FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON, D. C.

April 12, 1946

MEMORANDUM TO MEMBERS OF CLEAR CHANNEL COMMITTEES I II AND III.

SUBJECT: Draft "D" of "Method of Computing Service, etc."

As a result of the discussions at the joint meeting of your three committees on April 8th, 9th and 10th, Draft C of the subject document has been revised to Draft D, a copy of which is enclosed.

It is hoped that on its main essentials, the committees are now in substantial agreement, and that any further changes will be few and minor.

As announced at the close of the meeting on Wednesday, the committees will meet in Room 2230, New Post Office Building, on Monday April 15th in the afternoon, at whatever hour is set for the resumption of the clear channel hearing after the lunch-time recess. At that meeting consideration will be given to the terms of Draft D and there will also be a discussion of the cooperative preparation of basic coverage maps.

H. H. Graham

For G. P. ADAIR
Chief Engineer

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON D. C.

DRAFT D

April 12, 1946

Method of Computing Service and Interference for Use in Connection with Docket #6741.

The following methods and procedures are recommended for the preparation of technical testimony concerning service and interference in the Clear Channel Hearing, Docket #6741. They are based on the results of the studies of Committees I, II and III. They constitute, in general, revisions in the methods presently established in the Standards of Good Engineering Practice. The latter may be used to The extent that they are not at variance with this document.

TABLE OF CONTENTS:

A. Definition of Terms:

Interference: The effect obtained in reception when the ratio of desired field intensity to undesired field intensity (atmospheric noise, man-made noise or radio signal) is less than the value considered by listeners to be the borderline between "satisfactory" and "unsatisfactory."

Hourly median value. (of skywave field intensity, atmospheric noise intensity, or any other function varying with time) That value which is exceeded for a total of 30 minutes in an hour.

P% Skywave signal. The hourly median skywave field intensity which is exceeded at a given receiving location on P% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

Radiated field. The inverse distance field at one mile from a transmitting antenna, in a particular direction.

Pertinent Angle. The angle θ_1 in Figure 6 of the Commission's present standards.

Groundwave Service. Service obtained from the groundwave signal.

Skywave Service. Service obtained from the skywave signal.

Iso-Service Contour. The contour defining a particular type of service.

B. Types of Service:

1. Standard Ratio of Desired Signal-to-Interference. 2/ This is the same for all types of service.

Kind of Interference	Ratio, Desired to Undesired
Atmospheric Noise 1/	100 * to 1, carrier to average noise. (4 kc e.b.w.)
Man-made noise	30 to 1, carrier to noise level (RCA 312 type meter)

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* Tentative: Subject to revision if required by further studies now in progress by Committee I.

Kind of Interference (Cont'd)	Ratio, Desired to Undesired
Other-Station Interference 1/ (co-channel)	20 to 1, instantaneous carrier ratio.
Other-Station Interference 1/ (adjacent channel)	Instantaneous Signal ratio For groundwave service / For skywave service 1st adjacent channel 1:1 / 1:5 2nd adjacent channel 1:20 / 1:100 3rd adjacent channel 3/ 1:100 / 1:500
Interference between Station's own skywave signal and its groundwave (distortion zone).	2 to 1, groundwave to instantaneous skywave or instantaneous skywave to groundwave

NOTES:

1/ In certain cases involving service or interference from skywaves, where there is variation of ratio within the hour, the standard ratio is adjusted by a factor which will account for this variation in order to indicate service for 90% of the hour. The ratio of the value exceeded 10% of the hour to the hourly median value is 1.83 and the ratio of the hourly median value to the value exceeded for 90% of the hour is 2.56.

2/ In any case a minimum signal of 01 mv/m is considered necessary for service.

3/ For purposes of clear channel hearing service exhibits, the 3rd adjacent channel interference need not be shown.

2. Types of groundwave service on a percent of time basis: (Groundwave signals are assumed not to vary with time.)

(a) Type A service.

(1) When limited by atmospherics, type A service will be assumed to be bounded by the contour at which the standard ratio is obtained for 90% of the time throughout the year. This will be determined from Figures 12-2 and 14-3 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, type A service will be assumed to be bounded by the contour at which the standard ratio is obtained.

(3) When limited by other-station skywave interference, type A service will be assumed to be bounded by the contour at which the adjusted standard ratio 1/ is obtained on 90% of the nights of the year. The groundwave signal required is as follows:

	Ratio of desired groundwave to undesired 10% skywave
Same channel	37:1
1st adjacent channel	1.8:1
2nd adjacent channel	1:11

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph E.

(4) When limited by interference from the station's own skywave (distortion zone, inner edge), type A service will be assumed to be bounded by the contour at which the standard ratio is obtained on 90% of the nights. This occurs at a point where the groundwave signal is twice the 10% skywave signal.

(5) When limited by man-made noise, type A service will be assumed to be bounded by the contour established by Figure 20-2 which will serve 90% of the population. Note that in calculating population served the number within the type A contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type A service at any point. In exhibits, the kind of interference defining the contour should be indicated.

(b) Type B service.

(1) When limited by atmospherics, type B service will be assumed to be bounded by the type A service area and the contour at which the standard ratio is obtained for 50% of the time throughout the year. This will be determined from Figures 12-2 and 14-3 in accordance with paragraph G.

(2) When limited by other-station groundwave interference, no type B service is defined.

(3) When limited by other-station skywave interference, type B service will be assumed to be bounded by the type A service area and the contour at which the adjusted standard ratio 1/ is obtained for 50% of the nights of the year. The groundwave signal required is as follows:

	Ratio of desired groundwave to undesired 50% skywave
Same channel	37:1
1st adjacent channel	1.8:1
2nd adjacent channel	1:11

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph Z.

(4) When limited by interference from the station's own skywave, (distortion zone, inner edge), type B service will be assumed to be bounded by the type A service area and the contour at which the standard ratio is obtained on 50% of the nights. This occurs at the point where the groundwave signal is twice the 50% skywave signal.

(5) When limited by man-made noise, type B service is assumed to be bounded by the contours established by figure 20-2 which will serve 90% and 70% of the population. Note that in calculating population served, the number within type B contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type B service at a point. In any exhibit, the kind of interference defining a contour should be indicated.

(c) Type C service.

(1) When limited by atmospherics, type C service will be assumed to be bounded by the type B service area and the contour at which the standard ratio is obtained for 20% of the time throughout the year. This will be determined from figures 12-2 and 14-3 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, no type C service is defined.

(3) When limited by other-station skywave interference, type C service will be assumed to be bounded by the type B service area and the contour at which the adjusted standard ratio 1// is obtained for 20% of the nights of the year. The groundwave signal required is as follows:

	Ratio of desired groundwave to undesired 80% skywave
Same channel	37:1
1st adjacent channel	1.8:1
2nd adjacent channel	1:11

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph E.

(4) When limited by interference from the station's own skywave, (distortion zone, inner edge), type C service is not defined, and the area between the type B and type E areas is considered to be all type F service in the absence of other kinds of interference.

(5) When limited by man-made noise, type C service is assumed to be bounded by the contours established by figure 20-2 which will serve 70% and 50% of the population. Note that in calculating population served, the number within type C contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type C service at a point. In any exhibit, the kind of interference defining a contour should be indicated.

3. Types of skywave service on a percent of time basis.

(a) Type D service.

(1) When limited by atmospherics, type D skywave service will be assumed to be bounded by the contour at which the ratio of 90% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C, is 2.5 to 1.

(2) When limited by other-station groundwave interference, type D skywave service will be assumed to be bounded by the contour at which the adjusted standard ratio 1/ is obtained on 90% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 90% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40

(3) When limited by other station skywave interference, type D skywave service will be assumed to be bounded by the contour at which the ratio of desired 90% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type D skywave service will be assumed to be bounded by the contour at which the ratio of the 90% skywave signal to the groundwave signal is 2 to 1.

(5) When limited by man-made noise, type D skywave service will be assumed to be bounded by the 50% skywave contour established by Figure 20-2 which will serve 90% of the population. Note that in calculating population served, the number within the type D contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type D service, at any point. In exhibits, the kind of interference defining the contour should be indicated.

(b) Type E service.

(1) When limited by atmospherics, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of the 60% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C is 2.5 to 1.

(2) When limited by other-station groundwave interference, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the adjusted standard ratio 1/ is obtained on 60% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 60% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40

(3) When limited by other-station skywave interference, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of desired 60% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of the 60% skywave signal to the groundwave signal is 2 to 1.

(5) When limited by man-made noise, type E skywave service will be assumed to be bounded by the 50% skywave contours established by Figure 20-2 which will serve 90% and 70% of the population. Note that in calculating population served, the number within the type E contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type E service at any point. In exhibits, the kind of interference defining the contour should be indicated.

(c) Type F. service

(1) When limited by atmospherics, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of the 30% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C is 2.5 to 1.

(2) When limited by other-station groundwave interference, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the adjusted standard ratio 1/ is obtained on 30% of the nights of the year. This requires a ratio of signal intensity as follows:

	Ratio of desired 30% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40

(3) When limited by other-station skywave interference, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of desired 30% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of the 30% skywave signal to the groundwave signal is 2 to 1. In addition, between this contour and the type B groundwave service area, the service which is part of the time a skywave service and part of the time a groundwave service will be considered also as type F service.

(5) When limited by man-made noise, type F skywave service will be assumed to be bounded by the type E service area and the 50% skywave contour established by Figure 20-2 which will serve 50% of the population. Note that in calculating population served, the number within the type F contour will be determined in accordance with paragraph F.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will

determine the existence or absence of type F service at any point. In exhibits the kind of interference defining the contour should be indicated.

4. Tabular Summary.

Abbreviations:

ANS: Annual noise-free signal; the field intensity which will be free of atmospheric noise for a given percent of the year.
SW: Skywave signal.
GW: Groundwave signal.
D: Desired.
U: Undesired.
SC: Same channel
AC: Adjacent channel.

Type of Service	When limited by: Atmospheric Noise	Other Station GW	Other Station SW	Distortion Zone	(Fig. 20-2) Man-made Noise
A	DGW = 90%ANS	DGW/UGW = SC 20:1 1st AC 1:1 2nd AC 1:20 3rd AC 1:100*	DGW/U10%SW = SC 37:1 1st AC 1.8:1 2nd AC 1:11	DGW/U10%SW 2:1	GW to serve above 90% population
B	DGW = 50%ANS	Not defined	DGW/U50%SW SC 37:1 1st AC 1.8:1 2nd AC 1:11	DGW/U50%SW 2:1	GW to serve 90% - 70% population
C	DGW = 20%ANS	Not defined	DGW/U80%SW SC 37:1 1st AC 1.8:1 2nd AC 1:11	Not defined	GW to serve 70% - 50% population
D	D90%SW=2.5:1 50%ANS	D90%SW/UGW SC 50:1 1st AC 1:2 2nd AC 1:40	D90%SW/U50%SW SC 60:1 1st AC 3:5 2nd AC 3:100	D90%SW/UGW 2:1	50% SW to serve above 90% population
E	D60%SW=2.5:1 50%ANS	D60%SW/UGW SC 50:1 1st AC 1:2 2nd AC 1:40	D60%SW/U50%SW SC 60:1 1st AC 3:5 2nd AC 3:100	D60%SW/UGW 2:1	50% SW to serve 90%-70% population
F	D30%SW=2.5:1 50%ANS	D30%SW/UGW SC 50:1 1st AC 1:2 2nd AC 1:40	D30%SW/U50%SW SC 60:1 1st AC 3:5 2nd AC 3:100	Area bounded by type E and type B	50% SW to serve 70%-50% population

* For clear channel hearing service exhibits, 3rd AC need not be shown.

C. Use of Atmospherics Maps.

Two maps are provided. (Figures 12-2 and 14-3). These show the daytime and the nighttime contours of field intensities in mv/m required to render atmospherics-free service (assuming 100 to 1 as the standard ratio) for 90% of the year for 1000 kc. Interpolation for points between contour lines may be accomplished by using the shortest line through the point and between adjacent contours. The required signal for other frequencies is determined by applying the following formulae:

$$\text{Daytime} \qquad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.86$$

$$\text{Nighttime} \qquad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.5$$

Where f_{kc} is the frequency in kilocycles
E_f is the field intensity at that frequency
E_{1000} is the field intensity indicated by the ma p
These functions are shown graphically in Figure 4-1.
For determining the field required for service 50% of the year, the field required for service for 90% of the year is multiplied by 0.16.

