ORDER

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
GREAT LAKES REGION

GL 6930.7

SUBJ: MAINTENANCE OF STRUCTURAL TOWERS AND GUYS

1. PURPOSE. This order provides procedures, technical standards and techniques to guide field personnel in the methods and use of equipment for maintenance of structural towers and related guys.

2. DISTRIBUTION. This order is distributed to the Airway Facilities Division, Branch level and above, and to all Airway Facilities field offices.

3. CANCELLATION. Order CE 6930.1 is cancelled.

4. SCOPE. This order is directed toward servicing microwave towers as most of the FAA tower maintenance work is on these. Much of the material in this order can, however, be applied toward any guyed or self-supporting tower.

5. BACKGROUND. Definite procedures have not previously been outlined for maintenance of towers and tower guys. These procedures are needed to provide the Regional Offices with guidelines for proper tower maintenance and to provide a uniform tower maintenance program.

6. STANDARDS AND TOLERANCES.

   a. Mast Alignment. The top of the mast shall be vertically above the base within a tolerance of not more than .2% (.002) of the tower height. The tower legs shall not deviate from the straight line connecting the top and bottom of the tower by more than three inches.

   b. Bolt Tension. The bolts shall be tensioned as indicated in Appendix 1, page 1.

   c. Guy Cable Tension. The initial (no wind load) guy tensions shall be maintained within a maximum tolerance of $\pm$ 300 pounds or $\pm$ 7% (.07) of the specified initial tension, whichever is greater. The specified initial tensions are shown on the tower erection drawings and should be available at each site.

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Cable tensions increase approximately 10 pounds for each degree (F.) drop in temperature and vice versa. All tension readings should be corrected to 60°F. before comparing them against specified tensions or previous tensions.

d. Guy Cable Grounds. The guy cable ground resistance shall not exceed 25 ohms. Experience indicates that ground resistance increases when the soil is dry. Ground resistance measurements should be made under extreme conditions to insure that ground resistance is within tolerances.

7. INSTRUMENTS AND EQUIPMENT FOR TOWER AND GUY ADJUSTMENTS.

a. Cable Tension Indicator. Lever operated shunt type tension indicators (with Federal gauge) are on hand in each Region for checking guy tensions. Calibration graphs are included with each indicator.

b. Transit. A transit is required to check the vertical mast alignment of the tower.

c. In-Line Tensiometer (Dynamometer). Direct reading in-line gauges are available in each Region for use in making major guy cable adjustments and for recalibration of the tension indicators.

c. Working Equipment. The following working equipment is available in each Region:

(1) Klein "Chicago" cable grips, 7/16" - 5/8"
(2) Klein "Chicago" cable grips, 3/5"
(3) Coffing chain hoist "come along", 3 ton.

Note: All grips must have bronze lined jaws to prevent damage to guys.

8. PROCEDURES FOR GUY ADJUSTMENTS.

a. Cable Tension Indicator.

(1) Indicator Use. Refer to Washington Drawing No. D-5559 for the proper operating procedure of the indicator. The indicator should be positioned on the cable in a spot where the cable has not been nicked or deformed. Read the dial indicator and refer to the conversion graph to obtain the tension in pounds. A minimum of 3 readings should be taken at different locations on the cable and an average used. Note subparagraph 6c regarding correcting readings to 60°F. equivalent.

(2) Indicator Care. The tension indicators are precision instruments and should be treated with extreme care when handling and storing. Past experience shows that a spot of rust or a slight misalignment of the dial micrometer shaft will give erroneous readings. If inconsistent readings are obtained, the instrument should be cleaned and a small amount of light oil placed on the micrometer shaft.

(3) Recalibration of Indicators. The tension indicators shall be checked for accuracy annually by the use of a direct reading in-line gauge. Recalibration may be accomplished by attaching the coffing chain hoist in series with the anchor, the in-line gauge and the cable grip as shown on Drawing No. D-5559. By releasing the turnbuckle, the entire tension in the cable is transmitted through the chain hoist and gauge. By varying the tension with the chain hoist, one may obtain different readings for comparison with the graph.

(4) Calibration Graphs. The calibration graphs included with the gauges were prepared in the Region using the in-line gauge. Past experience shows that the instrument must be calibrated under field conditions to obtain an accurate graph. Graphs prepared in a laboratory have proven unsatisfactory and it is therefore impractical to send the instruments to a laboratory for recalibration. It is suggested, however, that the direct in-line reading dynamometer used for field calibration of the shunt dynamometer by laboratory calibrated once a year.

b. Cable Tensioning.

