Verkehrssicherheitsarbeit für Österreich

DERAILMENT OF TRAIN 46676

on 16 June 2010

on the Arlberg line between Hintergasse and Braz stations

BMVIT-795.204-II/BAV/UUB/SCH/2010

Address for visits: A-1210 Vienna, Trauzlgasse 1
Postal address: A-1000 Wien, Postfach 207
Website: http://versa.bmvit.gv.at

BUNDESANSTALT FÜR VERKEHR
Federal Accident Investigation Bureau
Rail Section

Accident Investigation Report

Contents

Page

I. List of figures ... 3
II. List of regulations ... 4
III. List of abbreviations ... 5
IV Preliminary remarks ... 5
1. Summary ... 6
2. General information ... 7
2.1. Date and time ... 7
2.2. Weather, visibility ... 7
2.3. Location ... 7
2.4. Competent authority ... 7
2.5. Local circumstances ... 8
2.6. Details of the journey in question ... 10
2.7. Permitted speeds ... 10
2.7.1. Excerpt from the VzG [List of locally permitted speeds] for route section 10105 ... 10
2.7.2. Excerpt from book timetable leaflet 351 ... 12
2.7.3. Speed restrictions imposed by the La [(temporary) speed restrictions and (layout) changes notice] ... 14
2.7.4. Speed restrictions imposed by written orders ... 14
2.7.5. Signalled speed ... 14
3. Description of the event ... 15
4. Casualties, damage to property and disruption to operations ... 20
4.1. Casualties ... 20
4.2. Damage to railway infrastructure ... 20
4.3. Damage to third-party property ... 20
4.4. Disruption to operations ... 20
4.5. Damage to rolling stock ... 21
4.6. Environment damage ... 21
4.7. Damage to the consignment ... 21
5. Those involved, contractors and witnesses ... 22
6. Investigative process ... 22
7. Statements/Evidence/Results of the evaluation ... 23
7.1. Statement by the driver of train 46676 ... 23
7.2. Analysis of the data from the recording equipment on the locomotive ... 24
7.3. Federal Accident Investigation Bureau's analysis of the locomotive's journey data ... 26
7.4. Analysis of the temperature at train running checkpoints ... 29
7.5. Investigation of the technical aspects of the wagons in train 46676 ... 29
7.6. General description of locomotive 1116 173-4 ... 29
7.6.1. Braking equipment: ... 30
7.6.1.1. Direct brakes: ... 30
7.6.1.2. Indirect brakes: ... 30
7.6.1.3. E-brake: ... 30
7.6.2. Failure of a traction motor ... 31
7.6.3. Emergency brake button ... 32
7.6.4. Examination of locomotive 1116 173-4 ... 33
7.6.5. Overhaul and maintenance of the locomotive ... 35
7.7. The wagons involved ... 36
7.7.1. General vehicle data for wagon 23 87 437 2 372-4 ... 36
7.7.2. Brake equipment ... 37
7.7.3. Overhaul and maintenance of wagon 372-4 ... 38
7.7.4. Examination of derailed wagon 372-4 ... 39
7.7.5. Securing cable and cable grip from wagon 372-4 ... 41
7.7.6. Screw coupling in the middle of the vehicle ... 42
7.8. Behaviour of the driver ... 43
7.9. Inspection of wagons of identical construction to type 23 87 437 2 ... 43
7.10. Stacking of objects on the track ... 45
7.10.1. ZSB 9 ... 45
7.10.2. ZOV 48 [Handling and storage of permanent way materials] ... 46
7.10.3. ZOV 7 [Lineside structure gauge] ... 46
7.10.4. Stacked rails ... 46
7.11. Vertical movement of stacked rails ... 46
7.11.1. Results of the measurements ... 47
7.12. Application of the brakes ... 47
7.13. Analysis of braking distance calculation using the "Minden Formula" ... 48
7.14. Securing cable ... 49
7.14.1. Results of the tests on the cable ... 49
7.14.1.1. Interpretation of the visual findings concerning the damaged cable ... 50
7.14.1.2. Cause of the damage ... 51
7.14.1.3. Measures to avoid failure of the supporting sling ... 52
8. Summary of findings and conclusions ... 54
9. Other irregularities which did not contribute to the accident ... 56
9.1. Different information in the VzG [List of locally permitted speeds] and the Bsb [operating location description] 56
9.2. Markings on the Laaeks wagon involved ... 56
10. Cause ... 57

11. Comments considered ... 58
11.1. Comments by the wagon keeper ... 58
11.2. Comments by the BMVIT [Austrian Ministry of Transport] ... 67
11.2.1. Comment by Section IV/SCH2 ... 67
11.2.2. Comment by Section IV/SCH4 ... 67
11.3. Comments by the traction provider ... 67
11.4. Comments by the railway undertaking ... 67
12. Safety recommendations ... 68
Attachment A:ZOV 7 Table 7/2 Loading gauge ... 71
Attachment B:ZSB 9 Keeping the track clear ... 72
Attachment C:Excerpt from ZOV 48 Handling and storage of permanent way materials ... 73
Attachment D:Analysis of the recording equipment ... 75
Attachment E:UIC 541-1 Appendix B.2 Arrangement of air-brake connections ... 80
Attachment F:PWagon examination record in accordance with the GCU ... 81
Attachment G:Comments received within the timelimits ... 82
Attachment H:Report on the tests on the cable ... 134
Attachment I: Results of the measurements on the stacked rails ... 161

I. List of figures

Figure 1 Location of derailment 2 in Braz station ... 6
Figure 2 Diagram of railway lines in Austria ... 7
Figure 3 Table of operating locations and characteristics ... 9
Figure 4 Excerpt from the list of locally permitted speeds (source: infrastructure manager) ... 10
Figure 5 Continuation of the excerpt from the list of locally permitted speeds - line 10105 (source: infrastructure manager) ... 11
Figure 6 Excerpt from book timetable leaflet 351 (source: infrastructure manager) ... 12
Figure 7 Excerpt from book timetable leaflet 351 – outline timetable 4191 (source: infrastructure manager) ... 12
Figure 8 Continuation of the excerpt from book timetable leaflet 351 – outline timetable 4191 (source: infrastructure manager) ... 13
Figure 9 Sketch layout of Braz station (source: infrastructure manager) ... 14
Figure 10 Signs of shear in Blisadona Tunnel ... 15
Figure 11 Detail of the signs of shear ... 15
Figure 12 No 251 points Wald am Arlberg station ... 16
Figure 13 Detail of No 251 points ... 16
Figure 14 Stacked used rails ... 17
Figure 15 Point of impact ... 17
Figure 16 Kinked air hose with brake coupling (source: Bregenz CID) ... 17
Figure 17 Detail of the kinked air hose (source: Bregenz CID) ... 18
Figure 18 Analysis of casualties ... 20
Figure 19 Table of damage to rolling stock ... 21
Figure 20 Analysis of the data from the recording equipment on the locomotive (1) (source: traction provider) ... 24
Figure 21 Analysis of the data from the recording equipment on the locomotive (2) (source: traction provider) ... 25
Figure 22 Table showing the classification of values from the recording equipment ... 26
Figure 23 Route related analysis of data from the locomotive's recording device ... 27
Figure 24 Time related analysis of data from the locomotive's recording device ... 28
Figure 25 Report from the train running check point in Dalaas ... 29
Figure 26 Effectiveness of the E-brakes (source: traction provider) ... 31
Figure 27 Emergency brake button (source: traction provider) ... 32
Figure 28 Brake discs on the rearmost brake shaft ... 33
Figure 29 Traction controller ... 33
Figure 30 Brake handle ... 34
Figure 31 Bogie No 2 ... 35
Figure 32 Bogie No 1 ... 35
Figure 33 Outline design Laaeks (source: wagon keeper) ... 36
Figure 34 Brake coupling in the middle of the vehicle ... 37
Figure 35 Design of the brake coupling in the middle of the vehicle (source: wagon keeper) ... 38
Figure 36 Brake blocks of the front section of the wagon ... 39
Figure 37 Brake blocks from the following section of the wagon (source: Bregenz Criminal Investigation Department) ... 39
Figure 38 Brake coupling of the following section of the wagon ... 40
Figure 39 Metal plate with a new U-bolt ... 40
Figure 40 Cable grip ... 41
Figure 41 Securing cable ... 41

Figure 42 Screw coupling in the middle of the vehicle 42
Figure 43 Anti-rotation device 42
Figure 44 Securing pins extracted 42
Figure 45 Cable grip with CE marking 44
Figure 46 Securing cable with plastic sleeving 44
Figure 47 Wagon with a continuous brake pipe between the sections of the wagon 45
Figure 48 Excerpt from ZSB 9 (source: infrastructure manager) 45
Figure 49 Excerpt from Appendix 3 of DB 610 (source: infrastructure manager) 47
Figure 50 Calculation of the braking distance using the Minden Formula 48
Figure 51 Joint between the main brake pipe and brake hose 54
Figure 52 Kinked brake hose wagon 372-4 55
Figure 53 Table showing different information in the VzG and Bsb 56
Figure 54 Excerpt from Table 7/2 ZOV 7 60
Figure 55 Anti-rotation device 65
Figure 56 Hole in the anti-rotation device – detail 66