In the case of groundwave service, the field intensity required for service at the location of the transmitter will be considered as determining the field intensity required in all parts of the service area.

D. Use of Skywave Curves.

1. Separate graphs for the several P% skywave signals required by by paragraph B are provided.

2. The latitude to be used is the latitude of the mid point of the path between the transmitter and the receiving point. Note that only on paths along the meridian is this latitude exactly half way between the latitude of the transmitter and that of the receiver. On long east-west paths, particularly at the higher latitudes the difference may be significant. For mid-points above 49° and below 35°, the curve for 49° and 35° respectively shall be used. In the case of skywave interference to groundwave service of Class II stations and of stations on regional channels the latitude of the mid point between the cities in which the stations are located is to be used.

3. The radiation to be used is the radiation at the proper azimuth and at the pertinent angle. In the case of skywave interference to groundwave service, of Class II stations and of stations on regional channels, the distance between the cities in which the stations are located is to be used.

4. The accuracy of the skywave curves is not well established by experiment at distances less than 250 miles. They are extended to 50 miles by assuming the same attenuation of signal below the inverse distance field as was observed at distances from 250 miles to 600 miles. They will be used until such time as they may be corrected by further experimental evidence.

5. In the case of Class IV stations on local channels, because of the great amount of labor involved in determining the actual nighttime limitation from other station skywaves to any given station, a uniform value of 4.0 mv/m will be assumed as the limit of service which may be compared with type B service in other classes of stations.

E. Determination of RSS Interference

When two or more interfering 10% skywave signals on the same frequency exist at a point, their resultant is considered to be the Root-sum - square value of the components. In calculating the RSS value, if there are no more than five signals present all shall be included; if six or more exist, only the five highest shall be included. This method may also be used for two or more interfering P% skywave signals. It cannot be used, however, to determine the resultant interference when the signals are expressed as values exceeded for different percentages of time.

F. Use of Urban Service Chart - Figure 20-2.

The signal intensity required for the several types of service is defined in paragraph B. In calculating population within a particular type of service area, all of the population in the area is included. If the city is so located with respect to the station that the contour dividing two types of service areas passes through the city, ordinarily all the population will be considered as within that service area which includes more than 50% of the city area. However when a station delivers a large range of field intensities over a city, the population within each type of service area will be tabulated separately.

Interpolation between lines on the chart is to be used when necessary.

Signal intensities less than 0.5 mv/m, nor less than the value required for service to 50% of the population, will not be considered as rendering any service to urban areas.

In rural areas, including towns of less than 2500 population, the minimum signal intensity required to overcome man-made noise is considered to be uniformly 0.1 mv/m.

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON, D. C.

DRAFT C

April 3, 1946

Method of Computing Service and Interference for Use in Connection with Docket #6741.

The following methods and procedures are recommended for the preparation of technical testimony concerning service and interference in the Clear Channel Hearing, Docket #6741. They are based on the results of the studies of Committees I, II and III. They constitute, in general, revisions in the methods presently established in the Standards of Good Engineering Practice. The latter may be used to the extent that they are not at variance with this document. It is intended later to incorporate these methods and procedures into a general revision of the Commission's Standards.

TABLE OF CONTENTS:

A. Definition of terms:

Interference: The effect obtained in reception when the ratio of desired field intensity to undesired field intensity (atmospheric noise, man-made noise or radio signal) is less than the value considered by listeners to be the borderline between "satisfactory" and "unsatisfactory."

Hourly median value. (of skywave field intensity, atmospheric noise intensity, or any other function varying with time: That value which is exceeded for a total of 30 minutes in an hour.

P% Skywave signal. The hourly median skywave field intensity which is exceeded at a given receiving location on P% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

Radiated field. The inverse distance field at one mile from a transmitting antenna, in a particular direction.

Pertinent Angle. The angle θ_1 in Figure 6 of the Commission's present Standards.

Groundwave Service. Service obtained from the groundwave signal.

Skywave Service. Service obtained from the skywave signal.

Iso-Service Contour. The contour defining a particular grade of service.

B. Grades of Service:

1. Standard Ratio of Desired Signal-to-Interference. This is the same for all grades of service.

Type of Interference	Ratio, Desired to Undesired
Atmospheric Noise	100 * to 1, carrier to average noise. (4 kc e.b.w.)
Man-made noise	30 to 1, carrier to noise level (RCA 312 type meter)

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* Tentative: Subject to revision if required by further studies now in progress by Committee I.

Type of Interference (Cont'd)	Ratio, Desired to Undesired
Other-Station Interference (co-channel)	20 to 1, instantaneous carrier ratio. *
Other-Station Interference (adjacent channel)	See paragraph G
Interference between Station's own Skywave Signal and its Groundwave (distortion zone).	2 to 1, groundwave to instantaneous skywave or instantaneous skywave to groundwave.

1/ NOTE: In cases involving service or interference from skywaves, where there is variation of ratio within the hour at any point, the point at which the standard ratio is obtained for 90% of the hour shall be used to establish grades of service.

2/ NOTE: In any case a minimum signal of 0.1 mv/m is considered necessary for service.

2. Types of groundwave service on a percent of time basis: (Groundwave signals are assumed not to vary with time.)

(a) Type A service.

(1) When limited by atmospherics, type A service will be assumed to be bounded by the contour at which the standard ratio is obtained for 90% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, type A service will be assumed to be bounded by the contour at which the standard ratio is obtained.

(3) When limited by other-station skywave interference, type A service will be assumed to be bounded by the contour at which the standard ratio 1 / is obtained on 90% of the nights of the year. Since the value exceeded by the signal for 10% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of desired groundwave to undesired 10% skywave
Same channel	37:1
1st adjacent channel	1.8:1
2nd adjacent channel	1:11

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave (distortion zone, inner edge), type A service will be assumed to be bounded by the contour at which the standard ratio 1 / is obtained on 90% of the nights. This occurs at the point where the 10% skywave signal is 0.27 times the groundwave signal.

(5) When limited by man-made noise, type A service will be assumed to be bounded by the contour established by Figure 20-1 which will serve 90% of the population. Note that in calculating population serviced the number within the type A contour will be determined in accordance with paragraph H.

(6) When limited by more than one kind of interference, (Atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type A service at any point. In exhibits, the kind of interference defining the contour should be indicated.

(b) Type B service.

(1) When limited by atmospherics, type B service will be assumed to be bounded by the type A service area and the contour at which the standard ratio is obtained for 50% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, no type B service is defined and all areas outside the type A service area are considered as having no service.

(3) When limited by other-station skywave interference, type B service will be assumed to be bounded by the type A service area and the contour at which the standard ratio 1/ is obtained for 50% of the nights of the year. Since the value exceeded by the signal for 10% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of desired groundwave to undesired 50% skywave
Same channel	37:1
1st adjacent channel	1.8:1
2nd adjacent channel	1:11

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave, (distortion zone, inner edge) type B service will be assumed to be bounded by the type A service area and the contour at which the standard ratio 1/ is obtained on 50% of the nights. This occurs at the point where the 50% skywave signal is 0.27 times the groundwave signal.

(5) When limited by man-made noise, type B service is assumed to be bounded by the type A service area and the contour established by figure 20-1 which will service 70% of the population. Note that in calculating population served, the number within type B contour will be determined in accordance with paragraph H.

(6) When limited by more than one kind of interference, (Atmospherics, man-made noise, co-channel interference, adjacent channel interference or the distortion zone), tye kind involving the most severe interference will determine the existence or absence of type B service at a point. In any exhibit, the kind of interference defining a contour should be indicated.

(c) Type C service is defined as whatever groundwave service exists beyond the type B service area. However, in the case of groundwave service limited by the station's own skywave, the type of service beyond type B is considered as type F and is continuous with the type F skywave service limited by the interference from the station's own groundwave. In other words, in the absence of other kinds of interference, the service in the distortion zone between type B (groundwave) service and type E (skywave) service is all considered type F.

3. Types of skywave service on a percent of time basis.

(a) Type D service.

(1) When limited by atmospherics, type D skywave service will be assumed to be bounded by the contour at which the ratio of 90% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C, is 2.5 to 1.

(2) When limited by other-station groundwave interference, type D skywave service will be assumed to be bounded by the contour at which the standard ratio 1/ is obtained on 90% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 90% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40
3rd adjacent channel	1:100

(3) When limited by other-station skywave interference, type D skywave service will be assumed to be bounded by the contour at which the ratio of desired 90% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type D skywave service will be assumed to be bounded by the contour at which the ratio of the 90% skywave signal to the groundwave signal is 5.1 to 1.

(5) When limited by man-made noise, type D skywave service will be assumed to be bounded by the 50% skywave contour established by Figure 20-1 which will serve 90% of the population. Note that in calculating population served, the number within the type D contour will be determined in accordance with paragraph H.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type D service, at any point. In exhibits, the kind of interference defining the contour should be indicated.

(b) Type E service.

(1) When limited by atmospherics, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of the 60% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C is 2.5 to 1.

(2) When limited by other-station groundwave interference, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the standard ratio 1/ is obtained on 60% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 60% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40
3rd adjacant channel	1:100

(3) When limited by other-station skywave interference, type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of desired 60% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type E skywave service will be assumed to be bounded by the type D service area and the contour at which the ratio of the 60% skywave signal to the groundwave signal is 5.1 to 1.

(5) When limited by man-made noise, type E skywave service will be assumed to be bounded by the type D service area and the 50% skywave contour established by Figure 20-1 which will serve 70% of the population. Note that in calculating population served, the number within the type E contour will be determined in accordance with paragraph H.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will

determine the existence or absence of type E service at any point. In exhibits, the kind of interference defining the contour should be indicated.

(c) Type F service.

(1) When limited by atmospherics, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of the 30% skywave signal to the 50% nighttime atmospherics-free field intensity as determined in accordance with paragraph C is 2.5 to 1.

(2) When limited by other-station groundwave interference, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year. This requires a ratio of signal intensity as follows:

	Ratio of desired 30% skywave to undesired groundwave
Same channel	50:1
1st adjacent channel	1:2
2nd adjacent channel	1:40
3rd adjacent channel	1:100

(3) When limited by other-station skywave interference, type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of desired 30% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:5
2nd adjacent channel	3:100

(4) When limited by interference from the station's own groundwave (distortion zone, outer edge), type F skywave service will be assumed to be bounded by the type E service area and the contour at which the ratio of the 30% skywave signal to the groundwave signal is 5.1 to 1. In addition, between this contour and the type B groundwave service area, the service which is part of the time a skywave service and part of the time a groundwave service will be considered also as type F service.

(5) When limited by man-made noise, type F skywave service will be assumed to be bounded by the type E service area and the 50% skywave contour established by Figure 20-1 which will serve 50% of the population. Note that in calculating population served, the number within the type F contour will be determined in accordance with paragraph 4.

(6) When limited by more than one kind of interference, (atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the distortion zone), the kind involving the most severe interference will determine the existence or absence of type F service at any point. In exhibits, the kind of interference defining the contour should be indicated.

C. Use of Atmospherics Maps.

Two maps are provided. These show the daytime and the nighttime contours of field intensities required to render atmospherics-free service (assuming 100 to 1 as the standard ratio) for 90% of the year for 1000 kc. Interpolation for points between contour lines may be accomplished by using the shortest line through the point and between adjacent contours. The required signal for other frequencies is determined by applying the following formulae:

Daytime $E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.86$

Nighttime $E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.5$

Where f_{kc} is the frequency in kilocycles

E_f is the field intensity at that frequency

E_{1000} is the field intensity indicated by the map

For determining the field required for service 50% of the year, the field required for service for 90% of the year is multiplied by 0.16.

D. Use of Skywave Curves

1. Curves, in general, are calculated to give the 50% skywave field values of field exceeded for P% of the time may be determined therefrom by multiplying by the ratio of the P% skywave field to the 50% skywave field at the appropriate latitude as shown by Figure 5.1 of Exhibit 23.

2. The latitude to be used is the latitude of the mid point of the path between the transmitter and the receiving point. Note that only on paths along the meridian is this latitude exactly half way between the latitude of the transmitter and that of the receiver. On long east-west paths, particularly at the higher latitudes the difference may be significant. For mid-points above 49° and below 35°, the curve for 49° and 35° respectively shall be used.

