Report:

Testing: Digital automatic couplers

Phase I
Climate chamber tests

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List of revisions

Version	Date	Revisions	Editor
1.0	30.09.2021	First version	Dr. Daniel Jobstfinke
1.1	05.01.2022	- Removal of second list of revisions - Individual term adjustments - Addition of content in Sections 4.3.1 and 5	Dr. Daniel Jobstfinke

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List of abbreviations

Abbreviation	Meaning
BP	Brake pipe
DAC	Digital automatic coupler for freight wagons
DB	Deutsche Bahn AG
DB ST	DB Systemtechnik GmbH
E-coupler	Electrical contact coupling, used for the transmission of electrical power, information and signals
E-wagon	Eanos-x 059 type wagon
H-wagon	Hbbins 306 type wagon
Z-wagon	Zags type wagon

1 Details of the assignment

1.1 Assignment:

This research project commissioned by the German Federal Ministry of Transport and Digital Infrastructure (BMVI) has been created to test the viability of digital automatic couplers (DACs) as an important and future-oriented system innovation for rail freight transport. DACs from four manufacturers (Voith, Dellner, Wabtec, CAF) are being subjected to comprehensive real-world tests for this purpose in a two-phase project.

In Phase I, the practical tests are divided into overrun impact tests, coupling tests in small radius curves, longitudinal compression tests and tests under a variety of climatic conditions. Each manufacturer has provided a wagon group with three freight wagons and two installed DAC pairs. The results of the practical tests will be processed for Phase II and thus provide the basis for the decision-making process for the EDDP (European DAC Delivery Program).

Phase II is divided into Phases IIa and IIb and can be described as the operational testing phase. Phase IIa comprises the operational testing of selected DACs in marshalling yards, with the number of wagon groups per manufacturer being increased to up to five wagons. This will be followed by Phase IIb with a total of 24 wagons and the equipment of one DAC manufacturer. Further tests in operational processes are planned both domestically and in Germany's neighbouring countries.

Additional functions for the automation and digitisation of rail freight transport are planned throughout the project and will be tested in parallel during the two phases. These involve the power and data lines, some of which are used as communication lines.

This report deals with the **climate chamber tests**. Section 1.2 provides an overview of the documents.

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1.2 Overview of the documents

No.	Test report number
1	60226-01-DAK-Phase I – Overall report
2	60226-02-DAK-Phase I – Measurement technology
3	60226-03-DAK-Phase I – Coupling and running tests
4	60226-04-DAK-Phase I – Derailment tests under longitudinal compressive forces
5	60226-05-DAK-Phase I – Climate chamber tests
6	60226-06-DAK-Phase I – Electrical systems
7	60226-07-DAK-Phase I – Data measurements

2 Description of tests

2.1 Infrastructure

The climate chamber tests were conducted in the climate chamber “MEikE” (Minden facility for climate technical inspection of railway vehicles) operated by DB Systemtechnik GmbH.

The climate chamber encloses a straight and level section of track, which is connected to the other DB Systemtechnik track systems. A roller door separates the interior of the chamber from its surroundings. Fig. 1 shows the Z-wagon entering the climate chamber. The track ends at the opposite end of the chamber without a buffer stop.

Fig. 1: The Z-wagon entering the climate chamber

2.2 Vehicles

The wagons used in the tests were the same as those described in report 60226-03-DAK-Phase I – Coupling and running tests. The H-wagon was in load state 1 (empty) during the climate chamber tests. The Z-wagon was also in an unloaded state. The E-wagon was loaded with the concrete blocks described in report 60226-03-DAK-Phase I – Coupling and running tests.

The groups of wagons were lined up in such a way that the E-wagon was at the far end of the track in the climate chamber and the Z-wagon near the gate. This arrangement was necessary for performing the test procedure described in the following section.

2.3 Test procedure

The entire climate chamber test procedure described below is shown schematically in Fig. 1. The symbols used are explained in the report 60226-03-DAK-Phase I – Coupling and running tests. The specified letters of the individual steps are stated below in brackets.

In the initial situation, the E-wagon was positioned at the end of the climate chamber and restrained using stop blocks. Its BP was filled by an external compressed air supply. The H-wagon was coupled with the E-wagon. The Z-wagon stood in the climate chamber and was not coupled. All four DACs were climatically prepared (a).

In the chosen configuration, the heights of the coupled DACs were different due to the different load states of the E- and H-wagons and the effect of this on the wagons’ suspension. However, the heights of the non-coupled DACs were not different. The two coupling wagons were both unloaded and the DACs at a comparable height. This was considered a critical case for the coupling tests with ice and snow.

