Standardization of swappable H2 containers for inland shipping

Content

1. Motivation

In order to facilitate the use of H2 for inland barging, swappable compressed H2 containers can be used as a means of H2 supply for these ships. These H2 containers will be named ‘tanktainers’ in the rest of this document.

A standardized tanktainer has quite some advantages :
1. Can be used by all shipowners and refilled by all H2 suppliers
2. Reduced CAPEX for shipowners
3. Reduced investment cost for tanktainer due to economies of scale.
4. Reduced investment cost for ship connections due to economies of scale
5. Lower operational cost (due to higher utilization rate of tanktainer)
6. Will speed up decarbonization as it allows for scaling (faster market development)

In the Condor H2 consortium a smaller workgroup has been formed with the scope to develop a standard for the swappable tanktainers. The results of this workgroup have been frequently presented to the full consortium in order to include the comments of all consortium members.

The workgroup consisted of these organisations :
Argo Anleg
Air Liquide
Vitrite
H2storage
Shell
Linde
Lloyd’s register
BP
Port of Rotterdam
WaterstofNet
ZBT

The aim of this document is to describe the outcome and its argumentations of the different workshops.

2. Outcome of WP4 workgroups Condor H2

Different workshops have been organised around following topics :

A. Pressure levels
B. Container sizes
C. Transport modes
D. Location of pressure regulation
E. Design guidelines
F. Physical interface
G. Data communication
H. Communication protocol

The outcome and motivation of these workshops is summarised in next paragraphs.

A. Pressure levels

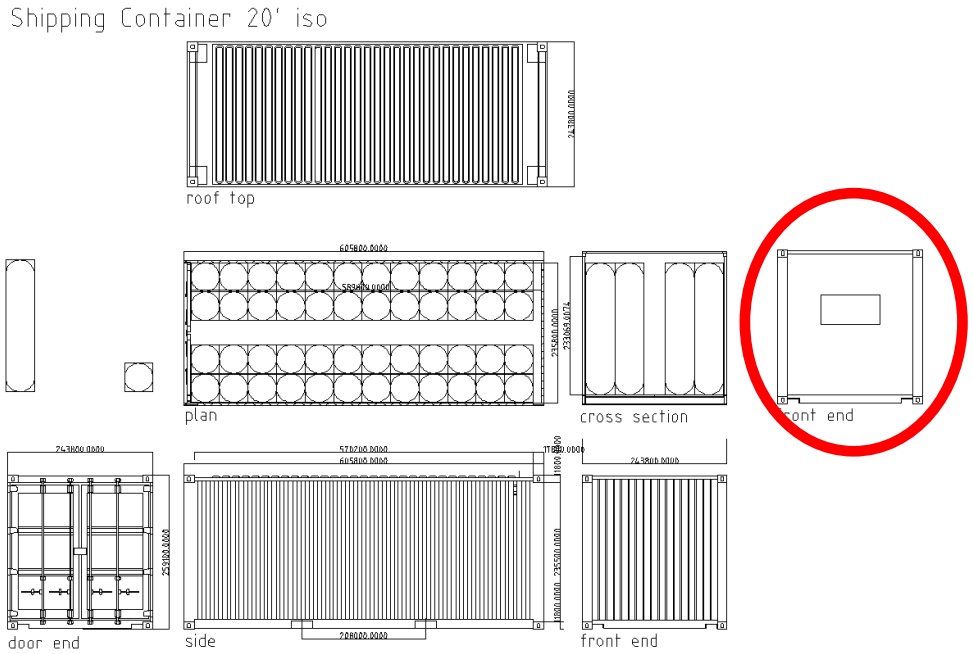
The pressure level is the maximum pressure for which the tanktainer can be used.
At this stage, only 3 maximum pressure levels are taken into account:

i. 300 bar
ii. 500 bar
iii. 700 bar

Lower pressure levels are economically not interesting. The volume of H2 that those tanktainers can carry will be too low for inland barging. Higher pressure levels are technically not feasible at this moment in time. However these can be developed in future.

B. Container sizes

All standard existing container sizes can be used :10”, 20”, 30” and 40” (+high cube).
The current standard container fixing system with ISO blocks (twist locks on board) will be used.
The area for connections will be located on the front side.



C. Transport modes

The tanktainer needs to be suited for all transport modes : truck, barge and train. As a result it has to comply to with the existing transport mode rules : ADN, ADR, RID, ES-TRIN, IMO.

