OPERATING & MAINTENANCE MANUAL

FOR

CRYOGENIC LIQUID TANK CONTAINER

DOCUMENT NO : D-21026446-SM

MODEL: GX47/10-ASME-01 CS

Manufacturer's serial number: 16GX40D-01~20

MANUFACTURED BY
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## CONTENTS:

1 INTRODUCTION ................................................................................................................................................. 3

2 DESCRIPTION ..................................................................................................................................................... 6

3 DEFINITIONS .......................................................................................................................................................... 7

4 SAFETY ................................................................................................................................................................... 10
   4.1 Foreword .......................................................................................................................................................... 12
   4.2 General characteristics of LNG(ethylene,ethane) ......................................................................................... 12
   4.3 Health and safety .......................................................................................................................................... 15
   4.4 General safety rules – LNG (ethylene, ethane) equipment .......................................................................... 16

5 OPERATION .......................................................................................................................................................... 19
   5.1 Description of function and control of fire safe system .................................................................................. 20
   5.2 Purging ............................................................................................................................................................ 20
   5.3 Filling of ISO container .................................................................................................................................. 20
       5.3.1 First filling of warm ISO container ..................................................................................................... 21
       5.3.2 Normal two hose filling of ISO container ........................................................................................... 22
   5.4 Liquid discharge ............................................................................................................................................. 23
       5.4.1 Pressure transfer .................................................................................................................................. 24
       5.4.2 Liquid transfer with an external pump to a terminal tank ................................................................... 25

6 TRANSPORT .......................................................................................................................................................... 27

7 POTENTIAL FAULTS AND METHOD OF THEIR REMOVAL ............................................................................ 27
   7.1 Valve faults ..................................................................................................................................................... 27

8 REGULAR MAINTENANCE AND REVISION INSPECTION OF ISO CONTAINER .................................................... 29
   8.1 Visual check .................................................................................................................................................... 29
   8.2 Check of safety valves ................................................................................................................................... 29
   8.3 Check of pressure gauge and differential pressure gauge ........................................................................... 29
   8.4 Vacuum level check measurement ............................................................................................................. 29
   8.5 Revision inspections and leakage test ........................................................................................................ 30
   8.6 Revision inspections of electric devices ..................................................................................................... 30
   8.7 Taking the ISO container out of service ...................................................................................................... 30
       8.7.1 Working steps for temporary taking out of service (and further re-usage) ......................................... 30
       8.7.2 Working steps for scrapping of ISO container .................................................................................... 31
       8.7.3 Disposal of ISO container ................................................................................................................... 31
   8.8 Maintenance of fire block ball valves .......................................................................................................... 31
1 INTRODUCTION:

The ISO container is intended for transport of refrigerated liquid Natural Gas, Ethane and Ethylene according to ADR, RID, IMDG. The ISO container fulfils requirements of the following rules and codes: CSC, ISO1496, ADR, RID and IMDG. This operating manual describes basic operating procedures for the ISO container itself. Simultaneously, it is necessary to take into account also operating procedures of the plant, where the ISO container will be filled and discharged. Further, the operator is obliged to acquaint its employees intended for operation of the container with the operating procedure. Ignorance of the operating procedure and/or non-adhering to it can cause the risk to the health of operating personnel, eventually failures of the equipment.

