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# TOTAL TRANSMISSION OF THE ATMOSPHERE IN THE NEAR-INFRARED

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**NAVAL RESEARCH LABORATORY**

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WASHINGTON, D.C.

FK-3828  
WRL REPORT 2828

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## ABSTRACT

By combining the results of two reports already in existence, the atmospheric transmission of near-infrared blackbody radiation has been calculated as a function of water vapor and carbon dioxide concentration, visibility, path length, and blackbody source temperature. No new experimental data are presented.

The results are presented in two forms: 1) curves from which the transmission of all the radiation between 0.7 and 12 microns can be read as a function of any given set of atmospheric conditions and blackbody source temperature (up to 6000°K) and 2) tables from which curves of the above nature can be manufactured for any desired wavelength region within the limits of 0.7 and 12 microns.

## PROBLEM STATUS

This is the final report on one phase of this problem.

## AUTHORIZATION

NRL Problem N07-17R  
RDB NO 284-511

## TOTAL TRANSMISSION OF THE ATMOSPHERE IN THE NEAR-INFRARED

### INTRODUCTION

At present the best information available on atmospheric transmission in the near-infrared is to be found in two reports, each dealing with one phase of the problem only. With the purpose of presenting a complete picture, these two reports have been combined to produce one set of results. With a blackbody source, the over-all radiation transmitted in an entire spectral region (0.7 - 12 microns) is calculated as a function of the atmospheric conditions and the temperature of the source.

In the wavelength region considered are two processes of major importance\*: (a) the selective absorption by water vapor and carbon dioxide in the air, and (b) the scattering by fog and dust particles suspended in the air. The first has been considered in detail in a report by John Nelson Howard of the Ohio State University Research Foundation(1). This report gives individually, as a function of path length and concentration of absorber, the absorption by all the important water-vapor and carbon-dioxide bands in the region 0.7-12 microns. Also included are graphs of the total transmission of the atmosphere between 0.7 and 12 microns calculated for various blackbody source temperatures, water-vapor concentrations, and path lengths. The empirical formulae used in these calculations were developed from absorption spectra (2,3,4) taken through a multiple-beam absorption cell where water-vapor contents between 0.002 cm and 0.02 cm precipitable water† and carbon-dioxide contents between 5.6 atmo. cm and 105 atmo. cm were investigated between 0.7 and 12 microns. It was considered that these measurements through small amounts of water vapor established the laws of absorption well enough to justify extrapolation to the larger amounts used here.

The second process, scattering, has been investigated and reported on by the Admiralty Research Laboratory(5). Measurements were made of the transmission in regions free of water-vapor and carbon-dioxide bands (the so-called "windows" between the bands), and the values obtained were related to the transmission of visible light as measured by eye and by their spectrometer at 0.61 micron. These results are shown in Figure 1, where, for four values of the visible transmission, values of the transmission at 2.18, 3.61, 10.01, and 11.48 microns are plotted and smooth curves drawn through the points. For convenience, the positions of the water-vapor and carbon-dioxide bands considered here are indicated above the wavelength scale.

The Admiralty data shows a sharp decrease in transmission beyond 7 microns due to weak bands of water vapor and the wings of rotation bands lying farther out. A strong dependence on water-vapor content was observed in this region. In order to separate the effects

\* All other effects (e.g., molecular scattering and absorption by atmospheric constituents other than water vapor and carbon dioxide) are small by comparison and have therefore been neglected.

† Defined as the thickness of the layer of liquid water which can be condensed from the column of air forming the path.

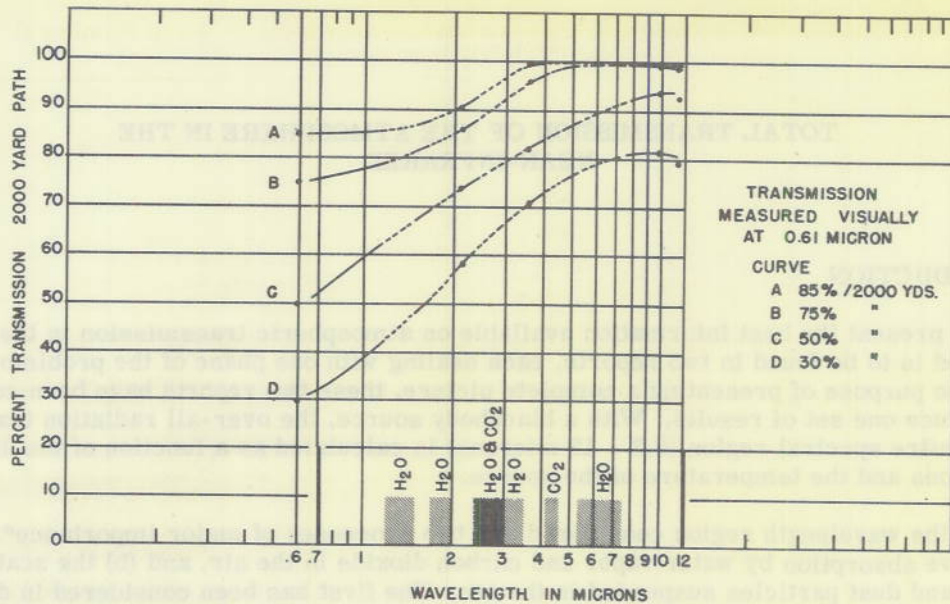


Figure 1 - Atmospheric transmission in regions between absorption bands

of haze from this dependence, it would have been necessary to take measurements on days of widely varying visual transmission and constant water-vapor concentration, a condition they were unable to realize. They therefore corrected all values of transmission measured at the 10.01- and 11.48-micron points to a standard day when there was 17 mm of precipitable water in their 2264-yard path. The expression found most satisfactory for this correction was  $T = Ce^{-bw}$ , where  $b$  is a constant at constant wavelength,  $C$  is a constant at constant visual transmission,  $w$  is the amount of water vapor in the path, and  $T$  is the transmission over the path.

In this report, the effects of the 17 mm of precipitable water are removed in a manner described later, and the corrected values showing the transmission of the haze alone are plotted in Figure 1 for the 10.01- and 11.48-micron regions. All other points in Figure 2 are taken directly from the Admiralty Report. The dependence of transmission on water-vapor content at the 2.18- and 3.61-micron points was observable but negligible compared to the effects of even small amounts of haze.

#### EXPLANATION AND DESCRIPTION

For the computations of this report, the spectrum from 0.7 to 12 microns was divided into 12 regions numbered 1 through 12 starting at the short-wavelength end. Five regions (Nos. 2, 4, 6, 7, and 11) contain water-vapor bands; two (Nos. 6 and 9) contain carbon-dioxide bands; and the remaining six (Nos. 1, 3, 5, 8, 10, and 12), the "windows" between the bands, are considered to contain no absorption bands of water vapor, carbon dioxide, or other atmospheric constituents—a condition true only to a first approximation as mentioned above. The exact limits of the regions, taken from the Ohio State report, are tabulated on the next page.

Figure 2 shows the division of energy among the regions for six blackbody temperatures. Also included for the same blackbody temperatures are the total energy radiated in watts/cm<sup>2</sup>, the wavelength at which the most energy is radiated, and the percent of the total energy lying in the whole region considered (0.7 to 12 microns). So far as possible the



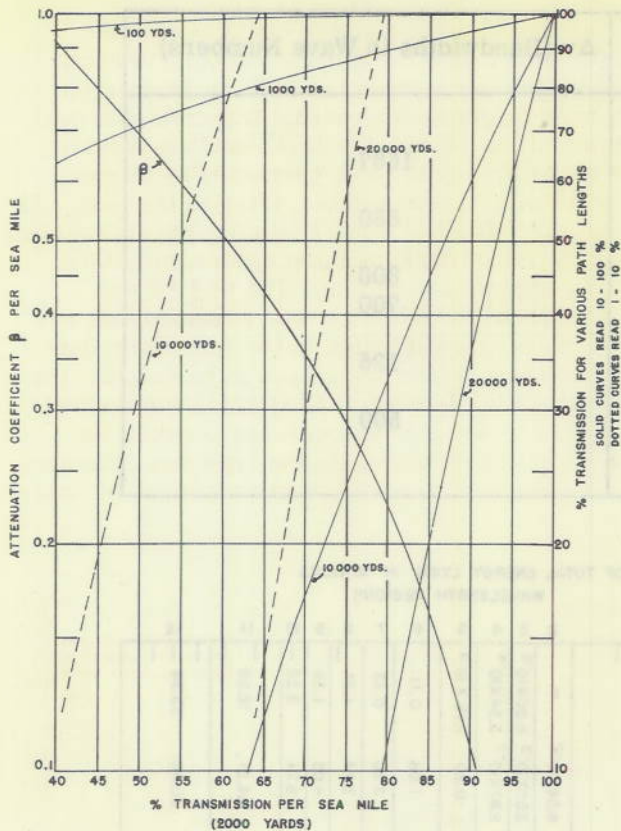


Figure 3 - Beer's law curves for calculations

Figure 4 is provided to convert water-vapor content from grams/cubic meter, as used in this report, to either relative humidity or centimeters of precipitable water per 1000 yards, as most convenient. The solid curves apply to the left-hand ordinate and convert to percent relative humidity. The dotted curve applies to the right-hand ordinate and converts to centimeters of precipitable water per 1000 yards of path. For example, a concentration of 10 grams of water vapor per cubic meter of air would correspond to 76% relative humidity when the temperature of the air (dry bulb) is 60°F. At this same concentration there would be 0.915 cm of precipitable water in a 1000-yard path.

The transmission in region 12 proved the most difficult to compute because of the pronounced effect of the water vapor present. Although this region contains no major water bands, it does contain sufficient structure (weak lines and the wings of the rotation bands lying farther out in the infrared) to make the water vapor in the atmosphere predominate over the haze as an attenuating agent. The problem arises in separating the effects of these two attenuating agents.

