

FP5TRAN S4M-R
Transforming
Europe's Rail Freight

Impact Tests

Test scenario

Title:	Impact Tests – Test scenario
Type:	Test scenario
Document-No.:	2025-014-DAC-TS01
Test Laboratory:	WP 14 – Train Test Lab
Version:	V02
Date:	27.02.2025

Document history

Revision	Date	Description
V01	14.06.2024	Initial report
V02	27.02.2025	Consolidated WP14 and WP13-Version
V03	21.03.2025	Consolidated WP4-Version
V04	04.04.2025	Final version

Contributing authors

Name	Company	Details of contribution
Saskia Discher	Havelländische Eisenbahn	Main author
Julian Beck	DB Systemtechnik	Contributing author
Martin Mählig	DB Systemtechnik	Contributing author
Daniel Wolfram	DB Cargo	Reviewer
Jan Sporleder	DB Cargo	Reviewer
Olaf Michael	DB Cargo	Reviewer
Anna Björkman	Lindholmen Science Park	Reviewer
Fabian Henche	Faively Transport	Reviewer
Eva Lohmeier	Knorr-Bremse	Reviewer
Fredrik Tunell	Dellner Couplers	Reviewer
Ulrich Deghela	Voith Group	Reviewer

Signatures

Name	Contact	Signature	
Saskia Discher	Havelländische Eisenbahn AG Schönwalder Allee 51, 13587 Berlin E-Mail: saskia.discher@hvle.de	author	
Expert XY	Company Address 1, Address 2 E-Mail: expert@company.com	reviewer	
Expert XY	Company Address 1, Address 2 E-Mail: expert@company.com	approver	

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Abbreviations & Acronyms

Abbreviation / Acronym	Description
AAR	Association of American Railroads
BP	Brake Pipe
DAC	Digital automatic coupler
DBC	DB Cargo AG
DBST	DB Systemtechnik GmbH
DC	Dellner Couplers
DMS	Strain gauge (ger.: DehnungsMessStreifen)
e-coupler	Electrical coupler
eLCF	Endurable Longitudinal Compressive Forces
ERJU	Europe's Rail Joint Undertaking
FDFT	Full Digital Freight Train
FP5	Flagship Project 5 of the ERJU project
FT	Faively Transport - Wabtec
HBK	Hottinger Brüel & Kjaer GmbH
KB	Knorr-Bremse AG
LCF	Longitudinal Compressive Forces
NNTR	Notified national technical rules
oLCF	occurring Longitudinal Compressive Forces
P/F	Pass / Fail - criteria
ToR	Top of rail
TRL	Technology Readiness Level
TTL	Train Test Lab
VT	Voith GmbH & Co. KGaA
WP4	Working Package 4 of the FP5 – Authorisation requirements
WP13	Working Package 13 of the FP5 – Test management
WP14	Working Package 14 of the FP5 – Train Test Lab

Symbol	Description
	Brake shoe
	Coupler not defined
	DAC - coupled
	DAC – not coupled
	Marker
	Screw coupler - coupled
	Screw coupler – not coupled / push off mode

1 Project description

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). Couplers are produced by various suppliers and sent to testing in accordance with the V-model process for validation.

The tests are coordinated by the test management (WP13) within TRANS4M-R and distributed across several test instances. This test scenario covers the tests that were executed by TRANS4M-R WP14 in the Train Test Lab. The objective of the tests within WP14 is to validate technical enablers in a safe, closed test environment (TRL 5 to TRL6). The systems under test must have been previously tested on test rigs and the corresponding verifications described in Quality Gate 1 must be available. The purpose of the tests in the Train Test Lab is to generate further evidence for quality gate 2 for operating demonstrator trains on public infrastructure (TRL 6 to TRL 7). [DEL13.2]

The test scenario described here involves tests that are to be used as verification for further trains and the general operation of vehicles on public infrastructure.

2 Test objective

The objective of tests described in this document is firstly to demonstrate that DACs withstand the forces during an impact test with selected vehicles. Furthermore, the impact on the vehicle in case of acceleration / energy absorption of the draft gear is tested. This is evaluated by impact tests representing impacts that could happen during shunting.