II. List of regulations

DB 822/1016/116	Operating instructions for class 1116 locomotives
DV V2	Infrastructure manager's signal regulations
DV V3	Infrastructure manager's operating instructions
DV M22	Service on traction units
DV M26	Braking regulations
DB 610	Infrastructure manager's staff instruction for compiling train data
DB 639	Infrastructure manager's staff instruction for timetable documents
EisbBBV	Railway Construction and Operation Regulations [Eisenbahnbau und – betriebsverordnung] Austrian Federal Law Gazette 2008, Part II, 398. Regulation
EisbG	Railways Act 1957 [Eisenbahngesetz 1957], Austrian Federal Law Gazette 2006, Part I, 125. Federal law
GCU	General Contract of Use for Wagons
HL-VO	Regulation: Declaration that a line is a high capacity line regulation (High Capacity Line Regulation [Hochleistungsstreckenverordnung]). Austrian Federal Law Gazette 1989, 370. Regulation
MeldeVO Eisb	Rail Accident Reporting Regulation 2006 Austrian Federal Law Gazette 2005, Part II, 279. Regulation
UIC leaflet	International Union of Railways leaflet
UIC leaflet 505-1	Railway transport stock - Rolling stock construction gauge
UIC leaflet 530-2	Wagons - Running safety
UIC leaflet 541-1	Brakes - Regulations concerning the design of brake components
UIC leaflet 541-2	Dimensions of hose connections (brake hoses)
UUG 2005	Accident Investigation Act, [Unfalluntersuchungsgesetz] Austrian Federal Law Gazette 2005, Part I, 123. Federal law
Directive 2004/49/EC	"Railway Safety Directive"
Directive 2006/861/EC	Technical specification of interoperability relating to the subsystem 'rolling stock — freight wagons' of the trans-European conventional rail system "TSI wagons"
ZOV 7	Lineside structure gauge and distance between the track centre lines
ZOV 48	Handling and storage of permanent way materials (Supplementary provisions to DV B51 Track regulations)
ZSB	Supplementary Provisions to the Signalling and Operating Regulations [Zusatzbestimmungen zur Signal- und Betriebsvorschrift]

III. List of abbreviations

ARTIS	Austrian Rail Transport Information System
AS	Starting signal [Ausfahrsignal]
AVS	Advanced starting signal [Ausfahrvorsignal]
BAV	Federal Office of Transport [Bundesanstalt für Verkehr]
BMVIT	Federal Ministry of Transport, Innovation and Technology [Bundesministerium für Verkehr, Innovation und Technologie]
Bh	Brake percentage [Bremshundertstel]
Bhmax	Brake percentage required
Bsb	Operating location description [Betriebsstellenbeschreibung]
CID	Criminal Investigation Department (Police organisation for investigating crime)
DB	Staff instruction [Dienstbehelf]
DV	ÖBB staff regulations [Dienstvorschrift]
E-brake	Electrodynamic brake
ERA	European Railway Agency
ES	Signal controlling entrance to a station [Einfahrsignal]
EVS	Advance signal controlling entrance to a station [Einfahrvorsignal]
EVU	Railway undertaking [Eisenbahnverkehrsunternehmen]
Fdl	Signaller [Fahrdienstleiter]
Hbf	Central station
HGV	High speed traffic [Hochgeschwindigkeitsverkehr]
HL-Strecke	High capacity line [Hochleistungsstrecke]
HS	Stop signal [Hauptsignal]
IM	Infrastructure manager
L	Loaded
La	Summary of (temporary) speed restrictions and (layout) changes
LKA-B	State criminal investigation department in Bregenz [Landeskriminalamt Bregenz]
NSA	National (Railway) Safety Authority
ÖBB	Austrian Federal Railways [Österreichische Bundesbahnen]
PZB	Intermittent automatic train control [Punktförmige Zugbeeinflussung]
RID	Regulation concerning the International Carriage of Dangerous Goods by Rail
RIV	Agreement governing the exchange and use of wagons between railway undertakings
SOK	Upper surface of the rail [Schienenoberkante]
TUE	Infrastructure manager's technical supervision
UIC	International Union of Railways [Union international des chemins de fer]
UUB	Federal Accident Investigation Bureau Rail Section [Unfalluntersuchungsstelle des Bundes]
VzG	List of locally permitted speeds [Verzeichnis örtlich zugelassener Geschwindigkeiten]
ZOV	Supplementary provisions to the track regulations Zusatzbestimmungen zu den Oberbauvorschriften
ZSB	infrastructure manager's Supplementary Provisions to the Signalling and Operating Regulations [Zusatzbestimmungen zur Signal- und zur Betriebsvorschrift des IM]

Artikel I. IV Preliminary remarks

In accordance with Section 5 of the Accident Investigation Act 2005 [Unfalluntersuchungsgesetz – UUG], the sole purpose of investigations is solely to establish the cause of the event so as to be able to make safety recommendations to prevent such events in the future. It is not the purpose of the investigation to establish fault or liability issues.

1. Summary

At 03:07 on 16 June 2010 train 46676, consisting of locomotive 1116 173-4 and 16 loaded car transporter wagons, derailed during its journey between Hintergasse and Braz stations on the Arlberg line (total train weight 863 t, total train length 548 m, 16 wagons, loaded with 208 trade cars).

The cause was the cable supporting the brake coupling between the two sections of the first wagon becoming detached. Hence the brake coupling swung down and caught against used rails stacked in the middle of the track. The impact pulled the coupling off the brake hose of the front section of the wagon. In consequence, the coupling together with the brake hose of the rear section of the wagon was thrown against the underframe of the following section of the wagon and become wedged in the underframe such that brake hose was kinked and prevented the air escaping from [the main brake pipe through] the following part of the train (15 ½ wagons). The gradient of up to 35 ‰ caused the unbraked 15 ½ wagons in the train to accelerate continuously. Some parts of the train derailed on the curves before Braz station at a speed of some 125 km/h. The locomotive and 13 wagons came off the formation and some finished up lying very close to private houses in Braz. The cargo (trade cars) was strewn over the area.

There were no fatalities. The driver was severely injured.

There was significant damage to property, rolling stock, cargo (trade cars), infrastructure and to crops. There was leakage from the rolling stock that had overturned (transformer oil from the locomotive and fuel from the cars forming the load).

Figure 1 Location of derailment 2 in Braz station

2. General information

2.1. Date and time

Wednesday, 16 June 2010, at 03:07

2.2. Weather, visibility

Overcast + 14˚ C, darkness, no further restrictions on visibility,
Condition of the rails, dry

2.3. Location

- Line from Innsbruck Hbf to the frontier near Lochau-Hörbranz (Lindau)
- Between Hintergasse and Braz stations
- km 128.498 to km 129.005

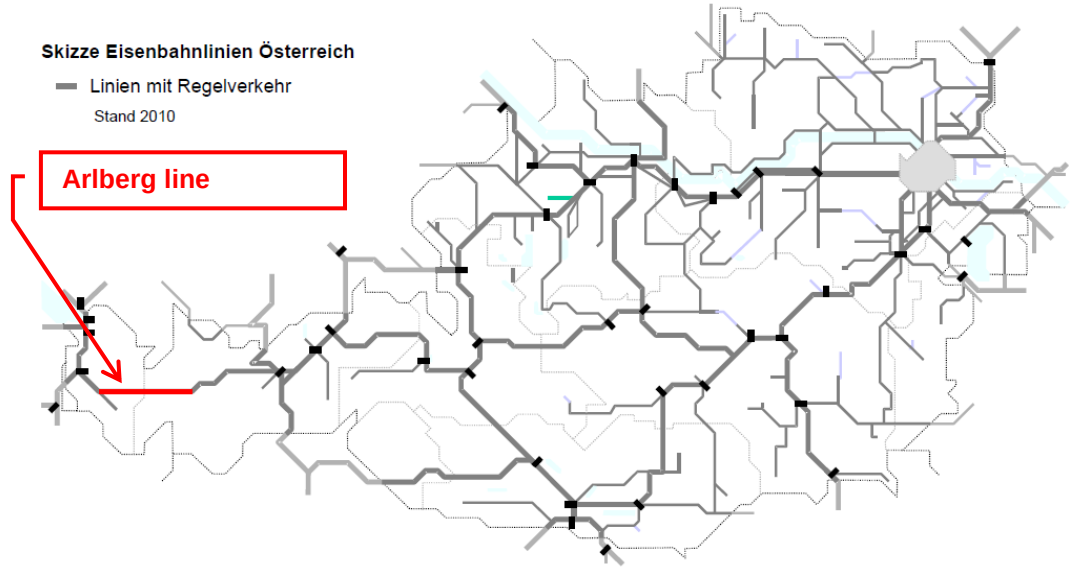


Figure 2 Diagram of railway lines in Austria

Linien mit Regelverkehr Stand 2010	Lines with regular traffic As at 2010

2.4. Competent authority

In accordance with the High Capacity Line Regulation [Hochleistungsstrecken-verordnung], the Landeck – Bludenz section of line is a high capacity line and is therefore a main line in accordance with the Railways Act Section 4(1).

