



## GUIDANCE DOCUMENT: COUPLINGS FOR BUTADIENE RAILCARS



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### Disclaimer

This document is intended for information only and sets out responsible care guidelines for the transport of 1,3-butadiene and 1,3-butadiene containing streams, as defined in the introduction of this document, via railcar.

This information is provided in good faith and, while it is accurate as far as the authors are aware, no representations or warranties are made with regards to its completeness. It is not intended to be a comprehensive guide. Each company, based on their individual decision-making process, may apply these guidelines, in full or partly or apply any other adapted measures.

No responsibility will be assumed by Cefic in relation to the information contained in these Guidelines.

## 1. Introduction

1,3 Butadiene is a gas which is mainly used as a raw material in the polymer industry. The most widespread use of 1,3-butadiene is in the manufacture of SBR and styrene-butadiene latex, the former being used in the production of synthetic rubber products and the latter in paper coating, carpet backing and paints. The other major uses of 1,3 butadiene is in the manufacture of polybutadiene rubber for use in tyres, tyre products and car body sealants and ABS and Nylon 6,6 for use in the production of oil resistant gaskets, business equipment and automotive parts.

1,3-Butadiene is considered a Carcinogenic 1A, Mutagenic 1B and a PBT (persistent, bio-accumulative and toxic). For this reason, the EU commission has added butadiene to the revised CMD (carcinogenic and mutagenic directive) with a community wide imposed OEL of 1 ppm, but some countries already apply a lower limit (eg Sweden 0.5 ppm).

Carcinogenicity not only applies to pure 1,3-butadiene, but also to any stream containing more than 0.1 %vol 1,3-butadiene.

**For ease of simplicity, in the sequel is document the term butadiene to mean both pure 1,3-butadiene as well as any C4 stream containing more than 0.1 % butadiene**

Butadiene manufacture and reaction to other products is carried in closed systems to limit the risk of exposure of workers to butadiene. Practices such as sealless pumps, pumps with double seals and valves with bellows are used to further reduce risk of leakage of butadiene to air.

However, one place where operators can get direct exposure to butadiene is when connecting and disconnecting rail cars used for transport of butadiene.

For this reason, the Lower Olefins Sector Group (LOSG), a sector group of Cefic, has started a reflection on the preferred couplings to be used on RTC's.

This document expresses the views of LOSG. The views are based on Responsible Care considerations to limit exposure of human beings to butadiene during coupling/uncoupling operations of RTC.

For more details on objectives of LOSG and its membership, reference is made to [Petrochemicals Europe website](#).

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## 2. Purpose and scope of this document

This guideline deals with rail transport of butadiene products, as defined in the introduction.

General principles for transporting bulk chemicals via rail tanks (RTC) car are described in Cefic document: [“Guidance on the design, construction and testing of standard rail tank cars for the transport of chemicals in bulk”](#) dd July 2016 that can be downloaded from the cefic website.

The present document focuses specifically on couplings used on RTC's for transport of butadiene and provides a comparison of the advantages and disadvantages of various types of couplings

### 2.1 Future extension of scope

Butadiene is also an inflammable gas under ambient conditions. So, in addition to the risk of exposure to butadiene in case of bad connection between loading/unloading arm and railcar, there is also a risk of releasing flammable gases to the atmosphere.

Some operators will use the same fleet of railcars for transporting butadiene and other C3 and C4 streams, with same risk of releasing flammable gases to atmosphere. The percentage of these railcars used to transport butadiene may vary over time, depending on balances between demand and production of the various streams. In view of fleet flexibility and multipurpose use and avoiding the need for a dedicated fleet of butadiene, Cefic will start to evaluate extension of the scope of this document to C3-C4 olefinic streams before end 2023 based on the evaluation of the butadiene case

Furthermore, the recommendations could also be considered to hold for truck transport and iso-container transport.

### 3. Type of couplings used on RTC's for butadiene transport.

Three types of couplings are currently used in Europe on RTC used for butadiene transport.

- Flange couplings (DN80 / DN50)
- Dry disconnect Couplings (NATO STANAG 3756)
- Screw type couplings (WECO-ACME fig. 602).

Photographs of three types are attached.