(1) Procedure. Cable testing and any required retensioning shall be started with the lowest set of guys first, and then work progressively upwards toward the top level. Usually the adjustment can be accomplished through the use of the turnbuckles. If the turnbuckles will not provide the take-up distance required, then chain hoists (come alongs) and suitable cable grips will be required. Retensioning can usually be best accomplished when all three guys are handled simultaneously or by carefully working back and forth between guys. If considerable adjustment is necessary, a chain hoist should be used in parallel with the turnbuckle to release the tension and reduce wear on the turnbuckle. Wear on the turnbuckles will also be reduced by placing a small amount of oil on the threads.

(2) Weather Conditions. Cable testing shall preferably be accomplished when the temperatures range between 50° and 80°F. and winds are under 15 MPH. When necessary to operate in windy weather, check the same cables in the wind and during lulls or early morning calms to determine wind effects and adjust operations accordingly. Cease cable adjustment operations when consistent results cannot be obtained.

c. Vertical Alignment Check. The tower vertical alignment shall be checked with a transit from at least two directions 90° apart on square towers or 120° apart on triangular towers. Three sitings should be made on all triangular towers that prove questionable after siting on 2 corners. On a triangular guyed tower it is best to set up near an outside guy anchor or farther out to reduce the maximum vertical angle. Siting should normally be on 1 leg from a set-up on a radial through that leg. On some towers the site may be made on the center of the tower from almost any location.

(1) Procedure. Level the transit, site on the top of the tower, lock the horizontal plates, recheck to insure the transit is on target and the plate bubble 90° to the site line is exactly centered. Then lower the telescope, siting on the tower leg at least at each guy level and at the bottom, noting the approximate deviations.

(2) Transit Accuracy Check. Repeat the operation with the transit reversed (plate rotated 180° and the telescope upside down), plate bubbles recentered, and using the same target at the top. If the transit is out of adjustment, the site points below the top with transit direct and reversed will not coincide, but a point halfway between them will be on the true vertical line below the top siting point. If the two sitings (direct and reversed) coincide, the transit is in good adjustment and only direct sitings will be satisfactory for the remainder of the day.

(3) Deviations. Based on known dimensions of structural members, deviations of the tower from plumb may be estimated. Where deviations are excessive, at least the bottom deviation should be measured.

9. SERVICE AND INSPECTION SCHEDULES.

a. Field Inspection and Maintenance of all guyed towers shall be performed semi-annually, preferably spring and fall, for the first two years after erection and annually thereafter or after a severe ice or windstorm. Appendix 1 provides a list of items to check when inspecting structural towers and guys.

b. Bolt Tensions should be checked on all bolts approximately six months to one year after the tower is erected. This will provide for tightening any bolts that may have been missed during original construction or which have loosened by the tower joints flexing and settling during wind loading. Bolt loosening should not present a problem after the initial check; however, a visual check of the bolts should be made during performance of annual field maintenance. If a re-lamping contract is used on high towers, it may be desirable to include an item for a one-time complete bolt tension check, and specify a careful visual inspection for loose bolts or signs of movement at connections every time the lamps are serviced.

c. Obstruction Lights. On high towers it may be desirable to contract for periodic replacement of obstruction lamps at about 80% of normal lamp life. Such a contract should include inspection and cleaning of lamp fixtures and glassware.

d. Microwave Reflectors. Carefully inspect the microwave reflector and mounting brackets for loose bolts and rivets and cracked members. The microwave reflector, framing and bracing members are constructed from aluminum. Although the tensile strength of the type aluminum used is quite high, the fatigue factor of the material is relatively low compared to steel. Wind currents tend to cause the reflectors and bracing to vibrate at high frequencies which gradually cause some of the structural members to break. Past experience has proven the three deformed angles that are welded to the back side of the reflector framing fail first. These three angles should be inspected closely for fine line cracks.

e. Experienced Crews. The work should preferably be accomplished throughout the Region by the same personnel, as a high degree of skill and care is required. A crew will develop uniform procedures, accuracy, speed and safety with experience.

10. RECORDS. Appendix 2 (Guyed Tower Cable Tension Report, GL Form 6930-1) and Appendix 3 (Guy Tension Log, GL Form 6930-2) offer a good method of recording the guy tensions. One completed copy of either Form should be filed at the facility each time the cable tensions are checked.

ALAN H. GLASS
Chief, Airway Facilities Division

APPENDIX 1. BOLT TENSIONS AND REQUIRED TORQUE VALUES.

