FEDERAL COMMUNICATIONS COMMISSION

STANDARDS OF GOOD ENGINEERING PRACTICE CONCERNING STANDARD BROADCAST STATIONS

(550–1600 kc.)

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INTRODUCTION

There are presented herein the Standards of Good Engineering Practice giving interpretations and further considerations concerning the Rules and Regulations of the Communications Commission governing standard broadcast stations. While the Rules and Regulations form the basis of good engineering practice, these standards may go beyond the Rules and Regulations and set up engineering principles for consideration of various allocation problems. These standards have been approved by the Commission and thus are considered as reflecting the opinion of the Commission in all matters involved.

The Rules and Regulations contain references to these standards; however, as further standards may be issued after the Rules and Regulations are published, the absence of such references does not relieve the responsibility of meeting the requirements specified herein. The Standards of Good Engineering Practice are collected in this publication for the convenience of all considering broadcast station operation and problems.

The Standards of Good Engineering Practice set forth herein are those deemed necessary for the construction and operation of standard broadcast stations to meet the requirements of technical regulations and for operation in public interest along technical lines not specifically enunciated in the regulations. These standards are based on the best engineering data available from evidence supplied in formal and informal hearings and extensive surveys conducted in the field by the Commission's personnel. Numerous informal conferences have been held with radio engineers, manufacturers of radio equipment and others for the guidance of the Commission in the formulation of these standards.

These standards are complete in themselves and supersede any previous announcements or policies which may have been enunciated by the Commission on engineering matters concerning standard broadcast stations.

While these standards provide for flexibility and set forth the conditions under which they are applicable, it is not expected that material deviation therefrom as to fundamental principles will be recognized unless full information is submitted as to the reasonableness of such departure and the need therefor.

These Standards of Good Engineering Practice will necessarily change as progress is made in the art, and accordingly it will be necessary to make revisions from time to time. The Commission will accumulate and analyze engineering data available as to the progress of the art so that its standards may be kept current with the developments.

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STANDARDS OF GOOD ENGINEERING PRACTICE CONCERNING STANDARD BROADCAST STATIONS

(550–1600 kc.)

1. ENGINEERING STANDARDS OF ALLOCATION

Section 3.28 requires that individual broadcast station assignments shall be made in accordance with the standards of good engineering practice prescribed and published from time to time by the Commission. These standards for each class of station are set out below.

Sections 3.21 to 3.34, inclusive, govern the allocation of facilities in the standard broadcast band of 550 to 1600 kc., inclusive. Section 3.21 establishes three classes of channels in this band, namely, clear channels for the use of high-powered stations, regional channels for the use of medium-powered stations, and local channels for the use of low-powered stations. The classes and power of standard broadcast stations which will be assigned to the various channels are set forth in section 3.22. The classification of the standard broadcast stations are as follows:

Class I stations are dominant stations operating on clear channels as follows:

(1) Class I stations operate with powers of not less than 10 or more than 50 kw. These stations are designed to render primary and secondary service over an extended area and at relatively long distances, hence have their primary service areas[1] free from objectionable interference from other stations on the same and adjacent channels and secondary service areas free from objectionable interference from stations on the same channels.[2] [3]

(2) From an engineering point of view, Class I stations may be divided into two groups:

(*a*) The Class I stations in Group 1 are those assigned to the channels allocated by section 3.25, paragraph (a), on which duplicate night-

[1] See section 3.11 for the definitions of primary and secondary service areas.

[2] See tables IV and V.

[3] The secondary service area of a Class I station is not protected from adjacent channel interference. However, in case of placing a station on an adjacent channel (10 kc. removed) to a Class I station which would substitute a primary service for the secondary service, the matter of the program service as well as the signal service of the two stations should be given consideration. That is, at the 0.5 mv/m 50 percent sky wave contour of a Class I station purely for the determination of comparative service, the area bound by 1 mv/m contour of a Class II, Class III or Class IV station 10 kc. removed may be taken as the area within which the secondary service of the Class I station is precluded. For higher values of 50 percent sky wave signal from a Class I station the ratio of the ground wave to sky wave shall be 2 to 1 and considered only within the 0.5 mv/m 50 percent sky wave contour of the Class I station.

time operation is not permitted, that is, no other station is permitted to operate on a channel with a Class I station of this group within the limits of the United States (the Class II stations assigned the channels operate limited time or daytime only), and during daytime the Class I station is protected to the 100 uv/m ground wave contour. Protection is given this class of station to the 500 uv/m ground wave contour from adjacent channel stations for both day and nighttime operations.[2] The power of each such Class I station shall not be less than 50 kw.

(*b*) The Class I stations in group 2 are those assigned to the channels allocated by section 3.25, paragraph (b), on which duplicate operation is permitted, that is, other Class I or Class II stations operating unlimited time may be assigned to such channels. During nighttime hours of operation a Class I station of this group is protected to the 500 uv/m 50 percent sky wave contour and during daytime hours of operation to the 100 uv/m ground wave contour from stations on the same channel. Protection is given to the 500 uv/m ground wave contour from stations on adjacent channels for both day and nighttime operation.[2] The operating powers of Class I stations on these frequencies shall be not less than 10 kw. nor more than 50 kw.

Hereafter, for the purpose of convenience, the two groups of Class I stations will be termed Class Ia or Ib in accordance with the assignment to channels allocated by section 3.25 (*a*) or 3.25 (*b*).

Class II stations are secondary stations which operate on clear channels with powers not less than 0.25 kw. or more than 50 kw. These stations are required to use a directional antenna or other means to avoid causing interference within the normally protected service areas of Class I stations or other Class II stations. These stations normally render primary service only, the area of which depends on the geographical location, power, and frequency. This may be relatively large but is limited by and subject to such interference as may be received from Class I stations. However, it is recommended that Class II stations be so located that the interference received from Class I stations will not limit the service area to greater than the 2500 uv/m ground wave contour, which is the value for the mutual protection of this class of station with other stations of the same class.[2]

Class III stations operate on regional channels and normally render primary service to the metropolitan district and the rural area contained therein and contiguous thereto, and are subdivided into two classes:

(*a*) Class III–A stations which operate with powers not less than 1 kw. or more than 5 kw. are normally protected to the 2500

[2] See tables IV and V.

uv/m ground wave contour nighttime and the 500 uv/m ground wave contour daytime.[2]

(*b*) Class III–B stations which operate with powers not less than 0.5 kw. or more than 1 kw. nighttime and 5 kw. daytime are normally protected to the 4000 uv/m ground wave contour nighttime and 500 uv/m ground wave contour daytime.[2]

Class IV stations operate on local channels normally rendering primary service only to a city or town and the suburban and rural areas contiguous thereto with powers not less than 0.1 kw. or more than 0.25 kw. These stations are normally protected to the 4000 uv/m ground wave contour nighttime and 500 uv/m ground wave contour daytime. On local channels the separation required for the daytime protection shall also determine the nighttime separation. Class IV stations may be assigned to regional channels on condition that interference will not be caused to any Class III station in accordance with the above, that the channel is used adequately and properly for Class III stations,[4] and that the Class IV station will be subject to such interference as may be received from the Class III stations. That is, the Class IV station assigned to a regional channel shall protect the Class III station to the required contour, but the Class III station is under no obligation to protect the Class IV station so assigned. However, it is recommended that the Class IV stations be so located that the interference received will not be greater than to the 4000 uv/m ground wave contour nighttime and 500 uv/m daytime.

The class of any station is determined by the channel assignment, the power, and the field intensity contour to which it renders service free of interference from other stations as determined by these standards. No station will be permitted to change to a class normally protected to a contour of less intensity than the contour to which the station actually renders interference-free service. Any station of a class normally protected to a contour of less intensity than that to which the station actually renders interference-free service, will be automatically reclassified according to the class normally protected, the minimum consistent with its power and channel assignment. Likewise, any station to which the interference is reduced so

[2] See tables IV and V.

[4] The assignment of a Class IV station to a regional channel normally is not considered as making the best usage of the assignment and will be made only when it is shown among other things that—

(1) There are no other transmission facilities in the town or towns in the proposed service area.

(2) There is no local channel assignment available for that area.

(3) Adequate economic support is not available for a Class III station.

(4) It is not practical from an engineering point of view to establish a Class III station and it would not prevent the establishment of any Class III station on that channel or an adjacent channel.

that service is rendered to a contour normally protected for a higher class will be automatically changed to that class if consistent with its power and channel assignment.

When it is shown that primary service is rendered by any of the above classes of stations, beyond the normally protected contour, and when primary service to approximately 90 percent of the population (population served with adequate signal) of the area between the normally protected contour and the contour to which such station actually serves, is not supplied by any other station or stations carrying the same general program service, the contour to which protection may be afforded in such cases will be determined from the individual merits of the case under consideration.

A Class II, III–B or IV station may be assigned to a channel available for such class, when a need therefor is shown, even though objectionable interference will be received to a field intensity contour greater than that specified as the normally protected contour for its class, provided that no objectionable interference will be caused by it to existing stations, and provided further, that the population residing in the area between the normally protected contour for its class and the contour to which objectionable interference will be received, does not exceed approximately 10 percent of the population in its actual primary service area. In case the station is located in a metropolitan area, the interference-free contour shall include 90 percent of the population of the metropolitan area.

When a station is already limited by interference from other stations to a contour of higher value than that normally protected for its class, this contour shall be the established standard for such station with respect to interference from all other stations.

Tables IV and V give a complete summary of the protected service contours and permissible interference signals for broadcast stations on the same and adjacent channels, respectively.

The several classes of broadcast stations have in general three service areas;[1] namely, primary, secondary, and intermittent service areas. Class I stations render service to all three service areas. Class II stations render service to a primary area but the secondary and intermittent service areas may be materially limited or destroyed due to interference from other stations depending on the station assignments involved. Class III and IV stations usually have only primary service areas as interference from other stations generally prevents any secondary service and may limit the intermit-

[1] See section 11 for the definitions of primary, secondary, and intermittent service areas.

tent service area. However, complete intermittent service may be obtained in many cases depending on the station assignments involved.

The signals necessary to render the different types of service are listed below.