**Figure 1: Flanged connection**



**Figure 2: Dry disconnect system**

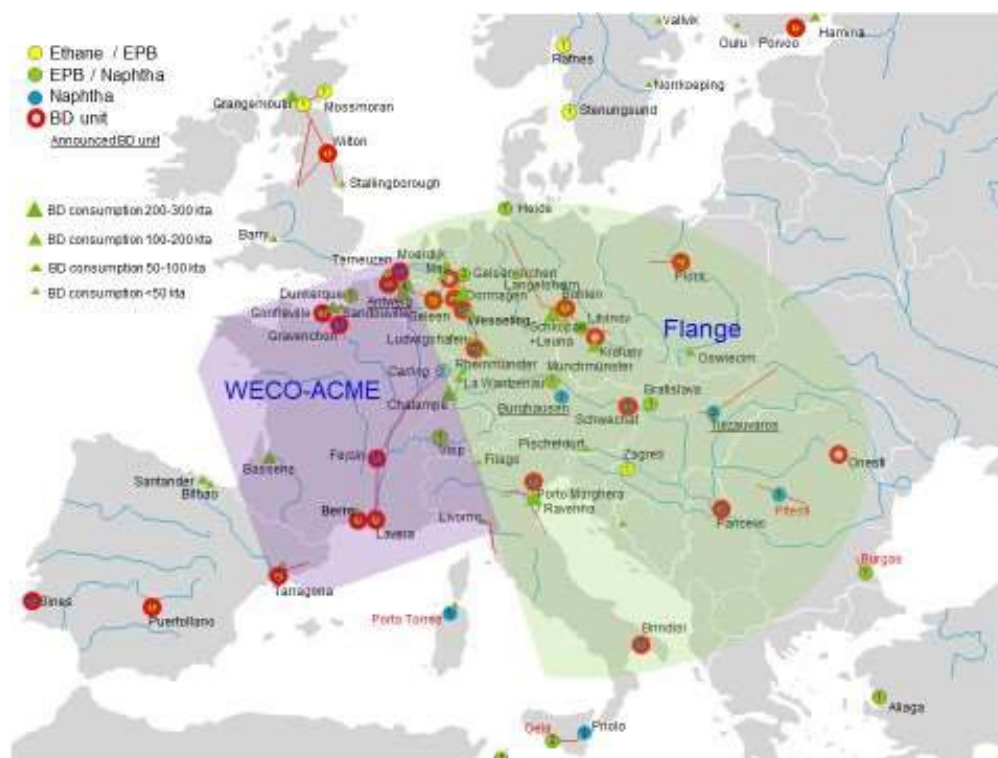


**Figure 3: Screw type connection**

Total production of crude C4 from steam crackers in EU-15 is about 6.4 Mton, total production of butadiene is about 1.9 Mton (Cefic data for 2015).

Of this quantity, it is estimated based on production locations that about 0,3 Mton crude C4 and 25% of the BD production (0,5 Mton) are transported by rail.

In Europe, it is observed that essentially west of the Rhine, the WECO system is used, whereas East of the Rhine mostly flanges are used.



**Figure 4: Location of BD units and indication which coupling system is used preferentially where (Courtesy of Lyondell Basell).**



When connecting/disconnecting the RTC to the loading/unloading arm, the main safety risk is the release to the atmosphere of the butadiene that may have accumulated in the dead spaces between the valves on the RTC and those on the loading/unloading arms. Due to low acceptable exposure levels of butadiene (CMR substance), a proper risk assessment needs to be carried out to see if exposure to butadiene is possible when connecting/disconnecting such RTCs.

Although RID legislation (art. 4.3.2.3.3 / art. 4.3.2.3.4 RID 2019) only requires that appropriate measures are taken to prevent the release of dangerous quantities of gases and vapors, it is recommended that the loading line is flushed (preferably with nitrogen<sup>1</sup>) after loading or discharging to minimize the butadiene content in the T-piece of the RTC.

Moreover, according to articles 4.3.3.4, which deals with loading procedures of liquid gas tank wagons, the leak-tightness should be checked before and after loading.

## 4. Comparison of different type of couplings.

### 4.1 Flanges

A flange system is a good solution if it is permanent, but these flanges are installed and uninstalled frequently.

And so, while flanges have some advantages (standard connection with bolts and nuts that is in principle easy to operate that can always be tightened in case of leakage and to maintain). However, flanges are cumbersome to handle and are quite time consuming. Unloading or loading one railcar involves up to 72 screw connections (see Appendix 1).

