Journal of Natural Gas Science and Engineering 9 (2012) 45–50

Contents lists available at SciVerse ScienceDirect

Journal of Natural Gas Science and Engineering

journal homepage: www.elsevier.com/locate/jngse

Assessment of calorific value at a gas transmission network

Nikolaos A. Tsochatzidis*, Elias Karantanas

Hellenic Gas Transmission System Operator (DESFA) SA, L. Messogeion 357-359, GR-15231 Halandri, Greece

ARTICLE INFO

Article history:
Received 27 September 2011
Received in revised form
29 March 2012
Accepted 21 May 2012
Available online 27 June 2012

Keywords:
Natural gas transmission
Calorific value
Uncertainty estimation
Gas analysis
Gas chromatographs

ABSTRACT

A method to determine the combined calorific value uncertainty of a number of chromatographic systems, in order to assess their performance, is proposed. Using this method the uncertainty of calorific value, determined from gas analysis of various chromatographic systems at the central – north region of the Hellenic Gas Transmission System, is estimated. Real gas calorific value data, from the same chromatographic systems of the selected region, are then evaluated. Analysis of data reveals that calorific values of natural gas are measured within acceptable tolerance for the systems studied. This uncertainty estimation method can be applied for various regions of gas transmission systems and time periods, with similar characteristics.

1. Introduction

The amount of gas energy, for balancing and custody transfer purposes at natural gas transmission systems, is calculated by the multiplication of the natural gas volume and its Gross Calorific Value (GCV). The calorific value is determined from gas analysis at process chromatographic systems. Usually several on-line gas chromatographs are used made by various manufactures and having different measuring capabilities. The performance of the chromatographic systems is controlling of various aspects and each of them from several parameters (Werff van der, 2001). All these aspects contribute to the measurement uncertainty of the gas analysis determination. A review of the sources of uncertainty associated with analysis by gas chromatography is reported by Barwick (1999).

The uncertainty of the gas analysis given by the chromatographic systems affects directly the uncertainty of calorific value determination. Calorific value uncertainty directly influences the overall uncertainty budget of energy content of natural gas. Martins et al. (2007) suggest that the overall uncertainty budget of energy content is influenced by the chemical analysis of natural gas.

Moreover, operators of gas transmission systems have a great interest about the estimation of the combined uncertainty of the calorific value reported by several chromatographic systems. This estimation of the calorific value uncertainty of transmitted natural gas is attempting at this study. Then the estimated combined calorific value uncertainty is used to evaluate the performance of the chromatographic systems by comparing their measurements. To minimize the effect of chemical properties fluctuations on gas, a number of chromatographs carefully selected from a specific geographical region of the Hellenic Gas Transmission System, analyzing practically a constant natural gas quality. Under such a condition, data of stream natural gas analyses is used to substitute analyses data of a transferring gas bottle. In order to compare the results of the chromatographs at the selected region, a reference calorific value is used, based on the methodology proposed by Cox (2002).

An initial study of this topic presented by the authors recently (Tsochatzidis and Karantanas, 2011), whilst a detail examination is attempting at this paper.

2. System description

The Hellenic Gas Transmission System Operator (DESFA) SA is operating and expanding the national gas transmission system (www.desfa.gr). This gas network and its future expansions at the broad geographical area are depicted on the map of Fig. 1. Currently, the gas system has three entrance metering stations and more than forty metering and regulating stations at exit points. Some aspects of this gas transmission system and its metering systems reported elsewhere (Tsochatzidis and Maroulis, 2007; Tsochatzidis, 2008). The gas quality determination is evaluated at this study.

At the Hellenic Gas Transmission System all metering stations are equipped with on-line gas chromatographs for analyzing

* Corresponding author. DESFA SA, Dept. of Metrology, GR-62300 Sidirokastro, Greece. Tel.: +30 23230 25363; fax: +30 23230 25362.
E-mail address: n.tsochatzidis@desfa.gr (N.A. Tsochatzidis).

1875-5100/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
doi:10.1016/j.jngse.2012.05.009

Fig. 1. The Hellenic Natural Gas Transmission System and its future expansions at the broad geographical area (www.desfa.gr).

natural gas samples. Gas chromatographs are utilizing a gas sampling unit next to the main flow meters. The sampling unit is designed according to ISO 10715. The gas chromatographs are connected to the flow computers, via supervisory computer systems, in order to provide the flow computers with all necessary data for the calculation of the mass, volumetric and energy flows. Energy is determined from gas quantity times the calorific value of natural gas. The gas chromatographs together with the flow meters and the flow and supervisory computers compose the station's metering and invoicing system. Since the calculated data are used for accounting purposes, the design is highly reliable and accurate according to the stage of the art. All chromatographs functions, including internal diagnostic tests, are completely automatic and designed for unattended operation.

The design of the chromatographic systems allows for re-calibration runs to be carried out automatically (usually once per 24-h period) with facilities for additional locally initiated calibrations to be carried out on demand. A single point calibration is performing. The chromatograph analyses are done according to ISO 6974, and all computations are in accordance with ISO 6976. Once a year some on-line chromatographs of the entire DESFA's gas network are validated in accordance with ISO 10723 using regression analysis (Squire, 2011).

3. Data selection of further study

In order to evaluate of calorific value data coming from various chromatographs the stream gas for analysis must be practically constant. To accomplice this task only a specific geographical region of the entire gas network is selected depicted with the green oval curve on Fig. 2 (central – north Greece). Gas entering at the selected geographical region flows to exit points within less than 12 h. Also, a time period selected based on measurements of %mole CH_4 on stream gas. This is because Methane is by far the most dominant constituent of the gas transmitted at the selected geographical region (Russian natural gas). Historical gas analysis data of the selected geographical region reveals that any change of stream gas composition always affects CH_4 concentration Fig. 3 depicts %mole CH_4 deviation (standard deviation over average values) coming from the chromatographic systems of the geographical region denoted with the green curve of Fig. 2. From Fig. 3 it is evident that values for the period February–May 2010 are almost constant.

Indeed, the natural gas composition at the part of the gas transmission system (within the oval curve at Fig. 2) is almost constant, for the period February–May 2010. At this period of time the ranges of the natural gas components, whose contents are measured, are as follow (in %mole):

	Min–Max
Methane (C1)	97.2609–97.5040
Ethane (C2)	1.1828–1.3808
Propane (C3)	0.3551–0.3828
Iso Butane (i-C4)	0.0604–0.0673
Normal Butane (n-C4)	0.0577–0.0681
Iso Pentane (i-C5)	0.0115–0.0149
Normal Pentane (n-C5)	0.0082–0.0108
Hexane plus heavier hydrocarbons (C6+)	0.0069–0.0091
Nitrogen (N_2)	0.7667–0.8868
Carbon dioxide (CO_2)	0.0448–0.0630