Secondly the document describes functional coupling tests in different infrastructural geometries and impact tests in prevent coupling position.

Concerning impact tests regarding standard, the DAC must be able to withstand the same forces as the screw coupler and the side buffers. This is defined in EN 15551:2017 [EN15551]. Appendix E describes the dynamic examination of the buffers. The DAC correspond to buffer of the category A. Section E.2 is required for testing.

However, all the documents presented assume vehicles with side buffers. The test procedure specified here is therefore based on the known procedures but has been adapted for use with centre buffer couplings.

The specific requirements for the tension and thrust load of the DAC are described in [DEL5.2] and relevant test procedures are described in [DEL5.3]. Further test procedures that have been implemented so far were realised in the DAC4EU project and are described in [DAC4EU01]. The test procedures according to [DEL5.3] are similar to [DAC4EU01].

The tests described in this document that are relevant for approval, take [EN15551] into consideration, while only the functional tests refer to the procedure described in [DAC4EU01].

3 Fundamentals, definitions and technical principles

3.1 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 Hooked 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)
- Draft gear, with:
 - o Compression force stop for form closure with wagon
- Vertical support (with centration)

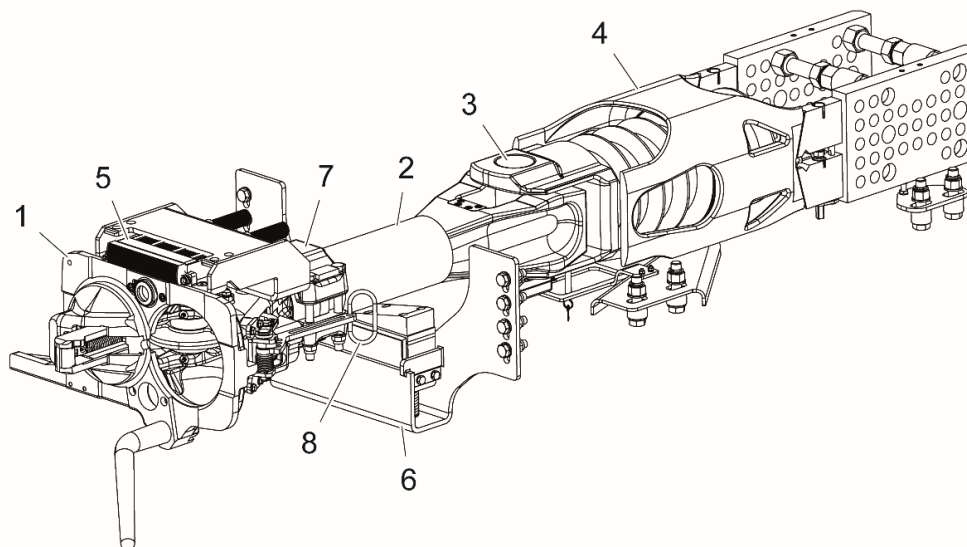


Figure 1: Scheme of the DAC. 1: mechanical coupler / coupler head, 2: coupler shank, 3: pivot pin, 4: draft gear (with compression force stop on the right end), 5: electrical coupler, 6: vertical support, 7: split collar, 8: manual uncoupling device; Source: [DEL5.3], edited.

3.2 Necessary tests regarding [EN15551]

Due to these several different functions, the functionality between two DACs of one supplier shall be tested under different boundary conditions, for example speed or weight.

The suppliers are currently providing DACs which might differ in:

- Design of front plate
- Behaviour of springs, hooked plate and coupler link of the coupler head
- Behaviour of draft gear (e.g. spring and attenuation constant, material, etc.)
- Design of mechanical uncoupling mechanism
- Behaviour of air valve
- Behaviour of e-coupler connection (e.g. spring characteristics)

Due to these differences, the interoperability between the DACs of different suppliers has to be tested – besides the testing of matching couplers of one supplier.

All tested DACs are tested in automation level 4.5 – “DAC 4.5”. Therefore, many different functions have to be tested.

