GERG Round-Robin Test of Z-Meters, a Burnett Apparatus, and an Interferometric Device for $pVT$ Measurements

M. Jaeschke, 2 S. Audibert, 3 P. van Caneghem, 4 A. E. Humphreys, 5 R. Janssen-van Rosmalen, 6 and Q. Pellei 7

The European Gas Research Group (GERG; Groupe Européen de Recherches Gazières) initiated a round-robin test of six Z-meters manufactured by Desgranges et Huot, a Burnett apparatus, and an interferometric device to back up the $pVT$ data of the Z-meters. Two gas mixtures were measured. One mixture contained 49.7 mol% of methane and 50.3 mol% of nitrogen; the second mixture 81.3 mol% of methane, 16.4 mol% of ethane, and 2.3 mol% of propane. The test temperatures were mainly 280 and 300 K for the first mixture and 290 and 320 K for the second mixture. The maximum pressures were 8 MPa for Z-meters and 12 MPa for the Burnett apparatus and the grating interferometer. The experimental compressibility factors Z of the six Z-meters are generally in agreement within $\pm 0.05\%$. The agreement with the reference data from the Burnett apparatus and the refractive index measurements is also within $\pm 0.05\%$. Only two isotherms of the binary mixtures differ by about 0.1% from the other data. Recent natural gas measurements show substantially the same results.

KEY WORDS: Burnett apparatus; compressibility factor; density; ethane; methane; mixtures; nitrogen; refractive index; Z-meter.

2 Ruhrgas AG, Halterner Strasse 125, 4270 Dorsten, Federal Republic of Germany.
3 Gaz de France, Centre de Recherches Gazières (CERSTA), 361 Avenue du Président Wilson, P.O. 93, 93211 La Plaine St. Denis Cedex, France.
4 Distrigaz S.A., Digue du Canal 102, 1070 Bruxelles, Belgium.
5 British Gas plc, London Research Station, Michael Road, London SW6 2AD, United Kingdom.
6 Nederlandse Gasunie N.V., Energieweg 17, P.O. Box 19, 9700 MA Groningen, The Netherlands.
7 SNAM S.p.A., Servizio Despacciamento e Misure, 20097 San Donato Milanese, Italy.
1. INTRODUCTION

In an effort to produce an accurate equation of state for natural gas mixtures, the European Gas Research Group (GERG; Groupe Européen de Recherche Gazières) has developed a unique data bank. The data bank combines sets of data from high-accuracy experimental compressibility factor measurements, made for pure gases and for binary and multicomponent mixtures by British Gas, Gaz de France, Gasunie and Ruhrgas, with similar data available from the published literature. The data bank was employed to develop an equation of state with a target uncertainty of less than 0.1% for predicted compressibility factors $Z(p, T)$. A large proportion of the data, used mainly for the preliminary (1986) GERG virial equation [1], was obtained from tests with commercial “Z-meters” manufactured by Desgranges et Huot (DEH). The final GERG virial equation [2-4] is based on a data bank which also contains many high-accuracy data points measured by a Burnett apparatus or a grating interferometer.

GERG members recognized the importance of clarifying two factors upon which the performance of the GERG equation would depend, viz., (a) the level of agreement between Z-meters operated with slightly different methodologies and (b) the level of agreement between Z-meters and alternative methods of high-accuracy $Z$ measurement. Obviously any systematic differences identified have implications for the accuracy of any equation ultimately developed. A particular problem for Z-meters was anticipated to be that the integrity of results might be prejudiced by adsorption or similar processes occurring during expansion within the apparatus. For this reason, GERG initiated a round-robin test of several Z-meters and other apparatus.

2. ROUND-ROBIN TEST

Two mixtures were used for the round-robin test:

(i) 49.7 mol% methane + 50.3 mol% nitrogen and
(ii) 81.3 mol% methane + 16.4 mol% ethane + 2.3 mol% propane.

Ruhrgas prepared the mixtures, each apportioned into seven samples and analyzed them. Some samples of the binary mixture were also analyzed by British Gas and Gasunie. The agreement for the analysis is within 0.15 mol%. Some samples of the ternary mixture were analyzed by Gaz de France and Gasunie. The agreement is within 0.05 mol%. The molar compositions of the sample gases tested using six DEH $Z$-meters from the laboratories of GERG members are listed in a GERG report [5]. Each individual sample of each mixture was only tested using one of the