

Impact Tests regarding EN15551 and prevent-coupling position

Test report

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Abbreviations & Acronyms

Abbreviation / Acronym	Description
BP	Brake pipe
CCU	Coupler control unit
CL	Coupling link
DAC	Digital automatic coupler
DBST	DB Systemtechnik GmbH
DC	Dellner Couplers AB
DMS	Strain gauge (ger.: Dehnungsmessstreifen)
e-coupler	Electrical coupler
ERJU	Europe's Rail Joint Undertaking
FT	Faiveley Transport SA / respective: Wabtec Corporation
HBK	Hottinger Brüel & Kjaer GmbH
HVLE	Havelländische Eisenbahn
KB	Knorr-Bremse AG
PC	Prevent coupling position
R2C	Ready-to-couple position
S/N	Serial number
T...	Test No. (e.g.: T123 = Test No. 123)
TOR	Top of rail
TTL	Train Test Lab
TTL-ID	Component ID given by the TTL for asset management
VT	Voith GmbH & Co. KGaA
WP	Wabtec position

1 Project description and objective

The TRANS4M-R consortium within Flagship Project 5 (FP5) of the ERJU project aims to develop and validate the Full Digital Freight Train (FDFT). A main component of the FDFT is the digital automatic coupler (DAC). Different suppliers developed DACs that ran through a process of impact tests with identical coupler types.

In order to gain information on the function of the couplers on special / difficult infrastructure, tests on these infrastructures shall be executed with couplers of non-identical type / supplier.

The tests are coordinated by the test management (WP1) within TRANS4M-R and distributed across several test instances. This report covers the tests that were executed by WP14 in TRANS4M-R in the Train Test Lab.

1.1 WP14 Train Test Lab – General overview

The Train Test Lab can be seen as an institution with different sites that have special characteristics and thus provides resources for special tests. The main site is located at the HVLE in Berlin-Spandau. However, since the special infrastructure is not present in Berlin, but available at the TÜV Süd Rail in Görlitz, the tests described in this report were executed there.

The goals pursued in the Train Test Lab can be divided into four areas of action.

On one hand, component testing on vehicle level enables the project participants to test ideas quickly and thus contribute to the development process.

On the other hand, it must be possible to make decisions on component types at defined milestones within the project. The evaluation of the various technical solutions is to be carried out on the basis of defined tests and the results are to be submitted to the decision-makers as a technical test report with a valid factual basis.

The third line of action involves the approval-relevant tests. Currently, there is no complete set of rules for the approval of technical solutions and the required standards still have to be created. Within the Train Test Lab, preliminary tests are to be made possible in order to develop approval tests, but also to check the approvability of the new components, freight wagons and locomotives.

The fourth action area involves the implementation of demonstrations. Experts and workers from the entire sector should be able to understand the new technologies and contribute their know-how and knowledge to the development process. In addition, personnel must be trained in the use of the new technology at an early stage. For this purpose, practical training courses are to be developed and tested in the Train Test Lab.

1.2 Objective for interoperability tests and report structure

The basis for the execution of impact tests regarding [EN15551] and functional tests of the prevent-coupling position is given in the test scenario Impact Tests [TS-2025-14].

The overall report consists of a main report and numerous annexes. The main report starts with a description of the project and the environment. The test objectives and report structure are explained in chapter 1. Chapter 2 introduces the DAC and describes the need for impact tests regarding [EN15551] and functional tests of the prevent coupling position. Chapter 3 describes the infrastructure (locations, vehicles, systems under test) used for the different tests. The test schedule summary is shown in chapter 4.

The description of the test concepts required for the realisation of test cases and the results are included as appendices to the main report.

The relevant annexes are listed in chapter 7.

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1.3 Contact persons

The work package (WP14) lead is overall responsible for the planning, execution and documentation of the tests in WP14 as well as for the allocation of required resources to do so.

The technical test lead is responsible for the proper planning and realisation of the tests, as well as the measurement technology.

The operational test lead is responsible for the operational realisation and ensures safety during the execution of the tests.

During the tests, it was essential to always have experts from the respective supplier on site. It was also important to have close contact with the leader of the expert group.

The report is distributed to the persons listed. Further distribution should only take place in accordance with the above-mentioned confidentiality.

Table 1: Contact persons

Role	Name	E-Mail
WP14 lead – responsible for content	Daniel Wolfram	Daniel.Wolfram@deutschebahn.com
Technical test lead	Julian Beck	Julian.J.Beck@deutschebahn.com
Supplier contact – Dellner	Johanna Wiklund	Johanna.Wiklund@dellner.com
Supplier contact – Knorr-Bremse	Eva Lohmeier	Eva.Lohmeier@knorr-bremse.com
Supplier contact – Voith	Ulrich Deghela	Ulrich.Deghela@voith.com

2 Fundamentals, definitions and technical principles

The following chapters describes the fundamentals of the DACs (chapter 2.1) and the resulting necessity of impact tests regarding [EN15551] (chapter 2.2) and functional tests of the prevent-coupling position (chapter 2.3).

The chapters summarize the respective content of the test scenario [TS-2025-014]. Further, more detailed information regarding the fundamentals, definitions and technical principles can be found in that document.

2.1 Basics of DAC in the Scharfenberg design

As the design of DACs was fixed to the Scharfenberg design, all suppliers of DACs within the TRANS4M-R FP5 are developing DACs of that type.

The general design consists of different parts (pneumatical parts in red, electrical parts in blue):

- Coupler head, with:
 - o Manual uncoupling device
 - o Actuator for automated uncoupling
 - With push buttons or remotely operated
 - o Hook plate + coupling link
 - o Guiding horn + cone
 - o Air pipe connection (brake pipe, eventually main reservoir pipe)
 - o Air valve (with connection to brake pipe of wagon)
- E-coupler, with:
 - o Power-line-connection
 - o Data-line-connection
- Coupler shank, with:
 - o Pivot pin for connection between shank and draft gear
- Split collar (or fix connection between shank and head)¹
- Draft gear, with:
 - o Compression force stop for form closure with wagon
 - o Mounting plate from below
- Vertical support (with centration)

¹ Note: at the time of tests all suppliers delivered DACs without split collars

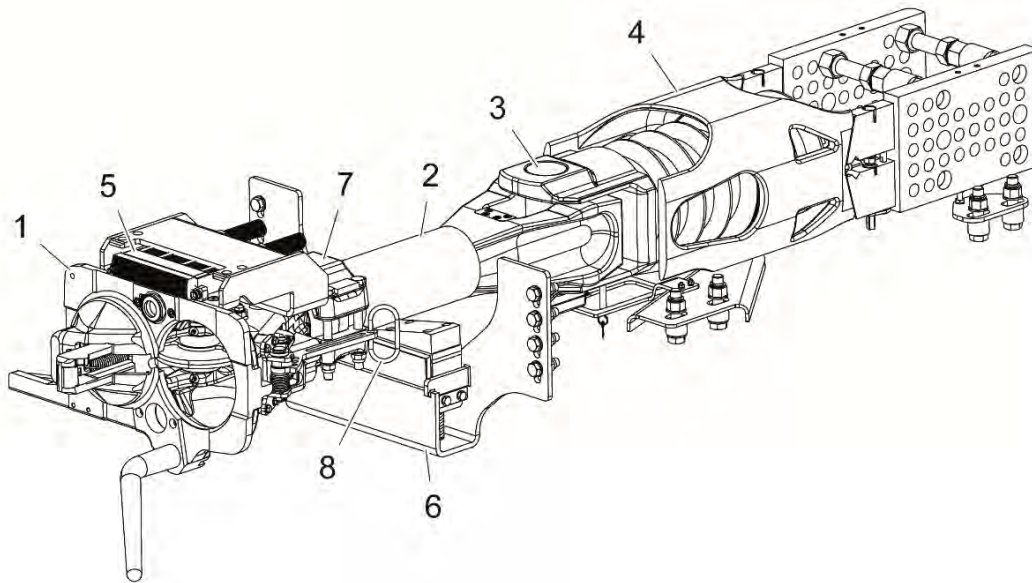


Figure 1: Scheme of the DAC. 1: mechanical coupler / coupler head, 2: coupler shank, 3: pivot pin, 4: draft gear (with compression force stop on the right end and mounting plate below), 5: electrical coupler, 6: vertical support, 7: split collar, 8: manual uncoupling device; Source: [TS-2025-014].

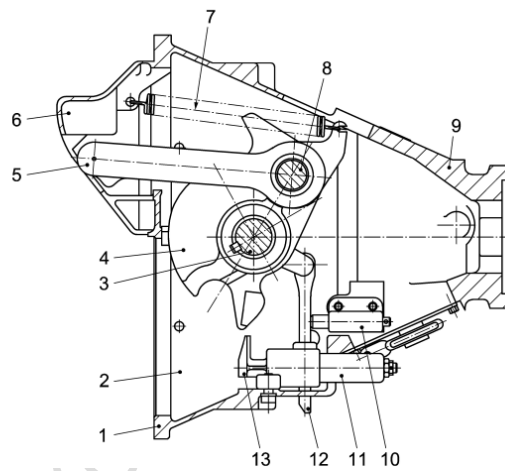


Figure 2: Scheme of the coupler head. 1: coupler face, 2: female cone, 3: main pin, 4: hook plate, 5: coupling link, 6: male cone, 7: tension spring, 8: coupling link pin, 9: coupler head housing, 10: release bar holder, 11: trigger device, 12: release bar, 13: trigger; Source [EN16019].

To control the electrical parts a CCU (coupler control unit) is used. The power-supply is connected to a junction box. To uncouple the coupler via the actuator, a synchronization signal is used to trigger both actuators and therefore reset both couplers into the prevent-coupling position (PC). After a dedicated amount of time without an impact onto the coupler, the coupler is reset to the ready-to-couple position (R2C).

The suppliers are currently providing DACs which might differ in (focus on mechanical and pneumatical parts):

- Design of front plate
- Behaviour of springs, hook plate and coupler link of the coupler head
- Design of draft gear (e.g. single components or caged)
- Behaviour of draft gear (e.g. spring and attenuation constant, material, etc.)
- Design of mechanical uncoupling mechanism
- Behaviour of air valve (always open or closed when ready-to-couple / prevent coupling)
- Behaviour of e-coupler connection (e.g. spring characteristics)

Due to these differences, the interoperability between the DACs of different suppliers should be tested.

2.2 Necessity of impact tests regarding [EN15551]

The functionality of the couplers and their structural strength should be proven. [TS-2025-015] defines the necessary tests regarding the [EN15551] and the worst-case scenarios in terms of wagon choice and infrastructure.

Tests regarding the [TS-2025-014] shall be executed. Tests on special infrastructure were executed at the TÜV Süd Rail in Görlitz and are described in [TR01-2025-014].

The tests on straight track are described in this report and were executed at the HVLE in Berlin-Spandau.

Further details regarding the test execution can be found in Annex 1.

2.3 Necessity of functional impact tests of prevent-coupling position

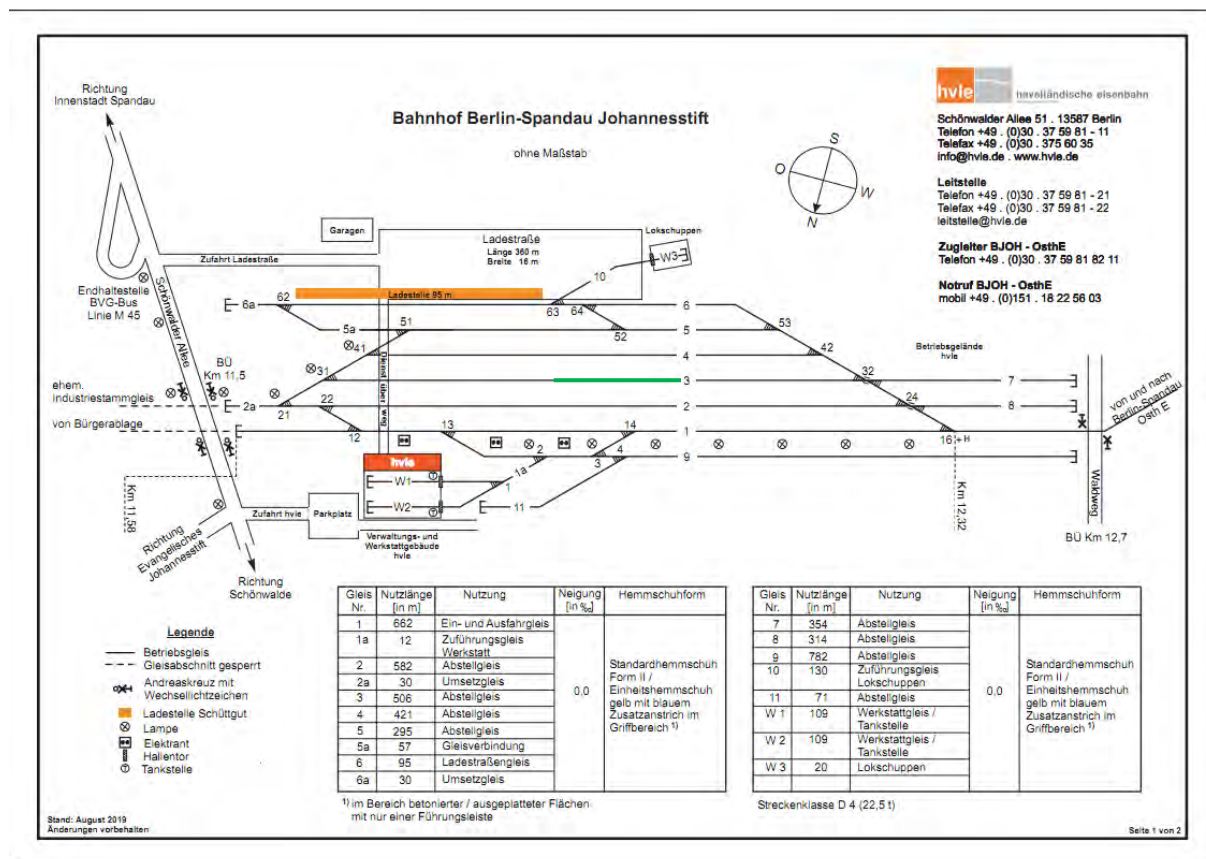
Besides the structural strength and functionality of coupling, the prevent-coupling position shall be tested. [TS-2025-014] describes the necessary tests to prove the functionality of the prevent-coupling position and the durability of the couplers and their actuators regarding the prevent-coupling position.

Further details regarding the test execution can be found in Annex 1.

3 Infrastructure

3.1 Test location

All tests were executed at the HVLE premises in Berlin-Spandau (Schönwalder Allee 51, GER-13587 Berlin).



Colour	Track	Test
Green	Track 3	Impact tests on straight track

Figure 3: Track layout of the HVLE, location Berlin-Spandau [HVLE_TL]. Edit: Test-tracks are coloured.

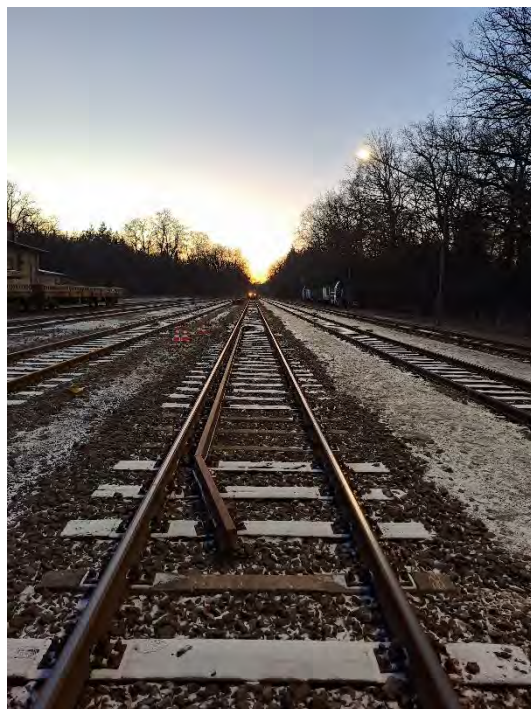


Figure 4: Straight track – track 3 at the HVLE – view into the direction of OstHE.

3.2 Vehicles

[TS-2025-014] defines the following requirements regarding the used vehicles for tests regarding [EN15551]:

Table 2: Requirements regarding vehicles from [TS-2025-014] – Impact tests [EN15551].

Moving wagon	Standing wagon
2-axle wagon 20 t	4-axle wagon 80 t
2-axle wagon 40 t	2-axle wagon 40 t
4-axle wagon 80 t	4-axle wagon 80 t

The following requirements are defined for the functional tests with prevent-coupling position:

Table 3: Requirements regarding vehicles from [TS-2025-014] – Prevent-coupling position.

Moving wagon	Standing wagon
4-axle wagon 80 t	4-axle wagon 80 t

The following wagon types were finally chosen, as they were used in the previous functional tests regarding [TS-2025-014] (see [TR01-2025-014]) and as best match for the given requirements:

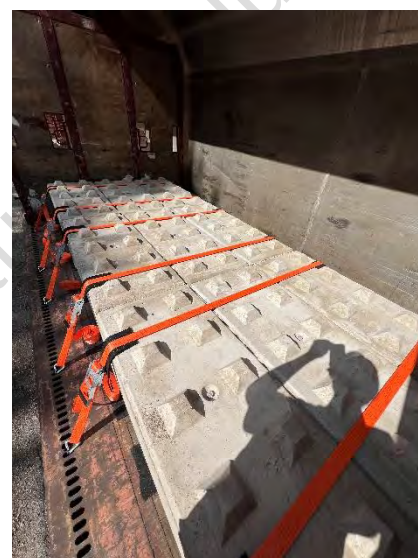
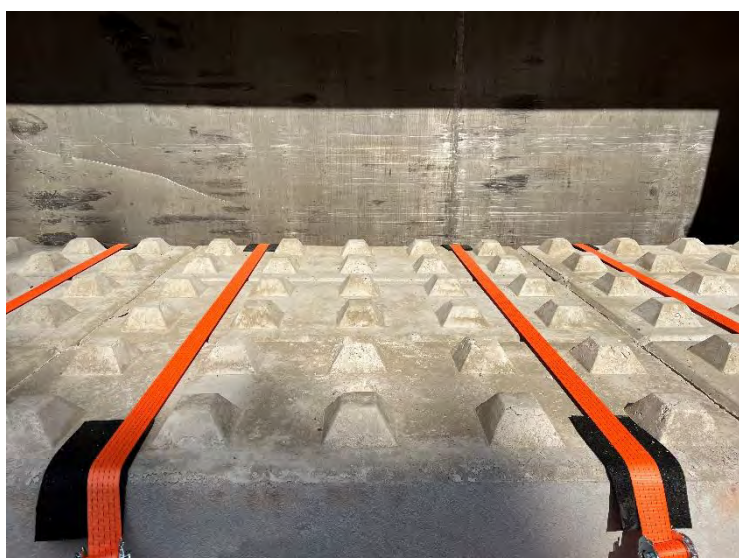
Table 4: Chosen vehicles.

	2-Axle wagon	4-axle wagon
Type	Hbbillns	Habbills 346
Description	Sliding wall wagon	Sliding wall wagon
Supplier	Mercitalia Rail	DB Cargo
Distance between bogie pivots / axles	9.00 m	18.59 m
Length over buffers	15.50 m	24.10 m
Overhang (without buffer)	2 630 mm	2 150 mm
Weight (tare)	16 500 kg	31 880 kg
Amount of vehicles	4	2

The 4-axle wagons were loaded with concrete blocks (see Figure 5). Per wagon 37 blocks were used (150 x 60 x 60 cm, 1.3 t weight) leading to an additional load of 48.1 t.

The 2-axle wagons were loaded with a mixture of different concrete blocks. Blocks with a weight of 2.7 t and 1.3 t were used to reach the expected load.

The following chapters show the detailed configurations of the used vehicles during the tests.



Scheme:

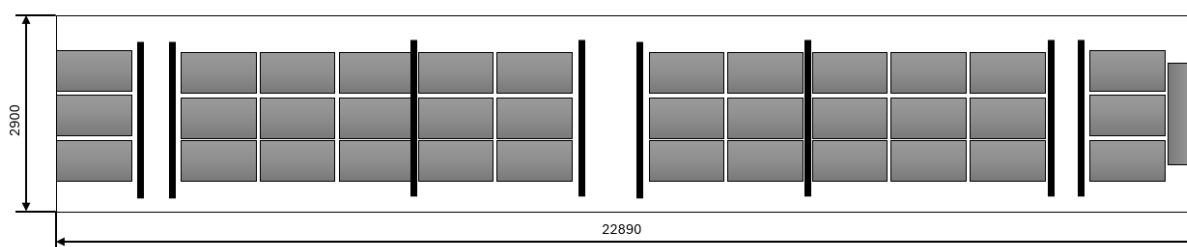


Figure 5: Loading of 4-axle wagons.

