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Refrigerated light hydrocarbon fluids — Sampling of liquefied natural gas — Continuous method

Hydrocarbures liquides légers réfrigérés — Échantillonnage de gaz naturel liquéfié — Méthode continue

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Contents

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Annex

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 8943 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Sub-Committee SC 5, *Measurement of light hydrocarbon fluids*.

Annex A of this International Standard is for information only.

Introduction

In the custody transfer of liquefied natural gas, hereinafter referred to as LNG, it is common practice to determine the quantity transferred on a calorific-content basis.

The total calorific content of quantities of LNG quoted in the custody transfer is determined by the liquid volume, liquid density and gross calorific value of the LNG delivered.

A knowledge of the composition of the LNG is required in order to calculate the density and the calorific content of quantities of LNG. Therefore, precise sampling is a prerequisite for precise analysis.

LNG is a complex mixture of low-molecular-weight hydrocarbons with nitrogen as a principal inert impurity. Typically, methane is the major component. Minor-component concentrations vary with the source of the raw gas, the liquefaction pre-treatment, the liquefaction process and the storage conditions.

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Refrigerated light hydrocarbon fluids — Sampling of liquefied natural gas — Continuous method

1 Scope

This International Standard specifies a method of continuous sampling of LNG whilst it is being transferred through an LNG transfer line.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 6712:1982, *Gas analysis — Sampling and transfer equipment for gases supplying an analytical unit.*

ISO 6578:—[1], *Refrigerated hydrocarbon liquids — Static measurement — Calculation procedure.*

3 Definitions

For the purposes of this International Standard, the following definitions apply.

3.1 accumulator: Storage vessel provided to absorb pressure pulsations of gasified LNG and to homogenize the same.

3.2 bubbling: Procedure to saturate the seal water of a gas sample holder with gasified LNG in order to suppress the effect of the seal water on the gas sample.

3.3 continuous sampling: Sampling in which the sample is drawn continuously, during the total stable-transfer time, from the source.

3.4 gas sample compressor: Compressor used for charging the gas sample collected in a gas sample holder into a gas sample container.

3.5 gas sample container: Sample container used for the retention of the gas sample and for its transfer to an analysing instrument.

3.6 gas sample holder: Holder used for collecting gasified LNG at the LNG sample vaporizer in order to obtain a representative gas sample.

3.7 gasified-LNG transfer compressor: Compressor used for boosting the pressure of gasified LNG when gasified LNG in the LNG sample vaporizer cannot be transferred to the gas sample holder by its inherent pressure.

3.8 LNG: Liquids composed predominantly of methane.

3.9 LNG sample vaporizer: Apparatus to completely gasify the LNG sample collected from the LNG transfer line.

3.10 LNG-transfer line: Pipeline used for transferring LNG.

3.11 pressure regulator: Pressure-regulating valve and pressure sensor provided to keep the gas pressure constant at the gas sample holder inlet.

3.12 sampling line: The whole line provided to carry the sample to be analysed from the sample probe in the LNG transfer line to the gas sample container, including any flexible or semi-rigid tubing.

3.13 sample probe: Device inserted into the LNG to be sampled from the LNG transfer line or fitted to the LNG transfer line to collect an LNG sample.

1) To be published.

3.14 seal water: Water used in the gas sample holder to preclude contact between the gas sample and the atmosphere.

3.15 subcooling: Lowering the temperature of LNG below its boiling point at a given pressure.

4 Outline of sampling system

The LNG sample collected through the sample probe provided on the LNG transfer line is gasified in the LNG sample vaporizer.

Gasified LNG from the LNG sample vaporizer outlet is continuously fed into the gas sample holder by its inherent pressure when the pressure is sufficiently high, or after its pressure is boosted by the compressor for transferring gasified LNG when the pressure is insufficient. In this process, the gas pressure in the sampling line is controlled by a pressure regulator and the flow into the gas sample holder is maintained by the gas sample holder inlet valve. Excess gas is discharged from the system.

