

Method and system for treating and feeding natural gas to an apparatus for generating power in order to propel a ship

Technical Field

The invention relates to the field of ships propelled by natural gas.

5 The invention relates more particularly to a method and a system for treating natural gas and conveying same from a liquefied gas storage tank to energy production equipment, such as a combustion engine.

Technical Background

Ships comprising combustion engines, fed with natural gas and propelling
10 these ships, are known from the prior art. In order to ensure correct operation of such combustion engines, the combustible natural gas needs to have certain properties. In particular, the methane number needs to be above a threshold, generally defined by the manufacturer of the engine, because gases with excessively low methane numbers do not burn correctly, giving rise to a
15 phenomenon of knock.

In order to guarantee that the natural gas fed to the engine has a methane number above a threshold, it is known practice for the engine supply circuit to be fitted with a phase separator that allows the heavy hydrocarbons of the natural gas to be returned to the storage tank in the form of condensate.

20 However, returning heavy hydrocarbons causes them to build up in the tank. Thus, as the level in the tank gets close to the bottom, a residue of heavy hydrocarbons remains that cannot be used for ship propulsion.

Summary

One idea underlying the invention is that of proposing a method and a
25 system for treating natural gas and conveying it from a liquefied gas storage tank to energy production equipment such as a combustion engine, for the propulsion of a ship, that provides a solution to the problems of concentration of heavy hydrocarbons at the bottom of the tank.

According to one embodiment, the invention provides a method for treating and
30 conveying natural gas, in a ship, from a liquefied-gas storage tank to energy

production equipment, on the one hand, and to a burner of an energy production installation, on the other hand, said method comprising in succession:

- a step of supplying the energy production equipment, during which step natural gas is carried through a phase separator allowing a heavy fraction of the natural gas containing the hydrocarbons that have the longest carbon chain to be returned to the tank in the form of condensate and allowing a light fraction of the natural gas containing the hydrocarbons that have the shortest carbon chain to be carried to the energy production equipment; then
- a step of recovering the heavy fraction of the natural gas during which step natural gas is carried from the tank to the burner, bypassing said phase separator.

Thus, by bypassing the phase separator, the heavy fraction of the natural gas can be eliminated by recovering it to an energy production installation fitted with a burner.

According to some embodiments, such a method may comprise one or more of the following features:

- the method comprises monitoring a variable indicative of the methane number of the natural gas being conveyed during a step of supplying the energy production equipment.
- The method comprises an automatic switchover to the step of recovering the heavy fraction of the natural gas and/or the generation of an alarm signal when the variable indicative of the methane number of the natural gas being conveyed crosses a threshold.
- The variable indicative of the methane number of the natural gas being conveyed is determined by measuring the flow rate of the light fraction of the natural gas downstream of the phase separator and/or by measuring the temperature of the evaporated natural gas collected in the tank and/or by measuring the level and/or the purge frequency of a condensate collecting container.

According to one embodiment, the invention also provides a system carried onboard a ship, for treating and conveying natural gas from a liquefied gas storage tank to energy production equipment on the one hand, and to a burner of an energy production installation on the other hand, the system comprising:

- a first supply circuit feeding the energy production equipment, said first circuit being fitted with a phase separator connected, downstream, on the one hand to a return pipe allowing a heavy fraction of the natural gas containing the hydrocarbons that have the longest carbon chain to be returned to the tank in the form of condensate and, on the other hand, to a carrying pipe leading to the energy production equipment conveying a light fraction of the natural gas containing the hydrocarbons that have the shortest carbon chain,
- a second supply circuit, feeding the burner, said second circuit bypassing said phase separator.

10 According to some embodiments, such a system may comprise one or more of the following features:

- the first circuit has, upstream of the phase separator, at least one circuit portion in common with the second circuit and designed to allow forced vaporization of the liquefied natural gas and/or to allow collection of the natural gas that has evaporated in the tank.
- A circuit portion common to the first and to the second circuit comprises an intake pipeline opening toward the bottom of the tank, equipped with a pump and a forced vaporization installation allowing the liquefied natural gas to be converted into a stream of gas.
- A circuit portion common to the first and to the second circuit comprises a pipeline opening into the top part of the tank to collect the natural gas that has evaporated in the tank.
- A circuit portion common to the first and to the second circuit is bounded downstream by a switchable three-way connection member allowing the circuit portion in common to be connected selectively to an inlet of the phase separator or to a portion of the second circuit leading to the burner.
- The second circuit for feeding the burner is fitted with a gas heating appliance.
- The first circuit for supplying natural gas to the energy production equipment comprises a compressor positioned downstream of the phase separator.
- The system comprises a device for monitoring a variable indicative of the methane number of the liquefied natural gas being carried.
- The device for monitoring a variable indicative of the methane number of the liquefied natural gas being carried comprises a sensor for measuring the flow rate in the carrying pipe leading toward the energy production equipment and/or

a sensor for measuring the temperature of evaporated natural gas collected in the tank and/or a sensor for measuring the level in a condensate collecting container and/or a counter for measuring the purge frequency of a condensate collection container.