In accordance with the Railways Act Section 12(3)(1), the Federal Minister of Transport, Innovation and Technology (BMVIT) is competent as the authority for all aspects of main lines.

2.5. Local circumstances

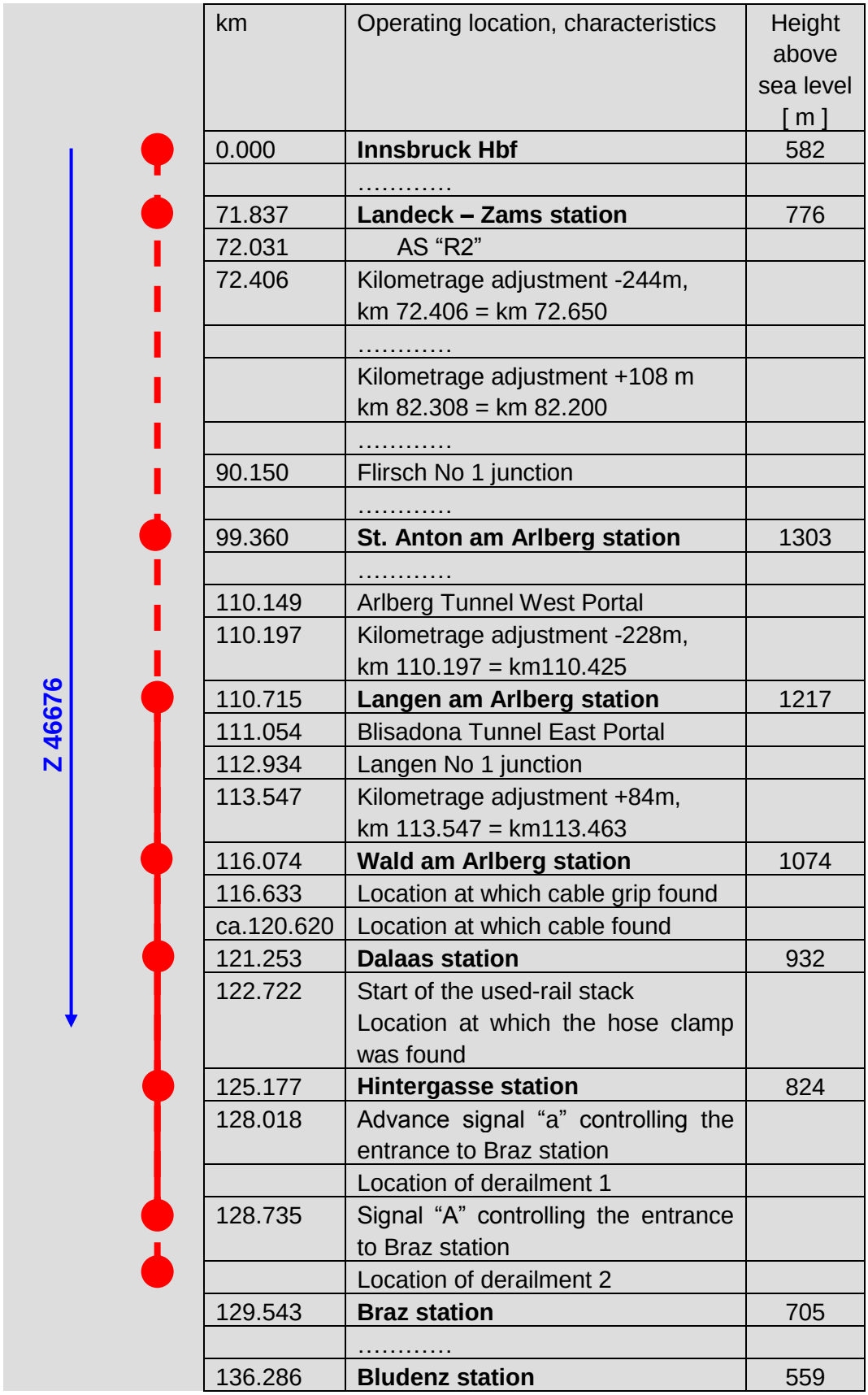
According to the BMVIT website, this section of line is a conventional interoperable section of line (http://www.bmvit.gv.at/verkehr/eisenbahn/interoperabilitaet/arbeitsgruppe/20040623/beilage2.pdf)

The section of line is partly double track but electrified throughout. The sections from Landeck-Zams to Flirsch No 1 junction and Langen No 1 junction to Bludenz are still single track.

Operating practices conform to the provisions and standards set by the infrastructure manager.

(Operations at) Wald am Arlberg and Hintergasse stations are controlled remotely from Dalaas station.

From Langen am Arlberg to Bludenz station, this section has steep gradients of up to 35 ‰. Exceptions are short sections through the stations at Wald am Arlberg, Dalaas, Hintergasse and Braz which have gradients of 0 to 3 ‰.



km	Operating location, characteristics	Height above sea level [m]
0.000	**Innsbruck Hbf**	582
	.....	
71.837	**Landeck – Zams station**	776
72.031	AS "R2"	
72.406	Kilometrage adjustment -244m, km 72.406 = km 72.650	
	.....	
	Kilometrage adjustment +108 m km 82.308 = km 82.200	
	.....	
90.150	Flirsch No 1 junction	
	.....	
99.360	**St. Anton am Arlberg station**	1303
	.....	
110.149	Arlberg Tunnel West Portal	
110.197	Kilometrage adjustment -228m, km 110.197 = km110.425	
110.715	**Langen am Arlberg station**	1217
111.054	Blisadona Tunnel East Portal	
112.934	Langen No 1 junction	
113.547	Kilometrage adjustment +84m, km 113.547 = km113.463	
116.074	**Wald am Arlberg station**	1074
116.633	Location at which cable grip found	
ca.120.620	Location at which cable found	
121.253	**Dalaas station**	932
122.722	Start of the used-rail stack Location at which the hose clamp was found	
125.177	**Hintergasse station**	824
128.018	Advance signal "a" controlling the entrance to Braz station	
	Location of derailment 1	
128.735	Signal "A" controlling the entrance to Braz station	
	Location of derailment 2	
129.543	**Braz station**	705
	.....	
136.286	**Bludenz station**	559

Figure 3 Table of operating locations and characteristics

A kilometrage adjustment is the shortening or lengthening of a section of line caused by realignments. Between Landeck and Dalaas stations the line has been shortened by 280 metres in total.

2.6. Details of the journey in question

Block freight train No 46676

Route: from Curtici (Romania) to Valenton (France),
On the Austrian network from Hegyeshalom (Hungary) via Vienna Central Marshalling Yard, Salzburg Gnigl, Saalfelden, Wörgl, Innsbruck Hbf, Landeck, Feldkirch to Buchs SG (Switzerland)

Composition (from Hegyeshalom):

- 863 t total weight (mass in accordance with the Weights and Measures Act)
- 548 m total train length
- 16 wagons (composed of two 2-axle wagon sections)
- locomotive 1116 173-4
- book timetable leaflet 351/Infrastructure manager's outline timetable M4191
  Timetabled speed regime 100 km/h
  Brake percentage required 69 %
- Brake percentage achieved 80 % (according to the train data)
- Adequate and continuous braking

Prohibition of banking between Saalfelden and Hochfilzen stations and between Landeck and St. Anton am Arlberg stations. Because of the load, an assisting locomotive was provided over these sections.