The mechanical part of the coupler must absorb the tensile and compressive forces during an impact to such an extent, that the acceleration of the vehicle does not exceed the limit values (load safety) and no part of the DAC or vehicle is damaged. As the impact forces are no longer absorbed via the side buffers but via the center buffer coupler, it must be possible for the DAC to endure forces of 2.000 kN.

When coupling, the air coupling must close completely. To check this the continuity must be tested after impact. A test of the air tightness after an impact will be tested regularly.

At the present time the DACs do not include an air valve. Therefore, tests in need of pressurized vehicles must be carried out by using the wagon air valves to shut the brake pipe.

The contacts of the electric coupler must meet correctly so that the current and information can be transmitted. The pins should not be influenced by the mechanical impact.

3.3 Functional tests

3.3.1 Functionality of coupling

As the tests regarding [EN15551] focus on the structural strength of the components and the energy absorption, a further investigation on the functionality of coupling on different infrastructure.

Within the DAC4EU project [DAC4EU01] functional tests on different track infrastructures were executed. These were:

- 190 m curve
- 150 m curve
- 190 m S-curve
- 150 m S-curve with 6 m intermediate straight
- 100 m curve
- 75 m curve

The aim of these tests was to cover a wide variety of operational scenarios.

The [DEL5.3] defines tests needed to achieve TRL8 of the DAC. The impact tests stated in this document echo the procedure done within the DAC4EU project.

3.3.2 Prevent coupling position

Concerning the behaviour of the components during impacts in prevent coupling position no examinations have taken place at the time. Therefore, tests regarding impact of the prevent coupling position during impact must be done. Especially the influence on the actuator must be examined.

4 Test procedure

4.1 Adaptation of [EN15551]

4.1.1 Infrastructure

The tests regarding [EN15551] are to be executed on a straight track without inclination.

4.1.2 Vehicles

According to [EN15551] the tests should be executed with two different types of wagons in a straight track with a defined speed. The following combinations must be done:

Table 1: Combination of tests to be executed according to [EN15551].

Moving wagon	Standing unbraked 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 type of wagon is not specified in the [EN15551].

4.2 Functional tests

4.2.1 Functionality of coupling – adaptation of [DAC4EU01]

In this chapter the tests defined in [DAC4EU01] are adapted to test the worst-case scenarios in terms of coupling on different infrastructures, mainly curves.

From a technical perspective the difficulty of coupling in curves is that the couplers must meet each other. This is more difficult the larger the coupling angle is. Therefore, impact tests must be executed on an infrastructure and with vehicles that force a large coupling angle.

Furthermore, coupling is harder the faster the standing wagon is pushed away. This is the case when a fully loaded wagon impacts on an empty wagon.

4.2.1.1 Infrastructure

From an infrastructural point of view, large coupling angles occur while running through curves with a small radius. In case of [DAC4EU01] this was the 75 m curve.

As during the tests regarding [EN15551] no tests with a full wagon impacting on an empty wagon are executed, tests with this wagon configuration must also be executed on the following infrastructure:

- straight
- 150 m curve
- 150 m S-curve with 6 m intermediate straight
- 75 m curve → worst case in terms of coupling angle

4.2.1.2 Vehicles

To echo the tests in [EN15551] the same wagons shall be used for the functional coupling tests with the following loading:

Table 2: Load states of vehicles according to [EN15551].

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

4.2.2 Prevent coupling position

For functional tests regarding the prevent coupling position a focus is the influence of the components regarding wear and damages. Therefore, the main goal is to do impact tests with resulting in high forces.

4.2.2.1 Infrastructure

As the infrastructure has no impact on the impact force tests shall be executed on straight track.

4.2.2.2 Vehicles

The higher the masses of the vehicles, the higher the force on impact. To echo the tests in [EN15551] the same wagons shall be used. Therefore, following wagons should be used for the tests:

Table 3: Choice of wagons according to [EN15551].