3.2.1 Ha_0136

Type regarding Table 4: 4-axle wagon

Number: 31 80 2777 013-6

Config:

Wagon	Config.	Date	Change
Ha_0136	#001	21.10.2025	Initial state: Coupler A: DC01 (DAC-r) Coupler B: KB06 Load state: full
Ha_0136	#002	04.11.2025	Change of KB06 to DAC-ready, installation of DC01: Coupler A: DC01 Coupler B: KB06 (DAC-r) Load state: full
Ha_0136	#003	24.11.2025	Exchange of electronic components on DC01: Coupler A: DC01 Coupler B: KB06 (DAC-r) Load state: full
Ha_0136	#004	13.01.2026	Change of coupler DC01 to VT05: Coupler A: VT05 Coupler B: KB06 (DAC-r) Load state: full
Ha_0136	#005	20.01.2026	New electronic installation for VT05: Coupler A: VT05 (new electronics) Coupler B: KB06 (DAC-r) Load state: full
Ha_0136	#006	23.01.2026	Change of VT05 to DAC-ready, installation of KB06: Coupler A: VT05 (DAC-r) Coupler B: KB06 Load state: full

Loading:

Load state	Weight	Source / description / remark
empty	31 880 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
full	79 980 kg	Sources: - Wagon-inscription. - Manufacturer information (37 concrete blocks with a weight of 1.3 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 6: Ha_0136.

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3.2.2 Ha_0458

Type regarding Table 4: 4-axle wagon

Number: 31 80 2777 045-8

Config:

Wagon	Config.	Date	Change
Ha_0458	#001	21.10.2025	Initial state: Coupler A: KB04 (DAC-r) Coupler B: VT03 Load state: full
Ha_0458	#002	05.11.2025	Installation of KB04, change of VT03 to DAC-ready: Coupler A: KB04 Coupler B: VT03 (DAC-r) Load state: full
Ha_0458	#003	28.11.2025	Deinstallation of electronics on KB04: Coupler A: KB04 (no electronics) Coupler B: VT03 (DAC-r) Load state: full
Ha_0458	#004	12.12.2025	Change of coupler head and reinstallation of electronics on KB04: Coupler A: KB04 Coupler B: VT03 (DAC-r) Load state: full
Ha_0458	#005	09.01.2025	Change of coupler from KB04 to DC02: Coupler A: DC02 Coupler B: VT03 (DAC-r) Load state: full
Ha_0458	#006	20.01.2025	Change of coupler from DC02 to VT06: Coupler A: VT06 Coupler B: VT03 (DAC-r) Load state: full
Ha_0458	#007	22.01.2025	Change of couplers, VT06 to DAC-ready and VT03 to KB04: Coupler A: VT06 (DAC-r) Coupler B: KB04 Load state: full

Loading:

Load state	Weight	Source / description / remark
empty	31 880 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
full	79 980 kg	Sources: - Wagon-inscription. - Manufacturer information (37 concrete blocks with a weight of 1.3 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 7: Ha_0458.

3.2.3 Hb_3235

Type regarding Table 4: 2-axle wagon

Number: 21 83 2457 323-5

Config:

Wagon	Config.	Date	Change
Hb_3235	#001	21.10.2025	Initial state: Coupler A: KB05 Coupler B: VT02 (DAC-r) Load state: empty
Hb_3235	#002	18.11.2025	Loading: Coupler A: KB05 Coupler B: VT02 (DAC-r) Load state: half loaded
Hb_3235	#003	09.12.2025	Demounting of Sim-Box on KB05: Coupler A: KB05 (no Sim-Box) Coupler B: VT02 (DAC-r) Load state: half loaded
Hb_3235	#004	09.12.2025	Change of KB05 to DAC-ready, installation of VT02: Coupler A: KB05 (DAC-r) Coupler B: VT02 Load state: half loaded
Hb_3235	#005	12.12.2025	Unloading: Coupler A: KB05 (DAC-r) Coupler B: VT02 Load state: empty
Hb_3235	#006	09.01.2026	Rebuilding of couplers: Coupler A: Screw Coupler B: Screw Load state: empty

Loading:

Load state	Weight	Source / description / remark
empty	16 400 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
half loaded	39 500 kg	Sources: - Wagon-inscription. - Manufacturer Information (5 concrete blocks with a weight of 2,7 t each + 6 concrete blocks with a weight of 1,6 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 8: Ha_3235.

3.2.4 Hb_3472

Type regarding Table 4: 2-axle wagon

Number: 21 83 2459 347-2

Config:

Wagon	Config.	Date	Change
Hb_3472	#001	21.10.2025	Initial state: Coupler A: DC03 Coupler B: VT01 (DAC-r) Load state: empty
Hb_3472	#002	30.10.2025	Loading: Coupler A: DC03 Coupler B: VT01 (DAC-r) Load state: half loaded
Hb_3472	#003	04.11.2025	Deinstallation of coupler head of DC03: Coupler A: DC03 (no coupler head) Coupler B: VT01 (DAC-r) Load state: half loaded
Hb_3472	#004	25.11.2025	Installation of coupler head of DC03: Coupler A: DC03 Coupler B: VT01 (DAC-r) Load state: half loaded
Hb_3472	#005	28.11.2025	Circuit board of DC03 Sim-Box deinstalled: Coupler A: DC03 (Sim-Box non-functional) Coupler B: VT01 (DAC-r) Load state: half loaded
Hb_3472	#006	09.12.2025	Change of DC03 to DAC-ready, installation of VT01: Coupler A: DC03 (DAC-r) Coupler B: VT01 Load state: half loaded
Hb_3472	#007	12.12.2025	Unloading: Coupler A: DC03 (DAC-r) Coupler B: VT01 Load state: empty
Hb_3472	#008	09.01.2026	Deinstallation of couplers: Coupler A: Screw Coupler B: Screw Load state: empty

Loading:

Load state	Weight	Source / description / remark
empty	16 500 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
half loaded	40 800 kg	Sources: - Wagon-inscription. - Manufacturer Information (9 concrete blocks with a weight of 2,7 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 9: Ha_3472.

3.2.5 Hb_3581

Type regarding Table 4: 2-axle wagon

Number: 21 83 2457 358-1

Config:

Wagon	Config.	Date	Change
Hb_3581	#001	21.10.2025	Initial state: Coupler A: Screw Coupler B: DC02 Load state: empty
Hb_3581	#002	28.10.2025	Loading: Coupler A: Screw Coupler B: DC02 Load state: half loaded
Hb_3581	#003	14.11.2025	Unloading: Coupler A: Screw Coupler B: DC02 Load state: empty
Hb_3581	#004	25.11.2025	Deinstallation of head of DC02: Coupler A: Screw Coupler B: DC02 (no head) Load state: empty
Hb_3581	#005	26.11.2025	Installation of KB coupler head and vertical support on DC02, deinstallation of electronics: Coupler A: Screw Coupler B: DC02 (KB head and vertical support - no electronics) Load state: empty
Hb_3581	#006	02.12.2025	Wagon in use for grounding tests. Different changes in coupler heads of DC02: Coupler A: Screw Coupler B: DC02 (numerous head changes for grounding tests) Load state: empty
Hb_3581	#007	03.12.2025	End of grounding tests. DC02 with FT head and no electronics: Coupler A: Screw Coupler B: DC02 (FT head and KB vertical support - no electronics) Load state: empty
Hb_3581	#008	09.12.2025	Deinstallation of coupler: Coupler A: Screw Coupler B: Screw Load state: empty

Loading:

Load state	Weight	Source / description / remark
empty	16 500 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
half loaded	40 800 kg	Sources: - Wagon-inscription. - Manufacturer Information (9 concrete blocks with a weight of 2,7 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 10: Ha_3581.

3.2.6 Hb_3746

Type regarding Table 4: 2-axle wagon

Number: 21 83 2459 374-6

Config:

Wagon	Config.	Date	Change
Hb_3746	#001	21.10.2025	Initial state: Coupler A: KB02 (DAC-r) Coupler B: VT04 Load state: empty
Hb_3746	#002	18.11.2025	Loading: Coupler A: KB02 (DAC-r) Coupler B: VT04 Load state: half loaded
Hb_3746	#003	28.11.2025	Installation of KB02, Change of VT04 to DAC-ready: Coupler A: KB02 Coupler B: VT04 (DAC-r) Load state: half loaded
Hb_3746	#004	02.12.2025	Wagon in use for grounding tests. Different changes in coupler heads of KB02: Coupler A: KB02 (numerous head changes for grounding tests) Coupler B: VT04 (DAC-r) Load state: half loaded
Hb_3746	#005	03.12.2025	End of grounding tests: Coupler A: KB02 Coupler B: VT04 (DAC-r) Load state: half loaded
Hb_3746	#006	10.12.2025	Unloading: Coupler A: KB02 Coupler B: VT04 (DAC-r) Load state: empty
Hb_3746	#007	09.01.2025	Deinstallations of couplers: Coupler A: Screw Coupler B: Screw Load state: empty

Loading:

Load state	Weight	Source / description / remark
empty	16 500 kg	Sources: - Wagon-inscription. Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.
half loaded	40 800 kg	Sources: - Wagon-inscription. - Manufacturer Information (9 concrete blocks with a weight of 2,7 t each) Remarks: - Installed electronic systems and measurement system not included. - Screw coupler exchanged with DAC.

Photo documentation:



Figure 11: Ha_3746.

3.3 Systems under test

Three samples of DACs (Dellner, Knorr-Bremse, Voith) were available in the Train Test Lab for the test.

Regarding the function of the air valve, all suppliers delivered couplers with an always-open air valve.

As at the time no fully developed CCUs were available, the electrical parts were controlled via a simulation box. The systems should provide the functions: uncouple and prevent coupling. The simulation box and the belonging systems (junction box and push buttons) are positioned the most practical for the tests and planned de-/reinstallations and not as they would be placed on future commercial vehicles.

Furthermore, Voith is the only supplier for e-couplers. Therefore, Voith delivered four e-couplers per supplier for the tests.

The suppliers delivered couplers with different functionalities. Table 5 summarizes these.

Table 5: Summary of the functionalities of the provided assets.

Supplier	Mechanical Coupler	Manual uncoupling	Actuator	Simulation Box / Push Buttons	Synchronization signal
DC	✓	✓	✓	✓	✓
KB	✓	✓	✓	✓	✗
VT	✓	✓	✓	✓	✗/✓ ¹⁾

¹⁾ Voith provided an updated electronic system with synchronization signal for tests on the 21.01.2026.

The systems under test are described in further detail in the following chapters. First the DAC of the respective supplier is introduced, followed by the configurations for each individual coupler.

3.3.1 Dellner

3.3.1.1 Overview of the coupler

Part	Type
Draft Gear	2013768-DE
Coupler Head	9230/2012892
Vertical support	- no type plate -

The coupler of Dellner is shown in the following figures.

The mechanical coupler consists of:

- Draft gear (one cage)
- Vertical support
- Coupler head (with manual uncoupling)

The electronic system consists of:

- Actuator mounted from the outside of the coupler
- Couple status sensors with couple status flag in a separate box mounted on top of the coupler
- Actuation plate for the e-coupler on separate bolt, mounted onto the coupler
- Simulation box (containing the junction box)
- Push buttons (optional on both sides) [Buttons: Enable (orange), Prevent Coupling (grey)]

Functionality of electronic components regarding [DC_DACCU]:

- Buttons:
 - o Press the orange and the grey button simultaneously to wake-up the system
 - o Press orange button ("Engage") to enable functions
 - Engage status is reset after 20s
 - o Short press on grey button ("Prevent Coupling / Reset"):
 - Uncouple and set to prevent coupling position for 60 s
 - Reset to ready-to-couple position if coupler is in prevent coupling state
 - o Long press (5s) on grey button ("Prevent Coupling / Reset"): Uncouple and set to prevent coupling position for infinite time
- Actuator:
 - o In Prevent coupling position the actuator is fixed and braked to prevent movement of the hook plate

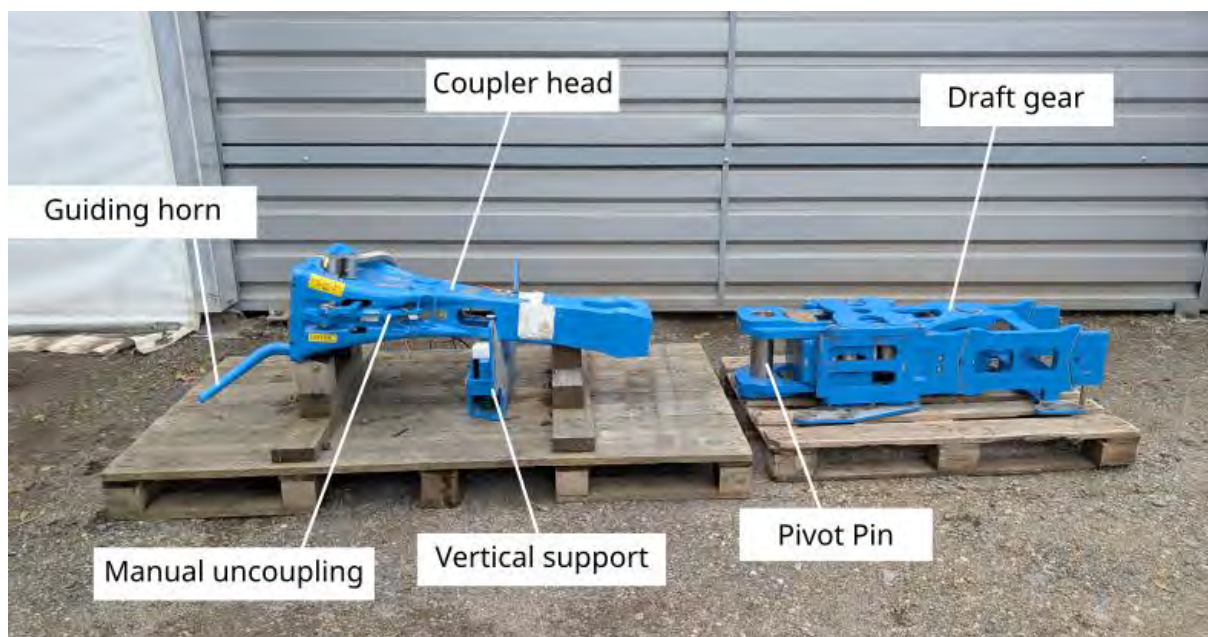


Figure 12: Dellner – Overview of coupler parts – side view.

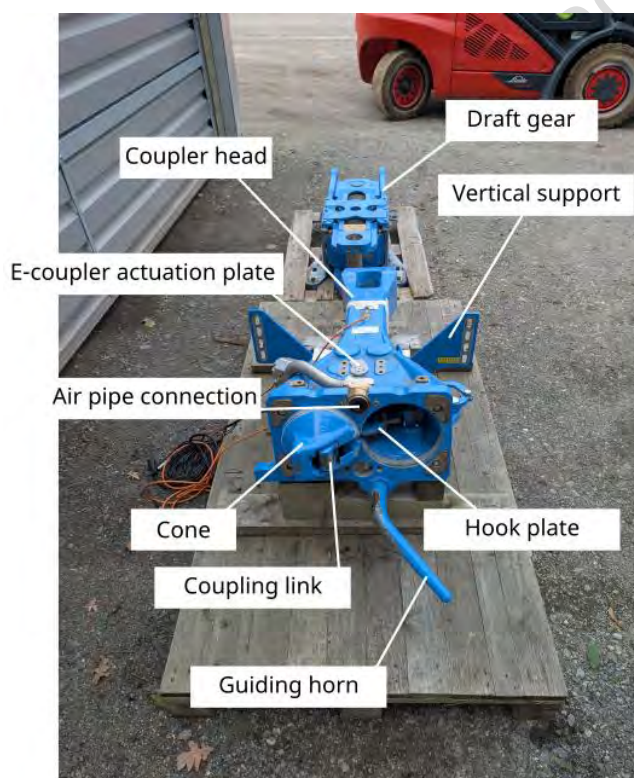


Figure 13: Dellner – Overview of coupler parts – front view.

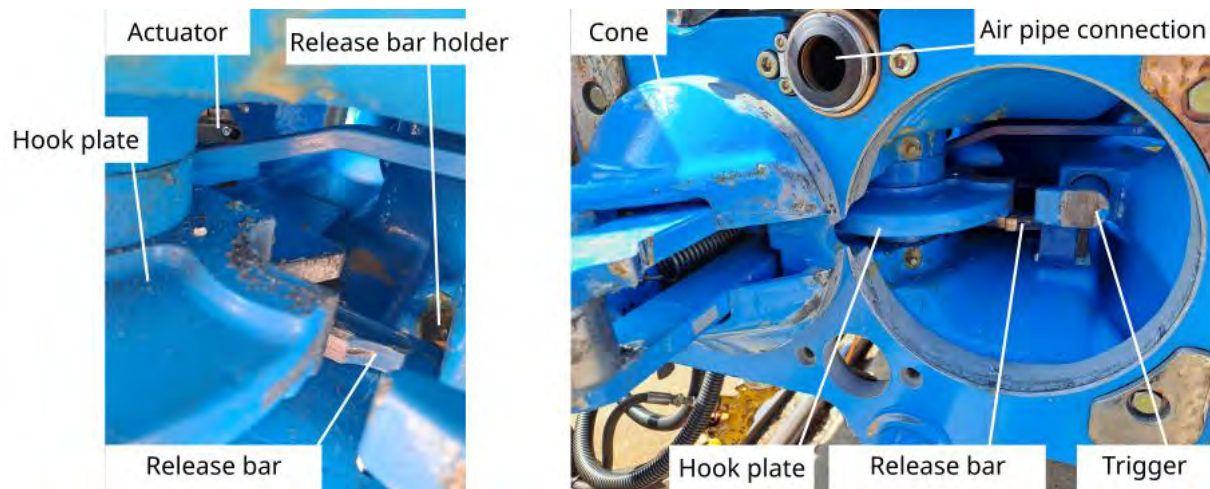


Figure 14: Dellner – Overview of the coupler head.

EXTRACT - 24.02.2026
(Confidential information excluded)

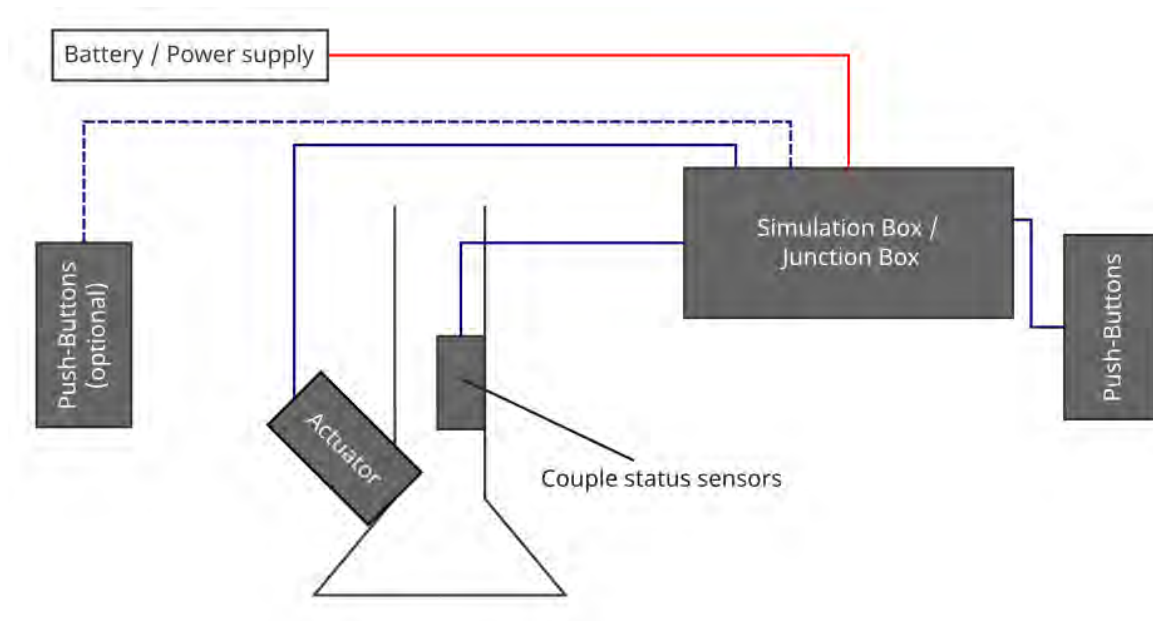


Figure 15: Dellner – Scheme of electronic system.

