Deliverable D 5.2
Technical Specifications of Wagon and Locomotive DAC up to Level 5

Project acronym:	FP5-TRANS4M-R
Starting date:	2022-07-01
Duration (in months):	45
Call (part) identifier:	HORIZON-ER-JU-2022-01 (Topic: HORIZON-ER-JU-2022-FA5-01)
Grant agreement no:	101102009
Due date of deliverable:	Month 17
Actual submission date:	2023-12-20 (V1) 2025-04-24 (V2)
Responsible/Author:	Johan Ahman
Dissemination level:	PU
Deliverable Type:	Report
Status:	V2.0

Reviewed: (yes)

This project has received funding from the European Union's Horizon Europe research and innovation programme under Grant Agreement No 101102009.

Document history		
Revision	*Date*	*Description*
Preliminary 1	2023-08-04	First working draft
Preliminary 2	2023-08-11	Second working Draft
Preliminary 3	2023-10-01	Third draft based on feedback of FA5
Preliminary 4	2023-11-02	Forth working draft Reviewed by DAC core corrected based on FA5 feedback
Preliminary 5	2023-12-18	Ready for publication – new base line
Released 1.0	2023-12-20	First official revision of Deliverable 5.2 after updating figures 1, 7,9,10,11
Preliminary A	2025-01-14	Review against CEN and open item list
Preliminary	2025-04-01	Reviewed and ready for cleanup
Preliminary	2025-04-10	Cleaned and released for final review
Release 2.0	2025-04-24	Released 1. Synchronisation of values of D5.2 to prEN18171 2. Closing of open points from first revision 3. Addition of E-coupler requirements to reflect those in prEN18171 4. Addition of Hybrid couplers to reflect our new knowledge after testing in February. 5. Editorial – corrections such as duplicate text and spelling errors 6. Inclusion of current open topic list for transparency

Report contributors		
Name	Beneficiary Short Name	Details of contribution
Andreas Schuhmacher	Voith	Contributor
Fredrik Tunell	Dellner	Contributor
Nils Möhle	Knorr Bremse	Contributor
Martin Schueler	Voith	Contributor
Stefan Faas	Wabtec	Contributor
Johan Ahman	Dellner	Main author
Christian Radewagen	Voith	Reviewer (DAC Core)
Jan Sporleder	DB	Main reviewer
Stefan Hagenlocher	ÖBB	Main reviewer
Marten Strotkoetter	SBB	Contributer V2

Table of Contents

List of figures

List of tables

1 Executive Summary

Based on the requirements outlined in this document an interoperable DAC and DAC hybrid coupler that meets the main demands for a future digital operations of freight trains in Europe.

This document outlines the functional and where needed the mechanical requirements needed for an interoperable design of the Digital Automatic Coupler for freight. The document covers both DAC and Hybrid DAC/Hook couplers to be used in the rail freight segment. The requirements are trying to strike a balance between mechanical and functional requirements, which allows for future innovation and development within the given area.

This document is supported by the EDDP input parameters, the CEN NWIP WI00256A0K and deliverable 2.1 “Future operational procedures”.

Due to the low technical readiness level of the Data and Electrical systems within the FA5 the Electrical and Data interfaces are intentionally left un-concluded.

The document was compiled by using existing peer reviewed standards and the input from technical experts from the main suppliers of automatic couplers within the European Union and from operators and owners of rail vehicles. The draft document was reviewed in open sessions within the FA5 to gather inputs from all stake holders.

The method of verification of the requirements set out in this document are to be found in Deliverable 5.3 of FA5 project.

There are several open points which cannot be closed due to the need of future work and testing. The aim of the project is to close these during the next phase of the project.

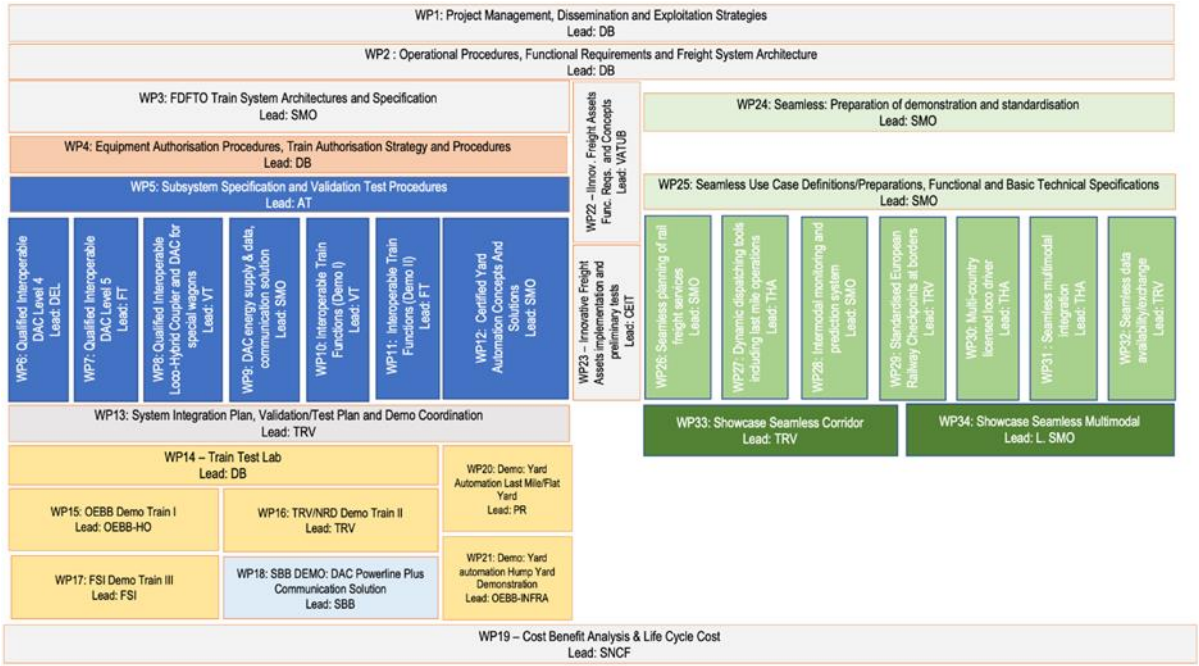
2 Abbreviations and acronyms

Abbreviation / Acronym	Description
ADIF	Administrador de Infraestructuras Ferroviarias
AUCO	Automatic Coupler
CAN	Controller Area Network
CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation Electrotechnique, Europäisches Komitee für elektrotechnische Normung
DAC	Digital Automatic Coupler
DB	Deutsche Bahn
DEL	Dellner
DIN	Deutsches Institut für Normung
EDDP	European DAC Delivery Program
EN	European Norm
ERA	European Union Agency
FA	Flagship Area
FKM	Forschungskuratorium Maschinenbau e.V (7th edition 2020)
FT	Faiveley Transport
KB	Knorr Bremse
N/A	Not applicable
OEBB-RCA	Österreichische Bundesbahnen Rail Cargo Austria AG
RAL	Reichs-Ausschuss für Lieferbedingungen (Imperial Committee for Delivery and Quality Assurance)
SC	Subcommittee
SMO	Siemens
TC	Technical Committee
TRV	Trafikverket
UIRR	International Union for Road-Rail Combined Transport
VT	Voith
WG	Working Group
[...]	Assumed/Proposed value but more testing or investigation needed to validate

3 Background

The present document constitutes the Deliverable D5.2 “Technical Specifications of Wagon and Locomotive DAC up to Level 5” in the framework of the Flagship Project FP5- TRANS4M-R as described in the EU-RAIL MAWP and contributes as well to the Flagship Project 5 - TRANS4M-R.

The project aims to boost innovation for the European rail freight sector, concretely by developing, validating, and demonstrating FP5-TRANS4M-R technical enablers. The work to reach this level of TRL is complex and thus divided into several work packages highly dependent on each other.



The work on deliverable D5.2 has been achieved in Work Package 5 Subsystem specification and validation test procedures.

3.1 Work methodology

The original document is a merger of three main sources. The first source is composed of the work done by the DAC-Core team members consisting of 10 coupler experts. The second source was the CEN NWIP WI00256A0K work. The third source is the requirements carried over from the EDDP work (revision of the June 2022). These three work streams were then merged into one document. The originally reviewed document clearly separated the CEN part and the DAC specialist added additional comments.

The second revision builds on the knowledge accumulated during 2024 as well as the enquiry

stage CEN document.

One important input was Deliverable 2.1 which has been used by the DAC experts where the use cases have been translated into functional requirements.

The document with revision number 3 was then put to an open review process by all parties of the FA5 project. For the deliverable 5.2, 127 comments were captured. Currently only 2 of these comments are not resolved and will have to be handled as future work.

During the final review process (revision 4.1) the two parts were merged to enable easier reading and editing of the document.
New requirements have been added by the reviewers during the review phase resulting in a long but fruit full discussion. Several of the amended requirements will need more work and have been captured in a future work section.

It has been agreed that a future revision of this document is needed but that this document would serve as a basis for the current project deliverables and for a bases to handle future requirement changes.

3.2 Structure

The structure and content of this document follows the basic structure of the CEN NWIP WI00256A0K. The main sub chapters outline general requirements and then the requirements of the sub-components to facilitate testing. The document is structured in three main parts first defining the Wagon DAC coupler, second then the interface to the wagon and finally a chapter on the loco hybrid coupler.

4 Objective/Aim

The primary aim of this document is to capture the functional requirements and where needed the mechanical definitions needed to design an interoperable DAC of level 5 for Wagon and Locomotives at this moment in time.

Since this is a project aiming to show a high TRL the V model is being followed new requirements will be identified and introduced during the project lifetime.

The second objective is to come to a mutual understanding in the functional requirements such that the CEN approval process can be closed in a timely manner.

The third objective of this document is to create a bases of requirements for deliverable 5.3 to verify.

5 Terms and definitions

Note for terms not defined in this text please refer to ISO and IEC maintained terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp/

— IEC Electropedia: available at https://www.electropedia.org/

Digital Automatic Coupler (DAC)
central buffer end coupling system for freight applications that couples automatically.

Note 1 The degree of automation is defined in DAC functional levels 1-5. See functional levels.

Note 2 The requirements described in this standard are valid for digital automatic couplers for use in freight trains. For digital automatic couplers for use in passenger trains there exist different or additional requirements.

Note 3 An additional electrical contact coupling for the transmission of voltages and data/signals is out of scope of this document.

Note 4 The mechanical housing for the electrical coupler will be covered in this document.

Electrical Coupler
system that is used for connecting or disconnecting the electrical lines automatically which transfer control signals or power supply / current from one railway vehicle to another within a train

Note 1: If relevant the Electrical coupler will also house data connections and lines. The electrical components of the electrical coupler are defined in CENELEC.

Note 2: For clarity -the mechanical interfaces but not the transmission conduits (pins) and their configuration of the electrical coupler are covered in this standard.

Horizontal and Vertical Support
system that moves or aids - in the uncoupled condition - the complete coupler back into the central position after being deflected

Split Collar
fastening element consisting of two metal half-shells that are joined by fasteners.

Note: This is not an interface covered here.

Draft gear
element of the coupler that can transfer compressive and tensile forces into freight wagon or locomotive.

Note The draft gear can handle regenerative and non-regenerative energy.

Crash element
non-regenerative energy absorption device that absorbs energy in the event of a collision
Note: These devices are used to protect the main structure of the wagon, load or other rail device it is attached to. These elements may be sacrificial.

Coupler shank
connection between the coupler head and the draft gear

Pivot pin
pin used to connect the coupler shank to the draft gear. Also referred to as joint pin see figure c.2 in EN15566.

Manual uncoupling mechanism
device which provides manual rotation of the locking mechanism from the coupled position in to the ready to couple position.

Note It can be a lever, handle, rope or other tool which is connected to the coupling mechanism and is pulled until the ready to couple position is attained.

Uncoupling actuator
device which provides automatic rotation of the locking mechanism from the coupled position in to the ready to couple position.

Prevent coupling
state when the mechanical mechanism of the coupler is retained in an uncoupled state preventing coupling of the couplers even if two couplers are put in contact (buffed) with each other – which normally would result in coupling.

Note this enables buffing in hump and yard operations.

