A REFERENCE GUIDE ON CRYOGENIC TANKER PRODUCT CONVERSION

AIGA 101/19

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Acknowledgement

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Table of Contents

1 Introduction

It is sometimes necessary to convert the product transported in a cryogenic transport tanker from one to another.

When a cryogenic transport tanker which has previously been used for liquid nitrogen (LIN) or liquid argon (LAR), is then converted to transport liquid oxygen (LOX), the contaminants which are harmless in the inert gases may constitute an explosion risk in oxygen. Liquid oxygen can form easily ignitable mixtures with flammable materials. A spark or the energy from friction or an impact can initiate the ignition of a mixture of liquid oxygen and finely divided fuel, and cause it to detonate, even at cryogenic temperatures.

Likewise, when improperly converting from LOX to inert gases (LIN or LAR) there could be safety concerns and/or effects on the end user production process.

Conversion between inert gases (LIN, LAR) are considered to have no oxidising related safety risk, thus will not be discussed in this document.

This document is intended for guidance to companies when preparing new procedures or reviewing existing practices for the conversion of a cryogenic transport tanker and the usage of adapters. The typical procedures given here are not intended to be taken as work instructions and given directly to operators. Instead, individual companies should review and implement the principles for conversion in conjunction with their specific equipment and work practices.

2 Scope

This document applies to road tankers and ISO tanks only. It only covers liquefied air gas products (LOX, LIN, LAR).

It is recommended that cryogenic transport tankers in any other product service are not converted into oxygen service.

This document does not cover pre-fill purity analysis and tanker cool down requirements.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

Is used only to indicate the future, not a degree of requirement.

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Cryogenic transport tanker

A cryogenic transport tanker means:

- a road tanker, i.e. a tank vehicle
- an ISO tank container

The term "tanker" indicates liquid semi-trailers, rigids, and tank containers.

3.2.2 Oxygen service

Oxygen service includes any refrigerated liquefied gas that is classified as oxidizing, such as oxygen, nitrous oxide, liquid air and their mixtures.

3.2.3 Storage tank

Storage tank means a tank for storage of refrigerated liquid gases and liquefied gases.

3.2.4 Contamination

When converting from inert gases to oxygen, any combustible contaminant may react violently in oxygen service and must be avoided.

The contaminant guidelines in this document, however, only deal with hydrocarbon compounds.

3.5 Sources of contamination

- Back flow contamination from a process. This is a relatively high volatile component.
- Contamination from liquid taken from the customer tank. Could be either a high or low volatile component.
- Any activity that is not considered as normal service for tanker.

3.6 Conversion to oxygen service

The procedure by which a tank is prepared to be used in oxygen service after it has been in service with another gas.

3.7 Service conditions before conversion to oxygen service

3.7.1 Normal Service

- Direct delivery to a cryogenic storage tank where there is a non-return valve between the cryogenic transport tank and the storage tank.
- Direct delivery to a customer process where there is a non-return valve between the cryogenic transport tank and the process.
- Liquid taken from a cryogenic storage tank where there is a non-return valve between the tank and the process. The liquid must be analysed for hydrocarbons before transfer, and certified to be acceptable.

3.7.2 Other Service

- Any other service. Typically this would be direct delivery to a cryogenic storage tank or process without the use of non-return valves, or
- Collection of liquid from a cryogenic storage tank without hydrocarbon analysis (or when liquid is certified as unacceptable).

3.7.3 Adaptor

Any mechanical link including reducers that are used to connect a transfer hose to a tank / tanker / tank container to facilitate the transfer of any product in either direction.

4 Procedure for safe conversion of a cryogenic transport tanker

This section outlines the principles for safely converting a cryogenic transport tanker. The main safety features are the use of non-return valves to prevent back flow contamination, and the warm-up procedures for hydrocarbon removal.

There are two types of conversion, inert gases to oxygen and vice versa.

4.1 Safety precautions

The activities described below could cause one or more of the following hazards:

- Oxygen deficiencies
- Oxygen enrichment
- Cryogenic hazards
- Pressure hazards

At a minimum, the following PPE are required:

- Portable oxygen detector
- Cryogenic gloves
- Face shield and/or eye protection
- Long sleeve uniform and safety shoes

The following activities should preferably be carried out outdoors, in an open and well-ventilated area.