The gas sample collected in the gas sample holder is fed into the gas sample container by the gas sample compressor.

An outline flow process diagram of the sampling system is shown in figures 1 and 2.

5 Precautions

5.1 Precautions to be taken in handling LNG

Because LNG has a very low boiling point, contact of the skin with LNG may cause frostbite and, if the gas diffuses into the air, it will lower the oxygen content which may result in suffocation or, if ignited, fire. Suitable precautions shall be taken against these risks.

5.2 Partial evaporation of the LNG sample

LNG normally exists in a state close to its boiling point. Therefore, partial evaporation readily occurs in the LNG transfer line and sampling line with minute heat input or by pressure variation. For this reason, extreme precautions shall be taken so that the collected gas sample represents transferred LNG with best possible accuracy.

5.3 Supervision during continuous sampling

Pressures, temperatures and flow rates in the LNG transfer line and the sampling system shall be monitored continuously. Frequent inspection of the entire system shall be made, paying particular attention to any leak or failure of the thermal insulation. Defects identified by such inspections shall be remedied immediately.

6 Apparatus

6.1 Materials

The materials of construction of the sampling system shall have sufficient strength and durability to withstand the pressure and temperature conditions to which they will be exposed without failure. The possibility of embrittlement of materials at low temperatures shall be taken into account.

Materials shall neither be affected by exposure to the fluids handled, nor have any effect on the composition of the fluids.

6.2 Sample probe

6.2.1 Sample probes shall be located at points in the pipeline where the LNG is in a subcooled condition.

The degree of subcooling at a sampling point shall be ascertained by observation of the temperature and pressure of the LNG at that point and comparing the temperature with the boiling point of the LNG at the same pressure as calculated from the composition of the LNG (see annex A). In the case of multiple transfer lines, the sample probe shall be located downstream of the manifold, if one exists. Otherwise, each line shall be provided with a sampling point.