The producer of the ISO container is not responsible for failures, which were caused by nonadherence to instructions and principles stated in this operation manual. Nor is the producer responsible for common wear of the parts caused by the equipment operation, the repairs of which are covered by common maintenance (e.g. tightening of the valve seals, removing of humidity etc.).
1.1 Diagram of pipe connection, specification of valves and accessories
<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
<th>Chinese Description</th>
<th>Symbol</th>
<th>English Description</th>
<th>Chinese Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>PBC</td>
<td>PRESSURE BLDG COIL</td>
<td>增压器</td>
<td>V23</td>
<td>SAMPLE FOR GAS VALVE</td>
<td>气相取样阀</td>
</tr>
<tr>
<td>TC1</td>
<td>VACUUM GAUGE PORT</td>
<td>溢真空口</td>
<td>V22</td>
<td>SAMPLE FOR LIQUID VALVE</td>
<td>液相取样阀</td>
</tr>
<tr>
<td>EP</td>
<td>EVACUATION PORT</td>
<td>抽真空口</td>
<td>Y21</td>
<td>GAS PHASE VALVE</td>
<td>气相阀</td>
</tr>
<tr>
<td>TRN1-4</td>
<td>SAFETY RELIEF VALVE</td>
<td>管道安全阀</td>
<td>Y20</td>
<td>LIQUID PHASE VALVE</td>
<td>液相阀</td>
</tr>
<tr>
<td>SV1-4</td>
<td>SAFETY VALVE</td>
<td>容器安全阀</td>
<td>Y19</td>
<td>DRAIN VALVE</td>
<td>排放阀</td>
</tr>
<tr>
<td>R-2</td>
<td>SAFETY DISCHARGE DEVICE</td>
<td>安全泄压装置</td>
<td>Y18</td>
<td>DRAIN VALVE</td>
<td>排放阀</td>
</tr>
<tr>
<td>C1</td>
<td>BOTTOM FILL CONNECTION</td>
<td>底部充装连接口</td>
<td>Y17</td>
<td>VAPOR RECOVERY VALVE</td>
<td>气体回收阀</td>
</tr>
<tr>
<td>C2</td>
<td>VAPOR RETURN &amp; TOP FILL</td>
<td>回气/顶部充装口</td>
<td>Y16</td>
<td>GAS TO PBC VALVE</td>
<td>增压自气阀</td>
</tr>
<tr>
<td>C3</td>
<td>SPARE CONNECTION</td>
<td>备用口</td>
<td>Y15</td>
<td>GAS VENT VALVE</td>
<td>气体排泄阀</td>
</tr>
<tr>
<td>C4</td>
<td>VENT CONNECTION</td>
<td>放空口</td>
<td>Y14</td>
<td>EQUALIZER VALVE</td>
<td>平衡阀</td>
</tr>
<tr>
<td>C5</td>
<td>SRV MANIFOLD CONNECTION</td>
<td>安全阀排放口</td>
<td>Y13</td>
<td>GAS PHASE VALVE</td>
<td>气相阀</td>
</tr>
<tr>
<td>C6</td>
<td>PBC BOOSTER CONNECTION</td>
<td>增压扩充口</td>
<td>Y12</td>
<td>LIQUID PHASE VALVE</td>
<td>液相阀</td>
</tr>
<tr>
<td>C7</td>
<td>VAPOR RECOVERY CONNECTION</td>
<td>气体回收口</td>
<td>Y11</td>
<td>3-WAY DIVERTER VALVE</td>
<td>三通切换阀</td>
</tr>
<tr>
<td>C8</td>
<td>SAMPLE CONNECTION</td>
<td>取样口</td>
<td>Y10</td>
<td>BLOW DOWN VALVE</td>
<td>排放阀</td>
</tr>
<tr>
<td>C10</td>
<td>FLANGE</td>
<td>备用口</td>
<td>Y9</td>
<td>REGULATION VALVE</td>
<td>循环控制阀</td>
</tr>
<tr>
<td>C11</td>
<td>FLANGE</td>
<td>备用口</td>
<td>Y8</td>
<td>LIQUID TO PBC VALVE</td>
<td>增压出液阀</td>
</tr>
<tr>
<td>C12</td>
<td>LP CONNECTION</td>
<td>气相口</td>
<td>Y7</td>
<td>82% TRYCOCK VALVE</td>
<td>82%试填阀</td>
</tr>
<tr>
<td>C13</td>
<td>HP CONNECTION</td>
<td>液相口</td>
<td>Y6</td>
<td>95% TRYCOCK VALVE</td>
<td>95%试填阀</td>
</tr>
<tr>
<td>C14</td>
<td>INSTRUMENT AIR CONNECTION</td>
<td>气源口</td>
<td>Y4</td>
<td>LIQUID SUPPLY/BOTTOM FILL VALVE</td>
<td>出液/底部充装阀</td>
</tr>
<tr>
<td>V29</td>
<td>LIQUID PHASE VALVE</td>
<td>液相阀</td>
<td>V3</td>
<td>LIQUID FILL ACTIVATED BALL VALVE</td>
<td>充装气动阀</td>
</tr>
<tr>
<td>V28</td>
<td>GAS TO PBC VALVE</td>
<td>增压自气阀</td>
<td>V2</td>
<td>TOP FILL VALVE</td>
<td>顶部充装阀</td>
</tr>
<tr>
<td>V27</td>
<td>VACUUM PROBE ISOLATION VALVE</td>
<td>抽真空截止阀</td>
<td>V1</td>
<td>LIQUID FILL ACTIVATED BALL VALVE</td>
<td>充装气动阀</td>
</tr>
<tr>
<td>V26</td>
<td>BOOSTER VALVE</td>
<td>底部备用阀</td>
<td>LL1</td>
<td>LIQUID LEVEL INDICATOR</td>
<td>液位计</td>
</tr>
<tr>
<td>V25</td>
<td>EMERGENCY VALVE</td>
<td>紧急切断阀</td>
<td>PG1</td>
<td>VESSEL PRESSURE GAUGE</td>
<td>容器压力表</td>
</tr>
<tr>
<td>V24</td>
<td>EMERGENCY VALVE</td>
<td>紧急切断阀</td>
<td>PG2</td>
<td>VESSEL PRESSURE GAUGE</td>
<td>容器压力表</td>
</tr>
</tbody>
</table>
2 DESCRIPTION

**TANK** general term for the general information.

**ISO container** the product for which this manual is intended.

**STORAGE TANK** term for filling tank to ISO container or term for discharging tank from ISO container.

**VESSEL** either inner vessel or/ad outer vessel of ISO container.

**Pressure Build Up Coil** PBUC, ambient evaporator for pressurizing of inner vessel. The ISO container consists of the super insulated tank, piping system in a cabinet and ISO container frame.

**Basic parameters**

See the nameplate on the rear of the frame.

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**Tank**

The tank is made from internal and external vessel of cylindrical shape closed from both sides by heads.

The multi-layer isolation from the aluminium foil and glass-paper is wound up on internal vessel and the vacuum less than 1 Pa is in the space between the two vessels.

Internal vessel, in which the liquefied gas is transported, is fixed to external vessel by strap and skirt.

The inner vessel is connected to the piping system in the cabinet via penetrations in rear head of the outer vessel.

Internal vessel and interconnecting piping are made from austenitic stainless steel for cryogenic temperatures. All parts are welded. All welded joints, which have the influence on the vacuum tightness of internal and outer vessel, are checked by helium sensor during manufacture.

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**Vacuum devices**

The outer jacket is protected from over pressurising by a pressure relief device. The vacuum pump down valve, located on the rear head of the tanker. These devices are installed by the manufacturer. No manipulation is allowed.

The vacuum probe with vacuum probe valve is fitted in the cabinet.

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**Cabinet**

Outer interconnecting piping with valves and measuring devices are located in the cabinet, which is on the long side of the frame.

The main safety valves SV1,SV2,SV3,SV4 located in the cabinet.
Pressure build up coil

The ISO container is equipped with pressure build up circuit with the ambient air vaporiser. It serves for pressurizing of internal vessel to the required operation pressure.

3 Definitions

Cavitation

Partial or complete pump filling loss caused by insufficient subcooling (less than 0.5 bar ~1 bar). The pressure of the liquid incoming into the pump decreased under saturated vapour pressure. Acoustic changes during pump operation are often indications of partial loss of filling. By complete loss of filling, the pump stops to pump out. Cavitation can cause even damage of the pump.

Condensing

Change of the vapour gases into liquid by cooling. The liquid can be changed to vapours by heating and the vapour can be changed into liquid by cooling.

The pressure in the ISO tank container will increase above the saturated vapour tension of the liquid during normal operation. The warmer gas shall condensate to the pressure of cooler liquid during the transport. During normal stay in the ISO tank container, the liquid will spray itself into the gas area. The spraying causes the gas condensation and decrease the pressure. Upper filling of the ISO tank container without venting is possible due to condensation of the warmer gas to lower pressure.

Cryogenic temperatures

Cryogenic ISO tank containers effectively store the gases in cryogenic liquid state.

CRYOGENIC (generally): Product preserving the temperature –100°C or lower.