Berne or Berner rectangle
area between the vehicles ends defined by EN 16839:2022-10 ch 3.1 and 4.2

Functional levels (FL)
Functional level 1:
automated coupling of the mechanical connection; manual uncoupling possible

Functional level 2:

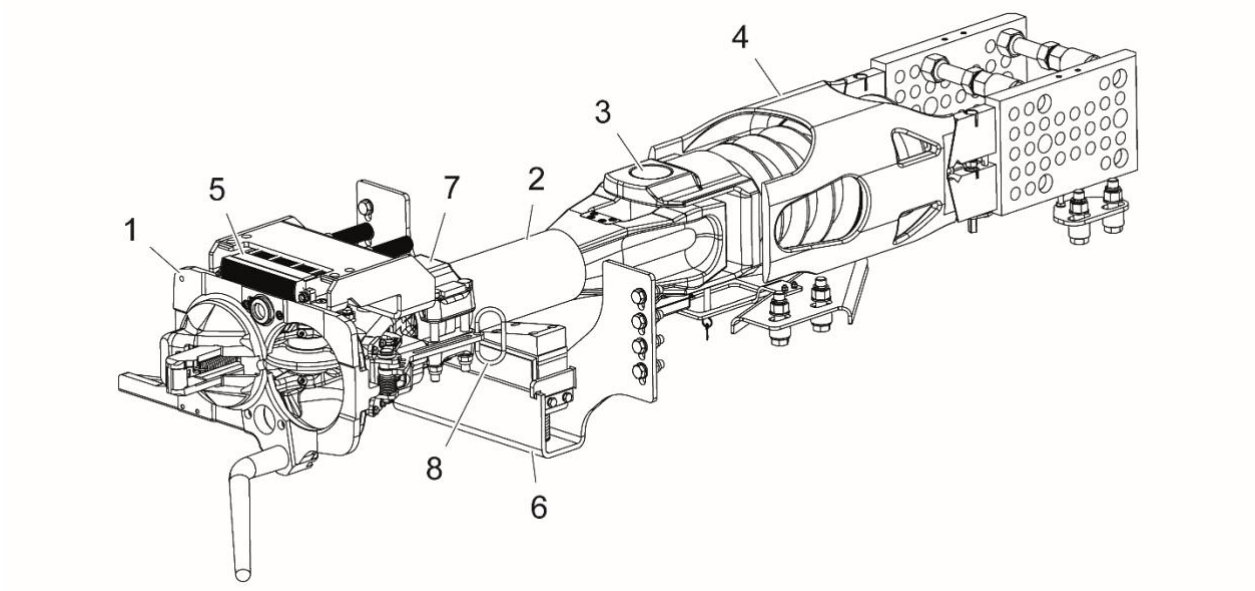
FL 1 plus automatic coupling of air pipe

Functional level 3:
FL 2 plus automatic coupling of electrical power line(s)

Functional level 4:
FL 3 plus automatic coupling of data line(s)

Functional level 5:
FL 4 plus full automated uncoupling

Note The full automated uncoupling can be achieved by means of remote access.



Key to figure 1

1. Mechanical coupler
2. Coupler shank
3. Pivot pin
4. Draft gear
5. Electrical coupler
6. Support
7. Split collar
8. Manual Uncoupling (emergency fall back)

Figure 1 Figure showing schematic view of the coupler's components

6 Product specification of wagon DAC

6.1 General requirements

For the components of the digital automatic coupler which transfer forces in the draw and buff line (for example coupler head, shank, pin and draft gear) the:

- inspection documents of materials used for the manufacture shall be according to 3.1 or 3.2 in EN 10204:2005
- bolted connections shall be in accordance to pEN 17976:2023
- welded parts shall be in accordance with EN 15085:2023

The couplers shall be prepared for upgradability from a lower functional level to a higher functional level.

The digital automatic coupler shall be able to withstand the following static loads without significant plastic deformations (Rp 0.2).

- tensile load = 1 000 kN
- compressive load = 2 000 kN

A pre-determined nominal breaking point for tensile loads of 1 500 kN + 15% /- 10% shall be located in the draw line, located in the tensile chain between the pivot pin and the front plate of the coupler head.[1]

Note: The couplers are not designed to withstand continues use at high forces (2 000 kN).

Note: The fatigue life as specified below is to be read in conjunction to document ORE B51 RP21 "Parameter der AK 69/Intermat – Betriebsfestigkeit". The given load cycles inside can be assumed to a fatigue life equivalence of +/- 295 kN, N = 1 000 000 cycles. Based on the assumptions from this reference document, the operational force in use of 850 kN must not be exceeded[2]

For new designs the proof of the fatigue loading shall be carried out.

Note: The dynamic test procedures can be supported by the methods described in EN15566:2022 Annex A for tensile loads and in EN15551:2022 for compressive loads.

The digital automatic coupler shall fulfil the following fatigue loading, to show a lifetime of 30 years:

[1] To be reopened as an open item

[2] To be confirmed after calculations have been performed. Data for yearly load spectrum to be provided by operators (DB-ÖB-TRV). Statement 850 kN has to be associated with a load spectrum in this standard. Add load spectrum as an Annex?

The proof of the fatigue loading shall be carried out by a test.

The load collective shall cover a damage equivalent load of at least 300 kN.

For an unwelded steel structure following load collective *F* shall be applied:

— $\Delta F1 = \pm 300$ kN

$F = 0$ kN ± 300 kN and N = 1 500 000 cycles

If welded connections are located in the load path. The proof shall be adjusted according to EN15085 or FKM supported by EN17149-3.

Note: The declared service life of the coupler is defined by an assumed distribution of loads. Real service life may be affected depending on real distribution of loads. Please see UIC B 51 RP 21 (ERRI B 51 RP 21) *for an assumed load spectrum.*

For evolved designs the proof of the fatigue load can alternatively be carried out by simulation with a validated FE-model.

The whole air connection system of the digital automatic coupler shall be suitable for a nominal 5 bar pressure on the brake pipe (BP).

For an optional main reservoir pipe (MRP) the air connection system of the digital automatic coupler shall be suitable for a nominal 10 bar pressure.

If no mating MRP exists, the valve of the MRP shall remain closed. All couplers shall be equipped with an opening (hole) of at least diameter 53 mm and position as outlined in 16019:2014 A1 and D2.

The digital automatic coupler shall work reliably under normal European environmental conditions, e.g. rain, pollution, washing water, snow, ice and particularly in hot summers as well as in cold winters. The coupler shall follow the requirements set out by EN 50125-1:2014.

The temperature class shall at least match the temperature class of the vehicle.

Coupler (excluding the regenerative energy absorption components) should be designed to commensurate with the service life of a vehicle.

The service life of the digital automatic coupler for wagons is defined as 30 years under the premises that all necessary maintenance and overhaul have been carried out. Based on 70 000 km per years, 3 coupling cycles per day, 250 operation days per year[3].

[3] Provided by operators

The service life of digital Automatic hybrid couples or digital automatic couplers for mainline locomotives is based on 150 000 km per year, 5 coupling cycles per day, and 360 days per year[4].

The service life of digital Automatic hybrid couples or digital automatic couplers for shunting locomotives is based on 50 000 km per year, 80 coupling cycles per day, and 320 days per year[5].

The distance between the centre line of the coupler and the top of the coupler shall not exceed 200 mm, independent of state (see 6.2). The height of the coupler is including additional components (such as e-coupler, cables, valves levers, etc).

The permissible longitudinal compressive forces of the wagons, equipped with automatic couplers, when passing a 150 m s-curve with 6 m intermediate straights, shall be above 500 kN[6].

The coupler shall be able to handle being rotated 180° (Upside down) when not connected to another wagon / DAC. This is for special processes where wagons are emptied by rotating 180°.

Wagon coupler target weight 380 kg and max weight [480 kg][7]

- Draft gear cat. A
- Support and centering device incl. fixing elements
- Coupler front part
- Brake pneumatic valve / line
- Electrical coupler
- Fixing elements with spacers
- Not including pneumatic hoses, wagon on board units, electrical cables, junction boxes, battery units, etc

The following requirements according to standard EN 50125 and EN 50155 must be fulfilled by passing the following test from ISO 9227:

Surface Protection ≥ 480 hours salt spray test

The stock color is RAL code 7016

[4] Provided by operators
[5] Provided by operators
[6] Under investigation. Value kept at 500kN until something other is agreed and to be read in conjunction with the product weight. Final value set after testing.
[7] Value to be rediscussed but lower weight in conflict with derailment safety requirement of 500 kN

Draw gear and DAC coupler head & shank shall get a visual indication of the centre of gravity, this can be a sticker or other means using standard sign. See figure bellow for standard pictogram.

Figure 2 Figure of standard gravity pictogram

6.1.1 Overhaul and maintenance

The wagon coupler shall be designed for the following overhauls under normal usage[8].

Minor every 6 years (G4.2[9])
Major every 12 years (G4.0[10])

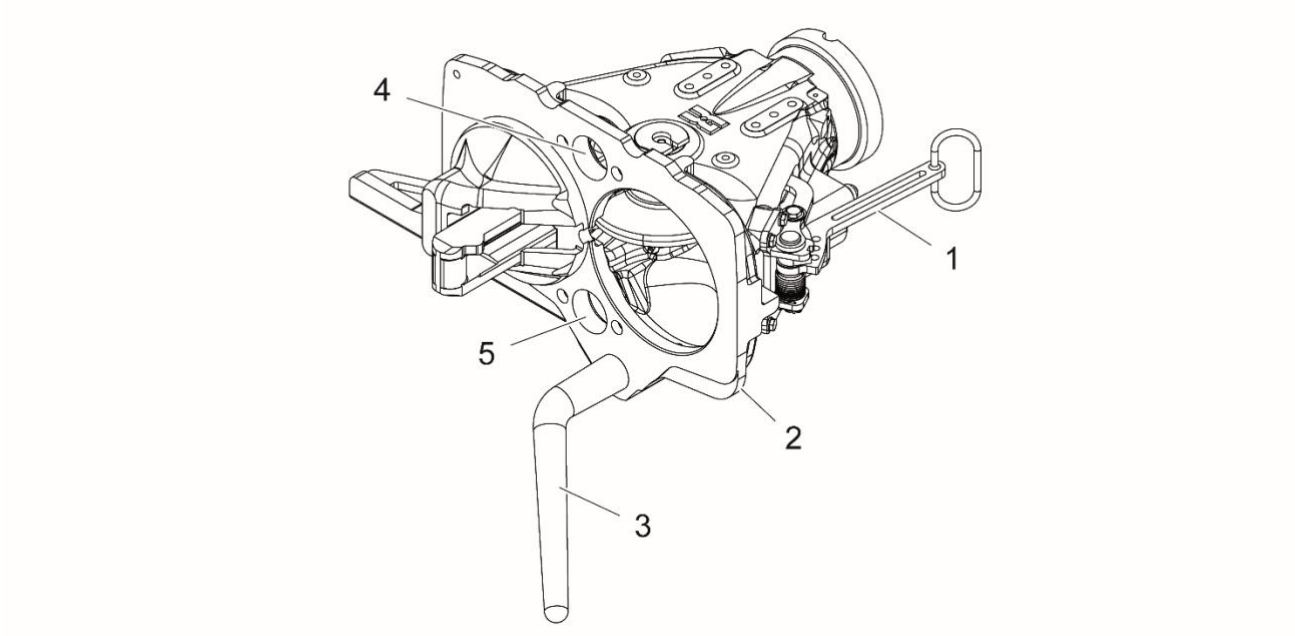
The user manual supplied by the producer defines the overhauls related to these time frames.

Greasing outside the planned minor and major overhauls shall be possible without removing any parts of the coupler.

For minor overhauls parts may need to be disassembled for greasing and inspection.

[8] Exception for special wagons eg Tank wagons can have a shorter interval
[9] VPI manual
[10] VPI manual

6.2 Mechanical coupler



Key

1 Manual uncoupling fallback solution
2 Coupler head
3 Gathering horn
4 Brake pipe valve (BP) position
5 Main reservoir valve (MRP) position

Figure 3 Mechanical coupler head example

The geometric requirements for the DAC coupler head are found in EN 16019:2014. Sections 5 of this document defines additional functional requirements. Figure 3 shows a coupler head.

6.2.1 Mechanical coupling

The coupler head of the automatic coupler shall be equipped with a pivoting coupler lock, enabling the mechanical connection of two vehicles.

The coupler lock consists of the following parts: hook plate, coupling link, main pin, lock rotation spring(s), release bar, and release bar with trigger device.

To ensure a maximum gathering range, both vertically and horizontally, the coupler head shall be provided with male cone and female cone such that the couplers can be aligned and centred also in curves and in case of vertical mismatch.

The coupler head shall have 4 different positions: Coupled position, ready to couple position, prevent coupling position and uncoupled position.

Asymmetric uncoupling (on one side of coupling partners only) should be avoided since this will increase ware of components.
It shall be possible to equip the DAC with a device "electrical or other" for automatic uncoupling:

- Max time for rotating the coupling mechanism to uncoupled position: [3 seconds]
- The operating voltage for the electrical actuator, if used, shall be 48 VDC.
- IP class of the actuator: IP54
- It shall be possible to electrically put the DAC in prevent coupling position
- The electrical prevent coupling position shall be released by an external signal after finished buffing, triggering an automatic position change.
- It shall be possible to override the actuator manually to enable release prevent recoupling.

The digital automatic coupler shall be designed to ensure that coupling is possible for a height mismatch between the centre lines of the couplers of up to 125 mm on straight tracks.

The horizontal gathering range of the coupler head shall be 220 mm minimum on each side. Use of gathering horns is not compulsory if this requirement is fulfilled.

On straight tracks and in curves down to R150 m (in transition zones manual intervention might be necessary) the couplers shall be designed able to couple automatically without manual intervention.