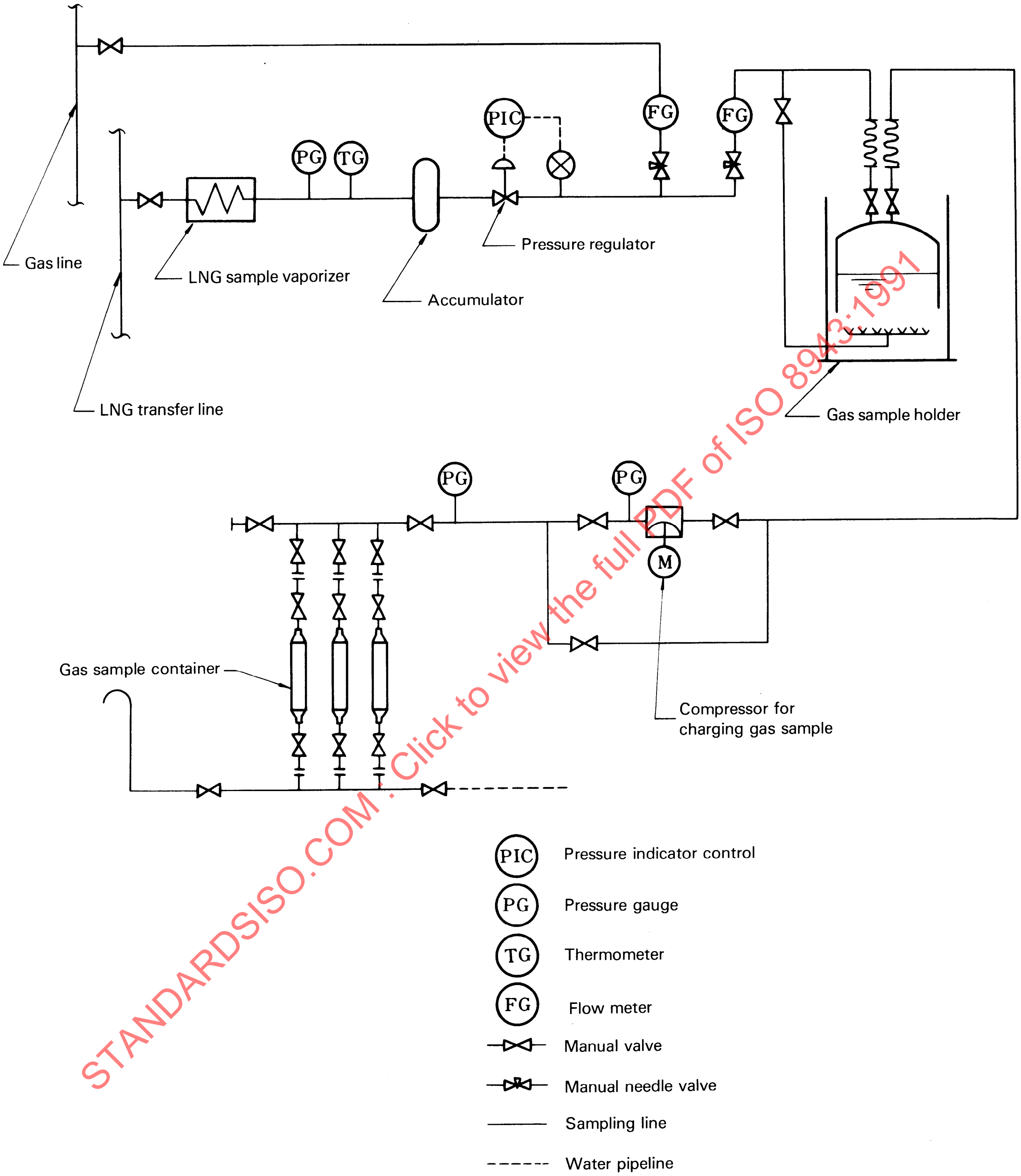


Figure 1 — Sampling system (example 1)

