

NORSOK STANDARD
SYSTEM REQUIREMENT
ON-LINE GAS CHROMATOGRAPH

I-SR-106

Rev. 1, January 1996

Please note that every effort has been made to ensure the accuracy of the NORSOK standards neither OLF nor TBL or any of their members will assume liability for any use thereof.

1 FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and remove unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and are jointly issued by OLF (The Norwegian Oil Industry Association) and TBL (The Federation of Norwegian Engineering Industries). NORSOK standards are administered by NTS (Norwegian Technology Standards Institution).

The purpose of this industry standard is to replace the individual oil company specifications for use in existing and future petroleum industry developments, subject to the individual company's review and application.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of this standard will be used to provide input to the international standardization process. Subject to implementation into international standards, this NORSOK standard will be withdrawn.

2 SCOPE

The scope of this standard is to establish technical requirements for on-line gas chromatograph system (OGC) for the purpose of continuous quantitative analysis of natural gas from a process stream.

The analysis is limited to the following main components: Nitrogen, carbon dioxide, methane, ethane, propane, iso-butane, normal-butane, iso-pentane, normal-pentane and the C6+ fraction.

The requirements shall be sufficient for a quality of the OGC to quantify the concentrations of the main components for the purpose of gas accounting, calculation of calorific value and reference density for fiscal purposes and for check of gas quality conformity with gas quality specifications defined by commercial gas agreements .

3 NORMATIVE REFERENCES

ISO/DIS 6974 1/5	Natural gas - Determination of composition with defined uncertainty by gas chromatography
ISO 6976	Natural gas - Calculation of calorific value - density and relative density
ISO 6568	Natural gas - Simple analysis by gas chromatography
ISO/DIS10715	Natural gas - Sampling guidelines
ASTMD1945	Analysis of natural gas by gas chromatography
NORSOK I-CR-100	Fiscal measurement systems
NORSOK Z-CR-010	Installation of Electrical, Instrument & Telecommunication

4 DEFINITIONS AND ABBREVIATIONS

4.1 Definitions

Normative references	Shall mean normative in the application of NORSOK standards.
Informative references	Shall mean informative in the application of NORSOK standards.
Shall	Shall is an absolute requirement which shall be followed strictly in order to conform with the standard.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-requirements are conditional and indicates a possibility open to the user of the standard.
% REL	Number given as % relative to the concentration.
Group of component	Group of components with so low concentrations that their measurement as individual would be difficult or require excessive time. Hydrocarbons heavier than Pentanes (denoted as C6+) is example of such a group
X	Non-normalised concentration in mol fraction (X, is concentration of component i).
X ^x	Normalised concentration in mol fraction.
Column	Tubes inside the temperature controlled oven of the GC packed with material suitable for separating the components of natural gas when flowing the sample through using carrier gas.
Carrier gas	Gas used to transport sample through the columns, normally Helium, Hydrogen or mix-mixture of Helium and Hydrogen.
Calibration	Determination of the response of the detector for a given component with known concentration given on the certificate of the calibration gas or comparing the reading from OGC with values given on the certificate of the WGM.
U _{XI}	Total uncertainty of X _i , $U_{Xi} = (U_{RXI}^2 + U_{LXI}^2)^{0.5}$.
U _{RXI}	Uncertainty of X, due to lack of repeatability. Determined from repeatability test. Expressed in mol fraction and calculated as one standard deviation from the repeatability test.
U _{LXI}	Uncertainty of X, due to lack of linearity. Determined from linearity test. Expressed in mol fraction and calculated as one standard deviation taken every averageresults from MLC.

4.2 Abbreviations

GC	Gas Chromatograph, a device which separates the components in a gas mixture and measure them individually with a detector.
OGC	On-line Gas Chromatograph, GC fed continuously and automatically with process gas.
TCD	Thermal Conductivity Detector, most commonly used detector to measure the main components in natural gas.
WGM	Working Gas Mixture, also called calibration gas, used for regular calibration of the OGC. Normally prepared by gravimetric method and supplied with a certificate listing the concentrations of all component and the uncertainty of the concentrations.
SPC	Single Point Calibration. Calibration using only one WGM with concentration as close as possible to the process gas or as close as necessary found by multi-level calibration).
MLC	Multi Level Calibration. Calibration using nor WGMs to either determine the uncertainty due to linearity of the GC for all components within actual range or to determine the response curves of the detector of each component. MLC may only be performed before installation or during commissioning.