Once the DACs had been climatically prepared, the H-wagon was first uncoupled from the E-wagon and then manually pushed into the middle of the climate chamber (b). Afterwards, stop blocks were laid out behind the H-wagon and the Z-wagon was pulled out of the hall through the open roller door to gain momentum for the coupling procedure. There the Z-wagon was uncoupled from the locomotive and its BP vented. The wagon was then pushed off by the locomotive at

approx. 5 km/h (c+d). The locomotive followed the wagon after the coupling impact (e). The locomotive then coupled to the stationary tank wagon and the BP was connected. After the BP was filled, the BP stopcock of the H-wagon was moved to the closed position in the direction of the E-wagon for approx. 15 s, so that venting took place via the vent hole. The stopcock was then opened again. This test step, which was an addition to the coupling tests performed in Görlitz, served as an extra continuity test of the BP (f). After the BP had been refilled, the two coupled wagons were pulled a little way towards the gate (to check that the coupling was properly connected, g). Finally the H-wagon was coupled to the E-wagon again and the Z-wagon uncoupled to prepare the next test (h).

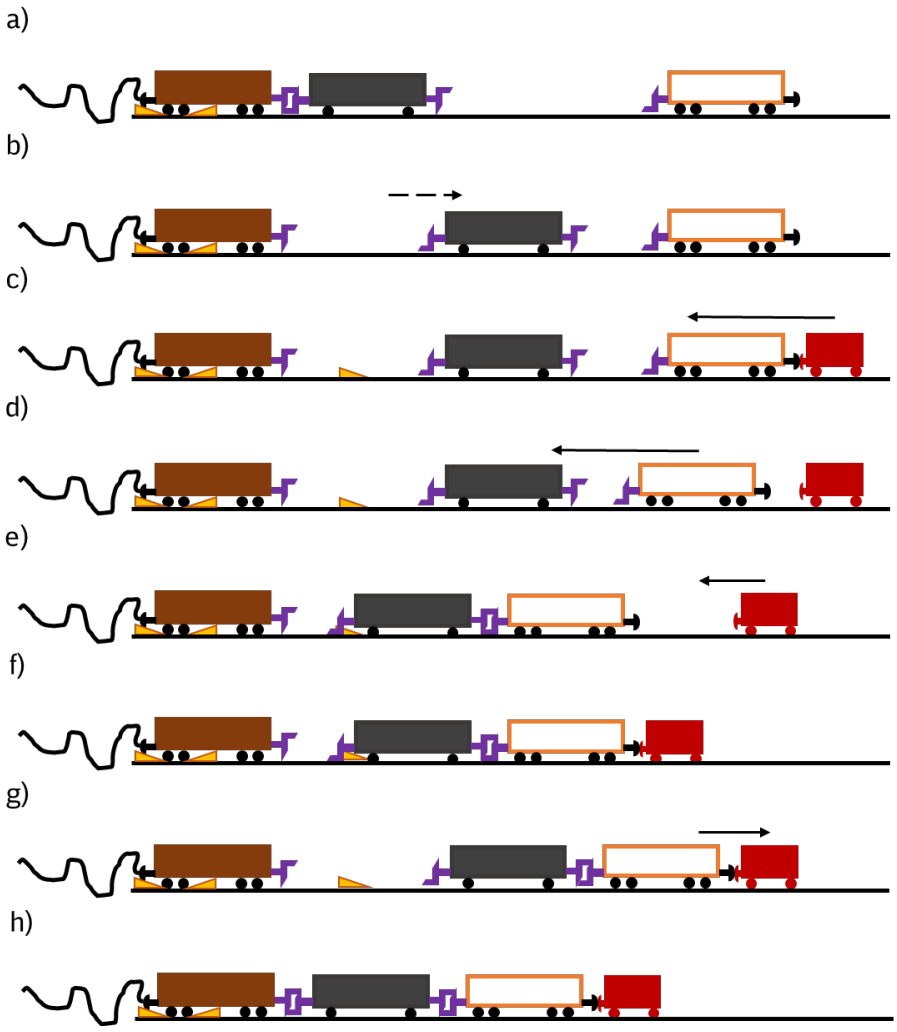

Fig. 2: Schematic diagram of the climate chamber tests

Coupling was studied under the following climatic conditions:

- **+45° C**, dry air
- **+45° C, 90 % humidity**
- **-5° C ... 0° C, wet snow**
- **-10° C**, dry air/no precipitation
- -**10° C, 3 to 5 mm ice** on DACs
- **-25° C**, dry air/no precipitation
- -**25° C, 3 to 5 mm ice** on DACs

To produce the 3 to 5 mm thick layers of ice on the DACs, the couplers were manually sprayed with water at regular intervals. Fig. 3 shows an example of a DAC prepared in this way.