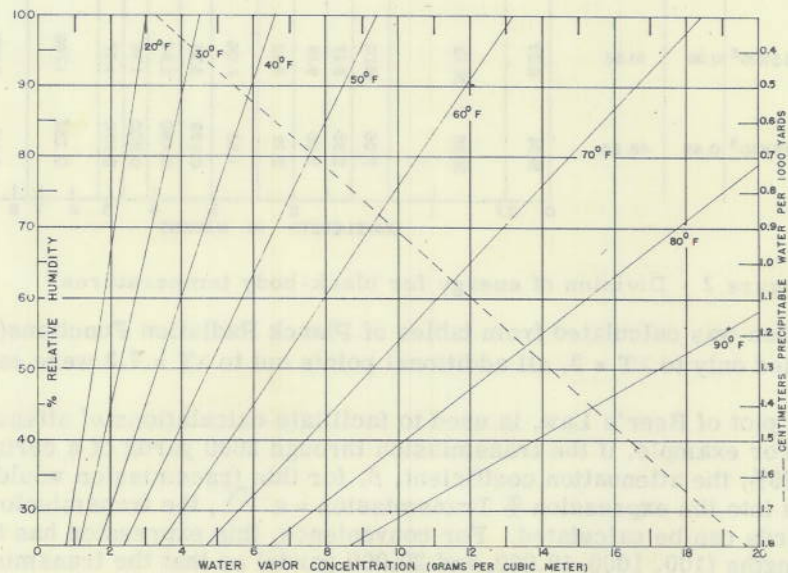


Figure 4 - Conversion of water-vapor content from grams per cubic meter to either humidity or centimeters water per 1000 yards

The best values for the transmission of a haze-free atmosphere containing water vapor are to be found in a report by Hulburt (7), where several sources of experimental data have been used to compute the effects of water vapor alone in the 7- to 14-micron region. In the Admiralty Report, all data on haze (expressed as visual transmission per 2000 yards at 0.61 micron) versus transmission at the 10.01- and 11.48-micron points, taken on days of widely varying water-vapor concentrations, were corrected by an exponential formula to a representative value of 15 mm of precipitable water in the path. As the visual transmission increased, the transmission at 10.01 and 11.48 microns approached the values of 88.0% and 78.5% respectively as the visual transmission approached 100%. Hulburt's tables give, for 15 mm of water, transmissions of 84% and 77% at 10.0 and 11.5 microns respectively—a fairly good agreement. Therefore, it was assumed that any departure from the values approached at 100% visual transmission in the Admiralty data were due to the haze present. The tables in Hulburt's report were used in calculating the effect of water alone. Figure 5, taken from the Admiralty report, illustrates the method of computing the effects of haze alone. For example, for 50% visual transmission, the transmission of the haze at 11.48 microns is  $72.5/78.5 = 92.3\%$ . At the right are indicated the values predicted from Hulburt's data for the transmission of the same amount of water vapor.

Figures 6 through 20 show, for various values of blackbody source temperature, water-vapor concentration, visual transmission, and normal carbon-dioxide concentration, the percent of the total energy between 0.7 and 12 microns that will be transmitted by the atmosphere, plotted as a function of path length or amount of air traversed. Each point represents the value of the expression

$$T = \frac{\int_{0.7}^{12} J_{\lambda} t_{\lambda_1} t_{\lambda_2} d\lambda}{\int_{0.7}^{12} J_{\lambda} d\lambda}, \quad (1)$$

where T is the total percent transmitted between 0.7 and 12 microns,  $J_{\lambda}$  is the spectra distribution of the source,  $t_{\lambda_1}$  is the transmission of the haze, and  $t_{\lambda_2}$  is the transmission of the water vapor and carbon dioxide. The actual calculation was a summation over the twelve regions defined earlier and not an integration. Therefore, it is better represented as

$$T = \frac{\sum_{\text{Region 1}}^{12} J_{\lambda} t_{\lambda_1} t_{\lambda_2} d\lambda}{\sum_{\text{Region 1}}^{12} J_{\lambda} d\lambda} \quad (2)$$

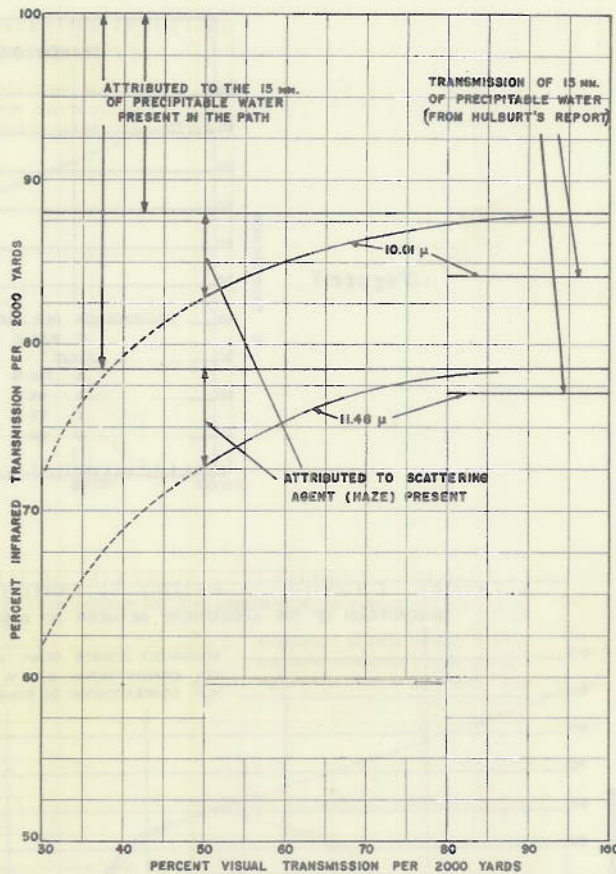


Figure 5 - Atmospheric transmission in the 10- to 12-micron region

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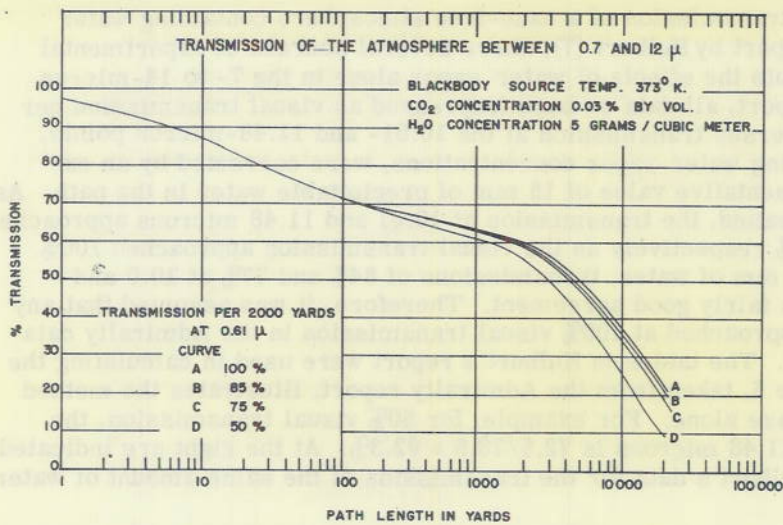