D. Location of pressure regulation

The pressure regulator can be put inside the tanktainer, or outside (on the shipl). It has been chosen to install it **OUTSIDE** the tanktainer for economical, technical and safety reasons.

Economical reasons :
The difference in cost price for each tanktainer will be +/- 15 000 euro higher with the pressure regulation inside the tanktainer.

Technical reasons :
- Technically it is easier to foresee the pressure regulation on board as the redundancy of this regulation system will only have to be foreseen on the ship. Otherwise the redundancy has to be built in each tanktainer separately.
- The flexibility of the tanktainer (towards different applications) will be lower when the pressure regulation will be built inside the tanktainer. If the output pressure is fixed at for example 20 bar, it might be too low for other applications and in the future even for large fuel cells.
- More connections are required, for instance double vent lines (before pressure regulator and after)

Safety reasons :
Following measures need to be foreseen, independent of the location of the pressure regulator :
    - Immediate flow cut off is required if hose is ruptured
    - After each connecting handling action, an immediate leak test is required for the hose (before putting pressure on it)
    - Break away couplings will be necessary installed
    - Operating procedures have to be foreseen for the handling of the tanktainers on the terminals
- The difference in safety between the 2 scenarios (pressure regulation inside or outside tanktainer): high outlet pressure versus reduced outlet pressure
    - The higher the pressure, the higher the impact in case of failure (although the volume H2 will be low in any case due to forementioned risk mitigations : only H2 in present in hose)
    - As the venting hoses cannot be pretested and if the pressure regulator is inside, two venting hoses are required.
    - In case of a failure in the pressure regulator, H2 after the pressure regulator will be blown off
        - PR inside : H2 will be blown off via the venting hose connected to the venting lines on the ship
        - PR outside : H2 will be blown off via fixed piping on the ship
        - The possibility of a rupture in the vent hose is higher compared to a fixed piping
    - All forementioned topics result in a higher probable failure when the Pressure Regulator (PR) is installed in the tanktainer.

E. Design Guidelines

In order not to complicate the (already complex) discussions it has been decided to postpone these workshops.
These workgroups need to be organised in future together with the classification bodies.
The aim of standardised design guidelines will be simplification of the design process so that a tanktainer can be automatically certified on condition it is designed and built according these

standard design guidelines. Nowadays each tanktainer needs to be certified individually which is a time-consuming and expensive process.

F. Physical interface

Following mechanical interfaces need to be foreseen and coupled :

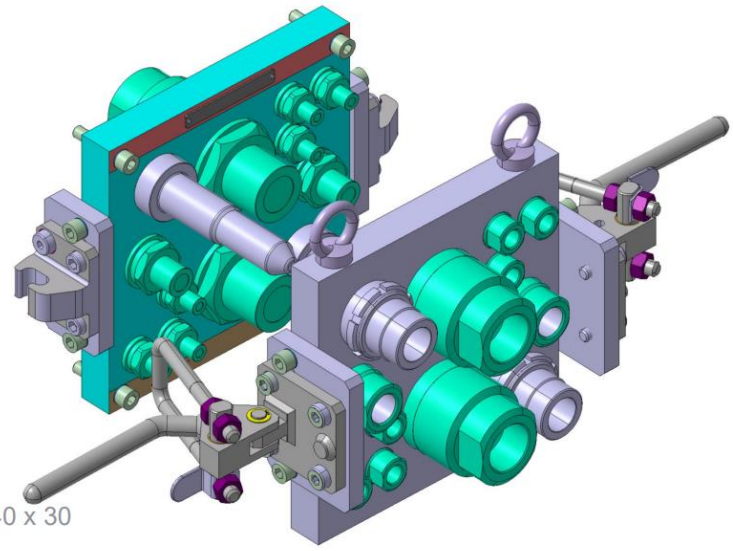
- Main H2 hose connection
- Vent hose connection
- Compressed air pressure hose connection(s) to operate the valves

It has been agreed that for each different pressure a different physical connection needs to be foreseen. To prevent connecting a high pressure tanktainer to a lower pressure application.

Two different types of physical interfaces have been discussed : quick coupling and multiconnector.