- 5 - The monitoring device is designed to generate an alarm signal and/or to act on a switchable three-way connection member so as to lead the natural gas toward the burner when the variable indicative of the methane number of the liquefied natural gas being carried crosses a threshold.

10 According to one embodiment, the invention also provides a ship comprising a liquefied gas storage tank, energy production equipment, an energy production installation equipped with a burner and a system for treating and conveying the natural gas of the above aforementioned type.

According to some embodiments, such a ship may comprise one or more of the following features:

- 15 - the energy production equipment is intended for the propulsion of the ship.
 - The energy production equipment is a dual-fuel diesel/natural gas combustion engine.
 - The liquefied gas storage tank is a tank with a membrane.
 - The tank is a storage tank at atmospheric pressure.

20 According to one embodiment, the invention also relates to a method for filling the tank of a ship as mentioned hereinabove, in which method a fluid is conveyed through insulated pipelines from a floating or on-shore storage facility toward the tank of the ship.

25 According to one embodiment, the invention also relates to a system comprising a ship as mentioned hereinabove, insulated pipelines arranged in such a way as to connect the tank installed in the hull of the ship to a floating or on-shore storage facility and a pump for driving a stream of fluid through the insulated pipelines from the floating or on-shore storage facility to the tank of the ship.

Brief Description of the Figures

30 The invention will be better understood, and further objects, details, features and advantages thereof will become more clearly apparent during the course of the following description of a number of particular embodiments of the

invention which are given solely by way of nonlimiting illustration, with reference to the attached drawings.

- **Figure 1** is a schematic view of a natural gas treatment and conveying system onboard a ship.
- 5 • **Figure 2** illustrates the system of figure 1, in which a path of the natural gas for supplying energy production equipment for propelling the ship and for supplying energy production equipment for generating electricity has been highlighted by emboldening.
- 10 • **Figure 3** illustrates the system of figure 1, in which a path of the natural gas for supplying energy production equipment for generating electricity has been highlighted by emboldening.
- **Figure 4** illustrates the system of figure 1, in which a path of the natural gas to a burner of an energy production facility for recovering and making use of the heavy fraction of the natural gas has been emphasized.
- 15 • **Figure 5** illustrates the system of figure 1, in which a path of the natural gas, evaporated in the tank, toward the burner of the energy production facility has been emphasized.
- **Figure 6** illustrates the system of figure 1, in which a path of the natural gas during implementation of a tank heating method has been highlighted.
- 20 • **Figure 7** illustrates a ship equipped with a gas storage tank and with energy production equipment supplied with natural gas for the propulsion of the ship.

Detailed description of the embodiments

In the description and the claims, the terms "upstream" and "downstream" are defined with reference to the direction in which the natural gas circulates.

- 25 Figure 7 depicts a ship 1 equipped with one or more liquefied natural gas storage tanks 2 and with a propulsion unit comprising one or more energy production equipment items 4 chosen from combustion engines, fuel cells or gas turbines, supplied with natural gas. Such a ship 1 may notably be a methane tanker intended for transporting liquefied natural gas, but may also be intended for any

other applications. By way of example, it may be a merchant ship, a passenger ship, a fishing boat, or the like.

Figure 1 depicts a natural gas storage tank 2 and a system 3, carried on board the ship 1, for treating and conveying the natural gas. The natural gas treatment and conveying system 3 is suited to supplying energy production equipment 4 of the propulsion unit, as depicted in figure 2, to feeding a burner 5, as depicted in figures 4, 5 and 6 and, as an option, to feeding further energy production equipment such as a combustion engine, a fuel cell or a gas turbine 6 of an electric generator, as depicted in figures 2 and 3.

10 The tank 2 is a sealed and thermally insulated tank suited to the storage of liquefied natural gas (LNG). The tank 2 may notably be of the type having membranes allowing liquefied natural gas to be stored at atmospheric pressure.

 The energy production equipment 4 of the propulsion unit is chosen from combustion engines, fuel cells and gas turbines. When the energy production equipment 4 is a combustion engine, the engine may be a hybrid engine running on diesel/natural gas. Such engines 4 can operate either in diesel mode, whereby the engine is fed wholly with diesel, or in natural gas mode whereby the fuel for the engine consists mainly of natural gas while a small pilot quantity of diesel is injected in order to initiate combustion.