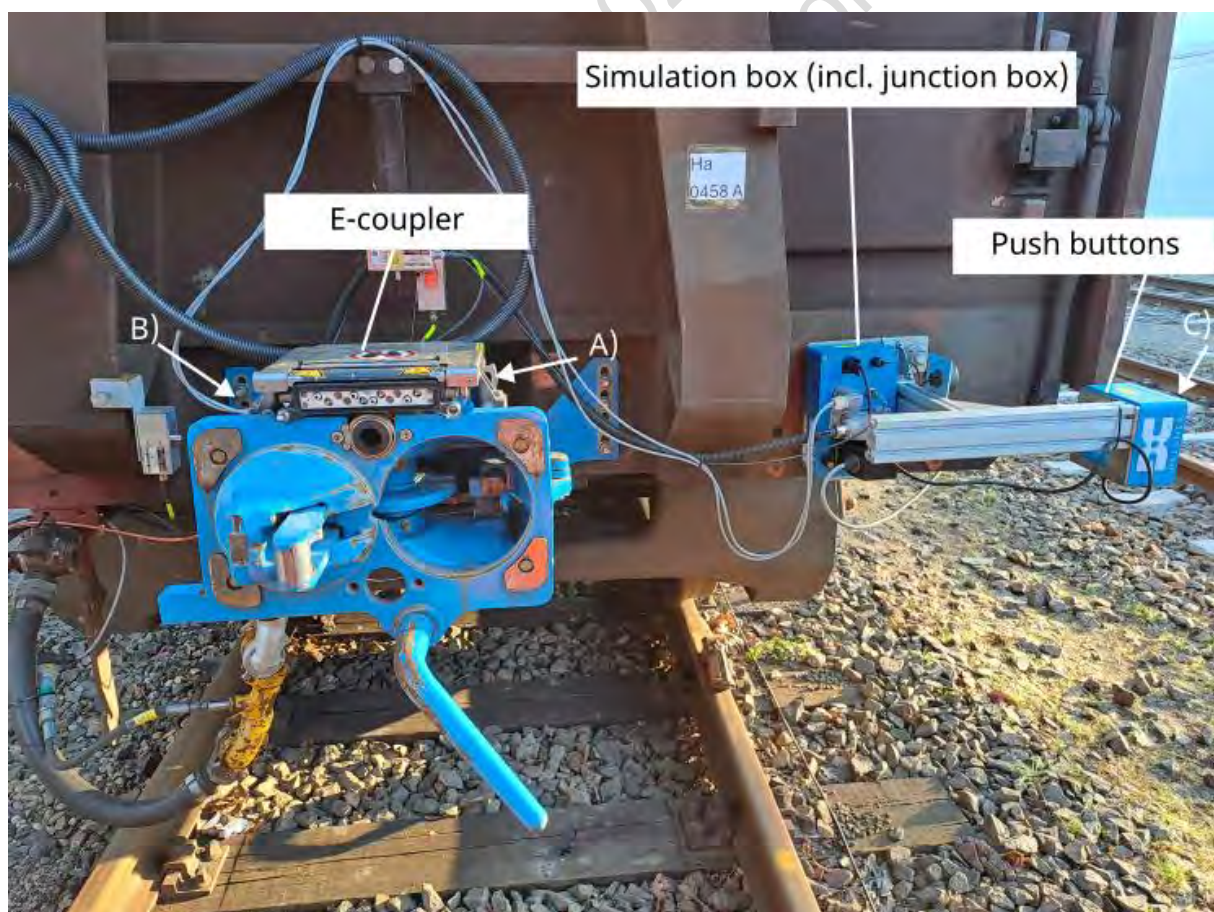


Figure 16: Dellner – Overview of electronic system.

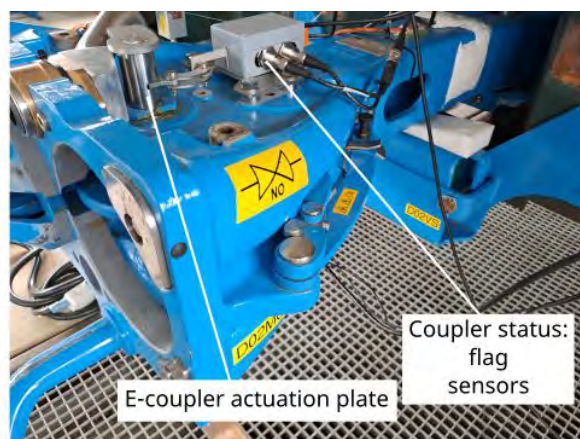
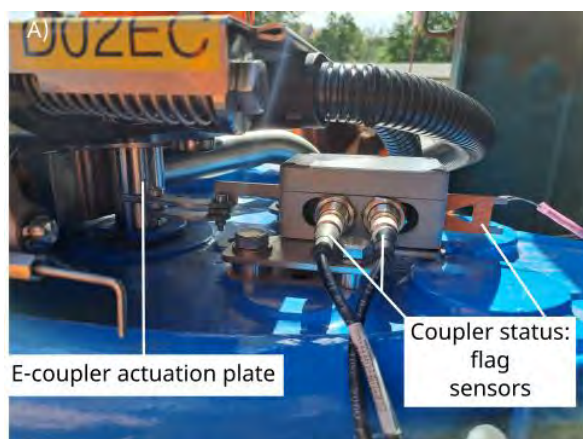


Figure 17: Dellner – Electronic system, View A).



Figure 18: Dellner – Electronic System, View B) and C).

3.3.1.1.1 Overview of used parts

Table 6: Overview of used parts - Dellner.

Part	Type	TTL-ID	Serial number
Draft Gear	2013768-DE	D01DG D02DG D03DG	008 009 007
Coupler Head	9230/2012892	D01MC D02MC D03MC	008 006 007
Vertical support	- no type plate -	D01VS D02VS D03VS	008 006 007
Simulation Box		D01SB D02SB	
Push Buttons		D01PB D02PB	
E-coupler	Voith: 230.103701-001	D01EC D02EC	4510049886-005 4510049886-003

3.3.1.2 DC01

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> Screw coupler	Ha_0136, side A
04.11.2025	#002	Installation of parts.	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #002 Remark: DMS installed. Actuator defect. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D01VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Ha_0136, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
05.11.2025	#003	Sim-Box defect (D01SB).	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #001 Remark: DMS installed. Actuator defect. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D01VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #002 Remark: Defect <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Ha_0136, side A
24.11.2025	#004	Change of electronics New actuator in D01MC. New circuit board for D01SB.	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #003 – new actuator Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D01VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #003 – new circuit board <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Ha_0136, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
25.11.2025	#005	Push-button box defect.	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #003 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D01VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #003 <u>Push Buttons:</u> TTL-IDs: D01PB Config: #002 Remark: Defect	Ha_0136, side A
28.11.2025	#006	Push-button box functioning again. Maybe a loose connection in D01PB or D01SB.	<u>Draft Gear:</u> TTL-ID: D01DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #003 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D01VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #003 Remark: Maybe a loose connection <u>Push Buttons:</u> TTL-IDs: D01PB Config: #003 - Functioning again Remark: Maybe a loose connection	Ha_0136, side A
13.01.2026	#007	Deinstallation		

3.3.1.3 DC02

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: D02DG Config: #001 Remark: Screws so far not changed regarding Dellner maintenance guide. <u>Coupler Head:</u> TTL-ID: D02MC Config: #001 Remark: DMS installed. <u>Vertical Support:</u> TTL-ID: D02VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3581, side A
27.10.2025	#002	Change of screws of D02DG. E-coupler installation.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 – change of screws <u>Coupler Head:</u> TTL-ID: D02MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D02VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3581, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
24.11.2025	#003	Changes of electronics. New actuator for D02MC. New couple-status sensors for D01MC. New circuit board for D01SB.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Coupler Head:</u> TTL-ID: D02MC Config: #002 – new actuator, new couple status sensors. Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D02VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #002 – new circuit board <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3581, side A
25.11.2025	#004	Deinstallation of coupler head and electronics. D02MC exchanged to DC03.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Vertical Support:</u> TTL-ID: D02VS Config: #001	Hb_3581, side A
26.11.2025	#005	Installation of KB coupler head and vertical support.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Coupler Head:</u> TTL-ID: K02MC Type: Knorr-Bremse: 04061272580221, KP6948598-1MX S/N: 3525150006 Config: #001 <u>Vertical Support:</u> TTL-ID: K02VS Type: Knorr-Bremse: 04061272577825, KP1835697-1MX S/N: 3525160014 Config: #001	Hb_3581, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
02.12.2025	#006	Installation of different coupler heads during grounding tests.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Coupler Head:</u> Remark: Numerous heads of different suppliers installed during grounding tests. <u>Vertical Support:</u> TTL-ID: K02VS Type: Knorr-Bremse: 04061272577825, KP1835697-1MX S/N: 3525160014 Config: #001	Hb_3581, side A
03.12.2025	#007	Status after grounding tests.	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Coupler Head:</u> TTL-ID: W02MC Type: Faiveley / Wabtec: 730-02067 S/N: BS38418 Config: #001 <u>Vertical Support:</u> TTL-ID: K02VS Type: Knorr-Bremse: 04061272577825, KP1835697-1MX S/N: 3525160014 Config: #001	Hb_3581, side A
09.12.2025	#008	Deinstallation		
09.01.2026	#009	Installation in Ha_0458	<u>Draft Gear:</u> TTL-ID: D02DG Config: #002 <u>Coupler Head:</u> TTL-ID: D02MC Config: #002 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #004 <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Ha_0458, side A
20.01.2026	#010	Deinstallation		

3.3.1.4 DC03

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D03MC Config: #001 <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Hb_3472, side A
29.10.2025	#002	Change of mechanical coupler.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #001 Remark: DMS installed <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Hb_3472, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
29.10.2025	#003	Actuator of D01MC defect.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D01MC Config: #002 – Actuator defect Remark: DMS installed. Actuator defect. <u>E-Coupler:</u> TTL-ID: D02EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: D01PB Config: #001	Hb_3472, side A
04.11.2025	#004	Deinstallation of E-coupler, coupler head and electronics.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001	Hb_3472, side A
25.11.2025	#005	Installation of coupler head, e-coupler and electronics.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D02MC Config: #002 Remark: DMS installed <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #002 <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3472, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
26.11.2025	#006	Defect of simulation box.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D02MC Config: #002 Remark: DMS installed <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #003 Remark: Defect. <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3472, side A
28.11.2025	#007	Deinstallation of circuit board of D02SB. Reparation of Push button box.	<u>Draft Gear:</u> TTL-ID: D03DG Config: #001 <u>Coupler Head:</u> TTL-ID: D02MC Config: #002 Remark: DMS installed <u>E-Coupler:</u> TTL-ID: D01EC Config: #001 <u>Vertical Support:</u> TTL-ID: D03VS Config: #001 <u>Sim-Box:</u> TTL-ID: D02SB Config: #004 – deinstallation of circuit board. Remark: No circuit board. Non-functional. <u>Push Buttons:</u> TTL-IDs: D02PB Config: #001	Hb_3472, side A
09.01.2026	#008	Deinstallation		

3.3.2 Knorr-Bremse

3.3.2.1 Overview of the coupler

Part	Type
Draft Gear inkl. Damper Kit	04061272585004 / KP5311349-3MX 04061272585011 / KP5311348-MX
Coupler Head	04061272580221 / KP6948598-1MX
Vertical support	04061272577825 / KP1835697-1MX

The coupler of Knorr-Bremse is shown in the following figures.

The mechanical coupler consists of:

- Draft gear with damper kit (in one cage)
- Vertical support
- Coupler head (with manual uncoupling)

The electronic system consists of:

- Actuator mounted inside the coupler
- (Couple status sensors - not connected to the electric system during the tests)
- Actuation plate for the e-coupler
- Simulation box (containing the junction box)
- Push buttons (both sides needed for a functioning system) [Buttons: uncouple (blue), reset prevent coupling timer (white), green button without function]
- (Synchronization signal over the e-coupler - not connected correctly during the tests)

Functionality of electronic components:

- Buttons:
 - o Press the blue button to uncouple and set the coupler into prevent-coupling-position for 30s (the time is reset after an impact)
 - o When in prevent-coupling position, press the white button to reset the timer (resetting of prevent-coupling into ready-to-couple position only automatically after the reset-time expired. No manual reset possible).
 - o Green button: no function.
- Actuator:
 - o In Prevent coupling position the actuator is fixed and braked to prevent movement of the hooked plate

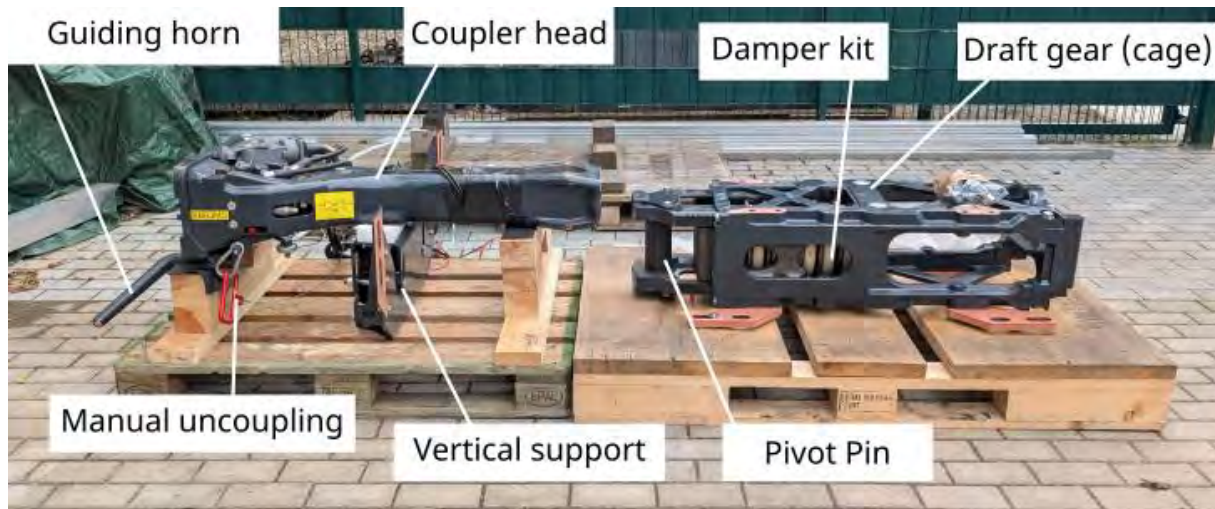


Figure 19: Knorr-Bremse - Overview of coupler parts - side view.

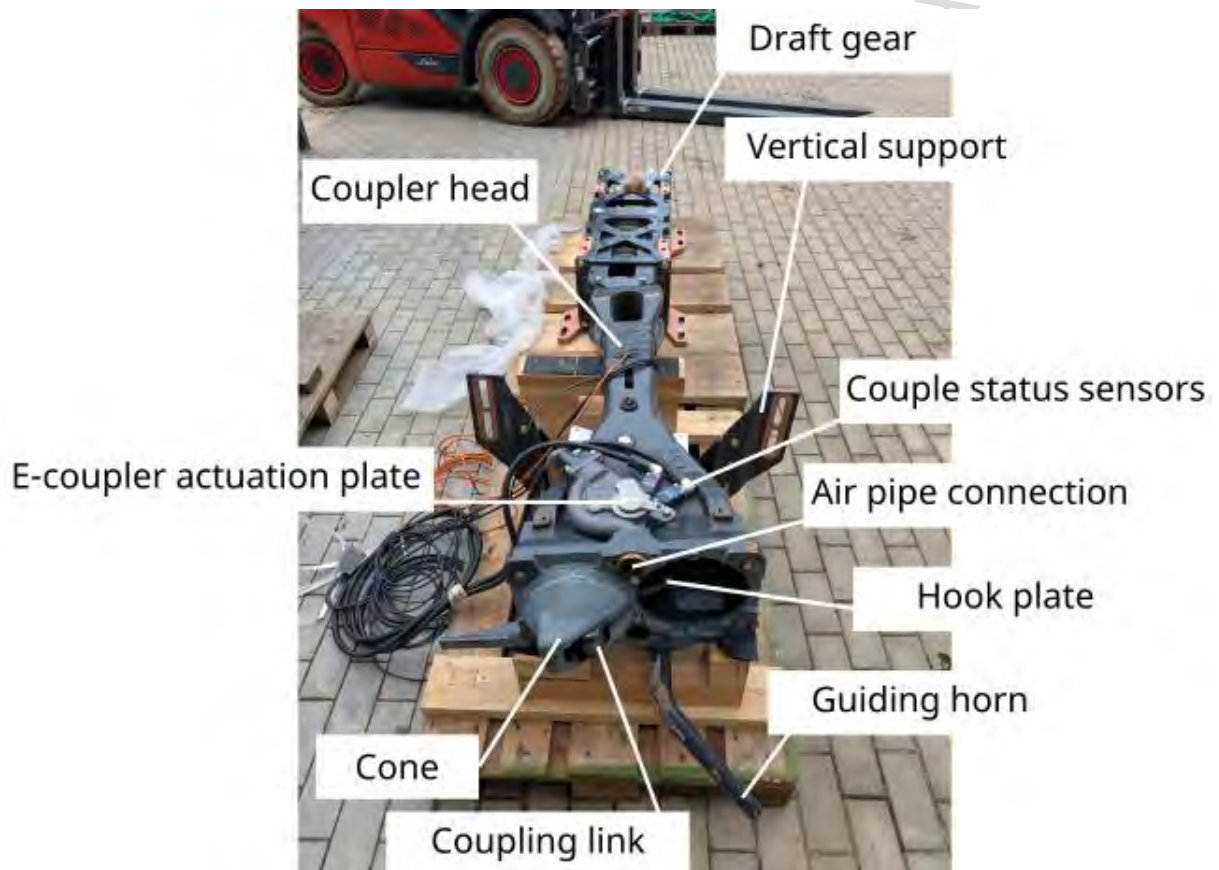


Figure 20: Knorr-Bremse - Overview of coupler parts - front view.

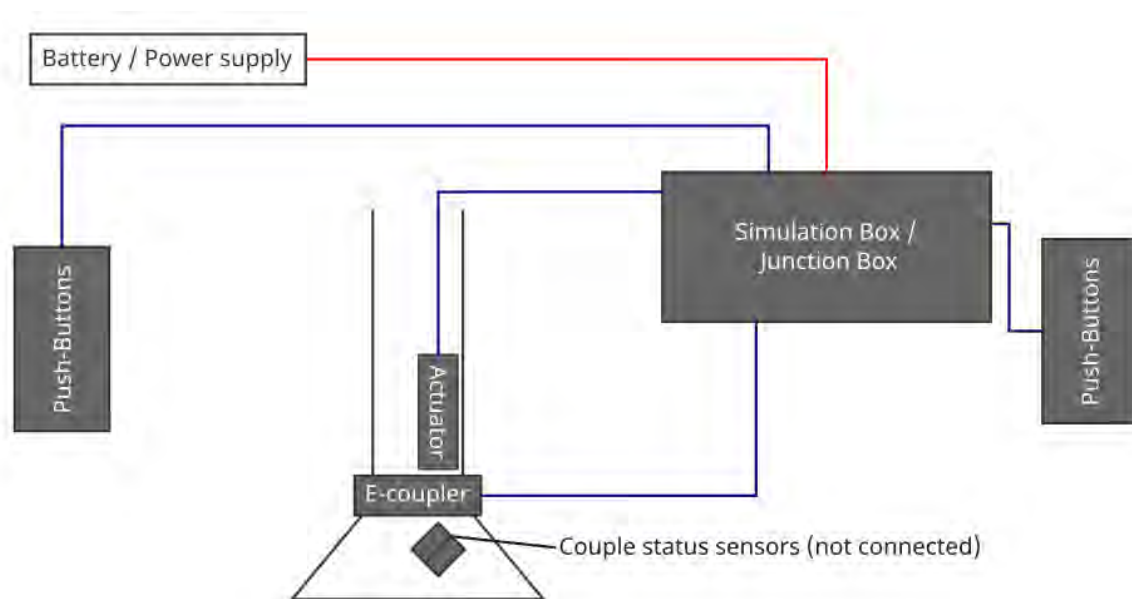


Figure 21: Knorr-Bremse – Scheme of electronic system.