2.7. Permitted speeds

2.7.1. Excerpt from the VzG [List of locally permitted speeds] for route section 10105

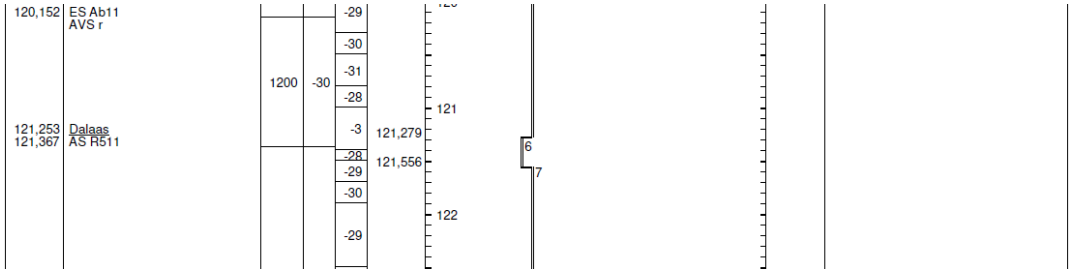


Figure 4 Excerpt from the list of locally permitted speeds (source: infrastructure manager)

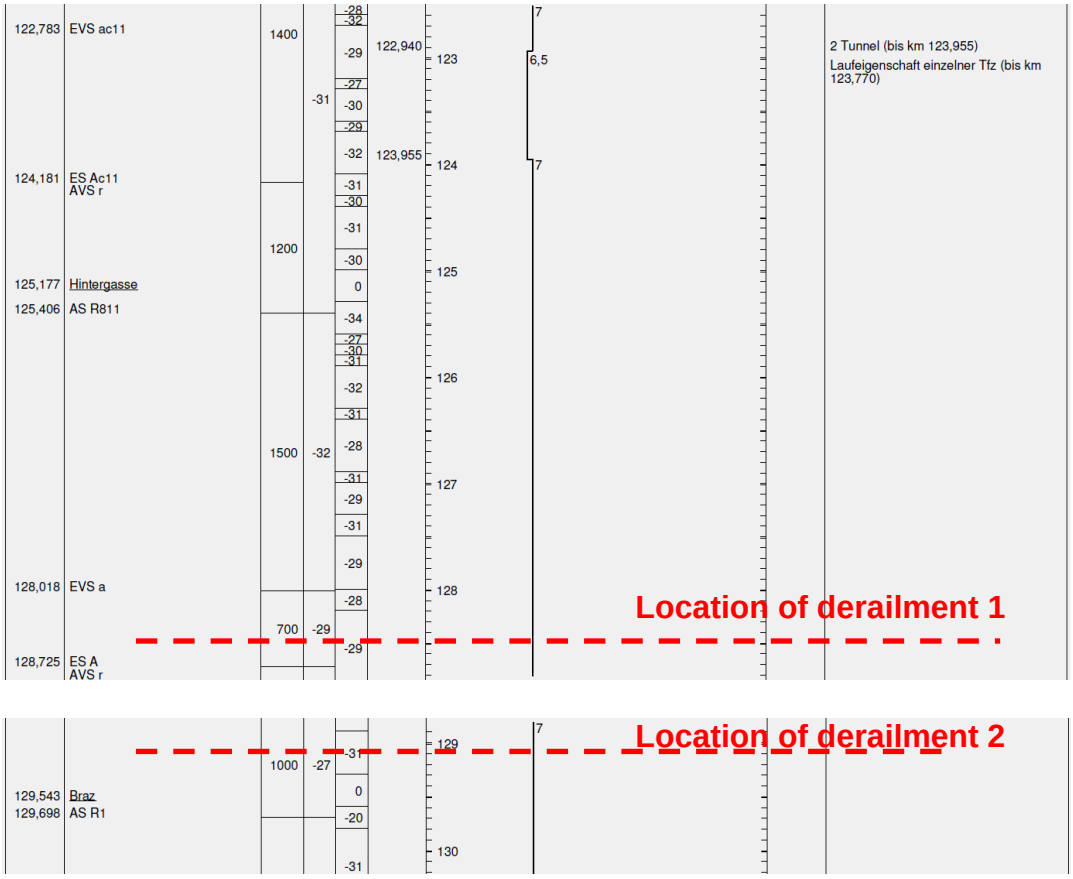
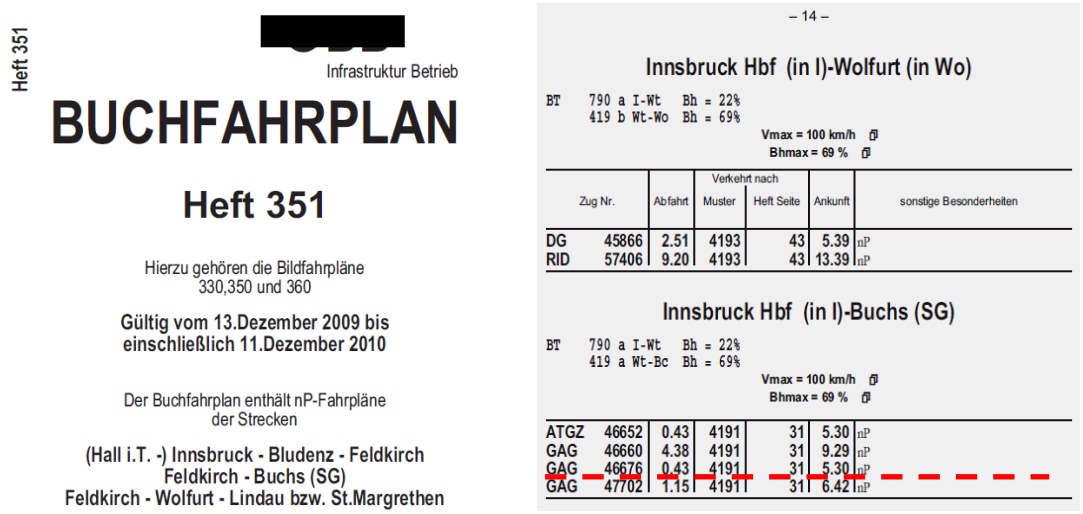


Figure 5 Continuation of the excerpt from the list of locally permitted speeds - line 10105 (source: infrastructure manager)

According to the infrastructure manager's list of locally permitted speeds, the speed permitted on the section of line on which the derailments occurred is 70 km/h.

2.7.2. Excerpt from book timetable leaflet 351



Heft 351

[redacted]
Infrastruktur Betrieb

BUCHFAHRPLAN

Heft 351

Hierzu gehören die Bildfahrpläne
330,350 und 360

Gültig vom 13.Dezember 2009 bis
einschließlich 11.Dezember 2010

Der Buchfahrplan enthält nP-Fahrpläne
der Strecken

(Hall i.T. -) Innsbruck - Bludenz - Feldkirch
Feldkirch - Buchs (SG)
Feldkirch - Wolfurt - Lindau bzw. St.Margrethen

– 14 –

Innsbruck Hbf (in I)-Wolfurt (in Wo)

BT 790 a I-Wt Bh = 22%
419 b Wt-Wo Bh = 69%
Vmax = 100 km/h
Bhmax = 69 %

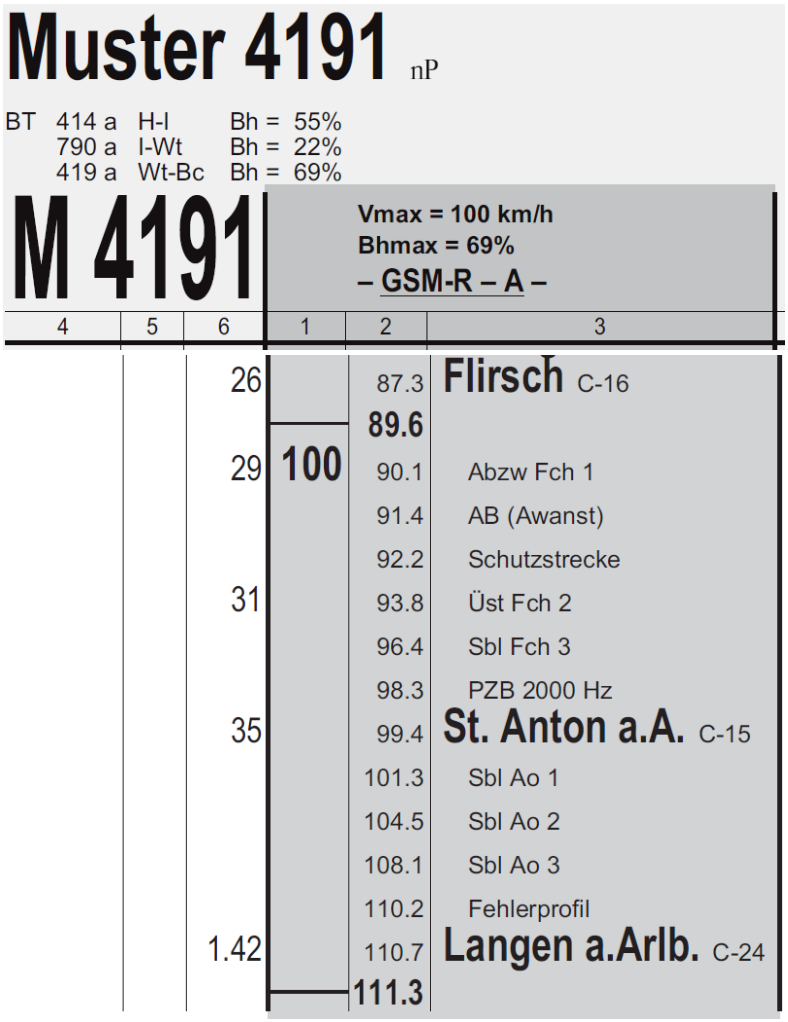
Zug Nr.	Abfahrt	Verkehrt nach Muster	Heft Seite	Ankunft	sonstige Besonderheiten
DG 45866	2.51	4193	43	5.39	nP
RID 57406	9.20	4193	43	13.39	nP