Figure 6

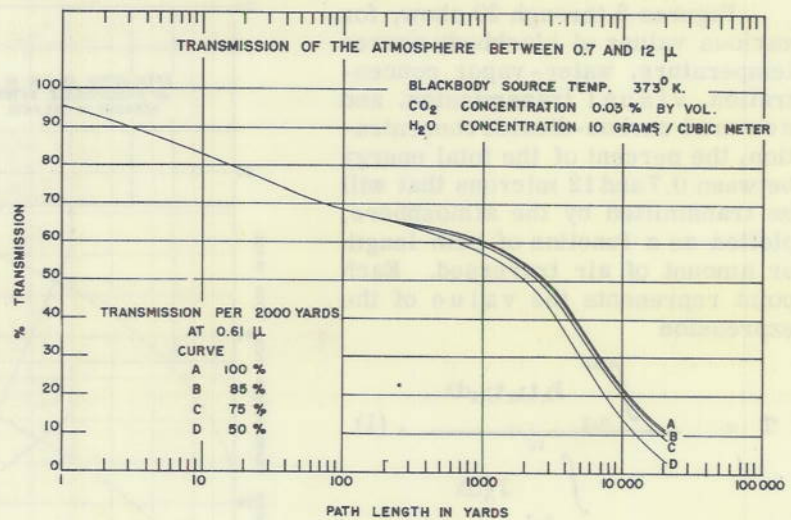


Figure 7

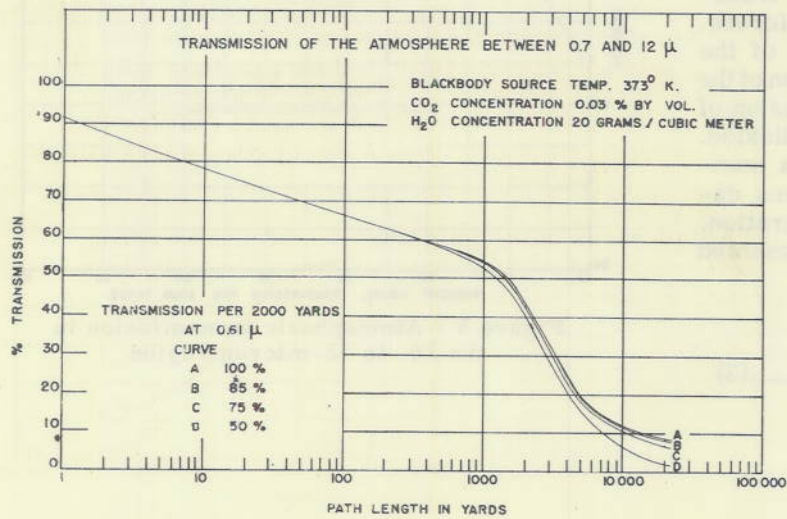


Figure 8

Figure 9

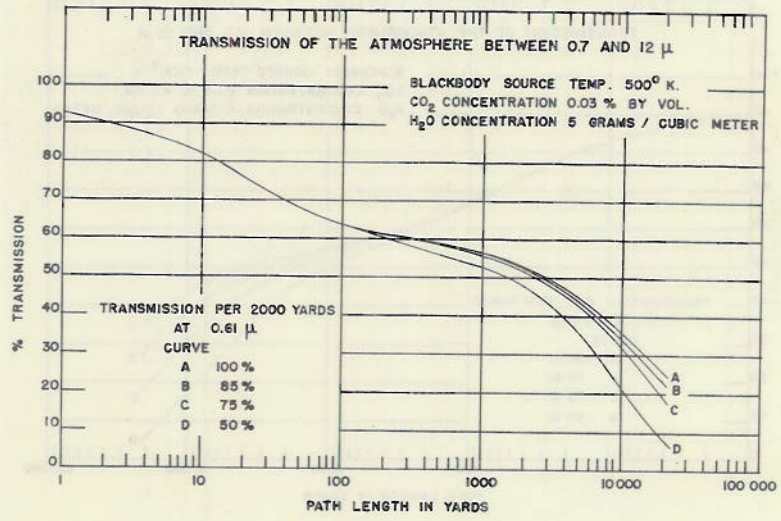


Figure 10

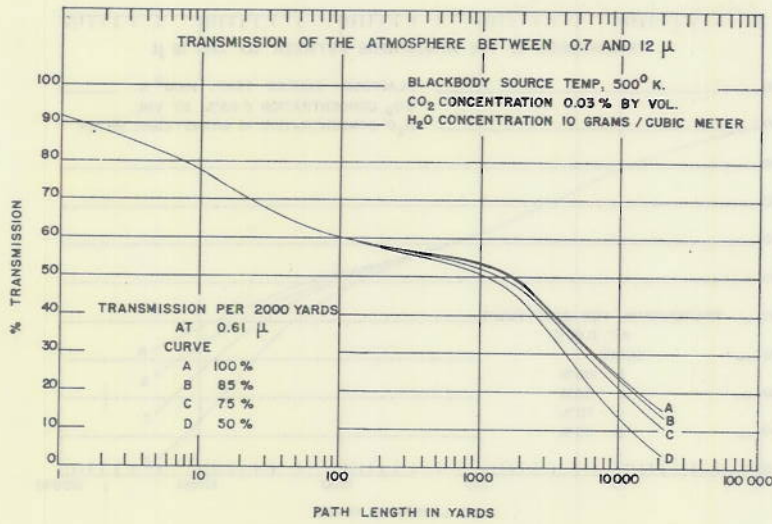
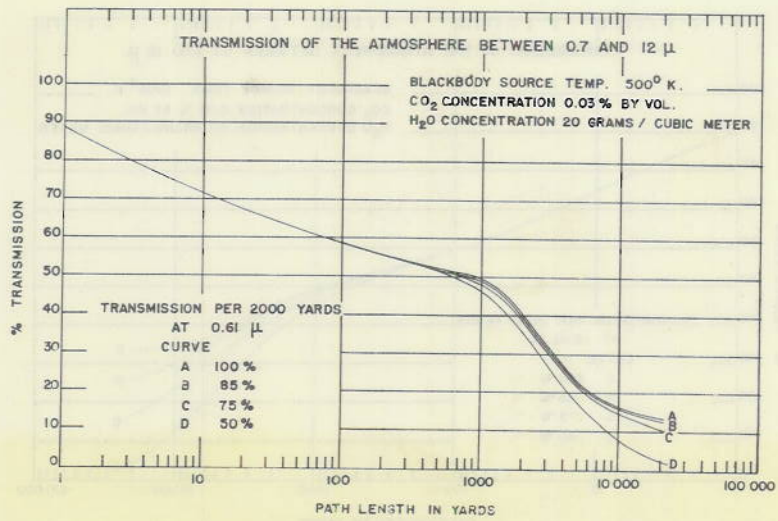


Figure 11



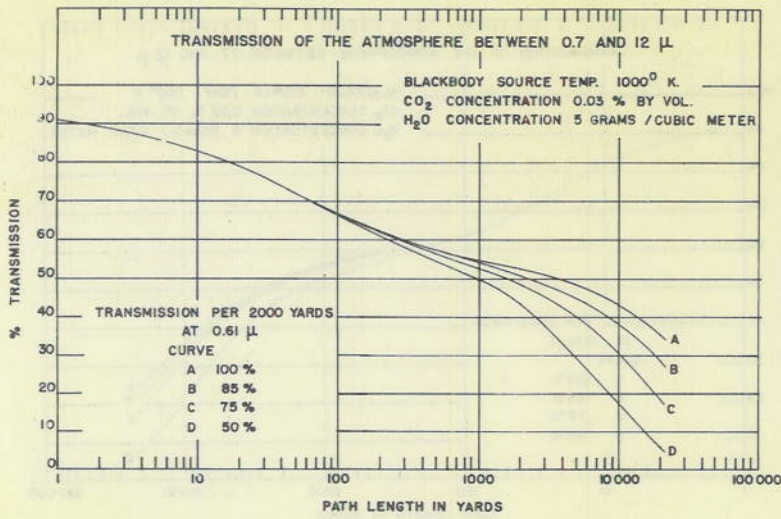


Figure 12

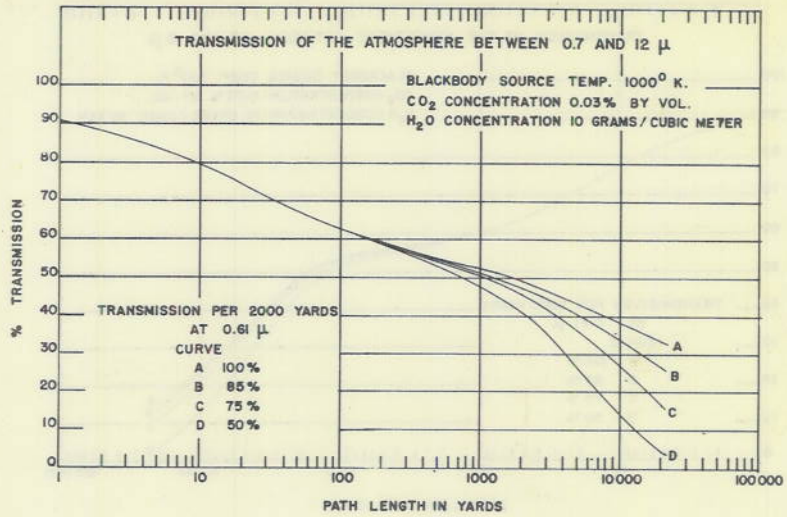


Figure 13

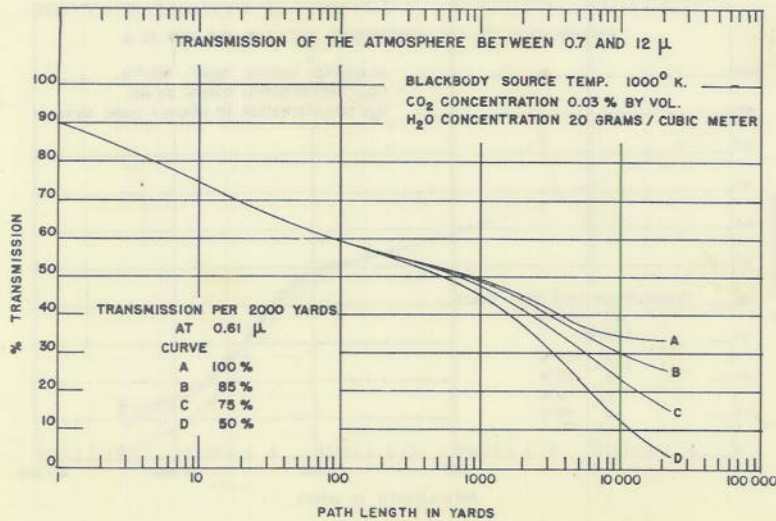


Figure 14

Figure 15

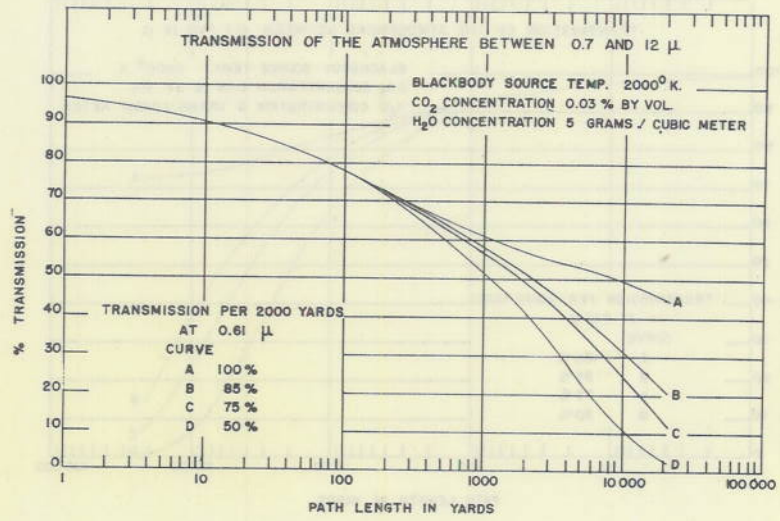


Figure 16

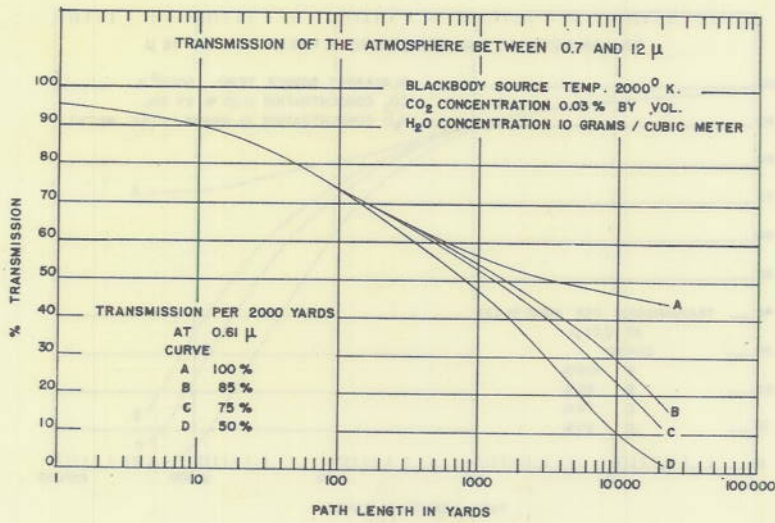
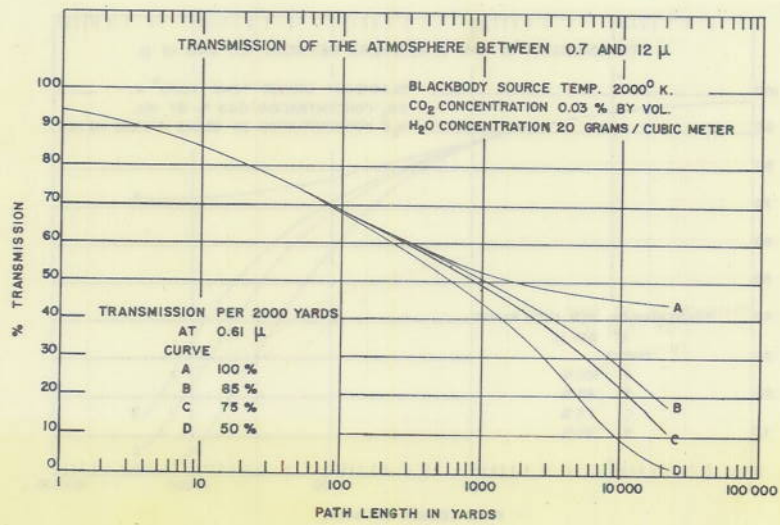