4.2 Conversion from inert gases to oxygen

The basic principle is that a cryogenic transport tank should always be warmed up and purged with hydrocarbon-free nitrogen before being filled with oxygen.

Any conversion shall be covered either by a Work Permit or a Management of Change (MOC) order. The conversion shall follow a written procedure approved by an appropriate authority in each company. In some countries in Asia, product conversions are governed by local government regulations, which shall always be adhered to.

Operators shall ensure that the following are checked and documented:

- Check the history of the equipment to confirm that there has not been any contamination of the tanker/tank container.
- The inner vessel shall be designed and constructed for oxygen service, e.g. stainless steel or 9% nickel alloy.
- All valves, pipework, filling and sampling hoses, and pump assembly are of oxygen compatible materials.
- The pump and its accessories are suitable for the required application after conversion, e.g. oxygen compatible gearbox oil.
- Maximum design payload of the cryogenic vessel and tractor trailer. Generally, larger capacity trailer will have two or three sets of trycock for different products (LIN/LOX/LAR).
- Ensure that the appropriate medium density is selected in the flow meter computer.
- The addition of an emergency shut off valve is considered a best practice for LOX service.

Note: In case of doubt, refer to the manufacturer's design specifications.

4.2.1 Initial examination

- Check for non-volatile hydrocarbons at the low points of the system, for example, the inlet of the evaporator coil or pump suction filter where hydrocarbons normally accumulate.

- If the results are satisfactory, the cryogenic transport tanker may proceed to the next step, warming and purging, as outlined in 4.2.2.

- If the results are unsatisfactory, please refer to the authorized person.

- Check for gaseous or volatile liquid hydrocarbons where required. Analysis methods are outlined in 4.2.3.

Appendix A shows an example of a record sheet that should be filled in as the examination and analysis are carried out. A copy of this form should be kept for reference.

4.2.2 Warming and purging

The objective is to ensure no hydrocarbons remain in the inner vessel before the change of service to oxygen. Containers and tankers have variations in piping but generally include the following circuits:

- top and bottom filling connections,
- pump suction, delivery and recycle lines,
- pressure build up circuit,
- relief and vent system, and
- full trycock and gauge connections.

Document the procedure covering these main circuits so that it can be applied in principle to all tankers. Draw up detailed work practices for each individual type of tanker.

Warm up the tanker and all piping to a temperature of 15 °C using cold N2 gas initially, then with warmed up N2 gas to a maximum of 50 °C. During this process, ensure that the cryogenic transport tanker and associated parts shall not exceed the maximum design temperature and the allowable rate of temperature increase.

The warming process can be expected to take 24 to 48 hours depending on the design and initial temperature of the individual cryogenic transport tanker. At the end of the warming process the tanker shall be left for a period to ensure that it has warmed up and then tested for hydrocarbons, where required.

4.2.3 Hydrocarbon analysis

If the tanker was in normal service (as defined in section 3.7.1), hydrocarbon analysis may not be required. The following analysis applies only to tankers used for other services, as defined in section 3.7.2. The objective is to ensure that the cryogenic transport tanker is free from volatile hydrocarbons by analysing the warm purge gas.

Analysis of the purge gas inlet and outlet

- Analysis of the incoming purge gas
  The analysis point for the incoming purge gas should be located near to the purging hose. If the purging gas is taken from a liquid source, it is not permitted to have the sampling point from the liquid phase or before the vaporiser.

- Analysis at the outlet from the tanker
  The analysis at the outlet from the tanker should be located near or directly connected to the purging outlet. In order to obtain reliable results, the purging outlet should be located at the opposite end of the tanker from the purging inlet and at the lowest point of the tank.

Analysis Procedure

- Measure the quantity of total hydrocarbons (THC) in the purge gas leaving the cryogenic transport tanker, and read off the quantity of total hydrocarbons expressed as methane.

- Calculate the hydrocarbon content in the tanker, i.e. the difference between measured THC in the outgoing purge gas and incoming purge gas.

