OE Rolling Stocks prepared to DAC

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Document history		
Revision	*Date*	*Description*
0.1	2024-07-15	*Initial draft*
0.2	2025-04-22	*Draft iteration #2 – alignment with D5.2 new revision, inclusion of D5.4 and OPE group feedback review*

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Name	Beneficiary Short Name	Details of contribution

NOTE THAT IF THERE IS A CONFLICT IN REQUIREMENTS THE REQUIREMENTS IN FORMAL FP5-TRANS4M-R DELIVERABLES (EG. D3.2, D5.2, D5.3, D5.4, etc.) ARE THE PREVAILING ONES.

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1 Executive Summary

For the **new production of wagons and locomotives** there is a rolling stock builders need for clarification about the interfaces between the rolling stocks and the DAC hardware.

The requirements for wagons are easier to identify as they are well covered for decades in the UIC normative framework. Locomotives have a too large interfaces variation to create a single standard.

This document outlines the requirements for wagons which follow the requirements set out in UIC 530 1 edition 2 from April 1982. The wagons must meet the requirements for centre buffer couplers.

The Information is compiled from issued FP5-TRANS4M-R deliverables and CEN NWIP WI 00256 A 0 K and XXXX

This document is not a deliverable.
This document is a working file that will be iterated following the maturity increase of the hardware developments.
This document can be used as an input to regulation and standardisation formal work (ERA, CEN)

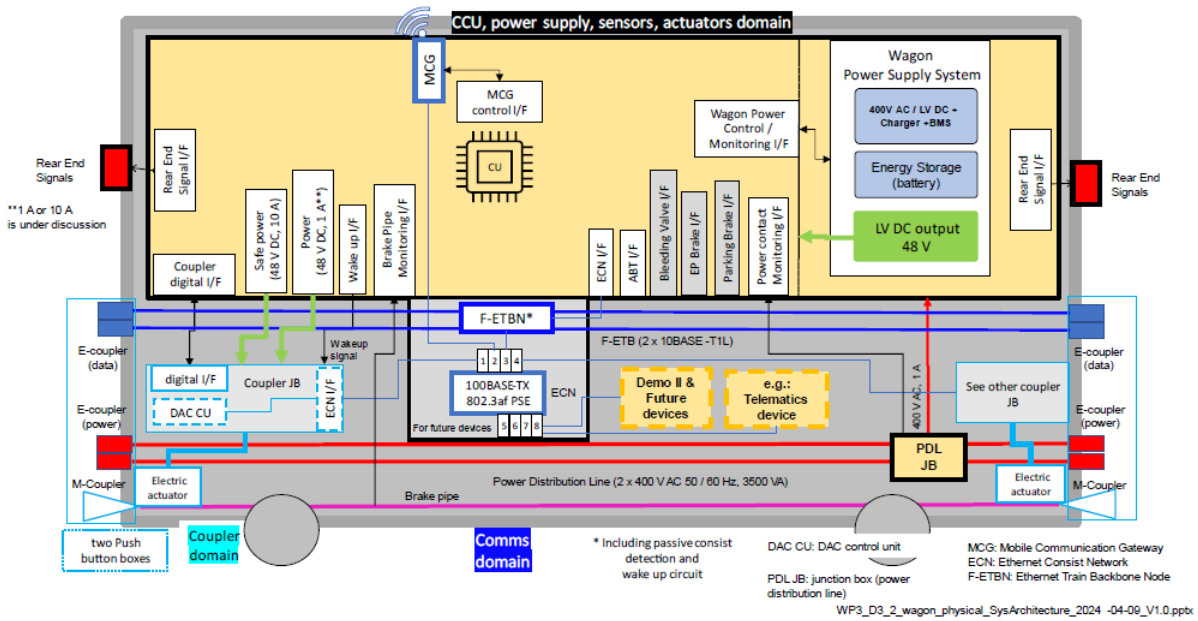
2 Abbreviations and acronyms

Abbreviation / Acronym	Description
ADIF	Administrador de Infraestructuras Ferroviarias
AUCO	Automatic Coupler
CAN	Controller Area Network
CCU	Consist Control Unit
CEN	Comité Européen de Normalisation
CENELEC	Comité Européen de Normalisation Electrotechnique, Europäisches Komitee für elektrotechnische Normung
DAC	Digital Automatic Coupler
DACCU	DAC Control Unit
DB	Deutsche Bahn
DEL	Dellner
DIN	Deutsches Institut für Normung
EDDP	European DAC Delivery Program
EN	European Norm
ERA	European Union Agency for Railways
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 Mobility
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

3.1 Work methodology

The approach is to start from the WP3 D3.2 and follow the same breakdown to sub-systems. Here below a picture of the architecture from D3.2



3.2 Structure

The document is structured in three main portions first describing the Coupler mechanical interfaces to the vehicles, second describing the electrical and digital interfaces to the vehicle and third describing the CCU.

4 Objective/Aim

Clarification about the interfaces between the rolling stocks and the DAC hardware.

5 Terms and definitions

Digital Automatic Coupler (DAC)
a 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 standard.

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

Note 5: The DAC uses the AC type 10 with the Scharfenberg principle.

Electrical Coupler
a 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 document.

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

Draft gear
an 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
a 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.

Manual uncoupling mechanism
device which provides manual rotation of the locking mechanism from the coupled position into 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 into 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 App F

Functional levels (FL)

Functional level 1:
automated coupling of the mechanical connection; manual uncoupling possible

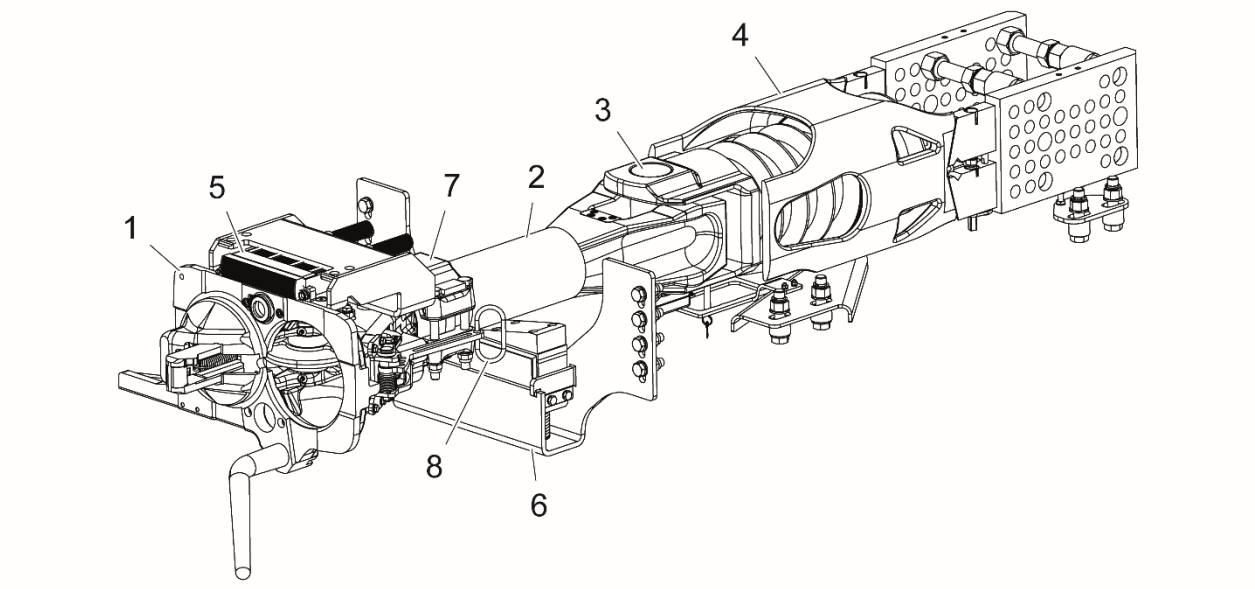
Functional level 2:
FL 1 plus automatic coupling of air pipe

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.



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)

6 Coupler mechanical interfaces

6.1 Wagon

6.1.1 General considerations

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

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 + 10% /- 15% 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]

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[2].
Note to note: only applicable to UIC standard gauge tracks and not to other gauges such as that of the Iberian Peninsula - 1668 mm)

Wagon coupler target weight 380 kg and max weight [480 kg][4]

- 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

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 below for standard pictogram.

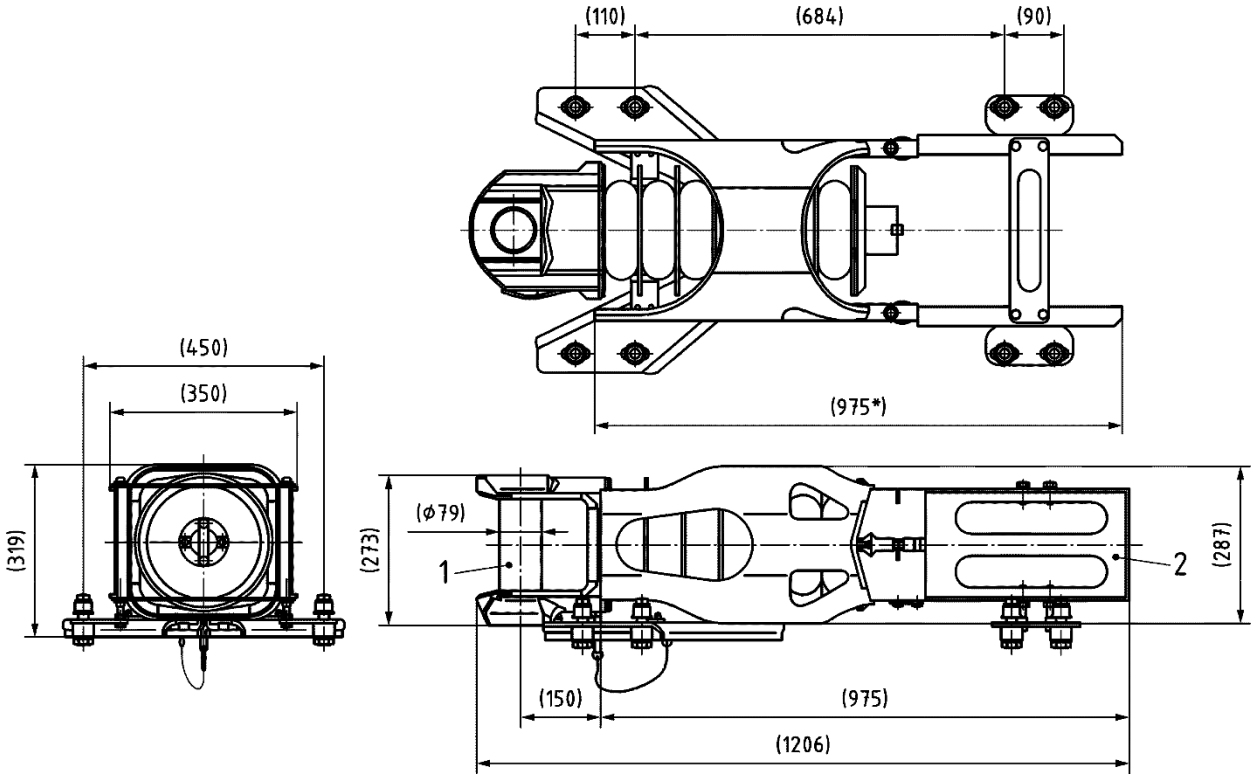
[1] To be reopened as an open item
[2] Under investigation. Value kept at 500kN until something other is agreed and to be read in conjunction with the product weight. Final value set after testing.
[4] Value to be rediscussed but lower weight in conflict with derailment safety requirement of 500 kN