Coupler shall be designed for the following operational procedures:

a. During normal operations on straight tracks the minimum impact speed shall be 0.6 km/h up to an impact speed of 6 km/h.
b. A maximum impact speed of 12 km /h shall not be exceeded.
c. In all other infrastructural conditions like curves, s-curves the maximum coupling speed of 5 km/h shall not be exceeded.

Collisions (impact speed) above 12 km/h is considered an incident and above 18 km/h an accident. In all cases of collisions (impact speed) above 12 km/h appropriate steps shall be taken according to the user manual.

Note: Please consult the user manual.

To prevent an overriding of impacting wagons, the couplers shall withstand a vertical load of at least 150 kN in the centre of two mating couplers and shall safely connect at impact speeds up to 36 kph in relation to conditions defined in EN 15227. [11]

[11] *Requirements from the RID have to be fulfilled please review*

6.2.2Prevent coupling position - (Buffer position)

It shall be possible, by means of a manual operation, to set the locking mechanism in a position in which the coupler head remains uncoupled in the uncoupled position when mated with another coupler. This is to prevent undesired coupling e.g. at the hump or during push off operations.

In manual operations, if two mated couplers are uncoupled to enable that both couplers are in prevent coupling, manual activation of prevent coupling the mated (opposite) coupler must be put into prevent coupling in a separate action.

It shall be possible by an external device to release the prevent coupling position.

For level 5 the prevent coupling shall be indicated using an electric device such as a lamp.

NOTE: For functional level 5 this can be an actuator.
NOTE: For couplers are equipped with an electronic actuator which can be operated from the side of the wagon the actuator can be used
NOTE: Sustainable uncoupling only with actuator

6.2.3 Ready to couple/uncoupled position

It shall be possible, by means of a manual operation, to set the locking mechanism in a position in which the coupler head is ready to couple.

6.2.4 Pneumatic coupling

The pneumatic connection and disconnection of the air pipes of the automatic coupler shall be done automatically synchronized with the mechanical connection.

The possibility of fitting a main reservoir pipe (MRP) (10 bar airpipe) must be provided.

If the digital automatic coupler is unintentionally disconnected due to a failure or an accident, the brake pipe (BP) valve shall remain open.

The diameter of the brake pipe (BP) and the valves inside the automatic coupler shall be minimum 1 1/4 inches (32 mm).

The diameter of the main reservoir pipe (MRP) shall be 1 inch (25 mm).

The venting capacity of the string of brake pipe components between two neighbouring

vehicles shall be equal or better to the venting capacity of the following string of components: End cock (EN 14601:2022) – air hose – pneumatic half coupling (EN 15807:2021) – pneumatic half coupling (EN 15807:2021) – air hose – end cock (EN 14601:2022).

The DACs' brake pipe (BP) curves and volume shall not degrade the propagation speed of the emergency brake command signal according to EN14198:2023 , clause 5.

6.2.5Uncoupling conditions

Uncoupling can be performed manually or automatically by releasing the coupler lock of a mating automatic coupler. This means that under normal conditions both couplers (mates) will be in the uncoupled position after the uncoupling has been performed.

Optimal uncoupling results are achieved when there are no tensile forces on the coupler. The larger the tensile forces that are applied the higher the force which needed for uncoupling will be (safety feature of design).

Uncoupling under tension can lead to lower performance of the uncoupling device.

For functional level 5 the automatic coupler shall be equipped with an automatically operated uncoupling device.

If the uncoupling device is not in action, it shall be in a neutral position (ready to couple position).
It shall be possible to uncouple without any part of the operator's body to enter between the wagons.

A solution should be provided where the uncoupling can be done from the side of the wagon with a lower force than 150 N according to EN1005-3 and EN15273, when the couplers are free of tension load. If a lever mechanism is used the length of the lever is allowed to be adapted to ensure a value of max 150 N.

If the uncoupling device is a pneumatical device, it´s not allowed to take the pressure (air) from the brake pipe (BP).

It shall be possible by an external device to release the prevent coupling position.

Manual uncoupling fallback solution shall always be possible from at least one wagon side.

For an emergency fallback at level functional level 5 for one time use a max value of 400 N is allowed.

For emergency uncoupling it is permitted to enter the safety zone between the wagons.

Note: For level 5, surrounding equipment such as actuator and electrical coupler is allowed to be disconnected manually prior to manually emergency decoupling.

6.2.6 Coupling status indicator

The coupling state for the DAC (coupled/uncoupled) must be visible from the side of the wagon, even in different weather conditions (darkness, snow, ice, ...). A lamp commonly used by operations may be used to detect the coupling state in the dark.

The indicator, which show the coupling state must be mechanically linked to the rotary movement of the hooked plate, or main pin. The dimension of the movable indicator is shown in the following picture. The indicator must be red and visible only in coupled position.

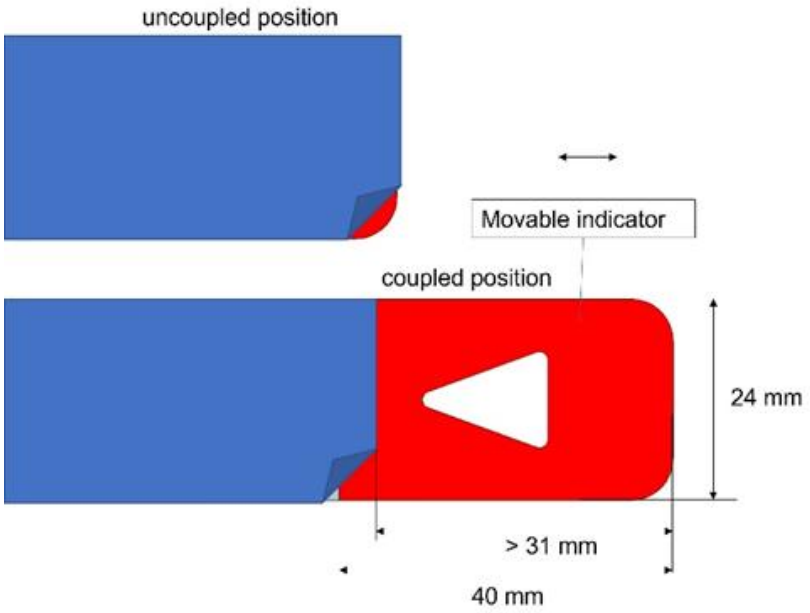


Figure 4 Showing example of a status indicator.

The colour of the coupled position shall be orange RAL 2005.

The indicator shall be mounted on the coupler head.

The indicator shall be clearly visible without stepping between the wagons entering the Berne rectangle, under normal weather conditions as defined for T1 in *EN 50125-1:2014*.

The coupler can be fitted with a sensor for the status indicator which can be relayed signal to the coupler control unit and further into the train consist to be used for operations.

6.3 Electric coupling

Figure A.1 shows the interface of the centering elements of the electrical coupler.

Dimensions in millimetre

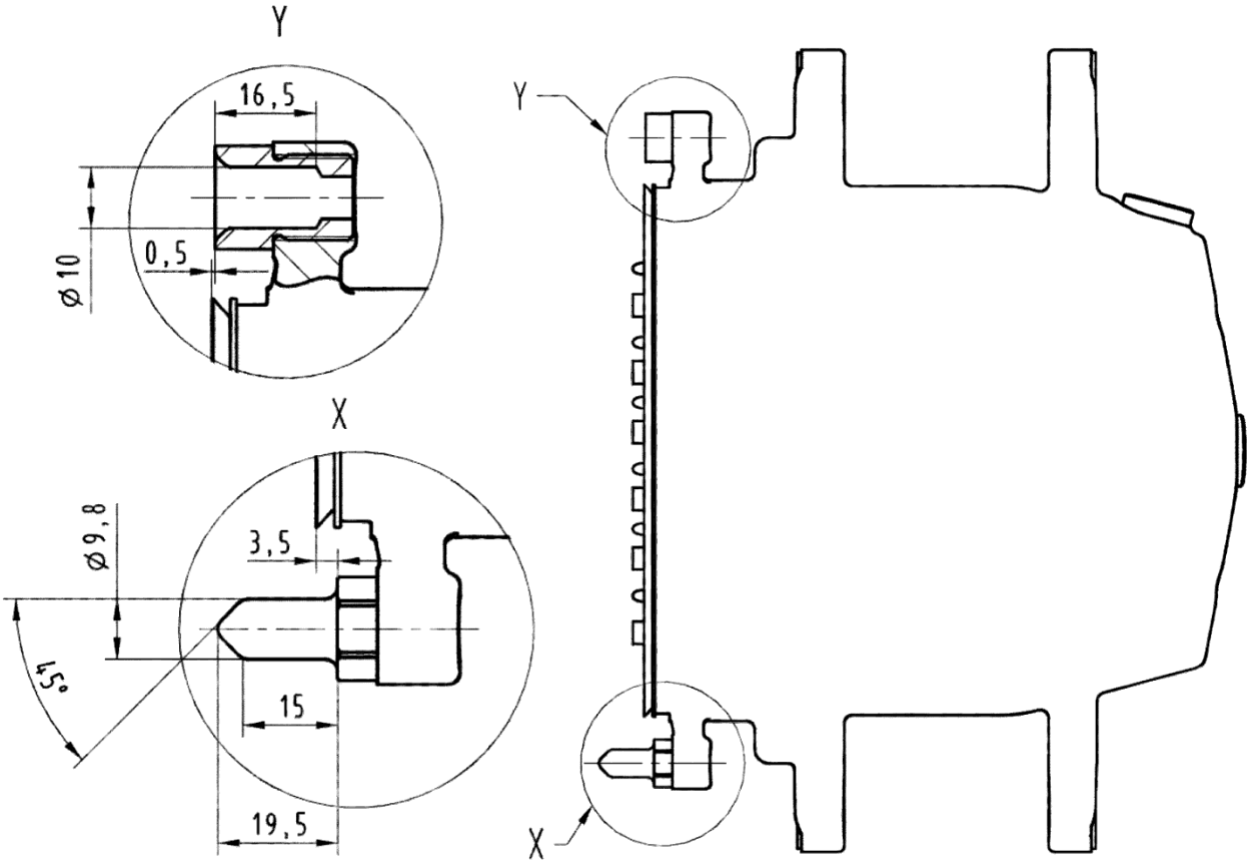


Figure A.1 — Electrical coupler housing view from below Centering elements.

Figure A.2 shows the geometry of the seal.

Dimentions in millimetre

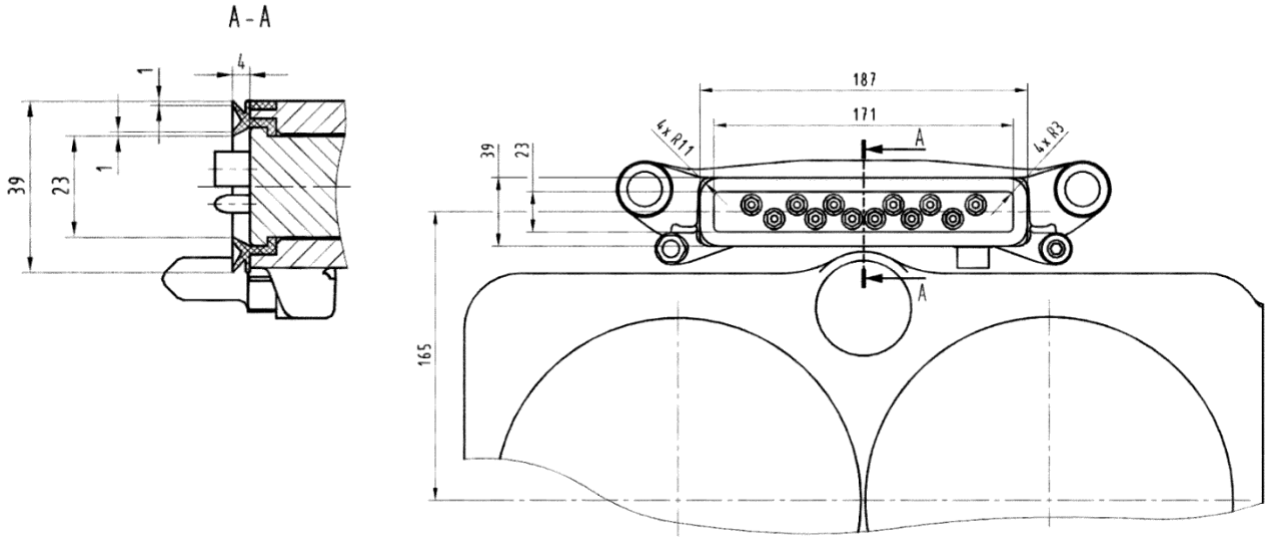


Figure A.2 —The sealing lips of the electrical coupler

NOTE The hardness of the sealing lip must result in sufficient contact pressure and flexibility to ensure the sealing effect.

Figure A.3 shows an example of the layout of the contacts and the layout of the centering elements.