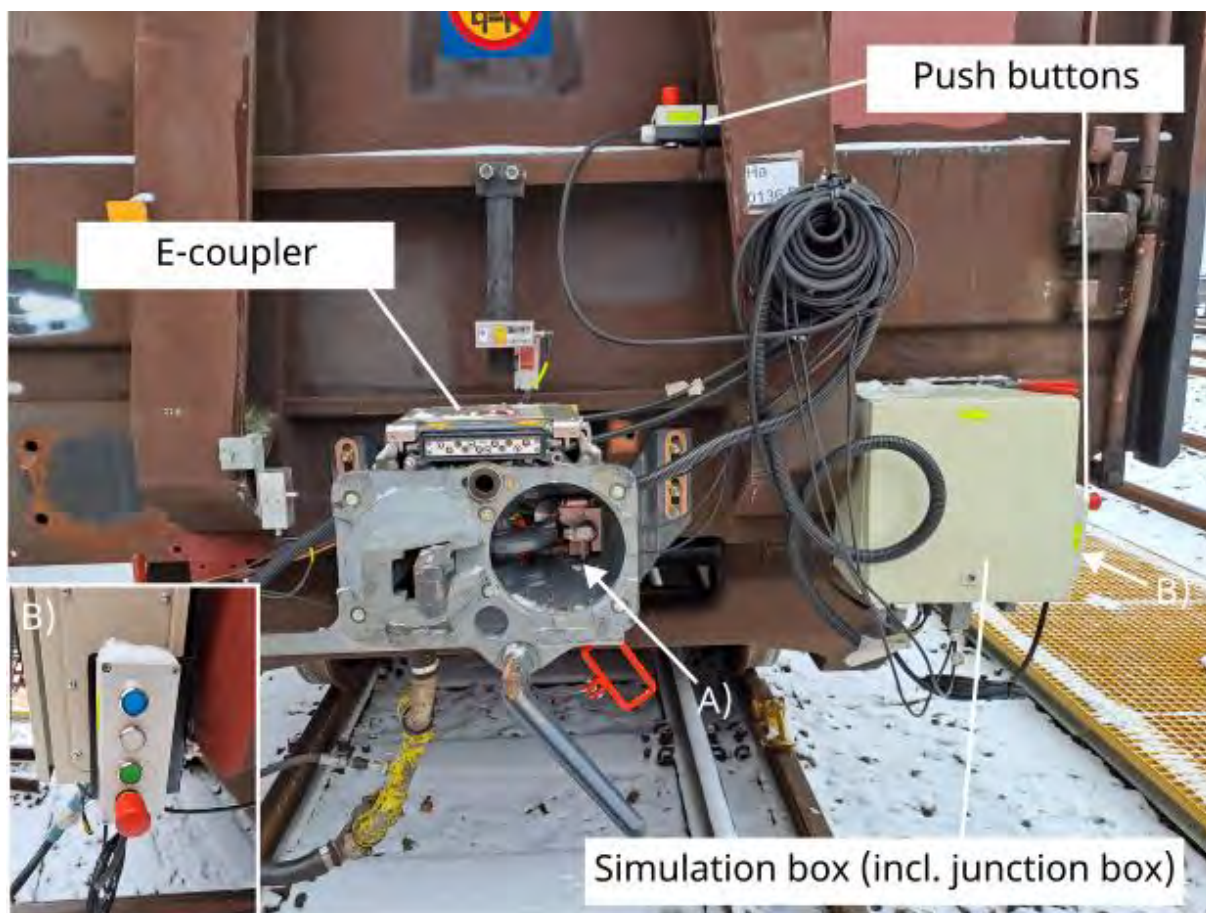


Figure 22: Knorr-Bremse - Overview of electronic system.

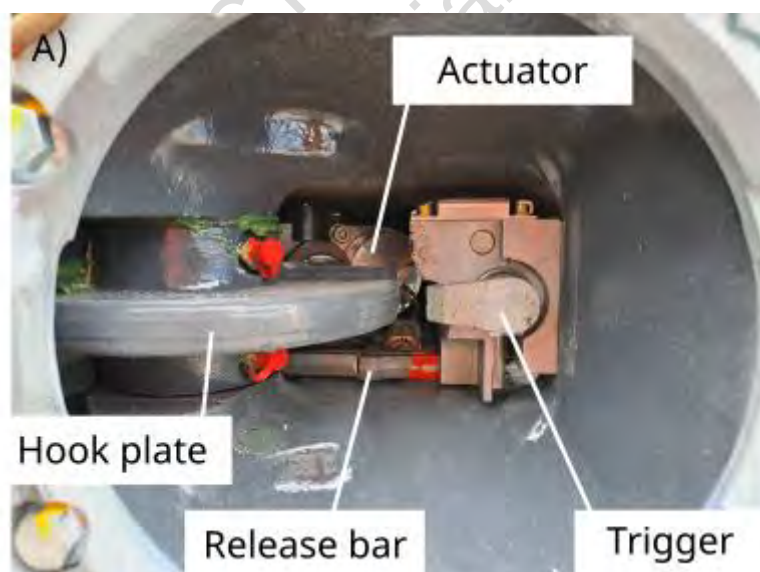


Figure 23: Knorr-Bremse - Overview of the coupler head.

3.3.2.1.1 Overview of used parts

Table 7: Overview of used parts – Knorr-Bremse.

Part	Type	TTL-ID	Serial number
Draft Gear Damper Kit	04061272585004 / KP5311349-3MX 04061272585011 / KP5311348-MX	K02DG	3525160008 3525190018
		K04DG	3525160016 3525190023
		K05DG	3525160009 3525190019
		K06DG	? (Serial number unknown – serial number was not documented before installation and is not visible when installed)
Coupler Head	04061272580221 / KP6948598-1MX	K01MC K03MC K04MC	3525160003 3525160004 3525160011
Vertical support	04061272577825 / KP1835697-1MX	K01VS K04VS K05VS	3525160023 3525160018 3525160017
Simulation Box		K01SB K02SB	
Push Buttons		K01PB K02PB K03PB K04PB	
E-coupler	Voith: 230.103701-001	K01EC K03EC	4510049886-006 4510049886-010

3.3.2.2 KB02

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: K02DG Config: #001 <u>Coupler Head:</u> Screw coupler	Hb_3746, side A
28.11.2025	#002	Installation of parts	<u>Draft Gear:</u> TTL-ID: K02DG Config: #001 <u>Coupler Head:</u> TTL-ID: K04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K05VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Hb_3746, side A
02.12.2025	#003	Installation of different coupler heads during grounding tests.	<u>Draft Gear:</u> TTL-ID: K02DG Config: #001 <u>Coupler Head:</u> Remark: Numerous heads of different suppliers installed during grounding tests. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K05VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Hb_3746, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
03.12.2025	#004	Installation Status after grounding tests. Sim-Box is defect (on 05.12.2025).	<u>Draft Gear:</u> TTL-ID: K02DG Config: #001 <u>Coupler Head:</u> TTL-ID: K04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K05VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #002 Remark: Defect <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Hb_3746, side A
09.12.2025	#005	Exchange of Sim-Box.	<u>Draft Gear:</u> TTL-ID: K02DG Config: #001 <u>Coupler Head:</u> TTL-ID: K04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K05VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Hb_3746, side A
09.01.2026	#006	Deinstallation		

3.3.2.3 KB04

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> Screw coupler	Ha_0458, side A
05.11.2025	#002	Installation of parts	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0458, side A
07.11.2025	#003	Change of coupler head.	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #002 Remark: DMS installed. DMS defect. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0458, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
28.11.2025	#004	Deinstallation of electronics.	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #002 Remark: DMS installed. DMS defect. <u>Vertical Support:</u> TTL-ID: K04VS Config: #001	Ha_0458, side A
12.12.2025	#005	Change of coupler head and electro installations.	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #002 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #002 Remark: Defect <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #002	Ha_0458, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
09.01.2026	#006	Deinstallation	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #002 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #002 Remark: Defect <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #002	
22.01.2026	#007	Installation	<u>Draft Gear:</u> TTL-ID: K04DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #002 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #002 (defect) Remarks: defect	Ha_0458, side B

3.3.2.4 KB05

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #001	Hb_3235, side A
23.10.2025	#002	E-coupler installation.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #001	Hb_3235, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
24.10.2025	#003	Exchange of push-button box (K02PB fell off and got damaged).	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB K04PB Config: #001 #001	Hb_3235, side A
28.10.2025	#004	K04PB deinstalled.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB Config: #001 Remark: Only one push button box installed. System not functional.	Hb_3235, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
30.10.2025	#005	Change of coupler head.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #002 Remark: DMS installed. DMS defect. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB Config: #001 Remark: Only one push button box installed. System not functional.	Hb_3235, side A
07.11.2025	#006	Change of coupler head, reparation of K02PB.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB Config: #001 K02PB #002 - Repaired	Hb_3235, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
01.12.2025	#007	Reparation of air sealing. Air sealing still gets stuck repeatedly.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #002 Remark: DMS installed. Air sealing gets stuck repeatedly. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Sim-Box:</u> TTL-ID: K01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #002	Hb_3235, side A
09.12.2025	#008	Sim-Box demounting.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #002 Remark: DMS installed. Air sealing gets stuck repeatedly. <u>E-Coupler:</u> TTL-ID: K03EC Config: #001 <u>Vertical Support:</u> TTL-ID: K01VS Config: #001 <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #002	Hb_3235, side A
09.12.2025	#009	Change to DAC-ready.	<u>Draft Gear:</u> TTL-ID: K05DG Config: #001 <u>Coupler Head:</u> Screw coupler	Hb_3235, side A
09.01.2026	#010	Deinstallation		

3.3.2.1 KB06

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #001 Remark: DMS installed. <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0136, side B
24.10.2025	#002	Demounting of one push button box (K04PB).	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #001 Remark: DMS installed. <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB Config: #001 Remark: Only one push button box installed. System not functional.	Ha_0136, side B

Date	Config.	Description	Parts / Serial Numbers	Wagon
28.10.2025	#003	Installation of e-coupler and push button box.	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0136, side B
29.10.2025	#004	Failure of DMS on K03MC.	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K03MC Config: #002 Remark: DMS installed. DMS defect. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0136, side B

Date	Config.	Description	Parts / Serial Numbers	Wagon
30.10.2025	#005	Change of coupler head.	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K01MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K04VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: K03PB K04PB Config: #001 #001	Ha_0136, side B
04.11.2025	#006	Change to DAC-ready.	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> Screw coupler	Ha_0136, side B
23.01.2026	#007	Installation of parts	<u>Draft Gear:</u> TTL-ID: K06DG Config: #001 <u>Coupler Head:</u> TTL-ID: K04MC Config: #002 (DMS damaged and defect) Remark: DMS installed. DMS defect. <u>E-Coupler:</u> TTL-ID: K01EC Config: #001 <u>Vertical Support:</u> TTL-ID: K05VS Config: #001 <u>Sim-Box:</u> TTL-ID: K02SB Config: #004 (repaired on 12.01.2026, but defect again on 04.02.2026.) Remark: Defect <u>Push Buttons:</u> TTL-IDs: K01PB K02PB Config: #001 #002	Ha_0136, side B

3.3.3 Voith

3.3.3.1 Overview of the coupler

Part	Type
Draft Gear	FN-RP2-01.00.00 P31
Compression force stop	FN-RP-KS-00.01.00 P31
Mounting plate	FN-RP-KS-00.02.00
Coupler Head	230.104399-001
Vertical support	230.054751-001

All tests executed in 2026 (from T440 onwards) were executed with a different type of draft gear. This effects the coupler configs VT05 and VT06. The type identifier on the type plates of the draft gears was not changed. They could only be differentiated by visual inspection. The visual differences are shown in Figure 28.

Part	Type
Draft Gear	FN-RP2-01.00.00 P39
Compression force stop	FN-RP-KS-00.01.00 P41

The coupler of Voith is shown in the following figures.

The mechanical coupler consists of:

- Draft gear and compression force stop with mounting plates
- Vertical support
- Coupler head (with manual uncoupling and couple status indicator [flag])

The electronic system consists of:

- Actuator mounted inside the coupler
- Couple status sensor
- Actuation plate for the e-coupler
- Simulation box
- Junction box
- Push buttons [Buttons: Uncouple (green), Prevent coupling (yellow)]

Functionality of electronic components (main amount of tests):

- Buttons:
 - o Press the green button to uncouple
 - o Press yellow button to uncouple and set the coupler into prevent couple position for an infinite time
 - Reset is possible by pressing the green button
- Actuator:
 - o In Prevent coupling position the actuator is not fixed. Once a movement of the hook plate is detected, the actuator uncouples directly again.

On the 21.01.2026 (T474 onwards, for 3 uncoupling tests in total) Voith updated their electronic system. The following functions were updated:

- Plug and connection to e-coupler for synchronization signal
- New colours for buttons (orange ["engage"] and white ["prevent coupling / reset"])
- New control unit with new functionalities of buttons
- New actuators

Functionality of the updated components regarding [VT_DACCU]:

- Buttons:
 - o Press orange and white button for 3s to wake up the system
 - Reset after 60s without input
 - o Press orange button to enable functions / engage system
 - o Short press on white button:
 - Uncouple and set to prevent coupling position for 60 s (the time is not reset after impact)
 - Reset to ready-to-couple position if coupler is in prevent coupling state
 - o Long press (3s) on white button: Uncouple and set to prevent coupling position for infinite time
- Actuator:
 - o New actuators installed with same functionality

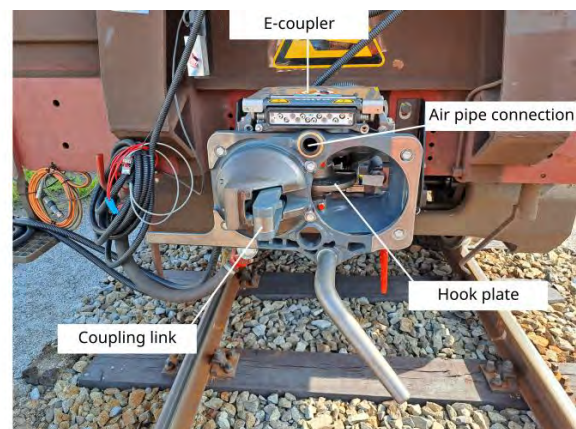
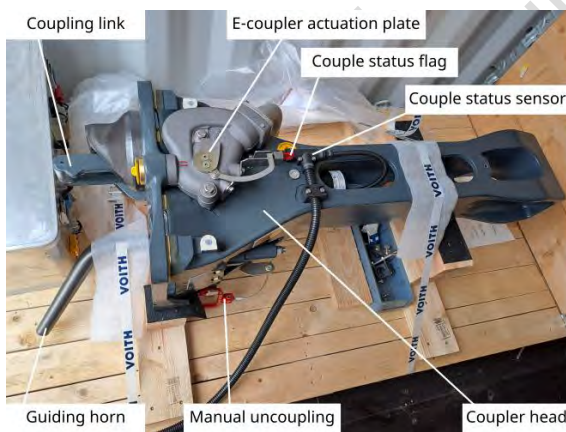


Figure 24: Voith - Overview coupler head.



Figure 25: Voith - Details of coupler head.

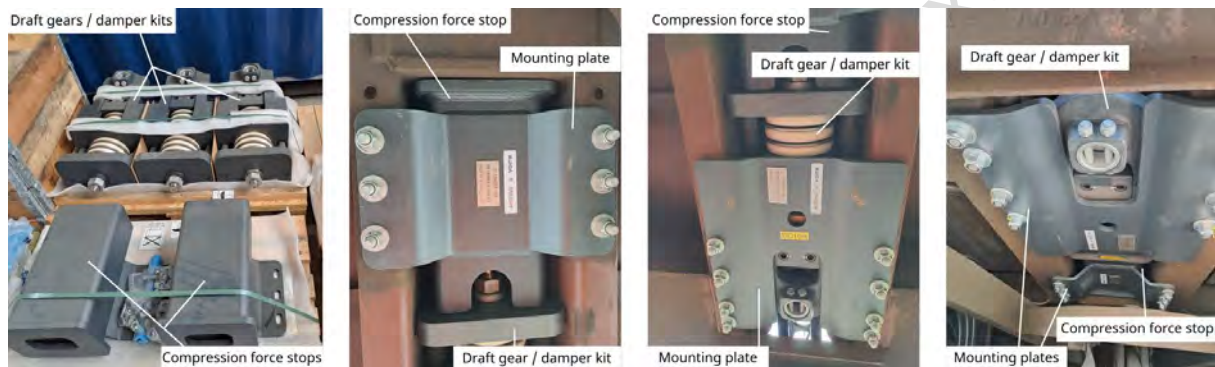


Figure 26: Voith - Overview of draft gear.

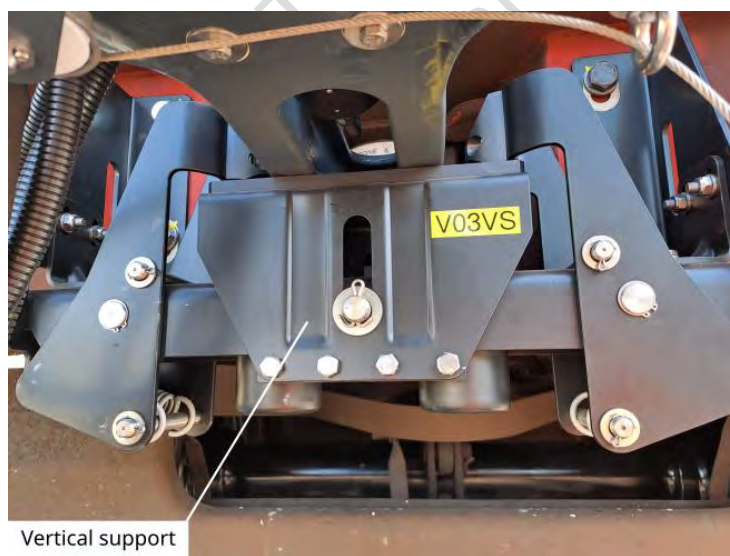


Figure 27: Voith - Vertical support.

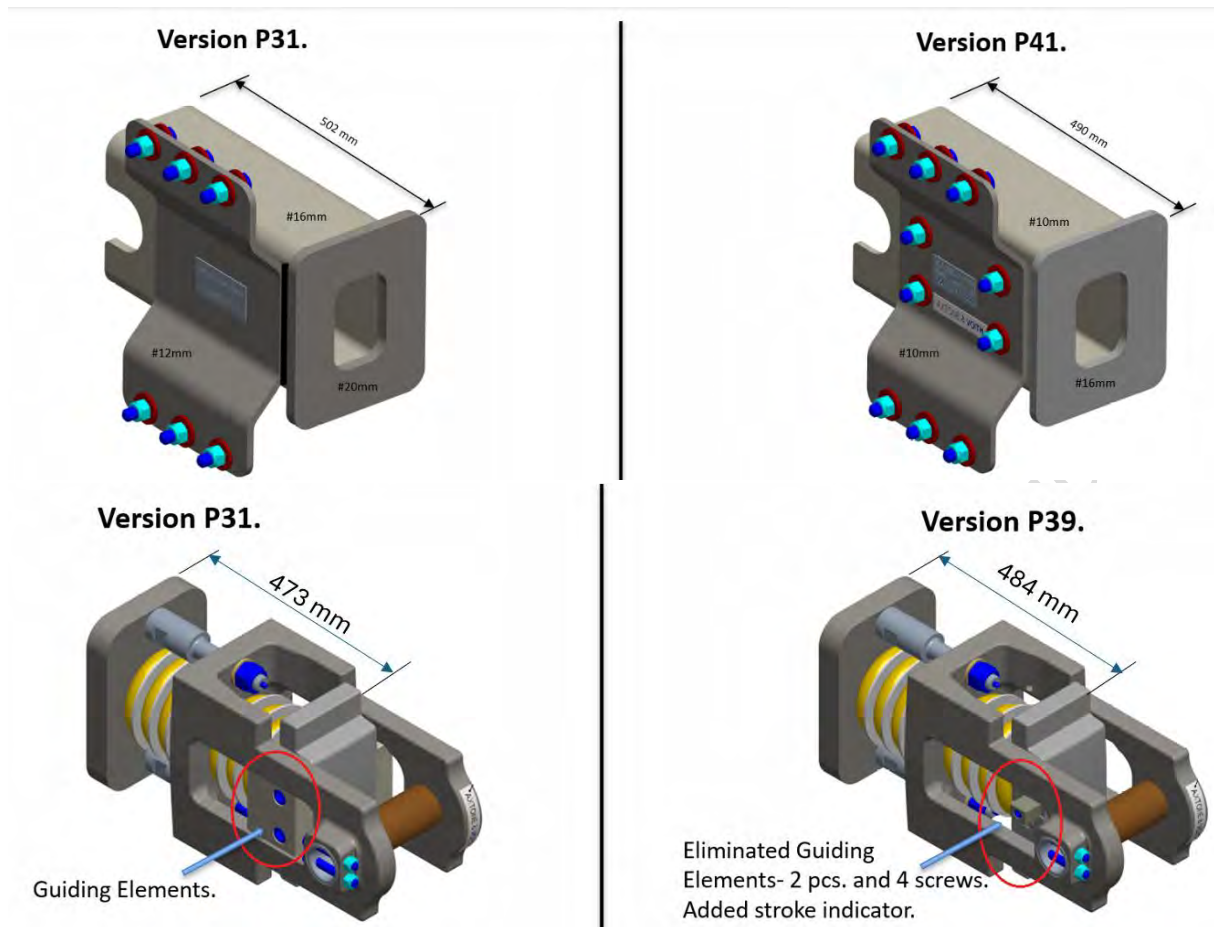


Figure 28: Differences between draft gear-types of Voith. Top: compression force stops. Bottom: draft gears. Versions P31 and P31 must be used together and Versions P39 and P41 must be used together.

