Azimuth	0	30	60	Vertical angle
247	82.62	51.52	26.38	

If we further assume that the station has a standard pattern, we find that Q, for θ=0, is 22.36.

Following is a tabulation of part of the standard pattern:

Azimuth	0	30	60	Vertical angle
0	28.86	68.05	72.06	
105	1286.78	860.97	246.41	
235	23.48	26.50	37.18	
247	89.87	57.03	28.87	

The RMS of the standard pattern in the horizontal plane is 719.63 mV/m at one kilometer.

[36 FR 919, Jan. 20, 1971, as amended at 37 FR 529, Jan. 13, 1972; 41 FR 24134, June 15, 1976; 46 FR 11991, Feb. 12, 1981; 48 FR 24384, June 1, 1983; 51 FR 2707, Jan. 21, 1986; 52 FR 36877, Oct. 1, 1987; 56 FR 64861, Dec. 12, 1991; 57 FR 43290, Sept. 18, 1992]

§ 73.151 Field strength measurements to establish performance of directional antennas.

The performance of a directional antenna may be verified either by field strength measurement or by computer modeling and sampling system verification.

(a) In addition to the information required by the license application form, the following showing must be submitted to establish, for each mode of directional operation, that the effective measured field strength (RMS) at 1 kilometer (km) is not less than 85 percent of the effective measured field strength (RMS) specified for the standard radiation pattern, or less than that specified in § 73.189(b) for the class of station involved, whichever is the higher value, and that the measured field strength at 1 km in any direction does not exceed the field shown in that direction on the standard radiation pattern for that mode of directional operation:

(1) A tabulation of inverse field strengths in the horizontal plane at 1 km, as determined from field strength measurements taken and analyzed in accordance with § 73.186, and a statement of the effective measured field strength (RMS). Measurements shall be made in the following directions:

(i) Those specified in the instrument of authorization.

(ii) In major lobes. Generally, one radial is sufficient to establish a major lobe; however, additional radials may be required.

(iii) Along additional radials to establish the shape of the pattern. In the case of a relatively simple directional antenna pattern, a total of six radials is sufficient. If two radials would be more than 90° apart, then an additional radial must be specified within that arc. When more complicated patterns are involved, that is, patterns having several or sharp lobes or nulls, measurements shall be taken along as many as 12 radials to definitely establish the pattern(s). Pattern symmetry may be assumed for complex patterns which might otherwise require measurements on more than 12 radials.

(2) A tabulation of:

(i) The phase difference of the current in each element with respect to the reference element, and whether the current leads (+) or lags (−) the current in the reference element, as indicated by the station's antenna monitor.

(ii) The ratio of the amplitude of the radio frequency current in each element to the current in the reference element, as indicated on the station's antenna monitor.

(3) A monitoring point shall be established on each radial for which the construction permit specifies a limit. The following information shall be supplied for each monitoring point:

(i) Measured field strength.

(ii) An accurate and detailed description of each monitoring point. The description may include, but shall not be limited to, geographic coordinates determined with a Global Positioning System receiver.

(iii) Clear photographs taken with the field strength meter in its measuring position and with the camera so located that its field of view takes in as many pertinent landmarks as possible.

(b) For stations authorized to operate with simple directional antenna systems (e.g., two towers) in the 1605–1705 kHz band, the measurements to support pattern RMS compliance referred to in paragraphs (a)(1)(ii) and (a)(1)(iii) of this section are not required. In such cases, measured radials are required only in the direction of short-spaced allotments, or in directions specifically identified by the Commission.

(c) *Computer modeling and sample system verification of modeled parameters to establish operation of a directional antenna consistent with the theoretical pattern.* Each element of the directional array shall be modeled by use of a method of moments computer program, using the physical characteristics of each element to establish a model that does not violate any of the internal constraints of the computer program. Only arrays consisting of series-fed elements may have their performance verified by computer modeling and sample system verification.