Figure 17



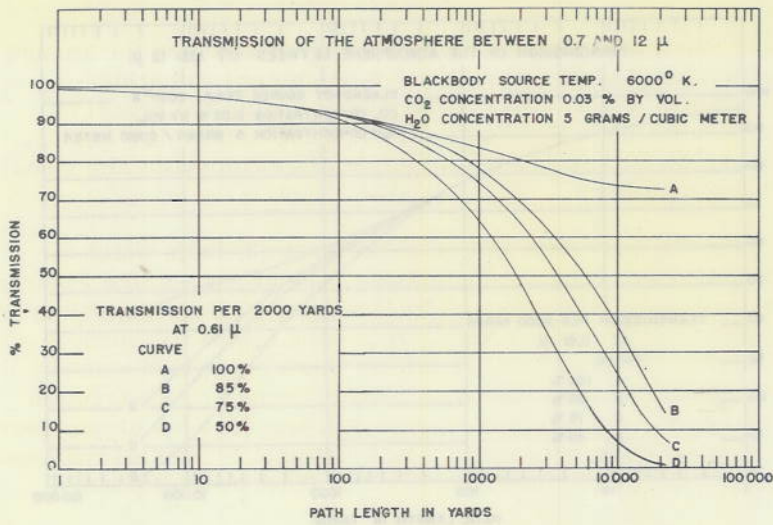


Figure 18

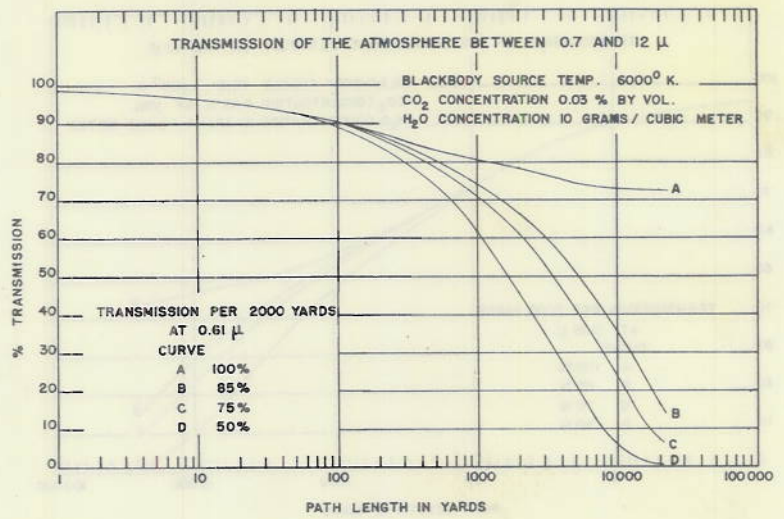


Figure 19

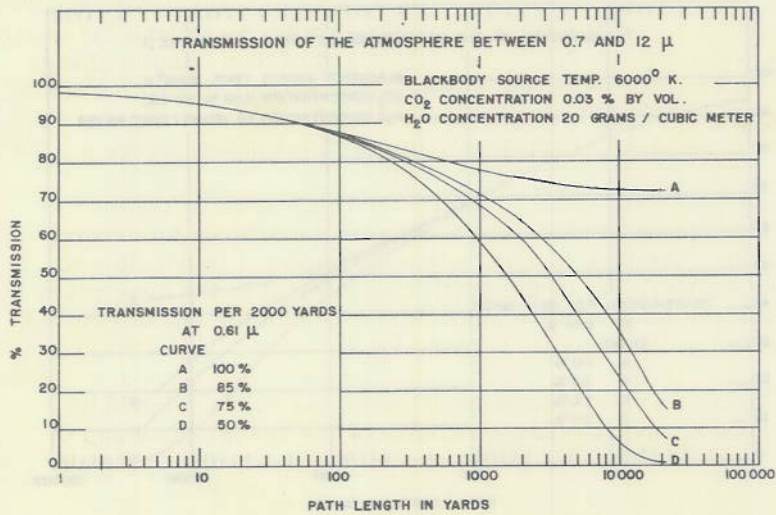


Figure 20

In each case the amount of water vapor present is specified in gm/meter<sup>3</sup> and the amount of haze is specified in terms of the percent transmission of 0.61-micron radiation through 2000 yards of the atmosphere. Values of  $t_{\lambda_2}$  were obtained from the report by Howard (1), and those of  $t_{\lambda_1}$  were taken from Figure 1. The inverse-square law has not been considered. The values from the curves are to be applied after computing the signal through an ideal or nonabsorbing atmosphere.

Tables 1 through 20 containing the individual values of Equation (2) from which the curves were plotted, are included to make possible the manufacture of curves like Figures 6 through 20 for wavelength regions other than from 0.7 to 12 microns. Here the points on a curve are presented broken down into the contributions from each region. Column W contains the water-vapor concentration in grams/cubic meter, there being four values for every set of remaining conditions. The numbers in subsequent columns are the fraction (not percent) of the total emitted energy of the blackbody that will traverse the atmosphere under the given conditions. The first three numbers are the significant figures, the number after the dash the negative power of 10 by which the first figures must be multiplied.

For example, in Table 4, 373°K, 50% visual transmission, the figure in column 7 for 100 yards and a water-vapor concentration of 5 grams/meter<sup>3</sup> is 3.07-3. This, a shorthand expression for  $3.07 \times 10^{-3}$ , means that between 3.00 and 3.50 microns (region 7) the flux density received from a 373°K blackbody placed 100 yards from the observer, in an atmosphere of 50% transmission per 2000 yards at 0.61 micron and with a water-vapor concentration of 5 grams/meter<sup>3</sup> would be

$$F \text{ watts/cm}^2 = 3.07 \times 10^{-3} \times 1.04 \times 10^{-1} \times \frac{1}{\pi(1.10 \times 10^5)^2} \times (\text{Area of Source in cm}^2)$$

$$= 8.42 \times 10^{-15} \times (\text{Area of Source in cm}^2),$$

where  $1.04 \times 10^{-1}$  is found from Figure 2 to be the total energy radiated in watts/cm<sup>2</sup> from a blackbody at 373°K and where  $1/[\pi(1.10 \times 10^5)^2]$  is the inverse-square-law factor (100 yards =  $1.10 \times 10^5$  cm). By summing all figures in the first row of Table 4 and substituting the result ( $4.02 \times 10^{-1}$ ) for  $3.07 \times 10^{-3}$  in the example above, we obtain the flux density received between 0.7 and 12 microns (regions 1 to 12 inclusive) through 100 yards of the same atmosphere.

## CRITIQUE

These curves have been calculated considering the atmosphere as an isotropic medium. They therefore apply only to horizontal paths through the atmosphere, since both the density of scattering materials and the concentrations of water vapor and carbon dioxide change considerably with altitude. Also, since there is a pressure effect on the absorption bands, and since there is reason to believe that the nature of the scattering agent changes with altitude, these curves should be considered to apply only to sea-level paths, where all the data were taken.

Disregard of the effect of absorption bands in the "windows" introduces an error, particularly for large path lengths. The lack of data, however, makes it impossible to include this effect. The alternate effect, that of the scattering present in the absorption bands, has been included, and the values used have been obtained from the smooth curves drawn through the points measured in the windows (Figure 1).

Finally, although they are based on valid experimental data, the curves should be subjected to an experimental check to investigate the validity of the assumptions and of the technique.

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TABLE 1  
(For 373°K, 100% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1	5			8.80-8	5.11-6	7.75-5	7.55-4	3.28-3	1.21-2	9.90-3	3.22-2	1.56-1	3.33-1
	10			"	4.70-6	"	7.07-4	3.27-3	"	"	"	1.46-1	"
	15			"	4.55-6	"	6.88-4	3.26-3	"	"	"	1.30-1	"
	20			"	4.43-6	"	6.72-4	3.25-3	"	"	"	1.24-1	"
10	5			8.80-8	5.25-6	7.75-5	4.44-4	3.24-3	1.21-2	7.10-3	3.22-2	1.02-1	3.33-1
	10			"	5.17-6	"	4.00-4	3.21-3	"	"	"	7.79-2	"
	15			"	5.13-6	"	3.62-4	3.18-3	"	"	"	6.37-2	"
	20			"	5.03-6	"	3.34-4	3.16-3	"	"	"	5.14-2	"
100	5			8.80-8	3.94-6	7.75-5	1.18-4	3.08-3	1.21-2	3.80-3	3.22-2	1.74-2	3.33-1
	10			"	3.36-6	"	6.95-5	3.00-3	"	"	"	4.30-3	3.30-1
	15			"	2.96-6	"	4.38-5	2.97-3	"	"	"	1.20-3	3.26-1
	20			"	2.64-6	"	2.56-5	2.87-3	"	"	"	"	3.23-1
1000	5			8.80-8	1.55-6	7.75-5	1.00-6	2.62-3	1.21-2	1.20-3	3.22-2		3.06-1
	10			"	6.93-7	"		2.38-3	"	"	"		2.90-1
	15			"	3.26-7	"		2.16-3	"	"	"		2.70-1
	20			"	1.60-7	"		2.00-3	"	"	"		2.60-1
2000	5			8.80-8	7.46-7	7.75-5		2.36-3	1.21-2	7.00-4	3.22-2		2.90-1
	10			"	1.65-7	"		2.03-3	"	"	"		2.60-1
	15			"	4.00-8	"		1.74-3	"	"	"		2.18-1
	20			"	"	"		1.52-3	"	"	"		1.97-1
10,000	5			8.80-8		7.75-5		1.39-3	1.21-2	1.00-4	3.22-2		1.67-1
	10			"		"		8.40-4	"	"	"		8.30-2
	15			"		"		5.28-4	"	"	"		4.16-2
	20			"		"		3.30-4	"	"	"		2.06-2
20,000	5			8.80-8		7.75-5			1.21-2		3.22-2		8.30-2
	10			"		"			"		"		2.06-2
	15			"		"			"		"		8.31-3
	20			"		"			"		"		1.85-3