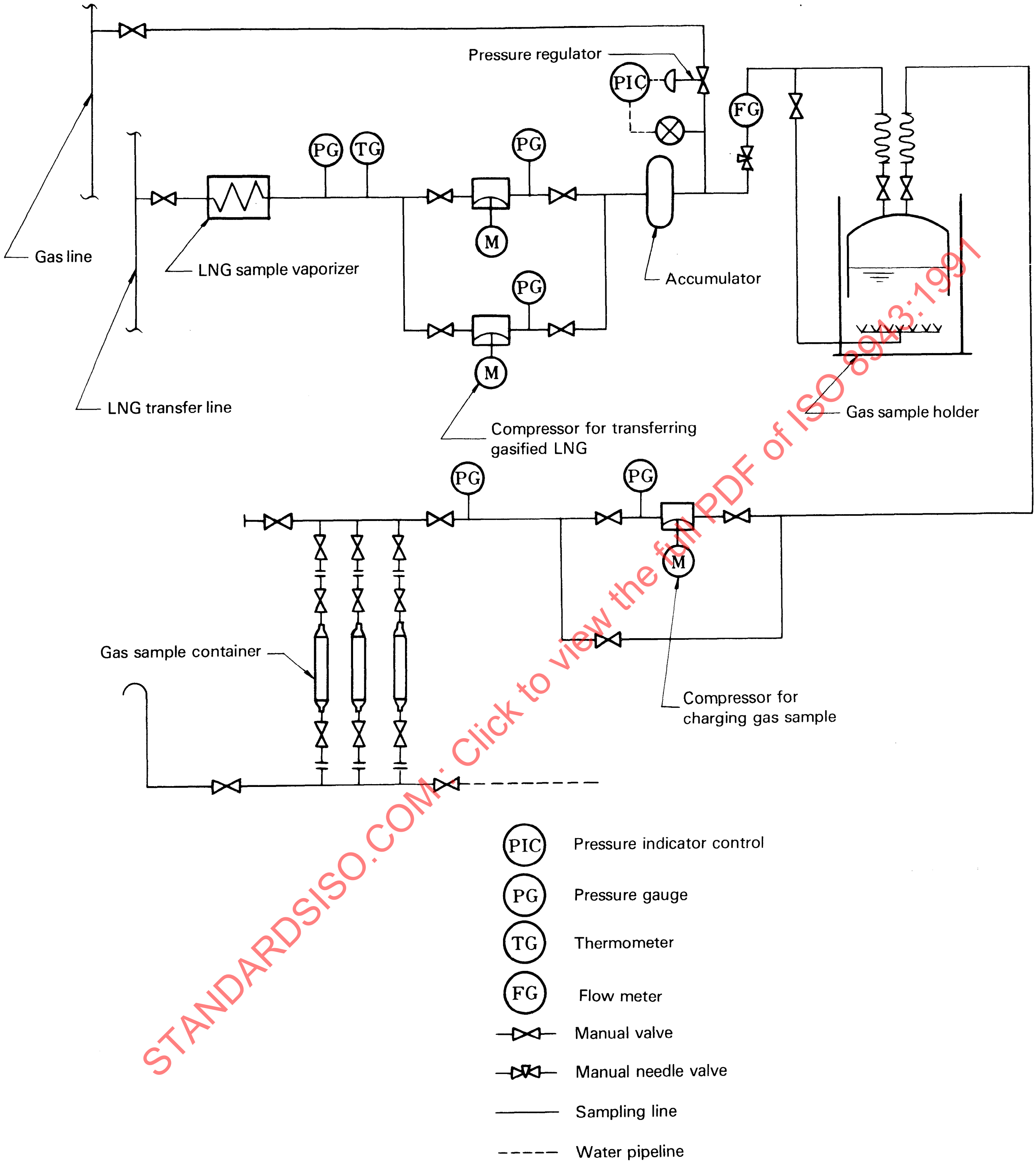


Figure 2 — Sampling system (example 2)

Where multiple lines are provided with individual sampling points and the flow rates in the respective lines differ, the flow rates in each line shall be measured and the sample flows made proportional to these rates.

6.2.2 Sample probes shall be located at a point where the degree of subcooling is high.

6.2.3 Sample probes shall be installed at a right angle to the axis of the LNG transfer line.

6.2.4 The shape of the extreme end of the sample probe is not critical and the end may be a straight tube. Typical sample probes are shown in figure 3.

6.3 LNG sample vaporizer

6.3.1 The heat exchange capacity of the LNG sample vaporizer shall be sufficient to gasify the whole volume of LNG which is being withdrawn for sampling.

6.3.2 The sample vaporizer shall be so constructed that the heavier components of the LNG shall not remain in the vaporizer.

6.3.3 Where a compressor transferring gasified LNG is provided, the maximum gasifying capacity (heat input) of the LNG sample vaporizer shall be greater than the capacity of the compressor.

6.4 Gasified-LNG transfer compressor

6.4.1 Gasified-LNG transfer compressors shall be of the oil-free type.

6.4.2 Means shall be provided to stabilize the gas discharge flow rate of any installed gasified LNG transfer compressor.