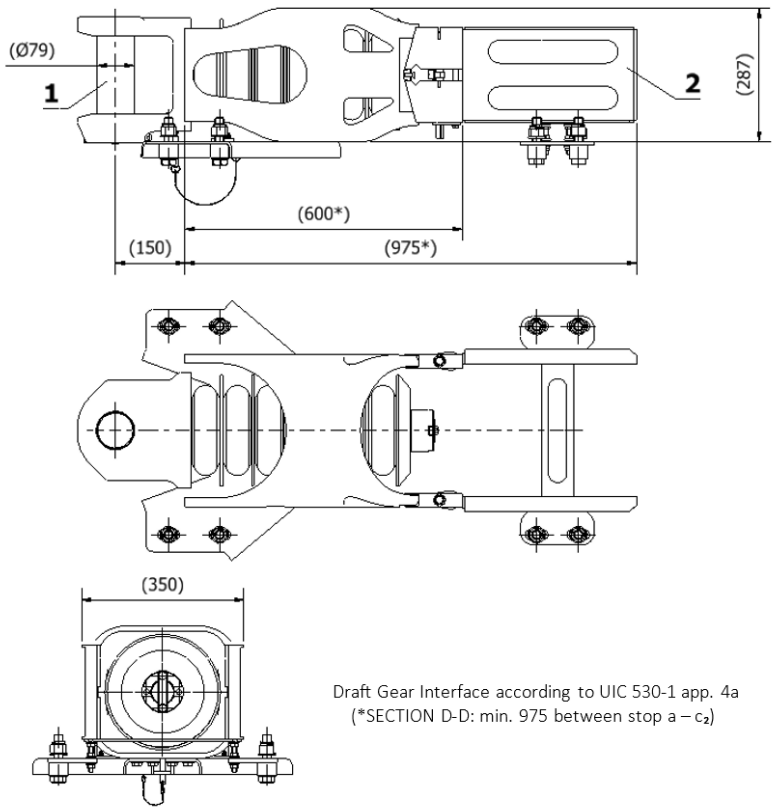
Figure 1: Figure of standard gravity pictogram

6.1.2Coupler 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 **Fehler! Verweisquelle konnte nicht gefunden werden.** Figure 2 shows an example a draft gear interface on the basis of UIC 530-1 Appendix 4b.





Key

1 Pin
2 Spacers

Figure 2: Draft gear interface according to UIC 530-1 appendix 4b

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 3: Installation space bottom view
- The interface areas between the plates and the wagon should be primer coated and the screw elements should have sufficient corrosion protect see chapter 6.2.

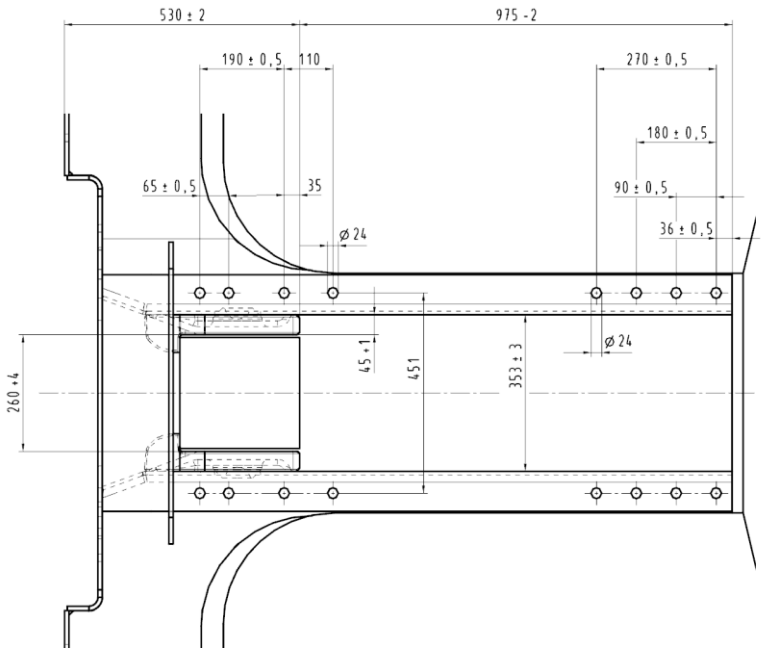


Figure 3: Installation space bottom view

Screw elements should have sufficient corrosion protection

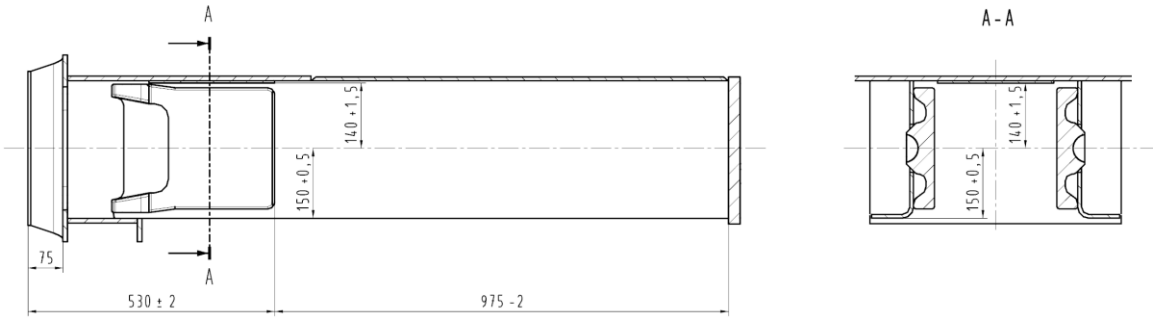


Figure 4: Installation space cut side view

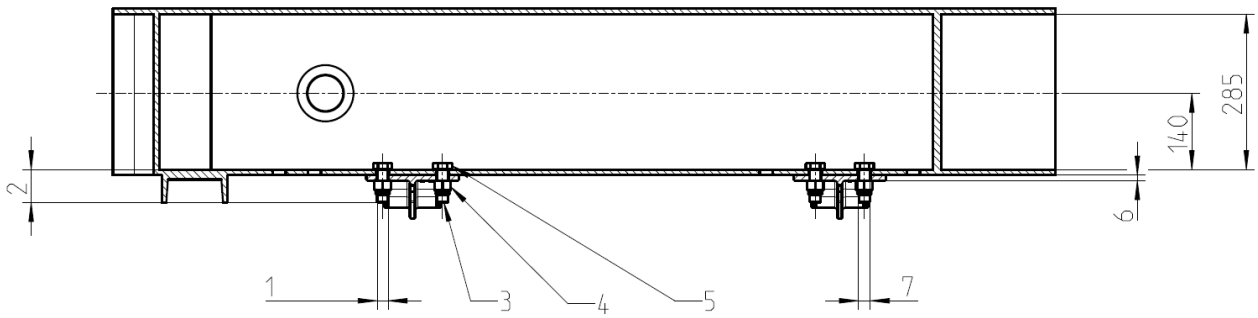


Figure 5: Installation space cut side view

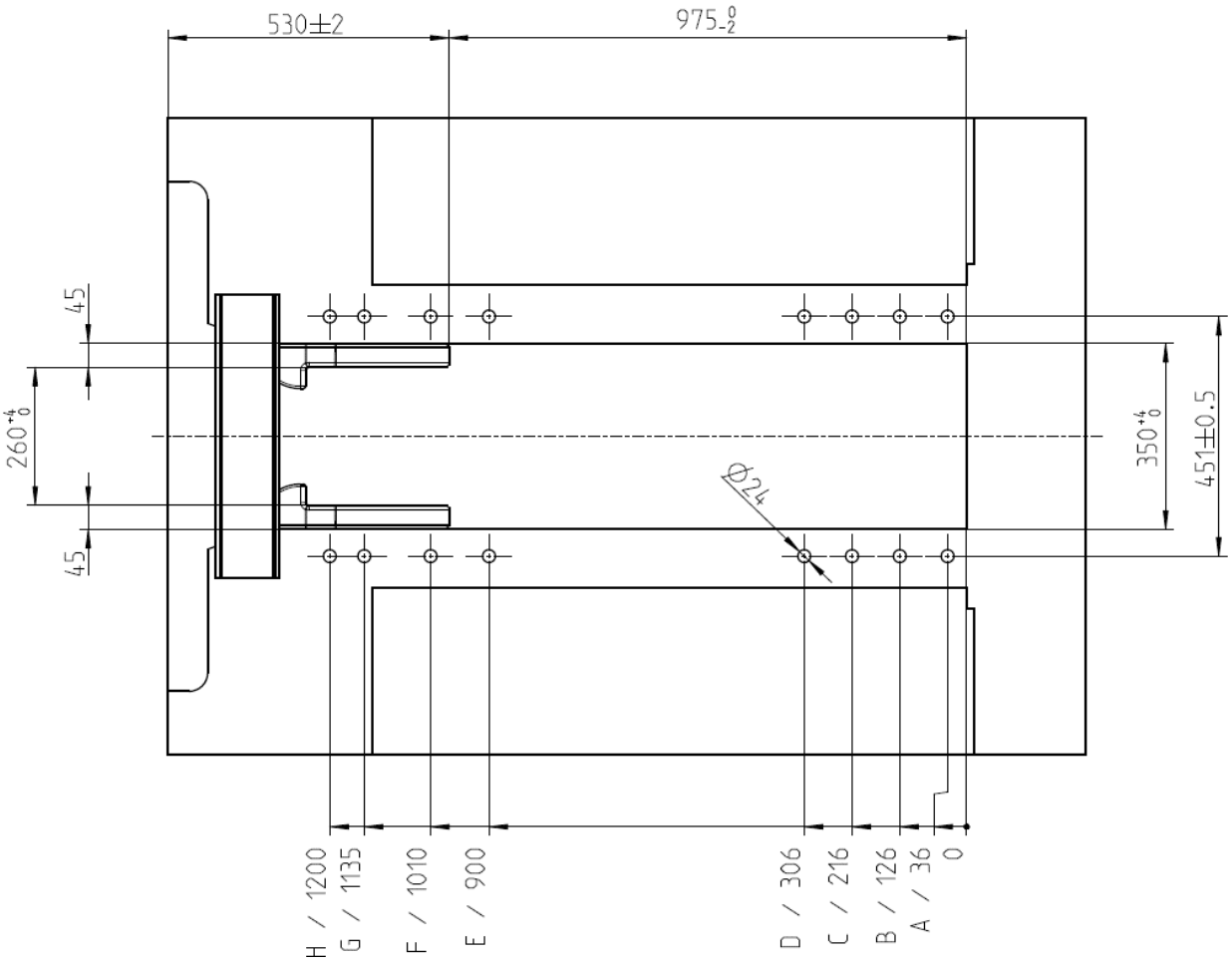
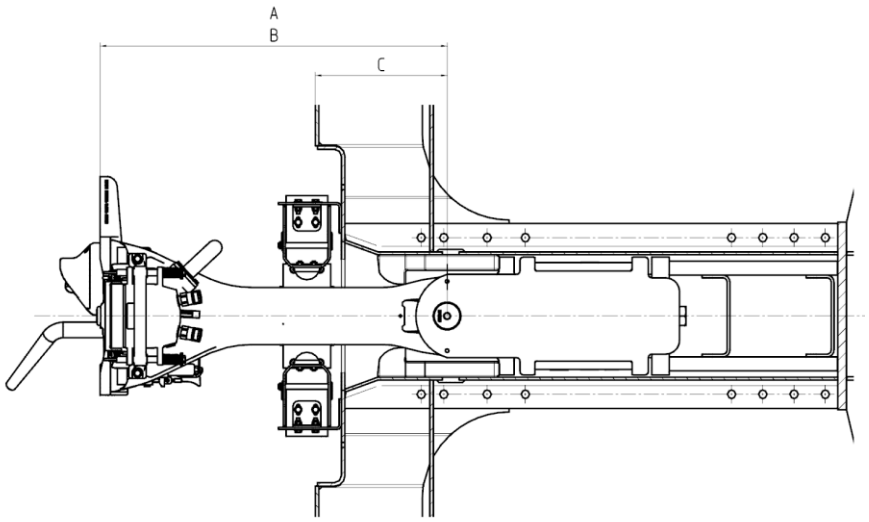


Figure 6: Installation space bottom view



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 7: Schematic drawing of coupler intended for freight wagon installation

6.1.3Pneumatic 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 must be min. 20mm. The position of the screw connection interface to the coupler is defined in Figure 8.

