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An Equation of State for Oxygen and Nitrogen

Recent measurements of the thermodynamic properties of oxygen and nitrogen have provided the data necessary for the development of a single equation of state for both fluids. With the appropriate coefficients, the equation describes the P-ρ-T surface for each gas within the estimated experimental uncertainty of the data. These data are available in a summary report and a two-part detailed study on the thermodynamic properties of oxygen and nitrogen (see Note).

The equation of state is fitted to the available experimental data (including P-ρ-T data, saturation data, and measured isochoric heat capacities) by a least-squares approximation. New vapor-pressure equations and equations for the ideal-gas heat capacities for both oxygen and nitrogen have been developed for use in the calculation of derived thermodynamic properties. By the use of a new fitting technique, continuous integration along isotherms through the two-phase region facilitates the calculation of liquid properties. A further advantage of this formulation is the ease of programming a single equation of state for computer calculations in design work.

The functional form of the equation of state has 32 terms; it is developed by a stepwise multiple-regression analysis of 50 terms considered likely to be appropriate in representing the body of selected data for nitrogen. The coefficients for the equation of state for both fluids are determined by weighted least-squares fits to selected data that are constrained to the appropriate critical-point parameters.

The same data are used to develop a vapor-pressure equation and a heat-capacity equation. Pressure-density-temperature data calculated from these equations are compared with experimental data. The data agree within experimental uncertainty except in the vicinity of the critical point, at very low temperatures (cryogenic liquids), and at high-pressure supercritical regions. Other properties, such as heat capacities, are calculated and also compare well with experimental data.

Note:

The reports describing this study are as follows:

1. "The Thermodynamic Properties of Oxygen and Nitrogen" – Summary report.
   Reference: NASA-CR-128525 (N72-30955)
   Single report price $3.00
   (or microfiche $0.95)
2. "The Thermodynamic Properties of Oxygen and Nitrogen" – Part One.
   Reference: NASA-CR-128527 (N72-30957)
   Single report price $13.75
   (or microfiche $0.95)
3. "The Thermodynamic Properties of Oxygen and Nitrogen" – Part Two.
   Reference: NASA-CR-128528 (N72-30958)
   Single report price $10.25
   (or microfiche $0.95)

These reports may be obtained from:
National Technical Information Service
Springfield, Virginia 22151

Source: R. T. Jacobsen, A. F. Myers, and R. B. Stewart of
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