**Moreover, they pose more risk for errors than the other type of couplings. Errors that can be made are**

- **Wrong bolting tension**
- **Missing bolts (see eg. picture)**
- **Issues with the gasket (gasket needs to be changed regularly due to wear and tear)**



Missing bolt

**Figure 5: flange system with missing bolt.**

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<sup>1</sup> When pipes and tank are not flushed with nitrogen or other inert gases, the oxygen from atmosphere could build Butadiene peroxide acting as initiator for radical polymerization. See for more information “Butadiene product steward ship guidance manual” published by ACC.

**These errors can result in leakage of product to atmosphere and hence exposure of human beings in the vicinity of the railcar.**

In view of the carcinogenicity of butadiene and its low binding Occupational Exposure limit (1 ppm) LOSG recommend to stop the use of flange connections.

#### 4.2 WECO couplings

Weco coupling is a screw connection, so no bolt connections are required.

Connection is easy and in case of leakage, tightening often is sufficient to stop the leak.

There are however some disadvantages.

- Special wrench is required for tightening that is however not always available at all locations.
- Two-type of screw connections are on the market (differing in thread and sense of rotation), with the ISO norm the one being less used. Supplier and user need to be aligned to use the same type.
- The dead space between shutoff valve on the railcar and the valve on the loading arm is bigger compared to flange system (compare Figure 5 and Figure 6), so in case client does not have a flushing system to clean the space between shutoff valve on the railcar and the unloading arm, more material will be released to atmosphere compared to a flange system.
- In case of erroneous manipulation (wrong tightening procedure and damage to thread), more chance of leakage of material to atmosphere.
- WECO cap nut are after a short time difficult to open.



**Figure 6: example of WECO connection mounted on flange.**

As for flanges, most of these disadvantages can be taken care of by taking appropriate measures, but reality does not always equal the best practice, and mistakes can be expected to occur.

Moreover, WECO system offer the option to have adapted connectors so that is not possible to connect to wrong product. Currently there are two selectivity's.

#### 4.3 Dry disconnect couplings

For a picture of dry-disconnect coupling see Figure 2.

This type of coupling involves no screw or bolt connections and is very easy to connect.

It provides the lowest emissions to atmosphere and hence exposure of operator to product, even if



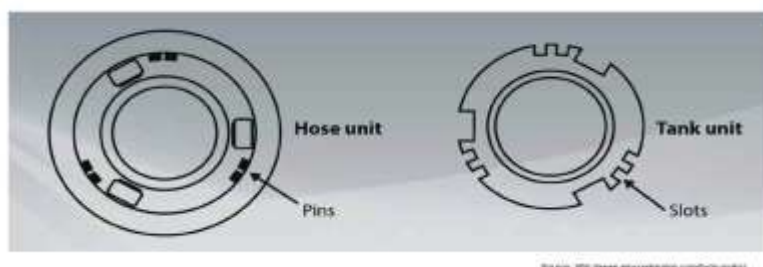
no proper flushing procedure would be applied at the client location.<sup>2</sup>

Moreover, as this system has the lowest dead space volume between shutoff valve and the valve on the loading arm, this system has the lowest risk and lowest quantity of oxygen introduced in the system and hence least polymerization risk.

Disadvantages are:

- In case of leakage, tightening is not possible. Leak can only be stopped using an additional pressure cap.
- This system needs more and proper maintenance than flanges and WECO couplings. Dry disconnect coupling might need higher inspection/maintenance frequency than inspection of the RTC.

Moreover, Dry Disconnect system offer the option to have multiple adapted connectors so that is not possible to connect to wrong product (see Figure 7). The recommended connection for butadiene is DN80 (with Selectivity “1,3”) for the liquid phase and DN50 (Selectivity “Y”) for the vapour phase, when multiple products are discharged at the same gentry.



**Figure 7: example of adapter connectors for Dry-Disconnect**

It is also recommended to install a plastic cap to protect against dirt. Alternatively, one can also install a metal cap on the dry-disconnect coupling (see Figure 8). This can act as a “leak-detection of the valves” and acts as an extra closure according to RID.