Dimensions in millimetre

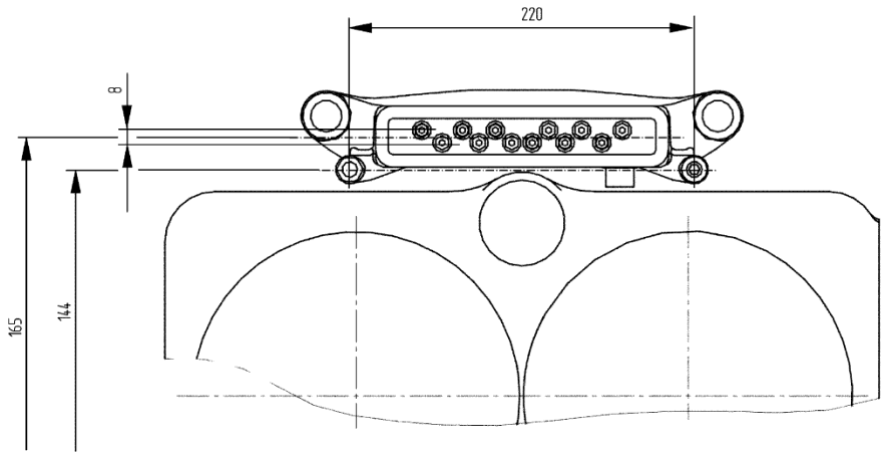


Figure A.3 — Example of the layout of the contacts and the layout of the centering elements

NOTE 1: The dimensions and the positions of the contacts are defined prEN 50746 and prEN 50747.
The centering elements (pin and bushing) align the two electrical couplers with each other.

The play between the mechanical couplings is compensated by the play of the plain bearings on the guide rods. The electrical couplings have no relative movements and can therefore remain rigidly connected to each other.

NOTE 2: The play of the plain bearings on the guide rods is ideal when plain bearing diameter is 2 mm wider than guide rod diameter.

Without a counter coupler, the electrical coupler shall move (2 to3) mm beyond the coupler front plate, so that movements of the coupler heads can be compensated in the coupled state. The electrical couplers shall always be pressed against each other e.g. by compression springs.

NOTE 3: Reliable coupling movement is performed at higher than 50 N coupling force of electrical couplers.

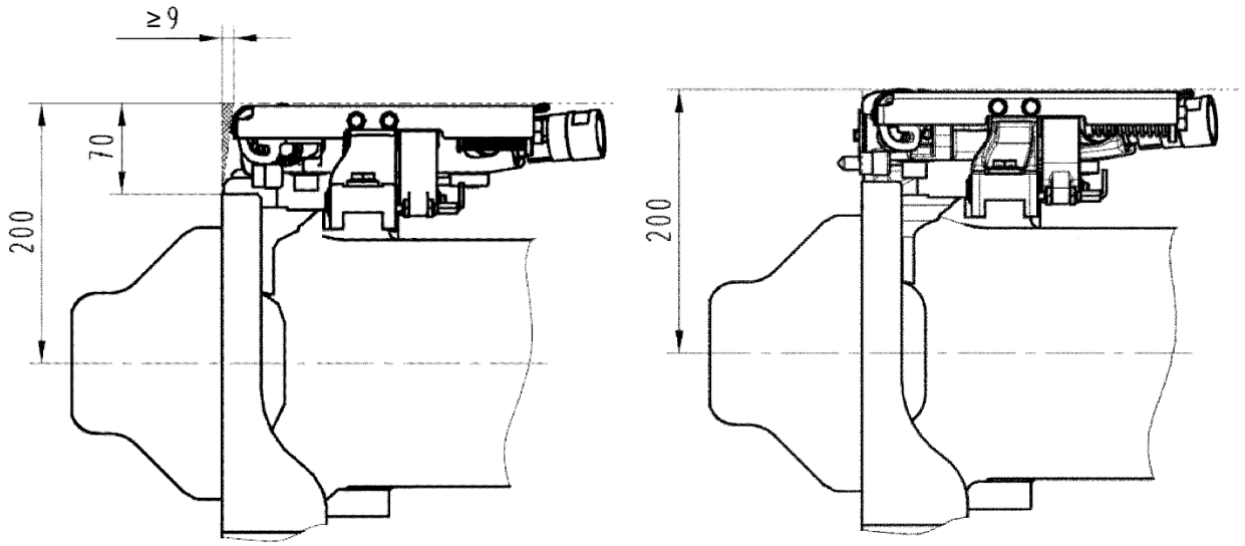
The flap shall fully open during the stroke and shall not protrude beyond the coupling plane.

The front plates of the mechanical couplers may stay in an "A-position" to each other. And therefore, the electrical couplers, too. To prevent collision of the electrical couplers, they must be mounted retracted from the front of the front plate (see grey marked area in Figure A.4).

NOTE 4: "V-position" of the front plates of the mechanical couplers is uncritical for electrical couplers.

The height limitation and free space for impacts with vertical angular offset are shown in Figure A.4.

Dimensions in millimetre



a) ready-to-couple position **b) coupled position**

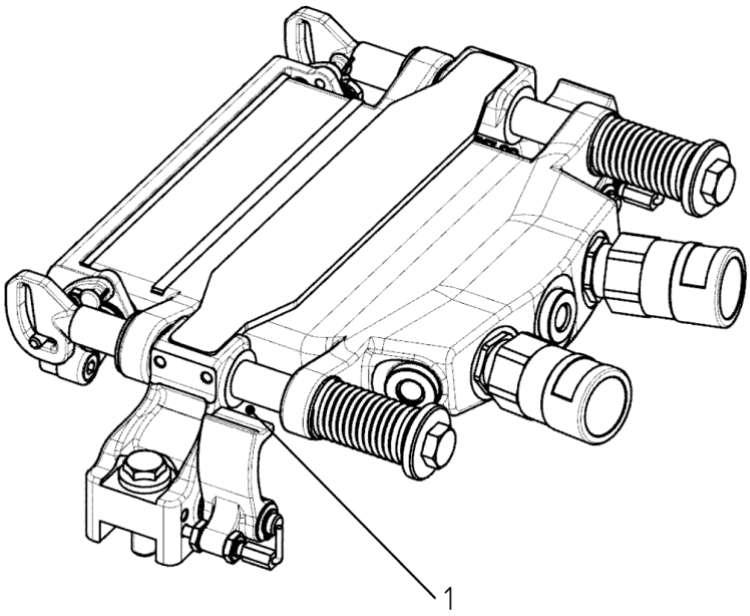
Figure A.4 — Side view of height limitation and free space for impacts with vertical angular offset

As defined in Annex H, a locking device shall be used to prevent flap opening.

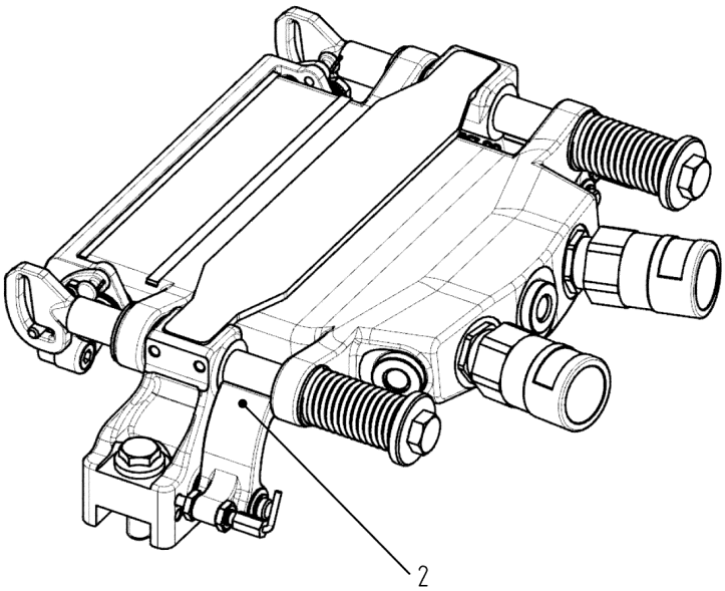
An example of the locking device for the housing which prevents the electrical coupler from opening is shown in Figure A.5.

The inactive locking device is shown in Figure A.5a). It shows the ready-to-couple position of the electrical coupler.

The active locking device is shown in Figure A.5b). It shows the ready-to-couple position but with the locked electrical coupler.



a) open position



b) closed position

Key

1 unlocked

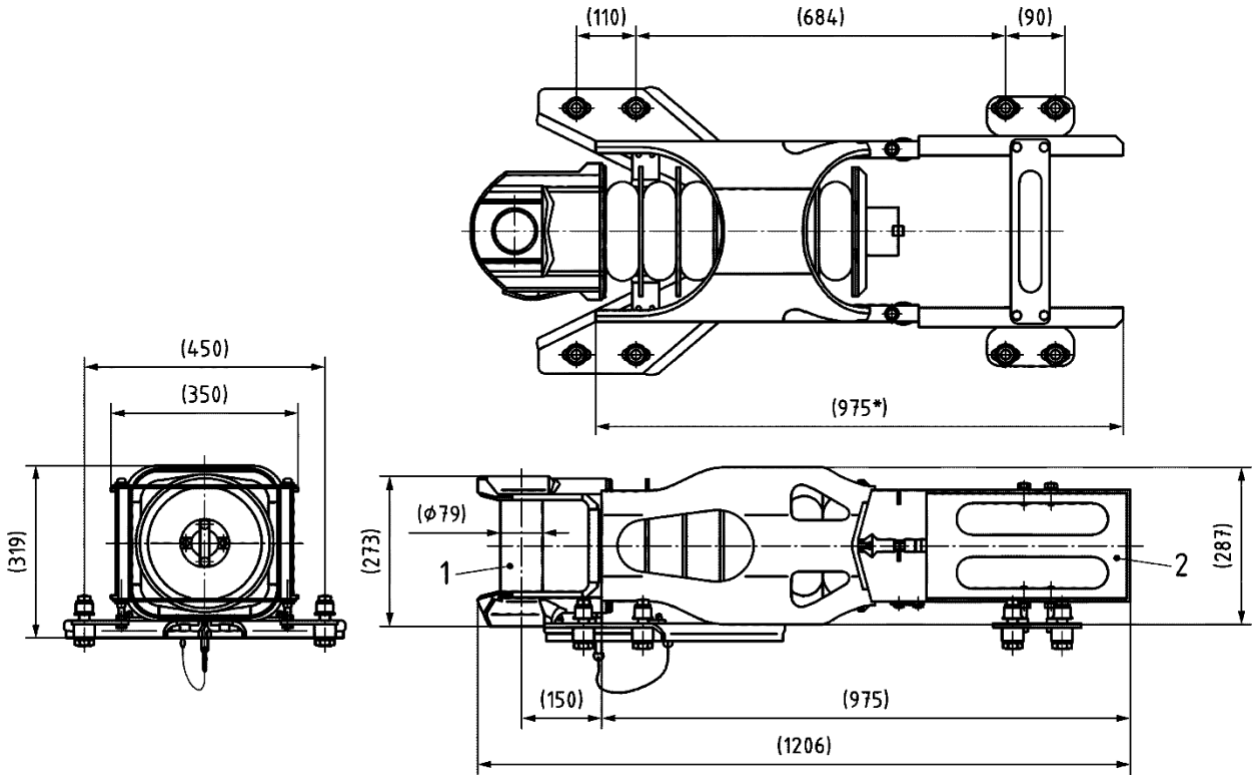
2 closed

Figure A.5 — Locking device

6.4 Coupler Draft gear

The coupler draft gear contains an energy absorption element and represents the mechanical connection between the DAC and the freight wagon. The coupler draft gear is classified by the stroke and dynamic energy capacity based on the standard DIN EN 15551 and DIN EN 15566.