3. The radiation to be used is the radiation at the proper azimuth and at the pertinent angle. In the case of antennas with minima in the vertical plane it is recognized that the field intensity at a distant point may be in excess of the value calculated from the radiation at a pertinent angle in a minimum. The following will be used to make allowance for this fact:

In case of antennas with a vertical pattern in which radiation at any angle above the pertinent angle for first reflection is greater than the radiation at the pertinent angle for first reflection, the skywave field at the point of reception will be computed in the following manner: The 50% skywave field at a point X miles distant is considered to be the RSS value of three 50% skywave fields, the effect of transmission by one, two and three ionosphere reflections. E_1, E_2 and E_3 are the 50% skywave field components from rays arriving by one, two and three reflections respectively when the radiated field at the pertinent angle for each ray is 100 mv/m. Three curves are provided to show the variation of E_1, E_2 and E_3 as functions of the total distance to the receiving point and the midpoint latitude. These values are to be multiplied by the ratio of the actual radiated field at the pertinent angle to 100 mv/m, before the RSS value of the three is determined. As an example, suppose it is desired to determine the value of 50% skywave field at 300 miles. From Figure 6 of the present Standards, the pertinent angle for E_1 is 23°, for E_2 42° and for E_3 is 53°. E_1 is determined for 300 miles and the appropriate latitude and multiplied by the ratio of the actual radiation at 23° to 100 mv/m. Similarly E_2 is determined for the same distance and latitude and multiplied by the ratio of the actual radiation at 42° to 100 mv/m. Similarly with E_3. The 50% skywave field at the receiving point is then the RSS of the three values thus determined.

4. The accuracy of the skywave curves is not well established by experiment at distances less than 250 miles. They are extended to 50 miles by assuming the same attenuation of signal below the

inverse distance field as was observed at distances from 250 miles to 600 miles. They will be used until such time as they may be corrected by further experimental evidence.

E. Method of Using Groundwave Curves.

Where accurate measurements of groundwave signals are not available, the Commission's groundwave curves (Appendix I of present Standards) shall be used. If the conductivity has not been established by measurements, the Commission's map of conductivity shall be used (Figure 3 of the present Standards). The recommended procedure where the signal traverses terrain of several conductivities is the equivalent distance method proposed by H. L. Kirke. In this method, the actual transmitter is replaced by an imaginary transmitter of equal power but at a different distance, the distance being such that the field at the junction of the two conductivities is the same as that from the actual transmitter but for a path having the conductivity of the second part of the path. In the case of high conductivity followed by low conductivity the imaginary transmitter will be moved nearer the receiver, and conversely. As an example, suppose on 700 kc a signal of 100 mv/m at a mile is radiated over a conductivity of 10 x 10 $^{-14}$ c.m.u. for 15 miles, and over 2 x 10 $^{-14}$ thereafter. Suppose further it is desired to determine the distance to the 0.5 mv/m contour. The field at 15 miles will be 4.3 mv/m and the equivalent distance for conductivity of 2 x 10 $^{-14}$ is 8 miles, which is 7 miles closer than the actual transmitter. The distance to the 0.5 mv/m contour for conductivity 2 x 10 $^{-14}$ is 25 miles (from the imaginary transmitter) or 32 miles from the actual transmitter.

F. Determination of RSS Interference

When two or more interfering 10% skywave signals on the same frequency exist at a point, their resultant is considered to be the Root-sum - square value of the components. In calculating the RSS value, if there are no more than five signals present all shall be included; if six or more exist, only the five highest shall be included. This method may also be used for two or more interfering P% skywave signals. It cannot be used, however, to determine the resultant interference when the signals are expressed as values exceeded for different percentages of time.

G. Other-Signal Interference Ratios

The following table is to be used for determining the ratio of field strength of a desired to an undesired signal (or RSS value of two or more undesired signals) below which interference will exist.

Frequency Separation of desired & undesired signals	Desired groundwave to undesired groundwave	Desired groundwave to undesired 10% skywave (Type A)	Desired groundwave to undesired 50% skywave (Type B)	Desired 90% skywave to undesired groundwave (Type D)
0 kc	20:1	37:1	37:1	50:1
10 kc	1:1	1.8:1	1.8:1	1:2
20 kc	1:20	1:11	1:11	1:40
30 kc	1:50			1:100

Frequency Separation of desired & undesired signals	Desired 60% skywave to undesired groundwave (Type E)	Desired 30% skywave to undesired groundwave (Type F)	Desired 90% skywave to undesired 50% skywave (Type D)	Desired 60% skywave to undesired 50% skywave (Type E)	Desired 30% skywave to undesired 50% skywave (Type F)
0 kc	50:1	50:1	60:1	60:1	60:1
10 kc	1:2	1:2	3:5	3:5	3:5
20 kc	1:40	1:40	3:100	3:100	3:100
30 kc	1:100	1:100			

H. Calculating urban populations within service contours.

Coverage to a city will be assumed to be rendered to the percent of the population indicated in figure 20-1. The field intensity contour to be used is that which includes 50% of the area of the city, interpolating when necessary between appropriate lines on the chart. Signals less than 0.5 mv/m will not be considered to render any service to urban areas. Rural areas and towns of less than 2,500 population will not be considered to be limited by man-made noise. Where two or more cities are so located as to be effectively a single entity, the total population shall be used to determine the percentage of service from figure 20-1. When a station delivers a large range of field intensities over a city, the population receiving service will be computed as follows:

(1) Contours will be drawn in accordance with Figure 20-1 for 100%, 80%, 60%, 40%, and 20% of people served in accordance with the size of the city.

(2) Populations will be computed between these contours.

(3) The total population within each zone will be corrected by the average percent of people receiving service. The sum of these populations gives the number of people receiving service.

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON, D. C.

April 3, 1946

MEMORANDUM TO MEMBERS OF COMMITTEES I, II and III:

1. Draft C of the "Method of Computing Service, etc." is enclosed.

2. Curves referred to in paragraph D-3 are in preparation and will be duplicated by hectograph for prompt distribution by mail. They are based on the following assumptions:

   a. Attenuation for transmission by two reflections is the square of that for transmission by one reflection and the attenuation for transmission by three reflections is the cube of that for transmission by one reflection.

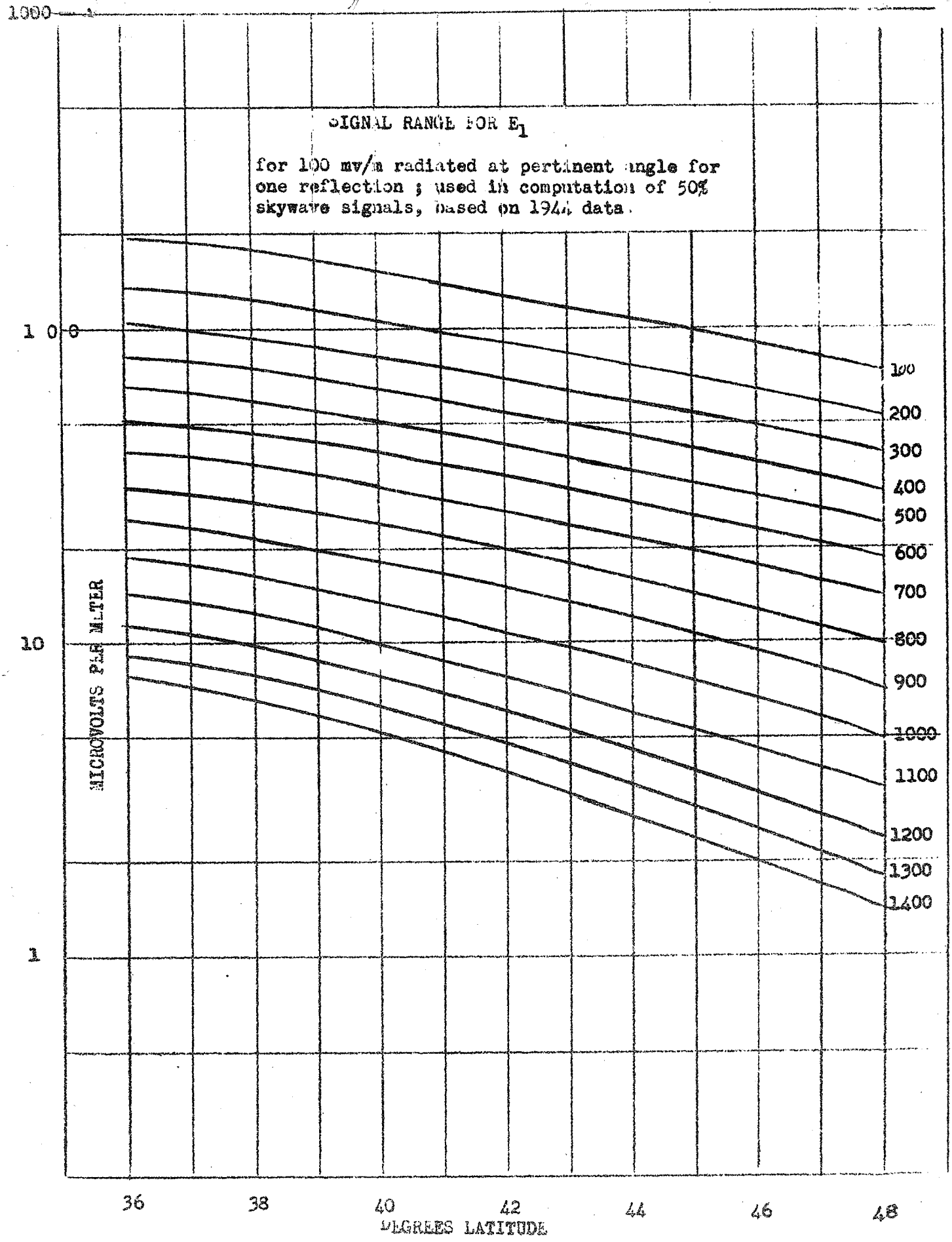
   b. Reflections are from E layer only.

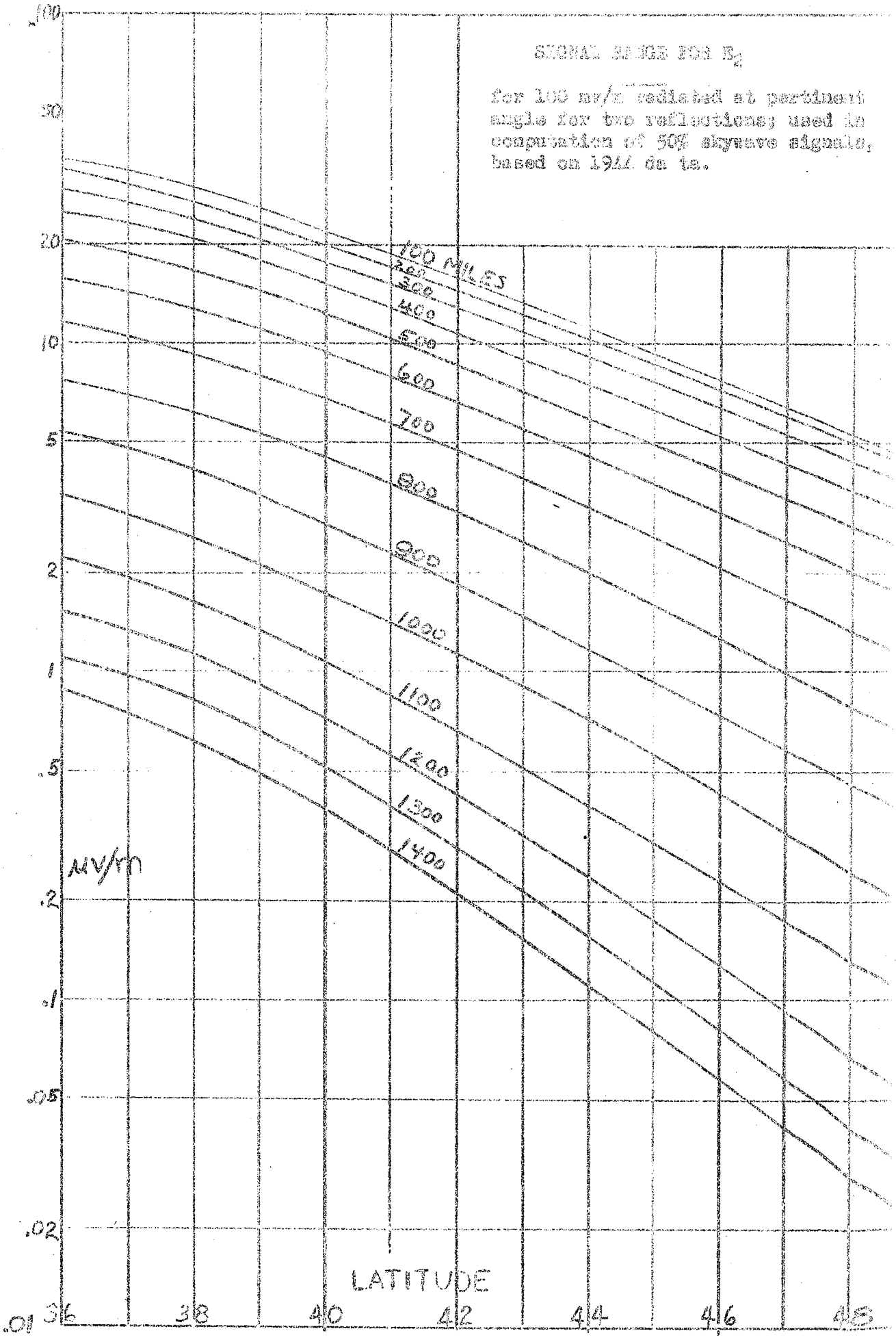
   From the method of deriving these, their application to a 0.311 antenna vertical pattern should give the same results as the 50% skywave signal range chart. Moreover for such distribution, the error involved in omitting E_2 and E_3 is small. Consideration might well be given to substituting this method in all cases in place of the 50% skywave signal range chart, making the criterion as to whether to include one, two or three rays, the amount of error involved in omitting the higher order of reflections.