The gases can be most effectively stored as liquids. E.g., the liquid methane increases the volume by 590 times during heating up into gas state. The gases can be liquidized by their pressurizing of by cooling into the liquid state. Each gas must be maintained on/under its respective boiling temperature to be stored into the gas state.

<table>
<thead>
<tr>
<th>Gas</th>
<th>Boiling temperature (at 0 bar)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquefied Natural Gas</td>
<td>-161°C</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>-196°C</td>
</tr>
<tr>
<td>Ethylene</td>
<td>-104°C</td>
</tr>
</tbody>
</table>
Losse caused by pressure decrease

Pressure decrease in the vapour area under the saturated vapour pressure of liquid will cause boiling of the liquid, which leads to considerable losses the medium. During venting of the tank below the saturated vapour pressure of liquid, the liquid temperature decreases, the density increases, the liquid weight decreases and saturated vapour pressure decreases.

Losses caused by carrying forward

Liquid carried forward by the gas during venting. This can occur during rapid tank depressurisation or during upper filling of the tank with open venting valve. Large losses of the medium occur during the above given situation.

Equilibrium

The temperatures of gas and liquid are the same in sealed vessel. If there is a temperature difference between gas and liquid (in sealed vessel), the gas and the liquid change their temperature, until they are the same.

Liquid volume increasing

As the liquid is warmed up to higher saturated pressure, the volume increases. The warmer liquid has lower density. The liquid of lower density occupies larger volume. The liquid volume increasing is linked with the safety, if the liquid can increase its volume up to the storage vessel filling. This state is called liquid filling or hydraulic filling. During these states, the pressure rapidly increases, the safety elements are activated and the liquid is released from the tank.

Pressure gradient

Decompression due to liquid flow. The more rapidly the liquid flows through the system, the higher is the pressure gradient.
Saturation

State in sealed ISO tank container, when there exist simultaneously the liquid and gas states at the same temperature (balanced). The density, temperature and liquid balance pressure are changed with the level of liquid saturation.

The saturation can be also described as an energy state. The liquid molecules at higher energy state (warmer) occupy more space.

Saturated vapour pressure

Pressure (usually in bars), that is used for description of the liquid and gas state inside sealed ISO tank container.

Substance state (phase)

The substance may exist as gas, liquid or as solid matter. Two-phase liquid is liquid with gas bubbles or with gas cores due to insufficient pressure for balance maintaining. The gas and the liquid can exist at various temperatures. The temperature is measure of energy amount inside the solid matter, liquid or gas.

Stratification

The warm liquid has lower density. In high vertical tank, the liquid of lower density can find its way up to the upper part of the tank. The cooler liquid remains at the bottom. The temperature change from upper to bottom is called the stratification.

Subcooling

Pressure increase in gas area above the saturated vapour tension. If the liquid is moved from the tank, the subcooling is important for maintaining of liquid in liquid state, while the liquid flows from the tank through the piping system.

In case of the ISO tank container, the required subcooling is 0.5 bar ~1 bar to prevent the occurrence of the two-phase liquid. The liquid leaving the pump must be replaced in the pump by the same quantity. The flowing liquid creates the pressure gradient, as it flows through filling line. If the pressure decreases below the saturated vapour tension of the liquid, it starts to boil, creating two-phase flow.
Double-phase liquid

By the decompression below vapour tension of liquid caused mixture of liquid/gas.

Liquid pressure

In the vapour area pressure. It is measured by pressure gauge value on the tank.

Evaporation

Change of the liquid into the gas by the liquid warming up due to sub cooling or usage of the gas

4 SAFETY

A. Ventilation

Adequate ventilation of the space, where ISO tank container is stored, manipulated, transported, used or maintained must be ensured. Some products stored in ISO tank containers are colorless and odorless inert gases, which can dilute air to unsafe oxygen levels. Respiratory and asphyxiation hazards can exist in confined, non-ventilated spaces.

B. Safety instructions for operation

The operation of the ISO tank container has to follow requirements given by following rules and codes: CSC, ISO1496, ADR or DOT, RID, IMDG, ISO 3874 (Handling and securing), local rules and operator rules

C. Manipulation (excerpt from ISO 3874)

The most used techniques for ISO tank container handling (without usage the special device): “6.3 Lifting by rope attachment – top lift” – for empty ISO tank container only (table 4 of ISO 3874)!
The ISO tank container has been lifted using all 4 top corner pieces, the forces are not vertical. The lifting device must be connected properly. The hooks must be always inserted in direction from inside to outwards.

“6.4 Lifting by rope attachment – bottom lift”.

The side holes of 4 bottom corner pieces are used for the lifting, the rope attachment is used. The rope attachment connection can take effect only into bottom corner pieces and the maximum distance between lifting force and the external surface of the corner piece can be 38 mm.

Minimum angle $\alpha=45^\circ$ for 20’ ISO tank container
Minimum angle $\alpha=30^\circ$ for 40’ ISO tank container

**D. Safety instructions for operation of the truck combination**

The vehicle must be marked in compliance with relevant regulations in force.
4.1 Foreword

The aim of these general safety rules is to attract attention to the various hazards that are involved in the use of liquefied natural gas (ethylene, ethane). Besides of this, management of each plant operating liquefied natural gas (ethylene, ethane) should work out local safety procedures with respect to specific local risks and regulations.

It is imperative that all persons operating the ISO container become familiar with all safety, operational and maintenance safety precautions and procedures contained in this manual and manuals for all installed equipment.

The training and testing of the personnel should take place regularly at least once a year for the equipment operation procedure and at least twice a year for the safety rules.

4.2 General Characteristics of LNG (ethylene, ethane)

Introduction

It is recommended that all personnel concerned with the handling of LNG (ethylene, ethane) should be familiar with both the characteristics of the liquid and the gas produced.

The potential hazard in handling LNG (ethylene, ethane) stems mainly from three important properties:

a) Extremely cold liquid
At atmospheric pressure, depending upon composition LNG boils at about -160°C (ethylene at -104°C, ethane at -89°C). Vapour is more dense than ambient air at this temperature.

b) Small quantity of liquid converts into large volume of gas
One volume of LNG, ethylene or ethane produces approximately 600 volumes of gas.

c) Flammability of Natural Gas, (ethylene, ethane)
Natural gas is flammable. At ambient conditions the flammable mixture range with air is from 5% to 15% gas by volume (ethylene from 2,7% to 36%, ethane from 3% to 12,4%).