20 The output shaft associated with the mechanical energy generated by the energy production equipment 4 of the propulsion unit may either be coupled to one or more screws for the propulsion of the ship or be coupled to an alternator to allow the mechanical energy to be converted into electrical energy, the electrical energy in that case being used to power an electric motor coupled to a screw for the propulsion of the ship. In the latter alternative, if a combustion engine is used, it may notably be an engine of the DFDE type, which stands for Dual Fuel Diesel Electric.

 The energy production equipment 6 for generating electricity may be a diesel/natural gas dual fuel combustion engine, for example of the DFDE type, a fuel cell or a gas turbine.

30 The burner 5 is incorporated into an energy production installation. The energy production installation may notably comprise a boiler for producing steam. The steam may be intended to feed steam turbines for the production of energy and/or to feed a heating network of the ship 1.

Figure 2 illustrates two circuits respectively feeding the energy production equipment 4 of the propulsion unit and the energy production equipment 6 for the generation of electricity. The circuit feeding the energy production equipment 4 of the propulsion unit will hereinafter be referred to as the "main circuit" whereas the circuit feeding the energy production equipment 6 for producing electricity will be referred to as the "secondary circuit". Note that the main circuit may also be used for conveying the natural gas to the secondary circuit or vice-versa. Such an arrangement provides redundancy of the supply of the energy production equipment 4, 6, thereby guarding against potential malfunctions.

The main circuit comprises an intake pipeline 7a opening toward the bottom of the tank 2 and fed by a pump 8a. The intake pipeline 7a carries the liquefied natural gas to a three-way connection 23 that allows the intake pipeline 7a to be connected, on the one hand, to a pipeline 24, equipped with a valve 123, connected to the inlet of a forced vaporization installation 9a also referred to as an evaporator and, on the other hand, to a pipeline 25 equipped with a valve 223, connected to an atomizer 10a. The forced vaporization installation 9a allows the liquefied natural gas to be converted into a stream of gas. The outlet of the forced vaporization installation 9a is connected by a pipe 26 to the atomizer 10a so as to carry the stream of gas toward said atomizer 10a. The atomizer 10a is able to spray, into the stream of gas obtained at the outlet of the forced vaporization installation 9a, liquefied natural gas that is collected upstream of said forced vaporization installation 9a. The atomizer 10a thus allows the stream of gas to be cooled so that the heaviest hydrocarbons, which means to say those having the longest carbon chain and the highest evaporation temperatures, condense. The stream of gas is typically cooled to a temperature of below -100°C .

On leaving the atomizer 10a, the stream of gas laden with droplets of natural gas in suspension is carried to a phase separator 11a via the pipeline 27. This phase separator 11a, sometimes referred to as a mist separator, allows the liquid phase to be separated from the gaseous phase. The liquid phase consists of a heavy fraction of the natural gas containing the heaviest hydrocarbons, which means to say those having the longest carbon chain. The heavy fraction of the natural gas is sent in the form of condensate to the storage tank 2 via a condensate return pipeline 12a. The condensate return pipeline 12a is equipped with a

condensate collection container 72a which is regularly purged when the level of condensate therein reaches a threshold.

5 The gaseous phase consisting of the light fraction of the natural gas containing the hydrocarbons that have the shortest carbon chain is itself carried, via the pipeline 28, to a gas heating appliance 13 that allows the gaseous phase to be heated to a typical temperature of 30°C. Such a gas heating appliance 13 is typically a gas/liquid or gas/gas heat exchanger. The gas heating appliance 13 here is equipped with a recirculation loop 29.

10 Finally, at the outlet of the gas heating appliance 13a, the stream of gas can be carried toward the energy production equipment 4 of the propulsion unit via the pipeline 30.

Similarly, the secondary circuit comprises an intake pipeline 7b opening toward the bottom of the tank 2 and fed by a pump 8b. The intake pipeline 7b allows the liquefied natural gas to be carried to a forced vaporization installation 9b and to 15 two atomizers 10b and 31. To do that, the intake pipeline 7b is connected via a three-way connection 32, on the one hand, to a pipeline 33 equipped with a valve 132 leading to an atomizer 31 and, on the other hand, to a pipeline 34 equipped with a valve 232 and itself connected to a three-way connection 35 allowing said pipeline 34 to be connected, on the one hand, to the atomizer 10b via the pipeline 36 20 equipped with a valve 135 and, on the other hand, to the inlet of the forced vaporization installation 9b via the pipeline 17 equipped with a valve 235.

The outlet of the forced vaporization installation 9b is connected by a series of pipelines 37, 38, 39 to the atomizers 10a, 31 allowing liquefied natural gas to be sprayed so as to condense the heaviest hydrocarbons. The stream of gas leaving 25 the atomizer 31 is carried to the inlet of a phase separator 11b via a pipeline 40.