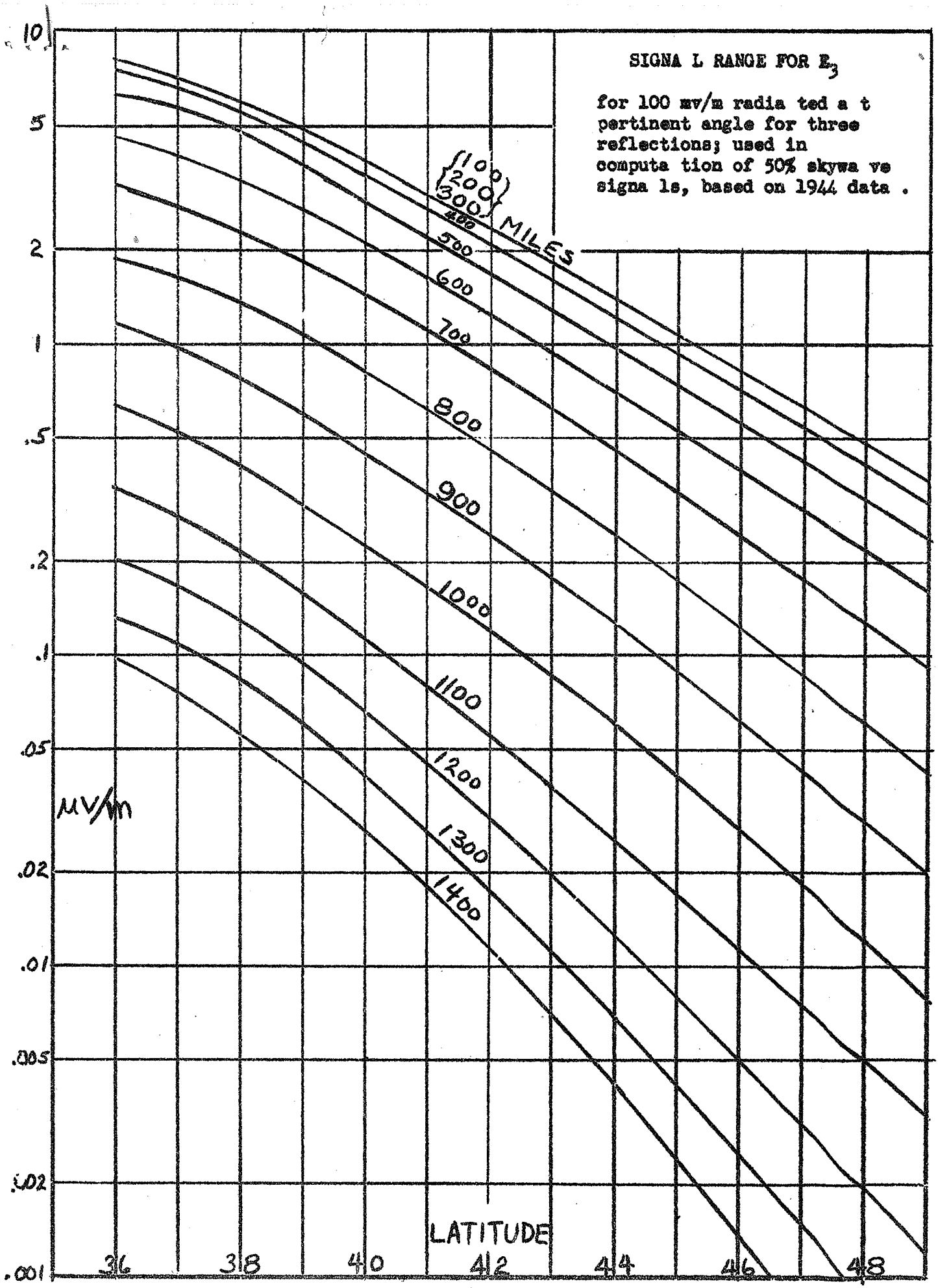
3. The promised revision in the 50% skywave signal range chart to show close distances is now on the drafting table and will be distributed as soon as duplicated (by multilith process).

4. Meeting 8 April, 10 am room 2230

for G. P. ADAIR
Chief Engineer


SIGNAL RANGE FOR E_1
for 100 mv/m radiated at pertinent angle for one reflection ; used in computation of 50% skywave signals, based on 1944 data.
1000
100
10
1
MICROVOLTS PER METER
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
36
38
40
42
44
46
48
DEGREES LATITUDE


SIGNAL RANGES FOR E_2
for 100 mv/m radiated at pertinent angle for two reflections; used in computation of 50% skywave signals, based on 1941 data.
100
30
20
10
5
2
1
.5
.2
.1
.05
.02
.01
MV/m
100 MILES
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
LATITUDE
36
38
40
42
44
46
48


SIGNAL RANGE FOR E_3
for 100 mv/m radiated at pertinent angle for three reflections; used in computation of 50% skywave signals, based on 1944 data.
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
MILES
10
5
2
1
.5
.2
.1
.05
.02
.01
.005
.002
.001
MV/m
LATITUDE
36
38
40
42
44
46
48

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON? D. C.

DAVIS

DRAFT B

March 28, 1946

Method of Computing Service and Interference for use in Connection with Docket #6741

The following methods and procedures are recommended for the preparation of technical testimony concerning service and interference in the Clear Channel Hearing, Docket #6741. They are based on the results of the studies of Committees I, II and III. They constitute, in general, revisions in the methods presently established in the Standards of Good Engineering Practice. The latter may be used to the extent that they are not at variance with this document. It is intended later to incorporate these methods and procedures into a general revision of the Commission's Standards.

TABLE OF CONTENTS

A. Definition of terms:

Interference: The effect obtained in reception when the ratio of desired field intensity to undesired field intensity (atmospheric noise, man-made noise or radio signal) is less than the value considered by listeners to be the borderline between "satisfactory" and "unsatisfactory."

Hourly median value. (of skywave field intensity, atmospheric noise intensity, or any other function varying with time): That value which is exceeded for a total of 30 minutes in an hour.

50% Skywave signal. The hourly median skywave field intensity which is exceeded at a given receiving location on 50% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

10% Skywave signal: The hourly median skywave field intensity which is exceeded at a given receiving location on 10% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

Radiated field: The inverse distance field at one mile from a transmitting antenna, in a particular direction.

Pertinent Angle: The angle θ_1 in Figure 6 of the Commission's present Standards.

Groundwave Service: Service obtained from the groundwave signal.

Skywave Service: Service obtained from the skywave signal.

Iso-service Contour: The contour defining a particular grade of service.

B. Grades of Service

1. Standard Ratio of Desired Signal-to-Interference. This is the same for all grades of service

Type of Interference	Ratio, Desired to Undesired
Atmospheric Noise	100* to 1, carrier to any noise. (4 kc e.b.w.)

*Tentative: Subject to revision if required by further studies now in progress by Committee I.

1/NOTE: In cases involving service or interference from skywaves, where there is variation of ratio within the hour at any point, the point at which the standard ratio is obtained for 90% of the hour shall be used to establish grades of service.

Type of Interference (Cont'd)	Ratio, Desired to Undesired
Man-made noise	30 to 1, carrier to noise level (RCA 312 type meter)
Other Station Interference (co-channel)	20 to 1, instantaneous carrier ratio*
Other Station Interference (adjacent channel)	See paragraph G
Station's own Skywave Signal (fading zone)	2 to 1, groundwave to instantaneous skywave or instantaneous skywave to groundwave

2. Grades of groundwave service ona percent of time basis: (Groundwave signals are assumed not to vary with time.)

(a) Grade A service.

(1) When limited by atmospherics, grade A service will be assumed within the contour at which the standard ratio is obtained for 90% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, grade A service will be assumed within the contour at which the standard ratio is obtained.

(3) When limited by other station skywave interference, grade A service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights of the year. Since the value of signal for 90% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of groundwave to 10% skywave
Same channel	37:1
1st adjacent channel	1.83:1
2nd adjacent channel	1:10.9

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave (fading zone, inner edge), grade A service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights. This occurs at the point where the 10% skywave signal is 0.27 times the groundwave signal.

(5) When limited by man-made noise, grade A service will be assumed within the contour established by figure 20-1 which will serve 90% of the population. Note that in calculating population served, the number within the grade A contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference, (Atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the fading zone), The type involving the most severe interference will determine the existence or absence of grade A service at any point.

(b) Grade B service.

(1) When limited by Atmospherics, grade B service will be

assumed beyond the grade A service area and within the contour at which the standard ratio is obtained for 50% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, no grade B service is defined and all areas outside the grade A service area are considered as having no service.

(3) When limited by other-station skywave interference, grade B service will be assumed beyond the grade A service area and within the contour at which the standard ratio 1/ is obtained for 50% of the nights of the year. Since the value of signal for 90% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of groundwave to 50% of skywave
Same channel	37:1
1st adjacent channel	1.83:1
2nd adjacent channel	1:10.9

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave, (Fading zone, inner edge) grade B service will be assumed beyond the grade A service area and within the contour at which the standard ratio 1/ is obtained on 50% of the nights. This occurs at the point where the 50% skywave signal is 0.27 times the groundwave signal.

(5) (When limited by man-made noise, grade B service is assumed beyond the grade A service area and within the contour established by figure 20-1 which will serve 70% of the population. Note that in calculating population served, the number within the grade B contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference. (Atmospherics, man-made noise, co-channel interference, adjacent channel interference or the fading zone.) The type involving the most severe interference will determine the existence or absence of grade B service at a point.

(c) Grade C service is defined as whatever groundwave service exists beyond the grade B service area.

3. Grades of skywave service on a percent of time basis.

(a) Grade D s ervice.

(1) When limited by atmospherics. Grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. Thus at a location where the value of 50% atmospherics indicates a required signal of 0.4 mv/m, this value represents the signal which must be exceeded for 90% of the hour 1/. Since the ratio of the skywave exceeded for 90% of the hour to the hourly median value is 0.39, the corresponding hourly median value required is 0.4/0.39 = 1.0 mv/m. This is the value which must be obtained on 90% of the nights of the year for grade D skywave service.

(2) When limited by other-station groundwave interference, grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 80% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 80% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:7.8
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference, grade D skywave service will be assumed within the contour at which the ratio of desired ~~50%~~ 80 skywave to undesired ~~10%~~ 50 skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 80% of the nights of the year. Since the ratio of the hourly median value of a skywave to the value exceeded for 90% of the hour is 2.56, the value of the 80% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made noise, grade D skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 90% of the population. Note that in calculating population served, the number within the grade D contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference, the rule is similar to that for grade A service.

(b) Grade E service

(1) When limited by atmospherics grade E skywave service will be assumed beyond the grade D service area and within the contour at which the standard ratio 1/ is obtained on 60% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. In the example given in paragraph 3 (a) (1) the 1.0 mv/m must be obtained on 60% of the nights of the year for grade E skywave service.

(2) When limited by other-station groundwave interference. grade E skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 50% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 50% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:78
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference.