6.4.3 A standby compressor shall be provided for use in the event of a compressor failure.

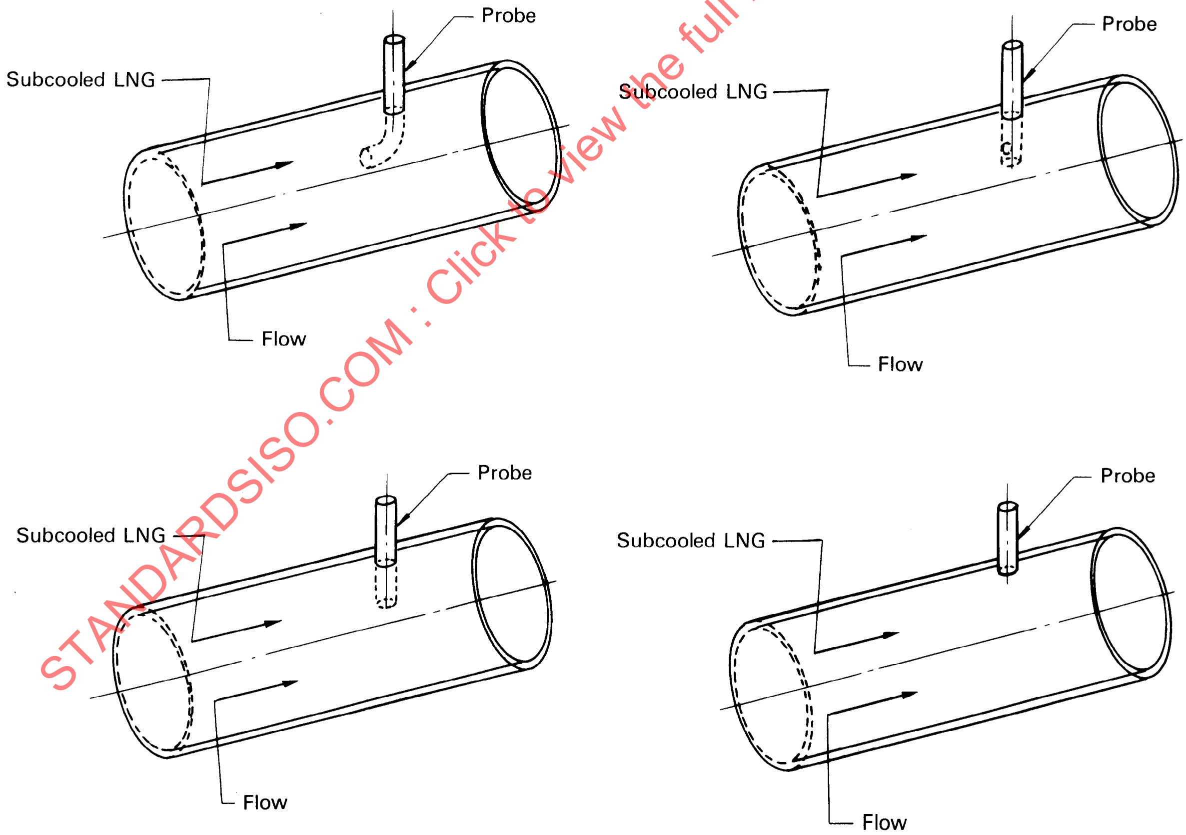


Figure 3 — Sample probe

6.5 Pressure regulator

6.5.1 The pressure regulator shall be provided on the outlet side of the LNG sample vaporizer where gasified LNG is transferred to the gas holder by its inherent pressure, or on the outlet side of the compressor where gasified LNG is transferred by the compressor.

6.5.2 The capacity of the pressure regulator shall be greater than the maximum flow of the LNG sample vaporizer.

6.6 Gas sample holder

6.6.1 The capacity of the gas sample holder shall be greater than the sum of the volume required for charging the gas sample container and an additional volume necessary for purging the line from the gas sample holder to the gas sample container.

6.6.2 In the case of water-seal-type gas sample holders, the construction shall be such that the gas inside the holder can be completely discharged by submerging the inner tank in the seal water. In the case of waterless-type gas sample holders, the construction shall be such that discharging of any residual gas can readily be carried out.

6.6.3 Where a water-seal-type gas holder is used, its construction shall be such that gasified LNG may be bubbled through the water to prevent contamination of the sample by atmospheric gases dissolved in the water.

6.7 Gas sample compressor

Gas sample compressors shall be of the oil-free type.

6.8 Gas sample container

6.8.1 A typical gas sample container is shown in figure 4. The sample container shall consist of a cylinder made of stainless steel tubing with welded ends and fitted with a stainless steel needle valve on each end.

6.8.2 The construction shall be such that the finished cylinder will withstand the pressure to which it may be subjected.