Properties of LNG

a) Composition
LNG is a mixture of hydrocarbons composed predominantly of methane and which can contain minor quantities of ethane, propane, nitrogen or other components normally found in natural gas.

b) Density
The density of LNG depends on the composition and usually ranges from 430 kg/m$^3$ to 470 kg/m$^3$.

c) Temperature
LNG has a boiling temperature depending on composition and usually ranging from -166°C to
Properties of Ethylene

a) Composition
Ethylene is a member of the elemental alkenes (formula C2H4)

b) Density
The density of liquified Ethylene is 568 kg/ m³ at atmospheric pressure.

c) Temperature
The boiling temperature of Ethylene is -104°C at atmospheric pressure.

Properties of Ethane

a) Composition
Ethane is a member of the elemental alkanes (formula C2H6)

b) Density
The density of liquified Ethane is 546 kg/ m³ at atmospheric pressure.

c) Temperature
The boiling temperature of Ethane is -89°C at atmospheric pressure.

Evaporation of LNG (adequate properties and conditions are valid for liquified Ethylene and Ethane)

a) Physical properties of boil-off gas
LNG is stored in the storage tank as a boiling liquid. Any heat input into the storage tank will cause some of the liquid to evaporate as a gas. This gas is known as boil-off gas. The composition of boil-off gas will depend on composition of the liquid. As example, boil-off gas can contain 20% nitrogen, 80% methane and traces of ethane. The nitrogen content in the boil-off gas can be about 20 times higher than in the LNG. Boil-off gases below about -113°C for pure methane and -85°C for methane with 20% nitrogen are heavier than ambient air. At normal conditions the density of these boil-off gases will be approximately 0.6 of air.

b) Spillage of LNG
When LNG is poured on the ground (as an accidental spillage), there is an initial period of intense boiling, after which the rate of evaporation decays rapidly to a constant value that is
determined by the thermal characteristics of the ground and heat gained from surrounding air. This rate can be significantly reduced by the use of thermally insulated surfaces where spillages are likely to occur.

c) Expansion and Dispersion of gas clouds

The gas produced by evaporation is at nearly the same temperature as the LNG and is more dense than ambient air. Such gas will at first flow in a layer along the ground until it warms by absorbing heat from atmosphere. When the temperature has risen to about -113°C (pure methane) or -85°C for LNG (depending on composition), it is less dense than ambient air. However the gas air mixture will only rise when its temperature has increased so that the whole mixture is less dense than ambient air.

"Fog clouds" - are formed by condensation of water in the atmosphere. It is normal state during operation of the vaporisers. When the fog can be seen, the visible fog is a useful indicator of the travel of the vaporised gas and the cloud will give a conservative indication of the extent of flammability of the mixture of gas and air.

In the case of a leak in pressure vessel or in piping, LNG will spray as a jet stream into the atmosphere under expansion and vaporisation. This process coincides with intense mixing with air. A large part of the LNG will be contained in the gas cloud initially as an aerosol.

d) Ignition

A natural gas/air cloud can be ignited where the natural gas concentration is in the range from 5% to 15% volume.

Other physical phenomena

a) Rapid Phase Transition (RPT)

When two liquids at two different temperatures come into contact, explosive forces can occur, given certain circumstances. This can occur when LNG (ethylene, ethane) and water come into contact. Although no combustion occurs, this phenomenon has all the characteristics of an explosion.

b) Boiling Liquid Expanding Vapour Explosion (BLEVE)

Any liquid at or near its boiling point and above a certain pressure will extremely rapidly vaporise if suddenly released due to failure of the pressure system.

A BLEVE is highly unlikely to occur on a LNG (ethylene, ethane) installation because of design the storage tank and other cryogenic equipment - piping. Both, the tank and other equipment are inherently protected from fire damage.
4.3 Health and Safety

The following recommendations are given in order to provide guidance to persons involved in operating LNG (ethylene, ethane) equipment and are not intended to supersede national requirements.

Exposure to cold

The low temperatures associated with LNG (ethylene, ethane) can result in a variety of effects on exposed parts of the body. If a person is not suitably protected against low temperatures, the person’s reactions and capabilities can be adversely affected.

Cryogenic liquids are extremely cold with temperatures as low as –196 °C (nitrogen), -161,5 °C (LNG), -104°C (ethylene), -89°C (ethane). At this temperature, cryogenic liquid or cold boil-off gas may result in cryogenic burns similar to frostbite.

Avoid all direct contact with cryogenic liquids, cold gas or cold pipework by using adequate protection (safety goggles, face shield, long sleeved clothing, trousers and non-adsorbent gloves). Prolonged inhalation of cold vapour or gas can damage the lungs. Low viscosity of cryogenic liquids means that they penetrate porous clothing material faster than, for example water.

The extremely cold temperatures of cryogenic liquids may also make certain materials, such as carbon steel or rubber, fragile enough to provoke ruptures.

First Aid

If contact with cryogenic liquids or cold boil-off gas results in cryogenic burns, flood or soak affected tissue with cold or tepid water (40°C). Cryogenic burns that result in blistering or deeper tissue freezing should be promptly examined by a physician.

Exposure to gas

a) Toxicity and Odour

LNG and natural gas are non toxic. Human senses cannot detect natural gas, as it is odourless, colourless and tasteless. Ethylene is non toxic, colorless gas with a slightly sweet odour (valid as well for liquid). Ethane is non toxic, colorless and odourless gas.

b) Asphyxia

Natural gas, ethylene and ethane are a simple asphyxiant. Without adequate ventilation, these gases will displace the oxygen from the air creating an Oxygen Deficient Atmosphere incapable of supporting life.

The normal oxygen content of air is approximately 21%. Depletion of oxygen content in air, either by combustion or by displacement with inert gas, is a potential hazard and users should exercise suitable precautions. Oxygen is necessary to support life and care must be taken to ensure that there is adequate ventilation when atmospheric gases are used. Following is a description of the
effects on humans exposed to an oxygen deficient atmosphere.