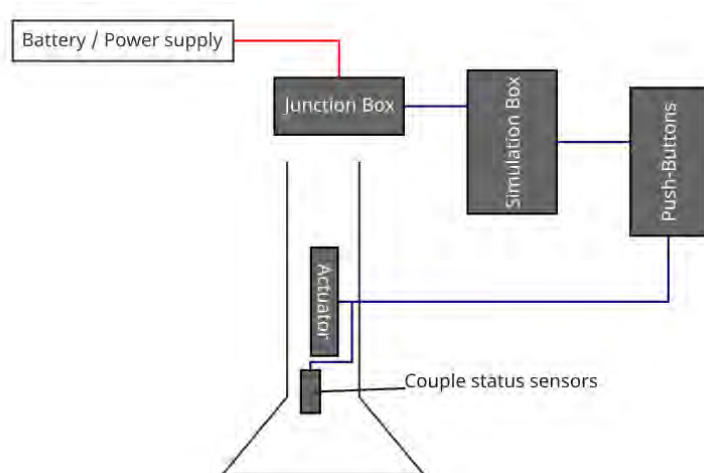


Figure 29: Voith - Scheme of electronic system.



Figure 30: Voith - Overview of electronic system.

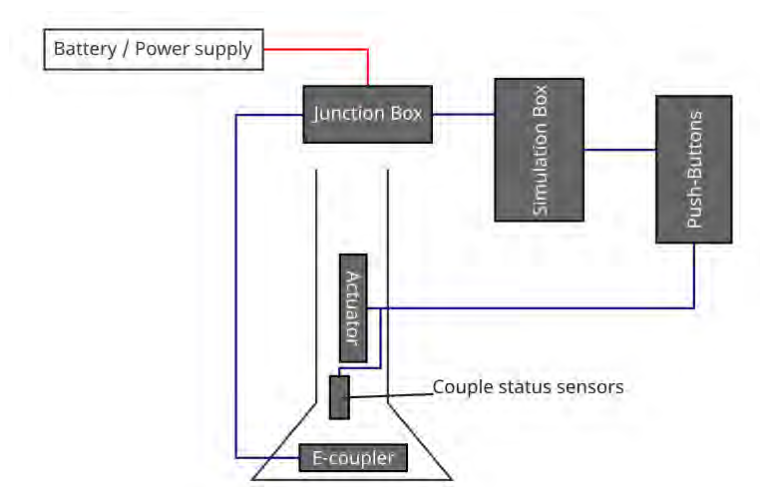


Figure 31: Voith - Scheme of updated electronic system.

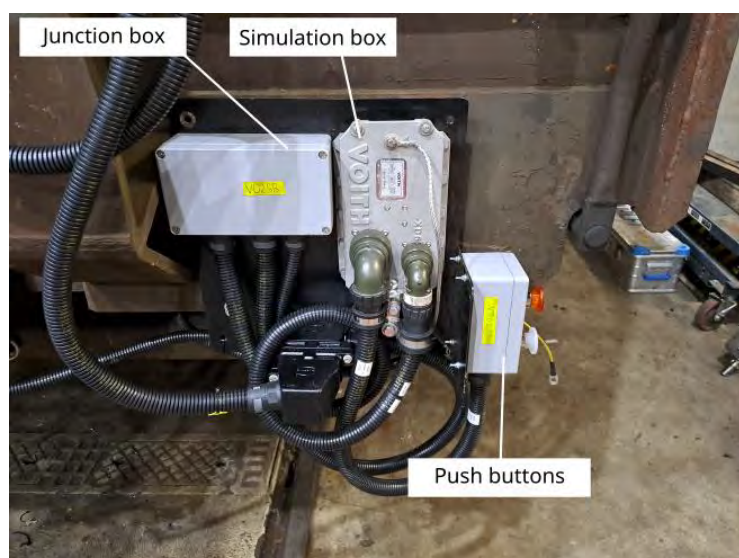


Figure 32: Overview of the updated electronic system.



3.3.3.1.1 Overview of used parts

Table 8: Overview of used parts – Voith.

Part	Type	TTL-ID	Serial number
Draft Gear Compression force stop Mounting plate	FN-RP2-01.00.00 P31 FN-RP-KS-00.01.00 P31 FN-RP-KS-00.02.00	V01DG	24/45386/01 24/45390/12 24/45391/11
		V02DG	24/45386/18 24/45390/11 24/45391/16
		V03DG	24/47154/16 24/45390/16 24/45391/17
		V04DG	24/47154/14 24/45390/08 24/45391/05
		V05DG	25/52069/07 25/52128/09 25/52130/06
		V06DG	25/52069/09 25/52128/10 25/52130/05
Coupler Head	230.104399-001	V03MC V04MC	1000028657 1000028655
Vertical support	230.054751-001	V03VS V04VS	100000106 100000100
Simulation Box		V01SB V02SB	
Push Buttons		V01PB V02PB	
E-coupler	230.103701-001	V01EC V02EC V04EC	4510049886-013 4510049886-020 4510049886-002

New types of draft gears:

Part	Type	TTL-ID	Serial number
Draft Gear Compression force stop Mounting plate	FN-RP2-01.00.00 P39 FN-RP-KS-00.01.00 P41 FN-RP-KS-00.02.00	V05DG	25/52069/07 25/52128/09 25/52130/06
		V06DG	25/52069/09 25/52128/10 25/52130/05

3.3.3.2 VT01

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: V01DG Config: #001 <u>Coupler Head:</u> Screw coupler	Hb_3472, side B
09.12.2025	#002	Installation of parts.	<u>Draft Gear:</u> TTL-ID: V01DG Config: #001 <u>Coupler Head:</u> TTL-ID: V04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V01EC Config: #001 <u>Vertical Support:</u> TTL-ID: V04VS Config: #001 <u>Sim-Box:</u> TTL-ID: V01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V01PB Config: #001	Hb_3472, side B
09.01.2025	#003	Deinstallation		

3.3.3.3 VT02

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: V02DG Config: #001 <u>Coupler Head:</u> Screw coupler	HaHb_3235, side B
09.12.2025	#002	Installation of parts	<u>Draft Gear:</u> TTL-ID: V02DG Config: #001 <u>Coupler Head:</u> TTL-ID: V03MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V04EC Config: #001 <u>Vertical Support:</u> TTL-ID: V03VS Config: #001 <u>Sim-Box:</u> TTL-ID: V02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V02PB Config: #001	Hb_3235, side B
09.01.2025	#003	Deinstallation		

3.3.3.4 VT03

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: V03DG Config: #001 <u>Coupler Head:</u> TTL-ID: V03MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V02EC Config: #001 <u>Vertical Support:</u> TTL-ID: V03VS Config: #001 <u>Sim-Box:</u> TTL-ID: V02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V02PB Config: #001	Ha_0458, side B
30.10.2025	#002	New e-coupler due to damaged pin.	<u>Draft Gear:</u> TTL-ID: V03DG Config: #001 <u>Coupler Head:</u> TTL-ID: V03MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V04EC Config: #001 <u>Vertical Support:</u> TTL-ID: V03VS Config: #001 <u>Sim-Box:</u> TTL-ID: V02SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V02PB Config: #001	Ha_0458, side B
05.11.2025	#003	Change to DAC-ready	<u>Draft Gear:</u> TTL-ID: V03DG Config: #001 <u>Coupler Head:</u> Screw coupler	Ha_0458, side B

Date	Config.	Description	Parts / Serial Numbers	Wagon
22.01.2026	#004	Deinstalled		

EXTRACT - 24.02.2026
(Confidential information excluded)

3.3.3.5 VT04

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
21.10.2025	#001	Initial state	<u>Draft Gear:</u> TTL-ID: V04DG Config: #001 <u>Coupler Head:</u> TTL-ID: V04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V01EC Config: #001 <u>Vertical Support:</u> TTL-ID: V04VS Config: #001 <u>Sim-Box:</u> TTL-ID: V01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V01PB Config: #001	Hb_3746, side B
28.11.2025	#002	Change to DAC-ready	<u>Draft Gear:</u> TTL-ID: V04DG Config: #001 <u>Coupler Head:</u> Screw coupler	Hb_3746, side B
09.01.2026	#003	Deinstallation		

3.3.3.6 VT05

Remark: This coupler configuration uses a draft gear of a different type (see chapter 3.3.3.1).

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
13.01.2026	#001	Initial state	<u>Draft Gear:</u> TTL-ID: V05DG Config: #001 Remark: This draft gear is of a different type <u>Coupler Head:</u> TTL-ID: V04MC Config: #001 Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V01EC Config: #001 <u>Vertical Support:</u> TTL-ID: V04VS Config: #001 <u>Sim-Box:</u> TTL-ID: V01SB Config: #001 <u>Push Buttons:</u> TTL-IDs: V01PB Config: #001	Ha_0136, side A

Date	Config.	Description	Parts / Serial Numbers	Wagon
20.01.2026	#002	Adjustments on electronics: - New actuator - New push buttons - new control unit / simulation-box - adjustments in junction box (connection of e-coupler for synchronization signal)	<u>Draft Gear:</u> TTL-ID: V05DG Config: #001 Remark: This draft gear is of a different type <u>Coupler Head:</u> TTL-ID: V04MC Config: #002 – new actuator type installed Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V01EC Config: #001 <u>Vertical Support:</u> TTL-ID: V04VS Config: #001 <u>Sim-Box:</u> TTL-ID: V01SB Config: #002 – new simulation box control unit and adjustments on junction box (connection to e-coupler) <u>Push Buttons:</u> TTL-IDs: V01PB Config: #002 – new buttons installed (orange and white)	Ha_0136, side A
23.01.2026	#003	Deinstallation		

3.3.3.7 VT06

Remark: This coupler configuration uses a draft gear of a different type (see chapter 3.3.3.1).

Configurations:

Date	Config.	Description	Parts / Serial Numbers	Wagon
20.01.2026	#001	Initial state Adjustments on electronics: - New actuator - New push buttons - new control unit / simulation-box - adjustments in junction box (connection of e-coupler for synchronization signal)	<u>Draft Gear:</u> TTL-ID: V06DG Config: #001 Remark: This draft gear is of a different type <u>Coupler Head:</u> TTL-ID: V03MC Config: #002 – new actuator type installed Remark: DMS installed. <u>E-Coupler:</u> TTL-ID: V04EC Config: #001 <u>Vertical Support:</u> TTL-ID: V03VS Config: #001 <u>Sim-Box:</u> TTL-ID: V02SB Config: #002 – new simulation box control unit and adjustments on junction box (connection to e-coupler) <u>Push Buttons:</u> TTL-IDs: V02PB Config: #002 – new buttons installed (orange and white)	Ha_0458, side A
22.01.2026	#002	Changed to DAC-ready	<u>Draft Gear:</u> TTL-ID: V06DG Config: #001 Remark: This draft gear is of a different type <u>Coupler Head:</u> Screw coupler	

3.3.4 E-couplers

The e-couplers for the executed tests were supplied by Voith. In total 16 e-couplers were delivered (four per supplier). As the e-couplers were delivered with plugs, these had to be modified to be attached to the measurement system (see Annex 1 and 2). One set of e-couplers was modified per supplier.

In the following chapters the e-couplers are described.

3.3.4.1 Overview of the e-couplers

The delivered e-couplers are of type 230.103701-001 and described in detail in [VT_SK0.7773]. They are mounted on top of the coupler head and are supplied with a moving lid that opens when coupling.

In ready-to-couple position the e-coupler is pulled back by a plate which is connected to the hook plate of the coupler. The lid is closed and protects the e-coupler from dust, water, mechanical damage and prevents inadvertent contact.

When two couplers are coupling, the plate releases the e-coupler, which is then moved in the direction of the coupling point by springs. The lid opens and a centration is done by centration pins.

The e-couplers were delivered with a contact block with mounting-holes for 12 pins, of which 8 pins were attached (4 data-pins and 4 power-pins). The sets of power-pins and data-pins were each connected to a plug of the manufacturer Harting.



Figure 33: E-coupler overview.

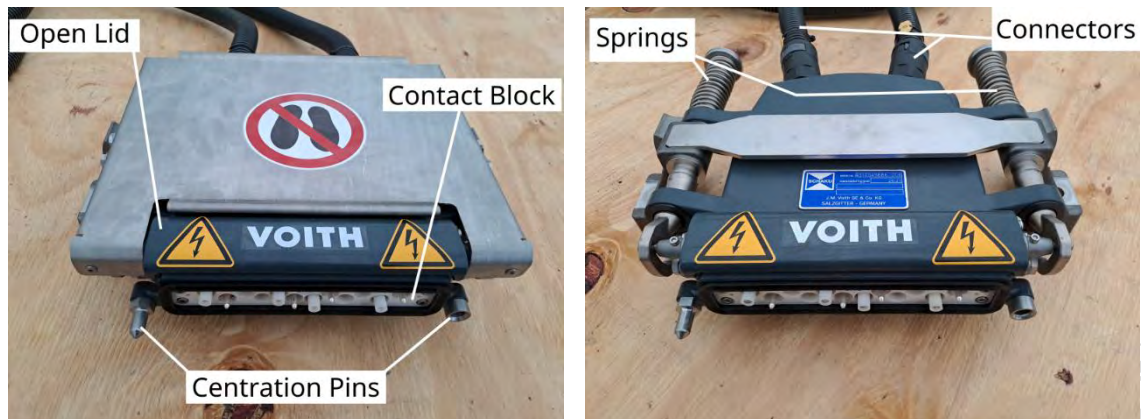


Figure 34: E-coupler top-view. Right side: Cover demounted.

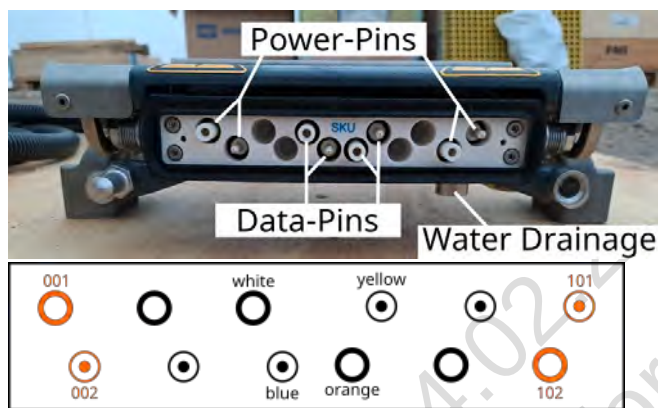


Figure 35: E-coupler front view with pin setup below. Orange: power-pins, black: data-pins.

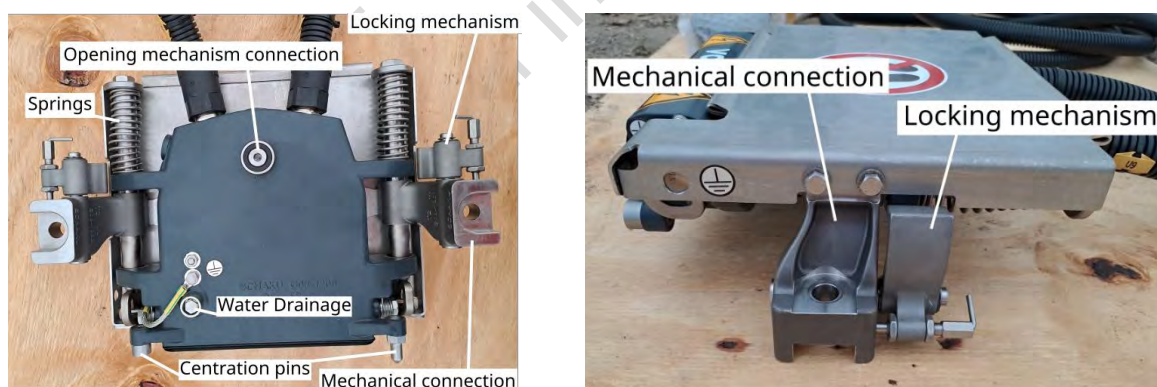


Figure 36: E-coupler bottom and side view.

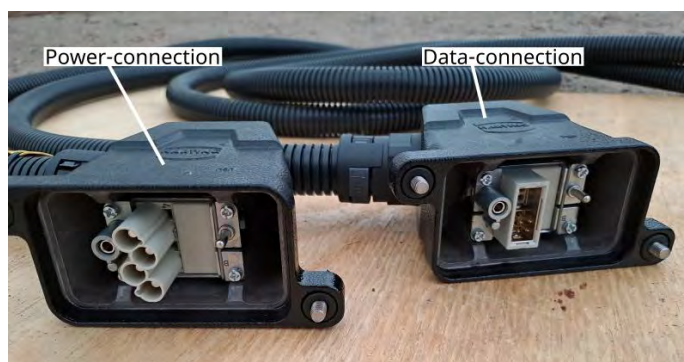


Figure 37: E-coupler Harting connectors.



Figure 38: E-coupler connections on the coupler head. Exemplary with Voith coupler head.

3.3.4.2 Modifications and pin-connections

All e-couplers were modified to apply a synchronization signal by the suppliers (if present) and to enable a throughput measurement with the measurement system (see also Annex 1). Therefore, the plugs were disconnected, and the cables were connected inside a waterproof box regarding Figure 39.

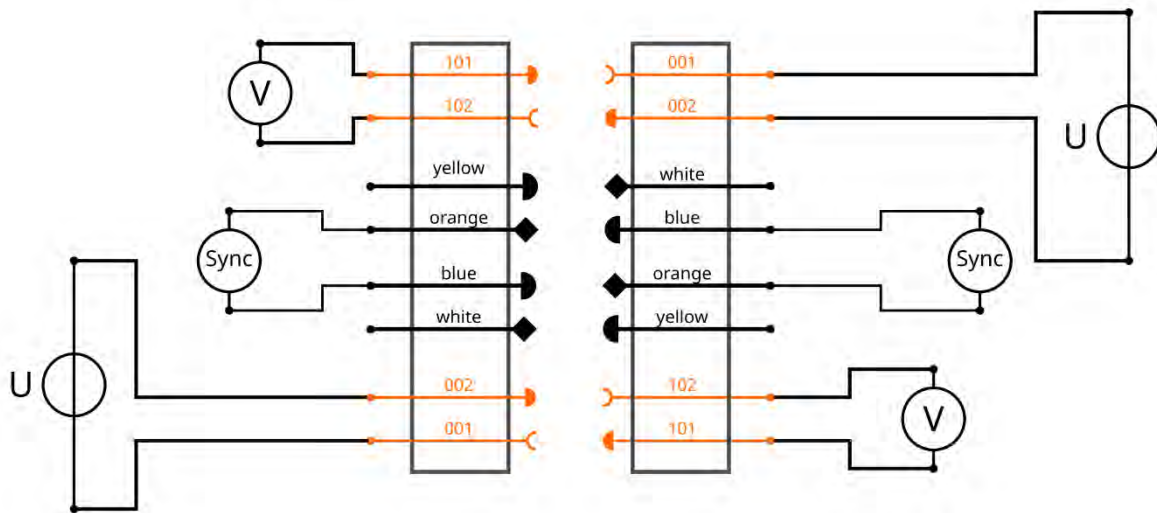


Figure 39: Wiring of the e-couplers for transfer of the synchronization signal ("Sync") and throughput measurement (Voltage input "U" and measurement "V" on the opposing measurement system).

