INTERNATIONAL STANDARD

ISO 8943

Second edition
2007-03-01

Refrigerated light hydrocarbon fluids — Sampling of liquefied natural gas — Continuous and intermittent methods

Hydrocarbures liquides légers réfrigérés — Échantillonnage de gaz naturel liquéfié — Méthodes en continu et par intermittence

Reference number
ISO 8943:2007(E)

PDF disclaimer

This PDF file may contain embedded typefaces. In accordance with Adobe's licensing policy, this file may be printed or viewed but shall not be edited unless the typefaces which are embedded are licensed to and installed on the computer performing the editing. In downloading this file, parties accept therein the responsibility of not infringing Adobe's licensing policy. The ISO Central Secretariat accepts no liability in this area.

Adobe is a trademark of Adobe Systems Incorporated.

Details of the software products used to create this PDF file can be found in the General Info relative to the file; the PDF-creation parameters were optimized for printing. Every care has been taken to ensure that the file is suitable for use by ISO member bodies. In the unlikely event that a problem relating to it is found, please inform the Central Secretariat at the address given below.

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

Contents

Page

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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 8943 was prepared by Technical Committee ISO/TC 28, *Petroleum products and lubricants*, Subcommittee SC 5, *Measurement of refrigerated hydrocarbon and non-petroleum based liquefied gaseous fuels*.

This second edition cancels and replaces the first edition (ISO 8943:1991), which has been technically revised.

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.

Refrigerated light hydrocarbon fluids — Sampling of liquefied natural gas — Continuous and intermittent methods

1 Scope

This International Standard specifies methods for the continuous and the intermittent sampling of LNG while it is being transferred through an LNG transfer line.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10715:1997, *Natural gas — Sampling guidelines*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
accumulator
storage vessel provided to absorb pressure pulsations of gasified LNG and to homogenize the same

3.2
bubbling
procedure, in the case of water-seal-type gas sample holder, to saturate the seal water in a gas sample holder with gasified LNG in order to suppress the effect of the seal water on the gas sample

3.3
compressor for transferring gasified LNG
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

3.4
constant pressure / floating piston sample container
CP/FP sample container
sample container, abbreviated as CP/FP sample container and usually used for intermittent sampling, capable of maintaining constant pressure during the sampling of gas from the process line into the gas cylinder

3.5
continuous sampling
sampling from gasified LNG with constant flow rate

3.6
gas sample container
sample container, usually used for continuous sampling, used for the retention of the gas sample and for its transfer to an analyzing instrument

3.7
gas sample compressor
compressor used for charging the gas sample collected in a gas sample holder into a gas sample container

3.8
gasify
term used to express “vaporization” related to a treatment during a process

3.9
intermittent sampling
sampling from gasified LNG with predetermined intervals or with predetermined flow amount intervals

3.10
LNG
liquids composed predominantly of methane

3.11
LNG sample vaporizer
apparatus to completely gasify the LNG sample collected from the LNG transfer line

3.12
LNG transfer line
pipeline used for transferring LNG

3.13
offline analysis
procedure of analysis implemented on the representative sample gas that is once charged into a gas sample container or a CP/FP sample container

3.14
online analysis
procedure of analysis implemented using an analytical equipment that is directly connected through pipelines or other means to the sampling device

3.15
online gas chromatograph
gas chromatograph that is directly connected to the pipelines or sampling device to implement online analysis

3.16
pressure regulator
pressure-regulating valve and pressure sensor provided to keep the gas pressure constant at the gas sample holder inlet

3.17
sample filter
filter used to protect the sampling valve for the online gas chromatograph from scoring due to the presence of foreign contaminants, such as metal shavings, dirt and so forth

3.18
sample probe
device inserted into the LNG to sample from the LNG transfer line to collect an LNG sample

3.19
seal water
water used in the water seal type gas sample holder to preclude contact of the gas sample with the atmosphere

3.20
sub-cooling
lowering the temperature of LNG below its boiling point at a given pressure

3.21
vaporize
used when express "vaporization" related to a facility

3.22
waterless-type gas sample holder
holder without seal water (typically using an expandable/contractible, transformable rubber membrane) and used for collecting gasified LNG

3.23
water-seal-type gas sample holder
holder with seal water used for collecting gasified LNG

