(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) **EP 4 306 842 A1**

(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
17.01.2024 Bulletin 2024/03

(21) Application number: **22020327.7**

(22) Date of filing: **11.07.2022**

(51) International Patent Classification (IPC):
F17C 5/02 *(2006.01)* ***F17C 13/02*** *(2006.01)*

(52) Cooperative Patent Classification (CPC):
F17C 5/02; F17C 13/026; F17C 2205/054; F17C 2205/058; F17C 2221/011; F17C 2221/013; F17C 2221/014; F17C 2221/016; F17C 2223/0161; F17C 2223/033; F17C 2223/046; F17C 2225/0161; F17C 2225/033; F17C 2227/0135; F17C 2227/04;

(Cont.)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Linde GmbH**
82049 Pullach (DE)

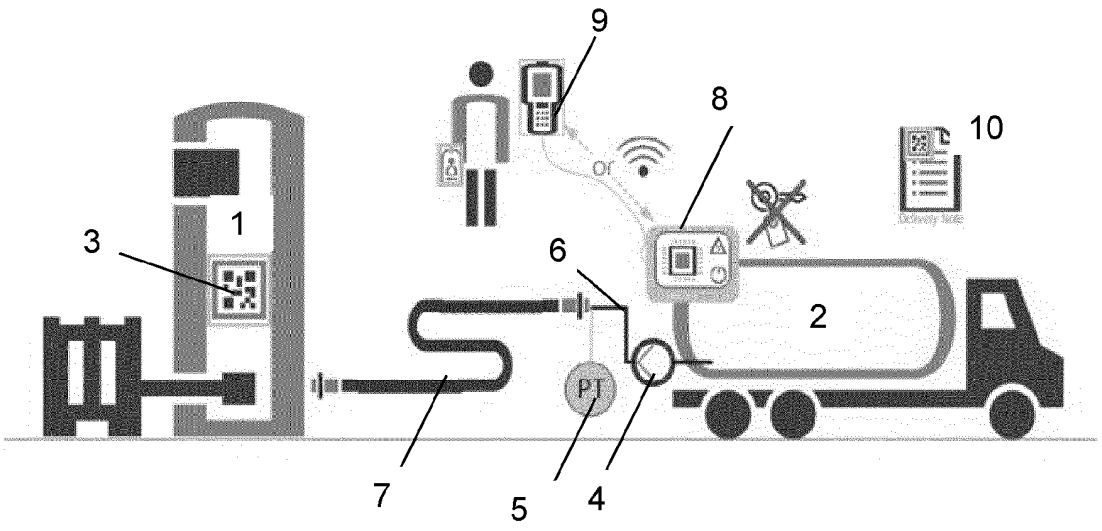
(72) Inventors:
- **Riecker, Matthias**
  82049 Pullach (DE)
- **Fürtauer, Wolfgang**
  82049 Pullach (DE)

(74) Representative: **Gellner, Bernd**
Linde GmbH
Intellectual Property EMEA
Dr.-Carl-von-Linde-Straße 6-14
82049 Pullach (DE)

(54) **METHOD FOR FILLING A VESSEL WITH A CRYOGENIC LIQUID**

(57) The invention relates to a method for filling a vessel (1) with a cryogenic liquid wherein the cryogenic liquid is transferred from a source of cryogenic liquid (2) into the vessel by means of a pump (4) wherein the pump transfers the cryogenic liquid at an operating pressure. A pump transfers cryogenic liquid from the source into the vessel. The pump is stopped when its operating pressure exceeds the maximum fill pressure.

Fig. 1



EP 4 306 842 A1

(52) Cooperative Patent Classification (CPC): (Cont.)
F17C 2250/032; F17C 2250/034; F17C 2250/043;
F17C 2250/0626; F17C 2250/075; F17C 2265/06

Description

[0001] The invention relates to a method for filling a vessel with a cryogenic liquid wherein the cryogenic liquid is transferred from a source of cryogenic liquid into the vessel by means of a pump wherein the pump transfers the cryogenic liquid at an operating pressure.