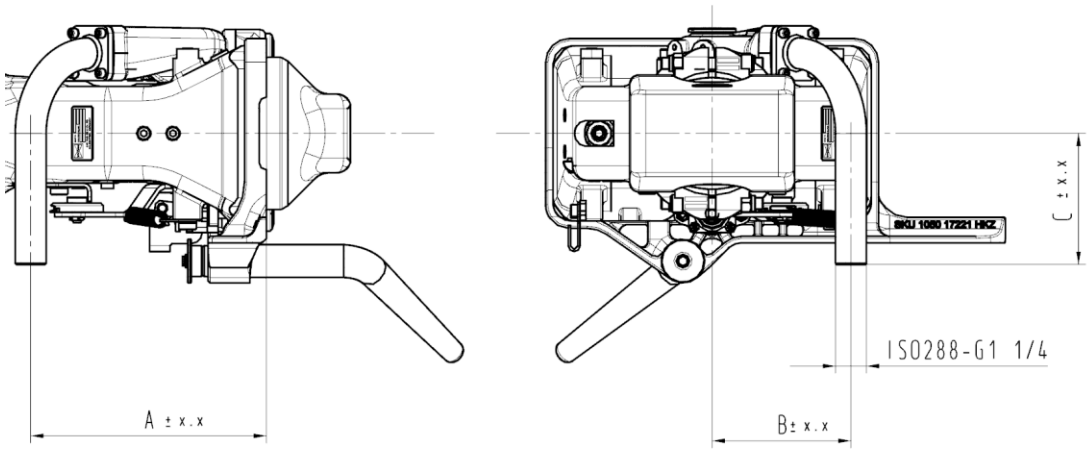


Figure 8: Position of the screw connection of the brake pipe (BP) - examples

The vehicle shall be equipped with connections for brake pipe (BP) according EN 16839:2022, Figure 8 (see D5.2)

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 must 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.

To limit the risk of collision in between the DAC components and the end cocks fitted on the wagon headstock, FP5 DAC experts recommend installing those end cocks in the green area as represented on Figure 9 below.

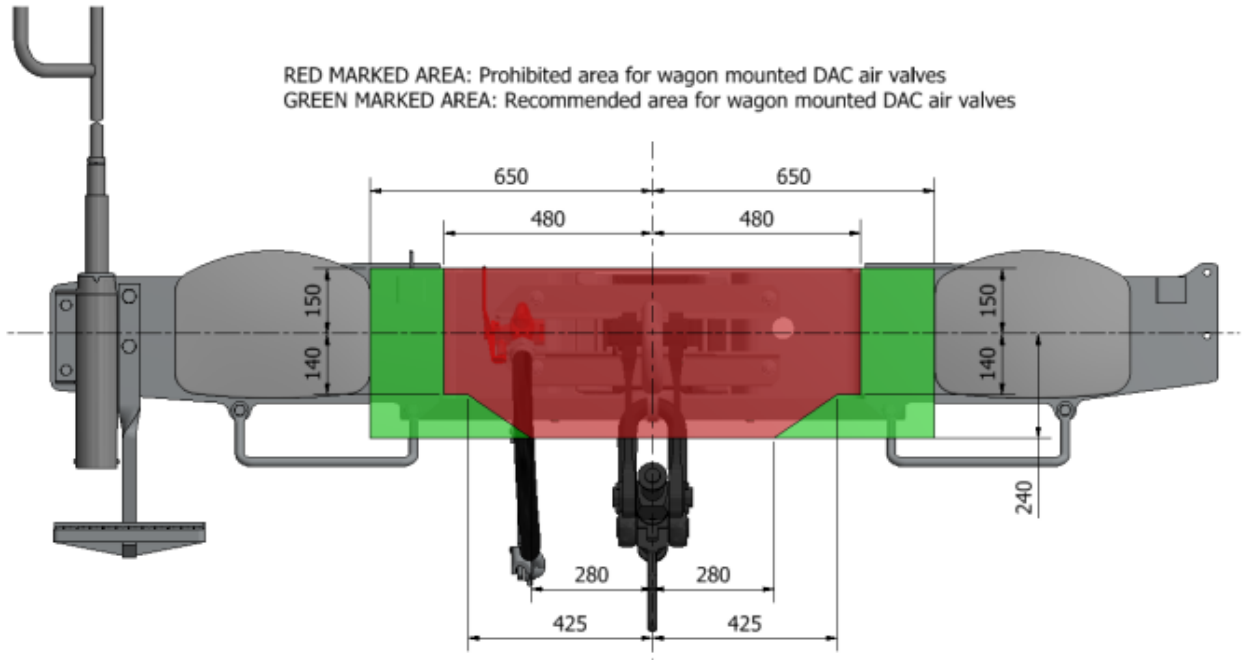


Figure 9: recommended area for installing end cocks

6.1.4Vertical Support and Centering 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 height 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.

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 end cocks.

The hole placements for vertical support are shown in Figure 10.

Dimensions in millimetre

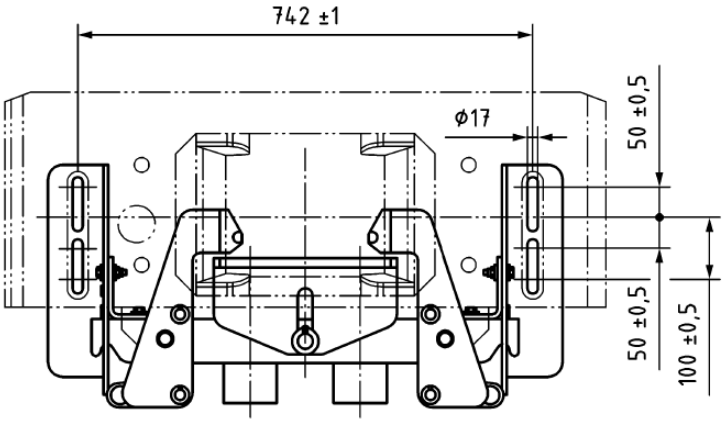


Figure 10: Hole placements for vertical support

6.1.5 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.

6.1.6Using 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 11.

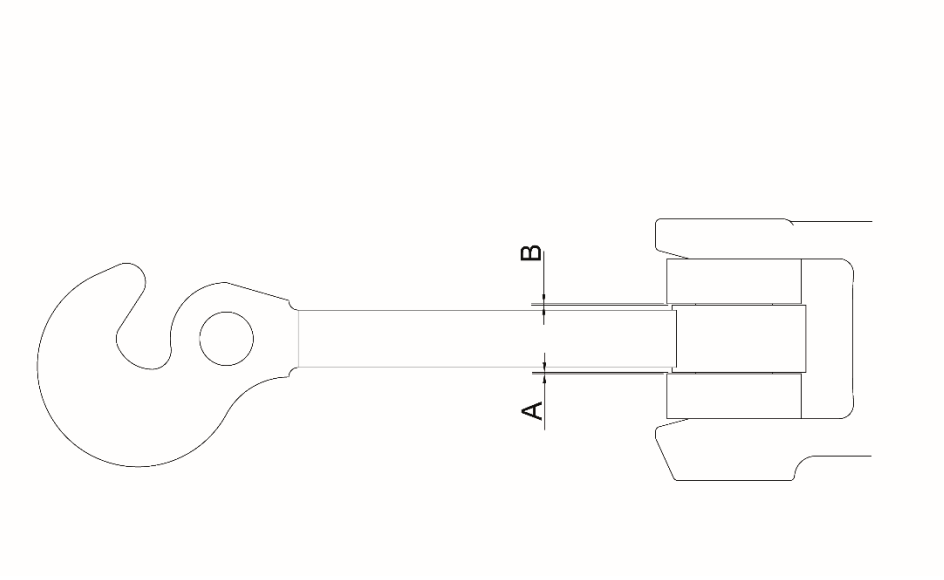


Figure 11: Spacers / adapters together with a EN 15566:2022 hook in a DAC draft gear

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.

6.2 Locomotive

6.2.1 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 clearance area (Berne rectangle) according EN 16839:2022 may be infringed for vehicles equipped with side buffers and DAC][6].

Side buffers will not be dismounted when the locomotive is equipped with Hybrid Couplers.

6.2.2 Digital Automatic Coupler for freight 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 dynamic. See figure below for a concept drawing.

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

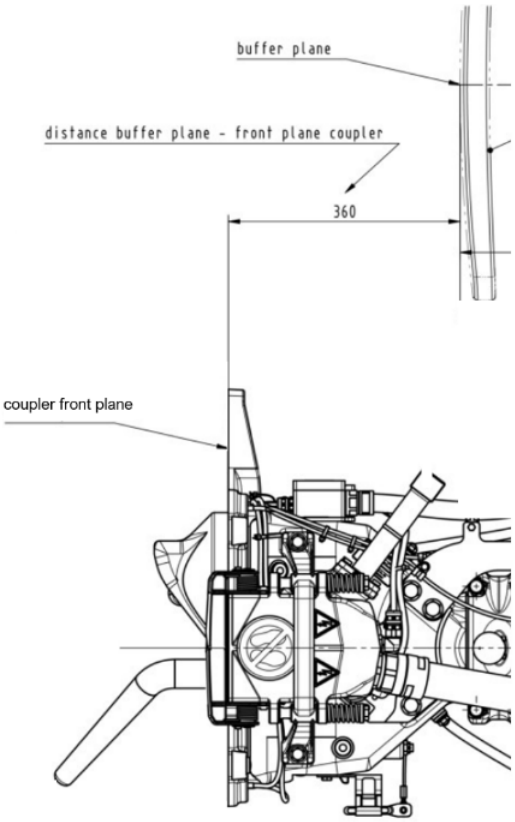


Figure 12: Showing the distance between the buff plane and the coupler plane

6.2.3Screw 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 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 the 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 requirements in Paragraph 5.4.1 in EN 16839:2022

6.2.4Berne 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 Figures 1 and 6 of EN 16839. 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.

6.2.5 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 in Figure 6 of EN 16839 (buffer centre line [A] above draw hook centre line).

6.2.6 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 L1 of the mixed train coupler shall be oriented to D1 = 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 L2 of fully tightened mixed train coupler shall be oriented to D2 = 750 mm +/-10 mm defined in EN15566:2022, chapter 6.1. See figure below for guidance.