Furthermore, the housings of the e-couplers used for the Dellner couplers had to be modified to fit the coupler. The following adjustments were done:

- Demounting of the water drainage and sealing by tape
- Demounting of locking mechanism (left side, front view)

4 Test schedule

Date	Location	Action	from Test-Nr.
16.09.2025	HVLE, Berlin-Spandau	Coupler inspection by Dellner	-
16.09.2025 to 21.10.2025	HVLE, Berlin-Spandau	Installation of couplers and measurement system	-
22.10.2025	HVLE, Berlin-Spandau	Tests: VT – VT Case: A	008
23.10.2025	HVLE, Berlin-Spandau	Tests: VT – VT Case: C	028
24.10.2025	HVLE, Berlin-Spandau	Tests: VT – KB Case: A KB – VT Case: C	042 061
27.10.2025	HVLE, Berlin-Spandau	Preparation of tests	-
28.10.2025	HVLE, Berlin-Spandau	Tests: VT – DC Case: A DC – VT Case: C Loading of Hb_3581	073 091
29.10.2025	HVLE, Berlin-Spandau	Tests: KB – DC Case: A DC – KB Case: C	105 126
30.10.2025	HVLE, Berlin-Spandau	Tests: DC – DC Case: D Loading of Hb_3472	141
31.10.2025	HVLE, Berlin-Spandau	Tests: VT – KB Case: B, E KB – VT Case: E	153 165
03.11.2025	HVLE, Berlin-Spandau	Tests: VT – KB Case: B, E (repetition of tests) KB – VT Case: B, E	173 182
04.11.2025	HVLE, Berlin-Spandau	Coupler installations	-
05.11.2025	HVLE, Berlin-Spandau	Tests: DC – VT Case: A VT – DC Case: C	191 205
06.11.2025	HVLE, Berlin-Spandau	Tests: KB – DC Case: B,E DC – KB Case: B,E	223 238
07.11.2025	HVLE, Berlin-Spandau	Tests: DC – KB Case: A KB – DC Case: C	252 266
13.11.2025 to 18.11.2025	HVLE, Berlin-Spandau	Unloading of Hb_3581 Loading of Hb_3235 and Hb_3746	-
24.11.2025	HVLE, Berlin-Spandau	Changes in electronics of Dellner	-
25.11.2025	HVLE, Berlin-Spandau	Tests: DC – DC Case: A, C	282
27.11.2025	HVLE,	Tests:	

Date	Location	Action	from Test-Nr.
	Berlin-Spandau	DC – VT Case: D VT – DC Case: D	308 317
28.11.2025	HVLE, Berlin-Spandau	Check of Dellner electronics. Coupler installations.	-
01.12.2025	HVLE, Berlin-Spandau	Tests: DC – KB Case: D KB – DC Case: D	325 335
02.12.2025 to 03.12.2025	HVLE, Berlin-Spandau	Grounding tests (not scope of this test scenario)	-
04.12.2025	HVLE, Berlin-Spandau	Coupler installations.	-
05.12.2025	HVLE, Berlin-Spandau	Tests: KB – KB Case: D Coupler installations.	343
09.12.2025	HVLE, Berlin-Spandau	Tests: KB – VT Case: D VT – KB Case: D Coupler installations.	356 367
10.12.2025 to 11.12.2025	HVLE, Berlin-Spandau	Preparation for further tests Unloading of Hb_3746	-
12.12.2025	HVLE, Berlin-Spandau	Unloading of Hb_3235 and Hb_3472 Tests: VT – VT Case: D	377
15.12.2025	HVLE, Berlin-Spandau	Tests: VT – KB Case: C	386
16.12.2025	HVLE, Berlin-Spandau	Tests: KB – VT Case: A	401
17.12.2025	HVLE, Berlin-Spandau	Tests: KB – KB Case: A,C	415
09.01.2026	HVLE, Berlin-Spandau	Coupler installations.	-
12.01.2026	HVLE, Berlin-Spandau	Tests: DC – DC Case: E	440
13.01.2026	HVLE, Berlin-Spandau	Coupler installations.	-
19.01.2026	HVLE, Berlin-Spandau	Tests: VT – DC Case: B, E DC – VT Case: B, E	447 463
20.01.2026	HVLE, Berlin-Spandau	Electro installations Voith. Coupler installations.	-
21.01.2026	HVLE, Berlin-Spandau	Tests: VT – VT Case: B, E	474
22.01.2026 to 23.01.2026	HVLE, Berlin-Spandau	Coupler installations.	
04.02.2026	HVLE, Berlin-Spandau	Tests: KB – KB Case: B, E	489

5 Execution and results

A detailed description of the executed tests can be found in the annexes listed in chapter 7.

6 References

Abbreviation	Document-Nr.	Title	Author	Date	Version
[DC_DACCU]	-	Documentation Mounting, Set up and usage First Simulation box – DACCU gen.3	AlCorn	29.10.2025	2,0
[EN15551]	EN15511:2017	Railway applications Railway rolling stock Buffers	-	05.2017	-
[EN16019]	DIN EN 16019:2014-06	Railway applications – Automatic coupler – Performance requirements, specific interface geometry and test method	-	06.2014	-
[TR01-2025-014]	2025-014- WP14-TR01	Running Ability and Impact Tests on special Infrastructure - Test report	Julian Beck	10.10.2025	V01
[TS-2025-014]	2025-014-DAC- TS01	Impact Tests – Test Scenario	Saskia Discher	27.02.2025	V02
[UIC_530-1]	UIC 530-1 VE	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	UIC	01.04.1982	2
[VT_DACCU]	-	Schnittstellenspezifikation WP14 Schnittstelle DACCU – DACCU On.Control.Cargo	Voith Group	15.01.2026	0.2
[VT_SK0.7773]	-	User manual – Semiautomatic Scharfenberg Coupler	Voith Group	17.04.2025	Issue 1

7 Appendices

Annex	Vn.	Title	Content
1	01	Description - Impact Tests	Description of the execution of the impact tests. Deviations regarding [TS-2025-014].
2	01	Results – General Results	Supplier independent results: - E-coupler
2.1	01	Results – Dellner	Results of the impact and running ability tests involving Dellner couplers.
2.2	01	Results – Knorr-Bremse	Results of the impact and running ability tests involving Knorr-Bremse couplers.
2.3	01	Results – Voith	Results of the impact and running ability tests involving Voith couplers.

FP5TRAN S4M-R

Transforming
Europe's Rail Freight

Annex 1

Description - Impact tests

Test report:	2025-015-WP14-TR01
Annex No.:	Annex 1
Annex - Version:	V01

Confidentiality

The overall report is only made available to the suppliers.
Distribution to third parties without the approval of the respective supplier and the WP14 test management is not permitted!

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Abbreviations & Acronyms

Abbreviation / Acronym	Description
BP	Brake pipe
CCU	Coupler control unit
CL	Coupling link
DAC	Digital automatic coupler
DBST	DB Systemtechnik GmbH
DC	Dellner Couplers AB
DMS	Strain gauge (ger.: Dehnungsmessstreifen)
e-coupler	Electrical coupler
ERJU	Europe's Rail Joint Undertaking
FT	Faiveley Transport SA / respective: Wabtec Corporation
HBK	Hottinger Brüel & Kjaer GmbH
HVLE	Havelländische Eisenbahn
KB	Knorr-Bremse AG
PC	Prevent coupling position
R2C	Ready-to-couple position
S/N	Serial number
T...	Test No. (e.g.: T123 = Test No. 123)
TOR	Top of rail
TTL	Train Test Lab
TTL-ID	Component ID given by the TTL for asset management
VT	Voith GmbH & Co. KGaA
WP	Wabtec position

1 Description of test case

This annex is focusing on the description of the impact tests on straight track. Basis for the tests is the test scenario [TS-2025-014]. This annex summarizes the test scenario and describes deviations.

[TS-2025-014] defines the following tests, that shall be executed on straight track:

Table 1: Summary of tests from [TS-2025-014] - Tests on special infrastructure.

Case	Moving wagon	Standing wagon	Infrastructure	Velocity	Amount of tests
Tests relevant for approval according to [EN15551]					
xxC1	2-axle 20 t	4-axle 80 t	Straight	7 km/h	3
xxC2				9 km/h	3
xxD1	2-axle 40 t	2-axle 40 t	Straight	12 km/h	1
xxE1	4-axle 80 t	4-axle 80 t	Straight	10 km/h	1
Functional impact tests					
xxA1	4-axle 80 t	2-axle 20 t	Straight	0,6 km/h	3
xxA2				2 km/h	3
Functional impact tests with prevent coupling position					
xxB1	4-axle 80 t	4-axle 80 t	Straight	0,6 km/h	3
xxB2				6 km/h	3
xxB3				10 km/h	1

The tests are to be executed with the following coupler configurations:

Table 2: Interoperability-configurations to be tested.

		Moving wagon		
		DL	KB	VT
Standing wagon	DL	DD xx	KD xx	VD xx
	KB	DK xx	KK xx	VK xx
	VT	DV xx	KV xx	VV xx

The different test-cases were coded. The report and test protocol refer to the test-cases with help of these codes. The coding system consists of 3 letters followed by a number.

The first two letters describe the coupler configuration regarding Table 2. The last letter and number describe the test case regarding Table 1.

During the tests the following parts had to be evaluated:

Table 3: Evaluation criteria impact tests in ready-to-couple position - overview.

To evaluate	Criteria
Impact / Coupling	
Mechanical coupling	The couplers are mechanically coupling during each impact test.
Compression force	The force does not exceed 2.000 kN during the impact phase.
Pneumatic coupling	The brake pipes of both wagons must be coupled during each impact tests. No major leakage of the brake pipe (and main reservoir pipe if present) shall be detected. ¹⁾
Electric coupling	The e-coupler must be coupled during each impact tests.
Critical damages coupler	The coupler must stay functional and not be critically damaged during or after the tests.
Critical damages wagon	The wagon must stay functional and not be critically damaged by the DAC during the tests.
Wear and tear	The wear of parts should be noted. Remark: The wear should not lead to failure of the parts, considering the amount of tests.
Energy absorption	Limit values regarding [EN15551] → dependent on testcase
Wagon acceleration	Limit values regarding [EN15551] → dependent on testcase
Uncoupling	
Uncoupling	By uncoupling on both couplers, both couplers reach the "ready-to-couple"-position.

¹⁾Leakages were not evaluated with the measurement system. Major, audible leakages were documented in the protocol.

Table 4: Evaluation criteria impact tests in prevent-coupling position - overview.

To evaluate	Criteria
Mechanical coupling	The couplers are mechanically not coupling during each impact test.
Compression force	The force does not exceed 2.000 kN during the impact phase.
Electric coupling	The e-coupler must be not coupled during each impact tests.
Critical damages coupler	The coupler must stay functional and not be critically damaged during or after the tests.
Critical damages wagon	The wagon must stay functional and not be critically damaged by the DAC during the tests.
Wear and tear	The wear of parts should be noted. Remark: The wear should not lead to failure of the parts, considering the amount of tests.

2 Test execution – Impact tests

2.1 Test procedure

The test procedure is described in detail in [TS-2025-014], chapter 5.2. The following deviations were made:

Pt. in [TS-2025-014], chapter 5.2	Content	Deviation
1.1	Measured parameters	See chapter 2.2.
1.2.4	Documentation of operator	The operator of the coupler during uncoupling was not documented, as the couplers should be electronically uncoupled. Mainly all operations were done by the same operator.
3	A push-off operation is performed	For tests with 2km/h or lower, no push-off operation was performed. The loco was connected to the moving wagon while coupling. Therefore, the impacting mass was increased. Data of the loco: Type: V60 Weight: 60 000 kg Length: 11.70 m Axles: 4
3.1.1 4a.1.3	Brake pipe of moving wagon is filled	The brake pipe was not filled in advance to the push off operation. When the wagons coupled, the brake pipe was filled, and the shut of cock was opened. Before uncoupling, the shut of cock was closed again, exhausting the brake pipe.
6	Uncoupling	- No Deviations – Remarks: - Uncoupling was always executed on the coupler of the standing wagon. - Uncoupling was done with the electronic system (push buttons and actuator). - If an electrical system failed, the couplers were uncoupled by the opposing, still functioning electrical system.

2.2 Measurement equipment / Documentation

The following data was documented or measured:

Documented in the protocol:

- Environmental conditions
- Initial status of couplers, wagons and track
- Coupler status after coupling and uncoupling
- Moving / Standing wagon and coupler
- Type of actuation of coupler and actuated coupler
- Abnormalities and deviations from procedure

Documentation by video/photo:

- Photo documentation of the couplers on a regular basis (approx. after every supplier configuration)
- Video documentation of most of the tests with two cameras (one stationary camera and one camera located on the wagon, facing the couplers)

Measured by measurement systems:

- Every test was recorded by a measurement system consisting of sensors on the moving and on the standing wagon described in the following chapters.

The measurement equipment consisted of various parts:

- systems installed on the wagons by DBST (chapter 2.2.1 ff.).
- a system for measurement of the coupler heights (chapter 2.2.2.1).

The measurement system was installed on both the standing and moving wagon.

2.2.1 On-wagon system

The measurement systems (T1 and T2) on the wagons consisted of a Datalogger and two measuring amplifiers. Calibrated measurement chains were used to record the data of the on-board system. The location of installation of the sensors, signal names, identifiers and descriptions are shown in the following tables:

Table 5: Measurement configuration, system T1.

Name	A = analogue D = digital	Description	Source / Installation	Connection	Range	Sampling Frequency
T1_F_z	A	Force on coupler	Calculated from Raw-Data	Dependent on installation by DBST	±2.000 kN	1000
T1_Im	A	Impulses (Distance)	Incremental Encoder	Pushed on wheel	0-70.000.000	1000
T1_S_DG	A	Travel of Draft Gear (x-axis -> Forward/Backward)	Wire sensor	Screw in pivot pin / pivot pin mounting plate	0 to 1.000 mm	100
T1_CoupleInd	A	Couple Indicator (Flag)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
T1_S_y	A	Displacement (y-axis -> Sideways)	Wire Sensor	Clamp -> left side of coupler	0 to 1.000 mm	100
T1_S_z	A	Displacement (z-axis -> Up/Down)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
T1_pBP	A	Brake Pipe Pressure	Pressure Sensor in Brake Pipe	Stäubli-socket-adapter between coupler and hose	0 to 10 bar	100
T1_U_EC	A	Voltage throughput E-Coupler	Voltage Sensor	Connection description	±60 V	100
T1_U_Act	A	Voltage Actuator	Voltage Sensor	Measured directly after Battery	±60 V	100
T1_I_Act_div	A	Current Actuator	Current Sensor (Clamp meter)	Measured directly after Battery (4x)	±100 A	100
T1_ax_Wag	A	Acceleration Wagon (x-axis)	Acceleration sensor (3ax) - M240TU	Screwed into middle of wagon	±10 g	1000
T1_ay_Wag	A	Acceleration Wagon (y-axis)	Acceleration sensor (3ax) - M240TU	Screwed into middle of wagon	±10 g	1000
T1_az_Wag	A	Acceleration Wagon (z-axis)	Acceleration sensor (3ax) - M240TU	Screwed into middle of wagon	±10 g	1000
T1_ax_Wag_filt	A	Acceleration Wagon (x-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T1_ay_Wag_filt	A	Acceleration Wagon (y-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T1_az_Wag_filt	A	Acceleration Wagon (z-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T1_P_Act	A	Power Actuator	calculated			
T1_s	A	Distance	calculated			
T1_v_kmh_filt	A	Speed, filtered (over 0.1 s)	calculated			

Table 6: Measurement configuration, system T2.

Name	A = analogue D = digital	Description	Source / Installation	Connection	Range	Sampling Frequency
T2_F_z	A	Force on coupler	Calculated from Raw-Data	Dependent on installation by DBST	±2.000 kN	1000
T2_Im	A	Impulses (Distance)	Incremental Encoder	Pushed on wheel	0-70.000.000	1000
T2_S_DG	A	Travel of Draft Gear (x-axis -> Forward/Backward)	Wire sensor	Screw in pivot pin / pivot pin mounting plate	0 to 1.000 mm	100
T2_CoupleInd	A	Couple Indicator (Flag)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
T2_S_y	A	Displacement (y-axis -> Sideways)	Wire Sensor	Clamp -> left side of coupler	0 to 1.000 mm	100
T2_S_z	A	Displacement (z-axis -> Up/Down)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
T2_pBP	A	Brake Pipe Pressure	Pressure Sensor in Brake Pipe	Stäubli-socket-adapter between coupler and hose	0 to 10 bar	100
T2_U_EC	A	Voltage throughput E-Coupler	Voltage Sensor	Connection description	±60 V	100
T2_U_Act	A	Voltage Actuator	Voltage Sensor	Measured directly after Battery	±60 V	100
T2_I_Act_div	A	Current Actuator	Current Sensor (Clamp meter)	Measured directly after Battery (4x)	±100 A	100
T2_ax_Wag	A	Acceleration Wagon (x-axis)	Acceleration sensor (3ax) - M241EK	Screwed into middle of wagon	±10 g	1000
T2_ay_Wag	A	Acceleration Wagon (y-axis)	Acceleration sensor (3ax) - M241EK	Screwed into middle of wagon	±10 g	1000
T2_az_Wag	A	Acceleration Wagon (z-axis)	Acceleration sensor (3ax) - M241EK	Screwed into middle of wagon	±10 g	1000
T2_ax_Wag_filt	A	Acceleration Wagon (x-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T2_ay_Wag_filt	A	Acceleration Wagon (y-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T2_az_Wag_filt	A	Acceleration Wagon (z-axis) - 32 Hz Lowpass Butterworth filter (4th order)	calculated			
T2_P_Act	A	Power Actuator	calculated			
T2_s	A	Distance	calculated			
T2_v_kmh_filt	A	Speed, filtered (over 0.1 s)	calculated			

To simplify the evaluations, the signals were renamed regarding their position on the moving or standing wagon:

Table 7: Measurement signals, moving wagon.

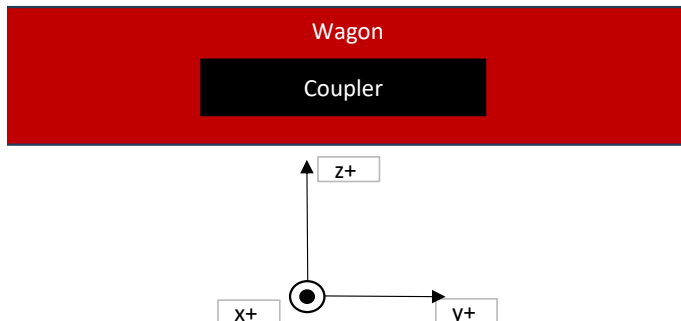
Name	Description	Source / Installation	Connection	Range	Sampling Frequency
F_z_Move	Force on coupler	DMS / strain gauges	Dependent on installation by DBST	±2.000 kN	1000
S_DG_Move	Travel of Draft Gear (x-axis -> Forward(Backward))	Wire sensor	Screw in pivot pin / pivot pin mounting plate	0 to 1.000 mm	100
CoupleInd_Move	Couple Indicator (Flag)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
S_y_Move	Displacement (y-axis -> Sideways)	Wire Sensor	Clamp -> left side of coupler	0 to 1.000 mm	100
S_z_Move	Displacement (z-axis -> Up/Down)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
pBP_Move	Brake Pipe Pressure	Pressure Sensor in Brake Pipe	Stäubli-socket-adaptor between coupler and hose	0 to 10 bar	100
U_EC_Move	Voltage throughput E-Coupler	Voltage Sensor	Connection description	±60 V	100
U_Act_Move	Voltage Actuator	Voltage Sensor	Measured directly after Battery	±60 V	100
I_Act_div_Move	Current Actuator	Current Sensor (Clamp meter)	Measured directly after Battery (4x)	±100 A	100
ax_Wag_filt_Move	Acceleration Wagon (x-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
ay_Wag_filt_Move	Acceleration Wagon (y-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
az_Wag_filt_Move	Acceleration Wagon (z-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
P_Act_Move	Power Actuator	calculated			
v_kmh_filt_Move	Speed, filtered (over 0.1 s)	calculated			

Table 8: Measurement signals, standing wagon.

Name	Description	Source / Installation	Connection	Range	Sampling Frequency
F_z_Stand	Force on coupler	DMS / strain gauges	Dependent on installation by DBST	±2.000 kN	1000
S_DG_Stand	Travel of Draft Gear (x-axis -> Forward(Backward))	Wire sensor	Screw in pivot pin / pivot pin mounting plate	0 to 1.000 mm	100
CoupleInd_Stand	Couple Indicator (Flag)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
S_y_Stand	Displacement (y-axis -> Sideways)	Wire Sensor	Clamp -> left side of coupler	0 to 1.000 mm	100
S_z_Stand	Displacement (z-axis -> Up/Down)	Wire Sensor	Clamp -> above coupler	0 to 1.000 mm	100
pBP_Stand	Brake Pipe Pressure	Pressure Sensor in Brake Pipe	Stäubli-socket-adaptor between coupler and hose	0 to 10 bar	100
U_EC_Stand	Voltage throughput E-Coupler	Voltage Sensor	Connection description	±60 V	100
U_Act_Stand	Voltage Actuator	Voltage Sensor	Measured directly after Battery	±60 V	100
I_Act_div_Stand	Current Actuator	Current Sensor (Clamp meter)	Measured directly after Battery (4x)	±100 A	100
ax_Wag_filt_Stand	Acceleration Wagon (x-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
ay_Wag_filt_Stand	Acceleration Wagon (y-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
az_Wag_filt_Stand	Acceleration Wagon (z-axis) - 32 Hz Lowpass Butterworth filter (4th order)	Acceleration sensor (3ax)	Screwed into middle of wagon	±10 g	1000
P_Act_Stand	Power Actuator	calculated			
v_kmh_filt_Stand	Speed, filtered (over 0.1 s)	calculated			

The following coordinate system was defined:

Front view on the coupler:



2.2.1.1 Data acquisition and processing

For Data acquisition a system by HBK was used, consisting of:

- Data logger: SomatXR CX22B-R-W (HBK) [HBK_CX22]
- Measuring amplifiers: SomatXR MX480B-R (HBK) [HBK_MX480]
SomatXR MX1601B-R (HBK) [HBK_MX1601]
- Data acquisition software: CatMan-Easy, Version 5.6.2 (HBK) [HBK_CM]

The measurement frequency is shown in Table 5 and Table 6.