6.8.3 The gas sample container shall be of such construction that it permits easy gas purging.

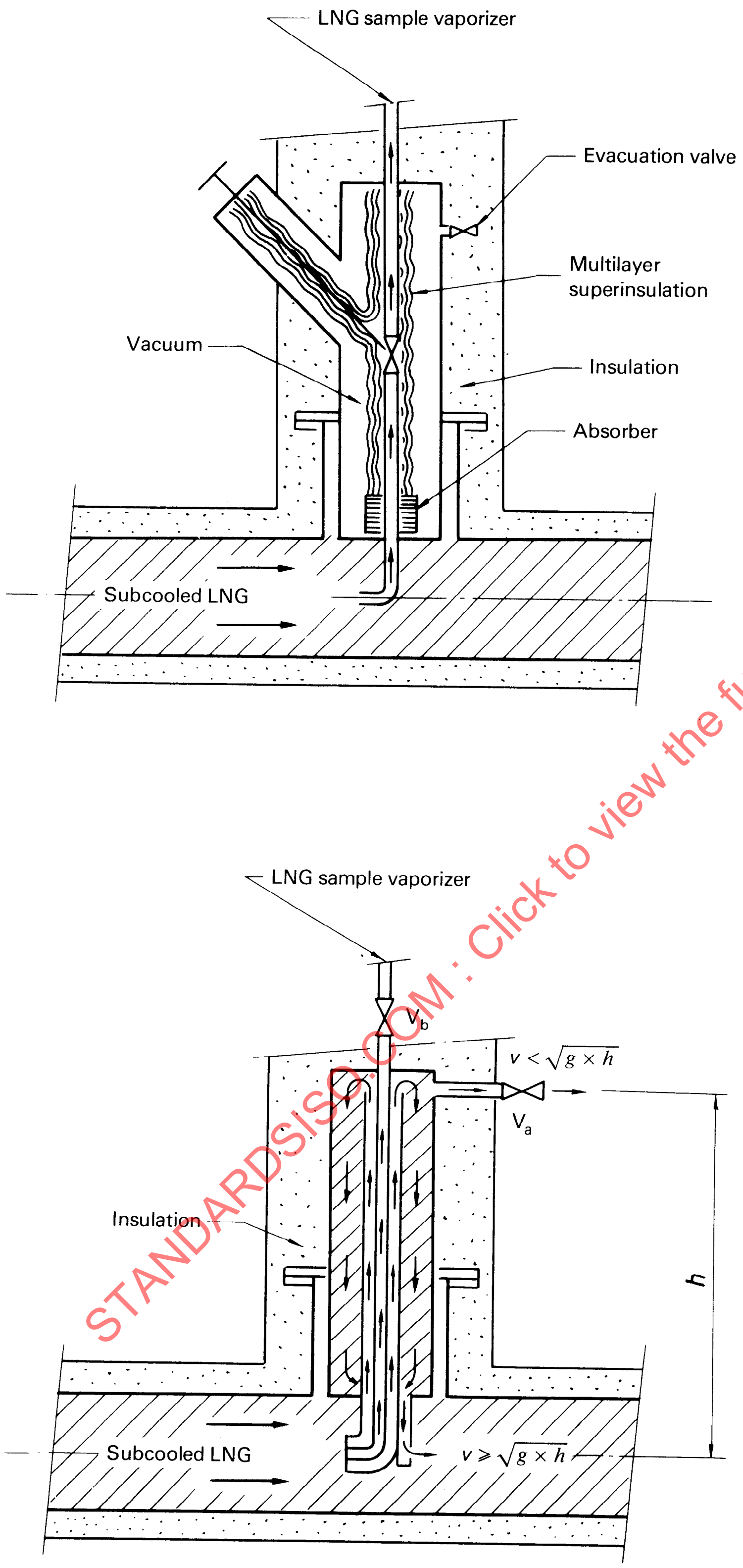
6.8.4 The capacity of the gas sample container shall be sufficient that the container will hold a volume of gas greater than that required for the determination of the composition of the gas sample.

6.9 Piping arrangement

6.9.1 The diameter and length of the sampling line shall be such that sampling may be carried out with the least possible time lag.