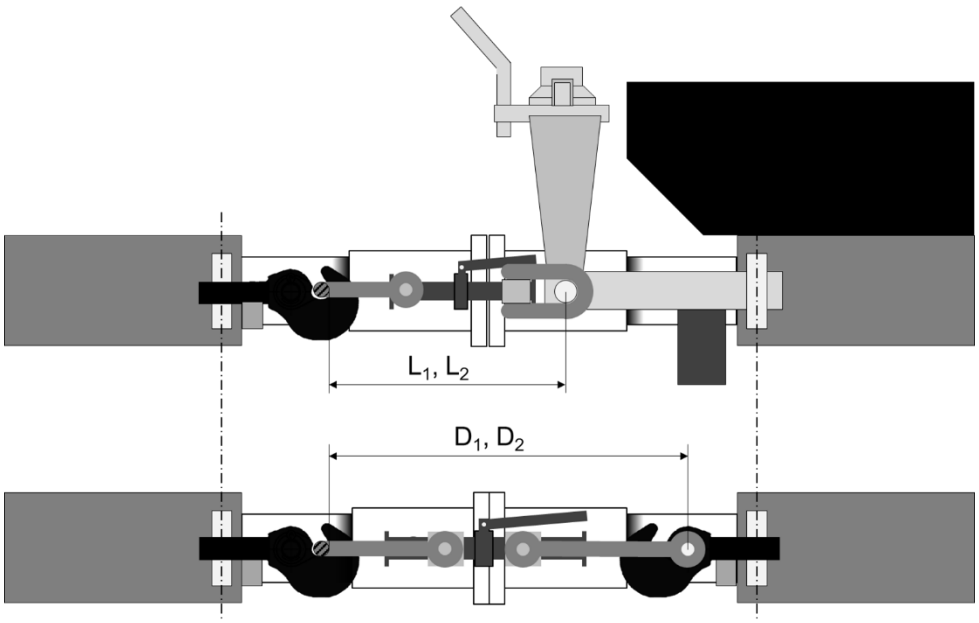


Figure 13: Length of mixed train coupler in screw coupler mode

6.2.7 Interaction 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.

6.2.8 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.

6.2.9 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.

6.2.10 Vertical Support and Centering Device

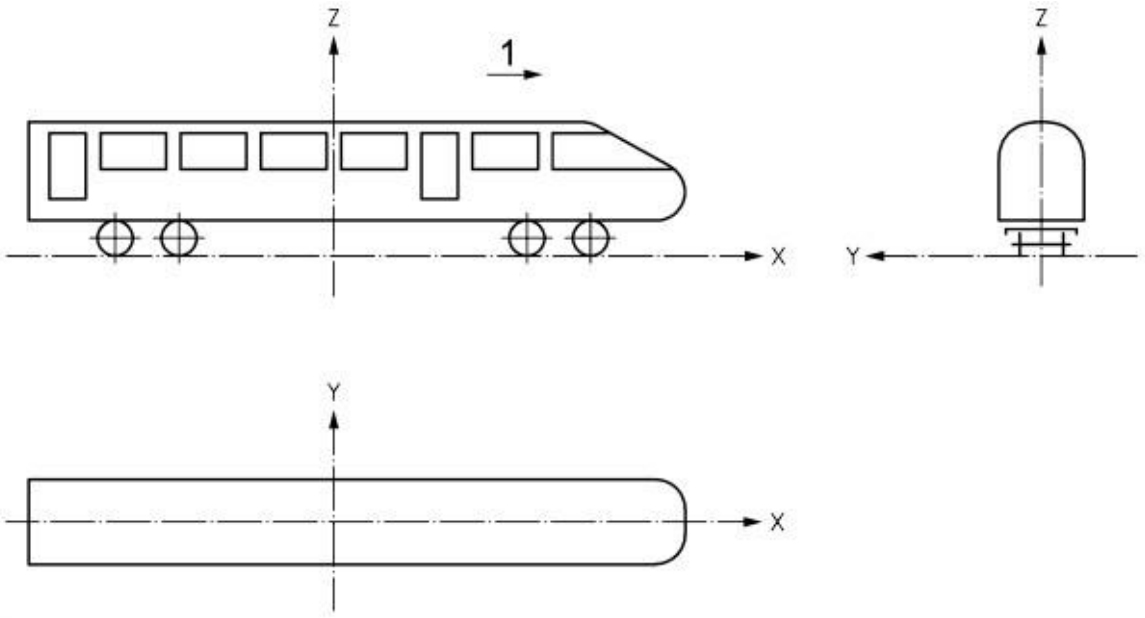
Not possible to standardize.

7 Electrical and Digital Interfaces

7.1 Wagon Interface

7.1.1 Considerations regarding Wording & Orientation

Each consist features the identical interface, point-symmetric to its centre. To avoid misunderstanding we will describe the head-side (in the direction of travel) of each consist only. The vehicle coordinate system shown in Figure 14 is a right-handed system where the x-axis describes the longitudinal direction, the z-axis the vertical direction, and the y-axis the transverse direction of the vehicle. The x-axis points in the direction of movement, and the z-axis points upward.



Key

1	driving direction
X	longitudinal direction
Y	lateral direction
Z	vertical direction

Figure 14: Consist Coordinate System (source: EN12663)

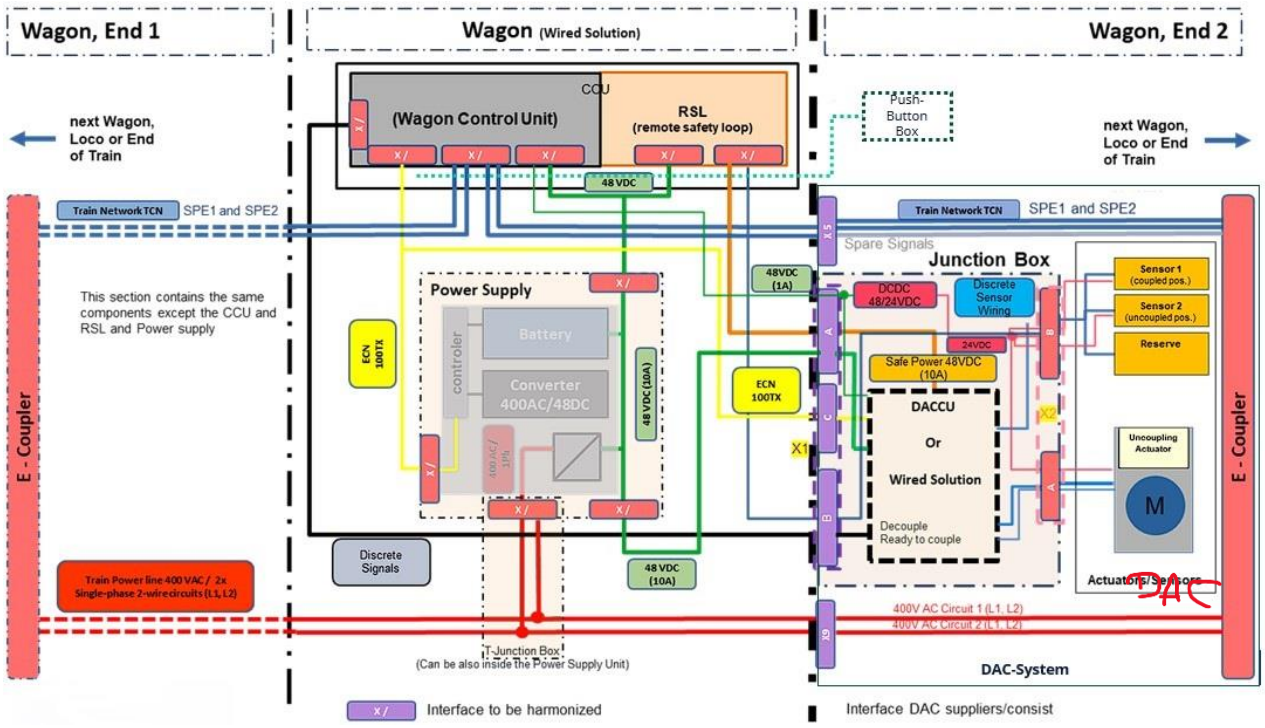


Figure 15: Interface Definition (detailed version based on D3.3)

Analogues to the mechanical interfaces between the DAC suppliers, also the electrical interfaces must be harmonized here. Therefore, the purple connector X1 (with the inlays A, B, C as former X6, X7, X8), X5 and X9 are reserved for this purpose. Interfaces between the CCU and its subsystems to the waggon and interface between said CCU and cabling on the waggon behind the harmonized interface is not scope of this document.

7.1.2Junction Box Installation

About the installation and placement of these components, especially regarding the Junction Box, the following considerations have been made:

- The recommendation is to define a standardized interface for placing the Junction Box.
- The area of the buffer interface is standardized according to EN15551:2017.

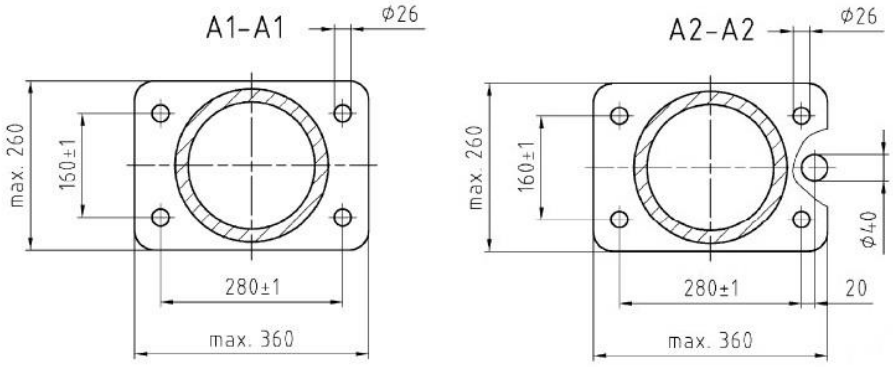


Figure 16: Buffer Interface (Source: EN15551:2017)

- With the usage of DAC on the wagon, the area of buffer interface is always free after removing both side buffers.
- The buffer mounting area on the inside of the wagon is not free, as here is a structure to lead the buffer forces.
- Cable routing to DAC is easier, because the individual structure of the wagon has less influence.
- The mandatory removal of handles under the side buffers increase the available free spaces for Junction Box installation. Therefore, their interface should be used to attach other parts, for instance plugs. cables fasteners etc.
- As the end steps are usually placed on the right side of the wagon, it would be better to place the Junction Box on the right side of the wagon. (This means that the box does not easily serve as an additional step thread, if the personal is already on that end step on the left side of the wagon.