For power-supply a battery pack with four 12 V batteries (12 V, 24 V and 48 V output possible) was installed. If no actuator was installed and therefore no high-ampere 48 V-output was needed, a smaller battery pack was installed.

Two measurement amplifier racks were used, that were switched between the wagons during change of wagons.

Python-Scripts for editing and graphical presentation of the data were developed by the TTL and executed on a measurement computer.

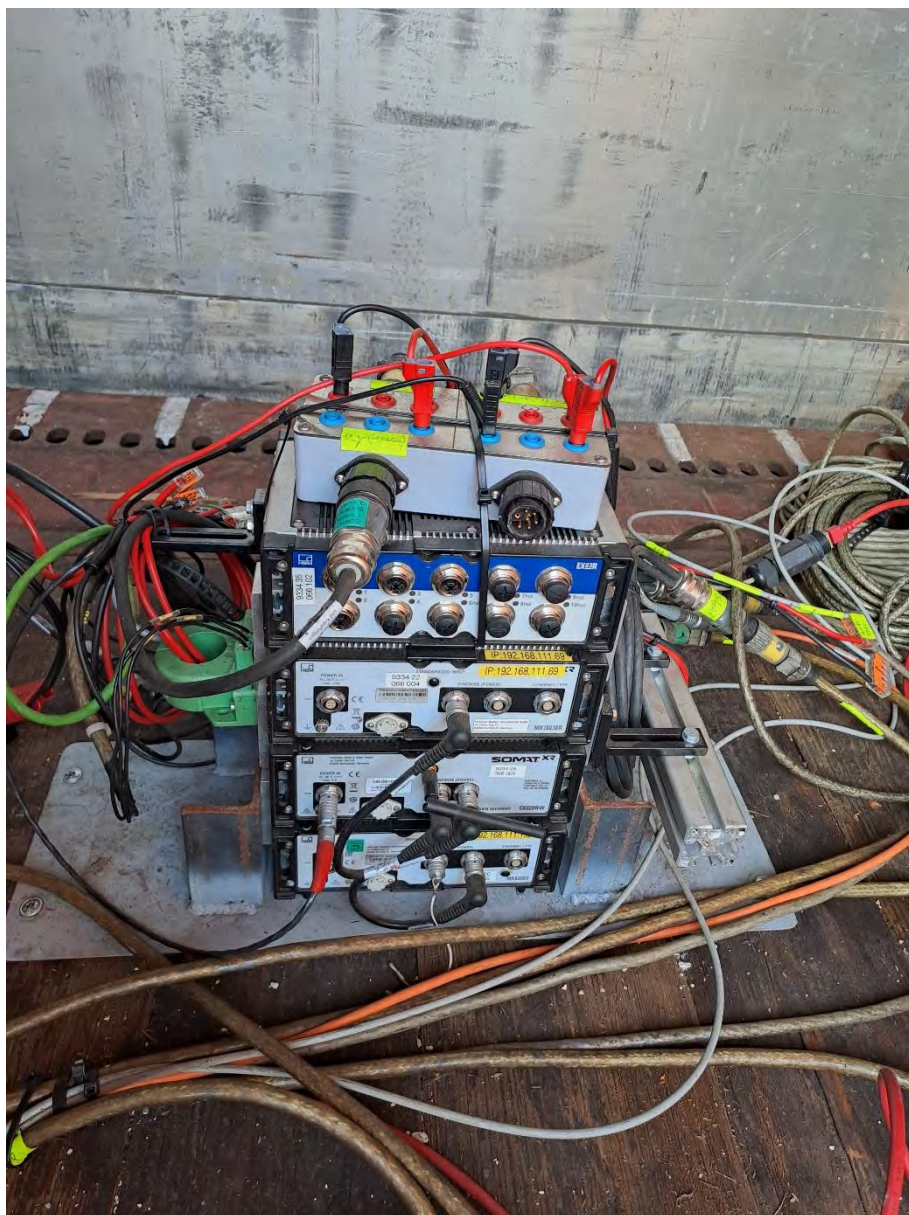


Figure 1: On-wagon measurement system: Data-logger and measuring amplifiers.



Figure 2: On-wagon measurement system: Battery pack and measuring amplifier.



Figure 3: On-wagon measurement system: Battery pack with different voltage outputs.



Figure 4: Antenna installed on the wagon to provide remote connection.

2.2.1.2 Couple indicator

The suppliers Dellner and Voith delivered couplers with couple indicators in form of a flag which shows when the coupler is coupled. As indication for Knorr-Bremse a hole in the e-coupler actuation-plate was used.

The status of the indicator is measured with the help of a wire sensor. A wire sensor with a high mechanical resistance was used to prevent vibrations. The zero position of the wire sensors is the coupled position.



Figure 5: Couple status measured with wire sensor. Top: Wire sensor directly connected to couple status indicator for Dellner and Voith. Bottom: Wire sensor connected to a hole in the e-coupler actuation plate.

2.2.1.3 Displacement of the coupler

To measure the displacement of the coupler wire sensors were used in y- (sideways), and z-axis (up-/down). Wire sensors with a high mechanical resistance were used to prevent vibrations. The sensors were aligned with the axis of movement to prevent high elongation during off-axis movement of the coupler. The zero position of the wire sensors is the straight aligned uncoupled position.



Figure 6: Wire sensors to measure y-displacement (left) and z-displacement (right) of coupler.

2.2.1.4 Deflection of the draft gear

The deflection of the draft gear was planned to be measured with a wire sensor that was attached to the pivot pin. Wire sensors with a high mechanical resistance were used to prevent vibrations. The sensors were aligned with the axis of movement.

To connect the sensors vertically a screw was attached to the pivot pin of the Dellner and Voith couplers. For Knorr-Bremse a screw was attached to the holding-plate of the pivot pin.

Remark: It must be remarked that the movement of the pivot pin was found to not be linked to the deflection of the draft gear. This is due to the coupler designs and was found out after a series of tests. As the deflection was not evaluated and a repetition of the tests was not realizable, the measurement was kept this way.



Figure 7: Connection of wire sensor for measurement of draft gear deflection. Left: Voith, right: Knorr-Bremse.



Figure 8: Connection of wire sensor for measurement of draft gear deflection on Dellner coupler.

2.2.1.5 Brake pipe pressure

The brake pipe pressure was measured with the help of an adapter equipped with a pressure sensor. The adapter could be inserted on the brake line couplings between the wagons hose and the couplers hose.



Figure 9: Pressure sensors attached to the adapter (yellow) between the wagons and couplers air hoses.

2.2.1.6 E-coupler connection

To measure the electrical connection of the e-coupler, a voltage (24 V) was applied from the battery pack. The voltage was applied to the pins 001 and 002 of the e-coupler. The voltage on the pins 101 and 102 was measured with the opposing measurement system.

See also further information in the main report, chapter 3.3.4.2.

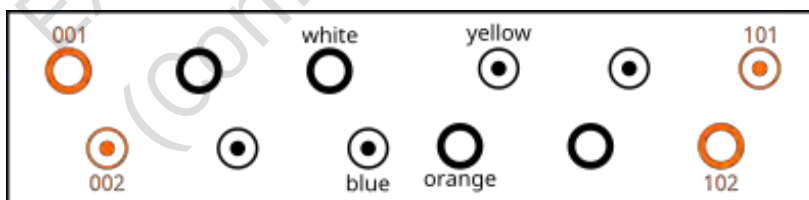


Figure 10: E-coupler - Pin layout, front view. Orange: power-pins, Black: data-pins.

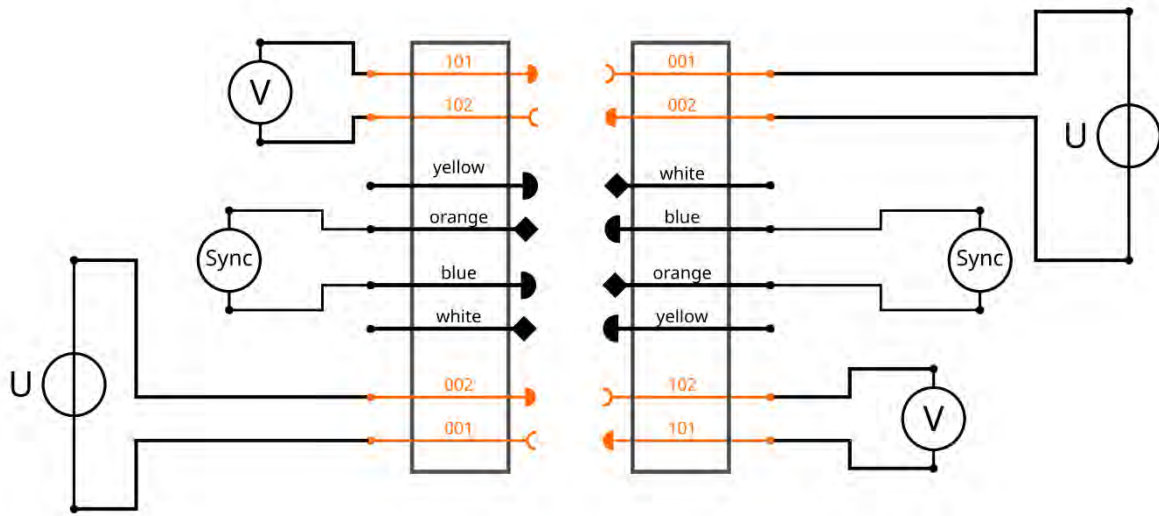


Figure 11: Circuit for measurement of electrical connection. "Sync": synchronization-signal (only connected if present), "U": voltage input, "V": voltage measurement.

2.2.1.7 Power consumption of the actuator

To measure the power consumption of the actuator, the supply-voltage and current were measured. They were measured directly at the battery connection point (48 V), which means, that the passive power consumption of the electronic system was also included in the measured data.

The current was measured with a clamp-on ammeter. To raise the sensitivity, the positive wire was passed through the clamp four times (corrected in the data-processing).

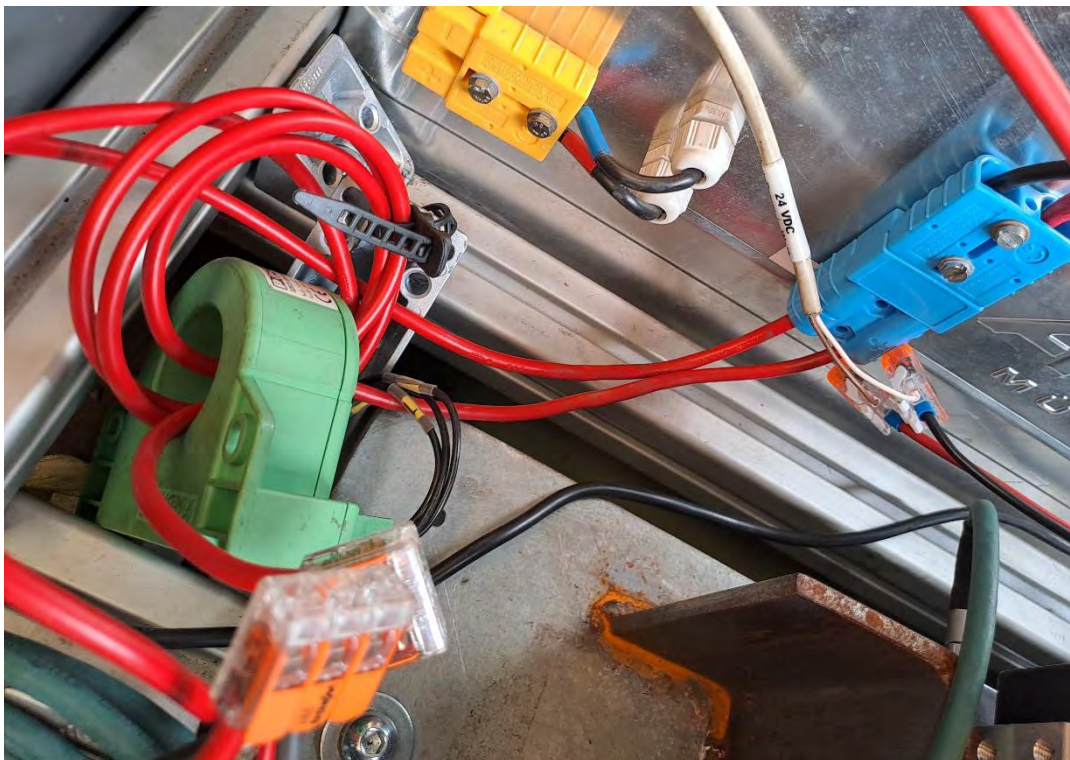


Figure 12: Clamp-on ammeter (green) to measure current of the actuator.

2.2.1.8 Force on the coupler

The tensile force and compression force were measured with a full bridge strain gauge (DMS). The strain gauge was installed and calibrated by the DBST in Minden.

Tests T135 to T140 were executed with a defect strain gauge on coupler KB06 (mechanical coupler: K03MC). The mechanical coupler was not used in later tests. Strain gauges were installed on further couplers, of which one was used during the further tests.

Tests T489 to T504 were executed with a defect strain gauge on coupler KB06 (mechanical coupler: K04MC).



Figure 13: Strain gauge on a Dellner coupler.

2.2.1.9 Impact speed

The speed of the moving wagon was measured with an incremental encoder. The incremental encoder was equipped with a wheel, which was pushed onto the wagons wheel and therefore measured its rotation. The impulses of the encoder were transformed into a distance and then differentiated by the time. A mean-filter of 0.1 s was applied for the speed.

To calculate the distance from the given impulses, a calibration was done over a distance of 50 m.



Figure 14: Incremental encoder pushed onto the wagons wheel.

2.2.1.10 Acceleration of the wagon

Acceleration sensors (3 axes, 10g) were installed in the middle of the wagons. The sensors were screwed into the wooden planks.

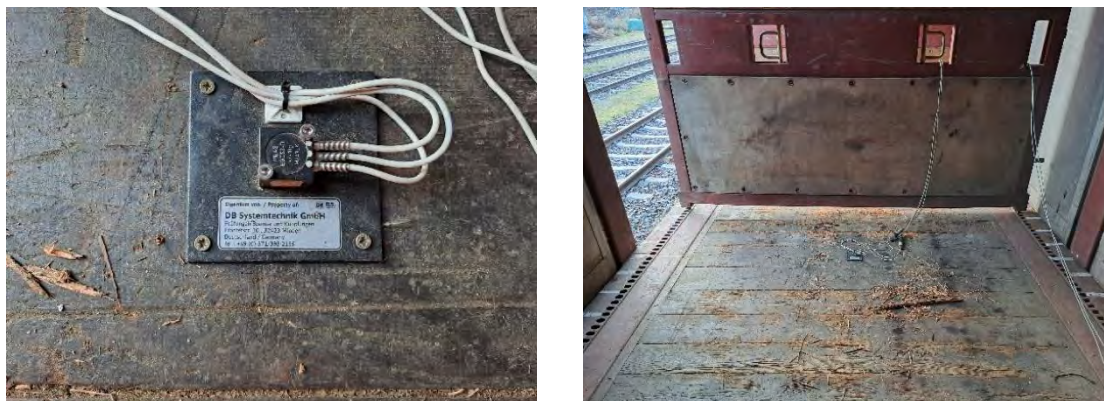


Figure 15: Attachement of 10g-acceleleration sensor in the middle of the wagon.

2.2.2 Further systems

2.2.2.1 Measurement of coupler heights

For evaluation of the vertical displacement during coupling, the heights of the couplers were measured.

The measurement of the height of the coupler consisted of two measured distances:

- Distance between top of rail and the bottom of the coupling link
- Height of coupling link

The distance between the top of rail and the bottom of the coupling link was measured with a laser-distance-sensor (Milwaukee LDM 30 [Milwaukee_LDM30]) fixed inside a rack of aluminium-profiles (see Figure 16 and Figure 17).

The heights of the coupling links were measured with a calliper gauge (see Figure 18).

The coupler height – the distance between the middle of the coupling link (CL) and the top of rail (TOR) - is calculated as:

$$\text{Coupler height} = \text{Distance}_{\text{TOR to bottom of CL}} + \frac{1}{2} \text{Height}_{\text{CL}}$$



Figure 16: Left: Laser distance sensor for coupler height measurement [Milwaukee_LDM30]. Right: Laser point on the coupler link.

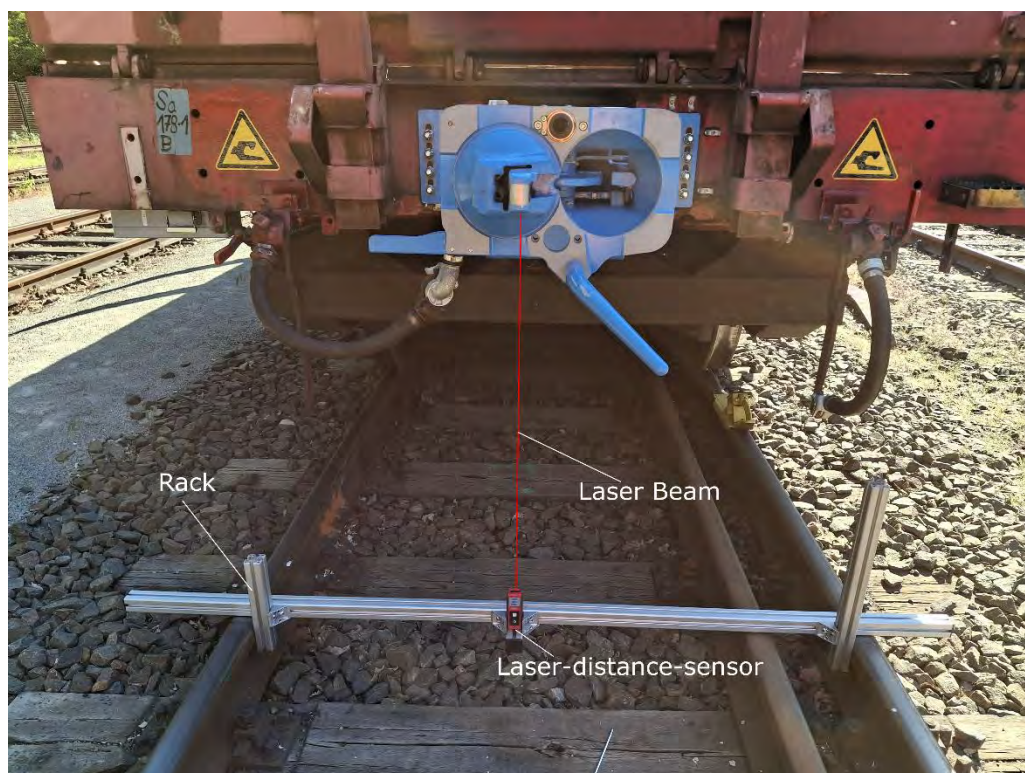


Figure 17: Aluminium rack with laser sensor for height measurement of the couplers.



Figure 18: Measurement of the height of the coupler link with a calliper gauge.

2.3 Criteria for a valid test execution

The test execution was defined as valid in case of:

- Deviation of impact speed < 1 km/h from defined impact speed
- No relevant abnormalities and deviations from test procedure

2.4 Evaluation

To evaluate	Way of evaluation						
Impact / Coupling:							
Mechanical coupling	→ Documentation of abnormalities in the test protocol Measurement of coupler status with on-wagon system: → Analysis of couple indicator signals						
Compression force	Measurement of force on the coupler with on-wagon system: → Max. compression force during test evaluated.						
Pneumatic coupling	Measurement of brake pipe pressure with on-wagon system: → Connection: Pressure rise after opening the air cock of impacting wagon evaluated (Automatic evaluation: max. pressure of brake pipe > 2 bar on both wagons) → Leakage: leakages were not evaluated with the measurement system. Major, audible leakages were documented in the protocol → Open air valve: no air valves are present in the couplers, therefore no testing						
Electric coupling	Measurement of e-coupler connection with on-wagon system: → Evaluated 5 s after impact: Rise of the voltage signal to min. 10 V.						
Critical damages coupler	→ Documentation of abnormalities in protocol → Regular photo documentation						
Critical damages wagon	→ Documentation of abnormalities in protocol → Regular photo documentation						
Wear and tear	→ Documentation of abnormalities in protocol → Photo documentation						
Energy absorption	Regarding [EN15551] → dependent on testcase. Remark: The energy absorption is not evaluated in this report.						
Wagon acceleration	→ Automatic evaluation: max. absolute acceleration per direction. Limit values dependent on testcase regarding [EN15551]: <table border="1"> <thead> <tr> <th>Case:</th><th>Limit value</th></tr> </thead> <tbody> <tr> <td>...C1</td><td>4 g</td></tr> <tr> <td>...C2</td><td>6 g</td></tr> </tbody> </table>	Case:	Limit value	...C1	4 g	...C2	6 g
Case:	Limit value						
...C1	4 g						
...C2	6 g						
Uncoupling:							
Uncoupling	→ Documentation of coupler status after uncoupling in protocol Measurement of coupler status with on-wagon system: → Analysis of couple indicator signals → Measurement of force on the coupler with on wagon-system. Force when uncoupling evaluated.						