Hydrocarbon levels

The highest concentration of hydrocarbon contaminant will be found in the liquid phase of the tanker
.
The nitrogen purge gas inlet should be in the 0.1 ppm range and any significant variation from this typical level should be investigated prior to the purge gas being used.

At the end of the purge there will be steady state levels for the inlet and outlet. These should effectively be the same reading, for the tanker to be considered as purged. Any significant difference (for example, 1 ppm) should be carefully investigated and the analysis continued to detect any upward or downward trend. A continuous upward trend would indicate that the tanker has residual hydrocarbons which will require further consideration.

If the nitrogen purge gas does not significantly change from inlet to outlet (for example, < 1ppm) hydrocarbon contamination is of an acceptable level, and the vessel is ready for conversion to LOX.

4.3 Conversion from oxygen to inert gases

Conversion from LOX to LIN or LAR involves different set of risks (refer to Sec 1)and ensure the following safe conversion guidelines. The conversion should be documented and records are kept.

4.3.1 Warming and purging

The objective is to make sure there is no liquid oxygen trapped in the tanker, which will contaminate the inert gas after conversion. The circuits which may trap liquid oxygen, and the warming and purging procedure are as described in section 4.2.2.

As much as possible, drain out all liquid oxygen from the tanker and by warming with N2 gas. When the vent gas temperature reaches more than 50° C, it can be assumed that there is no residual liquid oxygen left in the tanker and associated parts.

4.3.2 Hydrocarbon analysis

Hydrocarbon analysis is not required for inert gas application.

5 Control of the use of adaptors

After the purging of the cryogenic transport tanker, the loading and off-loading connector shall be replaced according to the desired product. The use of adaptors should be limited and if possible, eliminated.

If adaptors are needed:

- All adaptors shall have IDs legibly marked on a visible surface.
- Adapters should be permanently constructed by means such as welding, silver soldering or brazing so that parts cannot inadvertently become detached while being used.
- Worn out or damaged adapters shall be withdrawn from service, then either repaired or scrapped and deleted from the records by the authorized person controlling the adapter.
- As a minimum, adaptors should be of compatible material, cleaned for Oxygen service and having a valid pressure test certificate.

The control of adapters must be formalized. Detailed records of issue date, return date and to whom issued shall be maintained.

6 References

[1] EIGA Doc 87, Conversion of Cryogenic transport tankers to Oxygen service, www.eiga.eu

[2] AIGA 012, Cleaning of equipment for Oxygen service, www.asiaiga.org

[3] AIGA 066, Personnel Protective Equipment, www.asiaiga.org

Appendix A: Cryogenic Transport Tank Record: Conversion to Oxygen Service

1. Conversion requested by:
   Name : ____________________________
   Signature : _________________________
   Date requested : _____________________
   Tank serial no. : _____________________
   Tank designed for O_2 service: No ☐ Yes ☐

2. Conversion start authorized by:
   Name : ____________________________
   Signature : _________________________

   Present gas : Nitrogen ☐
   Argon ☐

   Required gas : Oxygen ☐
   Signature : _________________________

3. Product emptied by:
   Name : ____________________________
   Signature : _________________________

4. Hydrocarbon contamination test required?
   No ☐ Yes ☐

   If Yes, state type of purge gas :
   ______________Temp____°C
   a) THC in purge gas, before tank: ___ppm
   b) THC in purge gas, after tank : ______ppm
   c) △ THC : _______ppm [b- a < 1ppm]
   d) Gas analysis THC OK :
   No ☐ Yes ☐

   If No, stop conversion, refer to the authorized person.

5. Conversion authorized by:
   Name : ____________________________
   Signature : _________________________

6. Check vehicle ready for filling with product:
   Name : ____________________________
   Signature : _________________________
   (Product labelling, hazard & warning signs, hoses & connectors, metering configuration, etc.)

7. Tank authorized for operational service:
   Name : ____________________________
   Signature : _________________________
   Date authorized : _____________________

Remarks / Comments:

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Appendix B: Safe Conversion Procedure (Source: EIGA Doc 87/07/E)