5 GENERAL DESIGN

5.1 Design consideration

The OGC shall be of sufficient accuracy to fulfill the requirements in this standard. The system downtime for maintenance etc. must be kept to a minimum.

The OGC should be kept under sufficient controlled environment i.e. providing protection against cold, heat, rain, wind etc.

5.2 Sampling system

To ensure that the sample to the OGC is representative for the process stream and suitable for the OGC recommendations as specified in this document, by the analyser supplier and in the ISO/OIS 10715 Natural gas - Sampling guidelines shall be followed.

The following basic requirements shall apply:

The shortest practical sampling route between sampling point and analyser should be taken. The sampled gas shall reach the analyser within a 2 minute timelag. Time lag calculations shall be presented.

Slope of at least 1:12 shall be maintained along the sample line.

All fitting should be accessible for maintenance.

The sampling probe shall be designed so it is possible to be retracted under operating pressure by a method to be accepted.

Spot sampling connection shall be provided.

Conditioning equipment are required for the removal of dirt, liquid entrainment etc. and to reduce pressure to be suitable for the analyser.

Adequate protective filters and coalescer have to be installed. Care must be taken to allow for simple quick maintenance of filters and for proper choice of filter media. If necessary, spare filters shall be installed.

The temperature in all parts of the sample lines including sample conditioning equipment shall be kept at a temperature minimum 10°C above the hydrocarbon dew point temperature. The dew point temperature shall be calculated for every pressure level in the system. The temperature and pressure at critical points in the sampling system shall be indicated.

At normal sample flow through the system, line pressure variations between max and min shall not affect the rate and pressure of the sample gas to the analyser.

All manually controlled shut off valves in the cabinets shall have a proper open/close indication.

Waste samples from the analyser shall be vented via a separated vent line. Waste bypass gas from the cabinets can be vented to a common vent/drain system. The vent system shall be design in order to avoid influence from ambient conditions.

5.3 Analytical requirements

The scope of the analysis is normally limited to the following list of natural gas components and the concentrations for any application are anticipated to be within the indicated ranges:

Components	Concentration range in mol %
Nitrogen	0 - 15
Carbon Dioxide	0 - 10
Methane	60 - 100
Ethane	0 - 15
Propane	0 - 5
Iso-Butane	0 - 1
Normal-Butane	0 - 1
Iso-Pentane	0 - 1
Normal-Pentane	0 - 1
Hexane's and heavier	0 - 1

The hexane's and heavier fraction (C6+) includes components from 2,2-dimethylbutane (neo-hexane) and upwards in an increasing order of boiling point.

The normal-butane peak will normally include 2,2-dimethylpropane (neo-pentane).

The following requirements shall be fulfilled:

All components should be separated from each other down to the baseline of the detector signal. It is of special importance that nitrogen and carbon dioxide are well separated from methane and special attention concerning the separation of the 1 ght hexane`s from n-pentane has to be made.

The separation criteria shall be taken from ISO/DIS 6974.

The time required for a full analysis cycle shall be less than 15 minutes.

Quicker separation could be achieved by the use of capillary columns and/or by packed columns in parallel using two columns simultaneous and two detectors. The latter techniques will require bridge components in order to link the two separate analysis`s mathematically together in one quantitative report.

The chromatograph shall have a valve arrangement that provides the alternative selection of two sample streams and sufficient number of WGMs. Selection of sample stream and WGMs shall be possible from the central control unit.

Multi-stream systems should be provided with a system to avoid possible sample cross-contamination.

The oven temperature setpoint shall be adjustable from the central control unit. Range, step and accuracy shall be sufficient to obtain required stability and accuracy of the analysis. It should be possible to record the temperature continuously from the central control unit.

The chromatograph shall use carrier gas in accordance with requirement given by the application. Pressure and flowrate of carrier gas shall be controlled with sufficient accuracy. A pressure sensor that breaks the electric power to the oven and detector in case of failure in carrier gas supply should be installed.