Innsbruck Hbf (in I)-Buchs (SG)

BT 790 a I-Wt Bh = 22%
419 a Wt-Bc Bh = 69%
Vmax = 100 km/h
Bhmax = 69 %

ATGZ	46652	0.43	4191	31	5.30	nP
GAG	46660	4.38	4191	31	9.29	nP
GAG	46676	0.43	4191	31	5.30	nP
GAG	47702	1.15	4191	31	6.42	nP

Figure 6 Excerpt from book timetable leaflet 351 (source: infrastructure manager)



Muster 4191 nP

BT 414 a H-I Bh = 55%
790 a I-Wt Bh = 22%
419 a Wt-Bc Bh = 69%

M 4191

Vmax = 100 km/h
Bhmax = 69%
– GSM-R – A –

4	5	6	1	2	3
		26		87.3	Flirsch C-16
				89.6	
		29	100	90.1	Abzw Fch 1
				91.4	AB (Awanst)
				92.2	Schutzstrecke
		31		93.8	Üst Fch 2
				96.4	Sbl Fch 3
				98.3	PZB 2000 Hz
		35		99.4	St. Anton a.A. C-15
				101.3	Sbl Ao 1
				104.5	Sbl Ao 2
				108.1	Sbl Ao 3
				110.2	Fehlerprofil
		1.42		110.7	Langen a.Arlb. C-24
				111.3	

Figure 7 Excerpt from book timetable leaflet 351 – outline timetable 4191 (source: infrastructure manager)

Flirsch	Flirsch	St. Anton a A.	St. Anton am Arlberg.
Abzw Fch	Flirsch No 1 Junction single to double track	Sbl Ao	Ao automatic signal [Selbstblock]

	[Abzweigstelle]		
AB (Awanst)	AB refuge siding [Ausweichanschlussstelle]	Fehlerprofil	Kilometrage adjustment
Schutzstrecke	Section insulator	Langen a. Arlb.	Langen am Arlberg
Üst Fch2	Flirsch No 2 cross-over [Überleitstelle]	Sbl Fch3	FlirschNo 3 automatic signal

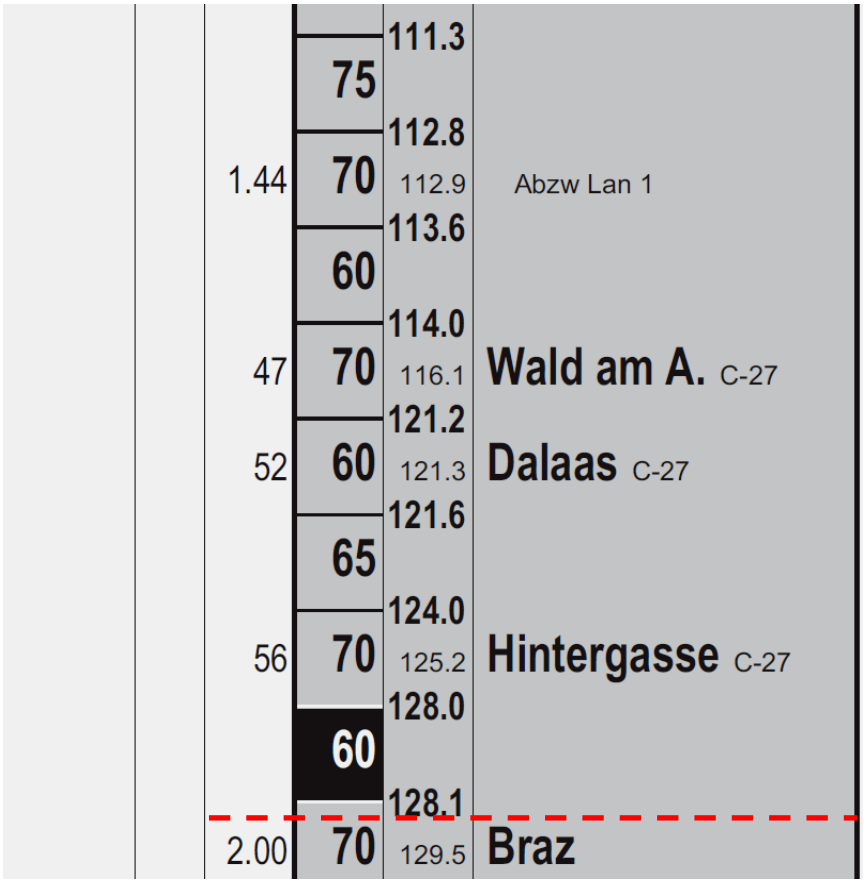


Figure 8 Continuation of the excerpt from book timetable leaflet 351 – outline timetable 4191 (source: infrastructure manager)

Abzw Lan 1	Langen am Arlberg No 1 Jn
Wald am A. c-27	Wald am Arlberg c-27
Dalaas c-27	Dalaas c-27
Hintergasse c-27	Hintergasse c-27
Braz	Braz

[translator's note: the "C" references may be cross references to pages showing track layouts, see Figure 9]

In accordance with the infrastructure manager's regulations *local speed restrictions for braking percentage reasons or included exceptionally as a stipulation for gradient reasons are shown in white print on a black background. The black background extends over the area to which the speed restriction applies*

According to the excerpt from the infrastructure manager's book timetable leaflet 351, outline timetable 4191, the speed permitted at the location of the derailment was 60 km/h.

2.7.3. Speed restrictions imposed by the La [(temporary) speed restrictions and (layout) changes notice]

None on the line between Dalaas and Braz stations.

2.7.4. Speed restrictions imposed by written orders

None on the line between Dalaas and Braz stations.

2.7.5. Signalled speed

All the signals controlling entry to stations between Langen am Arlberg and Hintergasse and exit from them gave a “line clear” indication. Advance signal “a” controlling entrance to Braz station showed “stop signal, clear to run at 60 km/h”; signal “A” controlling entrance to Braz station showed “clear to run at 60 km/h”.

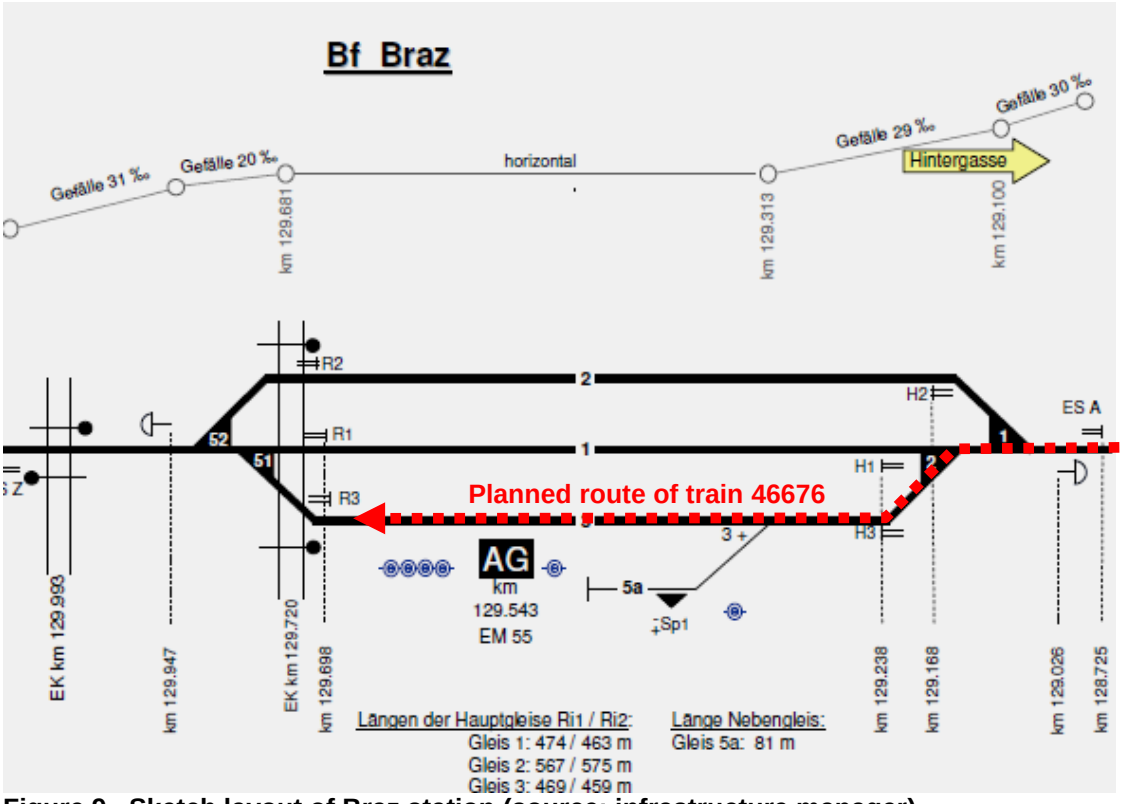


Figure 9 Sketch layout of Braz station (source: infrastructure manager)

Hintergasse	Hintergasse
Längen der hauptgleise R/1	Length of the principal track R/1
Länge Nebengleis	Length of subsidiary track
Gleis	Track

3. Description of the event

Train 46676 made an operating stop from 2:33 to 2:41 on 16 June 2010 in St. Anton am Arlberg station to uncouple assisting locomotive 1116 548-7. Before the train continued, the air brake of train 46676 was tested on the first wagon of the train using locomotive 1116 173-4 (partial brake test).