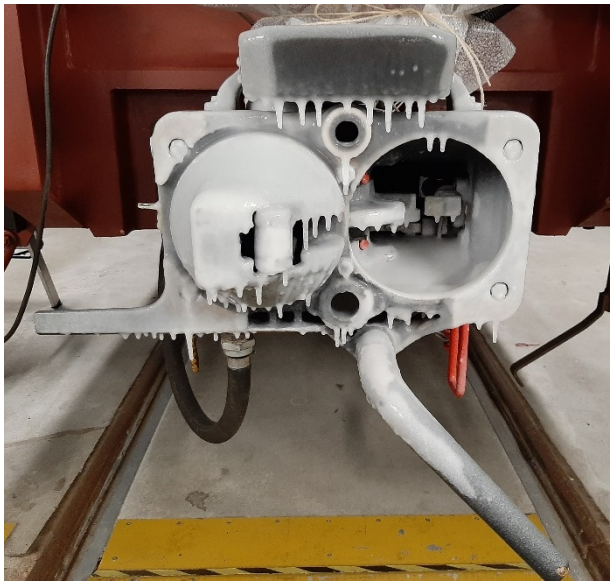

Fig. 3: DAC with 3 to 5 mm thick ice layer

To create the wet snow, artificial snow was first produced, moistened again if necessary, and then manually applied to the DACs. Fig. 4 shows the production of artificial snow (left) and an example of a prepared DAC (right).

Fig. 4: Production of artificial snow (left) and prepared DAC

The 90 % humidity at a temperature of 45° C was generated only in the immediate vicinity of the DACs. For this purpose, the DACs were wrapped in film together with a humidifier. Fig. 5 shows an example of the setup.

Fig. 5: Generation of 90 % humidity at +45° C in the area of the DAC

3 Evaluation methodology

The climate chamber tests were evaluated using the same semi-automated methods as the coupling tests. The procedure is described in the report 60226-03-DAK-Phase I – Coupling and running tests.

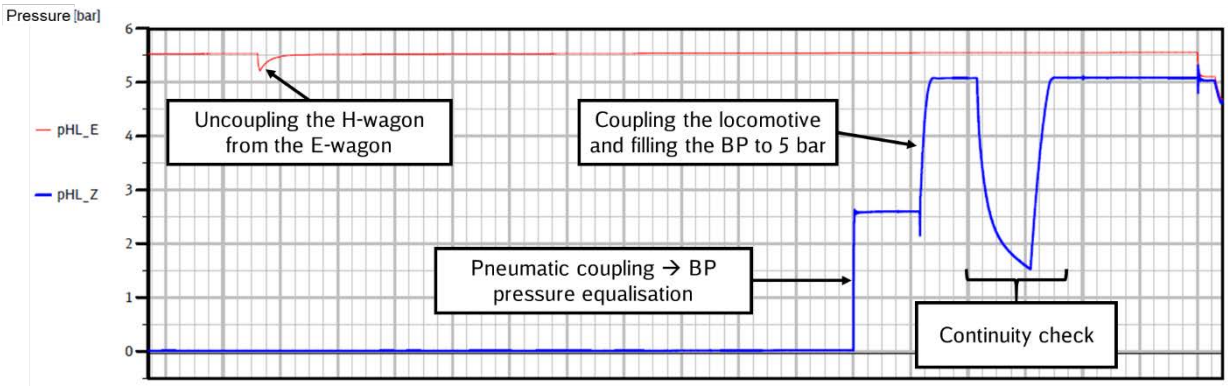

Fig. 6: Sample measurement record of the BP pressure curves during a climate chamber test

The test steps of the climate chamber tests were slightly modified compared to the coupling tests in Görlitz. The effects of these changes on the BP pressure measurement records are shown as an example in Fig. 6. This shows both the initial uncoupling of the H-wagon from the E-wagon and the additional test step of the BP continuity test.

The criteria applied for the evaluation of the mechanical, pneumatic and electrical coupling processes are the same as those used for the coupling tests in Görlitz. A summary of these is provided again in Table 1.