When calibrated torque wrenches are used, they shall show by dial or automatic release, the measure in foot-pounds of the torque induced by the wrench. The minimum torque for the sizes of bolts shall conform to the values listed below.

BOLT TENSION AND TORQUE VALUES

Bolt Size (in.)	Recommended Bolt Tension for Calibrating Wrenches (lb)	Required Bolt Tension (lb.)	Required Bolt Torque (lb. ft.)
	STRUCTURAL GRADE BOLTS per ASTM Specification A307		
1/2	4,500	3,900	32
5/8	7,150	6,250	65
3/4	10,550	9,200	115
	Per Federal Specification FF-B-575 (Type I Grade 2)		
1/2	5,650	4,900	41
5/8	8,300	7,250	75
3/4	12,300	10,700	134
	HIGH STRENGTH BOLTS per ASTM Specification A325		
1/2	12,500	10,850	90
5/8	20,000	17,250	180
3/4	29,000	25,600	320

Locking nuts (pal nuts) shall be tensioned at 25% of the required bolt tension for structural grade bolts. The wrenches shall be properly calibrated and the nuts shall be in motion when the torque is measured.

Note: Most high strength bolts will have been manufactured in accordance with ASTM Specification A325 and can be identified by the Symbol A325 of the head of the bolt. Other types of high strength bolts will have different identifying symbols. Bolts with no identifying symbols are structural grade bolts. High strength bolts are normally used only in special situations such as on the reflector supports of microwave towers.

CHECK LIST FOR STRUCTURAL TOWERS AND GUYS INSPECTIONS.

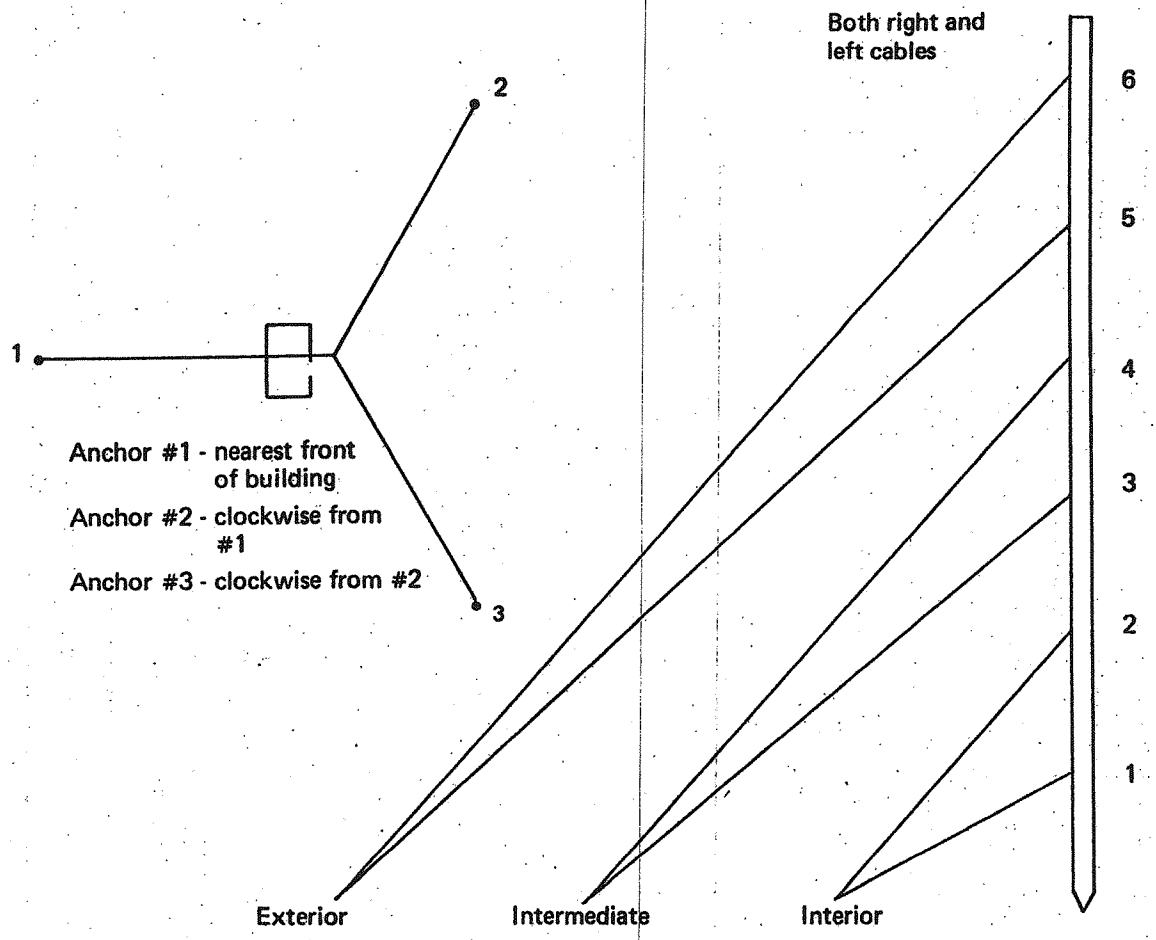
1. Vertical mast alignment.
2. Loose or missing bolts, nuts and pal nuts.
3. Missing, bent, cracked or broken members.
4. Reflectors - check for broken rivets and separation of sheet metal from frame.
5. Concrete base-settlement or cracks.
6. Tower anchors--frost heave--protection from livestock, erosion.
7. Guy cables--tensions, damage, rust.
8. Guy cable connections--check for damage, rust, loose bolts, served ends.
9. Turnbuckles-are they safety wired or jamb nut installed.
10. Tower insulators--chipped or cracked and cleanliness.
11. Grounds, tower and guy--mechanical condition, resistance.
12. Loose electrical conduit or other attachments.
13. Obstruction lighting - See SM P 6910.1.
14. Moisture or dirt in junction boxes.
15. Lightning rods--check if required and if properly installed.
16. Paint--check color scheme, condition, coverage.