The chromatograph shall use TCD.

The repeatability of the GC shall be within the following limits:

Component range (mole %)	Standard deviation (mole %)
0 - 25	0.01
25 - 100	0.02

The linearity of each component shall be so that the maximum deviation from values of any WGM when performing a MLC after adjustment of the OGC correct reading after a SPC shall, shall be so low that the resulting uncertainty in gross calorific value, U_{hw} , is less than 0.15% of the gross calorific value, H_s , when applying the following equation:

$$U_{hs} = [(H_s - H_{si})^2 \times (U_{xi})^2]^{1/2}$$

where H_s is the gross calorific value for each component found in the ISO 6976.

5.4 Central GC controller

The chromatograph should be controlled from a central unit. Programme software, interfaces and protocol should be robust with special consideration concerning automatic re-generation of all control and communicational functions after the event of a general powerfailure.

Communications between the analytical unit and the central controller should be according to the vendor's standard protocol.

The installation shall be according to Z-CR-010.

The software shall provide real time multi-tasking capabilities to support multiple activities concurrently. The software shall also provide extended maintenance tools, such as statistical tracking of analyser performance, availability reporting, and maintenance log.

The following functions shall all be available for the operator:

- Start and stop the analysis cycle.
- Display and/or change temperature setpoints for the Temperature Control Board.
- Change the serial communication protocol.
- Change the alarm limits.
- Override alarms.
- Define component table, retention time, RT tolerance, response factor, valve switching.
- Sequence, calibration frequency and WGM concentration.
- Password protected program modifications.
- User settings of high and low alarms on: concentration, relative response factor retention.
- Time, peak height, peak area, peak start time, peak end time and temperature (for each component) and total area.

The final analytical results should be traceable regarding sample point, time and date, with the possibility of later visual inspection. Start and stop of peak integration event marks and electronic baseline should be possible. Hard copies should be available on request from operator.

A main report for printouts and electronic transmission to the main network shall contain names of components, normalised and unnormalised mole % of each component rounded to the nearest 0.001%.

A quality control report for printouts and electronics transmission should contain information about retention time, peak height, peak width, peak area, response factor, mole % before and after normalisation.

A control function in the software should give alarm if one or more components are missing from the report or that the sum of non-normalised values are outside preset limits. This alarm shall inhibit the transmission of potential erroneous results onto the main computer network.

The system shall allow the operator flexibility in the selection of report types according to operational requirements.

Following requirements for display should be considered:

- Help screen, available to the operator at any level.
- Alarm status.
- The number of saved chromatograms.
- Historical analysis data for a single component in chart form.
- Historical analysis data in report format, average, max and min values for each component and calculated values.
- The last measured concentration value for each component and calculated values.
- Real time chromatogram and valve status.
- Daily averages of component concentrations.

5.5 Calibration

The central unit shall have the option of selecting an automatic calibration performed between a certain number of analysis, or executed at selected calendar dates or weekdays, or at a specific time during the day or when concentration values require a new calibration.

A normal calibration is performed using one gas cylinder, but it should be possible by operation from the central unit to select from 3 alternative calibration gas bottles.

The calibration gas bottles cabinet shall if necessary be electrically heated to prevent condensation.

It should be possible to store and select several calibration tables and use different calibration tables as basis for the calculation of the analytical reports.

The calibration software should have functions that give an alarm and inhibit the use of calibration tables containing response factors that are outside pre-set limits of acceptable values. It should be possible to automatically calculate response factors for components not present in the calibration gas by using a mathematical relation to other components, (i.e. calculate response factors for the hexane plus fraction from the response of pentanes or butanes).

5.6 Calculations

The computer system shall be capable of calculating the following figures based on the compositional data normalised values X^x :

- Compressibility factor at reference condition according to ISO 6976).
- Gross calorific value according to ISO 6976.
- Wobbe - index.
- Relative density (real / ideal) according to ISO 6976.
- Density at reference condition according to ISO 6976.
- Molecular weight.
- Critical pressure (bar A).
- Critical temperature (deg K).

The calculation shall have an uncertainty within 0.001%.