Grade E skywave service will be assumed within the contour at which the ratio of desired 50% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade E skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 50% of the nights of the year. Since the ratio of the hourly median value of a skywave tc the value exceeded for 90% of the hour is 2.56, the value of the 50% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made ndise, grade E skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 70% of the population. Note that in calculating population served, the number within the grade D contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference (atmospherics, man made noise, co-channel interference, adjacent channel, interference, or the fading zone). The type involving the most severe interference will determine the existence or absence of grade E service at any point.

(c) Grade F Service

(1) When limited by atmospherics grade F skywave service will be assumed beyond the grade E service area and within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. In the example given in paragraph 3 (a) (1) the 1.0 mv/m must be obtained on 30% of the nights of the year for grade F skywave service.

(2) When limited by other-station groundwave interference. Grade F skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year. This requires a ratio of signal intensity as follows:

	Ratio of desired 50% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:7.8
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference. Grade F skywave service will be assumed within the contour at which the ratio of desired 30% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade F skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year. Since the ratio of the hourly median value of a skywave to the value exceeded for 90% of the hour is 2.56, the value of the 30% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made noise, grade F skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 50% of the population. Note that in calculating population served, the number within the grade F contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference (atmospherics, man made noise, co-channel interference, adjacent channel interference, or the fading zone) The type involving the most severe interference will determine the existence or absence of grade F service at any point.

C. Use of Atmospherics Maps.

Two maps are provided: These show the daytime and the nighttime contours of field intensities required to render atmospherics-free service (assuming 100 to 1 as the standard ratio) for 90% of the year for 1000 kc. Interpolation for points between contour lines may be accomplished by using the shortest line through the point and between adjacent contours. The required signal for other frequencies is determined by applying the following formulas.

$$\text{Daytime} \quad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.86$$

$$\text{Nighttime} \quad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.5$$

Where f_{kc} is the frequency in kilocycles
E_f is the field intensity at that frequency
E_{1000} is the field intensity indicated by the map.

For determining the field required for service 50% of the year, the field required for service for 90% of the year is multiplied by 0.16.

D. Use of Skywave Curves.

1. The latitude to be used is the latitude of the midpoint of the path between the transmitter and the receiving point. Note that only on paths along the meridian is this latitude exactly half way between the latitude of the transmitter and that of the receiver. On long east-west paths, particularly at the higher latitudes the difference may be significant. For midpoints above 49° and below 35°, the curve for 49° and 35° respectively shall be used.

2. The radiation to be used is the radiation at the proper azimuth and at the pertinent angle. In the case of antennas with minima in the vertical plane it is recognized that the field intensity at a distant point may be in excess of the value calculated from the radiation at a pertinent angle in a minimum. The following will be used to make allowance for this fact:

In case of antennas with a vertical pattern in which radiation at any angle above the pertinent angle is greater than the radiation at the pertinent angle, the radiation at the pertinent angle shall be compared with the radiation of a short vertical antenna which would radiate the same total amount of power in the vertical quadrant. The actual radiation or the radiation of the equivalent short vertical antenna shall be used whichever is greater. The RMS value in the vertical plane where $E = K f(\theta)$ is given by the expression:

$$E^2_{RMS} = K^2 \int f^2(\theta) \cos \theta \, d\theta$$

Where θ is the angle above the horizon
$f(\theta)$ is the function describing the variation of radiation E with the angle θ.
K is a constant.

3. The accuracy of the skywave curves is not well established by experiment at distances less than 250 miles. They are extended to 50 miles by assuming the same attenuation of signal below the inverse distance field as was observed at distances from 250 miles to 600 miles. They will be used until such time as they may be corrected by further experimental evidence.

E. Method of Using Groundwave Curves.

Where accurate measurements of groundwave signals are not available, the Commission's groundwave curves (Appendix I of present Standards) shall be used. If the conductivity has not been established by measurements, the Commission's map of conductivity shall be used (Figure 3 of the present Standards). The recommended procedure where the signal traverses terrain of several conductivities is the equivalent distance method proposed by H. L. Kirke. In this method, the actual transmitter is replaced by an imaginary transmitter of equal power but at a different distance, the distance being such that the field at the junction of the two conductivities is the same as that from the actual transmitter but for a path having the conductivity of the second part of the path. In the case of high conductivity followed by low conductivity the imaginary transmitter will be moved nearer the receiver, and conversely. As an example, suppose on 700 kc a signal of 100 mv/m at a mile is radiated over a conductivity of 10 x 10^{-14} c.m.u. for 15 miles, and over 2 x 10^{-14} thereafter. Suppose further it is desired to determine the distance to the 0.5 mv/m contour. The field at 15 miles will be 4.8 mv/m and the equivalent distance for conductivity of 2 x 10^{-14} is 8 miles, which is 7 miles closer than the actual transmitter. The distance to the 0.5 mv/m contour for conductivity 2 x 10^{-14} is 25 miles (from the imaginary transmitter) or 32 miles from the actual transmitter.

F. Determination of RSS Interference

When two or more interfering 10% skywave signals on the same frequency exist at a point, their resultant is considered to be the Root-sum - square value of the components. Calculation is accomplished by considering the signals in or der of decreasing magnitude and excluding signals which are less than 25% of the RSS of signals already included. This method is also used for two or more interfering groundwave signals or for two or more interfering 50% skywave signals.

G. Other-Signal Interference Ratios

The following table is to be used for determining the ratio of field strength of a desired to an undesired signal (or RSS value of two or more undesired signals) below which interference will exist.

Frequency Separation of desired & undesired signals	Desired groundwave to undesired groundwave	Desired groundwave to undesired 10% skywave (Grade A)	Desired groundwave to undesired 50% skywave (Grade B)	Desired 80% skywave to undesired groundwave (Grade D)
0 kc	20:1	37:1	37:1	51:1
10 kc	1:1	1.83:1	1.83:1	2.56:1
20 kc	1:20	1:10.9	1:10.9	1:7.8
30 kc	1:50			1:19.5

Desired 50% skywave to undesired groundwave (Grade E)	Desired 30% skywave to undesired ground wave (Grade F)	Desired 80% skywave to undesired 50% skywave (Grade D)	Desired 50% skywave to undesired 50% skywave (Grade E)	Desired 30% skywave to undesired 50% skywave (Grade F)
51:1	51:1	60:1	60:1	60:1
2.56:1	2.56:1	3:1	3:1	3:1
1:7.8	1:7.8	3:20	3:20	3:20
1:19.5	1:19.5			

H. Calculating urban populations within service contours.

Coverage to a city will be assumed to be rendered to the percent of the population indicated in figure 20-1. The field intensity contour to be used is that which includes 50% of the area of the city, interpolating when necessary between appropriate lines on the chart. Signals less than 0.5 mv/m will not be considered to render any service to urban areas. Rural areas and towns of less than 2,500 population will not be considered to be limited by man-made noise. Where two or more cities are so located as to be effectively a single entity, the total population shall be used to determine the percentage of service from figure 20-1. When a station delivers a large range of field intensities over a city, the population receiving service will be computed as follows:

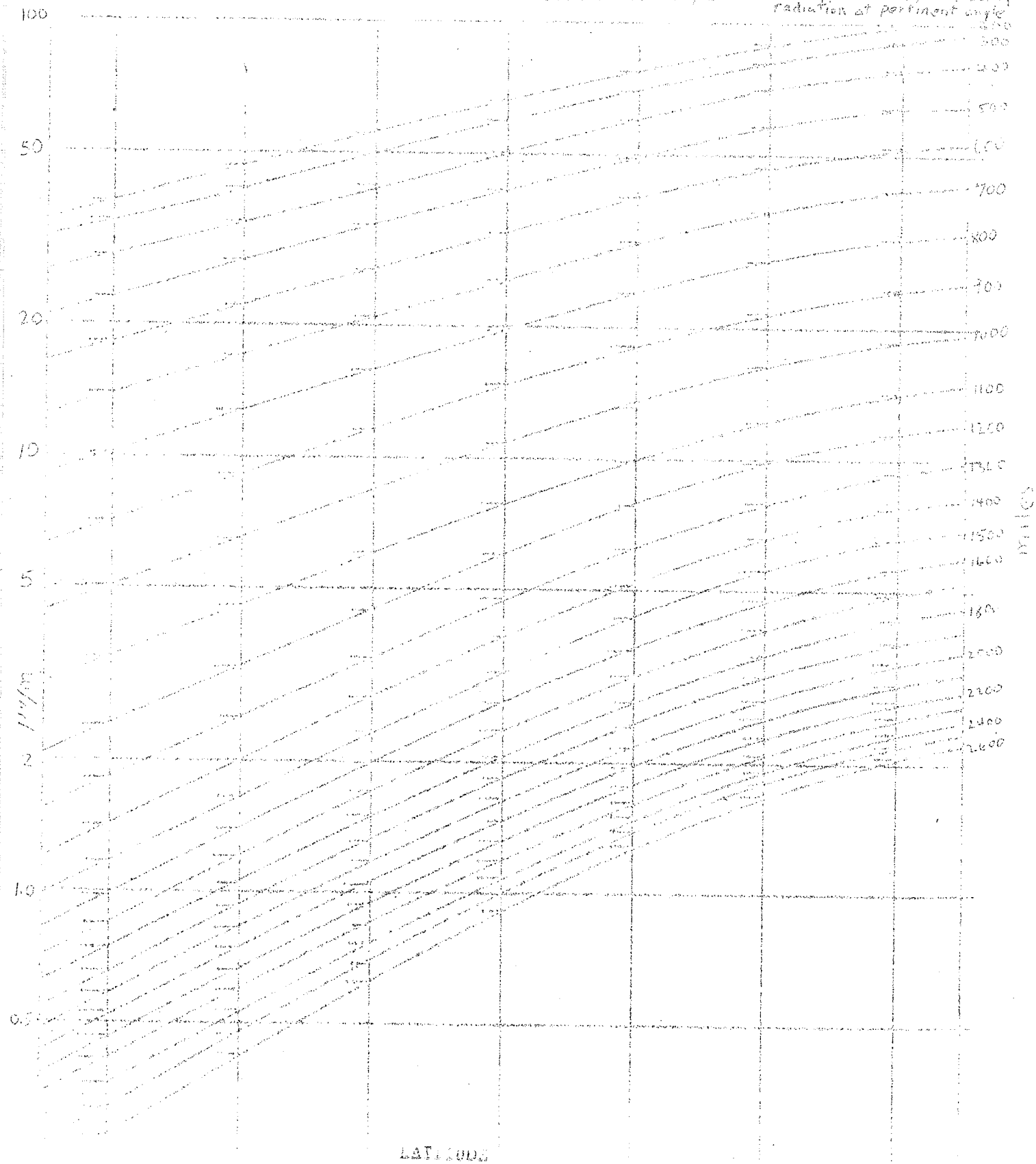
(1) Contours will be drawn in accordance with Figure 20-1 for 100%, 80%, 60%, 40%, and 20% of people served in accordance with the size of the city.

(2) Populations will be computed between these contours.

(3) The total population within each zone will be corrected by the average percent of people receiving service. The sum of these populations gives the number of people receiving service.

SIGNAL RANGE CHART
50% SIGNAL CIRCLE (2944)
from 0.311 λ antenna
with horizontal radiation of 100 mi/in

Note: Revised Charts under preparation for 90% and 10% signals, showing also close distances, and using radiation at pertinent angle



FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON? D. C.

DRAFT B

March 28, 1946

Method of Computing Service and Interference for use in Connection with Docket #6741

The following methods and procedures are recommended for the preparation of technical testimony concerning service and interference in the Clear Channel Hearing, Docket #6741. They are based on the results of the studies of Committees I, II and III. They constitute, in general, revisions in the methods presently established in the Standards of Good Engineering Practice. The latter may be used to the extent that they are not at variance with this document. It is intended later to incorporate these methods and procedures into a general revision of the Commission's Standards.

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A. Definition of terms:

Interference: The effect obtained in reception when the ratio of desired field intensity to undesired field intensity (atmospheric noise, man-made noise or radio signal) is less than the value considered by listeners to be the borderline between "satisfactory" and "unsatisfactory."

Hourly median value. (of skywave field intensity, atmospheric noise intensity, or any other function varying with time): That value which is exceeded for a total of 30 minutes in an hour.

50% Skywave signal. The hourly median skywave field intensity which is exceeded at a given receiving location on 50% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

10% Skywave signal: The hourly median skywave field intensity which is exceeded at a given receiving location on 10% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used.)