TABLE 2  
(For 373°K, 85% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5			8.80-8	3.94-6	7.75-5	1.18-4	3.08-3	1.21-2	3.80-3	3.22-2	1.74-2	3.33-1
	10			"	3.36-6	"	6.95-5	3.00-3	"	"	"	4.30-3	3.30-1
	15			"	2.96-6	"	4.38-5	2.97-3	"	"	"	1.20-3	3.26-1
	20			"	2.64-6	"	2.56-5	2.87-3	"	"	"	"	3.23-1
1000	5			8.27-8	1.46-6	7.36-5	9.50-7	2.60-3	1.21-2	1.20-3	3.22-2		3.06-1
	10			"	6.50-7	"		2.36-3	"	"	"		2.90-1
	15			"	3.06-7	"		2.14-3	"	"	"		2.70-1
	20			"	1.50-7	"		1.98-3	"	"	"		2.60-1
2000	5			7.75-8	6.56-7	6.97-5		2.34-3	1.21-2	7.00-4	3.22-2		2.87-1
	10			"	1.45-7	"		2.01-3	"	"	"		2.57-1
	15			"	3.52-8	"		1.72-3	"	"	"		2.16-1
	20			"	"	"		1.50-3	"	"	"		1.95-1
10,000	5			4.66-8		4.57-5		1.33-3	1.21-2	1.00-4	3.22-2		1.60-1
	10			"		"		8.10-4	"	"	"		7.96-2
	15			"		"		5.05-4	"	"	"		4.00-2
	20			"		"		3.16-4	"	"	"		1.98-2
20,000	5			2.46-8		2.72-5			1.21-2		3.22-2		7.47-2
	10			"		"			"		"		1.85-2
	15			"		"			"		"		7.48-3
	20			"		"			"		"		1.66-3

TABLE 3  
(For 373°K, 75% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1000	5			8.10-8	1.42-6	7.21-5	9.00-7	2.52-3	1.19-2	1.20-3	3.20-2		3.03-1
	10			"	6.37-7	"		2.29-3	"	"	"		2.87-1
	15			"	3.00-7	"		2.08-3	"	"	"		2.67-1
	20			"	1.47-7	"		1.93-3	"	"	"		2.57-1
2000	5			7.40-8	6.27-7	6.66-5		2.21-3	1.16-2	7.00-4	3.18-2		2.84-1
	10			"	1.39-7	"		1.90-3	"	"	"		2.55-1
	15			"	3.36-8	"		1.63-3	"	"	"		2.13-1
	20			"	"	"		1.42-3	"	"	"		1.93-1
10,000	5			3.65-8		3.64-5		1.03-3	1.00-2	1.00-4	3.09-2		1.52-1
	10			"		"		6.20-4	"	"	"		7.55-2
	15			"		"		3.90-4	"	"	"		3.78-2
	20			"		"		2.44-4	"	"	"		1.87-2
20,000	5			1.54-8		1.71-5			8.20-3		2.96-2		6.89-2
	10			"		"			"		"		1.71-2
	15			"		"			"		"		6.90-3
	20			"		"			"		"		1.53-3

TABLE 4  
(For 373°K, 50% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5			8.72-8	3.91-6	7.70-5	1.18-4	3.07-3	1.20-2	3.80-3	3.21-2	1.74-2	3.33-1
	10			"	3.33-6	"	6.92-5	3.00-3	"	"	"	4.30-3	3.30-1
	15			"	2.93-6	"	4.36-5	2.97-3	"	"	"	1.20-3	3.26-1
	20			"	2.61-6	"	2.55-6	2.87-3	"	"	"	"	3.23-1
1000	5			7.44-8	1.31-6	6.68-5	7.80-7	2.36-3	1.10-2	1.10-3	3.00-2		2.97-1
	10			"	5.85-7	"		2.14-3	"	"	"		2.81-1
	15			"	2.75-7	"		1.95-3	"	"	"		2.62-1
	20			"	1.35-7	"		1.80-3	"	"	"		2.52-1
2000	5			6.25-8	5.30-7	5.74-5		1.89-3	9.90-3	6.00-4	2.77-2		2.72-1
	10			"	1.17-7	"		1.62-3	"	"	"		2.44-1
	15			"	2.84-8	"		1.39-3	"	"	"		2.05-1
	20			"	"	"		1.21-3	"	"	"		1.85-1
10,000	5			1.58-8		1.74-5		4.48-4	4.50-3		1.51-2		1.24-1
	10			"		"		2.80-4	"		"		6.14-2
	15			"		"		1.76-4	"		"		3.08-2
	20			"		"		1.10-4	"		"		1.52-2
20,000	5			2.90-9		3.88-6			1.70-3		7.10-3		4.40-2
	10			"		"			"		"		1.09-2
	15			"		"			"		"		4.40-3
	20			"		"			"		"		9.80-4

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 TABLE 5  
 (For 500°K, 100% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1	5	9.68-8	5.91-6	3.50-5	2.78-4	2.00-3	9.70-3	3.30-2	3.44-2	2.88-2	6.21-2	2.12-1	3.04-1
	10	"	5.87-6	"	2.76-4	"	9.50-3	3.28-2	"	"	"	1.99-1	"
	15	"	5.81-6	"	2.73-4	"	9.20-3	3.26-2	"	"	"	1.90-1	"
	20	"	5.80-6	"	2.70-4	"	9.00-3	3.24-2	"	"	"	1.82-1	"
10	5	9.68-8	5.64-6	3.50-5	2.62-4	2.00-3	7.60-3	3.22-2	3.44-2	1.35-2	6.21-2	1.49-1	3.04-1
	10	"	5.48-6	"	2.52-4	"	6.80-3	3.20-2	"	"	"	1.15-1	"
	15	"	5.38-6	"	2.44-4	"	6.20-3	3.18-2	"	"	"	9.20-2	"
	20	"	5.24-6	"	2.38-4	"	5.70-3	3.16-2	"	"	"	7.50-2	"
100	5	9.68-8	4.80-6	3.50-5	2.12-4	2.00-3	3.20-3	3.08-2	3.44-2	7.30-3	6.21-2	2.66-2	3.04-1
	10	"	4.30-6	"	1.81-4	"	1.90-3	3.00-2	"	"	"	6.10-3	3.01-1
	15	"	3.98-6	"	1.59-4	"	1.20-3	2.92-2	"	"	"	2.00-3	2.98-1
	20	"	3.60-6	"	1.42-4	"	7.00-4	2.87-2	"	"	"	"	2.95-1
1000	5	9.68-8	2.44-6	3.50-5	8.33-5	2.00-3		2.64-2	3.44-2	2.10-3	6.21-2	6.10-3	2.80-1
	10	"	1.48-6	"	3.73-5	"		2.37-2	"	"	"	"	2.64-1
	15	"	9.33-7	"	1.78-5	"		2.16-2	"	"	"	"	2.46-1
	20	"	5.73-7	"	8.60-5	"		1.97-2	"	"	"	"	2.37-1
2000	5	9.68-8	1.51-6	3.50-5	4.02-5	2.00-3		2.35-2	3.40-2	2.02-3	6.21-2		2.64-1
	10	"	6.04-7	"	8.90-6	"		2.03-2	"	"	"		2.37-1
	15	"	2.66-7	"	2.15-6	"		1.74-2	"	"	"		1.99-1
	20	"	1.21-7	"	"	"		1.52-2	"	"	"		1.79-1
10,000	5	9.68-8	6.04-8	3.50-5		2.00-3		1.39-2	3.44-2	4.05-4	6.21-2		1.52-1
	10	"	"	"		"		8.25-3	"	"	"		7.57-2
	15	"	"	"		"		5.28-3	"	"	"		3.80-2
	20	"	"	"		"		3.30-3	"	"	"		1.89-2
20,000	5	9.68-8		3.50-5		2.00-3		7.60-3	3.44-2		6.21-2		7.54-2
	10	"		"		"		1.00-3	"		"		1.89-2
	15	"		"		"		1.00-4	"		"		7.60-3
	20	"		"		"		"	"		"		1.82-3

 TABLE 6  
 (For 500°K, 85% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	9.68-8	4.80-6	3.50-5	2.12-4	2.00-3	3.20-3	3.08-2	3.44-2	7.30-3	6.21-2	2.66-2	3.04-1
	10	"	4.30-6	"	1.81-4	"	1.90-3	3.00-2	"	"	"	6.10-3	3.01-1
	15	"	3.98-6	"	1.59-4	"	1.20-3	2.92-2	"	"	"	2.00-3	2.98-1
	20	"	3.60-6	"	1.42-4	"	7.00-4	2.87-2	"	"	"	"	2.95-1
1000	5	8.93-8	2.27-6	3.29-5	7.83-5	1.90-3		2.62-2	3.44-2	2.20-3	6.21-2		2.80-1
	10	"	1.38-6	"	3.50-5	"		2.38-2	"	"	"		2.64-1
	15	"	8.67-7	"	1.67-5	"		2.16-2	"	"	"		2.46-1
	20	"	5.33-7	"	8.09-6	"		1.98-2	"	"	"		2.37-1
2000	5	8.23-8	1.30-6	3.08-5	3.46-5	1.80-3		2.33-2	3.44-2	1.30-3	6.21-2		2.61-1
	10	"	5.19-7	"	7.65-6	"		2.01-2	"	"	"		2.35-1
	15	"	2.29-7	"	1.85-6	"		1.72-2	"	"	"		1.97-1
	20	"	1.04-7	"	"	"		1.50-2	"	"	"		1.77-1
10,000	5	4.30-8	2.84-8	1.86-5		1.20-3		1.35-2	3.44-2	3.00-4	6.21-2		1.46-1
	10	"	"	"		"		8.16-3	"	"	"		7.27-2
	15	"	"	"		"		5.20-3	"	"	"		3.65-2
	20	"	"	"		"		3.20-3	"	"	"		1.81-2
20,000	5	1.94-8		9.80-6		7.00-4		7.08-3	3.44-2		6.21-2		6.78-2
	10	"		"		"		8.00-4	"		"		1.70-2
	15	"		"		"		8.00-5	"		"		6.84-3
	20	"		"		"		"	"		"		1.64-3