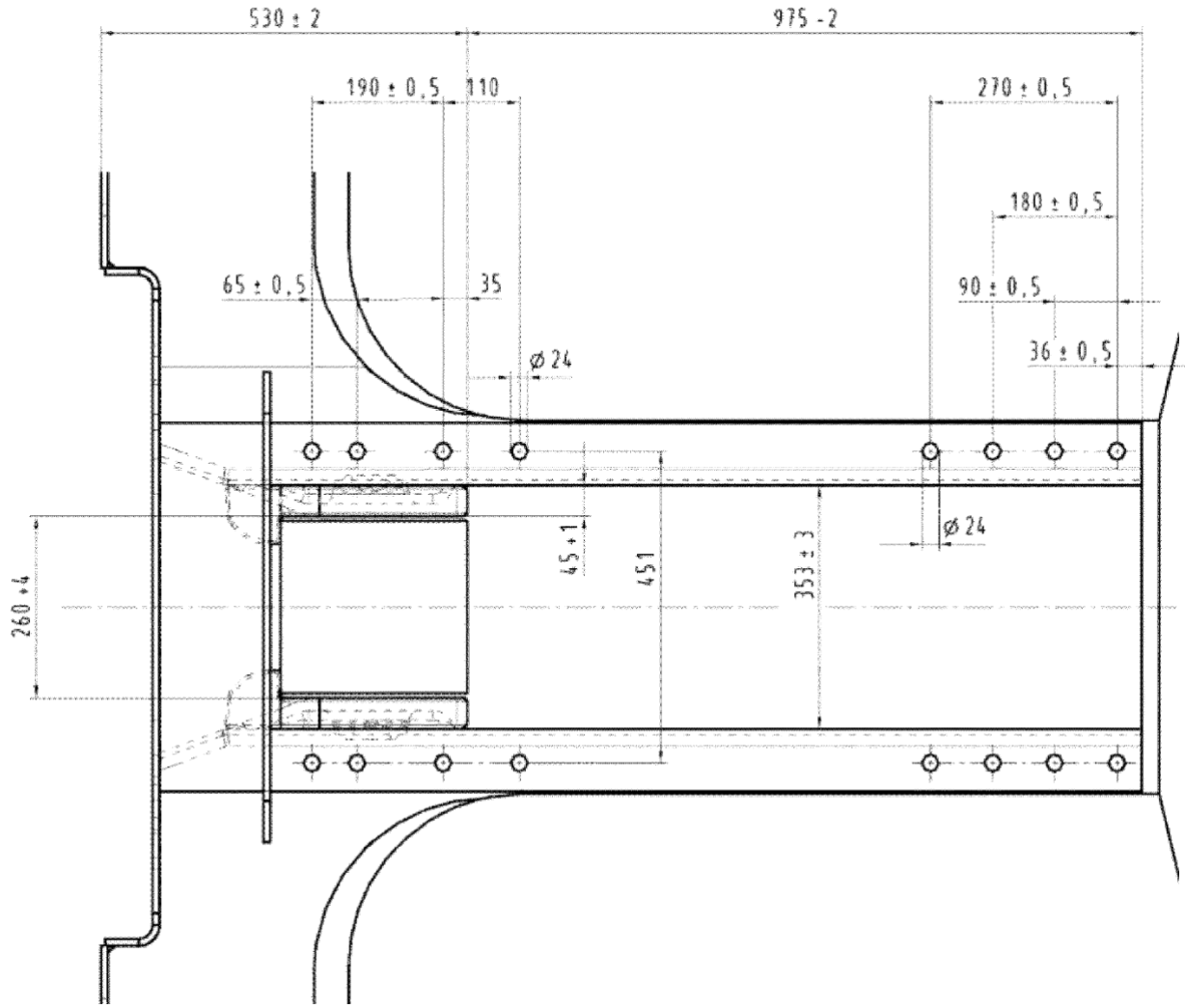
The standard coupler draft gears with a buff stroke of 110 mm are generally used for general freight wagons and category L rear parts are designed for impact-sensitive freight wagons and have therefore an increased buff stroke of 150 mm. The draw part of the energy absorption element is similar for all coupler draft gears. The stroke is limited to 70 mm to protect the wagon flaps during the service. The **Error! Reference source not found.** Figure 5 Draft gear interface according to UIC 530-1 appendix 4bshows an example a draft gear interface on the basis of UIC 530-1 Appendix 4b.



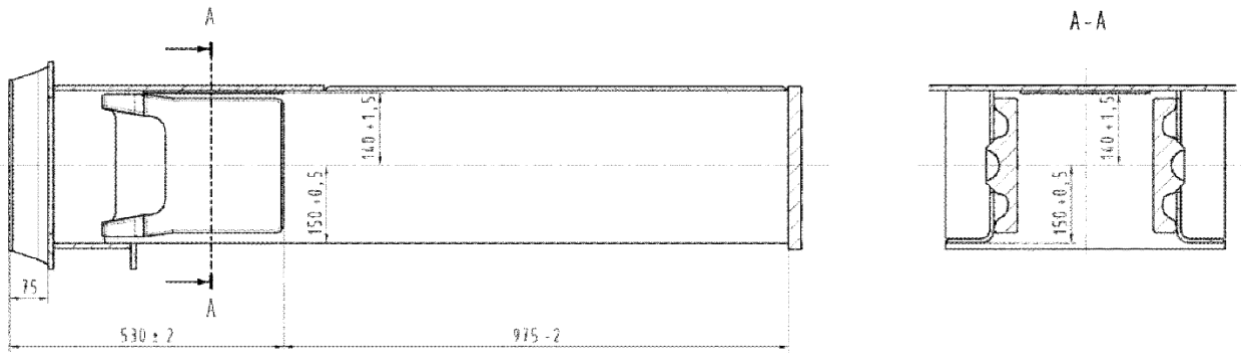
Key

1 Pin
2 Spacers

Figure 5 Draft gear interface according to UIC 530-1 appendix 4b



TBD: bottom view



TBD: Installation spaces

6.4.1Draft gear main characteristics

Table 2 shows force stroke characteristics of the different configurations which will allow for similar LCC. For reference Table 3 is included to show the characteristics of a draft gear only based on EN 15566.

	Category A Standard draft gear	**Category AX Standard draft gear and crash**	**Category C Hydraulic or hybrid draft gear**	**Category L Long stroke draft gear**	**(Long stroke) Special**
Space envelope	UIC530-1	UIC530-1	UIC530-1	UIC530-1	
Elastic compression stroke (mm)	110 mm (UIC524)	110 mm (EN 15551)	110 mm (EN 15551)	150 mm (EN 15551, Table I.4)	150 mm (EN 15551, Table I.4)
Elastic compression force (kN)	< 2,000	< 2,000	< 2,000	< 2,000	< 2,000
Tension stroke	40 to 70 mm	40 to 70 mm	40 to 70 mm	40 to 70 mm	*40 mm to 70 mm*
Energy absorption (kJ) Acceleration (g)	Absorbed energy (Wa) ≥ 75 kJ in Compressive direction ≥ 20 kJ Tensile direction	≥ 675 kJ incl. reversible and irreversible energy absorption	≥ 140 kJ	2 g	appr. 1 g (for the kingpin of trailers in intermodal transports)
Crash stroke (mm)		260 mm to 275 mm (length of coupler from head stock to coupler plane of 645 mm or 620 mm as defined in DAC SPEC			
Trigger force (kN)		3,000 kN (0 - 15%) for trigger force for irreversible energy absorption element (static)			
Impact speed	12 km/h 90 t. vs. 80 t	Tests defined in the standards for crash buffers EN 15551 ch. J.2 (impact speed has to be chosen between 18 km/h and 54 km/h for	According to EN 15551	Depending on scenario	7 km/h; Scenario 1: 80 t vs. 80 t with 1 g buffer on both wagons

	Category A Standard draft gear	Category AX Standard draft gear and crash	Category C Hydraulic or hybrid draft gear	Category L Long stroke draft gear	(Long stroke) Special
		gravel wagon 80 t vs tank wagon 90 t, so that energy level of 675 kJ is reached)			Scenario 2: 30 t vs. 80 t with CAT against CAT L buffer

Table 1: Draft gear characteristics wagons

Optionally the draft gear can be fitted with a stroke indicator. If the automatic coupler has been exposed to unacceptable loads that may have caused damage to the draft gear, this damage shall be readily visible by using a mechanical stroke indicator. The stroke indicator should be placed such that it is easily visible. 0
To keep the longitudinal force level occurring during braking as low as possible, the preload force should be between 20 to 100 kN. For buff characteristics table 2 shall be used. For more information see EN 15551.

Coupler systems installed on wagons indicated as dangerous good transport shall be equipped with draft gears of category AX.

6.4.2 Draft gear force stroke parameters

Category	A	AX	C	L
Stroke	$110^{+10}_{-5}\ mm$			$150^{+10}_{-5}\ mm$
Initial Force 5 mm	20 kN to 100 kN		15 kN to 100 kN	20 kN to 100 kN
Force 25 mm	60 kN to 260 kN		N/A	60 kN to 260 kN
Force 50 mm	-			60 kN to 200 kN
Force 60 mm	200 kN to 800 kN			-
Force 100 mm	-			300 kN to 900 kN
Force 105 mm	700 kN to 2 000 kN			-
Force 145 mm	-			700 kN to 2 000 kN
Dynamic Energy	≥ 75 kJ	≥ 75 kJ	≥ 140 kJ	-

Capacity W_{ed}				
Stored Energy W_e	25 kJ $W_e \leq$ 2 000 kN		-	36 kJ $\leq W_e \leq$ 1 760 kN
Absorbed Energy W_a corresponding to the preceding stored Energy for First Cycle	$\geq 0.5\ W_e$			
Absorbed Energy W_a corresponding to the preceding stored energy for the second and third cycle	$\geq 0.42\ W_e$			

Table 2: Overview Draft Gear Categories force stroke parameters compression (see EN 15551 - Railway applications – Railway rolling stock – Buffers for reference and definitions)

The length of the coupler from the head stock (buffer fastening plane) to the coupler plane shall be 620 mm for a DAC equipped with standard draft gear type A and C.

For a DAC equipped with a long stroke draft gear type L the length of the coupler from the head stock to the coupler plane shall be 665 mm.

Category	D
Stroke	$50_{0}^{+20}\ mm$
Initial Force 5 mm	20 kN to 100 kN
Force 25 mm	60 kN to 260 kN
Force 45 mm	350 kN to 1 000 kN
Force 65 mm	350 kN to 1 000 kN
Dynamic Energy Capacity W_{ed}	≥ 20 kJ

Table 3: Tensile characteristics EN 15566

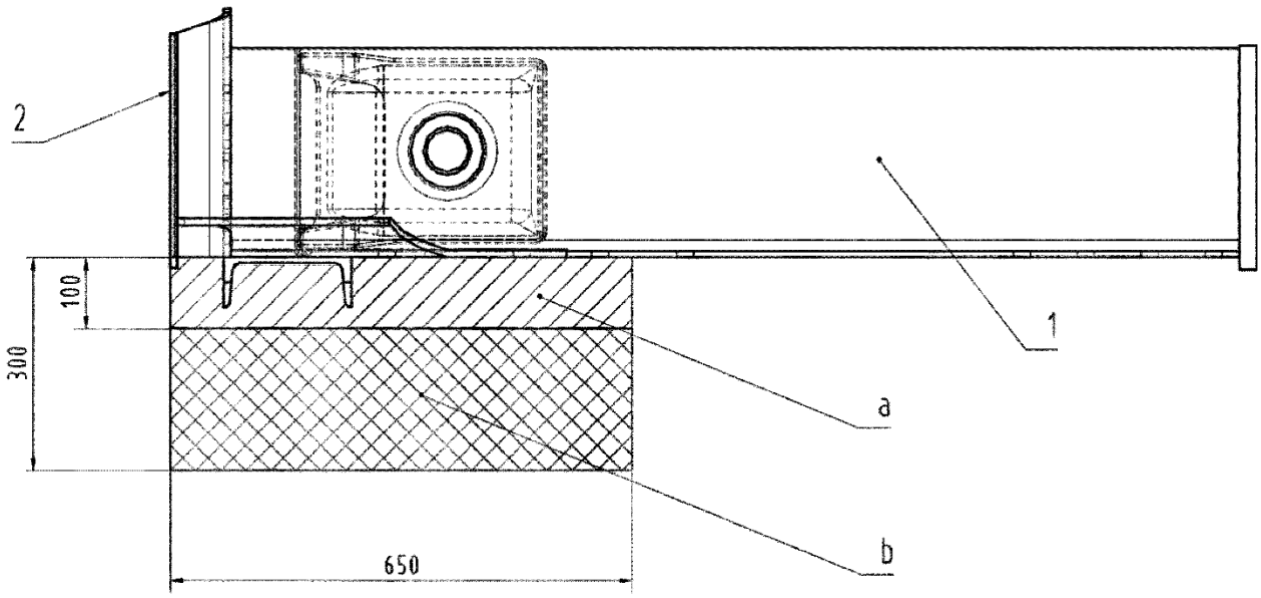
6.4.3 Mechanical stroke indicator

A mechanical stroke indicator can be seen as a optional feature.

If the automatic coupler has been exposed to unacceptable loads that may have caused damage to the draw gear.
The stroke indicator shall be visible from the bottom of the wagon and is in the area based on Figure 6 Full Stroke Indicator placement example side view.

To simplify the wagon inspections the stroke indicator shall be red (RAL 3001).

For functional level 5 systems optionally, an electrical device can be used to indicate a full stroke.



Key

1 Underframe
2 buff fixing plane
a Full stroke indicator shall be placed in this area when mounted
b Full stroke indicator shall be placed in this area when activated

Figure 6 Full Stroke Indicator placement example side view

6.5 Vertical Support and Centring Device

Due to the different distances between the upper edge of the rail and the center line of the coupler during operation and the variable horizontal positions of the vehicles on the track, the articulated front part of the coupler must be supported elastically.

The coupler shall be equipped with a horizontal and vertical support. The support shall enable adjustment of the coupler front face to be parallel to the mounting plane of the side buffers. Tolerance ± 0.5°.

The hight of the coupler middle line shall be according to EN 16839 table 2 under all loading and wear conditions: 940mm to 1 065 mm. Wagons should be able to accommodate this build height. Please see TSI Wag Annex C for more information.

