences should be installed according to standard, F-567, Standard Practice for the Installation of Chain Link Fence, published by the American Society for Testing and Materials.

Towers can be overturned by vandals that have some grievance with a station or its management. Guyed towers are generally more susceptible to vandalism than self-supporting towers. The cutting of one guy wire could cause damage or a total collapse. Equipment is available to improve the security of broadcast transmitting facilities and should be considered, especially for those that operate unattended. In addition to fences, security systems are available for detecting the presence of persons near a tower's base or any guy points. A warning signal can be sent to the transmitter building or to a remote control point. Systems are also available that will automatically turn on one or more bright lights at night when trespassers are sensed. Surveillance cameras with motion sensors focused at critical areas have proven effective. In areas where there is a high concentration of towers ("antenna farms"), private security firms are oftenretained to patrol the entire area.

Summary and Suggestions

In evaluating transmitting towers as potential risks, consideration should be given to the location of the tower and any guy anchors in relation to the surrounding houses, buildings, highways, power lines, telephone lines, recreational facilities, other towers, and other exposures. When convenient, towers should be located in isolated areas where a possible failure will not endanger people or damage the surrounding property. Locations where there are well defined flood regions should be avoided. Towers must meet the best engineering standards available.

The retention of a reputable and well qualified tower consultant is very important in the planning of a new transmitting tower or the modification of an existing structure. Employing a reputable and qualified tower-erecting contractor is also extremely important to protect against the possibility of a failure during construction and to help assure that the erection procedures used do not damage or weaken the tower.

As important as the design and construction of a tower is to its safe and reliable operation, so is its proper maintenance. Towers should be inspected regularly by qualified persons. The inspection reports should be obtained and reviewed to ascertain if any unsafe conditions exist. Any modifications or alterations of the original structure should be investigated to determine they were made by a qualified professional tower consultant.

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