From these advantages, the following design draft has been produced:

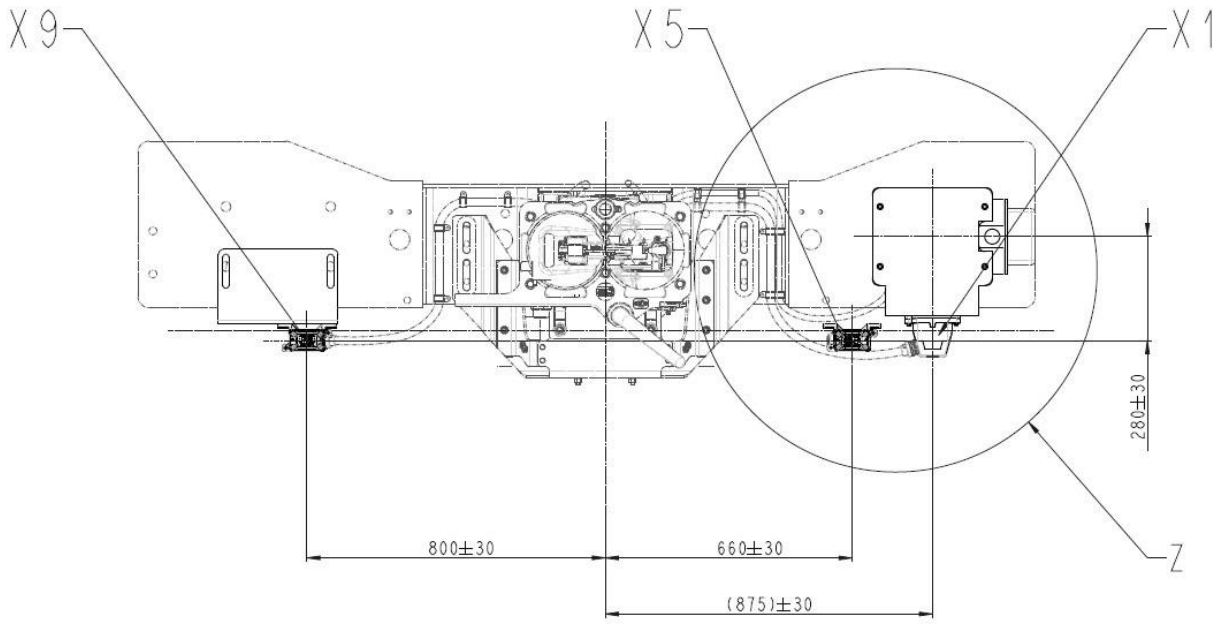


Figure 17: Front View of Setup with Junction Box and Connectors X1, X5, X9 (Source: KB)

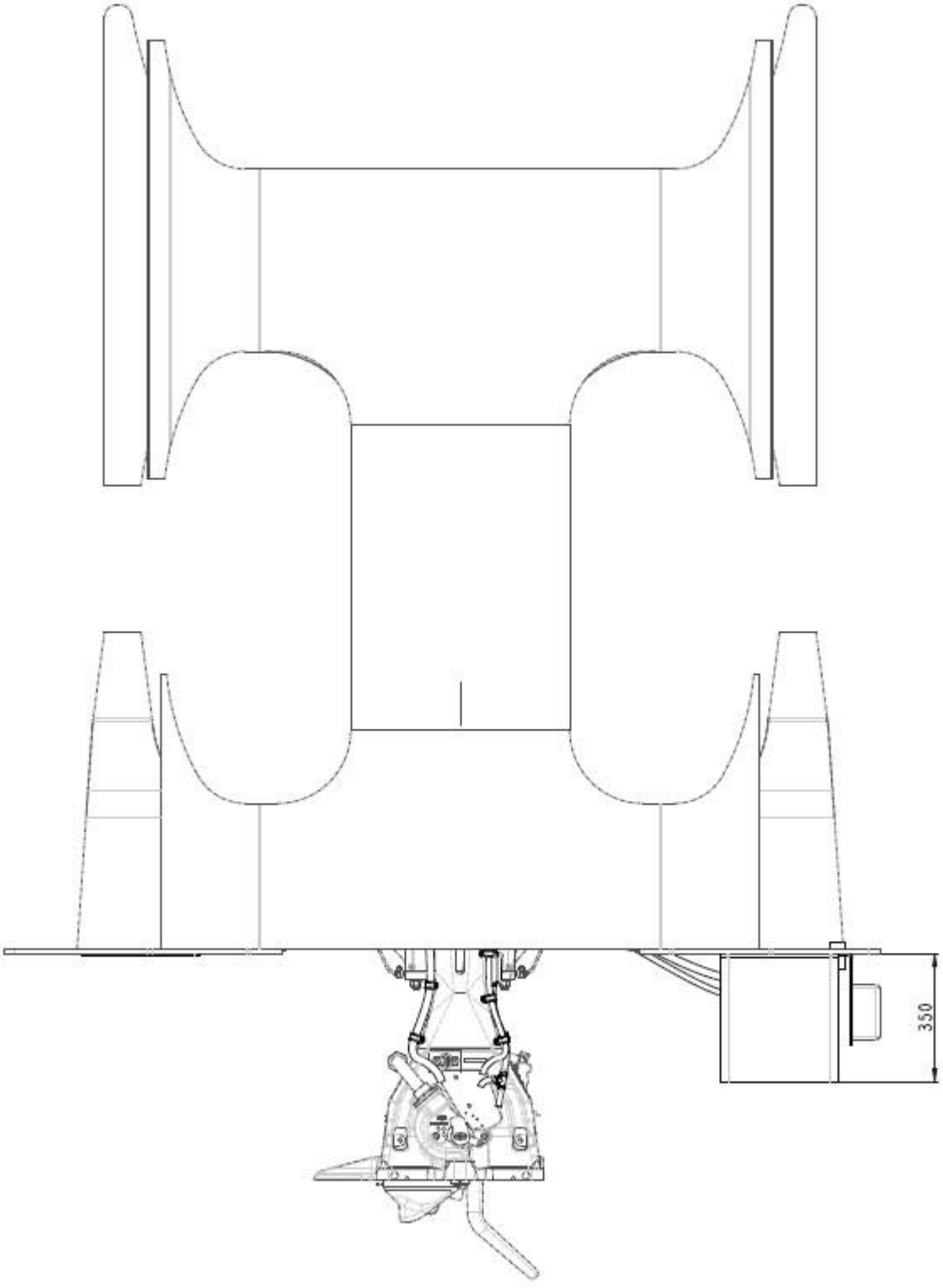


Figure 18: Max. allowable space in x-direction (Source: KB)

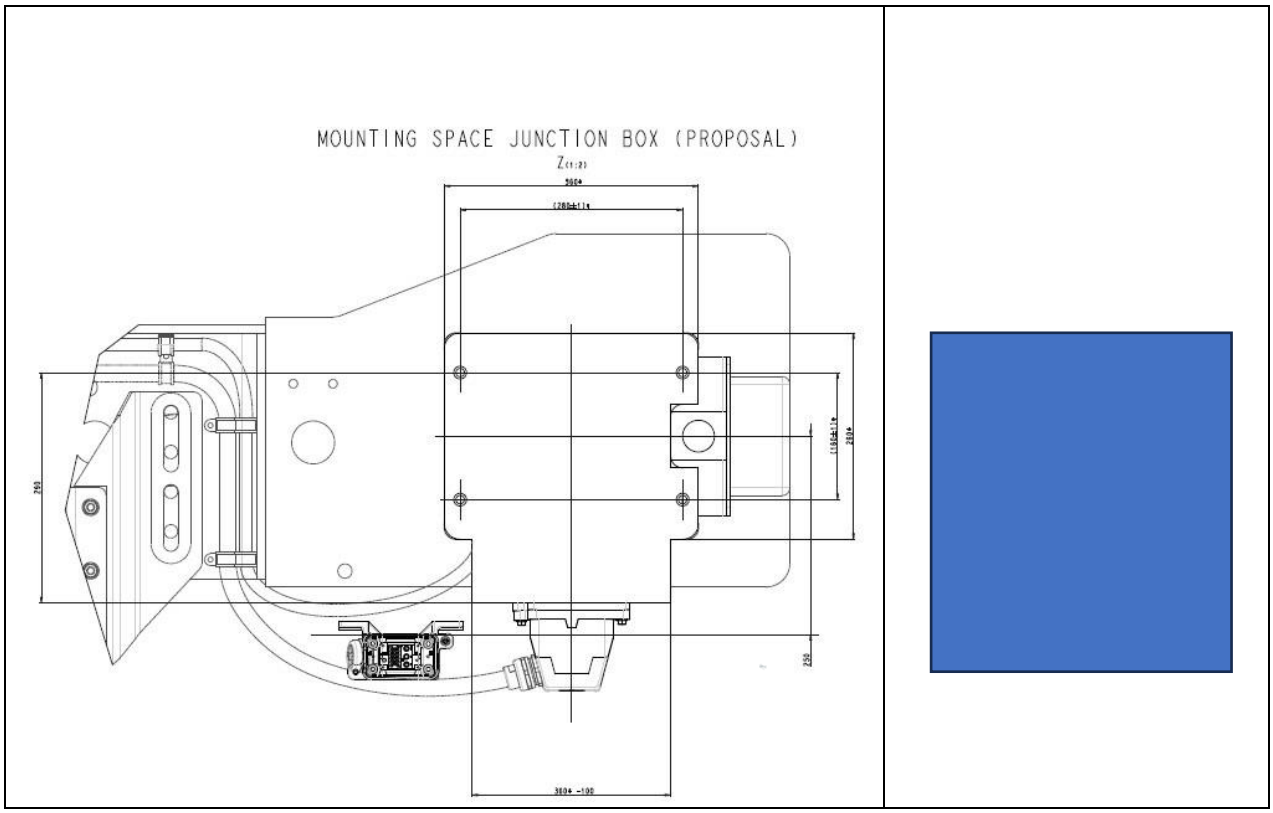


Figure 19: Mounting Interface for the Junction Box incl. connector interface position (connector shown as example only) & Max allowable footprint in y-z Plane (Source: KB)

From this example or proposal, some requirements for the mounting and size of the Junction Box can be derived:

- The Junction Box is held by a metal plate or similar, which fits to the buffer interface including the 4 screws for fixation according to EN15551:2017.
- The extent of the topside of the Junction-Box is limited due to certain variants of wagons (e.g. car transporter), so that it should not exceed the size of The max. allowable footprint shown in Fig. XX
- On the downside of the box, the interoperable connector X1 is placed according to Fig. XX.
- Moreover, the connector X5 for SPE lines shall be also placed in proximity to X1 at the downside of the Junction Box.
- The width of the whole box is limited by the screw interfaces of the metal sheet to the existing buffer interface.
- Therefore, only the length of the Junction Box can be more flexible for each DAC supplier, whereas the minimum length is defined by the interoperable connector

Misuse of the Junction Box as a step shall be prevented by sufficient measures, such as application of warning stickers in line with the state of the art and normative requirements.

the max. allowable dimensions of the Junction Box can be defined as follows:

- Extention in Z-direction: 320 mm
- Extention in Y-direction: 340 mm
- Extention in X-direction: 350 mm

Moreover, the possible space and installation area for a possible Push-Button Box in order to decouple locally are also considered. According to the following drawing as proposal / concept, the Push-Button Box is held by a separate metal sheet with 4 screws. This metal sheet can be additionally attached to the side of the buffer interface towards wagon side. Installation of Push-Button Box remains responsibility of the party responsible for installation of the CCU and must not affect the safe connection of the Junction-Box to the vehicle.

