Reprinted from JOURNAL OF APPLIED PHYSICS, Vol. 23, No. 11, 1283, November, 1952

Emissivity for CO_2 at Elevated Pressures*

R. J. HOLM,† D. WEBER, AND S. S. PENNER
Guggenheim Jet Propulsion Center and Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California
(Received August 26, 1952)

TOTAL absorptivity measurements have been carried out at room temperature as a function of partial pressure of CO_2 and of total pressure using nitrogen as pressurizing gas. The results

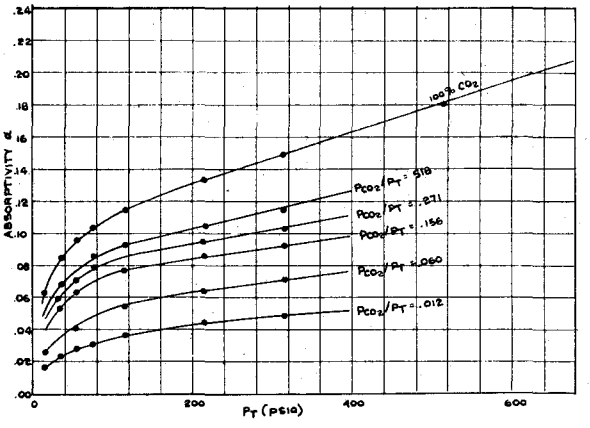

FIG. 1. Absorptivity α as a function of P_T for various fractional pressures of CO_2 at room temperature. The CO_2 was pressurized with nitrogen.

of these investigations are summarized in Fig. 1. Appropriate values at a total pressure of one atmos are compared with emissivity data published by Hottel and Mangelsdorf (1935) in Figs. 2 and 3.

The principal conclusions reached as the result of the present investigations are:

(a) At atmospheric pressure and room temperature, the results of total absorptivity measurements are in reasonably good agreement with the emissivity data of Hottel and Mangelsdorf, the difference increasing somewhat as the optical density is raised.

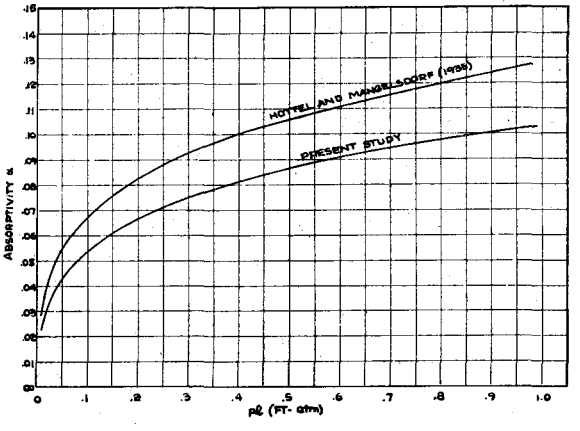

FIG. 2. Comparison of absorptivities for CO_2 at room temperature and atmospheric pressure with emissivities of Hottel and Mangelsdorf ($0 \leqslant pl$, ft-atmos $\leqslant 1.0$).

(b) At pressures in excess of one atmos, the absorptivity (and hence the emissivity) is quite insensitive to changes in total pressure. Thus, between 1.0 and 21 atmos total pressure, the measured values of total absorptivity at fixed optical density are equal within the rather wide limits of error (± 15 percent) of the present preliminary investigations. This result can be understood in terms of the ratio of rotational line width to rotational line spacing, which is relatively large for triatomic molecules such as CO_2. There are no apparent reasons why the observed insensitivity of emissivity to total pressure cannot be extrapolated to elevated temperatures. Thus, although the collision half-width of the rotational lines decreases roughly inversely as the square root of the absolute temperature, it also increases linearly with total pressure. Hence the ratio of half-width to line spacing at

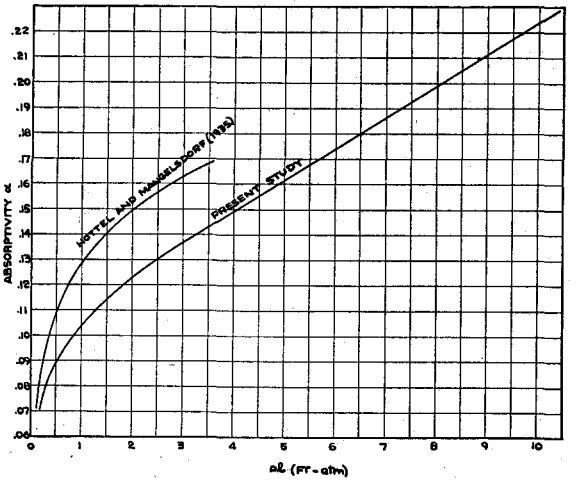

FIG. 3. Comparison of absorptivities for CO_2 at room temperature and atmospheric pressure with emissivities of Hottel and Mangelsdorf ($0 \leqslant pl$, ft-atmos $\leqslant 10$).

3000°K and 20 atmos should be comparable to conditions at 300°K and 11 atmos. Therefore, it appears unlikely that a large error is made if radiant heat transfer calculations involving CO_2 at elevated pressures are based on emissivity data for CO_2 determined at atmospheric pressure. The preceding statement should not be extrapolated indiscriminately to other molecules.[1]

* This paper presents, in part, the results of one phase of research carried out at the Jet Propulsion Laboratory, California Institute of Technology, under Contract No. DA-04-495-ORD 18, sponsored by the U. S. Army Ordnance Department. Supported, in part, by the ONR under Contract Nonr-220(03), NR 015 210.

† This article is based, in part, on a thesis submitted by R. J. Holm to the graduate school of the California Institute of Technology, in partial fulfillment of requirements for the degree of Aeronautical Engineer, June, 1952.

[1] For details concerning emissivity calculations on diatomic gases at elevated pressures, see S. S. Penner, J. Appl. Phys. **21**, 685 (1950) or J. Appl. Mech. **18**, 53 (1951).