*Atmosphere containing about 15% oxygen*
Flame of ordinary combustible materials, including those commonly used as fuel for heat and light, may be extinguished. Individuals in this atmosphere are mentally incapable of diagnosing the situation because the onset of symptoms such as sleepiness, fatigue, lassitude, loss of co-ordination, errors in judgement and confusion can be masked by state of “euphoria”.

*Atmosphere containing 8 to 12% oxygen*
Possible unconsciousness after a certain exposure period without warning and without the person realising.

*Atmosphere containing 6 to 8% oxygen*
a normal atmosphere.

*Atmosphere containing less than 6% oxygen*
Immediate unconsciousness, breathing stops but the heart may continue to beat for a few minutes.

Best protection of individuals working in oxygen deficient atmosphere is to equip them with portable supply of respirable air.

### 4.4 General Safety Rules – LNG (ethylene, ethane) equipment

These rules are not replacing specific user’s safety rules and should be treated as minimum safety requirements.

Pressure tanks can be operated only by authorised and trained personnel

Training programme shall at minimum include:
- normal operating procedures
- product and hazard identification
- safe operating limits
- emergency procedures
- physical and chemical properties of stored fluids and their effects on the human body
- personnel protective equipment

Each person operating the ISO tank container must have in mind, that careless and unprofessional handling with machine equipment and/or non-observing of safety, technological, and anti-fire regulations, can lead to equipment failures, to endangering of the health and lives of employees, to damaging of the production equipment etc.

Following records must be written with regard to operation of the ISO tank container:
- a) Daily records on the operation of the ISO tank container
b) Records on failures, their causes and method of their removal

c) Records and protocols on official revision tests and large repairs

For transferring processes between several installations or between static vessels and transport vessels, equalising of the electrical potentials is necessary.

Protective means prescribed by the operator must be used during the handling with liquefied gas.

Direct contact of skin both with the liquefied gas and with non-insulated parts of pipes and valves must be prevented.

Cabinet must be locked to protect the equipment against unwilling handling.

Filling and emptying of the ISO tank container must be realised only on places assigned to it.

During operation of the ISO tank container, the exceeding of highest working parameters and maximal filling of the ISO tank containers, is prohibited.

Be aware not to close the liquefied gas in the piping lines between the valves.

During manipulation with liquefied gas, it is necessary to use only the equipment, vessels, and other accessories intended only for particular gas.

The collection of water, including condensate, in the vent lines shall be prevented.

All parts of installation shall be bonded to ensure electrical continuity.

Workplace must be freely accessible and well lighted according to applicable norms.

When under pressure, leaking valves or connections shall only be tightened using suitable tools (e.g. non sparking tools) and procedures.

Avoid unauthorised manipulation with pump-out and outer vessel safety device and vacuum probe device. In case of observation of mechanical damage of pump-out and outer vessel safety device.

Prior to every filling operation make a visual inspection of the shell, fittings and pump-out/outer vessel safety device of ISO container.

Care should be taken in the choice of personnel clothing, to protect as much as possible against static charges and flames. Anti static footwear shall be worn.
Warning signs regarding product and operational hazards and personnel protective equipment requirements should be displayed.

Parts under pressure shall be disconnected only if they have been previously depressurized.

Valve outlets shall be kept clean, dry and free from contaminants.

Equipment shall not be modified without proper authorization.

Firefighting equipment must be accessible.

All equipments must be maintained entirely clean and in order. In case of any failure occurrence in the equipment operation, it is necessary to take appropriate measures to remove the failures, to notify the supervisor and to make the record into operation log.

Before operation launching and after repairs, the equipment must be tested in compliance with the regulations in force. It is necessary to make protocols and records into revision books with regarded to results of official revision tests. It is prohibited to operate the equipment, which is damaged, unprofessionally repaired, and which does not comply with official safety and anti-fire regulations. Only skilled employees with approval of relevant manager can perform the repairs.

The flow diagram of ISO container interconnecting piping must be located in control panel of the ISO container. On the sides of the ISO container, there must be located instructions for the eventual accident.

All control and measuring devices on the tank must be maintained in perfect order. The correctness of the measuring devices data must be validated and their maintenance performed in compliance with relevant regulations. Maximal allowed pressures must be marked by red on the pressure gauges. Faulty devices must be immediately repaired and adjusted, respectively replaced.

All repairs of the ISO container related to usage of flame (welding, soldering) can be realized only by professionally skilled and trained personnel. For such work, approval must be issued for each person by the responsible plant manager. During performing of the repairs, the ISO container must be emptied and properly purged by dry nitrogen to natural gas content lower than 1%.

Loosening of frozen valves is realised only after their warming up by the steam, hot water or hot air. It is prohibited to break away the ice from frozen parts of valves and piping with any subject. Usage of any levers is also prohibited.

Safety valves must be adjusted to relevant pressure. Inspection of their correct operation and adjustment must be realised in compliance with instructions of manufacturer and with relevant regulations for operation of pressure facilities. Record must be kept on the performed revision.
SMOKING, OPEN FLAME AND GENERAL-PURPOSE ELECTRICAL EQUIPMENT SHALL BE PROHIBITED WHERE LNG, ETHYLENE AND ETHANE ARE STORED AND HANDLED.

KEEP THE LNG EQUIPMENT AWAY FROM OPEN FLAMES AND ELECTRICAL SPARKS.

NEVER PERMIT SMOKING IN AN AREA WHERE THE REPAIR, USE OR STORAGE OF THESE GASES OCCURS.

WARNING SIGNS SHALL BE INSTALLED TO INFORM PEOPLE OF RISKS OR PROVIDE INSTRUCTIONS.

Caution!
The operator should include into the chapter of safety instructions of the operation procedure also the instructions regarding the vehicle operation on public roads.

5 OPERATION

This chapter contents the general rules for container operation. Any time it is necessary to take into account the rules for the connected device operation (filling station, plant, storage tank, gas take-off device, etc.) and to comply with relevant manuals.

Caution!
The operating pressure must not exceed the MAWP.