Radiated field: The inverse distance field at one mile from a transmitting antenna, in a particular direction.

Pertinent Angle: The angle θ_1 in Figure 6 of the Commission's present Standards.

Groundwave Service: Service obtained from the groundwave signal.

Skywave Service: Service obtained from the skywave signal.

Iso-service Contour: The contour defining a particular grade of service.

B. Grades of Service

1. Standard Ratio of Desired Signal-to-Interference. This is the same for all grades of service

Type of Interference	Ratio, Desired to Undesired
Atmospheric Noise	100* to 1, carrier to any noise. (4 kc e.b.w.)

*Tentative: Subject to revision if required by further studies now in progress by Committee I.

1/NOTE: In cases involving service or interference from skywaves, where there is variation of ratio within the hour at any point, the point at which the standard ratio is obtained for 90% of the hour shall be used to establish grades of service.

Type of Interference (Cont'd)	Ratio, Desired to Undesired
Man-made noise	30 to 1, carrier to noise level (RCA 312 type meter)
Other Station Interference (co-channel)	20 to 1, instantaneous carrier ratio*
Other Station Interference (adjacent channel)	See paragraph G
Station's own Skywave Signal (fading zone)	2 to 1, groundwave to instantaneous skywave or instantaneous skywave to groundwave

2. Grades of groundwave service ona percent of time basis: (Groundwave signals are assumed not to vary with time.)

(a) Grade A service.

(1) When limited by atmospherics, grade A service will be assumed within the contour at which the standard ratio is obtained for 90% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, grade A service will be assumed within the contour at which the standard ratio is obtained.

(3) When limited by other station skywave interference, grade A service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights of the year. Since the value of signal for 90% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of groundwave to 10% skywave
Same channel	37:1
1st adjacent channel	1.83:1
2nd adjacent channel	1:10.9

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave (fading zone, inner edge), grade A service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights. This occurs at the point where the 10% skywave signal is 0.27 times the groundwave signal.

(5) When limited by man-made noise, grade A service will be assumed within the contour established by figure 20-1 which will serve 90% of the population. Note that in calculating population served, the number within the grade A contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference, (Atmospherics, man-made noise, co-channel interference, adjacent channel interference, or the fading zone), The type involving the most severe interference will determine the existence or absence of grade A service at any point.

(b) Grade B service.

(1) When limited by Atmospherics, grade B service will be

assumed beyond the grade A service area and within the contour at which the standard ratio is obtained for 50% of the time throughout the year. This will be determined from Figures 12-1 and 14-1 in accordance with paragraph C.

(2) When limited by other-station groundwave interference, no grade B service is defined and all areas outside the grade A service area are considered as having no service.

(3) When limited by other-station skywave interference, grade B service will be assumed beyond the grade A service area and within the contour at which the standard ratio 1/ is obtained for 50% of the nights of the year. Since the value of signal for 90% of the hour is 1.83 times the hourly median value, the groundwave signal required is as follows:

	Ratio of groundwave to 50% of skywave
Same channel	37:1
1st adjacent channel	1.83:1
2nd adjacent channel	1:10.9

Two or more interfering skywave signals on the same channel will be considered as having an RSS value determined in accordance with paragraph F.

(4) When limited by interference from the station's own skywave, (Fading zone, inner edge) grade B service will be assumed beyond the grade A service area and within the contour at which the standard ratio 1/ is obtained on 50% of the nights. This occurs at the point where the 50% skywave signal is 0.27 times the groundwave signal.

(5) (When limited by man-made noise, grade B service is assumed beyond the grade A service area and within the contour established by figure 20-1 which will serve 70% of the population. Note that in calculating population served, the number within the grade B contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference. (Atmospherics, man-made noise, co-channel interference, adjacent channel interference or the fading zone.) The type involving the most severe interference will determine the existence or absence of grade B service at a point.

(c) Grade C service is defined as whatever groundwave service exists beyond the grade B service area.

3. Grades of skywave service on a percent of time basis.

(a) Grade D s ervice.

(1) When limited by atmospherics. Grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 90% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. Thus at a location where the value of 50% atmospherics indicates a required signal of 0.4 mv/m, this value represents the signal which must be exceeded for 90% of the hour 1/. Since the ratio of the skywave exceeded for 90% of the hour to the hourly median value is 0.39, the corresponding hourly median value required is 0.4/0.39 = 1.0 mv/m. This is the value which must be obtained on 90% of the nights of the year for grade D skywave service.

(2) When limited by other-station groundwave interference, grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 80% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 80% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:7.8
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference, grade D skywave service will be assumed within the contour at which the ratio of desired ~~50%~~ 80 skywave to undesired ~~10%~~ 50 skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade D skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 80% of the nights of the year. Since the ratio of the hourly median value of a skywave to the value exceeded for 90% of the hour is 2.56, the value of the 80% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made noise, grade D skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 90% of the population. Note that in calculating population served, the number within the grade D contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference, the rule is similar to that for grade A service.

(b) Grade E service

(1) When limited by atmospherics grade E skywave service will be assumed beyond the grade D service area and within the contour at which the standard ratio 1/ is obtained on 60% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. In the example given in paragraph 3 (a) (1) the 1.0 mv/m must be obtained on 60% of the nights of the year for grade E skywave service.

(2) When limited by other-station groundwave interference. grade E skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 50% of the nights. This requires a ratio of signal intensity as follows:

	Ratio of desired 50% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:78
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference.

Grade E skywave service will be assumed within the contour at which the ratio of desired 50% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade E skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 50% of the nights of the year. Since the ratio of the hourly median value of a skywave to the value exceeded for 90% of the hour is 2.56, the value of the 50% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made ndise, grade E skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 70% of the population. Note that in calculating population served, the number within the grade D contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference (atmospherics, man made noise, co-channel interference, adjacent channel, interference, or the fading zone). The type involving the most severe interference will determine the existence or absence of grade E service at any point.

(c) Grade F Service

(1) When limited by atmospherics grade F skywave service will be assumed beyond the grade E service area and within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year assuming variation of skywave service signal only and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. In the example given in paragraph 3 (a) (1) the 1.0 mv/m must be obtained on 30% of the nights of the year for grade F skywave service.

(2) When limited by other-station groundwave interference. Grade F skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year. This requires a ratio of signal intensity as follows:

	Ratio of desired 50% skywave to undesired groundwave
Same channel	51:1
1st adjacent channel	2.56:1
2nd adjacent channel	1:7.8
3rd adjacent channel	1:19.5

(3) When limited by other-station skywave interference. Grade F skywave service will be assumed within the contour at which the ratio of desired 30% skywave to undesired 50% skywave is as follows:

Same channel	60:1
1st adjacent channel	3:1
2nd adjacent channel	3:20

(4) When limited by interference from the station's own groundwave (fading zone, outer wall) grade F skywave service will be assumed within the contour at which the standard ratio 1/ is obtained on 30% of the nights of the year. Since the ratio of the hourly median value of a skywave to the value exceeded for 90% of the hour is 2.56, the value of the 30% skywave signal must be 5.1 times the groundwave signal.

(5) When limited by man-made noise, grade F skywave service will be assumed within the 50% skywave contour established by figure 20-1 which will serve 50% of the population. Note that in calculating population served, the number within the grade F contour will be determined in accordance with paragraph H.

(6) When limited by more than one type of interference (atmospherics, man made noise, co-channel interference, adjacent channel interference, or the fading zone) The type involving the most severe interference will determine the existence or absence of grade F service at any point.

C. Use of Atmospherics Maps.

Two maps are provided: These show the daytime and the nighttime contours of field intensities required to render atmospherics-free service (assuming 100 to 1 as the standard ratio) for 90% of the year for 1000 kc. Interpolation for points between contour lines may be accomplished by using the shortest line through the point and between adjacent contours. The required signal for other frequencies is determined by applying the following formulas.

$$\text{Daytime} \quad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.86$$

$$\text{Nighttime} \quad E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.5$$

Where f_{kc} is the frequency in kilocycles
E_f is the field intensity at that frequency
E_{1000} is the field intensity indicated by the map.

For determining the field required for service 50% of the year, the field required for service for 90% of the year is multiplied by 0.16.

D. Use of Skywave Curves.

1. The latitude to be used is the latitude of the mid-point of the path between the transmitter and the receiving point. Note that only on paths along the meridian is this latitude exactly half way between the latitude of the transmitter and that of the receiver. On long east-west paths, particularly at the higher latitudes the difference may be significant. For midpoints above 49° and below 35°, the curve for 49° and 35° respectively shall be used.

2. The radiation to be used is the radiation at the proper azimuth and at the pertinent angle. In the case of antennas with minima in the vertical plane it is recognized that the field intensity at a distant point may be in excess of the value calculated from the radiation at a pertinent angle in a minimum. The following will be used to make allowance for this fact:

In case of antennas with a vertical pattern in which radiation at any angle above the pertinent angle is greater than the radiation at the pertinent angle, the radiation at the pertinent angle shall be compared with the radiation of a short vertical antenna which would radiate the same total amount of power in the vertical quadrant. The actual radiation or the radiation of the equivalent short vertical antenna shall be used whichever is greater. The RMS value in the vertical plane where $E = K f(\theta)$ is given by the expression:

$$E^2_{RMS} = K^2 \int f^2(\theta) \cos \theta \, d\theta$$

Where θ is the angle above the horizon
$f(\theta)$ is the function describing the variation of radiation E with the angle θ.
K is a constant.

3. The accuracy of the skywave curves is not well established by experiment at distances less than 250 miles. They are extended to 50 miles by assuming the same attenuation of signal below the inverse distance field as was observed at distances from 250 miles to 600 miles. They will be used until such time as they may be corrected by further experimental evidence.

E. Method of Using Groundwave Curves.

Where accurate measurements of groundwave signals are not available, the Commission's groundwave curves (Appendix I of present Standards) shall be used. If the conductivity has not been established by measurements, the Commission's map of conductivity shall be used (Figure 3 of the present Standards). The recommended procedure where the signal traverses terrain of several conductivities is the equivalent distance method proposed by H. L. Kirke. In this method, the actual transmitter is replaced by an imaginary transmitter of equal power but at a different distance, the distance being such that the field at the junction of the two conductivities is the same as that from the actual transmitter but for a path having the conductivity of the second part of the path. In the case of high conductivity followed by low conductivity the imaginary transmitter will be moved nearer the receiver, and conversely. As an example, suppose on 700 kc a signal of 100 mv/m at a mile is radiated over a conductivity of 10×10^{-14} c.m.u. for 15 miles, and over 2×10^{-14} thereafter. Suppose further it is desired to determine the distance to the 0.5 mv/m contour. The field at 15 miles will be 4.8 mv/m and the equivalent distance for conductivity of 2×10^{-14} is 8 miles, which is 7 miles closer than the actual transmitter. The distance to the 0.5 mv/m contour for conductivity 2×10^{-14} is 25 miles from the imaginary transmitter, or 32 miles from the actual transmitter.

F. Determination of RSS Interference

When two or more interfering 10% skywave signals on the same frequency exist at a point, their resultant is considered to be the Root-sum - square value of the components. Calculation is accomplished by considering the signals in order of decreasing magnitude and excluding signals which are less than 25% of the RSS of signals already included. This method is also used for two or more interfering groundwave signals or for two or more interfering 50% skywave signals.

G. Other-Signal Interference Ratios

The following table is to be used for determining the ratio of field strength of a desired to an undesired signal (or RSS value of two or more undesired signals) below which interference will exist.