TABLE I.—*Primary service*

Area:	*Field intensity ground-wave* [1]
City business or factory areas	10 to 50 mv/m
City residential areas	2 to 10 mv/m
Rural—all areas during winter or northern areas during summer	0.1 to 0.5 mv/m
Rural—southern areas during summer	0.25 to 1.0 mv/m

[1] See Appendix I for curves showing distance to various ground wave field intensity contours for different frequency and ground conductivities and Annex I.

All these values are based on an absence of objectionable fading, either in changing intensity or selective fading, the usual noise level in the areas [5] and an absence of limiting interference from other broadcast stations. The values apply both day and night but generally fading or interference from other stations limits the primary service at night in all rural areas to higher values of field intensity than the values given.

In determining the population of the primary service area, it may be considered that the following signals are satisfactory to overcome man-made noise in towns of the population given.

TABLE II

Population:	*Field intensity ground wave*
Up to 2,500	0.5 mv/m
2,500 to 10,000	2.0 mv/m
10,000 and up	Values given in Table I.

These values are subject to wide variations in individual areas and especial attention must be given to interference from other stations. The values are not considered satisfactory in any case for service to the city in which the main studio of the station is located. The values in Table I shall apply except as individual consideration may determine.

[5] Standards have not been established for interference from atmospherics or man-made electric noise as no uniform method of measuring noise or static has been established. In any individual case objectionable interference from any source, except other broadcast signals, may be determined by comparing the actual noise interference reproduced during reception of a desired broadcast signal to the degree of interference that would be caused by another broadcast signal within 20 cycles of the desired signal and having a carrier ratio of 20 to 1 with both signals modulated 100 percent on peaks of usual programs. Standards of noise measurements and interference ratio for noise are now being studied.

All classes of broadcast stations have primary service areas subject to limitation by fading and noise, and interference from other stations to the contours set out for each class of station.

Secondary Service

Secondary service is delivered in the areas where the sky wave for 50 percent or more of the time has a field intensity of 500 uv/m or greater.[6] It is not considered that satisfactory secondary service can be rendered to cities unless the sky wave approaches in value the ground wave required for primary service. The secondary service is necessarily subject to some interference and extensive fading whereas the primary service area of a station is subject to no objectionable interference or fading.[7] Class I stations only are assigned on the basis of rendering secondary service.

Intermittent Service

The intermittent service is rendered by the ground wave and begins at the outer boundary of the primary service area and extends to the value of signal where it may be considered as having no further service value. This may be down to only a few microvolts in certain areas and up to several millivolts in other areas of high noise level, interference from other stations, or objectionable fading at night. The intermittent service area may vary widely from day to night and generally varies from time to time as the name implies. Only Class I stations are assigned for protection from interference from other stations into the intermittent service area.

Section 3.23 provides that the several classes of broadcast stations may be licensed to operate unlimited time, limited time, daytime, sharing time, and specified hours, with full explanation given in the section.

Section 3.24 sets out the general requirements for obtaining an increase in facilities of a licensed station and for a new station. Section 3.24 (b) concerns the matter of interference that may be caused by a new assignment or increase in facilities of an existing assignment.

[6] The secondary service area of a Class Ia station should be considered as having this limit only for determination of service in comparison with other stations.

[7] Standards have not been established for objectionable fading as such standards would necessarily depend on the receiver characteristics which have been changed considerably in this regard during the last several years. Selective fading causing audio distortion and the signal fading below the noise level are the objectionable characteristics of fading on modern design receivers. The AVC circuits in the better designed modern receivers in general maintain the audio output sufficiently constant to be satisfactory during most fading.

Objectionable interference from another broadcast station [8] is the degree of interference produced when, at a specified field intensity contour with respect to the desired station, the field intensity of an undesired station (or the root-sum-square value of field intensities of two or more stations on the same frequency) exceeds for ten (10) percent or more of the time the values set forth in these standards.

With respect to the root-sum-square values of interfering field intensities referred to herein, it shall be understood to apply in determining the interference between existing stations.[9] It is not considered that increased objectionable interference is caused when (in the case where interference is predominantly from a single station) a signal from another station is added which does not have an intensity greater than 70 percent of the value of the highest signal already causing interference. In case such highest value of signal cannot be determined separately then the maximum value of any signal that can be added without considering that an increase in objectionable interference results, should be determined as follows: For two interfering signals of approximately the same value the signal added should not exceed 85 percent of the computed value of a single signal from the estimated or measured RSS value. For more than two interfering signals of approximately the same value, the added signal should not exceed the value of a single signal computed from the RSS value. This formula should be used to compute the value of the single signal,

$$E=\sqrt{\frac{F^2}{N}}$$

where E is the value of a single signal.

F is RSS field intensity as measured by the usual field intensity meter.

N is the number of interfering signals of approximately the same value.

Objectionable interference from a station on the same channel shall be considered to exist to a station when, at the field intensity contour specified in Table IV with respect to the class to which the station belongs, the field intensity of an interfering station (or the root-sum-square value of the field intensities of two or more interfering stations) operating on the same channel, exceeds for ten (10) percent or more of the time the value of the permissible interfering signal set forth opposite such class in Table IV.

[8] See footnote 6.

[9] In computing interference to any station only the RSS value of all signals which are greater than 70 percent of the highest signal shall be considered.

Objectionable interference from a station on an adjacent channel shall be considered to exist to a station when, at the normally protected contour of a desired station, the field intensity of the ground wave of an undesired station operating on an adjacent channel (or the root-sum-square value of the field intensities of two or more such undesired stations operating on the same adjacent channel) exceeds a value specified in Table V.

For the purpose of calculating the presence and the degree of objectionable interference, stations of the several classes shall be assumed, in the absence of actual measurements or data on the design of the antenna system, to produce effective fields, for 1 kilowatt of input power to the antenna, as follows:

TABLE III

Class of station:	*Effective field*
I	225 mv/m
II and III	175 mv/m
IV	150 mv/m

In case a directional antenna is employed, the interfering signal of a broadcasting station will vary in different directions, being greater than the above values in certain directions and less in others, depending upon the design and adjustment of the directional antenna system. To determine the interference in any direction, in the absence of actual interference measurements, the horizontal and vertical field intensity patterns of the directional antenna must be calculated and compared with the appropriate vectors in the horizontal or vertical patterns of a nondirectional antenna having the same effective field. Thus the interfering signal toward any other station can be expressed in terms of kilowatts. This rating in kilowatts shall be applied in the use of mileage separation tables or in computing interference from the propagation curves.[10]

The existence or absence of objectionable interference from stations on the same or adjacent channels shall be determined by one of the following methods:

(*a*) By actual measurements made according to the method hereafter described;

or, in the absence of such measurements:

(*b*) By reference to the propagation curves in Figure 1 and Appendix I, or

(*c*) By reference to the distance tables set forth in Tables VI, VII, and VIII.

[10] See Annex II for further discussion and solution of a typical directional antenna case.

The existence or absence of objectionable interference may be proved by field intensity measurements or recordings made with suitable apparatus, duly calibrated. Such field intensity measurements of sky wave shall be made for a period of time not less than 10 days and an adequate check shall be made on the sky wave signal of other stations to determine the general conditions of propagation while such measurements are taken.[11]

In computing the distance to the 50 percent sky wave field intensity contour of a Class I station of a given power, and also in computing the 10 percent sky wave field intensity of an alleged interfering station, of any class and given power, at a specified distance, use shall be made of the appropriate graphs set forth in Figure 1 entitled "Average sky wave field intensity" (corresponding to the second hour after sunset at the recording station). The curves are drawn for an effective field of 100 millivolts per meter at 1 mile.

The distance to any specified ground wave field intensity contour may be determined from appropriate ground wave curves plotted for the frequency under consideration and the conductivity and dielectric constant of the earth between the station and desired contour. The frequency and the conductivity of the earth must be considered in every case and where the distance is great, due allowance must be made for loss due to curvature of the earth. Figure 2 entitled "Ground wave field intensity," drawn for a frequency of 1000 kc., conductivity of 10^{-13}, dielectric constant 15, and an effective field of 100 millivolts per meter at 1 mile, may be employed when applicable.

Table VI gives the required day separation in miles between broadcast stations on the same channel. Table VII gives the required separation in miles between broadcast stations on adjacent channels during both daytime and nighttime. Table VIII gives the required night separation in miles between broadcast stations operating on the same channel. The assumed conditions of operation are given on the first page of the tables.

The tables are based upon the use of nondirective antennas but, in case a directive antenna is employed at a particular station, it will be necessary to consider the radiation distribution of the directional antenna involved and to modify the mileage separation accordingly.[12] [13]

[11] See Annex III for detailed requirements and also section on "Field Intensity Measurements in Allocation."

[12] See Annex II for method of modification.

[13] The Commission will not authorize a directive antenna for a Class IV station assigned a local channel.

TABLE IV.—*Protected service contours and permissible interference signals for broadcast stations*

Class of station	Class of channel used	Permissible power	Signal intensity contour of area protected from objectionable interference [1]		Permissible interfering signal on same channel [2]	
			Day [3]	Night	Day [3]	Night [4]
Ia	Clear	50 kw	SC 100 uv/m AC 500 uv/m	Not duplicated	5 uv/m	Not duplicated.
Ib	Clear	10 kw. to 50 kw	SC 100 uv/m AC 500 uv/m	500 uv/m (50% sky wave).	5 uv/m	25 uv/m
II	Clear	0.25 kw. to 50 kw	500 uv/m	2500 uv/m [5] (ground wave).	25 uv/m	125 uv/m [5]
III-A	Regional	1 kw. to 5 kw	500 uv/m	2500 uv/m (ground wave).	25 uv/m	125 uv/m
III-B	Regional	0.5 to 1 kw. night and 5 kw. day.	500 uv/m	4000 uv/m (ground wave).	25 uv/m	200 uv/m
IV	Local [6]	0.1 kw. to 0.25 kw	500 uv/m	4000 uv/m (ground wave).	25 uv/m	200 uv/m

[1] When it is shown that primary service is rendered by any of the above classes of stations, beyond the normally protected contour, and when primary service to approximately 90 percent of the population (population served with adequate signal) of the area between the normally protected contour and the contour to which such station actually serves, is not supplied by any other station or stations, the contour to which protection may be afforded in such cases will be determined from the individual merits of the case under consideration. When a station is already limited by interference from other stations to a contour of higher value than that normally protected for its class, this contour shall be the established standard for such station with respect to interference from all other stations.
[2] For adjacent channels see Table V.
[3] Ground wave.
[4] Sky wave field intensity for 10 percent or more of the time.
[5] These values are with respect to interference from all stations except Class Ib, which stations may cause interference to a field intensity contour of higher value. However, it is recommended that Class II stations be so located that the interference received from Class Ib stations will not exceed these values. If the Class II stations are limited by Class Ib stations to higher values, then such values shall be the established standard with respect to protection from all other stations.
[6] Class IV stations may also be assigned to regional channels according to section 3.29.