In event of failure of the vertical support the coupler head shall not fall and reach the track. The support and centring shall ensure that the coupler returns to a centred position, thus when uncoupled and a wagon is moved the DAC should horizontal self-centre to a neutral position (0° to ± [2]°) on tracks without slope.

To guarantee that the gathering range is always maintained and to reduce the offsets between the center line of the coupler, the support must be provided with a device for centering the coupler after uncoupling.

The centring does not have to be immediate and may be gravitational.

Note: An acceptable readjustment to centre is within approximately 50 meters after moving the vehicle from standstill.

To ensure interoperability, the support must meet kinematic requirements. The support must not hinder the horizontal and vertical movement of the coupler. The support must allow a horizontal deflection of at least ± 17° degrees and a vertical deflection of ± 6° degrees. At maximum horizontal deflection of the coupler until contact with the vehicle undercarriage, the support shall not be damaged.

Manual deflection of the DAC to a maximum angle of 6° may be possible by overriding the self-centring functionality. The manual force to be applied for manual deflection shall not exceed 400 N.

The hole pattern to be used shall follow that defined in prEN18171 Annex C. See UIC 530-05 Appendix E for reference.

It must be ensured that the support and the bolted connection meet the strength requirements for equipment on car bodies according to DIN EN 12663-2.

Note: The designs should consider the placement of existing infrastructure on the wagon, such as endcocks.

The hole placements for vertical support is shown in Figure 7 Hole placements for vertical support.

Dimensions in millimetre

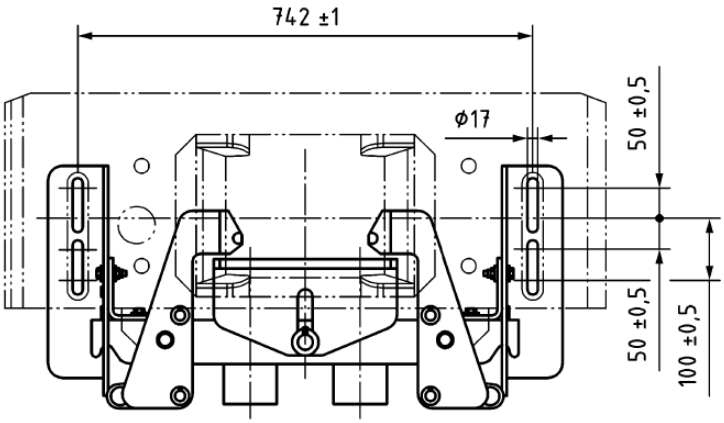
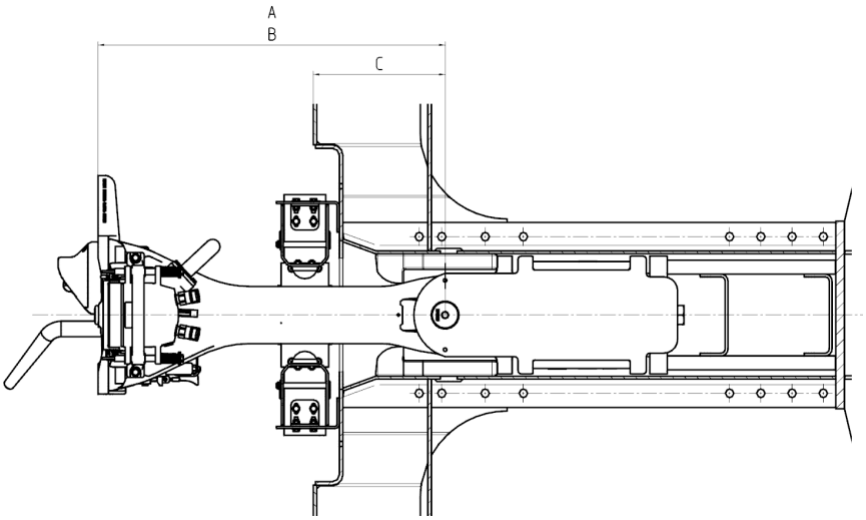


Figure 7 Hole placements for vertical support

6.6 Pivot point



Key
A 1000+10/-15 mm Coupler in relaxed position

B not used
C 380 mm buff fixing plane to pivot point (EN 15566:2022) for type A, AX and C draft gears
C 350 mm buff fixing plane to pivot point (EN 15566:2022) for cat L draft gears

Note: These lengths are chosen such that the length over DAC (coupling/buffer plane) needs to be unchanged compared to the length over buffers before retrofit. A change in length would result in too many changes in infrastructure (e.g., loading sites, loading connections to tank wagons, ...). Draft gear and DAC shank/head is defined accordingly.

Figure 8 Schematic drawing of coupler intended for freight wagon installation

The pivot is defined as the horizontal rotational point between coupler arm and draft gear. The pivot point shall be situated 380 mm behind the head stock (buffer fastening plane)

Note: This value is valid for a DAC equipped with draft gears category A, AX and C.

The diameter of the pivot pin for the DAC between the draft gear and coupler shank shall be designed according to EN 15566:2022, ie 79 mm (h11).

Note: This requirement can be adapted for special wagon types.

It shall be possible for one person to remove and install the main pin. Note special boogie configurations can conflict with this requirement.

6.7 Using UIC hook with pivot pin of DAC draft gear

The DAC draft gears shall via the pivot pin be compatible with a EN 15566:2022 hook interface. Adapters on the pin are acceptable to ensure correct height. See Figure 9 Spacers / adapters together with a EN 15566:2022 hook in a DAC draft gear.

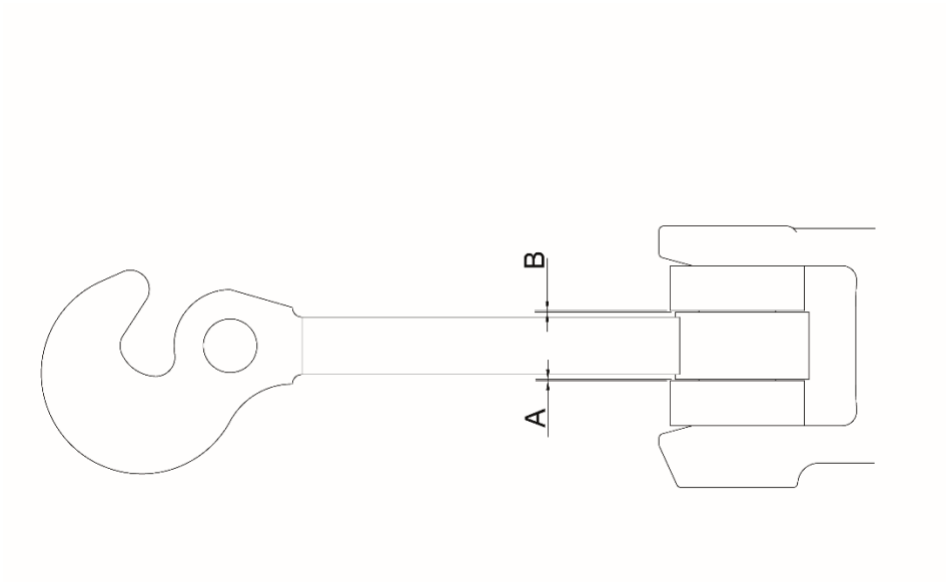


Figure 9 Spacers / adapters together with a EN 15566:2022 hook in a DAC draft gear

It shall be possible to install a DAC coupler head without special tools to a pin.

Note: This feature is necessary to ensure the DAC ready transition.

Key A and B are spacers.

7 Technical interface specification of wagon DAC

DAC is intended for the installation on a freight wagon that meets the relevant requirements for centre buff freight wagons.

7.1 Interface for existing wagons

The installation space according to UIC 530-1 annex 4a (edition 2, 1982.04), for the design of the coupler with cross beam support and for wagons with spring strut support annexes UIC 530-1 6a and 6 b (edition 2, 1982.04) are decisive. Contact point b is not required and can be neglected. It shall not be required to remove the contact point b to install a digital automatic coupler draft gear into the installation space.

For existing and new wagons not compliant to UIC 530-1 (edition 2, 1982.04) adaptations may be made. The characteristics defined for the draft gears and pivot point defined in this standard should be maintained.

Force transmission into the underframe shall be in accordance with UIC 530-1, Annex 1 (edition 2, 1982.04) to the tension and compression stops according to Section 5 or Annexes 4 and 6 (UIC 530-1 edition 2, 1982.04).

For wagons with modified installation space a maximum height of 120 mm above the centre line of the coupler draft gear should be considered.

The mechanic interface between the digital automatic coupler and the vehicle should fulfil the following specifications.

- Contact point b is not required and can be neglected. It shall not be required to cut-off the contact point b to install a DAC draft gear into the installation space.
- Force transmission into the underframe shall be in accordance with UIC 530-1, Annex 1 to the tension and compression stops according to Section 5 or Annexes 4 and 6. If necessary, side plates may be installed in the installation space.
- The fixing plates should have a thickness of 20 mm (position 6).
- The number of bolted connections can be defined by each company based on their own design based on the possible positions A to H in Figure 10 Installation space bottom view
- The interface areas between the plates and the wagon should be primer coated and the

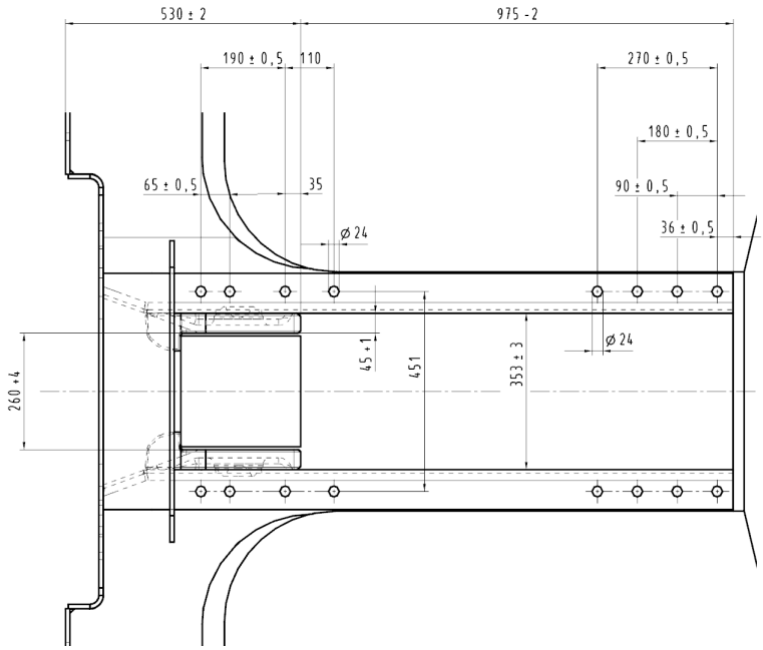


Figure 10 Installation space bottom view

Screw elements should have sufficient corrosion protect see chapter 6.2.

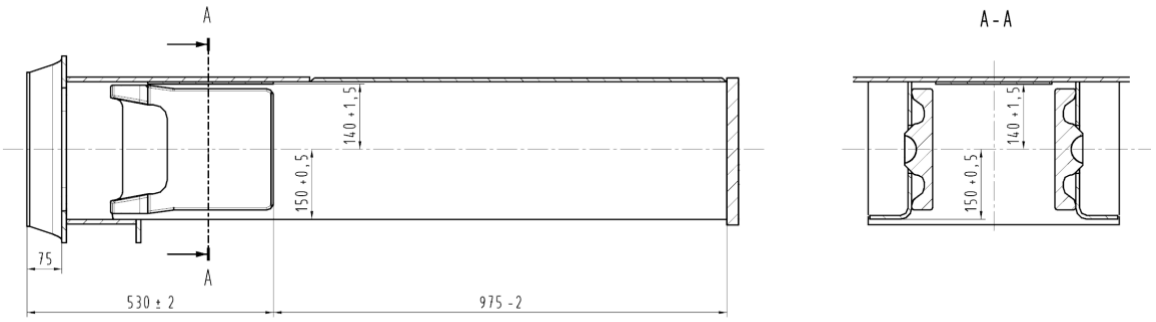


Figure 11 Installation space cut side view

7.2 Pneumatic interface to the vehicle

The vehicle shall be fitted with a pneumatic hose connected to the main brake pipe (BP) which can be attached via a screw connection G 1 ¼ inches to the coupler. The length of the thread has to be min. 20 mm. The position of the screw connection interface to the coupler is defined in picture Figure 12.