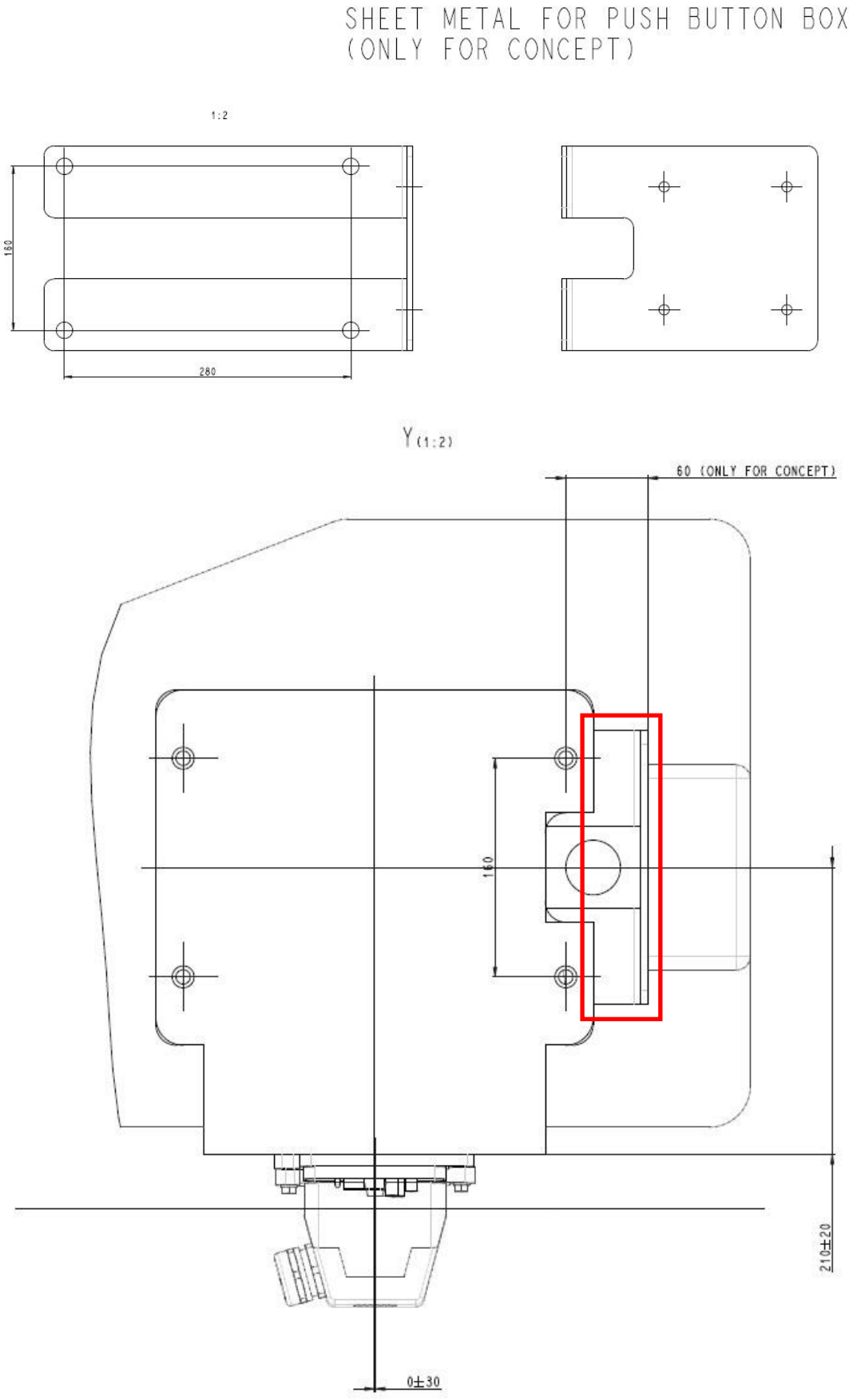


Figure 20: Example for additional Sheet Metal for mounting Push-Button-Box (Source: KB)

The following drawings visualize the installation of this metal sheets with an example of such a Push-Button Box as envelope model.

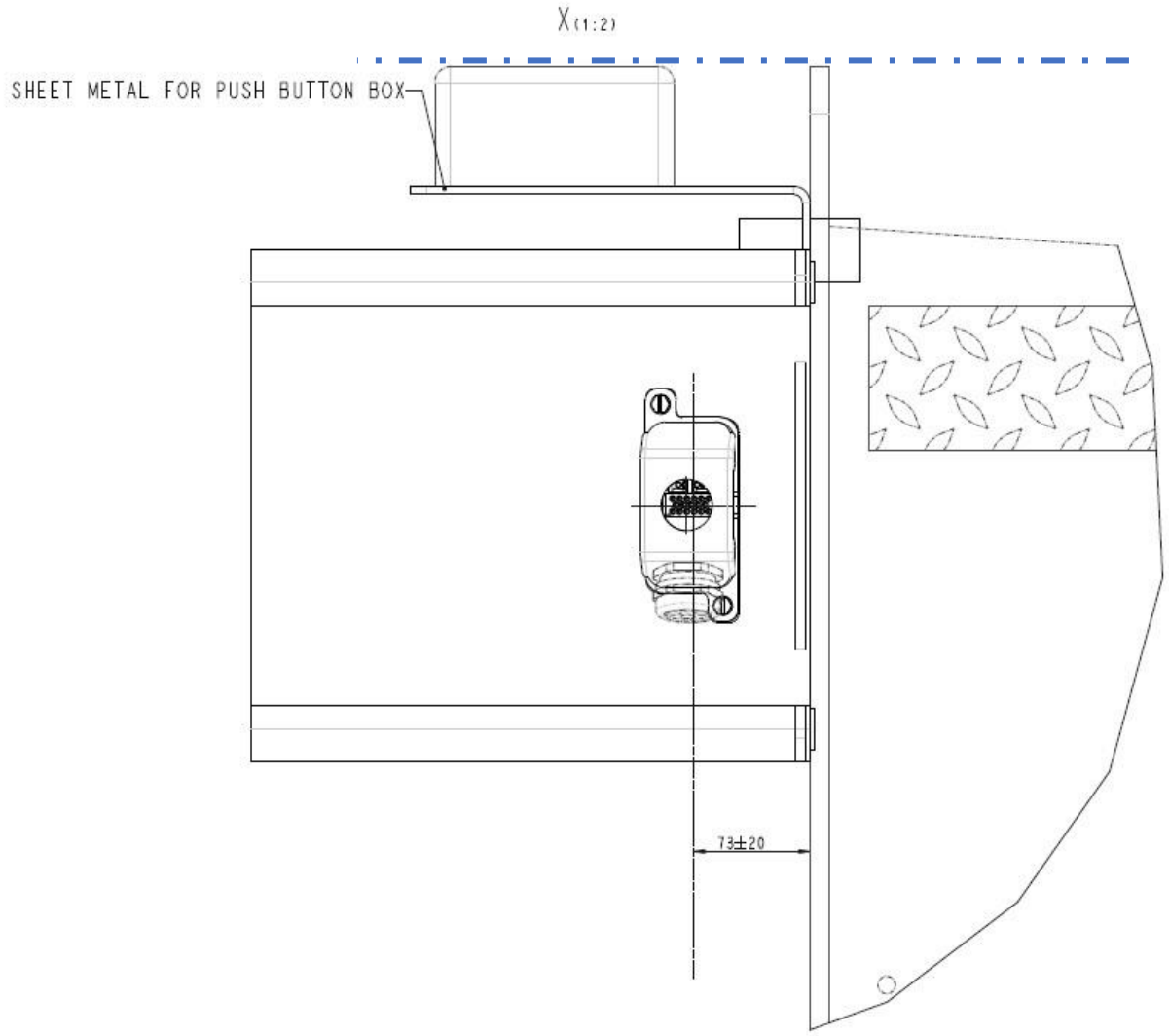


Figure 21: Envelope for possible Push-Button Box – must stay within Structural Gauge (Source: KB)

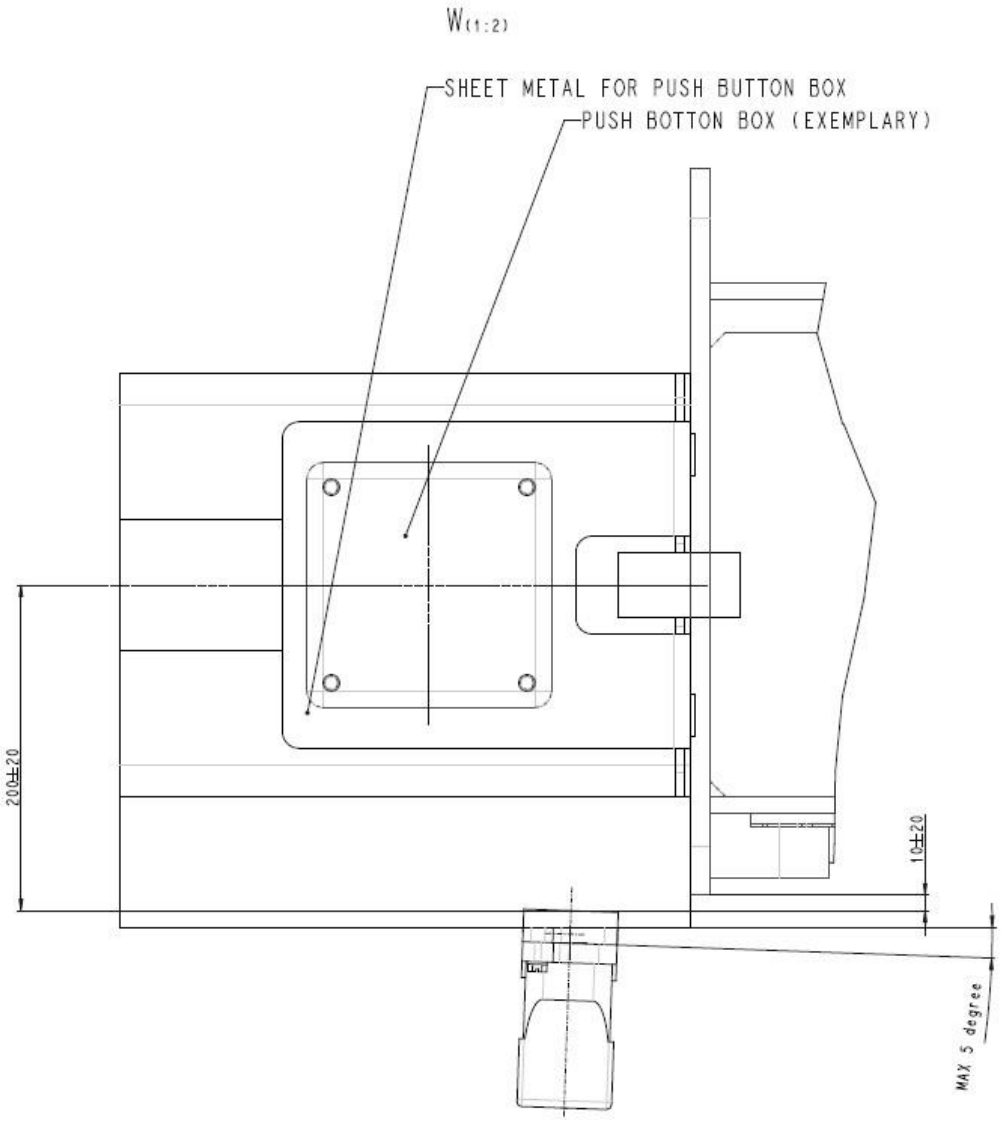


Figure 22: Side View of Sheet Metal for Push-Button Box and an envelope of a possible solution (Source: KB)