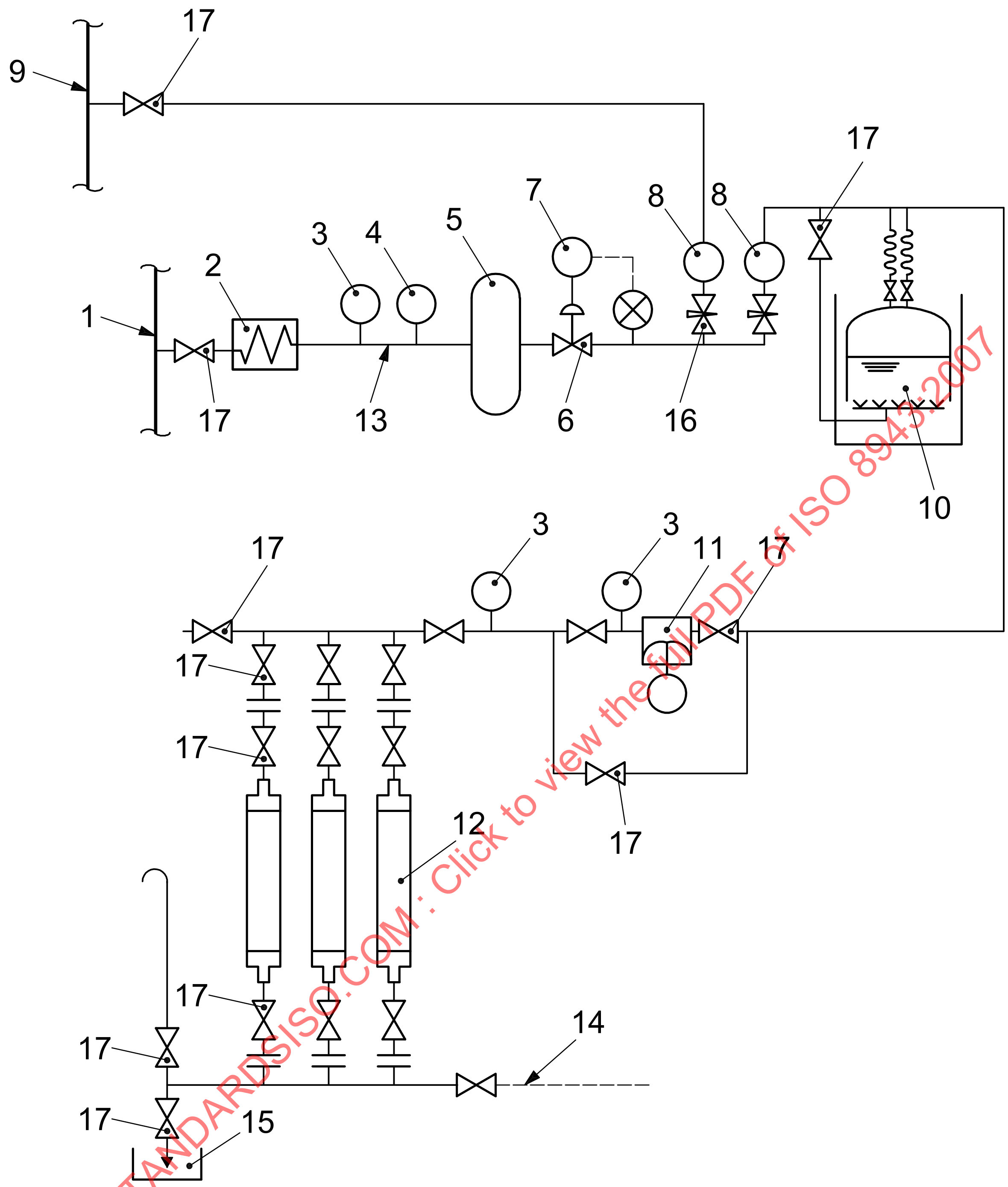
4 Outline of sampling system

4.1 General

Regardless of whether the sampling method is continuous or intermittent, the LNG sample collected through the sample probe provided on the LNG transfer line is gasified in the LNG sample vaporizer.

