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OPTICAL TRANSMITTANCE OF COMMON CERENKOV COUNTER GASES*

by

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Abstract

The optical transmittance of the commonly used Cerenkov counter gases, Freon 12, Freon 13, CO_2, SF_6, and N_2, was measured in the range from 1875 Å to 8000 Å, and normalized for a 100 cm × 1 atm path.

Calculations of efficiency for Cerenkov counters, particularly threshold type, require a knowledge of the optical transmittance of the counter filling for the Cerenkov light. For many of the gases with convenient values of refraction index, such information is not available. We have, therefore, measured the transmittance of Freon 12, Freon 13, CO_2, SF, and N_2 over the wavelength range of 1875 Å to 8000 Å.

The accompanying transmittance curves for various gases were derived from curves obtained with a Beckman DK-2A Ratio Recording Spectrophotometer, using a single F-075 High Pressure Ultraviolet Cell. The original curves gave the ratio of the transmittance of the 5-cm-long, quartz-window cell filled with the gas

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in question, to the transmittance of a path containing nitrogen gas, at a pressure of one atmosphere, and two quartz windows. (Nitrogen at one atmosphere is essentially transparent over the wavelength range of the spectrophotometer.) Two curves were run for each gas--one with the gas in the cell at atmospheric pressure and another at the highest pressure possible, limited either by the necessity of avoiding liquefaction of the gas, or by the 42-atmosphere cell pressure rating. The transmittance of the gas in question was then calculated for wavelengths in the absorbing regions using the relation

$$f_p = f_1^{\left(\rho_p/\rho_1\right)} \tag{1}$$

where f_1 and ρ_1 are the transmittance and gas density at one atmosphere and f_p and ρ_p the transmittance and gas density at an absolute pressure of p atmospheres.

According to the Lorenz-Lorenz law, the index of refraction n and density of a gas ρ are related by the function

$$\frac{n^2 - 1}{n^2 + 2} = \text{const} \times \rho \, . \tag{2}$$

If (n - 1) is no greater than 10^{-2}, this function can be expressed as

$$\text{const} \times \rho = (n - 1) \tag{3}$$

within an accuracy of 1/6%.

Values of (n - 1) as a function of pressure have been reported,[1,2] making it possible to rewrite (1) as

$$f_p = f_1^{\frac{(n-1)_p}{(n-1)_1}} \Rightarrow f_{1\,\text{calculated}} = \left(\frac{f_p}{f_1}\right)_{\text{measured}}^{\left[\frac{(n-1)_p}{(n-1)_1} - 1\right]^{-1}} \tag{4}$$

The resulting values were then normalized to a path of 100 centimeters at one atmosphere absolute of gas with the relation

$$T = f_{1_{\text{calculated}}}^{\frac{x}{x_1}} = f_{1_{\text{calculated}}}^{\frac{100}{5}} \qquad (5)$$

where T is the transmittance at one atmosphere over a path length x of 100 cm and f_1 is the transmittance calculated at one atmosphere absolute from the measurements in the x_1 = 5-cm-long cell. The results are presented in Fig. 1 and Table 1.

The errors are quite variable because of the different filling pressures and absorption coefficients. Representative errors are shown in Fig. 1 at various transmittance levels. For the N_2 and SF_6 curves, the error is about ± 1%.

Acknowledgment

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References

1. E. R. Hayes, R. A. Schluter and A. Tamosaitis, ANL-6916 (1964).
2. J. A. Niederer, BNL-6889 (1961).

Table 1

Gas	Measurement Pressure atm. abs.	$\frac{(n-1)_p}{(n-1)_1}$	Ideal gas approximation ρ_p/ρ_1	$p_\Delta{}^*$
N_2	41.8	42.2	41.8	41.8
SF_6	19.1	25.95	19.1	3.38
CO_2	41.8	50.8	41.8	2.56
Freon 12	3.72	3.88	3.72	1.885
Freon 13	28.2	41.6	28.2	2.49

*Absolute pressure in atmospheres at which ideal gas approximation deviates by 1% from (n - 1) ratio.