The graphical representation of the measured data of an exemplary coupling test is shown in Figure 19. Graphical representation of a prevent-coupling test is shown in

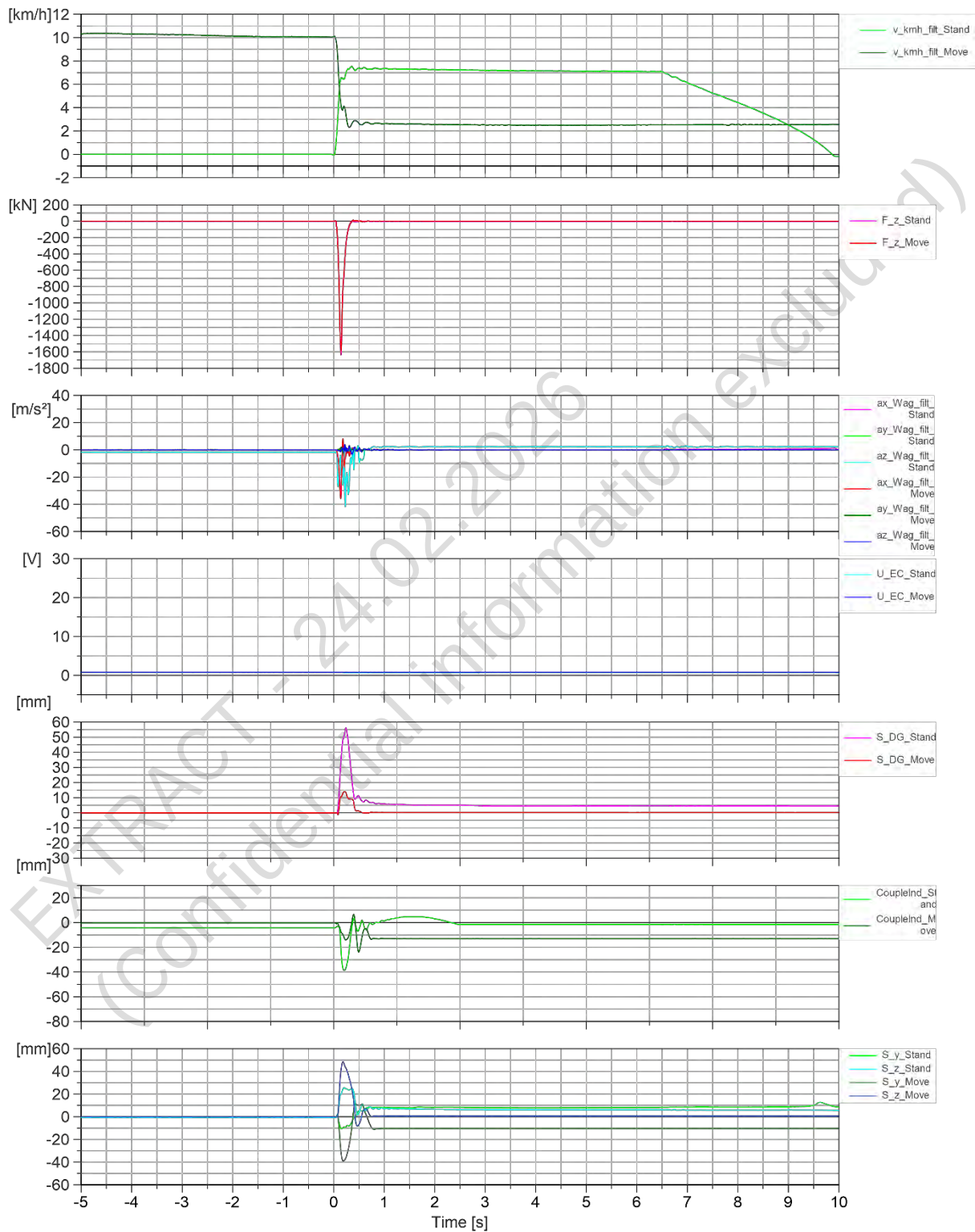


Figure 20. Graphical representation of an uncoupling test is shown in Figure 21.

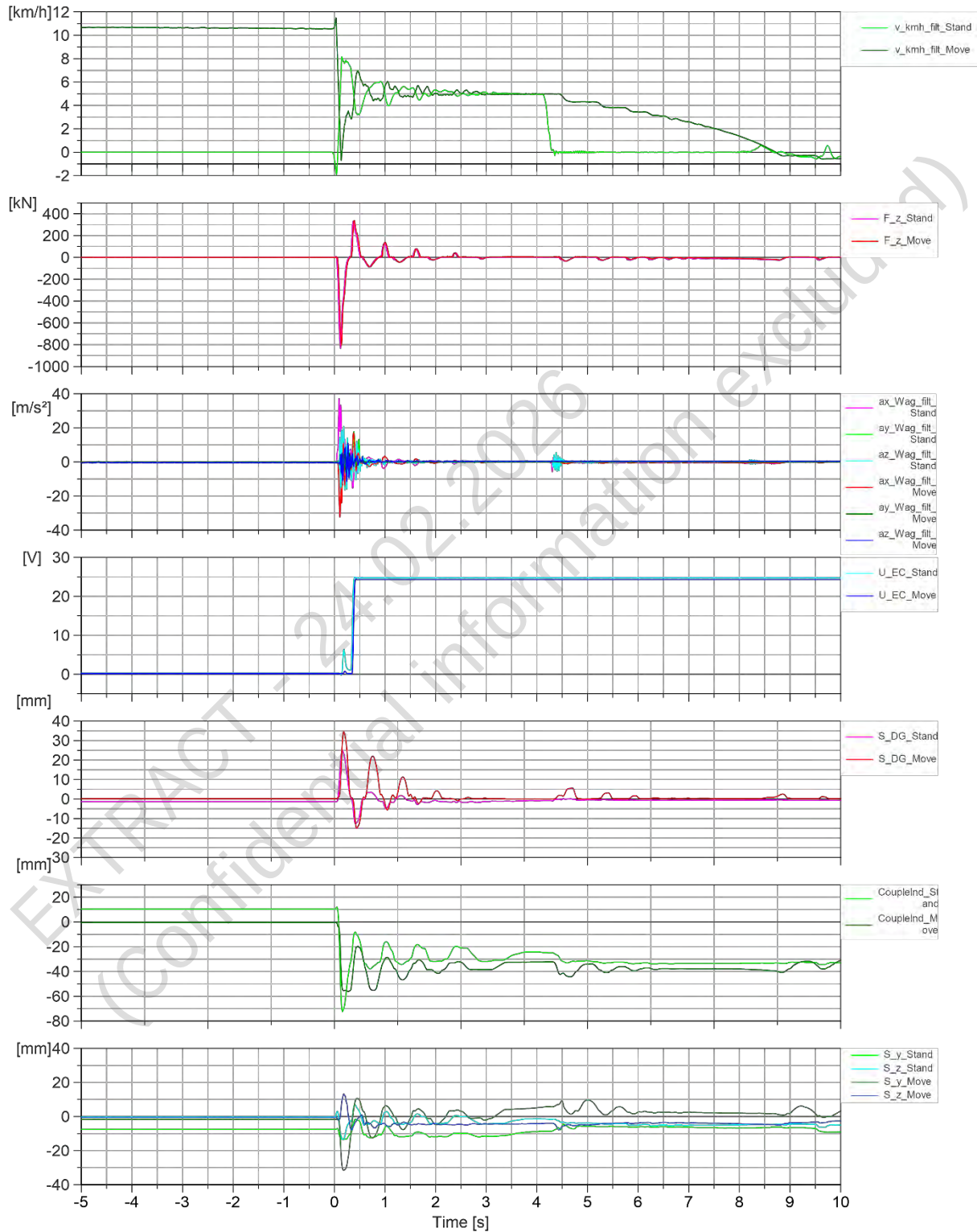


Figure 19: Graphical presentation of an exemplary coupling test.

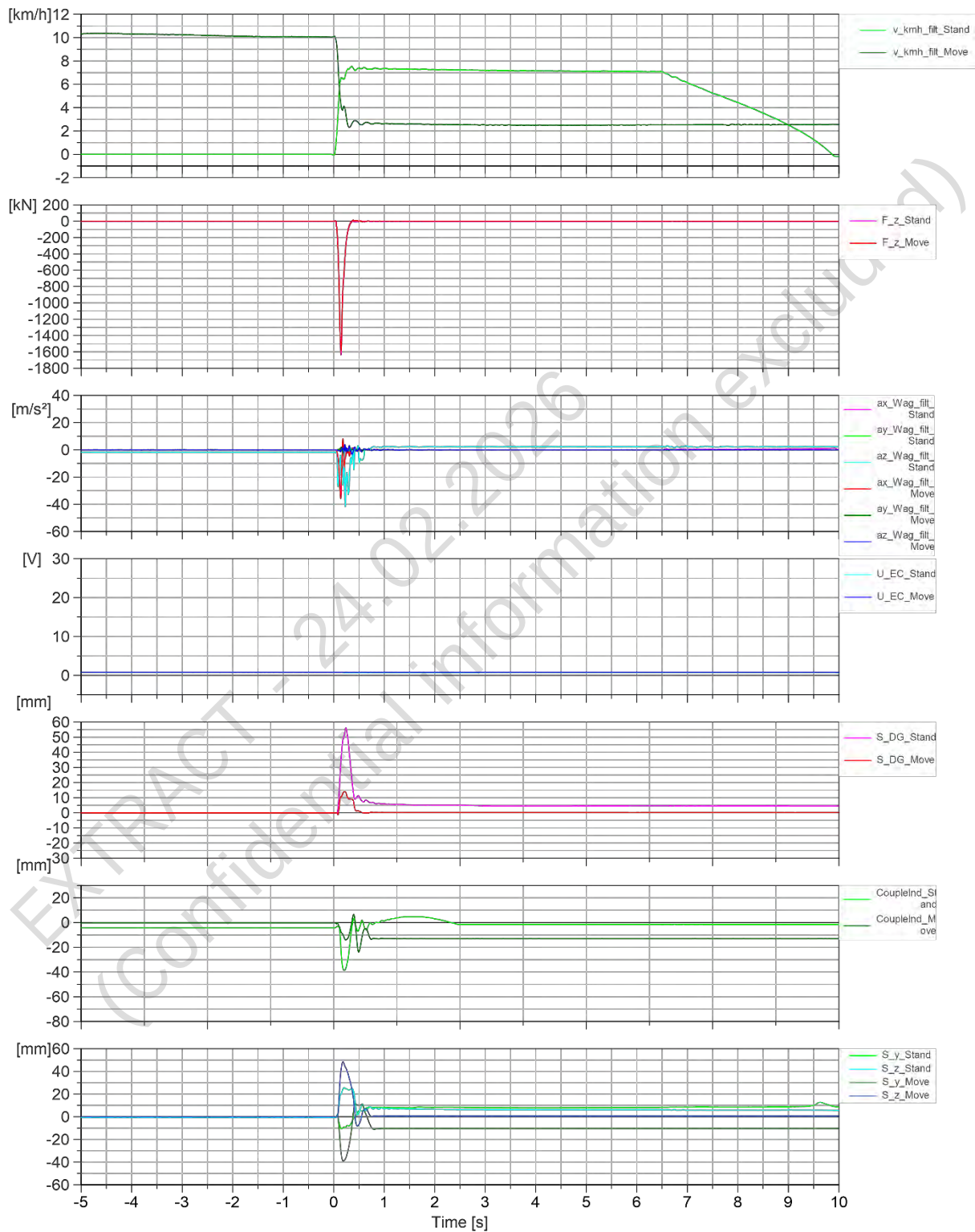


Figure 20: Graphical presentation of an exemplary prevent-coupling test.

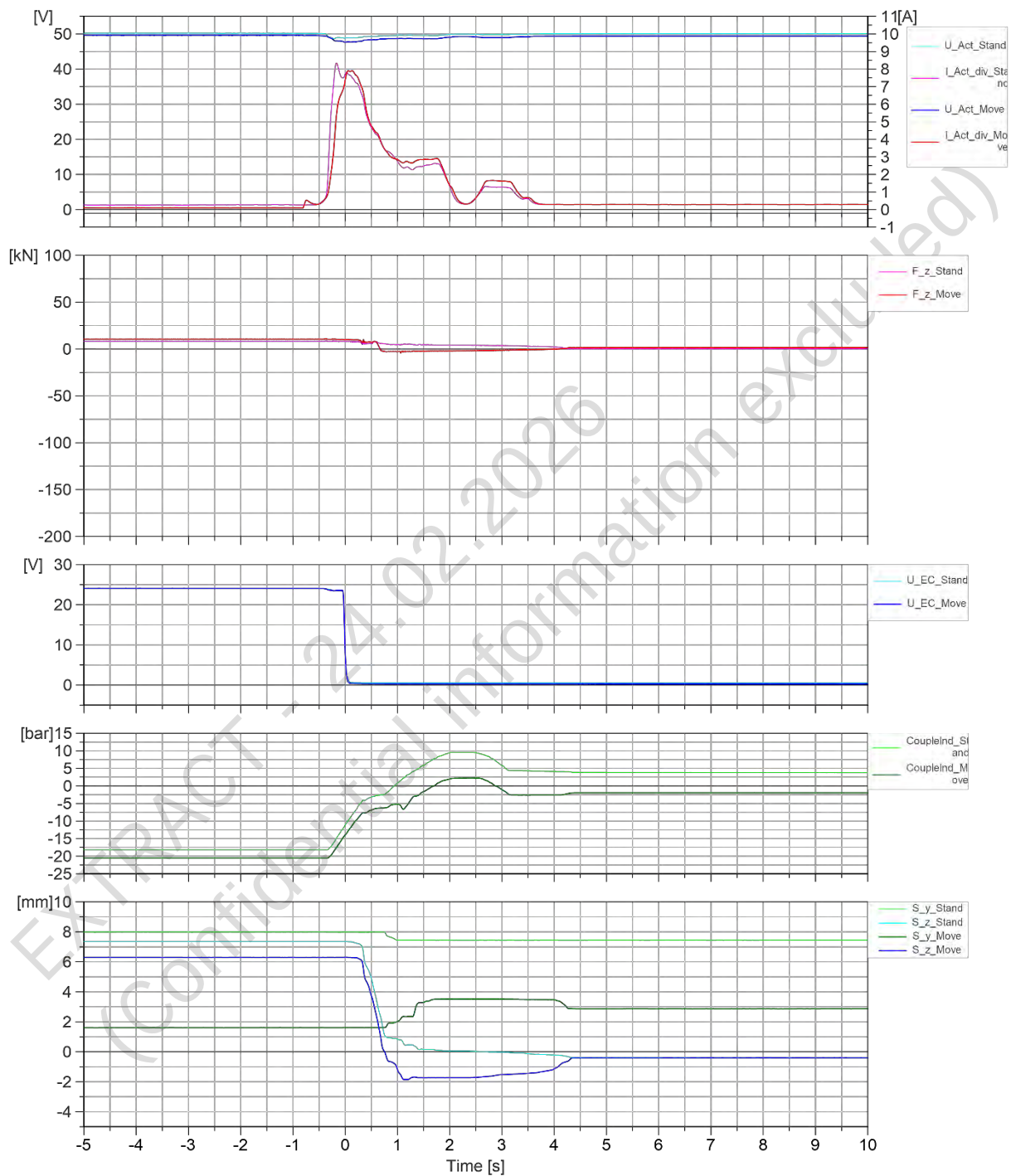


Figure 21: Graphical presentation of an exemplary uncoupling test with synchronization signal.

3 Results

3.1 Impact tests

For reasons of confidentiality, the results are presented per supplier in the annexes 2.1 to 2.3.

EXTRACT - 24.02.2026
(Confidential information excluded)

3.2 Coupler heights

The results of the coupler heights are summarized in the following table:

Coupler	Date	Wagon	Load state	Height CL	Height TOR - CL Mean of 3	Coupler height
				[mm]	[mm]	[mm]
DC01				70,4		
	05.11.2025	Ha_0136	Full		986	1022
	06.11.2025	Ha_0136	Full		981	1016
	07.11.2025	Ha_0136	Full		978	1013
	25.11.2025	Ha_0136	Full		980	1016
	12.01.2026	Ha_0136	Full		984	1020
DC02				70,4		
	28.10.2025	Hb_3581	Empty		955	991
	30.10.2025	Hb_3581	Half loaded		923	958
	25.11.2025	Hb_3581	Empty		956	992
	12.01.2026	Ha_0458	Full		988	1024
	19.01.2026	Ha_0458	Full		988	1025
DC03				70,4		
	29.10.2025	Hb_3472	Empty		973	1009
	30.10.2025	Hb_3472	Half loaded		931	967
	27.11.2025	Hb_3472	Half loaded		928	963
	01.12.2025	Hb_3472	Half loaded		936	971
KB02				71,4		
	05.12.2025	Hb_3746	Half loaded		947	983
	09.12.2025	Hb_3746	Half loaded		947	983
	16.12.2025	Hb_3746	Empty		998	1033
KB04				71,4		
	06.11.2025	Ha_0458	Full		972	1008
	15.12.2025	Ha_0458	Full		962	998
	16.12.2025	Ha_0458	Full		967	1002
	04.02.2026	Ha_0458	Full		1002	1038
KB05				71,4		
	24.10.2025	Hb_3235	Empty		981	1017
	07.11.2025	Hb_3235	Empty		981	1017
	01.12.2025	Hb_3235	Half loaded		958	994
	05.12.2025	Hb_3235	Half loaded		954	990
KB06				71,4		
	29.10.2025	Ha_0136	Full		964	999
	31.10.2025	Ha_0136	Full		967	1003
	04.02.2026	Ha_0136	Full		1009	1045
VT01				70,4		
	09.12.2025	Hb_3472	Half loaded		993	1029
	12.12.2025	Hb_3472	Half loaded		992	1027
VT02				70,4		
	12.12.2025	Hb_3235	Half loaded		979	1014

Coupler	Date	Wagon	Load state	Height CL	Height TOR - CL Mean of 3	Coupler height
				[mm]	[mm]	[mm]
	15.12.2025	Hb_3235	Empty		1028	1064
VT03				70,4		
	23.10.2025	Ha_0458	Full		978	1013
	24.10.2025	Ha_0458	Full		978	1013
	28.10.2025	Ha_0458	Full		978	1013
	31.10.2025	Ha_0458	Full		974	1009
VT04				70,4		
	23.10.2025	Hb_3746	Empty		991	1027
	05.11.2025	Hb_3746	Empty		984	1020
	27.11.2025	Hb_3746	Half loaded		957	992
VT05				70,4		
	19.01.2026	Ha_0136	Full		995	1030
	21.01.2026	Ha_0136	Full		986	1021
VT06				70,4		
	21.01.2026	Ha_0136	Full		1001	1036

4 References

Abbreviation	Document-Nr.	Title	Author	Date	Version
[EN15551]	EN15511:2017	Railway applications Railway rolling stock Buffers	-	05.2017	-
[HBK_CM]	B04486	Catman Universal data acquisition and analysis software Data Sheet	HBK	14.07.2023	06
[HBK_CX22]	B04717	Somat ^{XR} CX22B-R-W Data recorder Data Sheet	HBK	23.05.2023	04
[HBK_MX840]	B04309	Somat ^{XR} MX840B-R Rugged universal amplifier Data Sheet	HBK	27.07.2022	04
[HBK_MX1601]	B04019	Somat ^{XR} MX1601B-R Ultra-rugged Standard Amplifier Data Sheet	HBK	07.05.2024	05
[Milwaukee_LDM30]	-	Milwaukee – LDM 30 Original Instructions	Milwaukee	-	-
[TS-2025-014]	2025-014-DAC-TS01	Impact Tests – Test Scenario	Saskia Discher	27.02.2025	02

5 Appendices

Annex	Vn.	Title	Content