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TECHNICAL PAPER

# The precise designation of natural gas volumetric flow by measuring simple thermodynamic properties and using artificial intelligence methods

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**Abstract**
Determining the precise amount of natural gas (NG) volumetric flow rate is an important issue in trading NG. The temperature, pressure, and compressibility factor of NG are required parameters for calculating (NG) volumetric flow rate. To calculate the NG compressibility factor according to the acceptable standard methods, the NG composition analysis must be known. Considering that measuring NG composition analysis is a costly and complex method, an artificial intelligence (AI) method has been presented to calculate the NG compressibility factor by measuring simple thermodynamic properties and without any information about NG composition analysis. Temperature, pressure, density, and heating value have been selected as measurable properties as well as input parameters to the neural network models. A large database containing 50,000 distinct natural gases with thermodynamic properties has been generated using the GERG-2008 equation of state (EoS) to train the proposed neural network model. The proposed neural networks have been validated by using available experimental data. The statistical parameters show that the 4-input network calculates the compression factor with higher accuracy than the 3-input network. Average absolute percent relative error, root mean square error, and coefficient of determination have been reported 0.2%, 0.0028, and 0.9943 for 4-input network compared to experimental data. Moreover, the two proposed neural networks have been presented for NG samples collected from different regions of Iran and the results compared to the GERG-2008 EoS. The results show that the proposed neural network method calculated the NG compressibility factor with acceptable precision.

**Keywords** Natural gas · Compressibility factor · Volumetric flow rate · GERG-2008 · Artificial intelligence methods

## 1 Introduction

One of the most frequent tasks in the gas industry is measuring the quantity of natural gas (NG) in the pipelines. The flow meters (ultrasonic meters, turbine meters, etc.) are the primary component in the metering systems that are measured the volumetric flow rate of NG in the line conditions (fluid conditions). This measured flow rate should be converted to the volumetric flow at a certain temperature and pressure (i.e., standard conditions) [1]. Since the NG is compressible and also the temperature and pressure of NG are varied along the pipeline, the impact of the compressibility should be investigated in the metering stations. The correction factor (CF), which is a function of temperature, pressure, and compressibility factor, must convert volumetric flow rate from line conditions to standard conditions for trading NG [2]. The temperature and pressure of NG are measured by special sensors, but there is not any sensor to measure the compressibility factor of NG. As a result, various algorithms are introduced to calculate the NG compressibility factor at different conditions. These algorithms are developed based on the empirical correlations and equation of states (EoS) [3].

Empirical correlations are simple mathematical relations that are used to reduce computation time and prevent the complexity of conventional approaches. The most well-known empirical correlations that are developed to calculate the compressibility factor of NG are the studies

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