Table 1: Summary of the evaluation criteria for the semi-automated evaluation of the tests

Category	Condition for "successfully coupled"
	Climate chamber test
Mechanical coupling	▪ Tensile force stroke immediately after compression force stroke as a result of the coupling impact / wagon can be pulled back
Pneumatic coupling	▪ BP pressure build-up in the Z-wagon immediately after the coupling impact
Electrical coupling	▪ All electrical contacts are closed in the period from 6 s to 10 s after the coupling impact

Annex 1 presents the results of all the climate chamber tests. Analogous to the procedure for the coupling and running tests, a list is provided showing which test numbers were carried out in the respective configuration and what proportion of the tests resulted in successful mechanical, pneumatic and electrical coupling in each case. In the event that there were unsuccessful coupling procedures, the test numbers of these tests are also provided. Fig. 7 presents an example of such a case.

Load state 1

Test No.	Infrastructure	Eanos	Hbbins	Zags
1.6.K.ZH	Climate chamber "Meike" Minden	fully laden	empty	empty

-10°C (dry)			
Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings
6	83%	83%	17%
1034-1035-1037-1038-1040-1042	1034	1034	1034-1035-1037-1038-1040

Fig. 7: Extract from the evaluation of the climate chamber tests in Annex 1

4 Summary of the test results

4.1 Dellner DAC

4.1.1 Short summary

The evaluation of the **climate chamber tests with the Dellner DAC** can be found in **Annex 1.1**. The main findings are briefly summarised below. The timetable for the tests and any notable features are documented in the following section. Photographic documentation of damage and/or notable features can be found in the next but one section.

The Dellner DAC did not couple mechanically in any of the cases when the DAC was prepared with snow or ice. In all other cases, the mechanical coupling process was successful.

In all cases where mechanical coupling was successful, the pneumatic coupling process was also successful.

The electrical coupling process was similar to the pneumatic coupling process, with the difference that contact problems occurred in all cases at -25° C without ice.

4.1.2 Timetable and notable features

Table 2: Timetable and notable features – Dellner DAC

Date	Tests	Comments
16.02.2021	-5° C ... 0° C, wet snow	• Couplers in coupled state on one side despite un-successful mechanical coupling → Coupler had to be reset • Display of coupling status partly undefined • The wagon was pulled along despite the display showing that the coupler was uncoupled
17.02.2021	-10° C, dry	• Uncoupling incomplete on one occasion → Air valve remained open
18.02.2021 19.02.2021	-10° C, 3 to 5 mm ice	• No mechanical coupling • Cover of e-coupler remained open after uncoupling • Display of coupling status partly undefined • Couplers in coupled state on both sides despite un-successful mechanical coupling → Couplers had to be reset
22.02.2021	-25° C, dry	• Various e-contact faults
23.02.2021	-25° C, 3 to 5 mm ice	• No mechanical coupling • Cover of e-coupling remained open after uncoupling • Uncoupling incomplete → Air valve remained open
25.02.2021	+45° C, dry air	-
25.02.2021 26.02.2021	+45° C, 90 % humidity	-

4.1.3 Photographic documentation of damage and/or notable features

The following images show examples of some of the damage and/or notable features that have occurred. At this point, however, photographic documentation is not provided for all cases.

Fig. 8: The left DAC is in the coupled position despite the unsuccessful mechanical coupling procedure (photo 16.02.2021)

Fig. 9: Close-up of a DAC in coupled state after an unsuccessful mechanical coupling procedure. Highly compressed snow is visible on the face of the coupler (photo 16.02.2021)

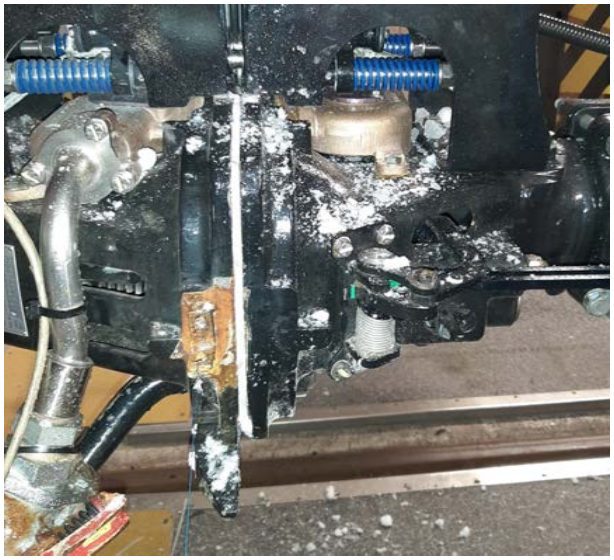

Fig. 10: Attempt to couple by pressing on both sides. DACs do not couple (indicator lines). A layer of snow is clearly visible between both the coupler heads (photo 16.02.2021)