**Figure 8: Pressure cap for installation on dry disconnect coupling**

<sup>2</sup> Regarding the BD exposure, Lyondell Basell made some trials before implementing the dry coupling system for CC4 RTCs. RTCs with flange ranged between <1 ppmv BD, to around 40 ppmv. Maximum values of 7500 ppmv Butadiene were measured incidentally as well. RTCs with a dry coupling system were always below <1 ppmv Butadiene. These values were measured at the location of the coupling of loading arm to the RTC.

#### 4.4 Additional advantages of WECO and DryDisconnect couplings to flanges.

The higher cost for WECO or Dry Disconnect coupling is partially outweighed by time savings to connect and disconnect the RTC, as the saved time to connect/disconnect an RTC frees up 10-15% of the total loading time, which either frees time of operators for other operations or allows to increase the capacity of the loading station. For more details see Appendix 1.

#### 4.5 Adapter

Currently, supplier and client do not always have the same type of connection. So for instance railcar of supplier might be equipped with dry-disconnect seal, whereas the hose of the client is equipped with flange system. An example of a connection piece that is given by supplier to downstream client in such case is shown in Figure 9. A proper risk analysis should be done when using adapter.



**Figure 9: Example of connector (dry disconnect coupling to flange, mounted to unloading arm)**

#### 4.6 Breakaway coupling

Independent of the type of coupling or the type of product transported, for safety reasons, break-away couplings on the loading arm are strongly recommended both on the liquid as on the vapor phase. This coupling protects the mechanical integrity of the whole connection between the loading arm and the railcar and can prevent major leaks in the environment.

## 5. Timing

Currently, flanges are still significantly used today for railcar transport of butadiene. Transforming the railcar fleet to eliminate this will require a certain transition period.

The LOSG members commit to eliminate flange couplings on their RTC Fleet for butadiene transport by end 2025.

The LOSG members intend discussing before the end of 2023 the extension of this guideline to other C3 and C4 olefinic streams and other forms of transport, but first want to gain more experience on the benefits of eliminating flanges on butadiene transports. When discussing extension to other C3 and C4 olefinic streams, new technological developments at that moment will be taken in consideration.

## 6. Conclusions

In principle, all three type of connections (flange, WECO, Dry-disconnect) when properly used are acceptable couplings (in line with the recommendations of the Cefic guideline cited in the introduction).

However, the chances for errors when not used as per best practices with resulting leakage of butadiene to atmosphere are higher for flange system.

Hence, LOSG members have committed to eliminate flange couplings for transporting butadiene by end 2025 and suggest other producers and consumers of butadiene to do the same.

LOGS members currently believe that both WECO and Dry-disconnect are valid alternative couplings to flanges. This guideline specifies advantages and disadvantages for both systems, so it is up to reader of this document to decide himself which is the best coupling.

In view of fleet flexibility and multipurpose use and avoiding the need for a dedicated fleet of butadiene, Cefic and its LOSG members will start to evaluate extension of the scope of this document to C3-C4 olefinic streams before end 2023 based on the evaluation of the butadiene case

## Appendix 1: Comparison of number of manual operations between flanges and WECO and dry-disconnect couplings.

In this appendix, a comparison is shown between the number of manual operations for flanges versus WECO or dry-disconnect couplings.

The following slide shows the number of screw connections to be made during a standard loading or unloading of a RTC.



Open RTC	<ul style="list-style-type: none"> <li>Blind flange liquid phase</li> <li>Blind flange vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
Open loading arm	<ul style="list-style-type: none"> <li>Blind flange liquid phase</li> <li>Blind flange vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
connect loading arm	<ul style="list-style-type: none"> <li>Check/replace gasket</li> <li>connection liquid phase</li> <li>connection vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
disconnect loading arm	<ul style="list-style-type: none"> <li>Check/replace gasket</li> <li>connection liquid phase</li> <li>connection vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
Close RTC	<ul style="list-style-type: none"> <li>Check/replace gasket</li> <li>Blind flange liquid phase</li> <li>Blind flange vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
Close loading arm	<ul style="list-style-type: none"> <li>Check/replace gasket</li> <li>Blind flange liquid phase</li> <li>Blind flange vapor return line</li> </ul>	8 screw connections 4 screw connections	-- -- -- -- -- -- -- -- -- --
Single RTC	72 screw connections!		

The following graph shows the actions to be taken using WECO or Dry Disconnect coupling.