4.2 Continuous sampling

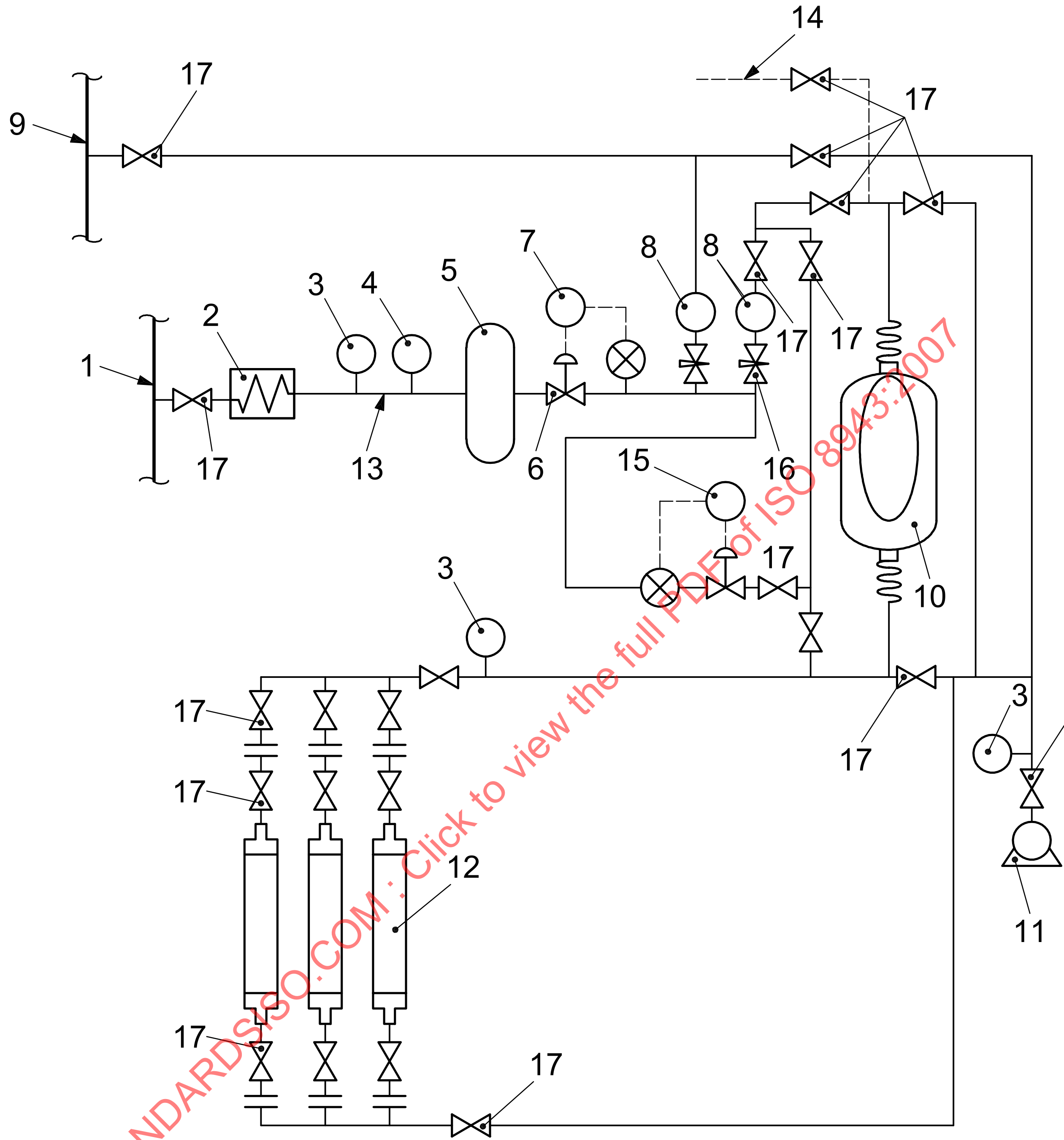
Gasified LNG from the LNG sample vaporizer outlet is continuously fed into the gas sample holder by its inherent pressure when the pressure is sufficiently high or after its pressure has been boosted by the compressor for transferring gasified LNG when the pressure is insufficient. In this process, the 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. The gas sample collected in the gas sample holder is fed into the gas sample container. An outline flow process diagram of the sampling system is shown in Figure 1 for a water-seal-type gas sample holder and in Figure 2 for a waterless-type gas sample holder.