Fig. 11: E-coupler cover remained open after uncoupling (photo 18.02.2021)

Fig. 12: Both DACs are in the coupled position despite the unsuccessful mechanical coupling procedure (photo 18.02.2021)

4.2 Voith DAC

4.2.1 Short summary

The evaluation of the **climate chamber tests with the Voith DAC** can be found in **Annex 1.2**. The main findings are briefly summarised below. The timetable for the tests and any notable features are documented in the following section. Photographic documentation of damage and/or notable features can be found in the next but one section.

With the exception of one test at -25° C and 3 to 5 mm ice, the Voith DAC successfully coupled mechanically in all cases.

The electrical coupling procedures frequently failed in the presence of a layer of ice. Under other climatic conditions there were some isolated unsuccessful electrical coupling procedures.

The pneumatic coupler showed a very marked behaviour. The evaluation shows failed coupling procedures in many (but not all) cases. This was due to the lack of (sustained) pressure build-up in the Z-wagon after the mechanical coupling procedure. The measurement records show only a brief pressure peak. The additional continuity test of the BP on the H-wagon led in all cases to a pressure drop in the Z-wagon and locomotive. The continuity of the BP was thus confirmed. The lack of an increase in pressure was therefore probably due to leaks. These were often audible in the area of the air coupling during the tests. It was not possible to locate the exact position of the leak. Two air valve housings were also broken during the tests (see also the following section). Although there may also have been leaks here before the fractures were detected, clearly audible air losses also occurred at the unaffected coupling point between the E- and H-wagons at -25° C.

4.2.2 Timetable and notable features

Table 3: Timetable and notable features – Voith DAC

Date	Tests	Comments
12.01.2021	-10° C, dry	• Cover of e-coupler remained open after uncoupling (rubber seal had become hard)
13.01.2021 14.01.2021 15.01.2021	-10° C, 3 to 5 mm ice	• Cover of e-coupler remained open after uncoupling • Uncoupling often incomplete → Air valve remained open • Cover of e-coupler became wedged during coupling • Air valve of Z-wagon leaking
18.01.2021	-25° C, dry	• Clear leakage between E- and H-wagons in coupled state • Cover of e-coupling remained open after uncoupling • No connection of e-contacts between E- and H-wagons
19.01.2021 20.01.2021 21.01.2021	-25° C, 3 to 5 mm ice	• Clear leakage between E- and H-wagons in coupled state • Cover of e-coupling remained open after uncoupling • No connection of e-contacts between E- and H-wagons • Mechanical coupling failed once • Uncoupling incomplete → Air valve remains open
25.01.2021 26.01.2021	-5° C ... 0° C, wet snow	• Cover of e-coupler remained open after uncoupling • Cover of e-coupler became wedged during coupling • Increased force required for uncoupling
28.01.2021	+40° C, dry air	• Air valve housing on Z-wagon broken
03.02.2021	+45° C, dry air	-
04.02.2021	+45° C, 90 % humidity	• Uncoupling incomplete → Air valve remained open • Air valve housing on H-wagon (Z-side) broken

4.2.3 Photographic documentation of damage and/or notable features

The following images show examples of some of the damage and/or notable features that have occurred. At this point, however, photographic documentation is not provided for all cases.

Fig. 13: Cover of e-coupler remained open after uncoupling (photo 12.01.2021)

Fig. 14: Jammed e-coupling cover during coupling (photo 13.01.2021)

Fig. 15: Broken air valve housing (photo 28.01.2021)

4.3 Wabtec DAC

4.3.1 Short summary

The evaluation of the **climate chamber tests with the Wabtec DAC** can be found in **Annex 1.3**. The main findings are briefly summarised below. The timetable for the tests and any notable features are documented in the following section. Photographic documentation of damage and/or notable features can be found in the next but one section.

At the beginning of the tests with the Wabtec DAC it was found that the uncoupled couplers could only be separated by using a considerable tensile force. It was therefore impossible to uncouple and move the wagons by hand. Instead, the couplers had to be separated by pulling with a locomotive. For this reason, it was necessary to deviate from the regular test procedure: the H-wagon was not initially coupled to the E-wagon but was already free at the beginning of the test. The external compressed air supply was connected at this wagon. After the coupling impact with the Z-wagon, both wagons were coupled with the E-wagon. After uncoupling, the tensile forces required to separate the wagons were measured.