Frequency Separation of desired & undesired signals	Desired groundwave to undesired groundwave	Desired groundwave to undesired 10% skywave (Grade A)	Desired groundwave to undesired 50% skywave (Grade B)	Desired 80% skywave to undesired groundwave (Grade D)
0 kc	20:1	37:1	37:1	51:1
10 kc	1:1	1.83:1	1.83:1	2.56:1
20 kc	1:20	1:10.9	1:10.9	1:7.8
30 kc	1:50			1:19.5

Desired 50% skywave to undesired groundwave (Grade E)	Desired 30% skywave to undesired groundwave (Grade F)	Desired 80% skywave to undesired 50% skywave (Grade D)	Desired 50% skywave to undesired 50% skywave (Grade E)	Desired 30% skywave to undesired 50% skywave (Grade F)
51:1	51:1	60:1	60:1	60:1
2.56:1	2.56:1	3:1	3:1	3:1
1:7.8	1:7.8	3:20	3:20	3:20
1:19.5	1:19.5			

H. Calculating urban populations within service contours.

Coverage to a city will be assumed to be rendered to the percent of the population indicated in figure 20-1. The field intensity contour to be used is that which includes 50% of the area of the city, interpolating when necessary between appropriate lines on the chart. Signals less than 0.5 mv/m will not be considered to render any service to urban areas. Rural areas and towns of less than 2,500 population will not be considered to be limited by man-made noise. Where two or more cities are so located as to be effectively a single entity, the total population shall be used to determine the percentage of service from figure 20-1. When a station delivers a large range of field intensities over a city, the population receiving service will be computed as follows:

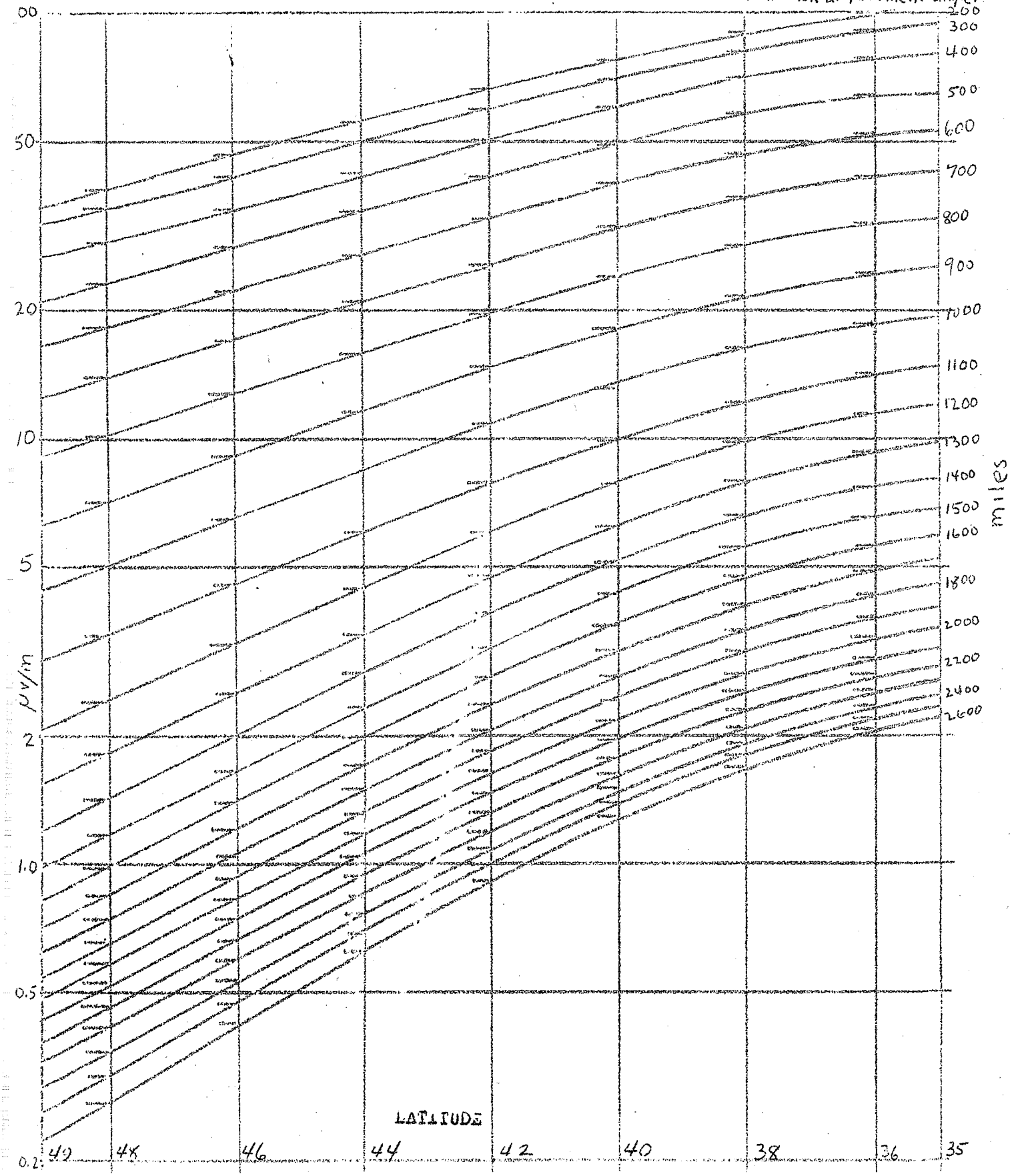
(1) Contours will be drawn in accordance with Figure 20-1 for 100%, 80%, 60%, 40%, and 20% of people served in accordance with the size of the city.

(2) Populations will be computed between these contours.

(3) The total population within each zone will be corrected by the average percent of people receiving service. The sum of these populations gives the number of people receiving service.

50% SKYWAVE SIGNAL (1944)
from 0.311 λ antenna
with horizontal radiation of 100 mv/m

preparation for 50% and 10% signals, showing also close distances, and using radiation at pertinent angle.



G.C. DAVIS

STATEMENT
ON
DAYTIME SKYWAVE
Statement by E. F. Vandivere

My testimony offers as an exhibit a report that contains a tabulation of data from recordings made by FCC engineers, an analysis of these data, and a representation of the results in the form of curves that may be used to estimate the intensity of interference, and its growth or duration.

The practical and general object of this analysis is to obtain curves representing "10% skywave field intensities" at any distance, in any direction, at any frequency, at any hour of transmitter local time for a station at any latitude.

In order to achieve the most accurate results possible as rapidly as possible this general aim has been limited here somewhat. Only noon, afternoon and evening data have been studied. The empirical curves, Figure 1a of the Standards of Good Engineering Practice, for 10% fields in the second hour after sunset have been used directly as point of departure in the derivation of curves representing fields in other hours. With respect to the first limitation, morning conditions are known to be not quite symmetrical with evening conditions, but they have been considered to be nearly enough symmetrical that the difference is of secondary practical importance. The second limitation is more serious but saved a great deal of time without perhaps limiting the immediately useful results very seriously. The chief effect of the direct use of the empirical curves for 10% fields in the second hour after sunset rather than the theoretical formulas for this second hour curve has been to limit the derivation skywave curves for other hours to distances less than approximately 1200 miles.

The analysis procedure is described in detail in the report. To outline it briefly: The curve of diurnal variation for 10% fields was determined for each transmission path and each year. As described in the report and for reasons stated there, the data from all years on a single path were combined to determine a composite diurnal curve for the path. This collection of diurnal curves was studied and it was determined that the fraction that the field in any particular hour is of the value ultimately attained in the second hour after sunset is predominantly a function of frequency and, as far as it has been possible to determine as yet, a function of frequency only. From this study, diurnal curves typical of 500, 1000, and 1500 Kc were drawn. These were applied to the 10% curve for 40° latitude in Figure 1a of the Standards of Good Engineering to produce curves East and West, North and South showing 10% fields in various hours for a station located at 40° latitude for each of three frequencies. This proliferation of curves, it should be noted, is mostly a matter of geometry -- of considering the equivalence of distance and time.

The accuracy of this great quantity of curves depends on the accuracy of the second hour curve and on that of the diurnal curves.

An estimate is made of the accuracy with which these curves may be expected to predict skywave signal intensities. It is estimated that measured data should deviate from the curves rather rarely by a factor as large as four to one, although in very unusual cases, where all the causes for deviation act in the same direction, larger deviations are quite possible. It may be noted that this compares quite favorably with the accuracy with which we are able to predict groundwave at large distances over ground of varying conductivity.

We may hope in the course of time -- and possibly even in the near future -- to remove all major sources of error in skywave propagation curves on account of inadequate physical theory, and we may even hope to get good measures of the fluctuations of measured data within the year and further, even, good measures of the fluctuations from year to year of annual statistics derived from the data. But in any case, we shall continue to be faced with measured data that deviates from any particular curve that we may draw. The approach of perfection of information would merely mean, for example, that it could be said that for a specified interval of years "10% fields" can be expected to deviate from the curves of this report by a ratio of 4 to 1 with a probability of, say, 10% rather than, as at present, with rare probability.

The concept of the "10% field" was, of course, introduced to dispose of statistical difficulties. The object was to provide protection from interference for most of the time, for 90% of the time. A difficulty however has arisen out of the fact that we engineers, all of us, have been reluctant statisticians. There is no such thing as a simple 10% field. This one rapidly learns when attempting to determine one from a mass of data. It is necessary to define what kind of field and 10% of what time. The annual "10% fields" tabulated in the report are"levels exceeded by hourly median field intensities on 10% of the days of the year". In the analysis of these data the 10% problem is immediately encountered again. The question is whether to take year to year 10% values of the annual 10% values. What has been taken is the year to year median. This has the result that from year to year annual 10% data can be expected to fall both above and below the curves shown.

The relative accuracy of the curves from frequency to frequency is considered to be fairly good -- a great deal better than the absolute accuracy.

The report also contains two illustrations of the application of the 10% curves. The one shows the encroachment of the

distortion zone on the primary service area with the approach of sunset for a station at 500, 1000 or 1500 Kc. The other illustrates the growth of interference at each of two stations 800 miles apart on a frequency of 1000 Kc, the one station at 50 Kw, the other at 10 Kw.

FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C.

March 19, 1946

MEMORANDUM TO MEMBERS OF CLEAR CHANNEL COMMITTEES I, II, AND III:

Subject: Meetings to Consider Changes in Allocation Standards

There will be a meeting of Committees I, II, and III on March 27, 28, and 29 respectively, at 11 A.M. in Room 2230, New Post Office Building, to consider proposed changes in allocation standards based on the results of the Committees' work.

A draft of the proposal will be completed and mailed to you by Friday, March 22.

It is intended to make use of the comments and recommendations of the Committees at these meetings, to further revise the proposal prior to consideration by a joint meeting of the three Committees on April 8. Confirmation of the latter date will be made later, but it is suggested that you mark it as reserved on your calendar.

E. W. Allen, Jr.
Chairman, Committee I

W. K. Roberts, Jr.
Chairman, Committee II

L. P. Wheeler
Chairman, Committee III

DAVIS

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON, D. C.

March 22, 1946

MEMORANDUM TO MEMBERS OF CLEAR CHANNEL COMMITTEES I, II AND III

Subject: Proposed Standards Revisions for Use in Docket #6741

In view of the urgency to obtain standards which will permit a uniform technical approach by all parties to the problems presented by the issues of Docket #6741, the Commission's Engineering Department has prepared the enclosed proposal. It is desired to obtain the advice and comments of the Clear Channel Technical Committees concerning them.

The subject matter falls entirely within the scope of the present part 3 of the Standards "Engineering Standards of Allocation." However, certain matters which do not appear immediately necessary for meeting the issues of Docket #6741, have been passed over for the time being, pending a general revision of the Standards as a whole.

It is requested that the enclosed document be studied carefully and comments be prepared for presentation at the meetings of Committees I, II and III on March 27, 28 and 29, 1946, at 11 A.M. in Room 2230, New Post Office Building. Comments may include recommendations as to matters which are not included in the attached document, but which are felt to be pertinent to the preparation of material for the hearing.

G. P. Adair
Chief Engineer

Enclosure

FEDERAL COMMUNICATIONS COMMISSION
ENGINEERING DEPARTMENT
WASHINGTON, D. C.

DRAFT A

March 22, 1946

Method of Computing Service and Interference for use in Connection with Docket #6741

The following methods and procedures are recommended for the preparation of technical testimony concerning service and interference in the Clear Channel Hearing, Docket #6741. They are based on the results of the studies of Committees I, II and III. They constitute, in general, revisions in the methods presently established in the Standards of Good Engineering Practice. The latter may be used to the extent that they are not at variance with this document. It is intended later to incorporate these methods and procedures into a general revision of the Commission's Standards.

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A. Definition of terms:

Interference: The effect obtained in a receiver when the ratio of desired field strength to undesired field strength (atmospheric noise, man-made noise or radio signal) is less than the value considered by listeners to be the borderline between "satisfactory" and "unsatisfactory."

Hourly median value (of skywave field intensity, atmospheric noise intensity, or any other function varying with time): That value which is exceeded for a total of 30 minutes in an hour.

50% Skywave signal: The hourly median skywave field intensity which is exceeded at a given receiving location on 50% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used).