Caution!
In case of container operation in the environment with higher corrosion risk, it is by manufacturer recommended the higher check frequency then within the regulations and norms. Namely the thorough check of the safety devices and pressure gauges is necessary. Only use PH neutral cleaning product to wash tank.
5.1 Description of function and control of fire block ball valves

Choose pneumatic or manual operation according to site working condition. Operation mode as follows:

1. Pneumatic operation
   a. Connect air source, valve opening. Start filling or off-load operation.
   b. Disconnect air source, valve closing. End filling or off-load operation.

2. Manual operation
   a. Push the valve handle to full open position, put fuse link into spring pin at the right hand, valve opening. Start filling or off-load operation.
   b. Pull up the valve handle to initial position, valve closing. End filling or off-load operation.

CAUTION: During manual operation, there should be no barrier within the valve handle moving range. Non-operator No approach!

5.2 Purging

Prior to filling, composition of tank and piping content should be known, and must be INERT nitrogen or its mixture with natural gas – NO OXYGEN.

The container can be shipped with a slight positive pressure of nitrogen gas. However some air can get into the tank. Hence, the system must be purged of air before filling with LNG, Ethylene or Ethane.

The recommended purging medium is nitrogen and either liquid or gaseous nitrogen can be used.

The basic purge method recommended is simply adding pressurized nitrogen to dilute any oxygen in the tank; allowing time for mixing; then blowing the nitrogen out through the all piping to displace air in all parts. Nitrogen should be admitted through the tank top fill line because that line is extended inside the inner vessel to near the far end.

Maximum acceptable final oxygen concentration is 2% in all inner parts of inner vessel and piping

The second purpose of purging is to dry the internal vessel and interconnecting piping to the dew point -40°C.
The dry nitrogen at the pressure below 1 bar is forced through the C2 terminal connection by opening of valve V2, V1 into the internal vessel. Gas is vented through the valve V28, V17. The other valves are closed. The humidity-meter is connected to the outlet (valve V19) and after the required dew point of -40°C is achieved, the inlet of the dry nitrogen is closed, valves will be closed and the drying is terminated.

5.3 Filling of ISO container

Caution!

Do not forget to ground the container to equalize the electric potentials before connection of filling hose to the tank.

There must be only natural gas, Ethylene, Ethane or Nitrogen in all inner parts of inner vessel, piping, valves, instruments, and vaporisers – NO OXYGEN. Blow through the gas through filling line to the venting system several times to remove the rest of air and moisture.

Do not leave the tank and container during the filling.

Note: Do not fill container up to the 95% trycock if a longer time period without the liquid offtake is expected. The liquid expands at rising temperature and it could overfill the container which would result in spraying liquid through relief valve.

5.3.1 First filling of warm ISO container

During first filling it may become apparent that the tank and/or tank’s plumbing shows leaks at low temperatures (which could not be recognised at normal temperatures).

During first filling and functional tests make sure, that:

- A qualified plumber is always present
- The tank is constantly observed for leaks
- The filling is stopped immediately when a leak is found
- Leaks are sealed immediately but only after depressurization

Possibility of leaks

Liquid storage tanks plumbing undergoes leak tests at room temperature but not at operating temperature (“cold tests”) before shipping from the factory. Due to vibrations during transport or thermal contraction of parts, threads or flange connections may leak during or after first filling and during functional tests of the downstream equipment.

Any leak found shall be sealed by a qualified plumber. Any work on the tank and/or plumbing may only be carried out at a depressurised system. When the respective part cannot be isolated from the inner vessel by a secondary valve, it may be necessary to remove any liquid in the tank already, before plumbing work can take place.
Initial filling procedure:

Basic procedure of first filling of warm ISO tank container is the same as at normal filling. The main difference is on the duration of inner vessel cooling down. The evaporation rate will be high because the equipment has not reached the operating temperature. ISO tank container can be also cooled down with gaseous nitrogen. The cooling down of the warm ISO tank container shall continue about one hour.

The first filling of liquid into per gas cooled ISO tank container should be delivered slowly into the top of the inner vessel.

Make sure that a qualified plumber is present.
Make sure that all valves are closed, except gas valves V21,V13 and liquid valve of the liquid V20,V12 at pressure indicator P1 and level indicator LL1.

First filling by nitrogen for cooling purposes is processed the same way as described below for normal fluid (LNG), but it is stopped when the quantity specified above was filled (which may not be visible on the differential pressure gauge because it can be vaporized simultaneously). The tank has to be vented to the atmosphere, then, and all the remaining liquid, if any, has to be drained or it has to be vaporized.

Check the tank and plumbing for any leaks.

5.3.2 Normal two hose filling of ISO container

The empty internal vessel contains residual liquefied gas and is cold during a normal operation before a new filling.

During filling and pipe inertisation proceed according to valid rules for actual filling station

1) Switch off the truck engine and all electric equipment according to local safety rules of filling place.

2) The equalising of the electrical potential is necessary. Connect the earth cable between ISO container and grounding point of filling equipment.

3) Connect the pressure air supply.

4) Check that filling nozzles and loading arms of storage tank are clean. Clean them if needed.

5) Connect the vapour return loading arm to the nozzle C2. (sealing of the hose must not be damaged).

6) Connect the filling loading arm to the nozzle C1. (sealing of the hose must not be damaged).

7) Leak detection/pressure tests to check for leakages in C1 and C2 terminals.
8) Open the valve V1,V2 for vapour return.

9) Open the valve V4 for liquid.

10) Executes the filling procedure according to local operating manual.

11) Open fire block ball valves V3

12) Control the liquid level in the inner vessel by weight during filling on the weight scale.

13) When it reaches maximum weight starts, stop immediately the filling.

14) Close air operated valves V1. Open the valve V3 for return of evaporated liquid from bottom filling line. Valve V2 should be closed after a certain time when the residual volume of liquid in the hose has evaporated. Le the hose be warmed and then close the V2, V3 and V9 valves. If the valvesV12, V13 ,V14 are used on the container, use them for depressurization of adjacent part of the piping.

15) Purging liquid and gas line with nitrogen.

16) Disconnect nozzles C1 and C3 from loading arms of storage tank. (IMPORTANT: Do not forget to check the sealing in C1 and C3 nozzles.)

17) Disconnect the pressure gas supply.

18) Disconnect the earthing of the ISO container and stow the earth cable.

19) Check, whether the P1 shows the pressure in the vessel.