The Wabtec DAC did not couple mechanically in the presence of a layer of ice. In two further cases, it did not couple at -25° C without ice and in one case it did not couple at -10° C without ice. It is notable that these cases were the first or the first two attempts after previous attempts with a layer of ice. In the tests with wet snow, the mechanical coupling procedure was successful in all cases.

The pneumatic coupling procedure was only performed successfully in all cases during tests at +45°C (with and without high humidity). Pneumatic coupling was unsuccessful at -10° C. In the tests with wet snow, it failed in four out of five attempts. At -25° C without ice, pneumatic coupling was not successful even in the cases where mechanical coupling was completed.

The behaviour of the electric coupler was similar to that of the pneumatic coupler. Here, too, only the tests performed at +45°C (with and without high humidity) were successful in all cases. In the remaining cases, unsuccessful electrical coupling procedures occurred even when mechanical coupling was successful. Please note that the electrical coupler of the Wabtec DAC was moved with air from the BP. Electric coupling was not possible without sufficient pressure in the BP. The underlying specification, however, requires that the electrical coupling is completed no later than six seconds after the mechanical and pneumatic coupling. This requirement applies regardless of the presence of compressed air.

4.3.2 Timetable and notable features

Table 4: Timetable and notable features – Wabtec DAC

Date	Tests	Comments
04.05.2021	General	• Wagons could not be separated manually despite uncoupled coupler → Significant tensile force required from locomotive • Normal test procedure could therefore not be carried out → H-wagon was supplied with compressed air, no initial uncoupling between E- and H-wagons, coupling with E-wagon after coupling impact between Z- and H-wagons • Measurement of the tensile forces required to separate the wagons after uncoupling
05.05.2021	-5° C ... 0° C, wet snow	• Force required to separate the wagons: E-side 9 to 10 kN, Z-side 15 to 20 kN
06.05.2021 07.05.2021	-10° C, 3 to 5 mm ice	• Incomplete coupling, display remained on "3", nevertheless force was required to separate the wagons
10.05.2021	-25° C, dry	• Problems with pneumatic coupling E- and H-wagon • Force required to separate the wagons: E-side 6 to 13 kN, Z-side 16 to 25 kN
11.05.2021	-25° C, 3 to 5 mm ice	• No mechanical coupling
12.05.2021	-10° C, dry	• No mechanical coupling on one occasion, on the H-wagon coupling indicator "3", on the Z-wagon "1" • Problems for pneumatic coupler E- and H-wagons • Force required to separate the wagons: E-side 10 to 19 kN, Z-side 14 to 20 kN
17.05.2021	+45° C, dry air	• Force required to separate the wagons: E-side 2 to 11 kN, Z-side 5 to 14 kN
18.05.2021	+45° C, 90 % humidity	• Force required to separate the wagons: E-side 5 to 9 kN, Z-side 8 to 13 kN

4.3.3 Photographic documentation of damage and/or notable features

The following images show examples of some of the damage and/or notable features that have occurred. At this point, however, photographic documentation is not provided for all cases.

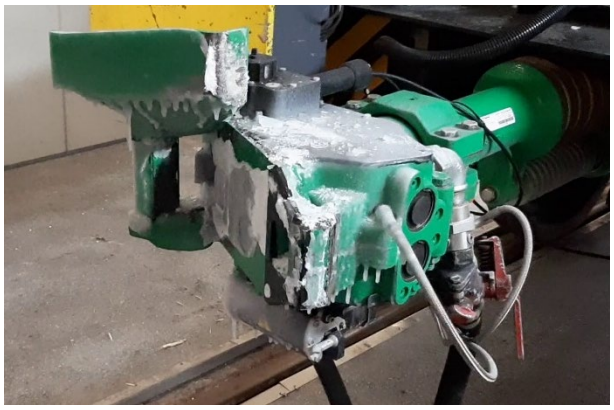

Fig. 16: Compressed layer of ice on the coupler head after failed mechanical coupling procedure (photo 06.05.2021)

Fig. 17: Incomplete coupling, left coupler head shows “3” in the coupler display, right coupler head shows “1” (not visible in photo, photo 10.05.2021)

5 Summary

Coupling tests were carried out with DACs from the manufacturers Dellner, Voith and Wabtec under various climatic conditions in the “MEikE” climate chamber operated by DB Systemtechnik GmbH in Minden.