Key

1	LNG transfer line	10	water-seal-type gas sample holder
2	LNG sample vaporizer	11	compressor for charging gas sample
3	pressure gauge	12	gas sample container
4	thermometer	13	sampling line
5	accumulator	14	water pipeline
6	pressure regulator	15	drain pit
7	pressure indicating controller	16	needle valve
8	flow meter	17	valve
9	gas line		

Figure 1 — Example of continuous sampling for a water-seal-type gas sample holder with a compressor



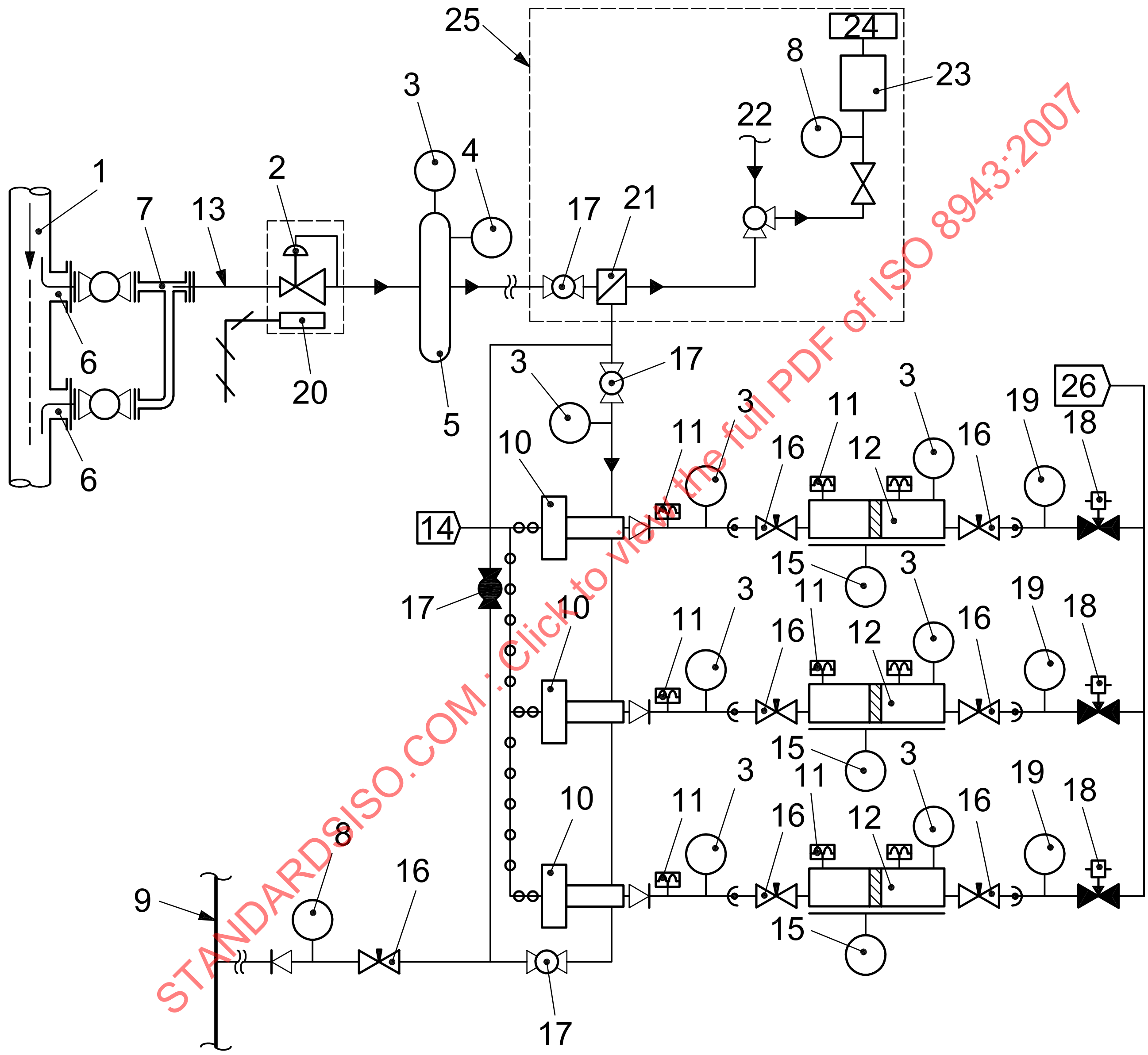
Key

1 LNG transfer line
2 LNG sample vaporizer
3 pressure gauge
4 thermometer
5 accumulator
6 pressure regulator
7 pressure indicating controller
8 flow meter
9 gas line
10 waterless-type gas sample holder
11 vacuum pump
12 gas sample container
13 sampling line
14 inert gas line (for compressing gas of inner layer of sampling holder)
15 flow indicating controller
16 needle valve
17 valve

Figure 2 — Example of continuous sampling for a waterless-type gas sample holder

4.3 Intermittent sampling

Gasified LNG from the LNG sample vaporizer outlet is continuously fed into the CP/FP sample container and to the online gas chromatograph by its inherent pressure when the pressure is sufficiently high, or after its pressure has been 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 CP/FP sample container is maintained by the CP/FP sample container inlet valve. The gas sample collected in the CP/FP sample container is for offline analysis. An outline process flow diagram of the sampling system is shown in Figure 3.