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TABLE 7  
(For 500°K, 75% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	9.64-8	4.80-6	3.49-5	2.12-4	2.00-3	3.20-3	3.08-2	3.44-2	7.30-3	6.21-2	2.55-2	3.04-1
	10	"	4.30-6	"	1.81-4	"	1.90-3	3.00-2	"	"	"	6.10-3	3.01-1
	15	"	3.98-6	"	1.58-4	"	1.20-3	2.93-2	"	"	"	1.50-3	2.98-1
	20	"	3.60-6	"	1.42-4	"	8.00-4	2.87-2	"	"	"	"	2.95-1
1000	5	8.56-8	2.20-6	3.18-5	7.60-5	1.90-3		2.52-2	3.37-2	2.20-3	6.20-2		2.77-1
	10	"	1.33-6	"	3.40-5	"		2.30-2	"	"	"		2.61-1
	15	"	8.40-7	"	1.63-5	"		2.10-2	"	"	"		2.43-1
	20	"	5.15-7	"	7.85-6	"		1.92-2	"	"	"		2.35-1
2000	5	7.55-8	1.21-6	2.87-5	3.38-5	1.80-3		2.22-2	3.30-2	1.30-3	6.15-2		2.59-1
	10	"	4.83-7	"	7.48-6	"		1.91-2	"	"	"		2.32-1
	15	"	2.13-7	"	1.81-6	"		1.64-2	"	"	"		1.95-1
	20	"	9.67-8	"	"	"		1.42-2	"	"	"		1.75-1
10,000	5	2.80-8	2.52-8	1.30-5		1.20-3		1.03-2	2.75-2	3.00-4	5.90-2		1.38-1
	10	"	"	"		"		6.20-3	"	"	"		6.89-2
	15	"	"	"		"		4.00-3	"	"	"		3.46-2
	20	"	"	"		"		2.50-3	"	"	"		1.72-2
20,000	5	7.75-9		4.90-6		7.00-4		5.06-3	2.20-2		5.60-2		6.26-2
	10	"		"		"		6.01-4	"		"		1.57-2
	15	"		"		"		6.00-5	"		"		6.31-2
	20	"		"		"		"	"		"		1.51-3

TABLE 8  
(For 500°K, 50% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	9.60-8	4.76-6	3.46-5	2.10-4	2.00-3	3.20-3	3.08-2	3.43-2	7.30-3	6.21-2	2.66-2	3.03-1
	10	"	4.26-6	"	1.79-4	"	1.90-3	3.00-2	"	"	"	6.10-3	3.01-1
	15	"	3.94-6	"	1.57-4	"	1.20-3	2.92-2	"	"	"	2.00-3	2.98-1
	20	"	3.56-6	"	1.40-4	"	7.00-4	2.87-2	"	"	"	"	2.95-1
1000	5	7.45-8	1.97-6	2.96-5	7.04-5	1.80-3		2.36-2	3.13-2	2.10-3	5.78-2		2.71-1
	10	"	1.20-6	"	3.15-5	"		2.14-2	"	"	"		2.56-1
	15	"	7.54-7	"	1.50-5	"		1.94-2	"	"	"		2.38-1
	20	"	4.63-7	"	7.26-6	"		1.78-2	"	"	"		2.30-1
2000	5	5.71-8	9.80-7	2.48-5	2.86-5	1.50-3		1.89-2	2.82-2	1.10-3	5.35-2		2.49-1
	10	"	3.92-7	"	6.31-6	"		1.62-2	"	"	"		2.23-1
	15	"	1.73-7	"	1.53-6	"		1.40-2	"	"	"		1.87-1
	20	"	7.85-8	"	"	"		1.22-2	"	"	"		1.68-1
10,000	5	6.58-9	7.00-9	6.30-6		5.00-4		4.60-3	1.27-2	2.00-4	2.92-2		1.12-1
	10	"	"	"		"		2.80-3	"	"	"		5.60-2
	15	"	"	"		"		1.80-3	"	"	"		2.81-2
	20	"	"	"		"		1.10-3	"	"	"		1.40-2
20,000	5	7.80-10		1.16-6		1.00-4		8.00-4	4.80-3		1.36-2		4.00-2
	10	"		"		"		1.00-4	"		"		1.00-2
	15	"		"		"		"	"		"		4.03-3
	20	"		"		"		"	"		"		9.64-4

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 TABLE 9  
 (For 1000°K, 100% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1	5	2.20-3	1.03-2	1.58-2	3.74-2	7.40-2	1.18-1	1.09-1	1.28-1	4.87-2	8.74-2	1.46-1	1.10-1
	10	"	1.02-2	"	3.70-2	"	1.14-1	1.09-1	"	"	"	1.37-1	"
	15	"	1.01-2	"	3.67-2	"	1.11-1	1.09-1	"	"	"	1.30-1	"
	20	"	1.00-2	"	3.63-2	"	1.09-1	1.08-1	"	"	"	1.25-1	"
10	5	2.20-3	9.80-3	1.58-2	3.53-2	7.40-2	9.33-2	1.08-1	1.28-1	3.50-2	8.74-2	1.02-1	1.10-1
	10	"	9.50-3	"	3.39-2	"	8.40-2	1.07-1	"	"	"	7.87-2	"
	15	"	9.30-3	"	3.28-2	"	7.60-2	1.06-1	"	"	"	6.40-2	"
	20	"	9.10-3	"	3.20-2	"	7.00-2	1.05-1	"	"	"	5.18-2	"
100	5	2.20-3	8.30-3	1.58-2	2.84-2	7.40-2	3.90-2	1.03-1	1.28-1	1.89-2	8.74-2	1.75-2	1.10-1
	10	"	7.40-3	"	2.43-2	"	2.30-2	1.00-1	"	"	"	4.30-3	1.09-1
	15	"	6.80-3	"	2.14-2	"	1.45-2	9.75-2	"	"	"	1.00-3	1.08-1
	20	"	6.30-3	"	1.92-2	"	8.60-3	9.54-2	"	"	"	"	1.07-1
1000	5	2.20-3	4.40-3	1.58-2	1.12-2	7.40-2	6.00-4	8.73-2	1.28-1	5.80-3	8.74-2		1.01-1
	10	"	2.70-3	"	5.00-3	"	"	7.90-2	"	"	"		9.57-2
	15	"	1.70-3	"	2.40-3	"	"	7.20-2	"	"	"		8.91-2
	20	"	1.00-3	"	1.20-3	"	"	6.63-2	"	"	"		8.58-2
2000	5	2.20-3	2.70-3	1.58-2	5.40-3	7.40-2		7.85-2	1.28-1	3.40-3	8.74-2		9.57-2
	10	"	1.10-3	"	1.20-3	"		6.75-2	"	"	"		8.58-2
	15	"	5.00-4	"	3.00-4	"		5.80-2	"	"	"		7.21-2
	20	"	2.00-4	"	"	"		5.05-2	"	"	"		6.49-2
10,000	5	2.20-3	1.00-4	1.58-2		7.40-2		4.60-2	1.28-1	7.00-4	8.74-2		5.50-2
	10	"	"	"		"		2.74-2	"	"	"		2.74-2
	15	"	"	"		"		1.75-2	"	"	"		1.38-2
	20	"	"	"		"		1.10-2	"	"	"		6.82-3
20,000	5	2.20-3		1.58-2		7.40-2		5.00-4	1.28-1		8.74-2		2.74-2
	10	"		"		"		"	"		"		6.82-3
	15	"		"		"		"	"		"		2.74-3
	20	"		"		"		"	"		"		6.80-4

 TABLE 10  
 (For 1000°K, 85% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	2.20-3	8.30-3	1.58-2	2.84-2	7.40-2	3.90-2	1.03-1	1.28-1	1.89-2	8.74-2	1.75-2	1.10-1
	10	"	7.40-3	"	2.43-2	"	2.30-2	1.00-1	"	"	"	4.30-3	1.09-1
	15	"	6.80-3	"	2.14-2	"	1.45-2	9.75-2	"	"	"	1.00-3	1.08-1
	20	"	6.30-3	"	1.92-2	"	8.60-3	9.54-2	"	"	"	"	1.07-1
1000	5	2.10-3	3.90-3	1.47-2	1.05-2	7.04-2		8.73-2	1.28-1	5.80-3	8.74-2		1.01-1
	10	"	2.38-3	"	4.70-3	"	"	7.90-2	"	"	"		9.57-2
	15	"	1.52-3	"	2.30-3	"	"	7.20-2	"	"	"		8.91-2
	20	"	8.57-4	"	1.10-3	"	"	6.63-2	"	"	"		8.58-2
2000	5	1.90-3	2.05-3	1.37-2	4.75-3	5.65-2		7.77-2	1.28-1	3.40-3	8.74-2		9.47-2
	10	"	8.90-4	"	1.05-3	"		6.68-2	"	"	"		8.50-2
	15	"	3.56-4	"	3.00-4	"		5.74-2	"	"	"		7.14-2
	20	"	1.78-4	"	"	"		5.00-2	"	"	"		6.42-2
10,000	5	1.00-3	5.85-5	7.90-3		4.40-2		4.41-2	1.28-1	7.00-4	8.74-2		5.28-2
	10	"	"	"		"		2.63-2	"	"	"		2.63-2
	15	"	"	"		"		1.68-2	"	"	"		1.32-2
	20	"	"	"		"		1.06-2	"	"	"		6.54-3
20,000	5	4.00-4		4.00-3		2.59-2		4.00-4	1.28-1		8.74-2		2.47-2
	10	"		"		"		"	"		"		6.14-3
	15	"		"		"		"	"		"		2.46-3
	20	"		"		"		"	"		"		6.10-4