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

4.3 Test objects

Within the impact tests, the couplers of all four DAC suppliers involved will be tested. Following components are needed from each of the DAC suppliers (Voith, Knorr-Bremse, Wabtec and Dellner):

- Coupler head
- Uncoupling actuator
- Push button control unit incl. connection/cabling to actuator
- Shank
- E-coupler
- Draft gear
- Spacer plates
- Vertical support
- Fastening material

All components shall be installed on the test wagons according to respective supplier's manual/instruction. Confirmation for correct installation shall be given by the suppliers.

5 Test execution

5.1 Description of test case

This chapter summarizes the test procedure into a defined test execution.

Aim of the impact tests is the evaluation of the mechanical, pneumatical and electrical parts of the DACs regarding the coupling capability, also in terms of coupling of couplers from different suppliers.

Impact tests shall be performed with different speeds, different loading conditions and different track geometries.

The quantity of tests is not specified in the [EN15551]. Therefore, it is necessary to execute all tests at a minimum of one time. The high speed with more or equal than 10 km/h shall be tested one time. After each test the spring package must cool down. Lower speeds will be tested three times to reproduce the tests.

The following individual tests are to be executed:

Table 4: Overview of test cases.

Moving wagon	Standing wagon	Infrastructure	Velocity	Amount of tests
Test relevant for approval according to EN 15551				
2-axle 20 t	4-axle 80 t	straight	7 kph	3
2-axle 20 t	4-axle 80 t	straight	9 kph	3
2-axle 40 t	2-axle 40 t	straight	12 kph	1
4-axle 80 t	4-axle 80 t	straight	10 kph	1
Functional impact tests				
4-axle 80 t	2-axle 20 t	straight	0,6 kph	3
4-axle 80 t	2-axle 20 t	straight	2 kph	3
4-axle 80 t	2-axle 20 t	150 m curve	2 kph	3
4-axle 80 t	2-axle 20 t	150 m curve	4 kph	3
4-axle 80 t	2-axle 20 t	75 m curve	2 kph	3
4-axle 80 t	2-axle 20 t	150 m s-curve	2 kph	3
Functional impact tests with prevent coupling position				
4-axle 80 t	4-axle 80 t	straight	0,6 kph	3
4-axle 80 t	4-axle 80 t	straight	6 kph	3
4-axle 80 t	4-axle 80 t	straight	10 kph	1

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

Table 5: Combinations of coupler configurations.

		Moving wagon			
		DC	KB	VT	FT
Standing wagon	DC	x	x	x	x
	KB	x	x	x	x
	VT	x	x	x	x
	FT	x	x	x	x

During the impact tests and functional coupling tests the following parts needs to be evaluated:

Table 6: Evaluation functional coupling tests - Criteria.

To evaluate	Criteria
Impact / Coupling	
Mechanical coupling	The couplers are mechanically coupling during each impact test. Remark: After a failed coupling the wagons will impact again with lower speeds due to a braking of the standing wagon. Only the first impact shall be evaluated.
Pneumatic coupling	The brake pipes of both wagons must couple during each impact test. No major leakage of the brake pipe shall be detected.
Electric coupling	The e-coupler must couple during each impact test.
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.

During the impact tests with prevent coupling position the following parts needs to be evaluated:

Table 7: Evaluation prevent coupling - Criteria.

To evaluate	Criteria
Mechanical coupling	The couplers must not couple during each impact test.
Electric coupling	The e-coupler must not couple during each impact test.
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.

5.2 Test procedure

In general, during the impact tests two DACs are coupled with a defined relative speed by a push-off operation. Therefore, one unbraked standing wagon is positioned on a defined location on a straight track. A moving wagon is accelerated and pushed-off.

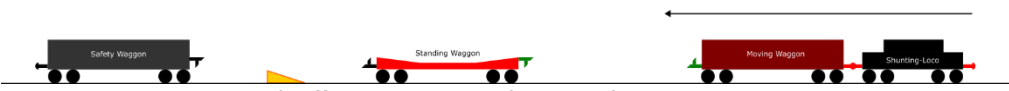
The moving wagon impacts on the standing wagon, the couplers impact on each other.

The steps are described in more detail in the following chapters.