5.7 External interface

External interface shall be designed according to operational needs.

Alarm generation shall be according to operational philosophies.

Communication with the main metering computer may be via serial data link.

6 INSPECTION AND TESTING

In addition to checks and verification of leakage testing, tagging, workmanship etc., the following test should be performed to check the gas chromatograph system's functions (See annex A for example of test procedures):

- Ability to separate component.
- Stability or repeatability.
- Linearity.
- Calculation function.
- Output signals.
- Alarm and event messages.
- System test.

ANNEX A EXAMPLE OF TEST PROCEDURES

A EXAMPLE OF TEST PROCEDURES

A.1 EXAMPLE OF TEST

A1.1 Functional Acceptance Test Procedures

The following test should be performed to check the gas chromatograph system's functions.

A1.2 Ability to separate component

A gas sample containing all components to be present in the actual process gas shall be applied to the inlet of gas chromatograph. The associated chromatograms for five consecutive runs shall be evaluated. Ref. Draft ISO 6974 Section 4 & 5.

A1.3 Stability test

Apply calibration gas with hydrocarbon components up to C5 and nitrogen and carbon dioxide to the sample inlet of the gas chromatograph and analyse continuously for 48 hours. Check on the printouts of normalised values that the precision is with the requirements.

A1.4 Linearity test

Three different certified calibration gases containing nitrogen, carbon dioxide, methane, ethane, propane, i-butane, n-butane, i-pentane and n-pentane should successively be applied for 10 consecutive cycles to the inlet of the gas chromatograph. One of the calibration gases shall be close to the normal sample gas composition. In the two other gases, methane shall be 70 and 90 mol % respectively and the gas mixtures should be balanced with nitrogen, carbon dioxide and ethane so that the extremes of expected compositions are covered.

Each of the components in the calibration gases should be determined by gravimetry and certified to the following or better accuracy at a 95% confidence level.

The linearity test should be performed on non-normalized as well as on normalized results.

A1.4.1 Test on non-normalized results

The average of the non-normalized concentration of methane, ethane, nitrogen and carbon dioxide from the 10 times 3 analysis shall be plotted against the certified values from the calibration certificates. The response factors shall be determined by the calibration gas representing the normal gas composition.

A linear of a straight line from origin through the 3 average values using the least squares method, shall have a constant of proportionality B, and a correlation coefficient R².

A1.4.2 Test on normalised results

The deviation between the reading of normalised value from the gas chromatograph and the certified value for any component for any calibration gas, A_i, shall be so that the resulting error in gross calorific value, -H_s, is less than (0.15%) specified value:

$$-H_s = [S(H_{si})^2 - (-A_i)^2]^{1/2}$$

where H_{si} is the gross calorific value for each component found in the ISO 6976.

If the above linearity test criterion cannot be met, the instrument linear dynamic range must be redefined and the chromatograph used only within a more narrow range that meets the requirements described above.

A1.5 Calculation test

The calculation of the relevant gas properties performed by the computer part of the gas chromatography like gross calorific value, real standard density, wobbe index etc. shall be checked for three different gas compositions. The compositions are entered into the computer. The calculations shall be checked against reference calculations to be with 0.001% specified value.

A1.6 Calibration function

The function automatic calibration shall be checked by connecting a gas sample to the process gas inlet and a calibration gas to the calibration gas inlet. Calibration interval (approximately 6hrs) and number of consecutive calibration runs (for example 3) shall be entered. With this configuration the chromatograph should run for minimum 24 hrs. It should be checked that the calibration reports and the updating of the response factors are according to specifications.

A1.7 Output signals

The output signals, analogue, digital or serial links should be checked for correct information.

A1.8 Alarm and event messages

Any alarm situation shall be simulated and it should be checked that the corresponding alarms are set and presented according to specifications. For example on flashing lights, on displays, on printers, on the serial communication etc.

A1.9 System test

Apply reference gas to the inlet of the sampling system which shall include preconditioning and conditioning cabinets as close as possible to normal operating temperature and at a minimum, medium and maximum operating pressure for 10 analysing cycles at each pressure. The readings of normalised values shall not depend on the pressure and the reading of the normalised values shall be within the required repeatability.