The test results highlighted major differences between the different types of DAC. With the exception of one test, the Voith DAC was the only coupler that successfully coupled mechanically even in the presence of ice and snow. Mechanical coupling procedures for the other two DACs failed when the coupling was covered in ice, the Dellner DAC also failed in wet snow and the Wabtec DAC also in low temperatures.

All three DACs tested had problems with the electrical coupler. In the case of the DACs from Voith and Wabtec, there were also problems with the pneumatic coupler. With the Wabtec DAC there is a connection between pneumatic and electrical coupling (see section 4.3.1).

6 Signatures

Approved:

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TT.TVE 31(2)

Created:

Daniel Jobstfinke

Digital unterschrieben von Daniel Jobstfinke
Datum: 2022.01.06 08:38:57 +01'00'

Dr. Daniel Jobstfinke
TT.TVP 21

Evalutation climate chamber tests xxx DAC

Appendix xx
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Load state 1

Test No.	Infrastructure	Eanos	Hbbins	Zags
1.6.K.ZH	Climate chamber "Meike" Minden	fully laden	empty	empty

-10°C (dry)				-10°C (3-5mm ice)			
Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings	Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings

Test No.	Infrastructure	Eanos	Hbbins	Zags
1.6.K.ZH	Climate chamber "Meike" Minden	fully laden	empty	empty

-25°C (dry)				-25°C (3-5mm ice)			
Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings	Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings

Test No.	Infrastructure	Eanos	Hbbins	Zags
1.6.K.ZH	Climate chamber "Meike" Minden	fully laden	empty	empty

+45°C (dry)				+45°C (90% humidity)			
Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings	Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings

Test No.	Infrastructure	Eanos	Hbbins	Zags
1.6.K.ZH	Climate chamber "Meike" Minden	fully laden	empty	empty

0°C / -5°C (wet snow)			
Number of valid tests	Proportion of successful mechnical couplings	Proportion of successful pneumatical couplings	Proportion of successful electrical couplings

Explanations:

	The coupling to be evaluated for **coupling tests** is between the blue-marked wagons

Breakdown of test no.:
w.x.y.z

w: **Load state Hbbins** (1=empty, 2=partially laden, 3=fully laden)
x: **Infrastructure tpye** (6=climate chamber)
y: **Test type** (K=coupling test)
z: **Waggon combination** (ZH= Zags/Hbbins, EH= Eanos/Hbbins)

Auswertung Klimakammerversuche Dellner DAK

Anlage 1.1
Seite 1 von 1

Ladezustand 1

Auswertung Datum: 29.09.21, Zeit: 08:05

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

-10°C (trocken)				-10°C (3-5mm Eis)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	100%	100%	100%	5	0%	0%	0%
1010-1012-1013-1014-1015				1017-1018-1019-1020-1021	1017-1018-1019-1020-1021	1017-1018-1019-1020-1021	1017-1018-1019-1020-1021

Auswertung Datum: 29.09.21, Zeit: 08:06

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

-25°C (trocken)				-25°C (3-5mm Eis)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	100%	100%	0%	5	0%	0%	0%
1022-1023-1024-1025-1026			1022-1023-1024-1025-1026	1027-1028-1029-1030-1031	1027-1028-1029-1030-1031	1027-1028-1029-1030-1031	1027-1028-1029-1030-1031

Auswertung Datum: 29.09.21, Zeit: 08:06

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

+45°C (trocken)				+45°C (90% Luftfeuchtigkeit)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	100%	100%	100%	5	100%	100%	100%
1032-1033-1034-1035-1036				1037-1038-1039-1040-1041			

Auswertung Datum: 29.09.21, Zeit: 08:06

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

0°C / -5°C (feucht/ Schneematsch))			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	0%	0%	0%
1001-1003-1007-1008-1009	1001-1003-1007-1008-1009	1001-1003-1007-1008-1009	1001-1003-1007-1008-1009

Erläuterungen:

Die auszuwertende Kuppelstelle bei **Kuppelversuchen** liegt zwischen den blau markierten Wagen

Aufschlüsselung Test-Nr.:

w.x.y.z

w: **Beladungszustand Hbbins** (1=leer, 2=teilbeladen, 3=vollbeladen)
x: **Infrastrukturtyp** (6=Klimakammer)
y: **Versuchsart** (K=Kupplungsversuch)
z: **Wagenkombination** (ZH= Zags/Hbbins, EH= Eanoas/Hbbins)