After leaving St. Anton am Arlberg station, train 46676 accelerated to some 100 km/h. Train speed was held by using the electronic brake as well as being braked to some 80 km/h by using the air brake after leaving the tunnel (Langen am Arlberg station). The section of line from St. Anton am Arlberg station to the exit from the Arlberg Tunnel just before Langen am Arlberg station has a maximum gradient of 16 ‰. It was possible to hold train speed just by using the electronic brake on this section of the line.

The steeply graded section to Bludenz begins at Langen am Arlberg station. Down to Dalaas station the line has a gradient of up to 32 ‰. On this section of line the electronic brake alone was no longer adequate and the driver also made use of the air brake.

When running through Langen am Arlberg station, the brake coupling between the sections of the first wagon had sunk so far that it reached the level of the rail surface or slightly below it. Right from the entrance to the Blisadona Tunnel (leaving Langen am Arlberg station) the first signs of scoring and shearing were evident on the decking of a crossing between the rails of the track that was used.

Figure 10 Signs of shear in Blisadona Tunnel

Figure 11 Detail of the signs of shear

At this point in time, the brake hose between sections of the first wagon was still intact. That was demonstrated by the braking performance of the train.

“Saw tooth braking” was applied to the continuing journey downhill. *That means that the driver reduced the speed using the air brake so far below the permitted speed that there was then time for the brakes on the whole train to be completely released. That avoids the wagons on a train being continuously braked downhill on steep sections and the wheel*

centres and brakes becoming thermally overstressed. A further consequence of thermal overstressing is less effective braking and damage to the wheel centres. When the brakes are released, the permitted speed must not be exceeded.

This saw tooth braking was applied five times between Langen am Arlberg and Dalaas stations. Each time the brakes were applied, the train decelerated in conformity with the reduction in air pressure.

As the journey continued downhill, the brake coupling, which was hanging down, struck the covers of the point mechanisms in Wald am Arlberg and Dalaas stations.

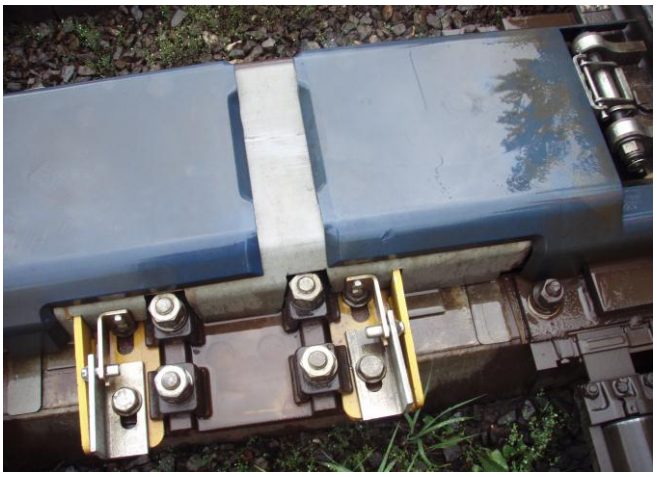


Figure 12 No 251 points Wald am Arlberg station

Figure 13 Detail of No 251 points

The continuous impacts and the dynamic movement of the brake coupling caused the securing cable to come completely out of the cable grip. The cable grip came off in Wald am Arlberg station between the last set of points and the entrance signal for the opposite direction; it was recovered at km 116.633.

The brake coupling was then no longer supported by the securing cable and now hung completely below rail level. The securing cable itself only was now held loosely in the hole in the anti-rotation device of the coupling screw and the retaining loops of the metal plate until it fell off in Dalaas station. The cable was recovered at km 120.620.

Between Dalaas and Hintergasse stations starting at km 122.722, used rails were being stacked on the track in accordance with the regulations and outside the normal loading gauge. As train 46676 ran over this section, the brake coupling which was hanging too low hit the end of the stacked used rails.

Figure 14 Stacked used rails

Figure 15 Point of impact

The impact pulled the coupling off the brake hose of the leading section of the wagon. In consequence, the coupling of the following section of the wagon together with the brake hose was thrown back and upwards and become wedged in the underframe between the buffer beam and the plate covering the springing of the draw gear of the following section of the wagon. In this way the brake hose was kinked at the point at which it met the main brake pipe so that air could not escape. (Figures 16 and 17).

Figure 16 Kinked air hose with brake coupling (source: Bregenz CID)

Figure 17 Detail of the kinked air hose (source: Bregenz CID)

The main brake pipe in the front part of the train (locomotive and leading section of the wagon) was open across most of cross-section and caused automatic braking of the locomotive and the first section of the wagon. The kinked brake hose prevented the air coming out of the following 15 ½ vehicles. The main brake pipe thus remained sealed so that no automatic braking took place on the following vehicles.

The sudden and complete fall in pressure in the main brake pipe in the front part of the train was evident on the locomotive cab display and on the main brake pipe pressure gauge on the locomotive. In principle, this meant that the train had divided (in accordance with DV V3 Section 94(7) [Infrastructure manager's operating instructions]). The driver supplemented the automatic brake application with rapid braking of the locomotive.

Despite that, the train did not slow down. The gradients on that section (*gradients of between 25 and 34 ‰*) made the speed of the train increase continuously. The train driver also tried to make an effective brake application using the direct brakes on the locomotive but that likewise proved unsuccessful. After the speed of the train had increased from 61 km/h to 67 km/h over a journey of 1.3 km, the emergency brake button on the locomotive was activated at km 123.899 (*rule contained in the locomotive's operating instructions*). That should have ensured the air brakes exerted the maximum braking effect. Activating the emergency brake button de-activated the E-brake on the locomotive and because the braking effort of the air brake operating on the locomotive and the first section of the first wagon was limited, the train accelerated down the gradient.

The last five wagons derailed at a speed of some 125 km/h on a 250 m radius left-hand curve before Braz station. They fell towards the right in the direction of travel from the embankment and came to rest in front of a private house.

Some four seconds later the locomotive and the following eight wagons derailed on the approach to Braz station (on a right-hand curve with a radius of 242 m). The locomotive and wagons fell off the embankment to the left into a residential area.

The majority of the cars being transported were thrown off the derailed wagons and were spread over a wide area in the village of Braz.

The driver of train 46676 was severely injured in the derailment. There were no further personal injuries.

There was significant material damage to railway infrastructure, rolling stock, goods being carried and to municipal infrastructure.

4. Casualties, damage to property and disruption to operations

4.1. Casualties

Casualties	none	fatality	serious injuries	slight injuries
Passengers	☒			
Railway staff	☐	-	**1**	-
Users of level crossings	☒			
Trespassers	☒			
Other	☒			

Figure 18 Analysis of casualties

4.2. Damage to railway infrastructure

The track, including safety related equipment and point work, was severely damaged over a length of some 670 m. Overhead electrical installations were severely damaged over a length of 670 m; five masts were completely destroyed. The cost of the damage is estimated as some € 1.5 million.

4.3. Damage to third-party property

Enormous damage to the property of neighbouring land owners and to municipal infrastructure.

4.4. Disruption to operations

Closure of the Arlberg line between Landeck and Bludenz stations between 16 June 2010 at 03:07 and 22 June 2010 at 19:31.
Alternative services [by road] were arranged for passenger trains. Overnight passenger trains and freight trains were diverted over a wide area.