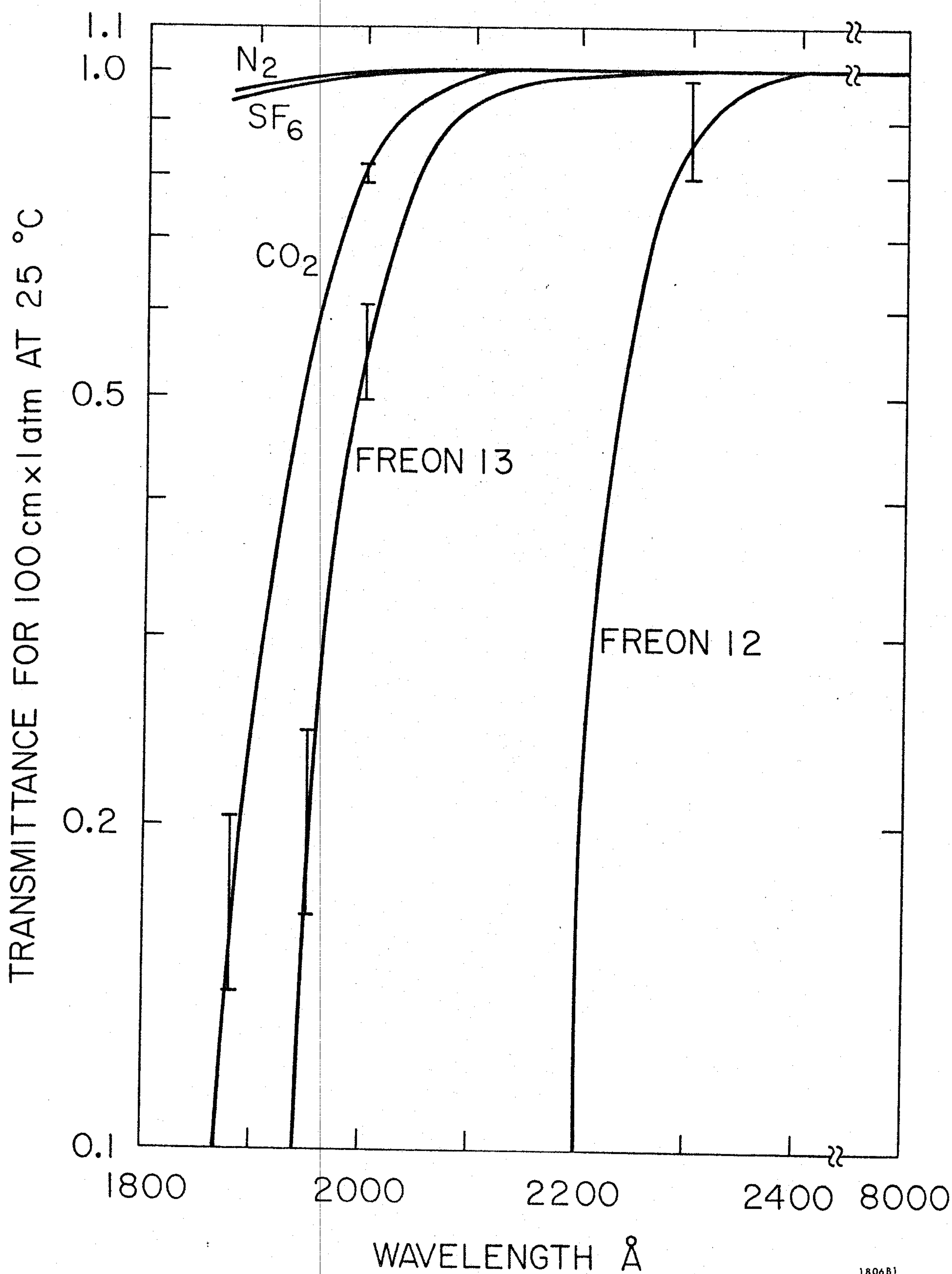

Fig. 1

Transmittances normalized for a 100 cm × 1 atmosphere path, vs wavelength.