Key

1 LNG transfer line flow
2 LNG sample vaporizer
3 pressure gauge
4 thermometer
5 accumulator
6 impact probe
7 capillary sample take-off probe
8 flow meter
9 low pressure gas line
10 gas compressor
11 rupture disc
12 CP cylinder
13 sampling line
14 air supply from sample controls
15 level gauge
16 needle valve
17 valve
18 solenoid valve
19 pressure transmitter
20 heater
21 sample filter
22 calibration gas
23 gas chromatograph
24 to vent
25 online gas chromatograph
26 auto pre-charge system
27 bypass valve

Figure 3 — Example of intermittent sampling for CP/FP sample container

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 can cause frostbite and, if the gas diffuses into the air, it will lower the oxygen content, which can 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 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 used

The materials of construction of the sampling system shall have sufficient strength and durability to withstand without failure the pressure and temperature conditions to which they are exposed. The possibility of embitterment 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 sub-cooled condition. The degree of sub-cooling 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.

Where multiple lines are provided with individual sampling points and the flow rates in the respective lines differ, the flow rate 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 sub-cooling 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.

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 Compressor for transferring gasified LNG

6.4.1 The compressor shall be of the oil-free type.

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

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

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 sample holder by its inherent pressure, or on the outlet side of the compressor where gasified LNG is transferred by the compressor.

Irrespective of this procedure, in the case that flow rate of the sample gas is kept constant, the pressure regulator can be provided at another appropriate position.

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.

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

6.6.4 Where a waterless-type gas sample holder is used, the construction shall be such that discharging of any residual gas can readily be carried out.

6.7 Gas sample compressor

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

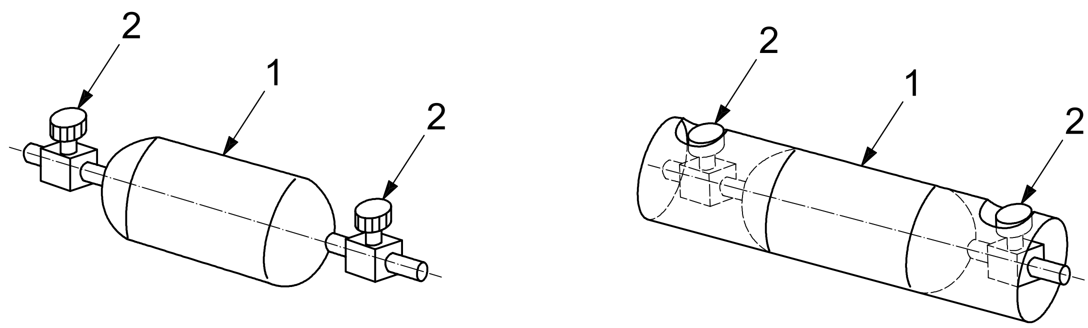
6.8 Gas sample container or CP/FP sample container

6.8.1 General.

The gas sample container or CP/FP sample container shall be of such construction that it permits easy gas purging.

The capacity of the gas sample container or CP/FP sample container shall be sufficient such that the container holds a volume of gas greater than that required for the determination of the composition of the gas sample.

6.8.2 Two typical gas sample containers used for continuous sampling are shown in Figure 4. The gas sample container shall consist of a cylinder made of stainless steel with welded ends and fitted with a stainless steel needle valve on each end The construction shall be such that the finished cylinder will withstand the pressure to which it may be subjected.