5.2.1 Preparation, initial situation and push-off operation

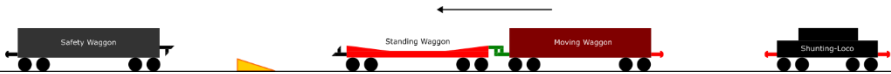
ID	
1	Preparation
1.1	Continuously measured parameters
1.1.1	Longitudinal and compression force on the coupler
1.1.2	Speed of the moving wagon on impact
1.1.3	Spring deflection of draft gear
1.1.4	Movement of the coupler in x-, y- and z-direction
1.1.5	Acceleration of the standing wagon
1.1.6	Connection of the e-couplers
1.1.7	Voltage and current of the actuator
1.1.8	Brake pipe pressure
1.2	Additionally measured parameters
1.2.1	A regular examination of the couplers (see point) should be executed in advance to a test series.
1.2.2	Height measurement of coupler heights in uncoupled state. Remark: This is not required in advance to every test, but after installation or change of load.
1.3	To document
1.3.1	Vehicles – Vehicle number – Vehicle type – Driving direction – Loading condition – ...
1.3.2	Couplers – Supplier – DAC Type – ID / Serial Number – Parts – ...
1.3.3	Weather conditions – Temperature – Rain / Snow – ...

1.3.4	Operator – For protection of data privacy an „operator-ID“ is sufficient
1.3.5	Infrastructure – Location – Geometry
1.3.6	Abnormalities and deviations from procedure
1.3.7	Time and date
2	Initial Situation
2.1	Description
2.1.1	Standing wagon: – Brakes deactivated – Coupler centred – Coupler status: ○ Impact tests with coupling: Coupler status „ready to couple“ ○ Impact tests with prevent coupling: Coupler status „prevent coupling“ – Air cocks: ○ Coupling side: open ○ Push off side: closed – Brake pipe exhausted
2.1.2	Moving wagon: – Brakes deactivated – Coupler centred – Coupler status: ○ Impact tests with coupling: Coupler status „ready to couple“ ○ Impact tests with prevent coupling: Coupler status „prevent coupling“ – Brake pipe filled – Air cocks are closed
2.1.3	The coupler of the standing wagon is placed on a defined location (couple location).
2.1.4	To brake the wagons after impact a brake shoe is placed behind the standing wagon.
2.1.5	 Figure 2: Impact tests: Initial setup.
2.2	To document
2.2.1	Abnormalities and deviations from procedure.

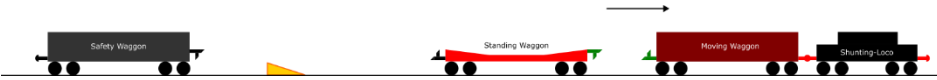
3	Push-off operation
3.1	Description
3.1.1	Brake pipe of moving wagon is filled by loco.
3.1.2	Air cocks of moving wagon are closed afterwards.
3.1.3	Screw-coupler and brake pipe of moving wagon is uncoupled.
3.1.4	Moving wagon is accelerated to target push-off speed.
3.1.5	A steady moving phase might be necessary to reduce the energy input into the loco-wagon system during acceleration phase.
3.1.6	As the moving wagon is slowing down due to different influences after push-off, the exact speeds during the push-off operation are not defined and decided by the loco driver based on his experience. Only the impact speed is defined.
3.1.7	 Figure 3: Impact tests: Push-off operation – acceleration phase.  Figure 4: Impact tests: Push-off operation – push-off.
3.2	To document
3.2.1	Abnormalities and deviations from procedure.