Similarly, the phase separator 11b allows the liquid phase to be separated from the gaseous phase and allows the condensate to be returned to the tank 2 via a condensate return pipeline 12b. The condensate return pipeline 12b is equipped with a container 72b for collecting the condensate which is regularly purged when 30 the condensate level therein reaches a threshold.

On the other hand, at the outlet from the phase separator 11b, the gaseous phase, consisting of the light fraction of the natural gas, is carried, via a pipeline 42, to one or more compressors 16a, 16b arranged in parallel. In order to allow the

stream of gas to be conveyed in parallel to a number of compressors 16a, 16b, the pipeline 42 is provided with one or more multi-way connections 43 leading to pipelines equipped with valves 143, 243. In figure 2, the stream of gas is conveyed only through one of the two compressors 16a, 16b. However, depending on the
 5 reference flow rate for supplying the energy production equipment 4 or 6, it may be envisioned for the stream of gas to be passed in parallel through both compressors 16a, 16b.

For example, the compressors 16a, 16b are multi-stage compressors allowing the stream of gas to be heated and compressed to pressures compatible
 10 with the specifications of the energy production equipment 6 fed with natural gas, for example of the order of 5 to 6 bar absolute in the case of combustion engines of the DFDE type. The compressor 16a, 16b may be a positive-displacement compressor, a centrifugal compressor or any other type of compressor compatible with the supply pressures on the inlet side of a combustion engine, a fuel cell or a gas turbine.

Advantageously, the system 3 is equipped with an anti-surge protection device for protecting the compressor 16a, 16b against speeds with a small volumetric flow rate on the inlet side. Such a device comprises, on the outlet side of the compressor 16a, 16b, a recirculation loop 44 that allows part of the compressed stream of gas to be returned upstream of said compressor 16. The recirculation loop
 15 44 is equipped with a valve 18a, 18b allowing control of the flow rate in the recirculation loop 44. In the embodiment depicted, the recirculation loop 44 is connected to a pipeline 14, the arrangement of which will be described hereinafter.

On exiting the compressor(s) 16a, 16b, the stream of gas is conveyed to a cooling apparatus 19 that allows the temperature of the stream of gas to be brought
 25 to a reference temperature. When the system comprises several compressors 16a, 16b in parallel, the outlets of said compressors 16a, 16b are connected to the inlet of the cooling apparatus 19 via three-way connections 45, 63.

Finally, on leaving the cooling apparatus 19, the stream of gas is carried to the energy production equipment 6 of the electric generator via a pipeline 46. Note
 30 that said pipeline 46 is equipped with a three-way connection 47 the two outlet paths of which are equipped with valves 147, 247 allowing the stream of gas to be directed selectively toward the energy production equipment 6 of the electric generator and/or toward the energy production equipment 4 of the propulsion unit.

Note also that, in the embodiment depicted, the main circuit, that supplies the energy production equipment 4, is not equipped with a compressor, unlike the secondary circuit, because the main circuit and the pump 8a feeding the intake pipeline 7a of the main circuit are capable of supplying pressures consistent with the conditions of operation of said energy production equipment 4.

Figure 3 depicts the conveying of the gas through the secondary circuit when natural gas evaporated in the storage tank is incorporated into the secondary supply circuit feeding the energy production equipment 6.

To do this, the system 3 comprises a pipeline 71 opening into the top part of the tank 2. A three-way connection 70 connects the pipeline 71 opening into the top part of the tank 2 to the secondary circuit via a pipeline 48 fitted with a valve 170 and to a pipeline 49, equipped with a valve 270 and forming part of a heating circuit the purpose of which will be detailed hereinafter. The three-way connection 70 and the valves 170, 270 form a switchable three-way connection member.

The pipeline 48 is moreover connected via a three-way connection 50 to a pipeline 14. The three-way connection 50 connects the pipeline 14 to a pipeline 51 equipped with a valve 150 and forming part of the heating circuit and to the pipeline 48 equipped with the valve 170. The three-way connection 50 and the valves 150 and 170 also form a switchable connection member.

The pipeline 14 is connected to the secondary circuit via a three-way connection 54 that allows the outlet of the atomizer 10b and said pipeline 14 to be connected to the inlet of the atomizer 31. The gas evaporated in the tank 2 is thus incorporated into the stream of gas leaving the forced vaporization installation 9b before being carried to the second atomizer 31, but also has the function of controlling the temperature of the stream of gas entering the phase separator 11b by spraying natural gas in the liquefied state into the stream of gas. Thus, the secondary supply circuit comprises, in the upstream portion thereof, a path for conveying evaporated natural gas, collected in the tank 2, and a path for forced vaporization of natural gas.