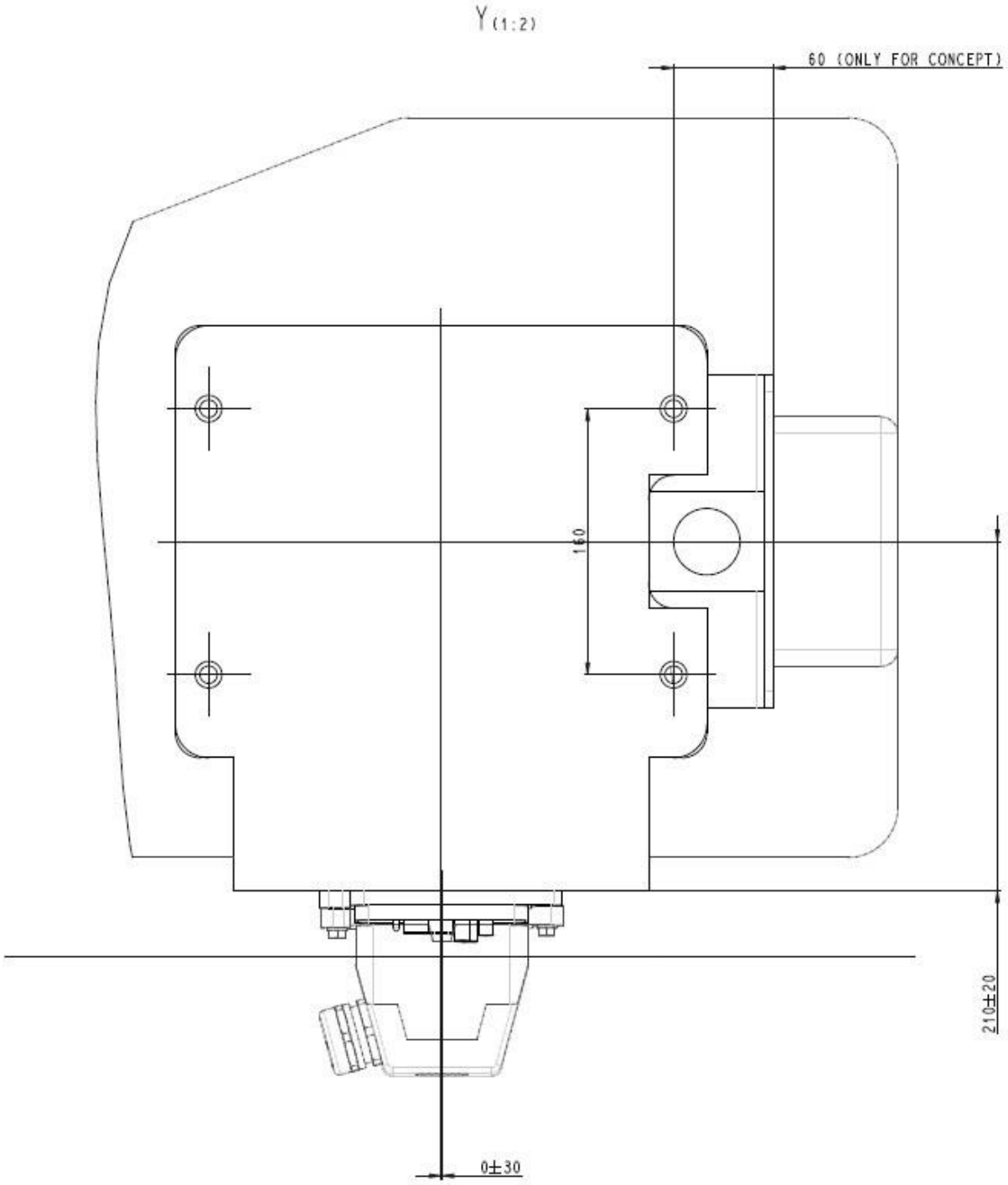


Figure 23: Front View of Sheet Metal for Push-Button Box and an envelope of a possible solution (Source: KB)

On the other wagon side, the buffer interfaces will be also used in order to place the holder for connector X9 of 400 VAC, which should be considered as a possible example.

7.1.3 Interoperable Connector X1 on Junction Box: Pin Assignment and Wiring

Regarding the interoperable connector X1 on the Junction Box, a merged one with 3 inlays (A,

B, C) is preferred towards other solutions with 2x or 3x single connectors. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1	Power Supply 48 VDC Safe	Max. 10 A	0.14…4.0mm²	QMM
A2	Power Supply GND Safe	Max. 10 A	0.14…4.0mm²	QMM
A3	Power Supply 48 VDC	Max. 10 A	0.14…4.0mm²	QMM
A4	Power Supply GND	Max. 10 A	0.14…4.0mm²	QMM
A5	Low-Power Supply 48 VDC Permanent*	Max. 1 A	0.14…4.0mm²	QMM
A6	Low-Power Supply GND Permanent*	Max. 1 A	0.14…4.0mm²	QMM
A7	n.c.		0.14…4.0mm²	QMM
A8	Shield		0.14…4.0mm²	QMM
B1	Wagon End Monitoring A		0.14…2.5mm²	AU
B2	Wagon End Monitoring B		0.14…2.5mm²	AU
B3	Wagon End Monitoring C		0.14…2.5mm²	AU
B4	Signal from Sensor “Coupled pos.” NO		0.14…2.5mm²	AU
B5	Signal from Sensor “Coupled pos.” NC		0.14…2.5mm²	AU

B6	Sensor “Coupled pos.” GND		0.14…2.5mm²	AU
B7	Signal from Sensor “Uncoupled pos.” NO		0.14…2.5mm²	AU
B8	Signal from Sensor “Uncoupled pos.” NC		0.14…2.5mm²	AU
B9	Sensor “Uncoupled pos.” GND		0.14…2.5mm²	AU
B10	CCU Command “Decouple enable” Signal		0.14…2.5mm²	AU
B11	CCU Command “Decouple enable” GND		0.14…2.5mm²	AU
B12	CCU Command “Decouple drive” Signal		0.14…2.5mm²	AU
B13	CCU Command “Decouple drive” GND		0.14…2.5mm²	AU
B14	CCU Command “Ready-to-couple enable” Signal		0.14…2.5mm²	AU
B15	CCU Command “Ready-to-couple enable” GND		0.14…2.5mm²	AU
B16	CCU Command “Ready-to-couple drive” Signal		0.14…2.5mm²	AU
B17	CCU Command “Ready-to-couple drive” GND		0.14…2.5mm²	AU
C1A	ECN (TX+)		0.14…2.5mm²	AU
C2A	ECN (RX+)		0.14…2.5mm²	AU
C3A	ECN (TX-)		0.14…2.5mm²	AU

C4A	ECN (RX-)		0.14…2.5mm²	AU
C1B	Sensor-reserve NO		0.14…2.5mm²	AU
C2B	Sensor-reserve NC		0.14…2.5mm²	AU
C3B	Sensor-reserve GND		0.14…2.5mm²	AU
C4B	Reserve pin		0.14…2.5mm²	AU
Housing	PE		6.0mm²	

7.1.4SPE Connector X5: Pin Assignment and Wiring

Regarding the SPE connector, also a merged connector is considered. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1A	F-ETB (DA+ Network 1)		0.14…2.5mm²	AU
A2A	F-ETB (DA- Network 1)		0.14…2.5mm²	AU
A3A	n.c.		0.14…2.5mm²	AU
A4A	n.c.		0.14…2.5mm²	AU
A1B	F-ETB (DA+ Network 2)		0.14…2.5mm²	AU
A2B	F-ETB (DA- Network 2)		0.14…2.5mm²	AU
A3B	n.c.		0.14…2.5mm²	AU
A4B	n.c.		0.14…2.5mm²	AU
B1	Spare-pin		0.14…2.5mm²	AU
B2	Spare-pin		0.14…2.5mm²	AU
B3	Spare-pin		0.14…2.5mm²	AU
B4	Spare-pin		0.14…2.5mm²	AU
B5 – B17	n.c.		0.14…2.5mm²	AU

Housing	PE		6.0mm²	

Moreover, the spare-pins should be connected isolated from the e-coupler to X5.

7.1.5400 VAC Connector X9: Pin Assignment and Wiring

For the 400 VAC lines, one connector is also the preferrable solution at the moment. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1	Power Distribution Line 400 VAC L1_1	Max. 40 A	1.5…6.0mm²	QMM
A2	Power Distribution Line 400 VAC L2_1	Max. 40 A	1.5…6.0mm²	QMM
A3	Power Distribution Line 400 VAC L1_2	Max. 40 A	1.5…6.0mm²	QMM
A4	Power Distribution Line 400 VAC L2_2	Max. 40 A	1.5…6.0mm²	QMM
B	Dummy module			
Housing	PE		6.0mm²	

7.2 Locomotive Interface

7.2.1 Overview and General Considerations

A junction box is used for the electrical connection of the locomotive to the respective coupler (one box per coupler). This allows sensor values to be read in and corresponding communication as well as supply voltages to be provided. The locomotive will use a hybrid coupler, which requires an extended interface (Connector X1). Additional sensors for position detection and the associated power supply (24 V DC) are required at interface X1 (see also Figure 24).

Furthermore, the locomotive must provide an interface for a possible electrical lifting device. This is described in more detail in chapter 7.2.6.

The power and data connections of the e-coupling (400 VAC, train network SPE) are each provided with a separate plug connector.

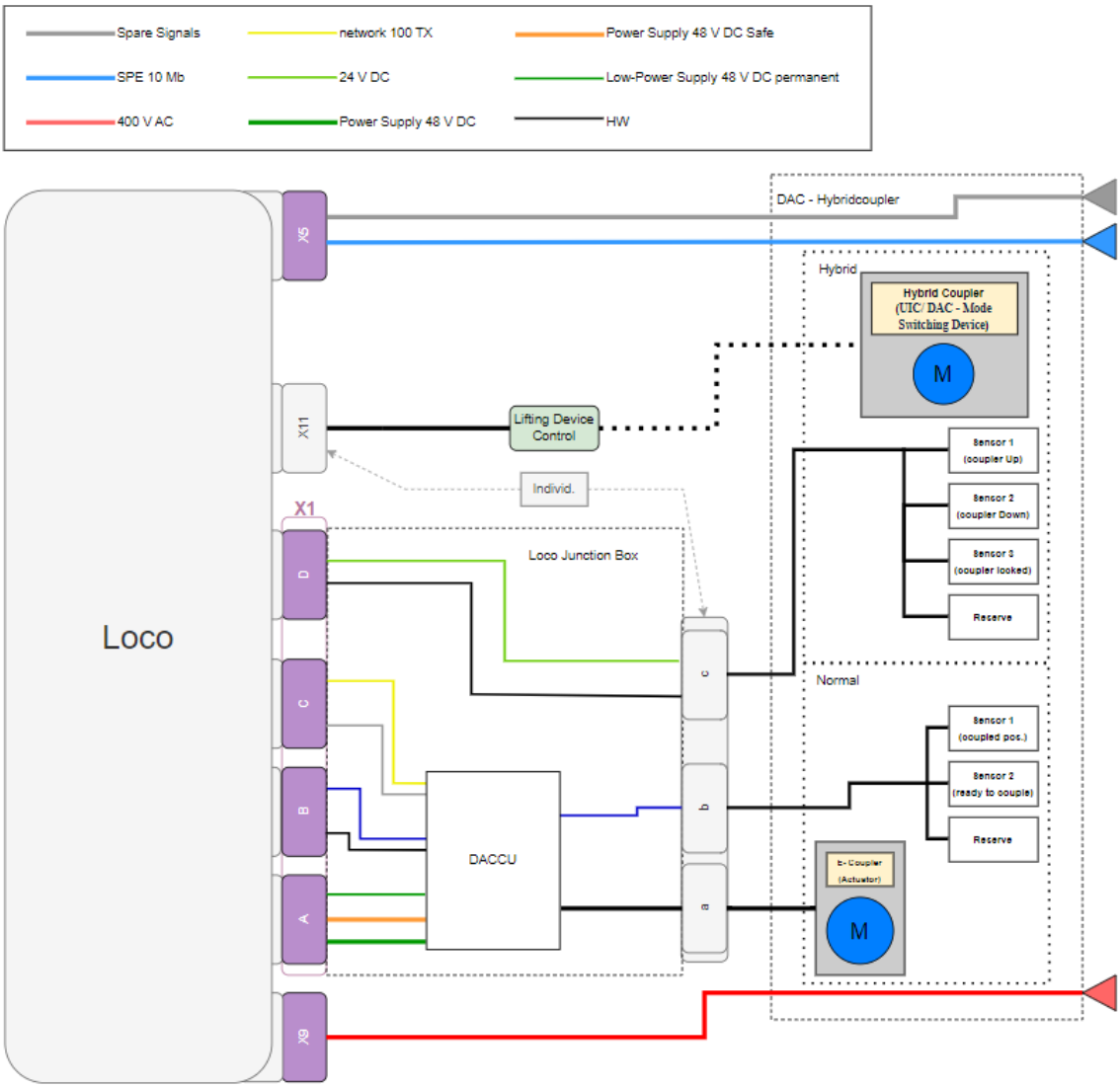


Figure 24: Interface between Locomotive and Junction Box (X1 and X11)

7.2.2Junction Box Installation

As the locomotive must still retain the side buffers, installation as described in previous chapters is not possible. For this reason, the locomotive manufacturer is required to find an individually suitable position and mechanical interface on his vehicle. This must be agreed with the relevant coupler supplier so that cable lengths and other factors can be adhered to.