6.9.2 The line from the sample probe to the inlet of the vaporizer shall be maintained in a subcooled state. Accordingly, this pipe shall be as short as possible, have the smallest possible diameter, and be provided with sufficient thermal insulation. If for any reason a longer line is necessary, suitable thermal insulation shall be constructed in accordance with one of the examples illustrated in figure 5.

Figure 4 — Gas sample container



If $v < \sqrt{g \times h}$, the valve V_a shall be open.

If $v \geqslant \sqrt{g \times h}$, the valve V_a shall be closed.

where

v is the flow speed, in metres per second;

g is the acceleration due to gravity (= 9,8 m/s²);

h is the liquid height of LNG, in metres.

Figure 5 — Thermal insulation of sampling lines (see 6.9.2)

6.9.3 The length of the pipeline from the sample probe to the vaporizer shall not be longer than the length calculated by the following formula:

$$L = \frac{W \times \Delta H}{q}$$

where

L is the length of pipeline, in metres;

W is the flow rate of sample LNG, in kilograms per hour;

ΔH is the degree of subcooling at the sample probe inlet, in joules per kilogram;

q is the heat input, in joules per metre-hour.

7 Sampling procedure

7.1 Sampling period

The sampling period for LNG movements (see figure 6) shall be only that period of time during which the flow rate has been sufficiently stabilized, thus excluding the initial start-up upsurge in the flow rate and the decreased flow rate before stopping.

In cases where the discharge rate is almost constant, a time-proportional sample rate is acceptable.

LNG sampling shall be carried out continuously throughout the sampling period at a constant LNG transfer flow rate.

If sudden changes in flow rate and pressure occur in the LNG transfer line during the sampling period due to a cargo pump being tripped or an emergency shut-off device being activated, collection of gasified LNG into the gas sample holder shall be temporarily suspended until the flow rate of LNG is normalized.

7.2 Operation of filling the gas sample holder with gasified LNG

a) Where the water-seal-type gas holder is used, the residual gas shall be completely discharged by submerging the inner tank in the seal water, before sampling is commenced.

Where the waterless-type gas holder is used, provision shall be made for the removal of any residual gas from previous operations, before sampling is commenced.

b) Prior to sampling, the seal water shall be subjected to bubbling using gasified LNG.

c) The collection of gasified LNG into the gas sample holder shall be carried out at a constant flow rate.

d) Where the water-seal-type gas holder is used, the sample shall be transferred to the sample containers with minimum delay following the completion of sampling in order to minimize the possibility of contamination by atmospheric gases.