SC=Same channel.
AC=Adjacent channel.

The night separation tables for stations on the same frequency are computed from the sky wave curve given in Figure 1. These curves are based on extensive measurements of the sky wave produced by broadcasting stations and shall be considered as accurate in all cases unless proof to the contrary is supplied. Such proof must be based on field intensity measurements taken in accordance with requirements set out in Annex III and must show what condition prevails that causes the signal to depart from the average.

The mileage separation tables for the same channel during daytime and for adjacent channels day and night are computed from the ground wave curves in Figure 2. These tables apply only in case the frequency is 1000 kc. and the assumed soil conductivity and dielectric constant prevail. Since these values vary in every case, the tables for daytime and adjacent channel separation cannot be used except as a general guide. In any case under consideration an estimate of the mileage separation required may be made from the operating frequency and known or assumed soil conditions.[14]

[14] See Annex I for a determination of interference from ground waves when actual measurements are not available.

TABLE V.—*Adjacent channel interference*

Channel separation between desired and undesired stations:	Maximum ground wave field intensity of undesired station
10 kc	0.25 mv/m
20 kc	5.0 mv/m
30 kc	25.0 mv/m

The undesired ground wave signal shall be determined at or within the 0.5 mv/m ground wave contour of the desired station. These values apply to all classes of stations both day and night and are based on ground waves which hold for an effective power up to 50 kw. Above this effective power, when an interfering sky wave signal for 10 percent or more of the time exceeds 5 times the desired signal 10 kc. removed in frequency (or undesired exceeds 25 times the desired signal 20 kc. removed in frequency), interference will be produced. This may result from the use of a directional antenna and in such cases the interference shall be determined from the 10 percent sky wave of an interfering station to the normally protected ground wave or to a sky wave of a desired station, on the basis of a ratio of 1 to 5 (or 1 to 25 for 20 kc.) for desired signal to the undesired sky wave signal for 10 percent or more of the time.

The mileages given in Table VII are based on ground waves only and do not apply for night operation where the 10 percent sky wave of an undesired station exceeds 5 times (or 25 times for 20 kc.) the normally protected field intensity of a desired station.

MILEAGE-SEPARATION TABLES

The required mileage separations between broadcasting stations as tabulated below are based upon the following conditions:

(1) The use of nondirectional antennas in the horizontal plane and the vertical pattern of a 0.311 wave-length antenna.

(2) Effective field in mv/m at 1 mile for 1 kilowatt.

Class I—225 mv/m
Class II and III—175 mv/m
Class IV—150 mv/m

(3) Frequency, 1000 kc.
(4) Soil conductivity, $s=10^{-13}$.
(5) Soil dielectric constant, $e=15$.
(6) Ground-wave transmission as shown on chart in Figure 2.
(7) Sky-wave transmission as shown on chart in Figure 1.
(8) Protection to service areas as shown in Table IV.

(9) Ratio of desired to undesired signal:

Channel separation:	*Ratio of desired to undesired*
Same frequency	20:1 ground wave or 10% sky wave.
Synchronized carriers	4:1.[1]
10 kc	2:1 ground wave.[2] 1:5 sky wave.
20 kc	1:10 ground wave. 1:25 sky wave.
30 kc	1:50.
40 kc. and above	No restriction.[3]

[1] Two stations are considered to be operated synchronously when the carriers are maintained within one-fifth of a cycle per second of each other, either automatically or manually and they transmit the identical program. While observations have been made on several synchronized stations, no definite standards as to ratio of desired carrier to undesired carriers have been established, inasmuch as the methods of operations have not been standardized and results vary appreciably. From the observations it would appear that for most types of synchronous operation a ratio of about 4 to 1 between desired and undesired carriers is necessary to avoid distortion. This ratio holds only when the audio modulation is in sufficiently close time phase to avoid echo effects. In computing the interference in the primary service areas between the ground waves of two synchronously operated stations the ratio of 4 to 1 should be used. No complete information is available as to the required ratio between sky waves; however, it would appear that a ratio less than 4 to 1 can be tolerated without objectionable interference, first because the standard of acceptance of a signal as satisfactory is lower for secondary service, and second, because several waves with random relative phases usually make up each sky wave and the combination of two such synchronized waves generally causes less distortion. Synchronous operation of two or more stations may enable an extension of the coverage and service on a channel without any materially increased interference range beyond that one station would produce.

[2] This ratio of desired to undesired signal is not based on the characteristics of the average receiver but upon what the characteristics of an ideal receiver would be which would permit high-fidelity reception of a station in the high-fidelity primary service area (primary area where no interference would be caused to a receiver responding faithfully to a band 15 kc. wide or 7.5 kc. audio response). The ratio of desired to undesired (1 to 5 and 1 to 25) for interference from a sky wave 10 and 20 kc. removed in frequency respectively is based on the characteristics of most good receivers placed in operation since 1936 and operated as most listeners adjust variable selectivity receivers where the signal is one millivolt or less.

[3] Two stations, one with a frequency twice that of the other, should not be assigned in the same primary service area unless special precautions are taken to avoid interference from the second harmonic of the lower frequency.

(10) Service and interference radii—night:

Class—Power and field at mile	Service radii			Interference radii		
				200 uv/m 10% S. W.	125 uv/m 10% S. W.	25 uv/m 10% S. W.
Class IV						
100 w.: 47.5 mv/m		8.5		G. W.	190	----------
250 w.: 75 mv/m		11.5		G. W.	370	----------
Class III						
500 w.: 124 mv/m	----	15		380	590	----------
1000 w.: 175 mv/m	25	20		535	710	----------
5 kw.: 392 mv/m	39	----------		840	1000	----------
Class II						
250 w.: 87.5 mv/m	17	----------		210	440	1040
500 w.: 124 mv/m	21	----------		380	590	1170
1000 w.: 175 mv/m	25	----------		535	710	1325
5 kw.: 392 mv/m	39	----------		840	1000	1840
10 kw.: 554 mv/m	42	----------		960	1125	2120
25 kw.: 875 mv/m	56	----------		1120	1320	2570
50 kw.: 1238 mv/m	65	----------		1265	1510	----------
Class I						
10 kw.: 712 mv/m			345	1045	1225	2345
25 kw.: 1125 mv/m			575	1225	1460	----------
50 kw.: 1592 mv/m			715	1395	1685	----------

G. W. = Ground wave. S. W. = Sky wave.

TABLE VI.—*Required day separation in miles between broadcast stations on the same channel* [1]

Class and power	Class IV		Classes II and III							Class I		
	100 w.	250 w.	0.25 kw.	0.5 kw.	1 kw.	5 kw.	10 kw.	25 kw.	50 kw.	10 kw.	25 kw.	50 kw.
Class IV												
100 w.	143	165	172	192	213	265	285	310	335	390	417	437
250 w.	165	173	180	200	221	273	293	318	343	415	442	462
Classes II and III												
0.25 kw	172	180	183	203	224	276	296	321	346	418	446	465
0.5 kw	192	200	203	210	231	283	303	328	353	446	473	493
1 kw	213	221	224	231	239	291	311	336	361	467	494	514
5 kw	265	273	276	283	291	313	333	358	383	520	547	567
10 kw	285	293	296	303	311	333	345	370	395	540	567	587
25 kw	310	318	321	328	336	358	370	389	414	565	592	612
50 kw	335	343	346	353	361	383	395	414	430	587	614	634
Class I												
10 kw	390	415	418	446	467	520	540	565	587	556	585	605
25 kw	417	442	446	473	494	547	567	592	614	585	612	632
50 kw	437	462	465	493	514	567	587	612	634	605	632	652

[1] See discussion above before using in any specific case.

TABLE VII.—*Required day and night separation in miles between broadcast stations on adjacent channels* [1]

Class and power	Class IV						Classes II and III														
	0.1 kw.			0.25 kw.			0.25 kw.			0.5 kw.			1 kw.			5 kw.			10 kw.		
	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.
Class IV																					
0.1 kw	73	37	32	82	45	40	86	47	42	94	55	50	105	63	58	133	84	79	149	98	93
0.25 kw	82	45	40	90	48	41	94	50	43	102	58	51	113	66	59	141	87	80	157	101	94
Classes II and III																					
0.25 kw	86	47	42	94	50	43	96	51	43	104	59	51	115	67	59	143	88	80	159	102	94
0.5 kw	94	55	50	102	58	51	104	59	51	112	62	52	123	70	60	151	91	81	167	105	95
1 kw	105	63	58	113	66	59	115	67	59	123	70	60	131	73	62	159	94	83	175	108	97
5 kw	133	84	79	141	87	80	143	88	80	151	91	81	159	94	83	180	104	87	196	118	101
10 kw	149	98	93	157	101	94	159	102	94	167	105	95	175	108	97	196	118	101	210	123	104
25 kw	172	115	110	180	118	111	182	119	111	190	122	112	198	125	114	219	135	118	233	140	121
50 kw	190	131	123	198	134	127	200	135	127	208	138	128	216	141	130	237	151	134	251	156	137
Class I																					
10 kw	162	107	102	170	110	103	172	111	103	180	114	104	188	117	106	209	127	110	223	132	113
25 kw	183	126	121	191	129	122	193	130	122	201	133	123	209	136	125	230	146	129	244	151	132
50 kw	203	144	139	211	147	140	213	148	140	221	151	141	229	154	143	250	164	147	264	169	150