[0002] Cryogenic storage vessels are used in the distribution and site storage of cryogenic liquids on customer sites. Such vessels are filled with cryogenic liquid from delivery trailers and trucks. During the filling process cryogenic liquid is pumped by means of a cryogenic pump to the vessel. Typically, the cryogenic pump is mounted on the delivery trailer.

[0003] Protective measures have to be implemented in order to prevent the vessel to be over-pressurized during the filling procedure. The driver of the delivery truck or trailer is trained and operates the filling process manually in accordance with a certain filling procedure. The operator (driver) must continuously monitor the tank pressure and adjusts the flow to the vessel manually by controlling the top and bottom fill valves to maintain the tank working pressure.

[0004] The filling process is normally finished when the operator (driver) observes that liquid issues from the try-cock valve and/ or the level indicator indicates full.

[0005] The first layer of protective measures consists of the main safety pressure relief valves and bursting discs, if installed, on the storage vessel. As a consequence of technical development the delivery pressures and flow rates of cryogenic pumps are increasing. The cryogenic pump power becomes stronger and stronger in order to accelerate the filling process. That means, even high-pressure vessels, for example vessels with a design limit of 36 bar, need to be protected against over-pressure.

[0006] But even the capacity of the safety pressure relief valve is not big enough to relief the full liquid capacity of the delivery pump. As a result, the pressure can further increase and exceed the design limits of the vessel, especially when the pump delivery pressure is higher than the vessel's design limits. Therefore, an overpressure protection system is installed to prevent rupture of the vessel. Rupture can lead to a fatality.

[0007] At each vessel installation prior filling, the operator has to pre-check individually the vessel conditions and the vessel limits. If the Operator disregards the filling instructions, it may lead to a hazardous situation.

[0008] There are several other protection systems worldwide in place. At least in central Europe, the most common over-pressure protection device is a vessel flow stop or limiting device. This device comprises a pressure sensor connected to the vessel or to the transfer line. The device will stop the cryogenic pump if the upper pressure limit of the vessel is exceeded.

[0009] There are many different vessel types from different manufacturers with different design limits (product, pressure, etc.) available and installed. Further, there are also customized tanks where alternative over-pressure protection solutions are installed. The known solutions must be manually adjusted. In some cases they can be easily manipulated by the operator, for example by by-passing the safety function.

[0010] It is an object of the present invention to provide an improved method for preventing excessive pressure during filling of a cryogenic vessel. In particular, the invention shall reduce the necessity to manually adjust set parameters and thereby reduce the risk of manipulation.

[0011] This object is achieved by a method according to claim 1.

[0012] For filling a vessel with a cryogenic liquid, the cryogenic liquid is transferred from a source of cryogenic liquid into the vessel by means of a pump. The pump transfers the cryogenic liquid at an operating pressure. The inventive method comprises the following steps:

- one or more parameters of the vessel, of the pump and/or of the cryogenic liquid are identified,
- a maximum fill pressure is determined depending on the one or more parameters,
- the pump is started and operated at an operating pressure below the maximum fill pressure whereby cryogenic liquid is transferred from the source into the vessel,
- the operating pressure of the pump is monitored and the pump is stopped or its operating pressure is reduced when the monitored operating pressure exceeds the maximum fill pressure.

[0013] The invention provides a protection system against overpressure while transfilling a cryogenic liquid from a source of cryogenic liquid to a vessel. Prior transfilling, the inventive system recognizes and identifies the vessel to be filled and sets the maximum fill pressure accordingly. As long as the operator operates the filling process at a pressure below the maximum fill pressure, the over pressure protection system will not trip the pump.

[0014] Each cryogenic tank is equipped with two redundant safety pressure relief valves and redundant bursting discs, if applicable These valves are activated or the discs rupture when the set tank pressure is reached and relief the stored gases to atmosphere where the surrounding area gets enriched with combustible gases (for example in the case of liquid oxygen) or inert gases (e.g. in the case of liquid nitrogen or liquid argon). Normally the Operator works alone during transfilling. If the Operator loses consciousness during the process, he may stay too long in this enriched atmosphere. The inventive solution will stop the pump before the safety pressure relief valves get activated by too high pressure.