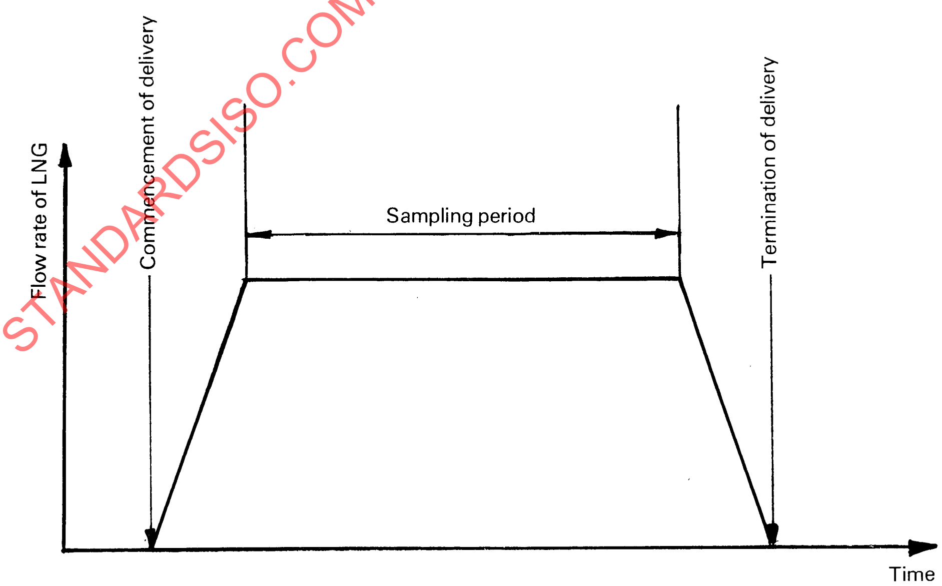


Figure 6 — Sampling period

7.3 Filling the gas sample container

a) The container shall be purged to remove any residual gas from previous operations. This may be achieved by displacing with water, evacuating (vacuum-pumping out) or purging with the gas from the sample holder. The residual gas in a balloon cannot be readily replaced with the gas sample, but it can be evacuated or vacuum-pumped out.

b) When gas from the gas holder is used as the purging medium, the gas shall first be allowed to flow through the container for sufficient time to displace any residual gas. The outlet valve shall then be closed and the pressure increased to between 500 kPa and 700 kPa and then discharged.

c) The procedure given in b) above shall be repeated three or more times, after which the container is filled with the sample gas to a specified value.

d) When the required pressure is obtained, the inlet valve of the container is closed and the container disconnected from the filling line.

e) The container valves shall be checked for leakage using a soap solution or by immersion in water.

8 Sampling report

The sampling report shall include the following information:

a) a reference to this International Standard;

b) all details necessary for complete identification of the sample:

- name of person taking sample,
- gas sample container number,
- origin of sample,
- date of sampling,
- size, type and material of gas sample container,
- gas-sampling period,
- LNG temperature and pressure at sampling points,
- stable-operation period of all cargo pumps,
- flow rate of gas sample,
- bubbling period;

c) any unusual features noted during the sampling period;

d) operations regarded as optional and those not included in this International Standard.

Annex A
(informative)

Example of calculation of degree of subcooling

A.1 Starting parameters

Sampling line size:

Outside diameter: 13,8 mm

Inside diameter: 7,8 mm

Length: 3 m

Insulation thickness: 80 mm

LNG condition at the sampling point:

Pressure: 250 kPa

Temperature: 113 K

Density: 421 kg/m³

Rate of flow of sample LNG: 20 kg/h

Temperature of atmosphere: 293 K

Pressure drop in line (including valve): 50 kPa

A.2 Solution

a) **Degree of subcooling**

From figure, degree of subcooling = 27 000 J/kg

b) **Heat absorption by sampling line**

Heat absorption by a pipe is obtained from the following equation:

$$Q = \frac{\pi(T_a - T_s)}{\dfrac{1}{h_a D_o} + \dfrac{1}{2\kappa} \ln \dfrac{D_o}{D_i}} \times L$$

where

Q is the heat absorption, in watts;

T_a is the temperature of the atmosphere (= 293 K);

T_s is the temperature of the LNG (= 113 K);

h_a is the surface coefficient of heat transfer (= 8,14 W/m²·K);

κ is the thermal conductivity of the insulation material (= 0,018 7 W/m²·K);

D_o is the outside diameter of the insulation (= 0,173 8 m);

D_i is the inside diameter of the insulation (= 0,013 8 m);

L is the pipe length (= 3 m).

Therefore

$$Q = \frac{\pi(293 - 113)}{\dfrac{1}{8{,}14 \times 0{,}173\ 8} + \dfrac{1}{2 \times 0{,}018\ 7} \ln \dfrac{0{,}173\ 8}{0{,}013\ 8}} \times 3$$

$$= 24{,}8 \text{ W}$$

c) **Enthalpy rise in sample LNG due to heat absorption through the sampling line**

$$\Delta H_1 = \frac{Q \times 3\ 600}{F}$$

where

ΔH_1 is the enthalpy rise, in joules per kilogram;

Q is the heat absorption (= 24,8 W);

F is the flow rate (= 20 kg/h).

Therefore

$$\Delta H_1 = \frac{24{,}8 \times 3\ 600}{20} = 4\ 460 \text{ J/kg}$$

Since $\Delta H_1 <$ degree of subcooling, fractionation will not have occurred in the sampling line.