Such a path for conveying gas evaporated in the tank is particularly appropriate when the liquefied natural gas is stored at ambient temperature resulting in considerable natural evaporation.

Figures 4 and 5 illustrate the path for supplying the burner 5 with natural gas. Figure 4 illustrates the path of forced vaporization of natural gas while figure 5 illustrates the path of the evaporated natural gas collected in the tank 2. It will be noted that, in both cases, the circuit for supplying the burner 5 bypasses the phase separator 11b so as to allow the energy contained in the heavy fraction of the natural gas to be recovered.

In figure 4, the supply circuit feeding the burner 5 comprises a circuit portion in common with the secondary circuit. This circuit portion in common allows the forced vaporization of the liquefied natural gas and comprises the intake pipeline 7b fed by the pump 8b, the forced vaporization installation 9b and, optionally, the atomizer 10b.

Downstream of the forced vaporization installation 9b, the treatment and conveying system 3 comprises a three-way connection 55 connecting the outlet of the forced vaporization installation 9b to the series of pipelines 38, 39, 40 which are equipped with a valve 155 and lead to the phase separator 11b, and a pipeline 56, equipped with a valve 255, allowing said phase separator 11b to be bypassed so that the heavy fraction of the natural gas can be recovered and used in the burner 5. Thus, the switchable connection member thus formed allows the outlet from the forced vaporization installation 9b to be conveyed selectively either toward the phase separator 11b or toward the burner 5.

The pipeline 56 carries the stream of gas leaving the forced vaporization installation toward a gas heating appliance 57. The gas heating appliance 57 is, for example, a gas/liquid or gas/gas heat exchanger. The gas heating appliance 57 here is equipped with a recirculation loop 58. The gas heating appliance 57 allows the gaseous phase to be heated, upstream of said burner 5, to a reference temperature typically of the order of 30°C. At the outlet from the gas heating appliance 57, pipelines 68, 59 carry the gas toward the burner 5.

In figure 5, the supply circuit feeding the burner 5 comprises another circuit portion in common with the secondary circuit. This circuit portion in common allows the natural gas evaporated in the tank 2 to be collected. This circuit portion in common comprises the pipeline 71 opening into the top part of the tank 2, the pipeline 48 connected to the pipeline 71 by the three-way connection 70 and the pipeline 14 connected to the pipeline 71 by the three-way connection 50. The

pipeline 14 is moreover connected to a three-way connection 60 connecting the pipeline 14 to the series of pipelines 39, 40 leading toward the phase separator 11b and toward the valves 143, 243 and to a pipeline 56, equipped with a valve 160, and allowing said phase separator 11b to be bypassed so that the heavy fraction of the natural gas can be recovered and used in the burner 5.

Later, as detailed hereinabove in conjunction with figure 4, the pipeline 56 carries the stream of gas toward the gas heating appliance 57 then, at the outlet of the gas heating appliance 57, pipelines 68, 59 carry the gas toward the burner 5.

Note that, while the path of the natural gas evaporated in the tank 2 and the path of the forced vaporization of the natural gas are illustrated in two different figures for the sake of ease of understanding, it is entirely possible to use these two paths simultaneously for carrying natural gas to the burner 5.

The natural gas treatment and conveying system 3 is advantageously equipped with a device for monitoring a variable indicative of the methane number of the liquefied natural gas being conveyed. The methane number indicates the ability of the gaseous mixture to withstand the undesirable phenomenon of knock and is comprised between 0 and 100. The methane number is dependent on the composition of the natural gas. The methane number for pure methane is 100. The number decreases as the proportion of heavier hydrocarbons such as propane and/or butane and/or pentane increases.

Such a device for monitoring a variable indicative of the methane number of the natural gas may notably comprise one or more flow meters arranged downstream of one or both phase separators 11a, 11b, in the pipeline 42 for example, so as to measure the flow rate of the stream of gas of the light fraction of the natural gas. This flow rate is indicative of the methane number of the liquefied natural gas being conveyed. This is because under steady state conditions, at a constant pumping flow rate, this flow rate will have a tendency to decrease as the tank 2 empties and as the concentration in heavy hydrocarbons increases.

Alternatively or in addition, it is equally possible to place a temperature sensor for example in the pipeline 48 for conveying the evaporated gas collected in the tank 2, so as to measure the temperature of the evaporated gas. This is because the higher the temperature of the evaporated gas is, the higher the

proportion of heavy hydrocarbons the tank contains, because it is getting close to the end of the voyage.

Furthermore, as an alternative or in addition, it is equally possible to log the purge frequency of at least one of the condensate collection containers 72a, 72b
5 and/or to monitor how the condensate level of at least one of the containers 72a, 7b evolves.