5.2.2 Impact

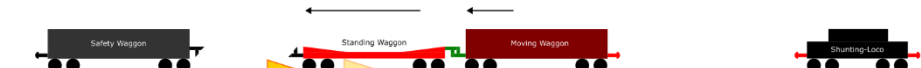
5.2.2.1 Impact - with coupling

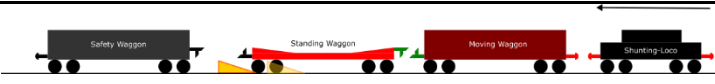
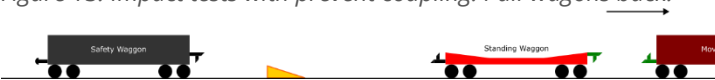
4	Impact - with coupling
4.1	Description
4.1.1	Impact and coupling of moving on standing wagon.
4.1.2	Both wagons move further and are braked by the brake shoe.
4.1.3	To check if a correct connection of the brake pipes is given, the closed air cock on the moving wagons coupling side is opened. Air pressure in the brake pipes is equalized between the wagons.
4.1.4	 Figure 5: Impact tests with coupling: Impact.  Figure 6: Impact tests with coupling: Braking after impact.
4.1.5	Remark: It is expected that both couplers couple on impact. If this is not the case, the wagons will move on. Latest when the previously standing wagon is braked by the brake shoe, the wagons will impact again with slower speed. Only the first impact is evaluated.
4.1.6	Remark: If the compression force exceeds 2.000 kN, the couplers must be inspected in accordance with the supplier's manual.
4.2	To document
4.2.1	Abnormalities and deviations from procedure.
4.2.2	Coupling status.

5	Leakage test
5.1	Description
5.1.1	A leakage test shall be executed regularly. It is not necessary after each test.
5.2	To document
5.2.1	Abnormalities and deviations from procedure.

6	Reset to couple-position and uncouple - with coupling
6.1	Description
6.1.1	Couple loco and moving wagon mechanically.
6.1.2	Pull the waggons back to the couple location.
6.1.3	Putting brake shoes back into position.
6.1.4	Uncouple wagons.
6.1.5	 Figure 7: Impact tests with coupling: Pull wagons back.  Figure 8: Impact tests with coupling: Uncouple and reset to initial setup.
6.1.6	Remark: The couplers are uncoupled. It is expected that both couplers are reset to the "ready-to-couple"-position. If a coupler stays in the "coupled" position, it should be reset on the specific coupler.
6.2	To document
6.2.1	Abnormalities and deviations from procedure.
6.2.2	Coupling status.
6.2.3	Actuated coupler.

5.2.2.2 Impact - with prevent coupling

7	Impact - with prevent coupling
7.1	Description
7.1.1	Moving wagon will impact on standing wagon a few times without coupling.
7.1.2	Both wagons move further and are braked by the brake shoe.
7.1.3	 Figure 9: Impact tests with prevent coupling: First impact  Figure 10: Impact tests with prevent coupling: Wagons separate.  Figure 11: Impact tests with prevent coupling: Wagons impact another time and are braked.
7.1.4	Remark: If the compression force exceeds 2.000 kN, the draft gear must be inspected in accordance with the supplier's manual.
7.2	To document
7.2.1	Abnormalities and deviations from procedure.
7.2.2	Coupling status.

8	Reset to couple-position - with prevent coupling
8.1	Description
8.1.1	Reset both wagons to ready to couple position.
8.1.2	Couple loco and moving wagon mechanically.
8.1.3	Pull the waggons back to the couple location.
8.1.4	Putting brake shoes back into position.
8.1.5	Uncouple wagons to prevent coupling position.
8.1.6	 Figure 12: Impact tests with prevent coupling: Reset couplers to ready to couple position. Couple the wagons and loco.  Figure 13: Impact tests with prevent coupling: Pull wagons back.  Figure 14: Impact tests with prevent coupling: Uncouple and reset to initial setup.
8.1.7	Remark: The couplers are uncoupled. It is expected that both couplers are reset to the "ready-to-couple"-position. If a coupler stays in the "coupled" position, it should be reset by on the specific coupler.
8.2	To document
8.2.1	Abnormalities and deviations from procedure.
8.2.2	Coupling status.
8.2.3	Actuated coupler.

5.2.3 Regular examination

9	Visual examination
9.1	Description
9.1.1	A visual examination of the couplers and draft gear should be done regularly. It is not to be executed after each test, but approx. after each test block.
9.1.2	The following is to be checked in detail: – Draft gear – E-coupler contacts – Screws – Wear – Air seal –
9.2	To document
9.2.1	Photo documentation
9.2.2	Abnormalities
10	E-Coupler contacts
10.1	Description
10.1.1	A measurement of the insulation-resistance and the resistance of the contacts of the e-coupler should be done regularly. It must not be executed after each test, but approx. once a day.
10.2	To document
10.2.2	Abnormalities
10.3	To measure additionally to 1
10.3.1	Measurement of the insulation-resistance between contacts and housing.
10.3.2	Measurement of the insulation-resistance between each contact.
10.3.3	Measurement of the resistance over the coupler.