[1] See discussion above before using in any specific case

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Class and power	Class II						Class I								
	25 kw.			50 kw.			10 kw.			25 kw.			50 kw.		
	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.	10 kc.	20 kc.	30 kc.
Class IV															
0.1 kw	172	115	110	190	131	126	162	107	102	183	126	121	203	144	139
0.25 kw	180	118	111	198	134	127	170	110	103	191	129	122	211	147	140
Classes II and III															
0.25 kw	182	119	111	200	135	127	172	111	103	193	130	122	213	148	140
0.5 kw	190	122	112	208	138	128	180	114	104	201	133	123	221	151	141
1 kw	198	125	114	216	141	130	188	117	106	209	136	125	229	154	143
5 kw	219	135	118	237	151	134	209	127	110	230	146	129	250	164	147
10 kw	233	140	121	251	156	137	223	132	113	244	151	132	264	169	150
25 kw	250	149	125	268	165	141	242	145	123	261	160	136	281	178	154
50 kw	268	165	141	284	172	145	260	161	139	279	163	144	297	185	158
Class I															
10 kw	242	145	123	260	161	139	232	137	115	253	156	134	273	174	152
25 kw	261	160	136	279	168	144	253	156	134	272	163	139	292	181	157
50 kw	281	178	154	297	185	158	273	174	152	292	181	157	310	190	161

Table VIII.—***Required night separation in miles between broadcast stations on the same channels***

The following tables indicate the mileage protection each class must give all other classes:

Table VIII–A

Class Ia should protect Class II stations as shown:

	Class II—All powers
Class Ia: 50 kw	Not duplicated at night

Table VIII–B

Class Ib should protect other Class Ib stations as shown below:

Class Ib	Class Ib		
	10 kw.	25 kw.	50 kw.
10 kw		3010	----
25 kw		([1])	([1])
50 kw		([1])	([1])

[1] Cannot be duplicated without directional antenna and then this table does not apply.

Table VIII–C

Class II should protect other classes as shown below—nondirectional antenna.

Class II	Class II							Class Ib		
	0.25 kw.	0.5 kw.	1 kw.	5 kw.	10 kw.	25 kw.	50 kw.	10 kw.	25 kw.	50 kw.
0.25 kw	455	[1] 460	465	480	485	495	505	1, 385	1, 615	1, 755
0.5 kw	605	610	615	630	635	645	655	1, 515	1, 745	1, 885
1 kw	725	730	735	750	755	765	775	1, 670	1, 900	2, 040
5 kw	1, 015	1, 020	1, 025	1, 040	1, 045	1, 055	1, 065	2, 185	2, 415	2, 555
10 kw	1, 140	1, 145	1, 150	1, 165	1, 170	1, 180	1, 190	2, 465	2, 695	2, 835
25 kw	1, 335	1, 340	1, 345	1, 360	1, 365	1, 375	1, 385	2, 915	3, 145	--------
50 kw	1, 525	1, 530	1, 535	1, 550	1, 555	1, 565	1, 575	--------	--------	--------

[1] The mileages in the upper right-hand half of this section of this table do not provide for protection to the lower power Class II station. Thus, if a 0.25 kw Class II station operated 460 miles from a 0.5 kw. Class II station, it would receive interference to greater than the 2.5 mv/m ground wave contour unless the 0.5 kw. Class II station used an appropriate directional antenna.

TABLE VIII–D

Class III–A should protect other classes as shown below:

Class III–A	Class III–A		Class III–B	
	1 kw.	5 kw.	0.5 kw.	1 kw.
1 kw	735	750 [1] 1,025	550	555
5 kw	1,025	1,040	855	735 860

[1] Where double figures are given, the lower and larger figure is the mileage required to protect the station in the left-hand column to its normally protected contour.

TABLE VIII–E

Class III–B should protect other classes as shown below:

Class III–B	Class III–A		Class III–B	
	1 kw.	5 kw.	0.5 kw.	1 kw.
0.5 kw	615	630 [1] 855	395	400 550
1 kw	735	750 860	550	555

[1] Where double figures are given, the lower and larger figure is the mileage required to protect the station in the left-hand column to its normally protected contour.

TABLE VIII–F

Class IV should protect other classes as shown below:

Class IV	Class III–A		Class III–B		Class IV	
	1 kw.	5 kw.[1]	0.5 kw.	1 kw.	0.1 kw.	0.25 kw.
0.1 kw	[2] 300	[2] 300	(3)	(3)	(3)	(3)
0.25 kw	395	410	(3)	(3)	(3)	(3)

[1] Where double figures are given, the lower and larger figure is the mileage required to protect the station in the left-hand column to its normally protected contour.
[2] The distance based on the minimum practical values.
[3] Daytime separation determines.

TABLE VIII–G

Distance Class II stations should be from Class Ib stations to obtain recommended protection to Class II station (2.5 mv/m ground wave contour):

Class II[1]	Class Ib		
	10 kw.	25 kw.	50 kw.
0.25 kw	1240	1475	1700
0.5 kw	1245	1480	1705
1 kw	1250	1485	1710
5 kw	1265	1500	1725
10 kw	1265	1505	1730
25 kw	1280	1515	1740
50 kw	1290	1525	1750

[1] The class II station should use a directional antenna to protect dominant station or stations with these separations.

Table VIII–H

Distance Class IV stations should be from Class III–A and III–B stations to obtain recommended protection to Class IV stations (4.0 mv/m ground wave contour):

Class IV	Class III–A or III–B		
	0.5 kw.	1.0 kw.	5.0 kw.
0.1 kw	388	543	850
0.25 kw	391	546	852

Annex I

INTERFERENCE FROM GROUND WAVE SIGNALS

Interference that may be caused by a proposed assignment or an existing assignment during daytime should always be determined, when possible, by measurements on the frequency involved or on another frequency over the same terrain and by means of the curves in Figure 4, interpolate for the desired frequency.

In determining the interference from field intensity measurements, two general steps are necessary: First, establish the outer boundary of the protected service area of the desired station in the direction of the station that may cause interference with it. Second, at this boundary, measure the interfering signal from the undesired station. The ratio of the desired to the undesired signal given on page twelve should be applied to the measured signals and if the required ratio is observed, then no interference is contemplated. The effective field of the antenna in the pertinent directions of the stations must be established and all measurements must be made in accordance with the section on "Field Intensity Measurements in Allocation."

In all cases where measurements taken in accordance with the requirements are not available,[15] the ground wave intensity must be determined by means of the conductivity of the terrain and the ground wave curves of field intensity versus distance. The conductivity of a given terrain may be determined by measurements of any broadcast signal traversing the terrain involved, or in case such measurements are not available, then conductivity must be taken from the map of ground conductivity in the United States, Figure 3. This map shows the conductivity throughout the entire United States by general areas of reasonably uniform conductivity. In areas of limited size, or over a particular path, the conductivity may vary

[15] The Commission will *not* authorize operation on a proposed assignment for the purpose of making measurements.

widely from the values given. This map is to be used only when accurate and acceptable measurements have not been made.

If an interfering signal traverses areas for which more than one conductivity is given by the map, then conductivity for two-thirds the distance should be taken and in case this involves more than one value, then the highest predominating value should be assumed to prevail. Where the conductivity along a given path varies over wide limits, the previous method may give erroneous results, in which case the signal at any given point, for a given value of field intensity at 1 mile from the antenna in the direction concerned may be determined by determining and adding the attenuation in decibels of each section of the intervening path.[16]

Figure 4 gives the ground wave field intensity curves with field intensity plotted against distance for various values of conductivity and by blocks of frequencies. To cover the standard broadcast band some 20 graphs in all are required and are attached as Appendix I. In all cases the curves are plotted on the basis of 100 mv/m effective field at a mile. An example of determining the interference by this method follows:

It is desired to find the interference that a 5 kw. Class III station on 990 kc. may cause to a 1 kw. Class III station on 1000 kc. The stations are separated by 130 miles. It is assumed that both stations use nondirectional antennas[17] having such height as to produce an effective field for 1 kw. of 175 mv/m.[18] From Figure 3, the conductivity at each station and intervening terrain is determined as 6×10^{-14}. The protection to Class III during daytime is to the 500 uv/m contour. The distance to the 500 uv/m ground wave contour of the 1 kw. station is determined by the use of the curves in Figure 4 as being 39.5 miles. Since these curves are plotted for 100 mv/m at a mile, to find the distance to the 500 uv/m contour of the 1 kw. station, it is necessary to determine the distance on the appropriate curve to the

$$\left(\frac{100\times500}{175}=285\right)$$

[16] For example, assuming three values of conductivity prevail such that for the frequency and distances concerned the signal is attenuated over the given conductivities 6, 8, and 14 db. respectively or a total of 28 db. over the entire path, then the signal at the point concerned for 100 mv/m at 1 mile would be $\frac{100}{25.119 \text{ (voltage ratio for 28 db.)}}$ or 3.98 mv/m.

[17] See Annex II in case of use of directional antennas.

[18] In all cases the effective field should be established from the dimensions of the radiating system. The value assumed here is in accordance with section 3.45 and the Standards of Good Engineering Practice promulgated pursuant thereto.

285 uv/m contour. Thus, the estimated radius of the service area for the desired station is established as 39.5 miles. Subtract this distance from the distance between the two stations, leaving 90.5 miles for the interfering signal to travel. Again from the appropriate curve in Figure 4 it is found that the signal from the 5 kw. station at this distance would be 158 uv/m. Since the stations are separated by 10 kc., the undesired signal at that point can have a value up to 250 uv/m without interference, but if the interference signal had been found to be greater than this value, then interference would have been determined. For other channel separations the appropriate ratio of desired to undesired signal would have been used. This principle holds for all cases except where a sky wave signal 10 percent or more of the time from the undesired station is in excess of 5 times the desired signal when the frequency separation is 10 kc. or 25 times when the frequency separation is 20 kc. In this case the interference must be estimated on the basis of the sky wave interference and the propagation curve in Figure 1 used to determine the interfering signals rather than Figure 4 for the ground wave signals.

Annex II

COMPUTATION ON INTERFERING SIGNAL FROM A DIRECTIONAL ANTENNA

In case of an antenna directional in the horizontal plane, the ground wave interference can be readily computed from the calculated horizontal pattern by determining the vectors toward the service area of the station to be protected and apply these values to the ground wave curves set out in Annex I.