GUYED TOWER CABLE TENSION REPORT

ANCHOR LOCATION	GUY LEVEL	CABLE SIZE	SPEC. LBS.	1ST READING	2ND READING	3RD READING	FINAL READING (LBS.)	REMARKS

Facility Location	Drawing No.	Height	Date
Wind Velocity	Temperature	Gauge No.	
Structural Condition Inc. Bolt Tension			
Condition of Paint			
Party		Signature	

GL Form 6930-1 (03/73) Supercedes CE Form 6930-5

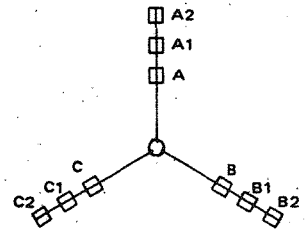


As cable locations vary at different sites in relation to the building, #1 anchor shall be considered as the one approximately directly in front of the building. If no anchors are located directly in front of the building then the first encountered clockwise about the tower shall be called #1.

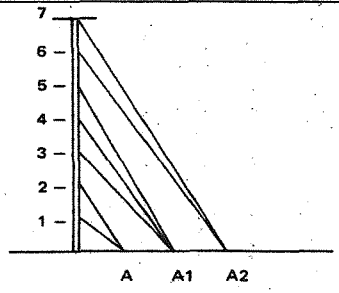
Most microwave towers have double sets of guys from the exterior anchor to top of the towers. These are to be indicated as to the top left and top right when observed by standing at an anchor and facing the tower.

GUY TENSION LOG

ANCHOR / GUY LEVEL	CABLE TYPE & SIZE	CABLE TENSION						REMARKS *(Include guys, turnbuckles, clamps, etc.)*
		INITIAL	READING	2nd	3rd	AVERAGE	CORR. –60°	



Guy Location Key



ANCHOR A - Nearest Front of Bldg.
ANCHOR B - Clockwise from A
ANCHOR C - Clockwise from B

Top level guys to be noted as
Left & Right when facing Tower.

GL Form 6930-2 (03/73)

TOWER AND GUY TENSION LOG

Facility Location_____ Date_____

Height_____ Drawing No._____ Guage No._____

Wind Velocity_____ Direction_____ Temperature_____

Foundation *(Cracks, etc.)*_____

Anchor Rods_____

Guy Anchors_____

Tower Condition *(Rusting, etc.)*_____

Straight *(Straightened)*_____

Painted_____ Condition_____

Bolts, Nuts, Pal Nuts *(tight/torqued)*_____ Condition_____

Lighting_____ Lights Burning_____ Flasher Unit_____

Conduit Condition_____ Wire_____

Photo-Electric Control_____ Glass Cover_____

Other

Grounding *(wire, rod, etc.)*_____ Resistance_____

Condition of Antenna, Mounting Bracket, etc._____

Condition of Coax Cable, Connection, etc._____

Ground wire bonded to conduit_____ Bonding Lugs_____

Lightning Rods, Grounds, etc._____

Additional Remarks

_____

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_____

Party_____ Signature_____

GL Form 6930-2 (03/73) Supercedes CE Form 6930-2

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