Key

1 cylinder

2 needle valve

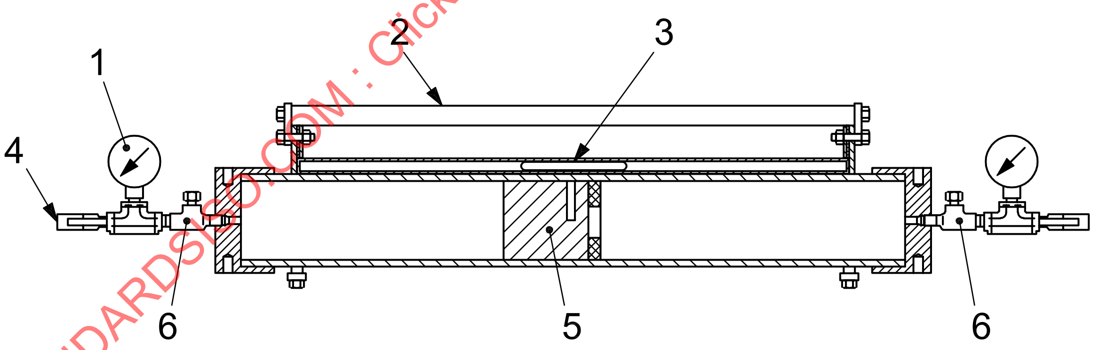
Figure 4 — Gas sample container

6.8.3 A typical CP/FP sample container used for the intermittent sampling is shown in Figure 5.

Pressure in the CP/FP sample container is maintained during retention of the gas sample and its transfer to an analyzing instrument. It has a free-floating internal piston that effectively divides the container into two separate compartments.

The CP/FP sample container shall consist of a cylinder made of stainless steel and fitted with a stainless steel needle valve on each end; see Figure 5.

Details of CP/FP sample container are given in Annex B. The construction shall be such that the finished cylinder can withstand the pressure to which it can be subjected.



Key

1 pressure gauge

2 carrying handle

3 magnetic indicator

4 valve

5 floating piston

6 rupture discs for pressure protection

Figure 5 — CP/FP sample container

6.9 Piping arrangement

6.9.1 The diameter and length of the sampling line shall be such that sampling can 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 sub cooled 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.

6.9.3 The length, L, expressed in metres, of the pipeline from the sample probe to the vaporizer shall not be longer than the length, calculated from Equation (1):

$$L = \frac{W \times \Delta H}{q} \quad (1)$$

where

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

ΔH is the degree of sub-cooling at the sample probe inlet, in joules per kilogram;

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

6.10 Sample filter

The sample filter should be of a small total volume, with a self-cleaning design and contain a replaceable/disposable element.

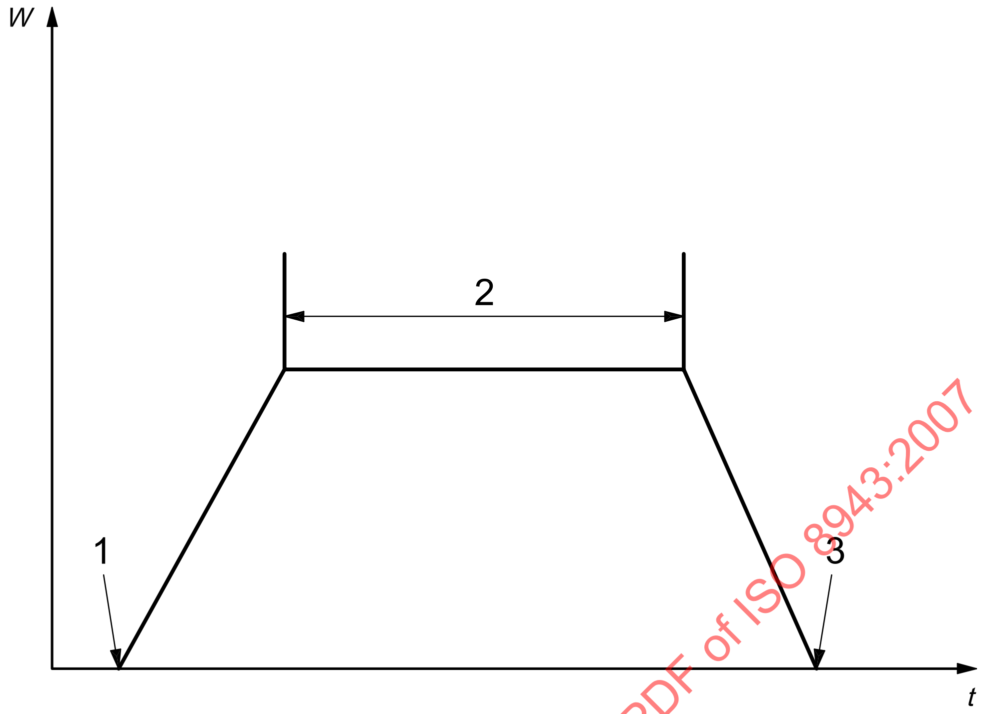
7 Sampling procedure

7.1 Sampling period

Regardless of whether the sampling method is continuous or intermittent, the sampling period for LNG movements (see Figure 6) shall be only that period of time during which the flow rate is sufficiently stable, which excludes the initial start-up upsurge in the flow rate and the decreased flow rate before stopping.