(1) A matrix of impedance measurements at the base and/or feed point of each element in the array, with all other elements shorted and/or open circuited at their respective measurement locations, shall be made. The physical model of the individual antenna elements used in the computer program may be varied to match the measured impedance matrix, but the actual spacings and orientations of the array elements must be used. Towers may be modeled using individual vertical wires to represent them, or with multiple wires representing their leg and cross-member sections. The resulting model description (consisting of the length, radius, and number of segments of each wire for arrays using vertical wire sections to represent the towers, or the length, end-point coordinates, and radius of each wire used to represent leg and cross-member sections for arrays using detailed tower structure representations) as well as the assumed input feed and base region stray reactances shall be used to generate the drive impedances and sample system parameter values for the operating directional antenna pattern parameters.

(i) For arrays using vertical wires to represent each tower, the radii of cylinders shall be no less than 80 percent and no more than 150 percent of the radius of a circle with a circumference equal to the sum of the widths of the tower sides.

(ii) For arrays using multiple wires to represent leg and cross-member sections, the individual legs of the tower may be modeled at their actual diameters with appropriate interconnecting segments representing cross-members at regular intervals.

(iii) No less than one segment for each 10 electrical degrees of the tower's physical height shall be used for each element in the array.

(iv) Base calculations shall be made for a reference point at ground level or within one electrical degree elevation of the actual feed point.

(v) For uniform cross-section towers represented by vertical wires, each wire used for a given tower shall be between 75 to 125 percent of the physical length represented.

(vi) For self-supporting towers, stepped-radius wire sections may be employed to simulate the physical tower's taper, or the tower may be modeled with individual wire sections representing the legs and cross members.

(vii) The lumped series inductance of the feed system between the output port of each antenna tuning unit and the associated tower shall be no greater than 10 μH unless a measured value from the measurement point to the tower base with its insulator short circuited is used.

(viii) The shunt capacitance used to model base region effects shall be no greater than 250 pF unless the measured or manufacturer's stated capacitance for each device other than the base insulator is used. The total capacitance of such devices shall be limited such that in no case will their total capacitive reactance be less than five times the magnitude of the tower base operating impedance without their effects being considered.

(ix) The orientation and distances among the individual antenna towers in the array shall be confirmed by a post-construction certification by a land surveyor (or, where permitted by local regulation, by an engineer) licensed or registered in the state or territory where the antenna system is located.

(2)(i) The computer model, once verified by comparison with the measured base impedance matrix data, shall be used to determine the appropriate antenna monitor parameters. The moment method modeled parameters shall be established by using the verified moment method model to produce tower current distributions that, when numerically integrated and normalized to the reference tower, are identical to the specified field parameters of the theoretical directional antenna pattern. The samples used to drive the antenna monitor may be current transformers or voltage sampling devices at the outputs of the antenna matching networks or sampling loops located on the towers. If sample loops are used, they shall be located at the elevation where the current in the tower would be at a minimum if the tower were detuned in the horizontal plane, as determined by the moment method model parameters used to determine the antenna monitor parameters. Sample loops may be employed only when the towers are identical in cross-sectional structure, including both leg and cross member characteristics; if the towers are of unequal height, the sample loops shall be mounted identically with respect to tower cross members at the appropriate elevations above the base insulator. If the tower height used in the model is other than the physical height of the tower, the sampling loop shall be located at a height that is the same fraction of the total tower height as the minimum in tower current with the tower detuned in the model. Sample lines from the sensing element to the antenna monitor must be equal in both length (within one electrical degree) and characteristic impedance (within two ohms), as established by impedance measurements, including at the open-circuit resonant frequency closest to carrier frequency to establish length, at frequencies corresponding to odd multiples of ⅛ wavelength immediately above and below the open circuit resonant frequency closest to carrier frequency, while open circuited, to establish characteristic impedance, and at carrier frequency or, if necessary, at nearby frequencies where the magnitude of the measured impedance is no greater than 200 ohms with the sampling devices connected. Samples may be obtained from current transformers at the output of the antenna coupling and matching equipment for base-fed towers whose actual electrical height is 120 degrees or less, or greater than 190 electrical degrees. Samples may be obtained from base voltage sampling devices at the output of the antenna coupling and matching equipment for base-fed towers whose actual electrical height is greater than 105 degrees. Samples obtained from sample loops located as described above can be used for any height of tower. For towers using base current or base voltage sampling derived at the output of the antenna coupling and matching equipment, the sampling devices shall be disconnected and calibrated by measuring their outputs with a common reference signal (a current through them or a voltage across them, as appropriate) and the calibration must agree within the manufacturer's specifications. A complete description of the sampling system, including the results of the measurements described in this paragraph, shall be submitted with the application for license.