4.5. Damage to rolling stock

Position in train	Vehicle No	Load status		
1	9381 1116 173-4	loco	derailed, four axles	total loss
2	2387 4372 372-4	L	derailed, four axles	total loss
3	2387 4372 379-9	L	derailed, four axles	total loss
4	2387 4372 097-7	L	derailed, four axles	total loss
5	2387 4372 025-8	L	derailed, four axles	total loss
6	2387 4372 394-8	L	derailed, four axles	total loss
7	2387 4372 030-8	L	derailed, four axles	total loss
8	2387 4372 066-2	L	derailed, four axles	total loss
9	2387 4372 103-3	L	derailed, four axles	total loss
10	2387 4372 069-6	L	not derailed	slightly damaged
11	2387 4372 380-7	L	not derailed	slightly damaged
12	2387 4372 033-2	L	derailed, two axles	heavily damaged
13	2387 4372 377-3	L	derailed, four axles	total loss
14	2387 4372 009-2	L	derailed, four axles	total loss
15	2387 4372 054-8	L	derailed, four axles	total loss
16	2387 4372 117-3	L	derailed, four axles	total loss
17	2387 4372 322-9	L	derailed, four axles	total loss

Figure 19 Table of damage to rolling stock

Cost of damage to rolling stock some € 3 million.

4.6. Environment damage

In consequence of the damage to the cargo (trade cars), fuel escaped.
2880 litres of transformer oil leaked from the overturned locomotive, of that, it was possible to recover some 100 litres.

4.7. Damage to the consignment

Of the total of 208 trade cars loaded, 96 were a total loss; a further 79 were severely damaged. Thirty-three cars on the wagons which were not derailed were undamaged.

Total costs of damage to the consignment some € 2 million.

5. Those involved, contractors and witnesses

- Keeper of the car transporter wagons
- Infrastructure manager
- Railway undertaking
- Traction provider and keeper of the locomotive
  - Driver of train 46676

6. Investigative process

The accident investigation report is based on the following action taken by the Federal Accident Investigation Bureau:

- Site investigation after the event on 16 and 17 June 2010 jointly with Bregenz Criminal Investigation Department. Forensics and documentation between Langen am Arlberg and the points of derailment.
- On-site inspection of wagons of identical design on 23 June 2010 in Hegyeshalom.
- On-site inspection at the location of the derailment[s] in Braz on 23 July 2010.
- Recovering a securing cable from wagons of identical design in Bludenz station on 23 July 2010 (as a reference for the tests in the accredited testing bureau).
- Functional test of the brakes on wagon 2387 4372 380-7
- Test of the screw coupling in the centre of the first wagon of train 46676 after it had been recovered by the Bregenz Criminal Investigation Department on 30 July 2010.
- Analysis of the data from the recording equipment on locomotive 1116 173-4.
- Tests on the securing cable by experts from an accredited testing bureau.
- Measurement of the vertical movement of the stacked rails.

Evaluation of the documentation received:

- Documentation from the wagon keeper, received on 5 August 2010
- Infrastructure managers report on ZOV 48 [Handling and storage of permanent way materials (Supplementary provisions to DV B51 Track regulations)], received on 3 September 2010
- Expert's report on the tests on the security cable,
  received on 11 January 2011
- Results of the measurement of the vertical movement of the stacked rails,
  received on 14 June 2011

7. Statements/Evidence/Results of the evaluation

7.1. Statement by the driver of train 46676

(A shortened form, just the gist is given, statement taken by Bregenz Criminal Investigation Department)

The journey to St. Anton am Arlberg station was uneventful. The driver of the assisting locomotive braked the train to a stop with a service application in St. Anton am Arlberg station. The assisting locomotive was uncoupled and then a brake test was made. The test was made in accordance with the regulations and everything was normal. When the brake test was finished, the journey was continued.

Because the E-brake was not sufficient to keep to the permitted speed, several service brake applications were made until the event (remark: using the air brake) these were made without problem. No irregularities were noted when making the brake applications.

On the section of line between Dalaas and Hintergasse stations, the message “main brake pipe leaking” was displayed on the locomotive. This message is normally [only] displayed when the train has divided and means that the fall in pressure in the main brake pipe causes an automatic application of the brake on the train but in this case that didn’t happen.
The first action taken after this message was to operate the brake lever to initiate a rapid braking. No braking effort was observed. The pressure gauge showed that there was no pressure in the main brake pipe, but nevertheless no deceleration through braking. From that point in time, it was clear that no braking effort could be expected.
Panic broke out as a consequence of the increasing speed, because it was realised that the train would accelerate out of control and that a derailment on the “Braz curves” would be unavoidable.

After taking the opportunity to make a final rapid brake application, the cab was evacuated. By leaving the cab, an application of the brake by the vigilance device [Sicherheitsfahreinrichtung] (SIFA) should have followed automatically. That didn’t happen, either. It became clear that that there were no further options to brake the train from the equipment compartment. Jumping off the train was considered but rejected because of the high speed.

After returning to the front cab, the emergency brake button was actuated and an emergency call by radio was made.
In the meantime, the speed had become so high that control could no longer be exercised. The final consequence was derailment.

Derailment was suffered in the front cab. Before leaving the locomotive, the signaller was informed by means of an emergency call that there were no dangerous goods (RID) on the train. After the derailment, the cab was exited through the emergency exit unaided. The driver was helped by first aiders and left the locomotive by means of a ladder (remark: the locomotive was on its side). Transport to the hospital in Bludenz followed. Shock and significant bruising was suffered as a result of the accident. Discharge from the hospital took place the following day.

7.2. Analysis of the data from the recording equipment on the locomotive

After the incident, the data on the event recording equipment of the locomotive of train 46676 (1116 173-4) was transferred to data media, analysed by the traction provider and the analysis made available to the Bregenz Criminal Investigation Department and Federal Accident Investigation Bureau.

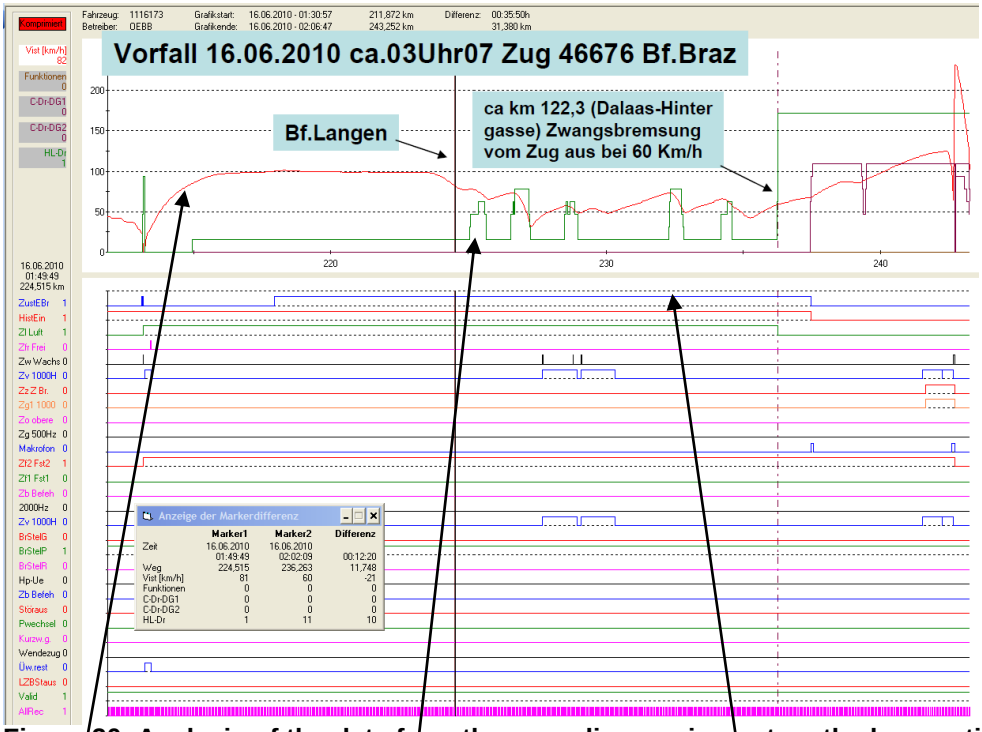


Figure 20 Analysis of the data from the recording equipment on the locomotive (1) (source: traction provider)

Vorfall 16.06.2010 ca. 03Uhr07 Zug 46676 Bf.Braz	Incident 16 06 2010 approx. 03:07 train 46676 Braz station
Ca km 122,3 (Dalaas-Hintergasse) Zwangsbremsung vom Zug aus bei 60 km/h	Approx 122.3 (Dalaas-Hintergasse) automatic braking of the train travelling at 60 km/h
Bf. Langen	Langen station