20) Check, whether all valves are closed (except gas valves V21, V13 and liquid valves V20, V12).

21) Shut the door of the control panel. Seal the door of the cabinet (register the serial number).

5.4 Liquid discharge

The ISO container does not have a pump. There are two possible discharging procedures:

- Pressure transfer with the pressurisation of ISO container to a higher operation pressure by Pressure Built Up Coil (PBUC).
- Liquid transfer with offload ground pump.
5.4.1 Pressure transfer

1) Switch off the truck engine and all electric equipment according to local safety rules of filling place.

2) The equalising of the electrical potential is necessary. Connect the earth cable between ISO container and grounding point of filling equipment.

3) Connect the pressure air supply

4) Check that filling nozzles and hoses are clean. Clean them if needed.

5) Connect the discharge hose to the discharge nozzle C1 and to the LNG satellite plant nozzle GNL (sealing of the hose must not be damaged).

6) Connect the vapour return hose to the gas return nozzle C2 and to the LNG satellite plant nozzle GN.

7) Purge shortly the ISO container discharge lines and hoses through a vent valve at LNG satellite plant.


9) Compare the pressures in LNG satellite plant to be filled and in the ISO container. The pressure in ISO container should be for about 1-3 bar higher than in the tank.

10) Pressurise the ISO container if necessary. Use pressure build up vaporizer and watch the pressure gauge PG1.

**Warning!**
Never leave the ISO container unattended during the pressurisation. Do not allow the pressure in tank higher than (MAWP minus 1 bar).

11) Open the filling valves on the LNG satellite plant and fill it according to LNG satellite plant operating manual.

12) Close the valves V3 and V2 after the filling of LNG satellite plant.

13) Let the hoses be warmed.

14) Close filling valves on LNG satellite plant according to LNG satellite plant operating manual.
15) Vent the ISO container discharge lines and hoses through a vent valve at LNG satellite plant.

16) Close valves V4. If the valves V10, V18 are used on the container, use them for depressurization of adjacent part of the piping.

17) Remove the hoses and cover nozzles C1, C2 and nozzles GNL, GN of LNG satellite plant by caps.

18) Disconnect the pressure gas supply.

19) Disconnect the earthing of the ISO container and stow the earth cable.

20) Check, whether the P1 shows the pressure in the vessel.

21) Check, whether all valves are closed (except gas valves V21, V13 and liquid valves V20, V12).

22) Shut the door of the control panel. Seal the door of the cabinet (register the serial number).

5.4.2 Liquid transfer with an external pump to a terminal tank

Caution!
For using and operation of the ground pump to comply with the pump operating manual

1) Switch off the truck engine and all electric equipment according to local safety rules of filling place.

2) The equalising of the electrical potential is necessary. Connect the earth cable between ISO container and grounding point of filling equipment.

3) Connect the pressure air supply

4) Check that filling nozzles and hoses are clean. Clean them if needed.

5) Connect the discharge hose to the discharge nozzle C1 and to the LNG satellite plant nozzle GNL (sealing of the hose must not be damaged).

6) Connect the vapour return hose to the gas return nozzle C2 and to the LNG satellite plant nozzle GN.
7) Purge shortly the ISO container discharge lines and hoses through a vent valve at LNG satellite plant.


9) Pressurise the ISO container for about the 0,5-1 bar above the pressure at arrival. This pressure has to be adjusted according to pump operating manual. Use PBU vaporizer and watch the pressure gauge PG1

**Warning!**

Never leave the ISO container unattended during the pressurisation. Do not allow the pressure in tank higher than (MAWP minus 1 bar).

10) Cool down pump according to LNG satellite plant manual.

11) Start the pump and fill the LNG satellite plant according to LNG satellite plant manual.

12) Stop the pump and finish the filling of LNG satellite plant according to LNG satellite plant manual.

13) Close the valves V3 and V2 after the filling of LNG satellite plant.

14) Let the hoses be warmed.

15) Vent the ISO container discharge lines and hoses through a vent valve at LNG satellite plant


17) Remove the hoses and cover nozzles C1, C2 and nozzles GNL, GN of LNG satellite plant by caps.

19) Disconnect the earthing of the ISO container and stow the earth cable.

20) Check, whether the PG1 shows the pressure in the vessel.

21) Check, whether all valves are closed (except gas valves V21, V13 and liquid valves V20, V12).

22) Shut the door of the control panel. Seal the door of the cabinet (register the serial number).

**6 TRANSPORT**
The ISO container internal vessel is protected against the pressure increase above MAWP by permanently connected safety valves. All valves must be closed during the transport. Except the valves for level measurement V21, V13 and V20, V12. These valves are permanently open and they are not manipulated with during the operation.

7 POTENTIAL FAULTS AND METHOD OF THEIR REMOVAL

All main failures, which may occur during the ISO container operation, are described in the chapter.

7.1 Valve faults

<table>
<thead>
<tr>
<th>Fault</th>
<th>Cause</th>
<th>Method of removing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing of seal .</td>
<td>Leaking seal.</td>
<td>Warm up the seal closure from outside by the hot air or steam, eventually add and tighten the seal. If the leakage is not removed, disassemble the valve and repair it by observing the rules according to table 3.</td>
</tr>
<tr>
<td>Freezing of piping, where nor liquid nor cold gas is flowing</td>
<td>Leaky valve.</td>
<td>Warm up the valve body by hot air or steam and retighten after blowing off. If there is still leakage, replace the sealing under the valve plug respective replace all upper part of the valve by adhering to the rules according to table 3.</td>
</tr>
<tr>
<td>Releasing of the safety valve at the pressure lower than the opening pressure.</td>
<td>Contamination in the valve seat, resp. damage of the valve seat.</td>
<td>Warm up the valve body from outside by hot air or steam and blow off the valve. If the leakage is not removed, disassemble the valve by observing the rules according to table 3.</td>
</tr>
<tr>
<td>Loss of insulation properties.</td>
<td>Pressurizing of the insulation space due to following causes: a) Mechanical damage of safety vacuum valve b) Internal leakage c) Outer leakage.</td>
<td>Perform the repair in co-operation with the production plant.</td>
</tr>
<tr>
<td>The pressure gauge shows lower value</td>
<td>a) Loosen connection of pressure gauge.</td>
<td>a) Re-tighten the connection. b) Replace the sealing.</td>
</tr>
</tbody>
</table>

Table 2
than the actual value. The piping is frosty.

b) Damaged sealing.