In case of determining sky wave interference from an antenna with a vertical pattern different from that on which Figure 1 is predicated (the basis of the night mileage separation tables), it is necessary to compare the appropriate vectors in the vertical plane.

The sky wave curves entitled "Average Sky Wave Field Intensity" (corresponding to the second hour after sunset at the recording station) as shown in Figure 1 are based on antenna systems having height of 0.311 wave length (112°) and producing a vertical pattern as shown in Figure 5. A nondirectional antenna system, as well as a directional antenna system having vertical patterns other than essentially the same as shown, must be converted to the pattern of a 0.311 wave length antenna having the same field intensity at the critical angle as does the pattern of the antenna involved. Example:

Figure 6 is a graph entitled "Variation with Distance of Two Important Parameters in the Theory of Sky Wave Propagation." The curve for θ showing the angle above the horizon at which radiation occurs plotted against distance, must be used for this purpose. For instance, assuming the station with which interference may be expected is located at a distance of 450 miles from a proposed station, the critical angle of radiation as determined from this curve is approximately 15°. Therefore, if the vertical pattern of the proposed station in the direction of the other station is such that at 15° above the horizon the radiation is 1.3 times that from an antenna having a vertical pattern as shown in Figure 5 and producing the same field intensity at 1 mile in the horizontal plane, the interfering signal would be 1.3 times that determined from Figure 1 for an antenna having the same field intensity in the horizontal plane. That is, if the field intensity in the horizontal plane of the proposed station is 124 mv/m the interfering field intensity exceeded 10 percent of the time at the other station would be

$$140 \times 1.30 \times \frac{124}{100} \text{ or } 225 \text{ uv/m}$$

and would cause interference to the 4.5 mv/m ground wave contour of the existing station.

When the distance is large, more than one reflection may be involved and due consideration must be given each appropriate vector in the vertical pattern, as well as the constants of the earth where reflection takes place between the transmitting station and the service area to which interference may be caused.

Annex III

INTERFERENCE FROM SKY WAVE SIGNALS

Set out below is the detailed method of making measurements of the sky wave signals to determine an interfering signal for 10 percent of the time.

The signal must be received on an acceptable field intensity meter duly calibrated and recorded on a continuous recording meter of suitable accuracy and sensitivity. Measurements at distances less than 350 miles from the station should be made with a vertical antenna only. At greater distances either a vertical antenna, loop, or other suitable antenna may be used. Two complete recording units are required so that two signals can be recorded simultaneously.

A monitor station on which interference free measurements can be made must be selected for simultaneous recordings. This station should be in the general direction of the principal station to be recorded. Preferably, such monitor station should have known antenna characteristics and the conductivity of the surrounding terrain should be known. The transmitters should be located in the same general area and the frequencies of the stations as close as possible. The reception of the two stations should be on the same antenna or on antennas in the same area so that both are influenced by the same surrounding objects.

Recordings may be made on both stations from sundown over the entire path until midnight at the recording station. These records should be analyzed for each night and for the entire period of recording and graphs drawn which show field intensity versus percent time. The 10-percent signal determined for the principal station for the entire period must be modified by a correction factor determined from a comparison of the 10-percent signal from the monitor station to the value determined from the 10-percent curve of Figure 1 for the same distance, power, and pertinent antenna characteristic. Thus, if the 10-percent signal from the Figure 1 10-percent curve is 500 uv/m and the measured 10-percent signal on the monitor station 350 uv/m, then the 10-percent signal from the principal station should be multiplied by the factor of 500/350 or 1.43 to determine the interfering signal. Recordings for at least 10 nights are required. If it is not practical to follow this procedure, due to interference to the reception of the principal station recorded, the following procedure is required:

Record the monitor station and the principal station during the earliest hour that the principal station can be recorded. The measurements must be for at least 1 continuous hour each night and preferably not less than 2 hours each night. In all cases the monitor station must be recorded simultaneously. These measurements must be taken for at least 10 nights. Establish the 10 percent value of the fields during the period when both are measured. The 10 percent value of the field for the principal station must be corrected in the following manner:

Compare the 10 percent value of the signal for the monitor station with the 10 percent value determined from Figure 1 for the same distance reduced to the same power for comparable radiation at the appropriate angle. Thus, if the 10-percent signal from the Figure 1 10-percent curve is 500 uv/m and the measured 10-percent signal on the monitor station is 400 uv/m then the 10-percent signal from the principal station should be multiplied by the correction factor of 500/400 or 1.25. The value obtained in this way is to be considered the interference value of signals for use in all allocation problems.

When it is claimed that the propagation over the path involved is normally less than the average, measurements must be made on two or more other stations of different paths for at least 30 days and the signals of all stations involved recorded in the above manner to establish that propagation conditions in general were normal and that the path under consideration was low as claimed due to some natural conditions. A full explanation of the theory or practical findings must be made.

In all other cases where the signal is substantially greater or less than the average determined from Figure 1, complete information must be supplied as to why the signal measured has departed from the average. If the reason this condition is based on the location of the antenna, its characteristics, the conductivity of the surrounding area or other natural limitations, a full explanation of the nature and character of such conditions must be supplied and also information as to whether the licensee could, by moving its station or by making other changes within its control, alter the situation so that the abnormal condition of propagation would no longer exist.

The interference signal determined by the above methods should be used to determine interference to a station in the same manner as the ground wave signals were employed, as set out in Annex I. These methods of measurement should be used to determine skyway service signal for 50 percent of the time.

2. FIELD INTENSITY MEASUREMENTS IN ALLOCATION

A. Field Intensity Measurements to Establish Effective Field Intensity at 1 Mile

Section 3.45 provides that certain minimum field intensities are acceptable in lieu of the required minimum physical vertical heights of the antennas proper. Also in other allocation problems, it is necessary to determine the effective field at 1 mile. The following requirements shall govern the taking and submission of data on the field intensity produced:

Beginning as near to the antenna as possible without including the induction field and to provide for the fact that a broadcast antenna not being a point source of radiation (not less than one wave length or 5 times the vertical height in the case of a single element, i. e., nondirectional antenna or 10 times the spacing between the elements of a directional antenna), measurements shall be made on eight or more radials, at intervals of approximately one-tenth mile up to 2 miles from the antenna, at intervals of approximately one-half mile from 2 miles to 6 miles from the antenna, at intervals of approximately 2 miles from 6 miles to 15 or 20 miles from the antenna, and a few additional measurements if needed at greater distances from the antenna. Where the antenna is rurally located and unobstructed measurements can be made, there shall be as many as 18 or 20 measurements on each radial. However, where the antenna is located in a city where unobstructed measurements are difficult to make, measurements shall be made on each radial at as many unobstructed locations as possible, even though the intervals are considerably less than stated above, particularly within 2 miles of the antenna. In cases where it is not possible to obtain accurate measurements at the closer distances (even out to 5 or 6 miles due to the character of the intervening terrain), the measurements at greater distances should be made at closer intervals.[19]

These data should be plotted for each radial in accordance with either of the two methods set forth below:

(1) Using log-log coordinate paper, plot field intensities as ordinate and distance as abscissa.

(2) Using semi-log coordinate paper, plot field intensity times distance as ordinate on the log scale and distance as abscissa on the linear scale.

However, regardless of which of these methods is employed, the proper curve to be drawn through the points plotted shall be determined by comparison with theoretical curves as follows: Plot theoretical curves (see paper by Mr. K. A. Norton, October 1936, Proc. I. R. E.) for several values of conductivities and dielectric constants, approximating the conductivity and dielectric constants indicated by the measurements on another sheet of the same coordinate paper. Place this sheet over the sheet on which the actual points have been plotted, hold to the light if necessary and adjust until the curve most closely matching the points is found. This curve should then be drawn on the sheet on which the points were plotted, together with the inverse distance curve corresponding to that curve. The field at 1 mile for the radial concerned shall be the ordinate on the inverse distance curve at 1 mile.

When all radials have been analyzed in this manner, a curve shall be plotted on polar coordinate paper from the fields obtained, which gives the inverse distance field pattern at 1 mile. The radius of a circle, the area of which is equal to the area bounded by this pattern, is the effective field. (See section 3.16.)

While making the field intensity survey, the output power of the station shall be maintained at the licensed power as determined by the direct method. To do this it is necessary to determine accurately the total antenna resistance (the resistance variation method, the substitution method or bridge method is acceptable) and to measure the antenna current by means of an ammeter of acceptable accuracy.[20]

[19] It is suggested that "wave tilt" measurements may be made to determine and compare locations for taking field intensity measurements, particularly to determine that there are no abrupt changes in ground conductivity or that reflected waves are not causing abnormal intensities.

[20] See section 3.54 and "Further Requirements for Direct Measurement of Power" and "Indicating Instruments Pursuant to Section 3.58."

Complete data taken in conjunction with the field intensity measurements shall be submitted to the Commission in affidavit form including the following:

(1) Tabulation by number of each point of measurement to agree with the map required in (2) below and the field intensity meter reading, the attenuation constant, the field intensity (*E*), the distance from the antenna (*D*) and the product of the field intensity and distance (*ED*) (if data for each radial are plotted on semi-logarithmic paper, see above) for each point of measurement.

(2) Map showing each point of measurement numbered to agree with tabulation required above.

(3) Description of method used to take field intensity measurements.

(4) The family of theoretical curves used in determining the curve for each radial properly identified by conductivity and dielectric constants.

(5) The curves drawn for each radial and the field intensity pattern (see subsection B 5 *a*, *b*, and *c*).

(6) Antenna resistance measurement:

a. Antenna resistance at operating frequency.

b. Description of method employed.

c. Tabulation of complete data.

d. Curve showing antenna resistance versus frequency.

(7) Antenna current or currents maintained during field intensity measurements.

(8) Description, accuracy, date, and by whom each instrument was last calibrated.

(9) Name, address, and qualifications of the engineer making the measurements.

(10) Any other pertinent information.

B. Field Intensity Measurements to Establish Performance of Directional Antennas

Section 3.33 (*b*) requires that proof of performance of directional antenna systems be submitted before any operation during the regular broadcast day may be permitted. These data shall be taken upon proper request and authorization therefor during the experimental period, and shall show that the pattern obtained is essentially the same as that predicted by the application and required by terms of the authorization, and that any specific requirements set out are fully met.