10% Skywave signal: The hourly median skywave field intensity which is exceeded at a given receiving location on 10% of the nights of the year or any other long period. (1944 curves for the second hour after sunset, as prepared by Committee III, are to be used).

Radiation: The unattenuated field at one mile from the transmitting antenna.

Pertinent Angle: The angle Θ_1 in Figure 6 of the Commission's present Standards.

Primary Service is service obtained from the groundwave signal.

Secondary Service is service obtained from the skywave signal.

B. Grades of Service

1. Standard Signal-to-Interference Ratio - This is the same for all grades of service and is predicated upon satisfying approximately two-thirds of the listeners:

Type of Interference	Ratio, Desired to Undesired
Atmospheric Noise	100* to 1, carrier to 4 kc c.b.w. noise

* Tentative: Subject to revision if required by further studies now in progress by Committee I.

Type of Interference (Cont'd)	Ratio, Desired to Undesired
Man made Noise	30 to 1, carrier to noise level (RCA 312 type meter)
Other Station Interference (co-channel)	20 to 1, carrier ratio*
Other Station Interference (adjacent channel)	See paragraph G
Station's own Skywave Signal (fading zone)	1 to 2) 2 to 1) groundwave to instantaneous skywave

2. Grades of ~~Primary~~ Groundwave Service on a Percent of Time Basis

(Groundwave signals are assumed not to vary with time).

a. When limited by atmospherics. (See paragraph C)

~~(1)~~ "Preferred" primary service will be assumed within the contour at which the standard ratio is obtained for 90% of the month of June. This contour is intended for use in allocation matters, only for establishment of a minimum field strength for coverage of the city in which the main studio is located.

(2) "~~Normal~~" primary gw service will be assumed within the contour at which the standard ratio is obtained for 90% of the time throughout the year. This value will ordinarily be used for determining service for comparative purposes.

(3) "~~Partial~~" primary service will be assumed beyond the "~~Normal~~" primary service area and within the contour at which the standard ratio is obtained for 50% of the time throughout the year.

(4) "Intermittent" ~~primary~~ groundwave service is whatever gw ~~primary~~ service is obtained beyond the "~~Partial~~" ~~primary~~ groundwave service area.

* For two or more ~~undesired~~ signals on the same frequency, the resultant value of interference is considered to be the RSS value determined in accordance with paragraph F.

b. When limited by man made noise.

(1) ~~Primary~~ GROUND WAVE coverage to a metropolitan district or to a city not in a metropolitan district* will be assumed to be rendered to the percent of the population indicated in the attached chart. The field ~~strength~~ AVERAGE contour to be used is that which includes 50% of the area of the ~~metropolitan district or~~ city, interpolating when necessary, between the appropriate lines on the chart. Signals less than 0.5 mv/m will not be considered to render any service to urban areas.

(2) Rural areas and towns of less than 2,500 population will not be considered to be limited by man made noise.

c. When limited by other-station interference.

(1) If interference is from groundwave, determination of service area will be as under present standards, except for changed adjacent channel interference ratios.

(2) If interference is from skywave:

(a) Satisfactory service during an hour will be assumed within the contour at which the standard interference ratio is obtained for 90% of the hour. From Figure 6.1, the value of the interfering signal exceeded for 10% of the hour is 1.83 times the hourly median value.

(b) Normal primary service will be assumed within the contour at which satisfactory service during the hour is obtained on 90% of the nights of the year. Thus, if the "10% skywave signal" at a point is 0.2 mv/m, the hourly median value for 90% of the nights of the year will be 0.2 mv/m or less. The signal for 90% of the hour, when the median value is 0.2 mv/m, will be 0.366 mv/m and the limitation to the full primary service

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* If a city is nominally in a metropolitan district, but it can be shown to be effectively separated physically from the rest of the district, the population of the city may be used in this determination.

of a station on the same channel at that point will be 7.3 mv/m. On an adjacent channel 10 kc removed, the limitation would be 0.366 mv/m.

(c) Partial primary service will be assumed beyond the normal primary service area and within the contour at which satisfactory service during the hour is obtained on 50% of the nights of the year.

(d) Intermittent primary service is whatever primary service is obtained beyond the partial primary service area.

(e) The RSS value of two or more interfering ~~groundwave signals on two or more interfering~~ 10% skywave signals will be used in accordance with paragraph F.

d. When limited by interference from the station's own skywave (Fading Zone).

(1) Satisfactory service during an hour will be assumed within the contour at which the standard interference ratio is obtained for 90% of the hour. Since the value of the skywave exceeded 10% of the hour is 1.83 times the hourly median value, the standard ratio of 2 to 1 is attained for less than 10% of the hour when the hourly median skywave is less than 0.27 times the groundwave.

(2) Normal primary service will be assumed within the contour at which satisfactory service during the hour is obtained on 90% of the nights. That is, the 10% skywave signal is 0.27 times the groundwave signal.

(3) Partial primary service will be assumed beyond the normal primary service area and within the contour at which satisfactory service during the hour is obtained on 50% of the nights of the year. That is, the 50% skywave signal is 0.27 times the groundwave signal.

e. When limited by more than one type of interference.

(Atmospherics, man made noise, co-channel other-station interference, adjacent channel interference, or the fading zone). The type which involves the greatest interference will be used in establishing each type of service at any point.

3. Grades of Secondary Service on a Percent of Time Basis.

a. Satisfactory service during an hour will be assumed within the contour at which the standard interference ratio is exceeded for 90% of the hour. The value of skywave exceeded for 90% of the hour will be 0.39 times the hourly median value.

b. When limited by atmospherics.

GRADE B "Normal" secondary service will be assumed within the contour at which satisfactory service during an hour is obtained on 50% of the nights of the year, assuming variation of the skywave service signal only, and a value of atmospheric noise fixed at the value obtained on 50% of the nights of the year. Thus at a location where the value of annual 50% atmospherics indicates a required signal of 0.4 mv/m, this represents the value of skywave signal which must be exceeded for 90% of the hour. The corresponding hourly median value is 0.40/0.39 = 1.0 mv/m. This value must be obtained on 50% of the nights of the year for normal secondary service.

c. When limited by man made noise.

"Normal" secondary service will be assumed to be rendered to the percent of population indicated in the attached chart. Calculations will be made in the same way as for primary service, substituting the 50% skywave contour for the groundwave contour.

d. When limited by other-station interference.

(1) If interference is from groundwave, "normal" secondary service will be assumed within the contour at which satisfactory service during an hour is obtained on 50% of the nights.

(2) If interference is from skywave, "normal" secondary service will be assumed within the contour at which satisfactory service during an hour is obtained on 50% of the nights. Note that from formula 3.4, Exhibit 23, satisfactory service during the hour corresponds to a ratio of 60 to 1 of the hourly

median values of desired to undesired signals on the same channel, 3 to 1 for first adjacent channel and 3 to 20 for second adjacent channel.

e. When limited by interference from the station's own groundwave signal (Fading Zone, outer limit).

(1) Satisfactory service during the hour will be assumed within the contour at which the standard interference ratio is obtained for 90% of the hour. Since the hourly median value of a skywave is 2.56 times the value exceeded for 90% of the hour, the skywave will be uninterfered with by the groundwave when it is greater than 5.1 times the groundwave.

(2) Normal secondary service will be assumed beyond the contour at which satisfactory service during an hour is obtained on 50% of the nights of the year. That is, the 50% skywave signal is 5.1 times the groundwave signal.

f. When limited by more than one type of interference.

(atmospherics, man made noise, co-channel other-station interference, adjacent channel interference, or fading zone interference). The type which involves the greatest interference will be used in establishing the service at any point.

C. Use of Atmospherics Maps.

Four maps are provided: Two of these show the daytime and the nighttime contours of field intensities required to render atmospherics-free service (assuming 100 to 1 as the standard ratio) for 90% of the year for 1000 kc. The third and fourth show the same contours based on service for 90% of the month of June. Interpolation for points between contour lines may be accomplished by using the shortest line through the point and between adjacent contours. The required signal for other frequencies is determined by applying the following formulas.

Daytime $$E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.86$$

Nighttime $$E_f = E_{1000} \times \left(\frac{1000}{f_{kc}}\right) 0.5$$

Where f_{kc} is the frequency in kilocycles
E_f is the field intensity at that frequency
E_{1000} is the field intensity indicated by the map.

For determining the field required for service 50% of the year, the field required for service for 90% of the year is multiplied by 0.15, daytime or by 0.17, nighttime.

D. Use of Skywave Curves.

1. The latitude to be used is the latitude of the mid-point of the path between the transmitter and the receiving point. Note that only on paths along the meridian is this latitude exactly half way between the latitude of the transmitter and that of the receiver. On long east-west paths, particularly at the higher latitudes the difference may be significant. For midpoints above 49° and below 35°, the curve for 49° and 35° respectively shall be used.

2. The radiation to be used is the radiation at the proper azimuth and at the pertinent angle. In the case of antennas with minima in the vertical plane it is recognized that the field intensity at a distant point may be in excess of the value calculated from the radiation at a pertinent angle in a minimum. The following will be used to make allowance for this fact:

In case of antennas with a vertical pattern in which radiation at any angle above the pertinent angle is greater than the radiation at the pertinent angle, the radiation at the pertinent angle shall be compared with the radiation of a short vertical antenna which would radiate the same total amount of power in the vertical quadrant. The actual radiation or the radiation of the equivalent short vertical antenna shall be used whichever is greater. The RMS value in the vertical plane where $E = K f(\theta)$ is given by the expression:

$$E^2_{RMS} = \frac{2}{\pi} K^2 \int_0^{\pi/2} f^2(\theta) \cos \theta \, d\theta$$

Where θ is the angle above the horizon
$f(\theta)$ is the function describing the variation of radiation E with the angle θ.
K is a constant.

3. The accuracy of the skywave curves is not well established by experiment at distances less than 250 miles. They are extended to 50 miles by assuming the same attenuation of signal below the inverse distance field as was observed at distances from 250 miles to 600 miles. They will be used until such time as they may be corrected by further experimental evidence.

E. Method of Using Groundwave Curves.

Where accurate measurements of groundwave signals are not available, the Commission's groundwave curves (Appendix I of present Standards) shall be used. If the conductivity has not been established by measurements, the Commission's map of conductivity shall be used (Figure 3 of the present Standards). The recommended procedure where the signal traverses terrain of several conductivities is the equivalent distance method proposed by H. L. Kirke. In this method, the actual transmitter is replaced by an imaginary transmitter of equal power but at a different distance, the distance being such that the field at the junction of the two conductivities is the same as that from the actual transmitter but for a path having the conductivity of the second part of the path. In the case of high conductivity followed by low conductivity the imaginary transmitter will be moved nearer the receiver, and conversely. As an example, suppose on 700 kc a signal of 100 mv/m at a mile is radiated over a conductivity of 10×10^{-14} c.m.u. for 15 miles, and over 2×10^{-14} thereafter. Suppose further it is desired to determine the distance to the 0.5 mv/m contour. The field at 15 miles will be 4.8 mv/m and the equivalent distance for conductivity of 2×10^{-14} is 8 miles, which is 7 miles closer than the actual transmitter. The distance to the 0.5 mv/m contour for conductivity 2×10^{-14} is 25 miles (from the imaginary transmitter) or 32 miles from the actual transmitter.

F. Determination of RSS Interference

When two or more interfering 10% skywave signals on the same frequency exist at a point, their resultant is considered to be the Root-sum - square value of the components. Calculation is accomplished by considering the signals in or der of decreasing magnitude and excluding signals which are less than 25% of the RSS of signals already included. This method is also used for two or more interfering groundwave signals or for two or more interfering 50% skywave signals.

G. Other-Signal Interference Ratios

The following table is to be used for determining the ratio of field strength of a desired to an undesired signal (or RSS value of two or more undesired signals) below which interference will exist.

Frequency Separation of Desired And Undesired Signals	Desired Groundwave to Undesired Groundwave	Desired Groundwave to Undesired 10% Skywave	Desired 50% Skywave to Undesired Groundwave	Desired 50% Skywave to Undesired 50% Skywave
0 kc	20:1	20:1	20:1	60:1
10 kc	1:1	1:1	1:1	3:1
20 kc	1:20	1:20	1:20	3:20
30 kc	1:50		1:50	

SIGNAL RANGE CHART
50% SKYWAVE SIGNAL (1944)
from 0.311 λ antenna
with horizontal radiation of 100 mv/m

Note: Revised Charts under preparation for 50% and 10% signals, showing also close distances, and using radiation at pertinent angle.