Multiconnector :

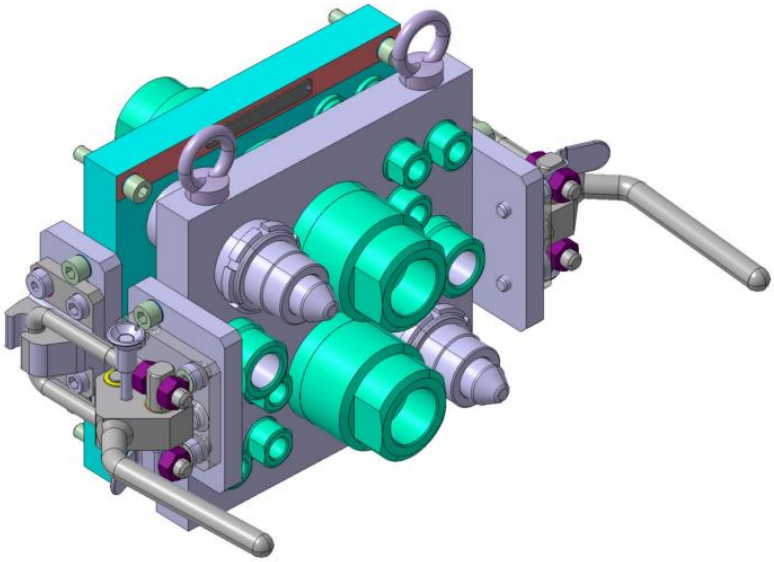
- Advantages
  - Fool proof connection
    - Ensure correct lines are connected (vent-vent, not accidentally vent-main H2)
    - Order of connecting lines fixed
    - For different pressures
  - Fewer training needed
- Disadvantages
  - Higher price
  - Handling needs a balancer due to weight



Dimensions :

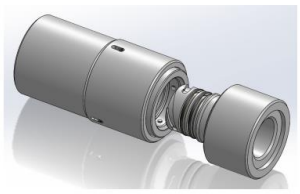
Mobile plate : 245 x 240 x 30
Weight : 27 Kg

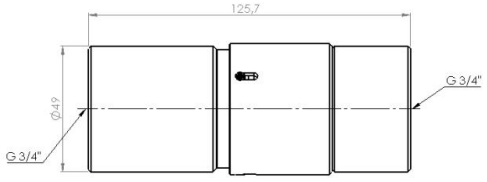
Fixed plate : 245 x 240 x 30
Weight : 24 Kg



Quick coupling

- Advantages
  - Lower price
  - Easy to handle manually (low weight)
  - Easier to transfer to other applications
- Disadvantages
  - More extensive training needed
  - Connection can be forgotten to make, or in the wrong order.





Options:
Venting Version with DN 30 with
3/2 way valve with needle valve
Customised solutions

The different aspects have been concluded in the next outcome :

- Multiconnector
  - Chosen as preferable option due to fool proof necessity
  - Backward compatibility should be possible
    - 300 bar : 2 conical pins
    - 500 bar : 3 conical pins
    - 700 bar : 4 conical pins
  - Weight should be lowered

- For inland navigation
    - Multiconnector with 4 connections = preferred option. (Main H2, Vent line, two air pressure lines)
- For land based applications
    - Only 1 connector needed (H2 supply)
    - Quick coupling = preferred option
- Multi-use should be possible !
    - Higher turnaround of tanktainers : will lower the cost
    - Use for inland navigation and land based applications should be combined

Overall Conclusion

- Multiconnector and 1 quick coupling combined on 1 tanktainer

G. Data communication

Some data are found to be necessary. This data should be available at all times, and be foreseen in a digital way (in the cloud) :

- Pressure in each section
- Temperature in each section
- Identification of design pressure
- Inspection status
    - Date of last inspection
    - Date of next inspection
- Maintenance status
    - Green : all ok
    - Yellow : all ok, extra attention to sensors required
    - Orange : can be used but repair needed
    - Red : can no longer be used

A section can contain 1 or more pressure vessels. Each section has an own Pressure Relief Valve (PRV) for overpressure and an own Thermal Pressure Relief Device (TPRD) for high temperature.

Other data are very useful, but are not seen to be necessary. A first selection of these kind of data

- Number of filling cycles
- Acceleration data (occurred G-forces)
- GPS position
- Safety check
- …

H. Communication protocol

The communication protocol J2799 (upgraded to WIFI) has been chosen as most appropriate.