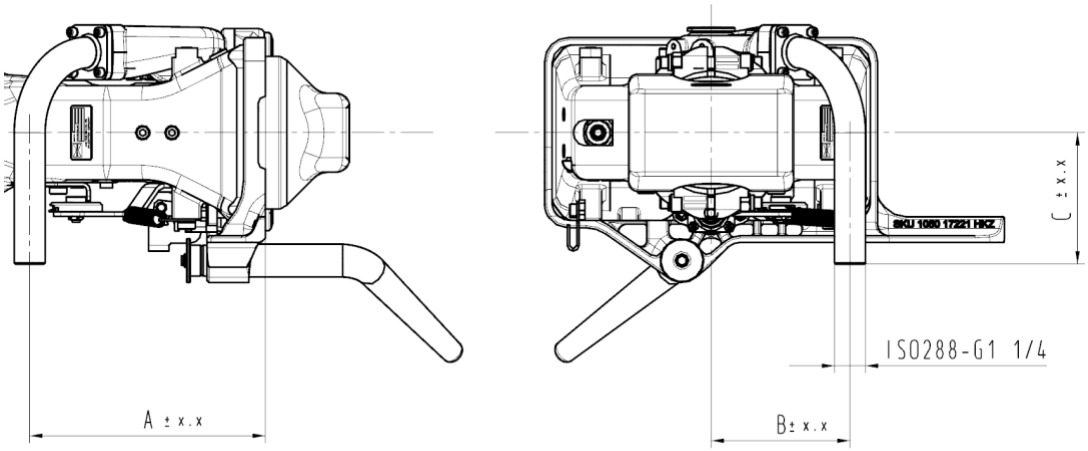


Figure 12 Position of the screw connection of the brake pipe (BP) - examples

Optionally the vehicle can be fitted with a pneumatic hose connected to the main reservoir pipe (MRP) which can be attached via a screw connection G 1 inch to the coupler.

The vehicle shall be equipped with connections for brake pipe (BP) according EN 16839:2022, Figure 9.

Air stopcocks in accordance with EN 14198:2016 + A2:2021 on the vehicles shall be retained.

Optionally the vehicle can be fitted with a pneumatic hose connected to the main reservoir pipe (MRP)which can be attached via a screw connection of 1 inch. The length of the thread has to be minimum 18 mm. The area of the screw connection interface to the coupler is defined for both sides to have a standard length for the hose of all suppliers.

The body of the end cock shall have an internal thread G1i-EN ISO 228-2 for the MRP line or G11/4i-EN ISO 228-2 for the BP line. The end of the body adjacent to the internal threads shall be of hexagonal form or have flats. If required by the Purchaser, the body end can have a flat sealing face for « Flange » type of connections.

7.3 Electrical and data connection to vehicles[12]

[The Electrical and data connections to vehicles are defined in 16839:2022 chapter 9]

In the future via plug connector or junction box. Ref to CENELEC CLC/SC 9XB

7.4 Uncoupling / prevent coupling from side of wagon

A manually operated device can be used to enable uncoupling and prevent coupling position from both sides of the wagon. The wagon shall be prepared in such a way that this lever can be installed and operated as intended.

[12] To be reworked after final decision of e-coupler

8 Product specification of Locomotive Hybrid Coupler

The hybrid coupler is a special design, incorporating the functional features and interoperability requirements of the digital automatic freight coupler for wagons but also accommodating the possibility to use a conventional UIC draw hook together with a side buffer system.

The hybrid coupler has two defined positions: DAC and screw coupler mode.

If required, the draw gears and draw gear/pivot interfaces may be adapted to enable the different operational modes.

The hybrid DAC used in locomotives shall meet the crash worthiness requirements set out in EN 15227:2020 for centre buffer freight couplers.

The installation for locomotive can be done using a flange system.

All hybrid couplers shall be prepared to have an optional electrical system to indicate the position “DAC” or “screw coupler” mode.

The DAC parts which will be subjected to 30 years life expectancy shall be tested according to load spectrum in ch 6.1 General requirements.

For exceptional special installation cases, if life expectancy of the locomotive is expected to be considerably lower than 30 years, exceptions to the load spectrum can be made.
The distribution between UIC and Hybrid mode is 1:2.

The clearance area (Berne rectangle) according EN 16839:2022 may be infringed for vehicles equipped with side buffers and DAC[13]. The infringement into the clearance area should be kept to a minimum in these cases.

For the coupled state all possible interference cases need to be investigated, in order to ensure a free horizontal and vertical deflection on both vehicle ends, also in relation to applicable longitudinal strokes of the draw gear. For a hybrid DAC, both coupler modes (DAC and Screw coupler) need to be analysed.

Note: One (Locomotive) hybrid-DAC in screw coupler mode and one (Locomotive) UIC-Screw coupler must be able to be coupled without negative interference from any component (e.g. DAC part of hybrid coupler) - rationale: ensure double traction while migration of the locomotive fleet. Since the other mating loco is not known it is advised that the hybrid coupler should not infringe the mating wagons Berne rectangle.

[13] This is to be checked and defined if needed.

8.1 Digital Automatic Coupler for freight mode

The coupler shall be compatible with and fulfil the relevant requirements of a digital automatic freight coupler system paragraphs 6 to 7 of this document.

If external components are needed to switch from Screw coupler to DAC mode or from DAC to screw coupler mode, the total weight of any hand handled component may not weight more than 25 kg. [14]

The maximum force needed to change modes manually shall not be more than [250 N], e.g. crank handle.

The hybrid coupler is to be designed for:

1. Smooth coupling between 0.6 to 3 km/h
2. coupling speeds up to 5 km/h to be handled on frequent bases
3. for 7 km/h the energy absorption system of the hybrid coupler shall be designed in the way that the deceleration (inside the driver's cab) does not exceed a mean deceleration of 2 g for coupling up to 7 km/h or a maximum force of 2 000 kN.

Note: As an accident scenario a speed of 7 km/h is defined for main line locomotives (running against a braked wagon with a total weight of 80 tons which is equipped with a digital automatic coupler with a standard draft gear (Cat. A). See EN15227:2020, Annex C.2 for definition of obstacle. EN 15227:2020 has to be used to determine the mean deceleration.
When the UIC coupling function is not in service, the UIC coupler shall be secured against unintentional movement.

The fatigue load shall be adapted to 20 years life expectancy based on 67% of usage in DAC mode.

The distance between the buffer plane and the coupler plane shall be 360 mm. The 360 mm ensure avoidance of buffer collision in double traction DAC mode as well as ensuring a safe train dynamics. See figure bellow for a concept drawing.

[14] Add reference to standard

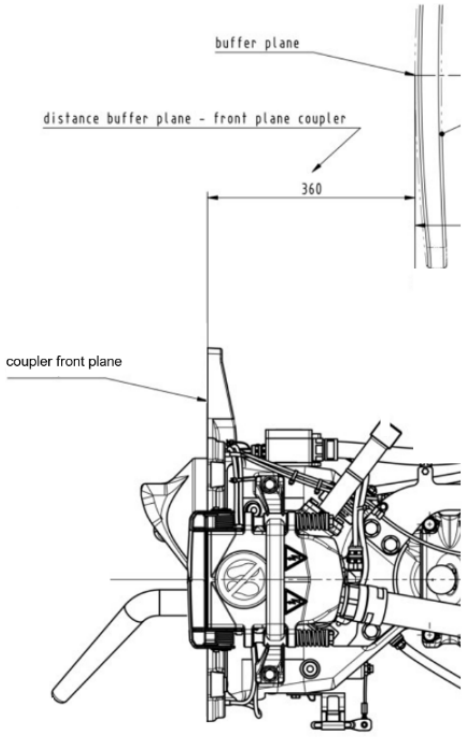


Figure 13 Distance between the buff plane and the coupler plane

8.2 Screw coupler mode

The hybrid coupler shall be compatible with the Screw coupling system (screw coupler, hook and side buffers) according to EN 15566:2022 and EN 15551:2022.

The DAC mode shall clearly be put out of use and the automatic coupler head shall not affect the function of the screw coupling systems coupling procedure.

When the automatic coupling function is not in service, the automatic coupler shall be secured against unintentional movement.

The connective element (mixed train coupler) as part of the hybrid coupler shall fulfil the strength requirements of 1.5 MN coupling system according to EN 15566:2022.

Fatigue loads shall be tested according to EN15566:2022 table A.3 for equivalent of 10 years to reflect a 33% usage of this position for a 1.5 MN screw coupler.

The used buffers shall fulfil the requirements according to EN 15551:2022.
If the automatic coupling function is not in use, the spaces to be respected according to the clearance gauge of EN 16839:2022 shall not be restricted.

If using the UIC coupling point the pneumatic connection between the vehicles shall be done manually.

The pneumatic connection between the vehicles with different coupling systems shall be made via a UIC/TSI compliant interface according EN 16839:2022

If the screw coupling system is in use, and an electrical and data connection is required between the vehicles this shall be connected manually.

Interaction of draw hook and side buffer in a 150 m curve shall follow the requirements inEN 16839:2022, 5.4.1.

8.3 Berne rectangle and design requirements

To operate the screw coupling, the Berne rectangle and the spaces around the draw hook must be left free according to EN 16839:2022, Figure 1 and 6. If this is not possible for a hybrid coupler with draw hook, the hybrid coupler cannot have a draw hook and coupling must be done with the draw hook of the adjacent car.

In this case, the hybrid coupler must be equipped with a functionally identical screw coupler, which allows to connect the shackle link to the towing hook and to adjust the short and long positions.

8.4 Installation conditions

The hybrid coupler must be designed so that the difference between the nominal height of the screw coupler and the nominal height of the buffer centre line of the hybrid coupler is between 0mm and 20 mm. These requirements are shown EN 16839:2022, Figure 6 (buffer centre line [A] above draw hook centre line).

8.5 Short and long position in screw coupler mode

The hybrid coupler must allow the screw coupling system to be extended to enable manual coupling or for example to enable driving on tight curves and decoupling using a rod in marshalling yards. The extended length L_1 of the mixed train coupler shall be oriented to D_1 = 986 mm +10/-5 mm according to EN15566:2022, chapter 6.1.

The hybrid coupler must allow tightening of the screw coupling system so that the buffer plates touch each other. To secure tightening the length L_2 of fully tightened mixed train coupler shall be oriented to D_2 = 750 mm +/-10 mm defined in EN15566:2022, chapter 6.1. See figure below for guidance.

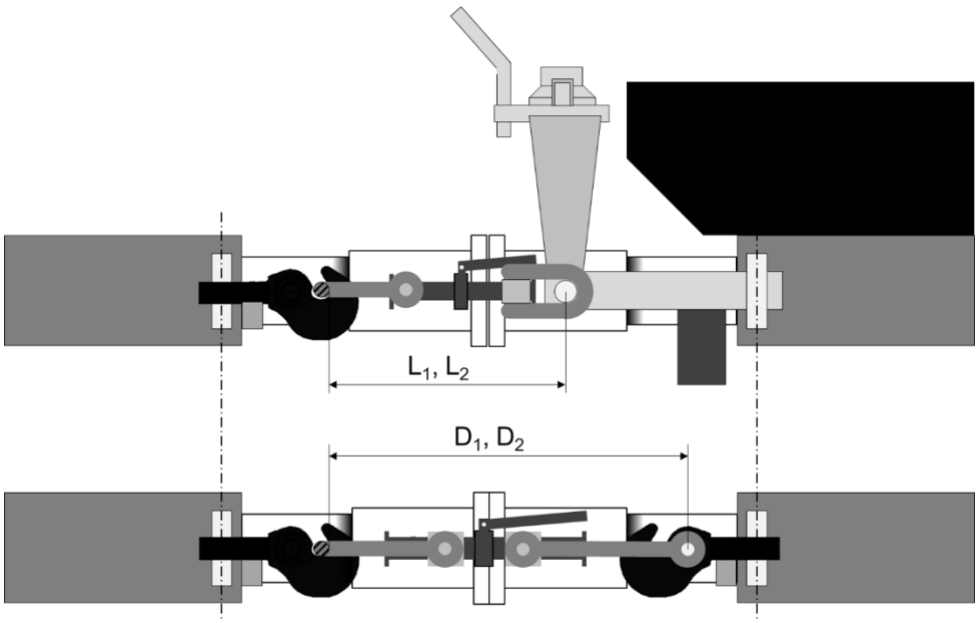


Figure 14 Length of mixed train coupler in screw coupler mode

8.5.1Interaction of draw- and buffing-gear

According to TSI Loc and Pas chapter A.3, the interaction of UIC draw gear must be checked with a hybrid coupler draft gear. The static characteristics of draw gears and buffers shall be coordinated in order to ensure that a train is able to negotiate curves with a minimum radius of 150 m under normal coupling conditions (e.g. without locking buffers, etc.). After replacing the screw coupling system of a locomotive with a hybrid coupler, it must always be checked whether the tight curves previously driven can be maintained in the coupled state.

8.5.2 Strength requirements

The DAC part of the hybrid coupler should follow the requirements set out in this document for DAC (chapter 6). For the UIC hook the coupler should follow the relevant UIC standards.

Note 1: The fatigue strength of the hybrid coupler shall consider the information on use on DAC and UIC mode in chapter 8.1 and 8.2.

Note 2: Requirements to prevent overriding shall be wagon specific.

8.5.3 Installation space for draft gear of hybrid coupler

There is no general installation space defined in any standard or norm. Each locomotive type will need an individually engineered solution.