7.2 Consecutiveness of sampling

Regardless of whether the sampling method is continuous or intermittent, the LNG sampling shall be carried out continuously throughout the sampling period at a constant LNG transfer flow rate.



Key

W flow rate of LNG

t time

1 commencement of delivery

2 sampling and online GC analysis period

3 termination of delivery

Figure 6 — Sampling period

7.3 Suspension of sampling

Regardless of whether the sampling method is continuous or intermittent, if a sudden change in the flow rate or in the pressure occurs in the LNG transfer line during the sampling period due to a cargo pump being tripped or an emergency shut-off device being activated, sampling shall be temporarily suspended until the flow rate of LNG is normalized.

7.4 Continuous sampling

7.4.1 Filling the gas sample holder with gasified LNG

a) Prior to initiating the sampling, any residual gas of the last operation that might remain in the gas sample holder shall be completely purged.

b) In case the water-seal-type gas sample holder is used, prior to initiating the sampling, the seal water shall be subjected to bubbling.

c) In case the water-seal-type gas sample holder is used, in order to prevent the possibility of contamination by atmospheric gases, the sample shall be transferred to the gas sample containers without delay following the completion of sampling.

d) In case the waterless-type gas sample holder is used, prior to initiating the sampling, it shall be confirmed that there is no leakage of gas between inner and outer compartments within the gas sample holder.

One of the advisable practices for this confirmation procedure is to maintain a vacuum condition in the inner compartment while maintaining a pressurized condition in the outer compartment for a certain period and then check the change of pressure with time.

e) In case the waterless-type gas sample holder is used, prior to initiating the sampling, the outer compartment of the holder, which will hold the sample gas, shall be treated to remove any residual gas from the previous operation which it still might contain. For example, keep the outer compartment in vacuum just before starting sampling.

f) Charging of the gas sample container with gasified LNG shall be carried out during a period in which the flow rate is constant.

7.4.2 Filling gas sample container

a) Purge any residual gas of previous operations from the gas sample container. This operation can be done by charging and discharging it with water, or by creating a vacuum with a vacuum pump, or purging it with sample gas introduced from the gas sample holder.

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

c) After the charging of the sample gas into the gas sample container is complete, the valves of the gas sample container shall be checked for leakage using a soap solution or by immersion in water.

7.5 Intermittent sampling

7.5.1 General

Although an online gas chromatograph is used for analysis, backup samples shall be charged into CP/FP sample containers to be used in case of dispute.

7.5.2 Filling the CP/FP sample container with gasified LNG

a) Prior to initiating the sampling, any residual gas from the last operation that might remain in the CP/FP sample container shall be completely purged.

b) Charging of the gasified LNG into the CP/FP sample container shall be carried out during a period in which the flow rate is constant.

7.5.3 Filling the CP/FP sample container

The basic procedure of purging the CP/FP sample container is identical with that mentioned in 7.4.2. Further details of the procedure shall be taken from the operation manual or instructions.

7.5.4 Online gas chromatograph

a) Set up the flow rate of the sampling system so as to ensure that a representative sample is provided to the online gas chromatograph during the operation.

b) Ensure that the data used for determining the analysis of the loading/unloading batch is carried out between the sampling period as indicated in Figure 6.

c) Minimum numbers of analysis per hour and, consequently, the total number of analysis carried out during a pre-determined sampling period is subject to negotiation among the parties concerned.

8 Test report

The test report for the sampling shall include the following information:

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 or CP/FP sample container number,

— origin of sample,

— date of sampling,

— size, type and material of gas sample container or CP/FP sample container number,

— gas sampling period,

— LNG temperature and pressure at sampling points,

— stable-operation period of all cargo pumps,

— flow rate of gas sample,

— bubbling period, when a water-seal-type gas sample holder is used;

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 sub-cooling

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/m^3.

Flow rate of LNG sample:	20 kg/h.
Temperature of atmosphere:	293 K.
Pressure drop at the end (including valve):	50 kPa.