To establish this performance, measurements shall be made in accordance with the preceding section A along sufficient number of radials to establish the effective field from the antenna system. In the case of a relatively simple directional antenna pattern, approximately eight radials in addition to the radials in the directions the field intensity values are specified by the authorization are sufficient. However, when more complicated patterns are involved, that is, patterns having several or sharp lobes or nulls, measurements shall be taken along as many additional radials as necessary to definitely establish the pattern.

In cases where the authorization requires a showing that actual field intensities of specified values be obtained in the various portions of the service area, sufficient measurements throughout these areas shall be made to show that at least the values specified are obtained. (See paragraph 2d of this section.)

In either of the above cases the following information shall be submitted in triplicate, even though such information was submitted with the original application:

(1) Complete description of antenna array.

a. Number of elements.

b. Manufacturer's name and type of each element (i. e., guyed or self-supporting, triangular or square, uniform cross-section or tapered, etc.).

c. If top loaded, give details.

d. Height of vertical lead of each element in feet (height above base insulator or base, if grounded).

e. Over-all height in feet of each element above ground level.

f. Over-all height in feet of each element above mean sea level.

g. Orientation of array with respect to true north and time (specify degrees leading or lagging) and space phasing of elements. (Space phasing should be given in feet as well as in degrees.)

h. Details of ground system for each element (length and number of radials, dimensions of ground screen, if used, and depth buried).

i. Current in each element (at point where antenna ammeter is located) and current and resistance at point of common input to the antenna system.[21]

j. Schematic sketch and description of method of feeding power to elements, including phasing and coupling equipment and locations of antenna ammeters (both regular, point of common input, and remote) in the circuits.

k. If not fully described above, give complete details and sketches if needed.

l. Full description of painting and lighting installed on each element.

[21] See "Further Requirements for Direct Measurement of Power" and "Construction, General Operation, and Safety of Life Requirements."

m. If phase monitor is employed, state phase readings (specifying whether leading or lagging) and ratio of current indications for each element.[22]

(2) Horizontal field intensity patterns for each power involved showing:

a. Directional field intensity at 1 mile and effective field intensity from the antenna determined from the field intensity measurements as set forth above.

b. Direction true north shall be shown at zero azimuth.

c. Direction of each station or city specified in the instrument of authorization in which direction a limiting field was specified and the actual field intensity obtained in each of such directions (all directions shall be determined by accurate calculation or from Lambert Conformal Conic Projection Map such as United States Coast and Geodetic Survey Map No. 3060a, or map of equal accuracy, and all distances shall be determined by accurate calculation or from United States Albers Equal Area Projection Map, Scale $\frac{1}{2,500,000}$ or map of equal accuracy. These may be obtained from the United States Coast and Geodetic Survey and from the United States Department of Interior, Geological Survey, for the sums of 40 cents and $1, respectively).

d. Actual field intensity contours for 25, 10, and 5 mv/m and any other contours specified by the instrument of authorization on a map having the largest practical scale. These contours need not be shown for distances over 15 miles from the antenna except that the field intensity contours on the far sides of the business and residential areas of the city in which the main studio is located shall be shown. This does not waive the requirement for measurements at greater distance under A above.

(3) Complete tabulation of all data used in plotting the above patterns.

(4) Any other pertinent information.

(5) Plotting of field intensity patterns:

a. All patterns shall be plotted on standard letter-size polar coordinate paper (main engraving approximately 7″ x 10″).

b. All patterns shall be plotted to the largest scale possible on the paper specified in (*a*) above, using divisions and subdivisions having values of 1, 2, 2.5, or 5 times 10^x. (No other values shall be used.)

c. All values of field intensity less than 10 percent of the r. m. s. field intensity of the pattern shall be shown on an enlarged scale in accordance with (*a* and *b*) above.

[22] See "Indicating Instruments Pursuant to Section 3.58."

As a check on the shape of the field intensity pattern obtained in accordance with the above, it is suggested that measurements be taken on each of the radials at approximately 1 mile from the antenna system for operation, both directional and nondirectional, and the ratios of these values plotted on polar coordinate paper in accordance with the above specifications.

C. Measurement of the Field Intensity of Broadcast Stations for Presentation in Support of Applications or Evidence at Hearings Before the Commission

Section 3.24 requires that among other things an application for a new standard broadcast station or increase in facilities of an existing station make a satisfactory showing that objectionable interference will not be caused to an existing station or stations.

In the determination of such interference in accordance with section 3.28, actual measurements will take precedence over theoretical values provided such measurements are properly taken and presented.

When measurements of either ground wave signal intensity or sky wave signal intensity are presented in evidence, they shall be supported by a field intensity survey of the station observed, which survey should be sufficiently complete in accordance with sections A and B above to determine the field at 1 mile in the pertinent directions for that station.

When measurements are made on sky wave signal intensity (either service or interference) they shall be graphic recordings as follows:

(1) Recordings shall be made on 10 or more nights for sufficient periods each night to obtain reasonable average values.[23]

(2) Observations shall be made on other stations to determine whether sky wave transmission conditions are normal or not.

(3) Scales on the graphic paper shall be such as to permit easy reading of both time and field intensity, and calibration shall be clearly indicated.

(4) Pertinent notes, such as predominance of signal of a certain station, when recording composite signals shall be made on the recording.

(5) Full description shall be given the point where recordings were made (geographically as well as field intensity of the station to which interference is being determined).

(6) Full explanation of to what extent signals from other stations on the same channel affected the accuracy of the recordings and what steps, if any, were taken to eliminate or compensate for such signals.

[23] See Annex III in section "Engineering Standards of Allocation" for detailed requirements.

If the observed station is owned or controlled by the party on whose behalf the measurements are made, then, in addition to the above, detailed reports on the measurement of the antenna resistance and on the amount of power actually radiated (as determined by the direct method) during the course of the field intensity measurements shall be presented. The applicant (or participant) shall also furnish a complete description of the antenna and ground system in use at the transmitting station during the period of observations and a statement as to whether or not this is the identical equipment regularly used by the station.

When measurements of both the "desired" and "undesired" station are made in one area to determine the point where objectionable interference from ground wave signals occurs, several measurements of each station shall be made within a few miles of the point where the ratio of signals is that selected as the appropriate ratio for the determination of objectionable interference.

All information on the above, including description and accuracy of equipment used, when and by whom last calibrated, and the name and qualifications of the engineer making the measurements, when filed with an application, shall be in affidavit form. At the time of the hearing on applications involving such observations, the applicant should be prepared to present, as sworn testimony, complete data on the above.

3. DATA REQUIRED WITH APPLICATIONS INVOLVING DIRECTIONAL ANTENNA SYSTEMS

Section 3.33 (a) requires that an application for authority to install a directional antenna specify a definite site and that full details of the directional antenna are given with the application. Any application not complete in these details will be returned to the applicant as "defective" under section 1.72.

In order to comply with the above and to permit proper consideration of any application involving a directional antenna, the following shall be submitted in triplicate, properly verified by the engineer designing the antenna, with each such application:

(1) Name, address, and qualifications of the engineer.

(2) Complete description of the proposed antenna system.

a. Number of elements.

b. Type of each element [i. e., guyed or self-supporting, uniform cross section or tapered (specify base width), grounded or insulated, etc.].

c. If top loaded, give details.

d. Height of vertical lead of each element in feet (height above base insulator or base, if grounded).

e. Over-all height in feet of each element above ground level.

f. Over-all height in feet of each element above mean sea level.

g. Orientation of array with respect to true north and time phasing of fields from elements (specify degrees leading or lagging) and space phasing of elements (identifying elements). (Space phasing should be given in feet, as well as in degrees.)

h. Details of ground system for each element (length and number of radials, dimensions of ground screen, if used, and depth buried).

i. Ratio of fields from elements (identifying elements).

j. If not fully described above, give complete details and sketches if needed.

(3) Calculated horizontal field intensity patterns for each power involved showing:

a. Directional field intensity at 1 mile and effective field.

b. Direction true north shall be shown at zero azimuth.

c. Direction and distance to each existing station with which interference may be involved, operating either directional or nondirectional (all directions shall be determined by accurate calculation or from Lambert Conformal Conic Projection Map such as United States Coast and Geodetic Survey Map No. 3060a, or map of equal accuracy, and all distances shall be determined by accurate calculation or from United States Albers Equal Area Projection Map, scale $\frac{1}{2{,}500{,}000}$ or map of equal accuracy. These may be obtained from the United States Coast and Geodetic Survey and the United States Department of Interior, Geological Survey, for the sums of 40 cents and $1, respectively).

d. Calculated field intensity contours for 250, 25, and 5 mv/m and the population residing within each of such contours in addition to the information required by section 29 (*d*) of F. C. C. Form 301, on a map having the largest practical scale.

(4) Calculated vertical field intensity patterns (for nighttime power) in the direction of each minimum and the maximum and in the direction of each station with which nighttime interference may be involved, operating either directional or nondirectional for angles from 0° to 90° above the ground plane, based on the ground wave field intensity at 1 mile from the antenna for the direction involved.

(5) Data used in computing the above patterns including:

a. Formula used for calculating both horizontal and vertical patterns, and sample calculations. (Derivation of formula if other than standard is used.)

b. All assumptions made and basis therefor, including electrical height, current distribution and efficiency of each element, and ground conductivities.

c. Complete tabulation of calculation data used in plotting patterns, including data for determination of r. m. s. value of horizontal and directional patterns.

(6) Any other pertinent information.

(7) Plotting of field intensity patterns:

a. All patterns shall be plotted on standard letter-size polar coordinate paper (main engraving approximately 7″ x 10″).

b. All patterns shall be plotted to the largest scale possible on the paper specified in section (*a*) above using scale divisions and subdivisions having values of 1, 2, 2.5, or 5 times 10^x. (No other values shall be used.)

c. All values of field intensity less than 10 percent of the effective field intensity of the pattern shall be shown on an enlarged scale in accordance with (*a* and *b*) above.

d. In the event actual inverse distance field intensities expected to be determined in practice (that is, the values determined from actual measurements particularly in sharp nulls) are different from the above calculated values, the expected values as well as the calculated values shall be shown on both the full patterns and the enlarged sections.