The maximum dimensions of the junction box are not allowed to exceed the following specifications:

- Width: 280 mm
- Height: 110 mm
- Length: 230 mm

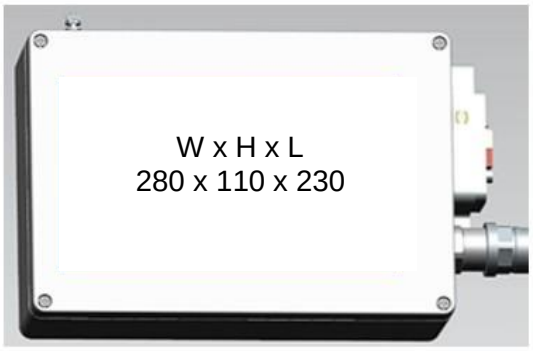


Figure 25: Max. Dimensions of a possible Junction Box (exemplary picture)

In the case that these dimensions cannot be realised by a coupler supplier or locomotive manufacturer, an individual solution must be agreed and developed.

7.2.3 Interoperable Connector X1 on Junction Box: Pin Assignment and Wiring

Regarding the interoperable connector X1 on the Loco Junction Box, a merged one with four inlays (A, B, C and D) is preferred towards other solutions with 2x single connectors. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1	Power Supply 48 VDC Safe	Max. 10 A	0.14…4.0mm²	QMM
A2	Power Supply GND Safe	Max. 10 A	0.14…4.0mm²	QMM
A3	Power Supply 48 VDC	Max. 10 A	0.14…4.0mm²	QMM
A4	Power Supply GND	Max. 10 A	0.14…4.0mm²	QMM
A5	Low-Power Supply 48 VDC Permanent*	Max. 1 A	0.14…4.0mm²	QMM
A6	Low-Power Supply GND Permanent*	Max. 1 A	0.14…4.0mm²	QMM
A7	n.c.		0.14…4.0mm²	QMM
A8	Shield		0.14…4.0mm²	QMM
B1	Wagon End Monitoring A		0.14…2.5mm²	AU
B2	Wagon End Monitoring B		0.14…2.5mm²	AU
B3	Wagon End Monitoring C		0.14…2.5mm²	AU
B4	Signal from Sensor “Coupled pos.” NO		0.14…2.5mm²	AU
B5	Signal from Sensor “Coupled pos.” NC		0.14…2.5mm²	AU
B6	Sensor “Coupled pos.” GND		0.14…2.5mm²	AU
B7	Signal from Sensor “Uncoupled pos.” NO		0.14…2.5mm²	AU
B8	Signal from Sensor “Uncoupled pos.” NC		0.14…2.5mm²	AU
B9	Sensor “Uncoupled pos.” GND		0.14…2.5mm²	AU
B10	CCU Command “Decouple enable” Signal		0.14…2.5mm²	AU
B11	CCU Command “Decouple enable” GND		0.14…2.5mm²	AU
B12	CCU Command “Decouple drive” Signal		0.14…2.5mm²	AU

B13	CCU Command “Decouple drive” GND		0.14…2.5mm²	AU
B14	CCU Command “Ready-to-couple enable” Signal		0.14…2.5mm²	AU
B15	CCU Command “Ready-to-couple enable” GND		0.14…2.5mm²	AU
B16	CCU Command “Ready-to-couple drive” Signal		0.14…2.5mm²	AU
B17	CCU Command “Ready-to-couple drive” GND		0.14…2.5mm²	AU
C1A	ECN (TX+)		0.14…2.5mm²	AU
C2A	ECN (RX+)		0.14…2.5mm²	AU
C3A	ECN (TX-)		0.14…2.5mm²	AU
C4A	ECN (RX-)		0.14…2.5mm²	AU
C1B	Sensor-reserve NO		0.14…2.5mm²	AU
C2B	Sensor-reserve NC		0.14…2.5mm²	AU
C3B	Sensor-reserve GND		0.14…2.5mm²	AU
C4B	Reserve pin		0.14…2.5mm²	AU
D1	Hybrid Coupler Sensor coupler-up NO		0.14…2.5mm²	AU
D2	Hybrid Coupler Sensor coupler-up NC		0.14…2.5mm²	AU
D3	Hybrid Coupler Sensor coupler-up GND		0.14…2.5mm²	AU
D4	Hybrid Coupler Sensor coupler-down NO		0.14…2.5mm²	AU
D5	Hybrid Coupler Sensor coupler-down NC		0.14…2.5mm²	AU
D6	Hybrid Coupler Sensor coupler-down GND		0.14…2.5mm²	AU
D7	Hybrid Coupler Sensor coupler-locked NO		0.14…2.5mm²	AU
D8	Hybrid Coupler Sensor coupler-locked NC		0.14…2.5mm²	AU
D9	Hybrid Coupler Sensor coupler-locked GND		0.14…2.5mm²	AU
D10	Hybrid Coupler Sensor reserve pin		0.14…2.5mm²	AU
D11	Hybrid Coupler Sensor reserve pin		0.14…2.5mm²	AU
D12	Hybrid Coupler Sensor reserve pin		0.14…2.5mm²	AU

D13	N.C.		0.14…2.5mm²	AU
D14	N.C.		0.14…2.5mm²	AU
D15	N.C.		0.14…2.5mm²	AU
D16	Hybrid Coupler Low-Power Supply 24 VDC		0.14…2.5mm²	
D17	Hybrid Coupler Low-Power Supply GND		0.14…2.5mm²	
Housing	PE		6.0mm²	

7.2.4SPE Connector X5: Pin Assignment and Wiring

The SPE Connector X5 will be the hand over point from the locomotive to the e-coupler. The wire from the e-coupler will be connected to this connector. Each side of the locomotive (Cab 1 and Cab 2) will have its own connector X5.
Regarding the SPE connector, also a merged connector is considered. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1A	F-ETB (DA+ Network 1)		0.14…2.5mm²	AU
A2A	F-ETB (DA- Network 1)		0.14…2.5mm²	AU
A3A	n.c.		0.14…2.5mm²	AU
A4A	n.c.		0.14…2.5mm²	AU
A1B	F-ETB (DA+ Network 2)		0.14…2.5mm²	AU
A2B	F-ETB (DA- Network 2)		0.14…2.5mm²	AU
A3B	n.c.		0.14…2.5mm²	AU
A4B	n.c.		0.14…2.5mm²	AU
B1	Spare-pin		0.14…2.5mm²	AU
B2	Spare-pin		0.14…2.5mm²	AU
B3	Spare-pin		0.14…2.5mm²	AU
B4	Spare-pin		0.14…2.5mm²	AU
B5 – B17	n.c.		0.14…2.5mm²	AU
Housing	PE		6.0mm²	

Moreover, the spare-pins should be connected isolated from the e-coupler to X5.

7.2.5400 VAC Connector X9: Pin Assignment and Wiring

The 400 V AC Connector X9 will be the hand over point from the locomotive to the e-coupler. The wire from the e-coupler will be connected to this connector. Each side of the locomotive (Cab 1 and Cab 2) will have its own connector X9.

For the 400 VAC lines, one connector is also the preferrable solution at the moment. This connector should be compatible to and with Harting HPR.

Pin	Signal Name	Max. Current Draw	Cross Section	Contact Material
A1	Power Distribution Line 400 VAC L1_1	Max. 40 A	1.5…6.0mm²	QMM
A2	Power Distribution Line 400 VAC L2_1	Max. 40 A	1.5…6.0mm²	QMM
A3	Power Distribution Line 400 VAC L1_2	Max. 40 A	1.5…6.0mm²	QMM
A4	Power Distribution Line 400 VAC L2_2	Max. 40 A	1.5…6.0mm²	QMM
B	Dummy module			
Housing	PE		6.0mm²	

7.2.6 Interface for an electrical lifting device (X11)

As there are several ways to raise or lower a hybrid coupler, this interface is only available if an electrical solution is used. That's why this interface is separate from the Junction Box. It only explains the basic requirements that the locomotive must fulfil, without detailing which connector to use or how to make the connection. The final connection will be agreed separately between the locomotive manufacturer and the coupling supplier.

- 24 V DC
- max. 15 A

The mechanical interface and the position of the lifting device controller must be defined individually between the coupler supplier and the locomotive manufacturer.

7.3 Outlook: Dimensions of CCU

As an outlook, the max. dimensions of a possible CCU will be presented. The container for the CCU consists of the consist control, the battery & power management, the SPE communication node and many other functionalities.

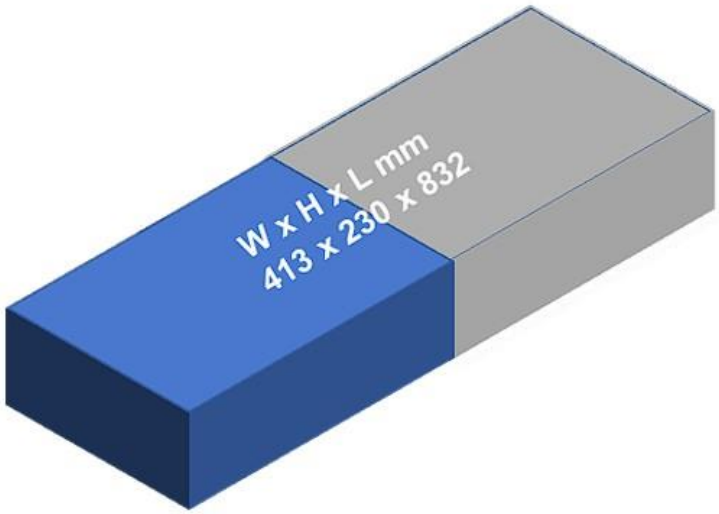


Figure 26: Max. Dimensions of a possible CCU (exemplary picture)

8 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. ORE B51 RP21 "Parameter der AK 69/Intermat – Betriebsfestigkeit"
28. VDI 2230 Blatt 1:2015-11 Systematic calculation of highly stressed bolted joints – Joints with one cylindrical bolt
29. VDI 2230 Blatt 2:2014-12 Systematic calculation of highly stressed bolted joints – Multi bolted joints
30. DIN EN 14198:2021-07 Railway applications – Braking – Requirements for the brake system of trains hauled by locomotives
31. UIC 522 Conditions for the acceptance of draw-only automatic couplers
32. 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
33. UIC 530-2 Wagons – Running safety
34. UIC 530-5 TBD
35. EN_DAC 2023 (WI 00256A0K)