[0015] The inventive solution may impact all tank installations worldwide and can significantly lower the investment costs for increased safety. The solution is suitable for any type of cryogenic vessel or tank. It can be used for filling stationary tanks, for example at a customer site, or for filling transport tanks, for example on trucks

or trailers. For example, the vessel receiving the cryogenic liquid could be a stationary or static vacuum-insulated vessel.

[0016] The source of cryogenic liquid could also be a stationary tank or vessel or a mobile tank or vessel. The source of cryogenic liquid especially includes fixed tanks of tank vehicles or tank wagons, demountable tanks, tank containers and swap bodies for cryogenic fluids.

[0017] The invention is preferably used to improve the safety of existing tanks and vessels. With the new solution it is not required to install an over-pressure protection system to every individual vessel.

[0018] The solution is able to cover all vessel or tank installations for different products, in particular for liquid nitrogen, liquid oxygen, liquid argon or liquid carbon dioxide. Further, the solution is not limited to certain pressure ranges but applicable to many design pressures. It can be implemented very easily with very low investment cost.

[0019] According to the invention the maximum fill pressure is determined depending on one or more parameters. These parameters are preferably selected from the group of the type of vessel, a vessel identifier, the cryogenic liquid in the source, the cryogenic liquid in the vessel, the maximum operating pressure of the pump and the maximum flow of the pump. One or more of these parameters are used to determine the maximum fill pressure. Of course, other parameters might be used in addition.

[0020] The one or more parameters are preferably transmitted to an input device. The input device could for example be a scanner, a keyboard or a RFID reader device. The transmission of the parameter or the parameters to the input device is preferably done by means of wireless communication.

[0021] According to a preferred embodiment the filling process includes some or all of the following steps:

- The identity of the operator who is responsible for the filling process is determined.
- The vessel is equipped with a label which comprises certain vessel parameters. One or more of the parameters are transmitted to an input device, preferably by wireless communication. The parameters may include information about the vessel itself, information about the product which is in the vessel or which is to be filled in the vessel, information about the maximum vessel pressure, the volume of the vessel and/or the vessel serial number and/or another vessel identifier.
- A delivery note includes information on the source of cryogenic liquid and on the product to be filled into the vessel. This information is transferred to a control unit. The control unit and the input device could be combined in one device or could be separate devices.
- The control unit compares and verifies the information from the delivery note and the information from the vessel label. The control unit 8 will not allow starting the filling process unless all parameters have been verified.
- The maximum fill pressure is determined depending on one or more parameters of the vessel and in particular depending on the maximum vessel pressure which is stored on the label.
- The source of cryogenic liquid and the vessel are connected, for example by means of a filling hose and a pump transfers cryogenic liquid from the source to the vessel.
- The operating pressure of the pump is monitored and compared to the maximum fill pressure. If the operating pressure of the pump exceeds the maximum fill pressure, the pump is stopped.
- The whole filling process is recorded

[0022] The invention as well as further preferred embodiments will be described with reference to the figure.

[0023] Figure 1 schematically shows a system for filling a vessel with a cryogenic liquid according to the invention.

[0024] Figure 1 illustrates the application of the invention for filling a cryogenic liquid from a vehicle with a cryogenic tank 2 into a stationary vessel 1. The stationary vessel 1 is preferably a vacuum insulated storage vessel. The vessel 1 is equipped with a label or sticker 3. The label 3 is preferably suitable to be used for wireless connection. It might comprise a barcode, a QR-code, a data matrix code, a tag, a RFID system (radiofrequency identification system) or a similar identification code in machine-readable form.

[0025] The vehicle, usually a truck or trailer, is provided with a cryogenic tank 2 which contains a cryogenic gas, for example nitrogen, in liquid form. The cryogenic tank 2 is the source of cryogenic liquid. The tank 2 is provided with a connector 6 where a filling hose 7 can be connected. A cryogenic pump 4 is provided for pumping cryogenic liquid from the tank 2 through a filling hose 7 to the stationary tank 1. A pressure transducer/ transmitter 5 is connected to the connector 6 and suitable to measure the pressure downstream of pump 4 and to transmit a pressure signal to a control unit 8.

[0026] The operator who is responsible for the filling process is provided with an input device 9. The input device 9 could be a scanner, a keyboard, a RFID reader device or any other device capable to read information from the label 3 on the vessel 1. Typically, the vehicle driver is the operator. The operator (vehicle driver) has further got a delivery note, for example in paper form or on a mobile device.