4. LOCATIONS OF TRANSMITTERS OF STANDARD BROADCAST STATIONS

Section 3.24 (*e*) requires that the location of the transmitter shall comply with the requirements of good engineering practice. There are set out below the general requirements considered appropriate at this time. These standards will change as the art progresses and changes will be made in accordance with the best information available.

All applications for approval of transmitter sites for regular broadcast stations must be submitted on F. C. C. Form 304. In some cases the applicant may be required to submit additional information, including the results of a field intensity survey, particularly where there is any question as to whether the area can be served properly from the proposed location or where the population of the blanket area is too large.

F. C. C. Form 304 requires among other things that triplicate copies of the following be submitted:

(*a*) Map or maps having reasonable scales (not less than one-half inch per mile) clearly showing:

(1) Proposed location and present location if existing station;

(2) The character of the surrounding areas, particularly the retail business, wholesale business, manufacturing, residential, and unpopulated areas (by symbols, cross-hatching, colored crayons, or other means);

(3) The density and distribution of population;

(4) The heights of all tall buildings or other structures in the vicinity of the antenna, indicating their location and how marked for air navigation;

(5) The location of airports, airways, and other radio stations, including receiving stations, except broadcast or amateur;

(6) The terrain and types of soil.

(*b*) Aerial photograph or photographs taken of the proposed location of the antenna showing clearly the character of the area within the 250 mv/m contour. (Ordinary photographs will be accepted if they clearly show the terrain to the 250 mv/m contour and are taken in at least eight directions from the site: North, northeast, east, etc.

Where available, United States Geological Survey topography quadrangle sheets should be submitted. In the event the map submitted does not give the topography, the height above sea level of the proposed location, hills, ridges, and other obstructions should be shown. A statement as to whether or not other obstructions in the vicinity are painted and lighted or otherwise marked should always be made. In some cases additional maps, sketches, or descriptions may be necessary to clearly show the conditions. Attention is invited to the fact that the submission of complete and accurate information will materially expedite action on a proposed location, as well as enable the Commission to reach a correct decision thereon.

Aerial photographs of adequate scale are normally considerably superior to photographs taken from the proposed site. However, if the latter clearly show the character of the surrounding area, they are acceptable. Photographs taken from a location lower than the surrounding terrain or where the view is obstructed by immediately surrounding objects are of little value. Taking the photographs from a step ladder or other support will aid materially.

As a guide, the Engineering Department has established certain engineering principles based on the extensive experience of the Engineering Department and all data available along this line, including that presented at the informal engineering hearings of October 5, 1936, Jannary 18, 1937, and June 6, 1938.

The four primary objectives to be obtained in the selection of a site for a transmitter of a broadcast station are as follows:

(1) To serve adequately the center of population in which the studio is located and to give maximum coverage to adjacent areas.

(2) To cause and experience minimum interference to and from other stations.

(3) To present a minimum hazard to air navigation consistent with objectives 1 and 2.

(4) To fulfill certain other requirements given below.

The following table is offered as a general guide to be used in determining the approximate site of broadcast transmitters:

TABLE A

Power of station	Population of city or metropolitan area [1]	Approximate radius of blanket area 250 mv/m [2]	Site—distance from center of city (business or geographical)	Maximum percentage of total population in blanket area [1]
		Miles	*Miles*	*Percent*
100 watts	5,000–50,000	0. 15	½–1	1
100 watts	50,000 or more	0. 15	(3)	...
250–500 watts	5,000–150,000	0. 3–0. 5	1–3	1
250–500 watts	150,000 or more	0. 3–0. 5	(3)	...
1 kilowatt	5,000 to 200,000	0. 6–0. 9	2–5	1
1 kilowatt	200,000 or more	0. 6–0. 9	(3)	...
5–10 kilowatts	All	1. 5–2. 5	5–10	1
25–50 kilowatts	All	3. 0–4. 5	10–15	1

[1] The total population is the population of the city sought to be served except in those instances when the station is to be located in an area classified by the Department of Commerce, Bureau of Census, as a metropolitan area, in which case the population of the metropolitan area shall apply: *Provided, however,* That when the power of the station is such that all the metropolitan area cannot be served, the population that will actually be served shall determine. The population figures are those determined by the latest official census and where greater population is claimed, the burden of proof is on the applicant.

[2] These radii are only approximate and the actual blanket area (area within the 250 mv/m contour) may be materially different depending on the antenna employed and other factors.

[3] In these instances it is usually necessary to locate the station within the city in order to render satisfactory service throughout the city. Such sites shall be in or near the center of the business district and under no circumstances will a site in the residential area be approved.

In case the power and the population of the city are such that it should be located at some distance from the center of the city, the approximate distance is given as well as the population of the so-called "blanket area." The "blanket area" of a broadcast station is defined as that area adjacent to the transmitter in which the usual broadcast receiver would be subject to some type of interference to the reception of other stations due to the strong signal from the station. The normal blanket area of a broadcast station is that area lying within the 250 millivolt per meter contour line. The average radii of the blanket areas for broadcast stations of the various powers are given in the above table.

In those cases where it is impossible or impractical to locate a station in accordance with the above specifications, the Commission will give consideration to approving locations where not more than 1 percent of the population (as above specified) is included within the 500 millivolt per meter contour, provided the applicant submits an affidavit setting forth the reasons why the normal specifications cannot be complied with, and further that the applicant will assume full responsibility for adjustment of any reasonable complaints arising from the excessively strong signals of the applicant's station. Particular attention must be given to avoiding cross modulation.

In this connection, attention is invited to the fact that it has been found very unsatisfactory to locate broadcast stations so that high signal intensities occur in areas with overhead electric power or telephone distribution systems and sections where the wiring and plumbing are old or improperly installed. These areas are usually found in the older or poorer sections of a city. These conditions give rise to cross-modulation interference due to the nonlinear conductivity characteristics of contacts between wiring, plumbing, or other conductors. This type of interference is independent of the selectivity characteristics of the receiver and normally can be eliminated only by correction of the condition causing the interference. Cross modulation tends to increase with frequency and in some areas it has been found impossible to eliminate all sources of cross modulation, resulting in an unsatisfactory condition for both licensee and listeners.

Broadcast station transmitters will not be permitted to be located in these areas even though the population is within the requirements of Table A, unless the licensee assumes full responsibility for and it appears it can adjust all complaints satisfactorily.

If the city under consideration is of irregular shape, the station is of high power, a directional antenna system is employed, or if other unusual conditions obtain, the table may not apply and special consideration must be given. However, the general principles set out will still apply.

In selecting a site in the center of a city it is usually necessary to place the radiating system on the top of a building. This building should be large enough to permit the installation of a satisfactory ground and/or counterpoise system. Great care must be taken to avoid selecting a building surrounded by taller buildings or where any nearby building higher than the antenna is located in the direction which it is desired to serve. Such a building will tend to cast "radio shadows" which may materially reduce the coverage of the station in that direction. Irrespective of the height of surrounding buildings, the building on which the antenna is located should not have height of approximately one-quarter wavelength. A study of antenna systems located on buildings tends to indicate that where the building is approximately a quarter wavelength in height, the efficiency of radiation may be materially reduced.

If from Table A it is determined that a site should be selected removed from the city, there are several general conditions to be followed in determining the exact site. The table gives the approximate distance from the center of the city. Three maps should be given consideration if available:

(1) Map of the density of population and number of people by sections in the area.

(2) Geographical contour map with contour intervals of 20 to 50 feet.

(3) Map showing the type, nature and depth of the soil in the area with special reference to the condition of the moisture throughout the year. (See Table B.)

From these maps a site should be selected that is approximately the required distance from the city, with a minimum population in the "blanket area" and with a minimum number of intervening hills between it and the center of the city. In general, because of ground conditions, it is better to select a site in a low area rather than on top of a hill, and the only condition under which a site on top of a hill should be selected is that it is only possible by this means to avoid a substantial number of hills, between the site and the center of a city with the resulting radio shadows. If a site is to be selected to serve a city which is on a general sloping area, it is generally better to select a site below the city than above the city.

If a compromise must be made between probable radio shadows from intervening hills and locating the transmitter on top of a hill, it is generally better to compromise in favor of the low area, where an efficient radiating system may be installed which will more than compensate for losses due to shadows being caused by the hills, if not too numerous or too high. Several transmitters have been located on top of hills, but so far as data has been supplied not a single installation has given superior efficiency of propagation and coverage.

The ideal location of a broadcast transmitter is in a low area of marshy or "crawfishy" soil or area, which is damp the maximum percentage of time and from which a clear view over the entire center of population may be had, and the tall buildings in the business section of the city would cast a shadow across the minimum residential area.

The type and condition of the soil or earth immediately around a site is very important. Important, to an equal extent, is the soil or earth between the site and the principal area to be served. Sandy soil is considered the worst type, with glacial deposits and mineral-ore areas next. Alluvial, marshy areas and salt-water bogs have been found to have the least absorption of the signal. One is fortunate to have available such an area and, if not available, the next best condition must be selected.

Table B indicates the values of inductivity and conductivity which it is recommended be used for various types of country in the absence of surveys over the particular area involved. Naturally, values obtained from the use of these figures will be only approximate and should, if possible, be replaced by actual measurements in the area under consideration.

TABLE B

Type of terrain	Inductivity	Conductivity	Absorption factor at 50 miles, 1000 kc.[1]
Sea water, minimum attenuation	81		1.0
Pastoral, low hills, rich soil, typical of Dallas, Tex., Lincoln, Nebr., and Wolf Point, Mont., areas.	20		0.50
Pastoral, low hills, rich soil, typical of Ohio and Illinois	14		0.17
Flat country, marshy, densely wooded, typical of Louisiana near Mississippi River.	12		0.13
Pastoral, medium hills, and forestation, typical of Maryland, Pennsylvania, New York, exclusive of mountainous territory and sea coasts.	13		0.09
Pastoral, medium hills, and forestation, heavy clay soil, typical of central Virginia.	13	4×10^{-14}	0.05
Rocky soil, steep hills, typical of New England	14	2×10^{-14}	0.025
Sandy, dry, flat, typical of coastal country	10	2×10^{-14}	0.024
City, industrial areas, average attenuation	5	10^{-14}	0.011
City, industrial areas, maximum attenuation	3	10^{-15}	0.003

[1] This figure is stated for comparison purposes in order to indicate at a glance which values of conductivity and inductivity represent the higher absorption. This figure is the ratio between field intensity obtained with the soil constants given and with no absorption.