The LL1 differential pressure gauge shows value different than the actual one. The intake piping is frosty.
a) Leakage of the V14 valve
b) Outer leakage on connections of the V12, V13, V14 valves or of the differential pressure gauge.
a) Check closing of the V14 valve, repair the leakage.
b) Re/tighten the connections.

<table>
<thead>
<tr>
<th>Table 3</th>
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<tbody>
<tr>
<td>Marking of the valve or measuring Device</td>
</tr>
<tr>
<td>Disassembly conditions</td>
</tr>
</tbody>
</table>

SV1~SV4,TRV1~4, V2,V4,V9, V10,V12,V13,V14,V15,V16,V17, V18,V19, V23,V26, V29, PG1,PG2,LL1
The disassembly can be performed at pressurized inner vessel of the ISO tank container provided other valves on the same line and connected with the line and located on the vessel direction are closed.

V1, V11, V21,V28
Disassembly only after depressurising and closing of eventual liquid lines in the direction of the vessel of the ISO tank container.

V5,V7
Disassembly only after depressurising and lowering the level below the overflow level.

V3,V8,V20,V22
Disassembly after release of the liquid from the inner vessel and depressurising.

V27,EP,R-2,TC1
Disassembly and any manipulations are prohibited

8 Regular maintenance and revision inspection of ISO tank container

8.1 Visual check
Check the outer vessel of the ISO tank container, valves, and evaporator regularly each 10 days during the operation of the ISO tank container.

8.2 Check of safety valves

Check the safety valves in compliance with the regulations in force in the country of operator.

8.3 Check of pressure gauges and differential pressure gauge

Check the pressure gauges and the differential pressure gauge at least once a year.

8.3.1 Adjustment of the differential pressure gauge LL1

The liquid level gauge indicates the differential pressure due to the depth of liquid and provides an approximation of the amount of liquid in the tank. It assumes a certain density of liquid and vapour. There is some uncertainty, due to unknown actual temperature gradients in the liquid and densities. This system should not be considered accurate enough for precise measurement of liquid in the tank.

IMPORTANT NOTICE – The gauge equalizer valve V14 in the measuring circuit has to be closed during the filling and service.

To adjust level indicator LLI:
   a) First open by-pass valve V14
   b) Close liquid (V20, V12) and gas (V21, V13) valves, level - indicator must give zero reading
   c) If necessary reset by means of correcting reset screw according to instrument operation manual
   e) Open liquid (V20, V12) and gas (V21, V13) valves.
   d) Close by-pass valve V14

8.4 Vacuum level check measurement

It is possible to measure the vacuum level (absolute pressure) in the interspace between inner vessel and outer shell. The installed thermocouple / vacuum probe TC1 and the isolation valve V18 are intended for this purpose. For the pressure measurement itself is recommended to use some of the Vacuum Meters from the Teledyne Hastings Instruments (producer of used Thermocouple) for suitable range. It is necessary to follow the producer rules for Gauge / Meter use. If the pressure in the vacuum space is above 10 Pa (warm), the ISO tank container would be evacuated. It is
recomended to consult the results of the measurement with ISO tank container producer (Chart China customer service), if any doubts about measurement results.

8.5 Revision inspections and leakage test

Perform revision inspections and leakage tests in compliance with relevant regulations and with regulations in force in the country of operator.

8.6 Revision inspections of electric devices

Perform the revision inspections of electric device in compliance with the regulations in force in the country of operator.

8.7 Taking the ISO tank container out of service

The taking of the ISO tank container out of service should be in compliance with the described procedure and results of individual steps should be recorded and archived at the operator.
Note: during emptying and depressurising of the inner vessels adhere to the safety measures related to the particular medium.

8.7.1 Working steps for temporary taking out of service (and further re-usage).

1) Empty and depressurise the inner vessel, take care on potential risk caused by evaporated liquid and extreme low temperature of the liquefied medium and risk related to the type of stored medium.
2) Purge the tank and accessories (all the pipe lines including fittings) with inert gas (nitrogen).
3) Leave small pressure of inert gas (from 0.2 to 0.3 barg) in the inner vessel and mark the ISO container by relevant manner.
4) Insert seal protecting plugs on all ends of the tubes up to pressure 0.7 barg. The plugs must resist to potential pressure drop due to ambient temperature and thus the pressure changes in the inner vessel.
5) Keep the vacuum in the ISO tank container inter-space during whole period.

8.7.2 Working steps for scrapping of ISO tank container

1) When the ISO tank container is put out of service and scrapped, proceed as follows.
2) Empty and depressurise the inner vessel, take care on potential risk caused by evaporated liquid
3) Purge the inner vessel and all piping and fittings with nitrogen. Vent outlet must be oriented to a safe area. There can be dangerous of asphyxiation or explosion.
4) Vent the vacuum inter-space. Either via the suction neck, or drill the hole into the outer jacket of the ISO tank container (thus the air fill the vacuum inter-space).
5) Recycling is to be carried out acc. to the chapter 8.7.3 Disposal of ISO tank container.

8.7.3 Disposal of ISO tank container

1) If the ISO tank container is to be finally taken out of service, the ISO tank container may be disassembled to individual components in compliance with the local regulations.
2) Generally the ISO tank container consists from the following materials:
   - Stainless steel: inner and (optionally) outer vessel or some parts of the frame
   - Carbon steel: outer vessel and the frame
   - Non-ferrous metals (such as copper, aluminium, ...).
   - Synthetic material (in devices, valves etc.)
   - Glass (in devices).
3) The materials may be recycled or disposed by usual manner. The competent staff of the service provider should sort and correctly process the used materials acc. to their nature
4) Local procedures and regulations must be adhered.

8.8 maintenance of fire block ball valves

1. Tools for maintenance

![Wrench set](image)

2. For V1 valve maintenance
   a) Field- strip hole
b) Fasten bolts (different location)

3. For V3 valve maintenance
   a) Disassemble back plate

b) Fasten bolts (different location)