Auswertung Klimakammerversuche Voith DAK

Anlage 1.2
Seite 1 von 1

Ladezustand 1

Auswertung Datum: 29.09.21, Zeit: 07:58

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags	-10°C (trocken)				-10°C (3-5mm Eis)			
					Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer	5	100%	20%	100%	5	100%	20%	40%
					1005-1009-1010-1011-1012		1009-1010-1011-1012		1013-1014-1015-1016-1017		1014-1015-1016-1017	1013-1014-1016

Auswertung Datum: 29.09.21, Zeit: 08:01

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags	-25°C (trocken)				-25°C (3-5mm Eis)			
					Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer	5	100%	0%	80%	5	80%	0%	0%
					1018-1019-1022-1023-1024		1018-1019-1022-1023-1024	1019	1025-1026-1027-1028-1029	1025	1025-1026-1027-1028-1029	1025-1026-1027-1028-1029

Auswertung Datum: 29.09.21, Zeit: 08:02

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags	+45°C (trocken)				+45°C (90% Luftfeuchtigkeit)			
					Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer	5	100%	0%	80%	5	100%	0%	100%
					1040-1041-1042-1044-1046		1040-1041-1042-1044-1046	1040	1047-1048-1049-1051-1052		1047-1048-1049-1051-1052	

Auswertung Datum: 29.09.21, Zeit: 08:02

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags	0°C / -5°C (feucht/ Schneematsch))				+40°C (trocken)			
					Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer	6	100%	100%	83%	4	100%	0%	100%
					1030-1031-1032-1033-1034-1035			1030	1036-1037-1038-1039		1036-1037-1038-1039	

Erläuterungen:

Die auszuwertende Kuppelstelle bei **Kuppelversuchen** liegt zwischen den blau markierten Wagen

Aufschlüsselung Test-Nr.:

w.x.y.z

w: **Beladungszustand Hbbins** (1=leer, 2=teilbeladen, 3=vollbeladen)
x: **Infrastrukturtyp** (6=Klimakammer)
y: **Versuchsart** (K=Kupplungsversuch)
z: **Wagenkombination** (ZH= Zags/Hbbins, EH= Eanoas/Hbbins)

Auswertung Klimakammerversuche Wabtec DAK

Anlage 1.3
Seite 1 von 1

Ladezustand 1

Auswertung Datum: 29.09.21, Zeit: 08:10

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

-10°C (trocken)				-10°C (3-5mm Eis)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
6	83%	83%	17%	5	0%	0%	0%
1034-1035-1037-1038-1040-1042	1034	1034	1034-1035-1037-1038-1040	1013-1015-1016-1017-1018	1013-1015-1016-1017-1018	1013-1015-1016-1017-1018	1013-1015-1016-1017-1018

Auswertung Datum: 29.09.21, Zeit: 08:10

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

-25°C (trocken)				-25°C (3-5mm Eis)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
6	67%	0%	0%	5	0%	0%	0%
1019-1020-1021-1022-1024-1026	1019-1020	1019-1020-1021-1022-1024-1026	1019-1020-1021-1022-1024-1026	1028-1029-1031-1032-1033	1028-1029-1031-1032-1033	1028-1029-1031-1032-1033	1028-1029-1031-1032-1033

Auswertung Datum: 29.09.21, Zeit: 08:11

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

+45°C (trocken)				+45°C (90% Luftfeuchtigkeit)			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt	Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	100%	100%	100%	5	100%	100%	100%
1044-1046-1048-1050-1052				1054-1056-1058-1060-1061			

Auswertung Datum: 29.09.21, Zeit: 08:11

Test-Nr.	Infrastruktur	Eanos	Hbbins	Zags
1.6.K.ZH	Klimakammer "Meike" Minden	vollbeladen	leer	leer

0°C / -5°C (feucht/ Schneematsch))			
Anzahl gültiger Versuche	Anteil mechanisch gekuppelt	Anteil pneumatisch gekuppelt	Anteil elektrisch gekuppelt
5	100%	20%	20%
1003-1004-1006-1009-1011		1003-1004-1006-1009	1003-1004-1006-1009

Erläuterungen:

Die auszuwertende Kuppelstelle bei **Kuppelversuchen** liegt zwischen den blau markierten Wagen

Aufschlüsselung Test-Nr.:

w.x.y.z

w: **Beladungszustand Hbbins** (1=leer, 2=teilbeladen, 3=vollbeladen)
x: **Infrastrukturtyp** (6=Klimakammer)
y: **Versuchsart** (K=Kupplungsversuch)
z: **Wagenkombination** (ZH= Zags/Hbbins, EH= Eanoas/Hbbins)