The monitoring device also comprises a control unit able to receive and process the data collected by at least one of the sensors mentioned hereinbelow. The control unit compares the variable(s) indicative of the methane number against
10 a threshold. On the basis of this comparison, the control unit is able to generate an alarm or to switch automatically from a mode of operation in which natural gas is fed to the energy production equipment 4, 6 of the propulsion unit and/or of the electric generator to a mode of operation in which the heavy fraction of the natural gas is recovered and carried to the burner 5 of the energy production installation. In
15 practice, when the variable indicative of the methane number corresponds to a methane number lower than a number of around 80, the control unit generates an alarm or switches automatically into the mode in which the heavy fraction of the natural gas is recovered and used.

In the embodiment that foresees such an automatic changeover in mode of
20 operation, the monitoring device is able to transmit a reference signal to one or more valves 155, 255, 160, 143, 243 with which the three-way connections 55 and 60 are equipped, so as to switch the stream of gas toward the burner 5, bypassing said phase separator 11b.

When the energy production equipment is a gas/diesel dual fuel
25 combustion engine, in parallel with the switch to a mode of operation in which the heavy fraction of the natural gas is recovered and carried to the burner 5, the combustion engine or the fuel cell or the gas turbine 4 of the propulsion unit and/or that of the electric generator 6 switches over to diesel mode in order to continue the propulsion of the ship and/or the generation of electricity.

30 Figure 6 illustrates the path of the natural gas when a method that allows the heating of the tank 2 is implemented. This method is implemented when the tank 2 is almost empty, the residual natural gas then being in gaseous form in the tank 2.

During implementation of the heating method, the natural gas is collected in the bottom part of the tank 2 using a pipeline 52 that opens into the bottom part of the tank 2.

5 In the embodiment depicted, the pipeline 52 opening into the bottom part of the tank 2 is connected to a switchable three-way connection member 53 that allows said pipeline 52 to be connected selectively either to a pipeline 51 of the upstream portion of the heating circuit so as to allow a stream of gas to be collected in the bottom part of the tank 2 or to a filling circuit 61 for filling the tank 2, allowing liquefied natural gas to be conveyed from an on-shore reservoir to the tank 2.

10 Moreover, the pipeline 51 of the upstream portion of the heating circuit is connected, downstream, to a three-way connection 50. The valves 170, 150 allow selective connection of either the pipeline 51 of the upstream portion of the heating circuit, or the pipeline 48 allowing the conveying of the evaporated gas, collected in the tank 2, to the pipeline 14.

15 The upstream portion of the heating circuit may thus be connected to the inlet of the compressors 16a, 16b by the pipelines 39, 40 and 42 so as to carry the gas collected at the bottom part of the tank to the compressors. The temperature of the stream of gas leaving the compressors 16a, 16b for implementing the method of heating the tank 2 is, for example, of the order of 50°C.

20 The circuit portion comprising the pipelines 14, 39, 40 and 42 and at least one of the compressors 16a, 16b is thus common to the secondary circuit that supplies gas to energy production equipment 4, 6 and to the heating circuit. As a result, the design of the system 3 for treating and conveying the gases is optimized and at least one of the compressors 16a, 16b both prepares a stream of gas for
25 supplying energy production equipment 4, 6 and is involved in implementing a method of heating the tank 2.

At the outlet from the compressors 16a, 16b, three-way connections 62, 63 connect the outlet of the compressors 16a, 16b to pipelines 64, 65 equipped with valves 162, 163 and to pipelines opening toward the secondary supply circuit and
30 equipped with valves 262, 263. Said pipelines 64, 65 are connected via three-way connections 66, 67 to the pipeline 56 that forms part of the supply circuit feeding the burner 5 leading to the gas heating appliance 57.

Thus, to heat the tank 2, the stream of gas passes both through the compressors 16a, 16b and through the heating appliance 57. On leaving the gas heating appliance 57, the stream of gas has, for example, a temperature of the order of 80°C.

5 Moreover, on leaving the gas heating appliance 57, a pipeline 68 leads to a three-way connection 69 that allows an excess part of the stream to be removed to the burner 5 via the pipeline 59 equipped with a valve 169 and allows the other part of the stream of gas to be returned to the tank 2 via a pipeline 49 equipped with a valve 269 and forming a return section leading to the tank 2.

10 It will thus be appreciated that the pipeline 56, the gas heating appliance 57 and the pipeline 68 define a circuit portion which is common to the heating circuit for heating the tank 2 and to the supply circuit feeding the burner 5 with gas. As a result, the pipelines 64, 65 form connection sections that allow the outlet of the compressors 16a, 16b to be connected to the circuit portion that is common to the
15 tank 2 heating circuit and to the supply circuit feeding the burner 5 with gas.