A.2 Solution

a) Degree of sub-cooling

From Figure A.1, the degree of sub-cooling is 27 000 J/kg.

b) Heat absorption by sampling line

Heat, Q, expressed in watts, that is absorbed by a pipe is obtained from Equation (A.1):

$$Q = \frac{\pi\left(T_a - T_s\right)}{\dfrac{1}{h_a \cdot D_o} + \dfrac{1}{2k}\ln\dfrac{D_o}{D_i}} \times L \qquad \text{(A.1)}$$

where

π is the circular constant;

T_a is the temperature of the atmosphere, equal to 293 K;

T_s is the temperature of the LNG, equal to 113 K;

h_a is the surface coefficient of heat transfer, equal to 8,14 W/m^2·K;

κ is the thermal conductivity of the insulation material, equal to 0,018 7 W/m^2·K;

D_o is the outside diameter of the insulation, equal to 0,173 8 m;

D_i is the inside diameter of the insulation, equal to 0,013 8 m;

L is the pipe length, equal to 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) The enthalpy rise, ΔH_1, expressed in joules per kilogram, in the LNG sample due to heat absorption through the sampling line is given by Equation (A.2):

$$\Delta H_1 = \frac{Q \times 3\,600}{F} \quad \text{(A.2)}$$

where

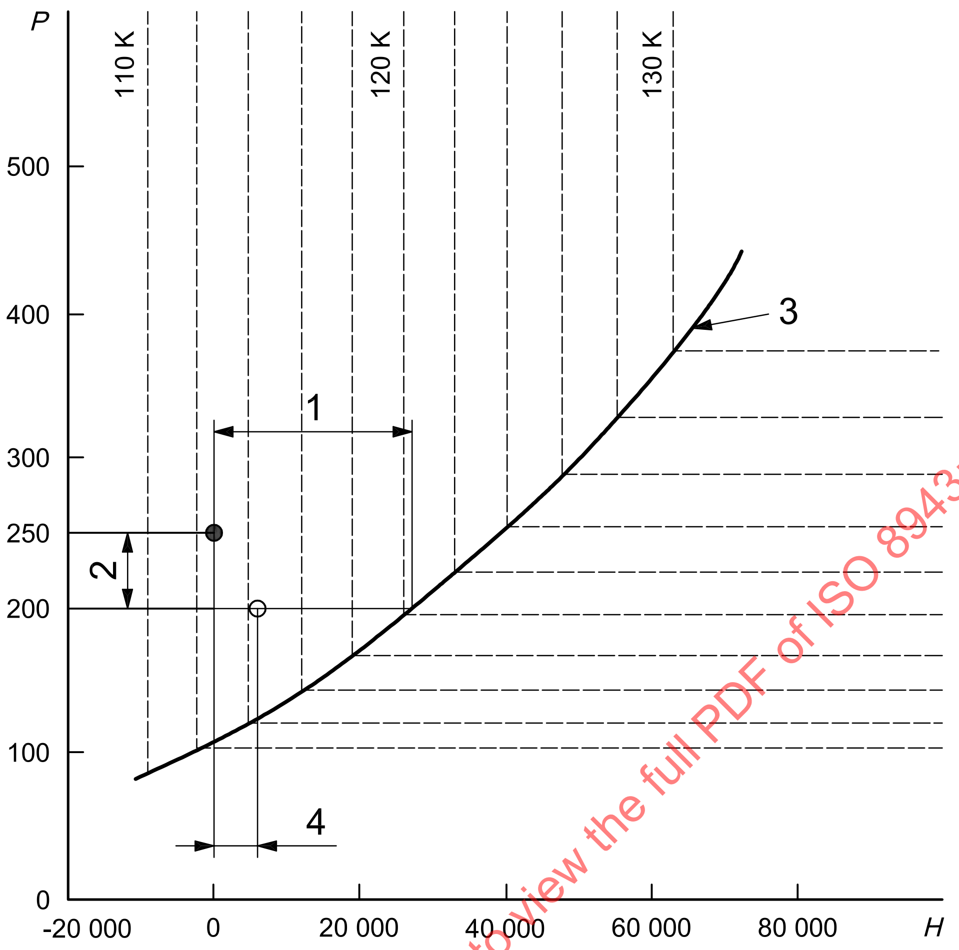
Q is the heat absorption, equal to 24,8 W;

F is the flow rate, equal to 20 kg/h.

Therefore

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

Since the enthalpy rise is smaller than degree of sub-cooling, fractionation will not have occurred in the sampling line.



Key

P pressure, expressed in kilopascal

H enthalpy, expressed in joules per kilogram

1 degree of sub-cooling

2 pressure drop

3 saturated liquid

4 heat absorption through sampling line

● sampling point

○ inlet of LNG sampling vapourizer

Figure A.1 — Enthalpy of the saturated liquid