TABLE 11  
(For 1000°K, 75% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	2.20-3	8.30-3	1.58-2	2.83-2	7.39-2	3.90-2	1.03-1	1.28-1	1.89-2	8.74-2	1.75-2	1.10-1
	10	"	7.40-3	"	2.42-2	"	2.30-2	1.00-1	"	"	"	4.30-3	1.09-1
	15	"	6.80-3	"	2.13-2	"	1.45-2	9.75-2	"	"	"	1.00-3	1.08-1
	20	"	6.30-3	"	1.91-2	"	8.60-3	9.54-2	"	"	"	"	1.07-1
1000	5	1.90-3	4.00-3	1.44-2	1.03-2	6.87-2		8.46-2	1.23-1	5.70-3	8.72-2		1.00-1
	10	"	2.40-3	"	4.60-3	"		7.66-2	"	"	"		9.47-2
	15	"	1.50-3	"	2.20-3	"		6.99-2	"	"	"		8.82-2
	20	"	9.00-4	"	1.10-3	"		6.43-2	"	"	"		8.50-2
2000	5	1.70-3	2.20-3	1.30-2	4.50-3	6.36-2		7.38-2	1.17-1	3.30-3	8.65-2		9.37-2
	10	"	9.00-4	"	1.00-3	"		6.35-2	"	"	"		8.40-2
	15	"	4.00-4	"	3.00-4	"		5.45-2	"	"	"		7.06-2
	20	"	1.60-4	"	"	"		4.75-2	"	"	"		6.36-2
10,000	5	6.00-4	3.33-5	5.90-3		3.48-2		3.40-2	8.43-2	6.00-4	8.39-2		5.00-2
	10	"	"	"		"		2.03-2	"	"	"		2.49-2
	15	"	"	"		"		1.30-2	"	"	"		1.25-2
	20	"	"	"		"		8.10-3	"	"	"		6.20-3
20,000	5	2.00-4		2.20-3		1.63-2		2.00-4	5.55-2		7.95-2		2.27-2
	10	"		"		"		"	"		"		5.66-3
	15	"		"		"		"	"		"		2.27-3
	20	"		"		"		"	"		"		5.63-4

TABLE 12  
(For 1000°K, 50% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	2.20-3	8.20-3	1.56-2	2.81-2	7.34-2	3.88-2	1.02-1	1.28-1	1.87-2	8.24-2	1.75-2	1.10-1
	10	"	7.30-3	"	3.40-2	"	2.38-2	9.95-2	"	"	"	4.30-3	1.09-1
	15	"	6.80-3	"	2.12-2	"	1.44-2	9.71-2	"	"	"	1.00-3	1.08-1
	20	"	6.30-3	"	1.90-2	"	8.50-3	9.50-2	"	"	"	"	1.07-1
1000	5	1.70-3	3.50-3	1.31-2	9.40-3	6.38-2	5.00-4	7.85-2	1.16-1	5.30-3	8.13-2		9.80-2
	10	"	2.20-3	"	4.20-3	"		7.10-2	"	"	"		9.28-2
	15	"	1.40-3	"	2.00-3	"		6.48-2	"	"	"		8.64-2
	20	"	8.00-4	"	1.00-3	"		5.96-2	"	"	"		8.32-2
2000	5	1.30-3	1.80-3	1.07-2	3.80-3	5.47-2		6.35-2	1.05-1	2.90-3	7.51-2		8.99-2
	10	"	7.00-4	"	9.00-4	"		5.46-2	"	"	"		8.06-2
	15	"	3.00-4	"	2.00-4	"		4.70-2	"	"	"		6.78-2
	20	"	1.00-4	"	"	"		4.10-2	"	"	"		6.10-2
10,000	5	2.00-4		2.40-3		1.67-2		1.52-2	4.73-2	3.00-4	4.10-2		4.07-2
	10	"		"		"		9.00-3	"	"	"		2.03-2
	15	"		"		"		5.80-3	"	"	"		1.02-2
	20	"		"		"		3.60-3	"	"	"		5.05-3
20,000	5			3.00-4		3.70-3		1.00-4	1.79-2		1.92-2		1.45-2
	10			"		"		"	"		"		3.61-3
	15			"		"		"	"		"		1.45-3
	20			"		"		"	"		"		3.60-4

## NAVAL RESEARCH LABORATORY

TABLE 13  
(For 2000°K, 100% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1	5	1.33-1	1.31-1	8.85-2	1.15-1	1.27-1	1.16-1	6.94-2	6.07-2	1.87-2	2.81-2	4.25-2	3.00-2
	10	"	1.30-1	"	1.14-1	"	1.12-1	6.92-2	"	"	"	3.70-2	"
	15	"	1.29-1	"	1.13-1	"	1.09-1	6.90-2	"	"	"	3.53-2	"
	20	"	1.28-1	"	1.12-1	"	1.07-1	6.89-2	"	"	"	3.38-2	"
10	5	1.33-1	1.25-1	8.85-2	1.09-1	1.27-1	8.50-2	6.88-2	6.07-2	1.35-2	2.81-2	2.80-2	3.00-2
	10	"	1.21-1	"	1.04-1	"	7.62-2	6.82-2	"	"	"	2.22-2	"
	15	"	1.18-1	"	1.01-1	"	6.91-2	6.76-2	"	"	"	1.72-2	"
	20	"	1.16-1	"	9.95-2	"	6.38-2	6.72-2	"	"	"	1.45-2	"
100	5	1.33-1	1.06-1	8.85-2	8.70-2	1.27-1	3.50-2	6.55-2	6.07-2	7.30-3	2.81-2	4.50-3	3.00-2
	10	"	9.50-2	"	7.50-2	"	2.06-2	6.38-2	"	"	"	1.20-3	2.97-2
	15	"	8.68-2	"	6.60-2	"	1.30-2	6.22-2	"	"	"	3.00-4	2.94-2
	20	"	8.00-2	"	5.87-2	"	7.60-3	6.10-2	"	"	"	"	2.91-2
1000	5	1.33-1	5.08-2	8.85-2	3.20-2	1.27-1		5.57-2	6.07-2	2.20-3	2.81-2		2.76-2
	10	"	3.06-2	"	1.45-2	"		5.05-2	"	"	"		2.61-2
	15	"	1.90-2	"	6.80-3	"		4.60-2	"	"	"		2.43-2
	20	"	1.18-2	"	3.40-3	"		4.20-2	"	"	"		2.34-2
2000	5	1.33-1	3.34-2	8.85-2	1.66-2	1.27-1		5.01-2	6.07-2	1.30-3	2.81-2		2.61-2
	10	"	1.33-2	"	3.70-3	"		4.32-2	"	"	"		2.34-2
	15	"	6.00-3	"	9.00-4	"		3.70-2	"	"	"		1.96-2
	20	"	2.60-3	"	"	"		3.22-2	"	"	"		1.77-2
10,000	5	1.33-1	1.30-3	8.85-2		1.27-1		3.94-2	6.07-2	3.00-4	2.81-2		1.50-2
	10	"	"	"		"		1.78-2	"	"	"		7.50-3
	15	"	"	"		"		1.12-2	"	"	"		3.75-3
	20	"	"	"		"		7.00-3	"	"	"		1.86-3
20,000	5	1.33-1		8.85-2		1.27-1			6.07-2		2.81-2		7.97-3
	10	"		"		"			"		"		1.86-3
	15	"		"		"			"		"		7.50-4
	20	"		"		"			"		"		1.80-4

TABLE 14  
(For 2000°K, 85% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	1.33-1	1.06-1	8.83-2	8.70-2	1.27-1	3.50-2	6.55-2	6.07-2	7.30-3	2.81-2	4.50-3	3.00-2
	10	"	9.50-2	"	7.50-2	"	2.06-2	6.38-2	"	"	"	1.20-3	2.97-2
	15	"	8.68-2	"	6.60-2	"	1.30-2	6.22-2	"	"	"	3.00-4	2.94-2
	20	"	8.00-2	"	5.87-2	"	7.60-3	6.10-2	"	"	"	"	2.91-2
1000	5	1.23-1	5.08-2	8.28-2	3.20-2	1.20-1		5.57-2	6.07-2	2.20-3	2.81-2		2.76-2
	10	"	3.06-2	"	1.45-2	"		5.05-2	"	"	"		2.61-2
	15	"	1.90-2	"	6.80-3	"		4.60-2	"	"	"		2.43-2
	20	"	1.18-2	"	3.40-3	"		4.20-2	"	"	"		2.34-2
2000	5	1.13-1	2.80-2	7.70-2	1.46-2	1.14-1		5.00-2	6.07-2	1.30-3	2.81-2		2.58-2
	10	"	1.13-2	"	3.20-3	"		4.31-2	"	"	"		2.31-2
	15	"	5.10-3	"	8.00-4	"		3.68-2	"	"	"		1.94-2
	20	"	2.30-3	"	"	"		3.20-2	"	"	"		1.75-2
10,000	5	5.90-2		4.43-2		7.60-2		2.95-2	6.07-2	3.00-4	2.81-2		1.44-2
	10	"		"		"		1.79-2	"	"	"		7.20-3
	15	"		"		"		1.12-2	"	"	"		3.60-3
	20	"		"		"		7.00-3	"	"	"		1.78-3
20,000	5	2.67-2		2.21-2		4.44-2		1.00-4	6.07-2		2.81-2		7.17-3
	10	"		"		"		"	"		"		1.67-3
	15	"		"		"		"	"		"		6.75-4
	20	"		"		"		"	"		"		1.62-4

TABLE 15  
(For 2000°K, 75% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	1.33-1	1.06-1	8.84-2	8.67-2	1.26-1	3.50-2	6.55-2	6.06-2	7.30-3	2.81-2	4.50-3	3.00-2
	10	"	9.50-2	"	7.48-2	"	2.06-2	6.36-2	"	"	"	1.20-3	2.97-2
	15	"	8.65-2	"	6.58-2	"	1.30-2	6.22-2	"	"	"	3.00-4	2.94-2
	20	"	7.98-2	"	5.86-2	"	7.60-3	6.10-2	"	"	"	"	2.91-2
1000	5	1.08-1	4.88-2	8.05-2	3.16-2	1.18-1		5.40-2	5.98-2	2.20-3	2.80-2		2.73-2
	10	"	2.96-2	"	1.42-2	"		4.90-2	"	"	"		2.53-2
	15	"	1.85-2	"	6.60-3	"		4.46-2	"	"	"		2.40-2
	20	"	1.14-2	"	3.30-3	"		4.08-2	"	"	"		2.31-2
2000	5	1.04-1	2.64-2	7.25-2	1.40-2	1.09-1		4.75-2	5.89-2	1.30-3	2.78-2		2.56-2
	10	"	1.06-2	"	3.10-3	"		4.10-2	"	"	"		2.29-2
	15	"	4.60-3	"	7.00-4	"		3.50-2	"	"	"		1.92-2
	20	"	2.10-3	"	"	"		3.04-2	"	"	"		1.73-2
10,000	5	3.87-2	4.00-4	3.28-2		5.94-2		2.28-2	5.28-2	3.00-4	2.71-2		1.36-2
	10	"	"	"		"		1.39-2	"	"	"		6.82-3
	15	"	"	"		"		8.70-3	"	"	"		3.41-3
	20	"	"	"		"		5.40-3	"	"	"		1.69-3
20,000	5	1.07-2		1.24-2		2.78-2			4.44-2		2.53-2		6.61-3
	10	"		"		"			"		"		1.54-3
	15	"		"		"			"		"		6.22-4
	20	"		"		"			"		"		1.49-4