[0027] Prior to filling the vessel 1 with a cryogenic liquid the operator has first to log on to the system. The operator enters the personnel ID into the input device 9, for example by scanning an identification card or typing an identification code into the input device 9.

[0028] By means of the input device 9 the operator scans or otherwise reads the label 3 of the vessel 1 to receive information about the product which is in the ves-

sel 1 or is to be filled in the vessel 1. The label 3 further comprises information about the maximum vessel pressure and other vessel information, such as for example the volume of the vessel and the vessel serial number, which is also read by the input device 9. The information entered into or read by the input device 9 is transferred to the control unit 8, preferably by wireless communication means.

[0029] The operator reads the information from the delivery note 10 and transfers it to the control unit 8, too. Reading the information and/or transmitting the information to the control unit 8 is preferably done by wireless communication means.

[0030] The control unit 8 compares and verifies the information from the delivery note 10 and the information from the vessel label 3. The product in the vessel 1 has to the same as the product in the tank 2. The tank serial number or other tank identifying parameters are compared to the information on the delivery note 10 and if all parameters have been verified, a maximum fill pressure is set. The maximum fill pressure is determined depending on one or more parameters of the vessel 1 and in particular depending on the maximum vessel pressure which is stored on the label 3.

[0031] The control unit 8 will not allow starting the filling process unless all parameters have been verified. For example, when the product in the tank 2 does not fit to the product in the vessel 1 or when the label 3 and/or the delivery note 10 has not been scanned, the filling process is not possible.

[0032] Only when all parameters have been verified by the control unit 8, a filling hose 7 is connected to the vessel 1 and to the connector 6 on the tank 2. The pump 4 is started and the operator can start the filling process. The pump 4 transfers liquid nitrogen from the tank 2 to the stationary vessel 1. The operating pressure of the pump 4, i. e. the pressure at which cryogenic liquid is pumped through the connector 6 and through the filling hose 7 to the vessel 1 is monitored by means of the pressure transmitter 5. Pressure transmitter 5 determines the pressure and sends a corresponding signal to the control unit 8. The control unit 8 compares the operating pressure with the set maximum fill pressure. As long as the operating pressure is below the maximum fill pressure the pump 4 continues to pump liquid nitrogen from tank 2 to vessel 1. If the operating pressure of the pump 4 exceeds the maximum fill pressure, control unit 8 disconnects the power supply to pump 4 and pump 4 stops to operate. Thereby, the pump 4 cannot cause over-pressurization of vessel 1.

[0033] The whole filling process is recorded by the control unit 8. The control unit 8 records

- the operator's personnel ID (name, identification number or identification code),
- the product in the tank 2 which is transferred into the vessel 1,
- the product in the vessel 1 prior to filling,
- vessel parameters, such as the vessel serial number and the maximum vessel pressure,
- the operating pressure during filling, preferably together with a time stamp,
- and any interruptions of the filling process or any other issues or events.

Claims

1. Method for filling a vessel with a cryogenic liquid wherein the cryogenic liquid is transferred from a source of cryogenic liquid into the vessel by means of a pump wherein the pump transfers the cryogenic liquid at an operating pressure,
   characterized in that

   - one or more parameters of the vessel, of the pump and/or of the cryogenic liquid are identified,
   - a maximum fill pressure is determined depending on the one or more parameters,
   - the pump is started and operated at an operating pressure below the maximum fill pressure whereby cryogenic liquid is transferred from the source into the vessel,
   - the operating pressure of the pump is monitored and
   - the pump is stopped or its operating pressure is reduced when the monitored operating pressure exceeds the maximum fill pressure.

2. Method according to claim 1, **characterized in that** the one or more parameters are selected from the group of a vessel identifier, the cryogenic liquid in the source, the cryogenic liquid in the vessel, the maximum operating pressure of the pump and the maximum flow of the pump.

3. Method according to any of the preceding claims, **characterized in that** the cryogenic liquid is selected from the group of liquid nitrogen, liquid oxygen, liquid argon or liquid carbon dioxide.