(ii) Proper adjustment of an antenna pattern shall be determined by correlation between the measured antenna monitor sample indications and the parameters calculated by the method of moments program, and by correlation between the measured matrix impedances for each tower and those calculated by the method of moments program. The antenna monitor sample indications must be initially adjusted to agree with the moment method model within ±5 percent for the field ratio and ±3 degrees in phase. The measured matrix impedances must agree with the moment method model within ±2 ohms and ±4 percent for resistance and reactance.

(3) Reference field strength measurement locations shall be established in directions of pattern minima and maxima. On each radial corresponding to a pattern minimum or maximum, there shall be at least three measurement locations. The field strength shall be measured at each reference location at the time of the proof of performance. The license application shall include the measured field strength values at

each reference point, along with a description of each measurement location, including GPS coordinates and datum reference.

[36 FR 919, Jan. 20, 1971, as amended at 42 FR 36828, July 18, 1977; 49 FR 23348, June 6, 1984; 50 FR 32416, Aug. 12, 1985; 56 FR 64862, Dec. 12, 1991; 63 FR 33876, June 22, 1998; 66 FR 20756, Apr. 25, 2001; 73 FR 64561, Oct. 30, 2008]

§ 73.152 Modification of directional antenna data.

(a) If, after construction and final adjustment of a directional antenna, a measured inverse distance field in any direction exceeds the field shown on the standard radiation pattern for the pertinent mode of directional operation, an application shall be filed, specifying a modified standard radiation pattern and/or such changes as may be required in operating parameters so that all measured effective fields will be contained within the modified standard radiation pattern. Permittees may also file an application specifying a modified standard radiation pattern, even when measured radiation has not exceeded the standard pattern, in order to allow additional tolerance for monitoring point limits.

(b) If, following a partial proof of performance, a licensee discovers that radiation exceeds the standard pattern on one or more radials because of circumstances beyond the licensee's control, a modified standard pattern may be requested. The licensee shall submit, concurrently, Forms 301–AM and 302–AM. Form 301–AM shall include an exhibit demonstrating that no interference would result from the augmentation. Form 302–AM shall include the results of the partial proof, along with full directional and nondirectional measurements on the radial(s) to be augmented, including close-in points and a determination of the inverse distance field in accordance with § 73.186.

(c) Normally, a modified standard pattern is not acceptable at the initial construction permit stage, before a proof-of-performance has been completed. However, in certain cases, where it can be shown that modification is necessary, a modified standard pattern will be acceptable at the initial construction permit stage. Following is a non-inclusive list of items to be considered in determining whether a modification is acceptable at the initial construction permit stage:

(1) When the proposed pattern is essentially the same as an existing pattern at the same antenna site. (e.g., A DA-D station proposing to become a DA–1 station.)

(2) Excessive reradiating structures, which should be shown on a plat of the antenna site and surrounding area.

(3) Other environmental factors; they should be fully described.

(4) Judgment and experience of the engineer preparing the engineering portion of the application. This must be supported with a full discussion of the pertinent factors.

(d) The following general principles shall govern the situations in paragraphs (a), (b), and (c) in this section:

(1) Where a measured field in any direction will exceed the authorized standard pattern, the license application may specify the level at which the input power to the antenna shall be limited to maintain the measured field at a value not in excess of that shown on the standard pattern, and shall specify the common point current corresponding to this power level. This value of common point current will be specified on the license for that station.

(2) Where any excessive field does not result in objectionable interference to another station, a modification of construction permit application may be submitted with a modified standard pattern encompassing all augmented fields. The modified standard pattern shall supersede the previously submitted standard radiation pattern for that station in the pertinent mode of directional operation. Following are the possible methods of creating a modified standard pattern:

(i) The modified pattern may be computed by making the entire pattern larger than the original pattern (*i.e.*, have a higher RMS value) if the measured fields systematically exceed the confines of the original pattern. The larger pattern shall be computed by using a larger multiplying constant, k, in the theoretical pattern equation (Eq. 1) in § 73.150(b)(1).