TABLE 16  
(For 2000°K, 50% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
100	5	1.31-1	1.04-1	8.75-2	8.65-2	1.26-1	3.48-2	6.51-2	6.06-2	7.30-3	2.80-2	4.30-3	2.99-2
	10	"	9.25-2	"	7.40-2	"	2.05-2	6.34-2	"	"	"	1.00-3	2.96-2
	15	"	8.50-2	"	6.53-2	"	1.29-2	6.18-2	"	"	"	"	2.93-2
	20	"	7.85-2	"	5.80-2	"	7.60-3	6.06-2	"	"	"	"	2.90-2
1000	5	1.01-1	4.40-2	7.35-2	2.90-2	1.09-1		5.01-2	5.53-2	2.10-3	2.24-2		2.66-2
	10	"	2.65-2	"	1.30-2	"		4.55-2	"	"	"		2.53-2
	15	"	1.65-2	"	6.00-3	"		4.14-2	"	"	"		2.36-2
	20	"	1.03-2	"	3.00-3	"		3.78-2	"	"	"		2.27-2
2000	5	7.74-2	2.17-2	6.00-2	1.18-2	9.40-2		4.05-2	5.00-2	1.10-3	2.40-2		2.45-2
	10	"	8.70-3	"	2.50-3	"		3.50-2	"	"	"		2.20-2
	15	"	3.90-3	"	7.00-4	"		2.98-2	"	"	"		1.84-2
	20	"	1.70-3	"	"	"		2.59-2	"	"	"		1.66-2
10,000	5	8.40-3	1.30-3	1.31-2		2.91-2		1.02-2	2.25-2	2.00-4	1.32-2		1.11-2
	10	"	"	"		"		6.20-3	"	"	"		5.55-3
	15	"	"	"		"		3.90-3	"	"	"		2.77-3
	20	"	"	"		"		2.40-3	"	"	"		1.37-3
20,000	5	7.00-4		2.00-3		6.30-3			8.50-3		6.20-3		4.22-3
	10	"		"		"			"		"		9.86-4
	15	"		"		"			"		"		3.97-4
	20	"		"		"			"		"		9.54-5

## NAVAL RESEARCH LABORATORY

TABLE 17  
(For 6000° K, 100% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1	5	3.03-1	6.91-2	2.85-2	2.52-2	2.16-2	1.36-2	6.53-3	4.80-3	1.40-3	1.90-3	2.20-3	1.10-3
	10	"	6.85-2	"	2.49-2	"	1.32-2	6.50-3	"	"	"	2.14-3	"
	15	"	6.80-2	"	2.47-2	"	1.29-2	6.48-3	"	"	"	1.97-3	"
	20	"	6.77-2	"	2.45-2	"	1.26-2	6.40-3	"	"	"	1.89-3	"
10	5	3.03-1	6.56-2	2.85-2	2.37-2	2.16-2	1.07-2	6.50-3	4.80-3	1.02-3	1.90-3	1.55-3	1.10-3
	10	"	6.40-2	"	2.28-2	"	9.65-3	6.40-3	"	"	"	1.19-3	"
	15	"	6.24-2	"	2.21-2	"	8.73-3	6.30-3	"	"	"	9.70-4	"
	20	"	6.13-2	"	2.16-2	"	8.04-3	6.25-3	"	"	"	7.82-4	"
100	5	3.03-1	5.58-2	2.85-2	1.92-2	2.16-2	4.48-3	6.21-3	4.80-3	5.50-4	1.90-3	2.65-4	1.10-3
	10	"	5.00-2	"	1.44-2	"	2.64-3	6.00-3	"	"	"	6.30-5	1.09-3
	15	"	4.56-2	"	1.64-2	"	1.66-3	5.90-3	"	"	"	2.00-5	1.08-3
	20	"	4.20-2	"	1.29-2	"	9.75-4	5.70-3	"	"	"	1.07-3	"
1000	5	3.03-1	2.88-2	2.85-2	7.55-3	2.16-2	7.50-5	5.29-3	4.80-3	1.70-4	1.90-3		1.01-3
	10	"	1.73-2	"	3.38-3	"		4.75-3	"	"	"		9.57-4
	15	"	1.07-2	"	1.58-3	"		4.32-3	"	"	"		8.91-4
	20	"	6.70-3	"	7.80-4	"		4.00-3	"	"	"		8.58-4
2000	5	3.03-1	1.76-2	2.85-2	3.64-3	2.16-2		4.72-3	4.80-3	1.00-4	1.90-3		9.57-4
	10	"	7.05-3	"	7.80-4	"		4.06-3	"	"	"		8.58-4
	15	"	3.17-3	"	1.95-5	"		3.50-3	"	"	"		7.21-4
	20	"	1.41-3	"		"		3.04-3	"	"	"		6.49-4
10,000	5	3.03-1	4.37-5	2.85-2		2.16-2		9.00-4	4.80-3		1.90-3		5.50-4
	10	"	"	"		"		5.00-4	"		"		2.74-4
	15	"	"	"		"		3.00-4	"		"		1.38-4
	20	"	"	"		"		2.00-4	"		"		6.82-5
20,000	5	3.03-1		2.85-2		2.16-2			4.80-3		1.90-3		2.74-4
	10	"		"		"			"		"		6.82-5
	15	"		"		"			"		"		2.74-5
	20	"		"		"			"		"		6.85-6

TABLE 18  
(For 6000° K, 85% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1000	5	2.78-1	2.69-2	2.66-2	7.10-3	2.05-2		5.25-3	4.80-3	1.70-4	1.90-3		1.01-3
	10	"	1.64-2	"	3.00-3	"		4.74-3	"	"	"		9.57-4
	15	"	9.80-3	"	1.40-3	"		4.33-3	"	"	"		8.91-4
	20	"	6.20-3	"	8.00-4	"		3.96-3	"	"	"		8.58-4
2000	5	2.57-1	1.71-2	2.45-2	3.20-3	1.95-2		4.66-3	4.80-3	1.00-4	1.90-3		9.47-4
	10	"	7.00-3	"	7.00-4	"		4.02-3	"	"	"		8.50-4
	15	"	3.20-3	"	1.00-4	"		3.45-3	"	"	"		7.14-4
	20	"	1.40-3	"		"		3.00-3	"	"	"		6.42-4
10,000	5	1.35-1	3.10-3	1.43-2		1.30-2		2.64-3	4.80-3		1.90-3		5.38-4
	10	"	"	"		"		1.60-3	"		"		2.63-4
	15	"	"	"		"		1.00-3	"		"		1.32-4
	20	"	"	"		"		6.30-4	"		"		6.71-5
20,000	5	6.05-2		4.63-3		8.00-3			4.80-3		1.90-3		2.46-4
	10	"		"		"			"		"		6.14-5
	15	"		"		"			"		"		2.46-5
	20	"		"		"			"		"		6.16-6

TABLE 19  
(For 6000°K, 75% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1000	5	2.68-1	2.57-2	2.58-2	6.93-3	2.03-2	7.70-5	5.10-3	4.73-3	1.70-4	1.90-3		1.00-3
	10	"	1.57-2	"	3.10-3	"		4.60-3	"	"	"		9.47-4
	15	"	9.80-3	"	1.45-3	"		4.20-3	"	"	"		8.82-4
	20	"	6.03-3	"	7.15-4	"		3.94-3	"	"	"		8.50-4
2000	5	2.36-1	1.42-2	2.34-2	3.06-3	1.86-2		4.42-3	4.61-3	1.00-4	1.88-3		9.38-4
	10	"	5.67-3	"	6.55-4	"		3.81-3	"	"	"		8.41-4
	15	"	2.55-3	"	1.65-5	"		3.27-3	"	"	"		7.06-4
	20	"	1.13-3	"	"	"		2.85-3	"	"	"		6.36-4
10,000	5	8.78-2	2.35-4	1.07-2		1.03-2		2.06-3	3.95-3	2.00-5	1.83-3		5.00-4
	10	"	"	"		"		1.23-3	"	"	"		2.49-4
	15	"	"	"		"		7.85-4	"	"	"		1.25-4
	20	"	"	"		"		4.90-4	"	"	"		6.20-5
20,000	5	2.58-2		4.00-3		4.90-3			3.26-3		1.71-3		2.27-4
	10	"		"		"			"		"		5.66-6
	15	"		"		"			"		"		2.27-5
	20	"		"		"			"		"		5.69-6

TABLE 20  
(For 6000°K, 50% Transmission)

Path Length (yards)	Water-Vapor Content (gm/meter <sup>3</sup> )	Region											
		1	2	3	4	5	6	7	8	9	10	11	12
1000	5	2.24-1	2.34-2	2.37-2	6.30-3	1.88-2		7.20-3	4.36-3	1.00-4	1.77-3		9.80-4
	10	"	1.43-2	"	2.80-3	"		6.50-3	"	"	"		9.28-4
	15	"	8.60-3	"	1.30-3	"		5.90-3	"	"	"		8.64-4
	20	"	5.40-3	"	7.00-4	"		5.40-3	"	"	"		8.32-4
2000	5	1.68-1	1.14-2	1.94-2	2.60-3	1.62-2		5.80-3	3.94-3		1.64-3		8.99-4
	10	"	4.60-3	"	6.00-4	"		5.00-3	"	"	"		8.06-4
	15	"	2.10-3	"	"	"		4.10-3	"	"	"		6.78-4
	20	"	9.00-4	"	"	"		3.70-3	"	"	"		6.10-4
10,000	5	1.49-2		4.20-3		5.20-3		1.60-3	1.80-3		9.10-4		4.07-4
	10	"		"		"		9.00-4	"		"		2.03-4
	15	"		"		"		6.00-4	"		"		1.02-4
	20	"		"		"		3.00-4	"		"		5.04-5
20,000	5	6.00-3		7.00-4		1.20-3			6.73-4		4.27-4		1.45-4
	10	"		"		"			"		"		3.61-5
	15	"		"		"			"		"		1.45-5
	20	"		"		"			"		"		3.66-6

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