 The pipeline 49 that forms a return section leading to the tank 2 is connected, via the three-way connection 70, to the pipeline 71 opening into the top part of the tank 2. Thus, depending on the position of the valves 170, 270, the pipeline 71 opening into the top part of the tank 2 can be used for collecting the gas
20 evaporated in the tank 2 when there is a desire to supply energy production equipment 4, 6 or the burner 5, with natural gas, or for injecting hot gas where there is a desire to heat the tank 2.

 As a result, during implementation of the method for heating the tank 2, hot gas is injected into the top part of the tank 2 while the gas is extracted from the
25 bottom part of the tank 2. As the hot gas by nature has a tendency to rise to the top of the tank 2, such an arrangement makes it possible to obtain thermal stratification of the tank 2 thereby increasing the efficiency of the method of heating the tank 2.

 In a way known per se, as depicted in figure 7, loading/offloading pipelines may be connected, by means of suitable connectors, to a maritime or harbor
30 terminal for transporting a cargo of LNG from or to the tank 2.

 Figure 7 depicts one example of a maritime terminal comprising a liquefied natural gas supply station 82, an underwater pipe 83 and an on-shore installation 81. The liquefied natural gas supply station 82 is a fixed off-shore installation

comprising a mobile arm 84 and a tower 85 supporting the mobile arm 84. The mobile arm 84 supports insulated flexible hoses 80 that can be connected to the loading pipelines. The orientable mobile arm 84 adapts to all sizes of ships. A connecting pipe, not depicted, extends up inside the tower 85. The liquefied natural gas supply station 82 allows the tank of the ship 1 to be filled from the on-shore facility 81. The latter comprises liquefied gas storage tanks 86 and connecting pipes 87 connected by the underwater pipe 83 to the liquefied natural gas supply station 82. The underwater pipe 83 allows the liquefied gas to be transferred between the liquefied natural gas supply station 82 and the on-shore facility 81.

10 In order to generate the pressure needed for transferring the liquefied gas, use is made of the pumps onboard the ship 1 and/or the pumps with which the on-shore facility 81 is equipped and/or the pumps with which the loading and offloading station 82 is equipped.

15 Although the invention has been described in conjunction with a number of particular embodiments it is quite obvious that it is not in any way restricted thereto and that it comprises all technical equivalents of the means described and combinations thereof where these fall within the scope of the invention.

20 In particular, although in the embodiments described hereinabove the ship comprises just one liquefied natural gas storage tank, it is equally possible for the gas treatment and conveying system to be connected to a plurality of storage tanks. In that case, the storage tanks are each equipped with intake pipelines fed by pumps and with pipelines opening into the top and the bottom of the tank, these being connected to the treatment system circuits as described hereinabove.

25 It will moreover be noted that while the term connection member has been used hereinabove to describe the combination of a three-way connection with several valves equipping one or more incoming pipelines or one or more outgoing pipelines, this term extends to all technical equivalents that allow two incoming pipelines to be connected to an outgoing pipeline or one incoming pipeline to be connected to two outgoing pipelines, and which are equipped with means which, according to the circumstances, allow a selection to be made in order to promote either a stream from one of the two incoming pipelines or a stream toward one of the two outgoing pipelines or allow either an incoming stream to be split between two

outgoing streams or two incoming streams to be combined into one outgoing stream.

5 The use of the verbs “comprise”, “have” or “include” and the conjugated forms thereof does not exclude there being other elements or other steps present than those listed in a claim. The use of the indefinite article “a” or “an” for an element or a step does not, unless mentioned otherwise, exclude there being a plurality of such elements or steps.

 In the claims, any reference sign between parentheses must not be interpreted as implying a limitation on the claim.

CLAIMS

1. A method for treating and conveying natural gas, in a ship (1), from a liquefied gas storage tank (2) to energy production equipment (4, 6), on the one hand, and to a burner (5) of an energy production installation, on the other hand, said
5 method comprising in succession:
 - a step of supplying the energy production equipment (4, 6), during which step natural gas is carried through a phase separator (11a, 11b) allowing a heavy fraction of the natural gas containing the hydrocarbons that have the longest carbon chain to be returned to the tank (2) in the form of condensate and
10 allowing a light fraction of the natural gas containing the hydrocarbons that have the shortest carbon chain to be carried to the energy production equipment (4, 6); then
 - a step of recovering the heavy fraction of the natural gas during which step natural gas is carried from the tank (2) to the burner (5), bypassing said phase
15 separator (11a, 11b).
2. The method as claimed in claim 1, in which a variable indicative of the methane number of the natural gas being conveyed is monitored during a step of supplying the energy production equipment (4, 6).
3. The method as claimed in claim 2, in which there is an automatic switchover to
20 the step of recovering the heavy fraction of the natural gas and/or an alarm signal is generated when the variable indicative of the methane number of the natural gas being conveyed crosses a threshold.
4. The method as claimed in claim 2 or 3, in which the variable indicative of the methane number of the natural gas being conveyed is determined by measuring
25 the flow rate of the light fraction of the natural gas downstream of the phase separator (11a, 11b) and/or by measuring the temperature of the evaporated natural gas collected in the tank and/or by measuring the level and/or the purge frequency of a condensate collecting container.
5. A system carried onboard a ship (1), for treating and conveying natural gas from
30 a liquefied gas storage tank (2) to energy production equipment (4, 6), on the one hand, and to a burner (5) of an energy production installation, on the other hand, the system comprising:

- a first supply circuit feeding the energy production equipment (4, 6), said first circuit being fitted with a phase separator (11a, 11b) connected, downstream, on the one hand, to a return pipe (12a, 12b) allowing a heavy fraction of the natural gas containing the hydrocarbons that have the longest carbon chain to be returned to the tank (2) in the form of condensate and, on the other hand, to a carrying pipe (42) leading to the energy production equipment (4, 6) conveying a light fraction of the natural gas containing the hydrocarbons that have the shortest carbon chain,
 - a second supply circuit, feeding the burner (5), said second circuit bypassing said phase separator (11a, 11b).
6. The system as claimed in claim 5, in which the first circuit has, upstream of the phase separator (11b), at least one circuit portion in common with the second circuit and designed to allow forced vaporization of the liquefied natural gas and/or to allow collection of the natural gas that has evaporated in the tank (2).
 7. The system as claimed in claim 6, in which a circuit portion common to the first and to the second circuit comprises an intake pipeline (7b) opening toward the bottom of the tank (2), equipped with a pump (8b) and a forced vaporization installation (9b) allowing the liquefied natural gas to be converted into a stream of gas.
 8. The system as claimed in claim 6 or 7, in which a circuit portion common to the first and to the second circuit comprises a pipeline (71) opening into the top part of the tank (2) to collect the natural gas that has evaporated in the tank (2).
 9. The system as claimed in any one of claims 5 to 8, in which a circuit portion common to the first and to the second circuit is bounded downstream by a switchable three-way connection member (55; 155; 255-60; 160; 143; 243) allowing the circuit portion in common to be connected selectively to an inlet of the phase separator (11b) or to a portion of the second circuit leading to the burner (5).
 10. The system as claimed in claims 5 to 9, in which the second circuit for feeding the burner (5) is fitted with a gas heating appliance (57).
 11. The system as claimed in any one of claims 5 to 10, in which the first circuit for supplying natural gas to the energy production equipment (4, 6) comprises a compressor (16a, 16b) positioned downstream of the phase separator (11b).

12. The system as claimed in any one of claims 5 to 11, comprising a device for monitoring a variable indicative of the methane number of the liquefied natural gas being carried.
- 5 13. The system as claimed in claim 12, in which the device for monitoring a variable indicative of the methane number of the liquefied natural gas being carried comprises a sensor for measuring the flow rate in the carrying pipe (42) leading toward the energy production equipment and/or a sensor for measuring the temperature of evaporated natural gas collected in the tank (2) and/or a sensor for measuring the level in a condensate collecting container (72a, 72b) and/or a
10 counter for measuring the purge frequency of a condensate collection container (72a, 72b).
14. The system as claimed in claim 12 or 13, in which the monitoring device is designed to generate an alarm signal and/or to act on a switchable three-way connection member (55; 155; 255-60; 160; 143; 243) so as to lead the natural
15 gas toward the burner (5) when the variable indicative of the methane number of the liquefied natural gas being carried crosses a threshold.
15. A ship comprising a liquefied gas storage tank, energy production equipment (4, 6), an energy production installation equipped with a burner and a system for treating and conveying the natural gas as claimed in any one of claims 5 to 14.
- 20 16. The ship as claimed in claim 15, in which the energy production equipment is intended for the propulsion of the ship.
17. The ship as claimed in claim 15 or 16, in which the liquefied gas storage tank is a tank with a membrane.
18. The ship as claimed in any one of claims 15 to 17, in which the tank is a storage
25 tank at atmospheric pressure.
19. A method for filling a tank of a ship (1) as claimed in any one of claims 15 to 18, in which method a fluid is conveyed through insulated pipelines (80) from a floating or on-shore storage facility (81) toward the tank (2) of the ship (1).
- 30 20. A fluid transfer system, the system comprising a ship (1) as claimed in any one of claims 15 to 18, insulated pipelines (80) arranged in such a way as to connect the tank (2) installed in the hull of the ship to a floating or on-shore storage

facility (81) and a pump for driving a stream of fluid through the insulated pipelines from the floating or on-shore storage facility to the tank of the ship.