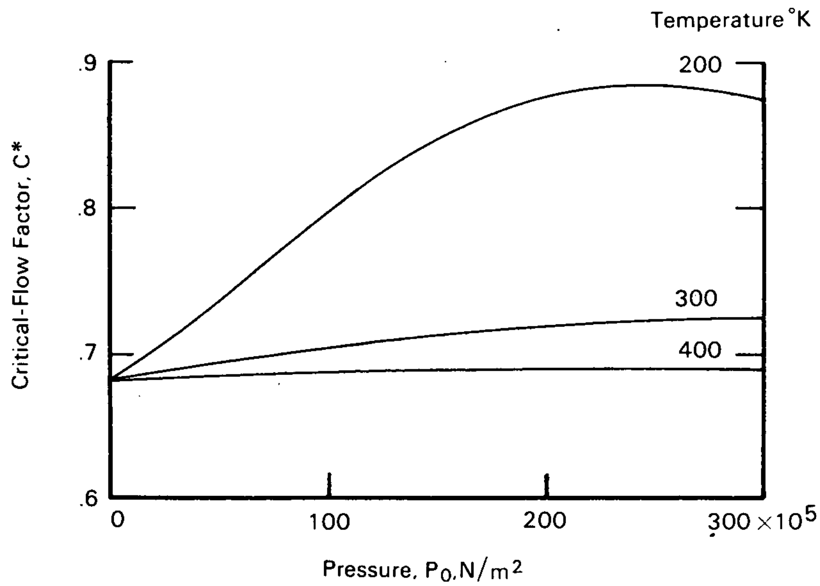
NASA TECH BRIEF

High Pressure Real Gas Effects for Helium and Nitrogen



An analysis has been performed to obtain the real-gas isentropic flow functions for nitrogen and helium. Real-gas effects are not negligible for gases at high pressures and low temperatures. The calculations cover a temperature range from near condensation to 400°K and a pressure range of 0 to 300 $\times$ 10^5 newtons per square meter (approximately 300 atm).

A critical flow factor is calculated that permits the isentropic mass-flow rate of the gases through critical flow nozzles to be calculated from plenum conditions. In addition, the results include the nozzle throat velocity, the compressibility factor, the entropy, the enthalpy, the specific heat at constant pressure, the specific-heat ratio, and the ratios of throat to plenum pressure, density, and temperature. These results are tabulated as functions of the plenum pressure and temperature.

An example of these calculations is illustrated by the figure. The graph is for nitrogen expanded from rest in a plenum to sonic velocity through a critical-flow measuring nozzle. The flow rate, G, in Kg/(m^2sec) is given by:

$$G = C^* \frac{P_0}{\sqrt{RT_0}}$$

where R is the gas constant for nitrogen (296.8m^2/(sec^2K)), T_0 is the plenum temperature in °K, P_0 is the plenum pressure in N/m^2, and C* is critical-flow factor. The deviation in the curve of C* from a horizontal line gives the magnitude of the real-gas effects.

(continued overleaf)

Notes:

1. Technical questions may be directed to:

   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B69-10669

2. The computer program that provided these results is applicable to other gases for which the equation of state is known. It also permits three different sets of independent variables. In addition to the plenum pressure and temperature, the other independent variable is either the nozzle exit pressure, the nozzle exit mach number, or the nozzle exit temperature. Inquiries concerning the computer program used for this analysis (NASA Tech Brief 69-10222) should be directed to:

   COSMIC
   Barrow Hall
   University of Georgia
   Athens, Georgia 30601
   Reference: B69-10222

Patent status:

No patent action is contemplated by NASA.

Source: Robert C. Johnson
Lewis Research Center
(LEW-10819)