5.3 Detailed overview of Measurement equipment

The measurement equipment must be installed on the moving wagon. Therefore, it has to be installed on two axle and one four axle wagon. In the following the sensors currently used for measurement of the different parameters by the TTL (WP14) and during the DAC4EU project [DAC4EU01] are described:

Table 8: Overview of measurement equipment.

Measured parameter	Sensor and installation	Used in projects
Speed of the wagons	Incremental encoder pushed on the wheel	TTL – WP14
	Incremental encoder installed into the axle	[DAC4EU01]
Acceleration on the wagon	Acceleration sensor mounted in the middle of the wagon	TTL – WP14
Longitudinal force on the coupler	Strain gauge on the coupler shank	TTL – WP14 [DAC4EU01]
Deflection of the draft gear	Wire sensor installed on the wagon, measuring the distance to the coupler head	TTL – WP14 [DAC4EU01]
Connection of mechanical coupler	Wire sensor connected to the couple indicator	Not measured in any project so far
Movement of the coupler	Wire sensor in x-, y- and z-direction on the coupler	TTL – WP14 [DAC4EU01]
Connection of e-couplers	Measurement of a voltage over all pins of the e-coupler.	TTL – WP14
Functionality of Actuator	Measurement of the voltage and the current of the actuator	Not measured in any project so far
Pressure loss in brake pipe / main reservoir pipe	Pressure sensor at the distributor valve or at the brake pipe / main reservoir pipe	TTL – WP14 [DAC4EU01]

5.4 Evaluation

The given criteria for the tests with coupling are evaluated the following way:

Table 9: Evaluation functional coupling tests - Way of 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 coupling
Pneumatic coupling	Measurement of brake pipe pressure with on-wagon system: → Connection: Pressure drop after opening the air cock on the moving wagon (due to equalization of brake pipe pressures) evaluated
Electric coupling	Measurement of e-coupler connection with on-wagon system: → Analysis of electric connection during test.
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	Calculated regarding [EN15551] → dependent on testcase
Wagon acceleration	Calculated regarding [EN15551] → dependent on testcase
Uncoupling:	
Uncoupling	→ Documentation of actuated coupler and coupler status after uncoupling in protocol Measurement of coupler status with on-wagon system: → Analysis of uncoupling

The given criteria for the tests with prevent coupling are evaluated the following way:

Table 10: Evaluation prevent coupling - Way of 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 no coupling
Electric coupling	Measurement of e-coupler connection with on-wagon system: → Analysis of electrical connection during test.
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

6 References

Abbreviation	Document-Nr.	Title	Author	Date	Version
[DAC4EU01]	60226-TT.TVP21-PR01-V1.3-192843	Testing: Digital automatic coupler Phase I Coupling and running tests	DB Systemtechnik – Testing Brakes and Couplers	10.01.2022	1.3
[DEL13.2]	-	TRANS4M-R - D13.2 Consolidated full system integration plan, test concept & validation concept and plan	Anna Åkerman	11.04.2024	4
[DEL5.2]	-	TRANS4M-R – D5.2 Technical Specifications of Wagon and Locomotive DAC up to Level 5	Johan Ahman	20.12.2023	1
[DEL5.3]	-	TRANS4M-R – D5.3 Validation/Test Procedures of Wagon and Locomotive DAC up to Level 5	Andreas Schuhmacher	31.10.2023	4
[EN15551]	EN 15551:2017	Railway applications Railway rolling stock Buffers	DIN-Normenausschuss - FSF	05.2017	-
[TS_DAC_016]	2025-016-DAC-TS01	Climate chamber tests – Test scenario	Jan Sporleder	-	01

7 Appendices

Annex	Vn.	Title	Content