8.6 Change mode between DAC and UIC

In the DAC mode the coupler has to transfer high tension and compression forces it is to be foreseen to have a manual lock between the head and ideally the coupler shank. The manual locking device has to be designed in a way that it can be used to secure the mode position of the hybrid coupler in the same way for both UIC and DAC mode.

8.7 Coupler draft gear

The draft gear must meet the requirements of the locomotive.

For crash worthiness EN 15227:2020 for heavy duty couplers shall be followed.

8.8 Vertical Support and Centring Device

Not possible to standardize.

9 Future work items (DB/SBB)

One of the most important tasks remaining is to move requirements defined in this deliverable into Polarion (requirement handling tool) to give each requirement a unique identifier and match them with the operational requirements.

As work with testing and using the DAC several requirements are being identified and refined. Here a list identified areas of requirements which need to be incorporated in the next official revision of the DAC requirements. This shall be done using a change management process which can assess the impact of the suggested change.

Area	Requirements	Note	Action
Hybrid couplers	Two hybrid-DAC on locomotives must be able to be coupled in DAC-Mode without negative interference from the side buffers or any other component -rationale: ensure double traction after migration of the locomotive fleet. "Distance between side buffer plane and DAC buffer plane?"	From Revision 1 Closed	Collect data from Rail Freight Operators Added to Revision 2 released Feb 2025
Hybrid couplers	One (Locomotive) hybrid-DAC in screw coupler mode and one (Locomotive) UIC-Screw coupler must be able to be coupled without negative interference from any component (e.g. DAC part of hybrid coupler) - rationale: ensure double traction while migration of the locomotive fleet	From Revision 1 Closed	Collect data from Rail Freight Operators Added to Revision 2 released Feb 2025
Environmental conditions	Environmental conditions / special operating areas (e.g. corrosive environment, hot loading on wagons)	From Revision 1 Closed	Collect data from Rail Freight Operators Added to Revision 2 released Feb 2025 See salt spray test
Special operations	Wagons 180° upside-down in emptying-mechanisms must be possible (max top deflection to be considered)	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Added to Revision 2 released Feb 2025 Not possible with DAC in connected wagon configuration. Added that the coupler shall be able to handle being rotated 180° (Upside down)
Pivot	One person managing the 79 mm pin at DAC-ready to DAC	From Revision 1 Closed	Feasibility from DAC core Added to Revision 2 released Feb 2025

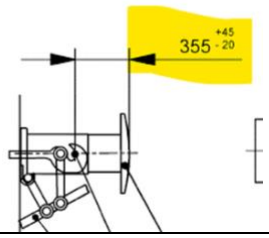
Draw gear	Draw gear and DAC coupler head & shank shall get a visual indication of the centre of gravity	From Revision 1 Closed	Feasibility from DAC core
Support and centring	The connection of the vertical support to the wagon needs to be harmonized. When the wagon is made DAC ready, this interface needs to be prepared (e.g. drilling of new holes for screws; if not already given according to UIC standards or others). In the second step, it shall be possible to mount vertical supports of all manufactures (together with the respective coupler head) to the prepared wagon without further modifications of the wagon front (e.g., no drilling of holes at other positions).	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core See prEN18171 Annex C Mounting points are the same
Hybrid coupler	Load spectrum distribution and number of years need to be revised based on better running data	From Revision 1 Open	Collect data from Rail Freight Operators Feasibility from DAC core No new data has been put forward by operators. For revision 2025 no change.
Definition - Hybrid	The clearance area (Berne rectangle) according EN 16839:2022 may be infringed for vehicles equipped with side buffers and DAC	From Revision 1 Open	Feasibility from DAC core No new definition has been put forward. Added: The infringement into the clearance area should be kept to a minimum in these cases. Smaller gathering range can improv situation. Operators to revert with feedback if the gathering range can be reduced and how much. This will be tested in WP8
Actuator	Max time for rotating the coupling mechanism to uncoupled position: <3 seconds	From Revision 1 Open	Collect data from Rail Freight Operators Feasibility from DAC core Open due to connection to other dependencies
Coupling	Time signal time from signal to prevent coupling and or external device remove prevent uncoupling	From Revision 1 Open	Collect data from Rail Freight Operators Feasibility from DAC core Open due to connection to other dependencies

Coupling	For level 5 systems the prevent coupling system should be visible even without power.	From Revision 1 Closed	Feasibility from DAC core Buff will only be possible with an actuator according to latest architecture. Thus, light for buff. Added: “For level 5 the prevent coupling shall be indicated using an electric device such as a lamp.”
Coupling	Prevent coupling system should be visible	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Added: “For level 5 the prevent coupling shall be indicated using an electric device such as a lamp.”
Electrical coupler	The electrical coupler shall be protected from falling material and manage a force of XX	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Included
Draft gears	Stroke indicator only for AX draft gears	From Revision 1 Open	Collect data from Rail Freight Operators Operator alignment pending
General	“The couplers should be designed so that the occurrence of an unintentional mechanical disconnection without the working of the brake on the hauled train or /and the leading train shall not exceed 10-9 per train operation hour and the occurrence of unintentional uncoupling shall not exceed 10-6 per train operating hour.”	From Revision 1 Closed	Feasibility from DAC core Removed. It is a part of the train requirements and cannot be moved into D5.2
General	Weight of wagon coupler	From Revision 1 Open	Collect data from Rail Freight Operators DAC Core 480 kg max stands if derailment value of 500 kN stands Operator alignment pending
General	Weight hybrid coupler	From Revision 1 Closed	Collect data from Rail Freight Operators DAC core: too large variation on Locomotives. No standardisation of values possible

General	Impact test requirements. Should these be added? What values?	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Included in draft gear table and D5.3
General	Fatigue load spectrum updated	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Updated via CEN WG
Uncoupling	3 second for electrical uncoupling	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core See above. Double entry
Draft gear	Trigger force for AX	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core See table 6.2 (AX)
Support and centring	Re-centring – review of requirements 4 degree to 2 degree	From Revision 1 Open	Feasibility from DAC core Changed to 2 degrees in CEN For type 10 4 degrees is enough Lower value needs to be evaluated. Vs safety case
Workers health and safety	- The maximum force needed to change modes manually shall not be more than [250 N], eg crank handle. - Uncoupling force of wagon DAC [150N] - Max weights for extra parts 25 kg - Emergency uncoupling forces 400 N - Manual deflection 400 N	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Workshop Note Manual uncoupling not selected
Workers health and safety	- Colour of uncoupling indicator - Size of the uncoupling indicator	From Revision 1 Closed	Collect data from Rail Freight Operators Feasibility from DAC core Workshop included

DAC control	Requirements for interface DAC control unit and train consist unit	From Revision 1	Feasibility from DAC core
Coupling	Definition of “normal” conditions for uncoupling	From Revision 1	Collect data from Rail Freight Operators Feasibility from DAC core

Table 4: Future work items

Area	Requirements	Note	Action
Environmental conditions	INSTA 851 - what should be included	New rev 2	
Running safety	Nominal breaking point and consequences	New rev 2	
Running safety	Definition of airvalve in 5.2 text	New rev 2	
General	Manual Uncoupling (cross-check if text reflects current decision status)	New rev 2	
Pneumatic	Thread length pneumatic connection	New rev 2	
Pneumatic	Definition of pneumatic performance DAC air housing	New rev 2	
Hybrid coupler	Screw coupler tightening to be taken into acount 15566 appendix A3	New rev 2	
Shank	gear type L the length of the coupler from the head stock to the coupler plane	New rev 2	
General	Standardized earthing solution. E-coupler coupler and coupler to wagon.	New rev 2	

10 Conclusions

The objective of deliverable 5.2 is to create a specification for the design of an interoperable DAC coupler and a DAC hybrid coupler. It is meant to be used by professionals in the industry and require good knowledge of the base products to use correctly.

The report gives good bases for the design of a common interoperable DAC coupler. The document also describes the requirements of the hybrid coupler.

The requirements were developed by using existing standards, preferably CEN / CENELEC as well as the EDDP input documentation. The authors are all experts form the leading coupler suppliers within the passenger rail segment. The document has been reviewed together with freight experts for the operators. The document has been reviewed by other parties within the FA5 project to create objective relevant requirements.

The requirements presented are a mix of mechanical and functional requirements. Where the needed requirements are described at a deeper level than the CEN to allow the FA5 project to achieve a high TRL level faster by eliminating differences in interpretation. There are several areas where there is a fine balance between functional and mechanical requirements where space has been given for future innovation by using functional requirements.

The results for the electrical and data interfaces cannot be finally concluded due to the low TRL (currently level 3-4). It is the view of the main authors that a separate or amended requirements specification for the electrical and data interfaces coupler to coupler and coupler to wagon shall be done when the TRL for data and electrical systems reach a minimum of level 6.

Further amendments, in the future, might occur during or after the testing phase of FA5, as experience is feedback into the project. The authors propose that, if the changes are substantial, a new extra revision should be done as an added deliverable. This is also considering the 27 remaining unsolved requirements which need further testing, have been added late in the review process or have a larger system impact thus cannot be closed without system engineering decisions.

The work in Polarion must be prioritized to ensure that the requirements described in this document are handled correctly.

Based on the requirements outlined in this document there is a high probability of achieving an interoperable wagon DAC and hybrid DAC.

11 References

1. DIN EN 12663-1:2015-03 Railway applications - Structural requirements of railway vehicle bodies – Part 1: Locomotives and passenger rolling stock (and alternative method for freight wagons)
2. DIN EN 12663-2:2010-07 Railway applications - Structural requirements of railway vehicle bodies – Part 2: Freight wagons
3. DIN EN 15085-1:2023-09 Railway applications – Welding of railway vehicles and components – Part 1: General
4. DIN EN 15227:2020-06 Railway applications – Crashworthiness requirements for rail vehicles
5. DIN EN 15551:2022-08 Railway applications – Railway rolling stock – Buffers
6. DIN EN 15566:2022-08 Railway applications – Railway Rolling stock – Draw gear and screw coupling
7. DIN EN 15839:2016-01 Railway applications – Testing and simulation for the acceptance of running characteristics of railway vehicles
8. DIN EN 16019:2014-06 Railway applications - Automatic coupler - Performance requirements, specific interface geometry and test method
9. DIN CEN/TR 16251:2016-08 Railway applications – Environmental conditions – Design guidance for rolling stock
10. DIN EN 16839:2022-10 Railway applications – Rolling stock – Head stock layout
11. DIN 25201-1:2015-12 Design guide for railway vehicles and their components – Bolted joints - Part 1: Classification of bolted joints
12. DIN EN 45545-1:2013-08 Railway applications – Fire protection on railway vehicles – Part 1: General
13. DIN EN 50121-1:2017-11 Railway application – Electromagnetic compatibility – Part 1: General
14. DIN EN 50125-1:2014-11 Railway applications – Environmental conditions for equipment – Part 1: Rolling stock and on-board equipment
15. DIN 50125:2022-08 Testing of metallic materials - Tensile test pieces
16. DIN EN 50126-1:2018-10 Railway Applications – The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS) – Part1: Generic RAMS Process
17. DIN EN 50129:2019-06 Railway applications – Communications, signaling and processing systems – Safety related electronic systems for signaling
18. DIN EN 50153:2018-01 Railway applications – Rolling Stock – Protective provisions relating to electrical hazards
19. DIN EN 50155:2022-06 Railway applications – Rolling stock – Electronic equipment

20. DIN EN 50343:2014-09 Railway applications – Rolling stock – Rules for installation of cabling
21. DIN EN 50467:2012-10 Railway applications – Rolling stock – Electric connectors, requirements and test methods
22. DIN EN 60352-2:2014-04 Solderless connections – Part 2: Crimped connections – General requirements, test methods and practical guidance
23. DIN EN 60529:2014-09 Degrees of protection provided by enclosure (IP Code)
24. DIN EN IEC 61238-1-1:2020-11 Compression and mechanical connectors for power cables – Part 1-1: Test methods and requirements for compression and mechanical connectors for power cables for rated voltages up to 1 kV (U_m = 1,2 kV) tested on non-insulated conductors (IEC 61238-1-1:2018)
25. DIN EN 61373:2011-04 Railway applications – Rolling stock equipment – Shock and vibration tests (IEC 61373:2010)
26. ISO 8573-1:2010-04 Compressed air – Part 1: Contaminants and purity class
27. VDI 2230 Blatt 1:2015-11 Systematic calculation of highly stressed bolted joints – Joints with one cylindrical bolt
28. VDI 2230 Blatt 2:2014-12 Systematic calculation of highly stressed bolted joints – Multi bolted joints
29. DIN EN 14198:2021-07 Railway applications – Braking – Requirements for the brake system of trains hauled by locomotives
30. UIC 522 Conditions for the acceptance of draw-only automatic couplers
31. UIC 530-1 Constructional conditions for wagons to be observed with a view to fitting the automatic coupler of the member railways of the UIC and OSJD respectively
32. UIC 530-2 Wagons – Running safety
33. UIC 530-5 TBD
34. EN_DAC 2023 (WI 00256A0K)