Careful consideration must be given to selecting a site so that the number of people in the blanket area is a minimum. The last column of Table A gives the percentage of the total population of the city or metropolitan area that may be permitted in the blanket area. In general, broadcast transmitters operating with approximately the same power can be grouped in the same approximate area and thereby reduce the interference between them.

If the city is of irregular shape, it is often possible to take advantage of this in selecting a suitable location that will give a maximum coverage and at the same time maintain a minimum of people within the blanket area. The maps giving the density of population will be a key to this. The map giving the elevation by contours will be a key to the obstructing hills between the site and city. The map of the soil conditions will assist in determining the efficiency of the radiating system that may be erected and the absorption of the signal encountered in the surrounding area.

Another factor to be considered is the relation of the site to airports and airways. There are no regulations or laws with respect to distance from airports and airways, but a distance of 3 miles from each is used as a guide. In case a suitable location is found at less distance than this, it may be satisfactory if the towers are suitably painted and lighted in conformity with the requirements of the Civil Aeronautics Administration, or if the towers are not higher than the surrounding objects. The latter is normally considered poor engineering practice; however, in selecting a site the local aeronautical authorities should always be consulted if there is any question concerning erecting a hazard to aviation, and in case of towers over 200 feet high this should always be done. In passing on a location and antenna installation, the Engineering Department refers each case to the Civil Aeronautics Administration for its recommendation. The action of the Administration will be materially expedited by the district airline inspector and local representatives of the airports and airlines forwarding their approval or comments to the Civil Aeronautics Administration, Washington, D. C.

In finally selecting the site, consideration must be given to the required space for erecting an efficient radiating system, including the ground or counterpoise (see section 3.45). It is the general practice to use direct grounds consisting of a radial buried wire system. If the area is such that it is not possible to get such a ground system in soil that remains moist throughout the year, it probably will be found better to erect a counterpoise. (Such a site should be selected only as a last resort.) It, like the antenna itself, must of course be designed properly for the operating frequency and other local conditions.

While an experienced engineer can sometimes select a satisfactory site for a 100-watt station by inspection, it is necessary for a higher power station to make a field-intensity survey to determine that the site selected will be entirely satisfactory. There are several facts that cannot be determined by inspection that make a survey very desirable for all locations removed from the city. Often two or more sites may be selected that appear to be of equal promise. It is only by means of field-intensity surveys taken with a transmitter at the different sites or from measurements on the signal of nearby stations traversing the terrain involved that the most desirable site can be determined. There are many factors regarding site efficiency that cannot be determined by any other method.

The site selected should meet the following conditions:

(1) A minimum field intensity of 25 to 50 millivolts per meter will be obtained over the business or factory areas of the city.

(2) A minimum field intensity of 5 to 10 millivolts per meter will be obtained over the most distant residential section.

(3) The absorption of the signal is the minimum for any obtainable sites in the area. As a guide in this respect the absorption of the signals from other stations in that area should be followed, as well as the results of tests on other sites.

(4) The population within the blanket radius (250 mv/m) does not exceed that specified by Table A.

When making the final selection of a site, the need for a field-intensity survey to establish the exact conditions cannot be stressed too strongly. The selection of a proper site for a broadcast station is an important engineering problem and can only be done properly by experienced radio engineers.

5. MINIMUM ANTENNA HEIGHTS OR FIELD INTENSITY REQUIREMENTS

Section 3.45 requires that all applicants for new, additional, or different broadcast facilities and all licensees requesting authority to move the transmitter of an existing station, shall specify a radiating system, the efficiency of which complies with the requirements of good engineering practice for the class and power of the station.

The specifications deemed necessary to meet the requirements of good engineering practice at the present state of the art are set out in detail below.

The licensee of a standard broadcast station requesting a change in power, time of operation, frequency, or transmitter location must also request authority to install a new antenna system or to make changes in the existing antenna system which will meet the minimum height requirements, or submit evidence[24] that the present antenna system meets the minimum requirements with respect to field intensity, before favorable consideration will be given thereto. In the event it is proposed to make substantial changes in an existing antenna system, the changes shall be such as to meet the minimum height requirements or will be permitted subject to the submission of field intensity measurements showing that it meets the minimum requirements with respect to effective field intensity.

These minimum actual physical vertical heights of antennas permitted to be installed are shown by curves A, B, and C of Figure 7 as follows:

A. Class IV stations, 150 feet[25] or a minimum effective field intensity of 150 mv/m for 1 kilowatt (100 watts 47.5 mv/m and 250 watts, 75 mv/m).

B. Class II and III stations, or a minimum effective field intensity of 175 mv/m for 1 kilowatt.

C. Class I stations, or a minimum effective field intensity of 225 mv/m for 1 kilowatt.

The heights given on the graph for the antenna apply regardless of whether the antenna is located on the ground or on a building. Except for the reduction of shadows, locating the antenna on a building does not necessarily increase the efficiency and where the

[24] See Field Intensity Measurements in Broadcast Allocation, section A.

[25] This height applies to a Class IV station on a local channel only. In case a Class IV station is assigned a regional channel Curve A shall apply.

height of the building is in the order of a quarter wave the efficiency may be materially reduced.

To obtain the maximum efficiency of which any antenna is capable a good ground system must be employed (a counterpoise may be substituted under certain conditions).

At the present development of the art, it is considered that where a vertical radiator is employed with its base on the ground, the ground system should consist of buried radial wires at least one-fourth wave length long. There should be as many of these radials evenly spaced as practicable and in no event less than 90. (120 radials of 0.35 to 0.4 of a wave length in length and spaced 3° is considered an excellent ground system and in case of high base voltage, a base screen of suitable dimensions should be employed.)

It should be borne in mind that the above specifications are the minimum and where possible better antenna and ground systems should be installed.

In case it is contended that the required antenna efficiency can be obtained with an antenna of height or ground system less than the minimum specified, a complete field intensity survey [24] must be supplied to the Commission showing that the field intensity at a mile without absorption fulfills the minimum requirements. This field survey must be made by a qualified engineer using equipment of acceptable accuracy.

The main element or elements of a directional antenna system shall meet the above minimum requirements with respect to height or effective field intensity. No directional antenna system will be approved which is so designed that the effective field of the array is less than the minimum prescribed for the class of station concerned, or in case of a Class I station less than 90 percent of the ground wave field which would be obtained from a perfect antenna of the height specified by Figure 7 for operation on frequencies below 1000 kilocycles, and in the case of a Class II or III station less than 90 percent of the ground wave field which would be obtained from a perfect antenna of the height specified by Figure 7 for operation on frequencies below 750 kilocycles.

In all cases of new construction where concentric transmission line is used between the transmitter and antenna, such line shall be installed in duplicate with adequate switching facilities for immediate connection of the second line in case of failure of the first line, or permanently installed auxiliary facilities such as an auxiliary transmitter and antenna system, auxiliary antenna system or other means whereby operation may be continued in the event of failure of the transmission line.

[24] See Field Intensity Measurements in Broadcast Allocation, section A.

Before any changes are made in the antenna system, it is necessary to submit full details to the Commission for approval. These data may be submitted by letter.

6. STANDARD LAMPS AND PAINTS

Section 3.45 (*d*) requires that the antenna and supporting structure shall be painted and illuminated in accordance with the specifications supplied by the Commission pursuant to section 303 (*q*) of the Communications Act of 1934.

These individual specifications are issued for and attached to each authorization for an installation.[26] The details of the specifications depend on the degree of hazard presented by the particular installation. The following standard lamps and paints shall be used for the type of marking specified:

(*a*) *Painting.*—Each tower shall be painted throughout its height with alternate horizontal bands of international orange and white, terminating with orange bands at both top and bottom. (Orange yellow No. 5 color card, supplement to U. S. Army Quartermaster Corps Specifications No. 3–1, color chip below.) The width of the orange bands shall be approximately one-seventh of the height of any structure less than 250 feet in height, and between 30 and 40 feet for structures over 250 feet in height. The width of the white bands shall be one-half that of the orange bands.

(*b*) *Lighting.*—(1) Towers, the over-all heights of which do not exceed 200 feet, shall be lighted as follows:

At the top of each tower there shall be installed two 100-watt lamps, enclosed in aviation red prismatic obstruction light globes. At least one of these lamps shall burn continuously from sunset to sunrise. When only one lamp is operated, the circuit shall be equipped with a relay for instant automatic switchover to the other lamp in case of lamp failure.

At both the one-third and two-thirds levels of each tower there shall be installed two 100-watt lamps enclosed in aviation red prismatic obstruction light globes, at each level, one each on diagonally opposite corners of the structure.

All 100-watt lamps shall be type A–21 clear bulb traffic signal lamps (2,000 hours or equal).

All lamps shall be enclosed in aviation red prismatic obstruction light globes, and all lighting shall be exhibited from sunset to sunrise.

* * * * * * *

Special conditions of terrain and location with respect to airports or airways may require additional lighting of the character hereinafter specified for towers the over-all height of which exceeds 200 feet.

* * * * * * *

(2) Towers, the over-all heights of which exceed 200 feet but do not exceed 300 feet, shall be lighted as follows:

At the top of each tower there shall be installed a hazard beacon similar and equal in effectiveness to the standard 300 m./m. airways electric lantern. This beacon shall flash and shall be equipped with two 500-watt lamps (both lamps to burn simultaneously) and aviation red color shades. The 300 m./m. electric code beacon shall be equipped with a flashing mechanism producing 40 flashes per minute, having a luminous period of 1 second, and a period of darkness of one-half second.

The one-third and two-thirds levels of the tower shall be marked by 100-watt obstruction lights the same as specified for towers not exceeding 200 feet in height.

* * * * * * *

Towers over 300 feet in height (and less than 300 feet in height where special conditions obtain) may be required to install additional marking as follows:

[26] Specifications normally attached to authorization.