4. Method according to any of the preceding claims, **characterized in that** the vessel is a stationary tank.

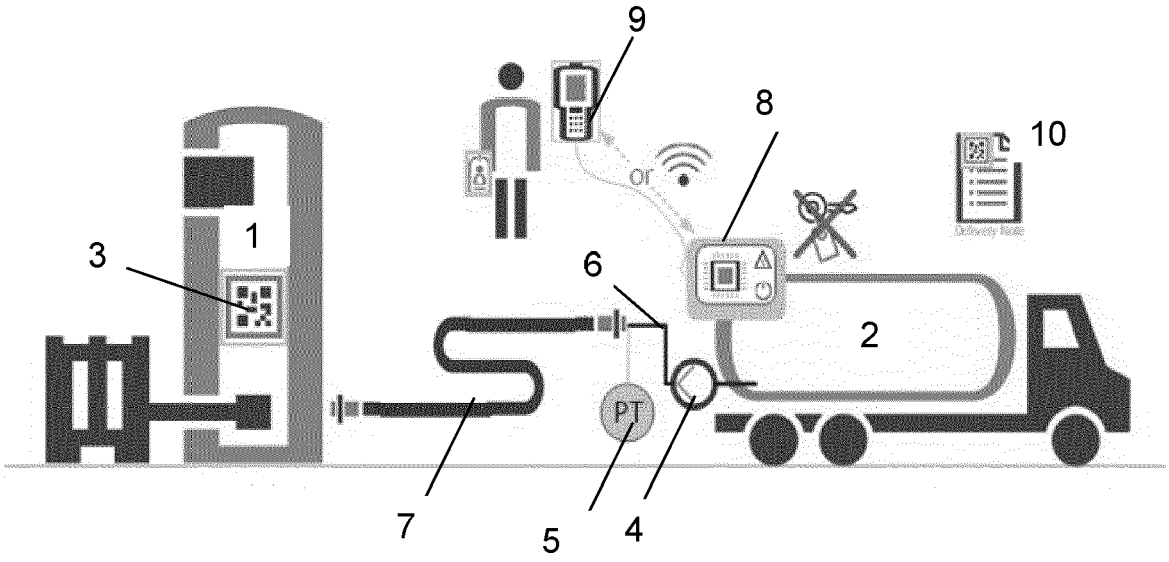
5. Method according to any of the preceding claims, **characterized in that** the source of cryogenic liquid is a transport tank, in particular a tank on a vehicle.

6. Method according to any of the preceding claims, **characterized in that** the one or more parameters are transmitted to an input device.

7. Method according to claim 6, **characterized in that** the input device is a scanner, a keyboard or a RFID reader device.

8. Method according to any of claims 6 or 7, **characterized in that** the one or more parameters are transmitted to the input device by means of wireless communication.

Fig. 1



Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 02 0327

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 2021/039937 A1 (TANSEY JR FRANCIS X [US] ET AL) 11 February 2021 (2021-02-11) * paragraphs [0074], [0076], [0077], [0079], [0092], [0096], [0105], [0146], [0149]; figure 2a *	1-8	INV. F17C5/02 F17C13/02
A	WO 2007/072073 A1 (BOC GROUP PLC [GB]; TAYLOR MARK JONATHAN [GB]) 28 June 2007 (2007-06-28) * page 1, lines 6-21 * * page 2, lines 6-23; figures 1-4 *	4-6	
A	EP 3 825 597 A1 (SMOQI AGIM [IT]) 26 May 2021 (2021-05-26) * paragraphs [0020], [0021]; figure 2a *	1,2,4-8	
			TECHNICAL FIELDS SEARCHED (IPC) F17C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	9 December 2022	Fritzen, Claas

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 02 0327

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

09-12-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2021039937 A1	11-02-2021	AU 2020267488 A1	06-01-2022
		CA 3139252 A1	12-11-2020
		EP 3966489 A1	16-03-2022
		US 2021039937 A1	11-02-2021
		US 2022106177 A1	07-04-2022
		WO 2020227425 A1	12-11-2020
WO 2007072073 A1	28-06-2007	EP 1991787 A1	19-11-2008
		WO 2007072073 A1	28-06-2007
EP 3825597 A1	26-05-2021	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82