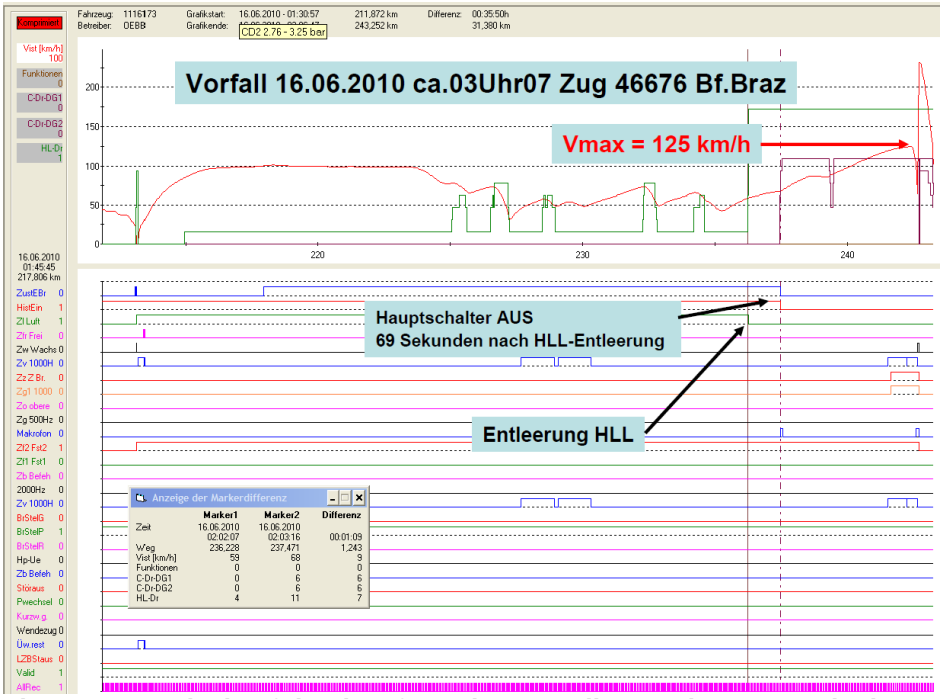


Figure 21 Analysis of the data from the recording equipment on the locomotive (2) (source: traction provider)

Vorfall 16.06.2010 ca. 03Uhr07 Zug 46676 Bf.Braz	Incident 16 06 2010 approx. 03:07 train 46676 Braz station
Vmax = 125 km/h	Maximum speed 125 km/h
Hauptschalter AUS 69 Sekunden nach HLL-Entleerung	Master controller OFF 69 seconds after the emptying of the main brake pipe
Entleerung HLL	Main brake pipe empties

7.3. Federal Accident Investigation Bureau's analysis of the locomotive's journey data

Some 7200 data elements were analysed in the evaluation of the journey of locomotive 1116 173-4 from Landeck station to the point at which train 46676 derailed. A high degree of consistency with the journey taken by the locomotive on that section of line was noted.

HLL-Druck [bar]	
Stufe	Wert
0	Füllstoß
1	Bremse gelöst
2	4,8 (letzte Lösestufe)
3	4,6 (1.Bremsstufe)
4	4,40
5	4,28
6	4,15
7	4,00
8	3,85
9	3,70
10	Vollbremsung 3,5
11	Schnellbremsung < 3,2

C-Druck-DG1 und DG 2 [bar]	
Stufe	Wert
0	0,00 bis 0,21
1	0,22 bis 0,75
2	0,76 bis 1,25
3	1,26 bis 1,75
4	1,76 bis 2,25
5	2,26 bis 2,75
6	2,76 bis 3,25
7	> 3,25

Zug-Brems-Kraft [kN]	
Stufe	Wert
7	> 480
6	401 bis 480
5	321 bis 400
4	241 bis 320
3	161 bis 240
2	81 bis 160
1	1 bis 80
0	0
-1	-1 bis -80
-2	-81 bis -160
-3	-161 bis -240

Figure 22 Table showing the classification of values from the recording equipment

C-Druck-DG1 und DG 2 (bar)	Brake cylinder pressure bogie 1 and 2 (bar)
Stufe Wert	Stage Value
HLL-Druck (bar)	Main brake pipe pressure
Stufe	Stage
Wert	Value
Füllstoß	Filling stroke
4,8 (letzte Lösestufe)	4,8 (final release stage)
4,6 (1. Bremsstufe)	4,6 (first braking stage)
Vollbremsung 3,5	Full brake application 3,5
Schnellbremsung 3,2	Rapid brake application 3,2
Zug-Brems-Kraft (kN)	Traction/braking force (kN)

The speed of locomotive 1116 173-4 at the time of the derailment was evaluated by defining the exact time graphically in terms of time and distance. The table showing the analysis of the data from the recording equipment on the locomotive is shown in Attachment C.

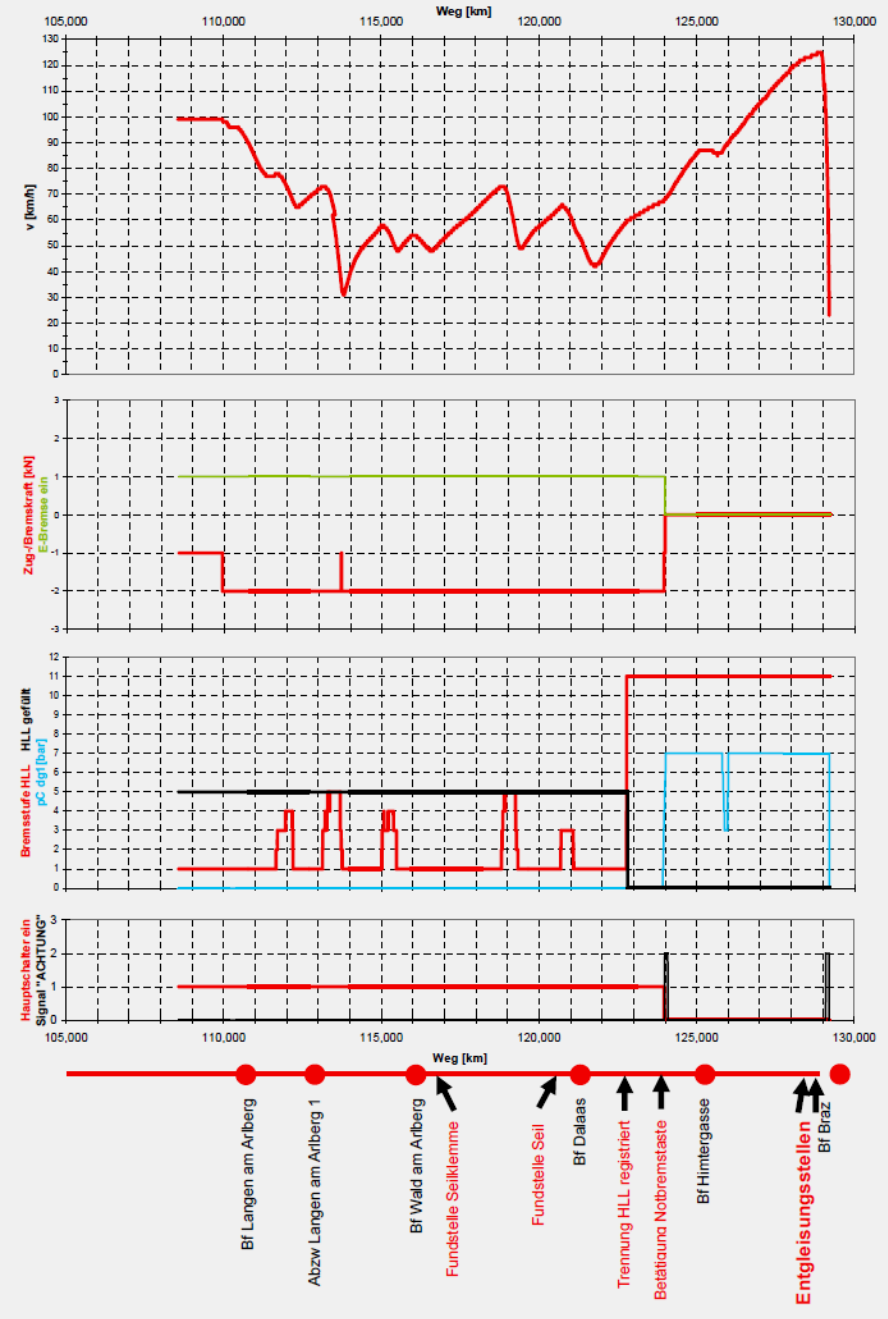


Figure 23 Route related analysis of data from the locomotive's recording device

Hauptschatter ein Signal „ACHTUNG“	Master controller on “WARNING” signal
Bremsstufe HLL HLL gefült	Main brake pipe braking stage Main brake pipe filled
Zug/Bremskraft (kN)	Traction/braking force (kN)
V(km/h)	Speed (km/h)
Bf Langen am Arlberg	Langen am Arlberg station
Abzw Langen am Arlberg 1	Langen am Arlberg No 1 junction
Bf Wald am Arlberg Fundstelle Seiklemme	Wald am Arlberg station Location at which the cable grip was found
Fundstelle Seil Bf Dalaas	Location at which the cable was found Dalaas station
Trennung HLL registriert Betätigung Notbremstaste	Separation of the main brake pipe recorded Emergency brake button activated
Bf Hintergasse	Hintergasse station
Entgleisungsstellen Bf Braz	Location of the derailment Braz station

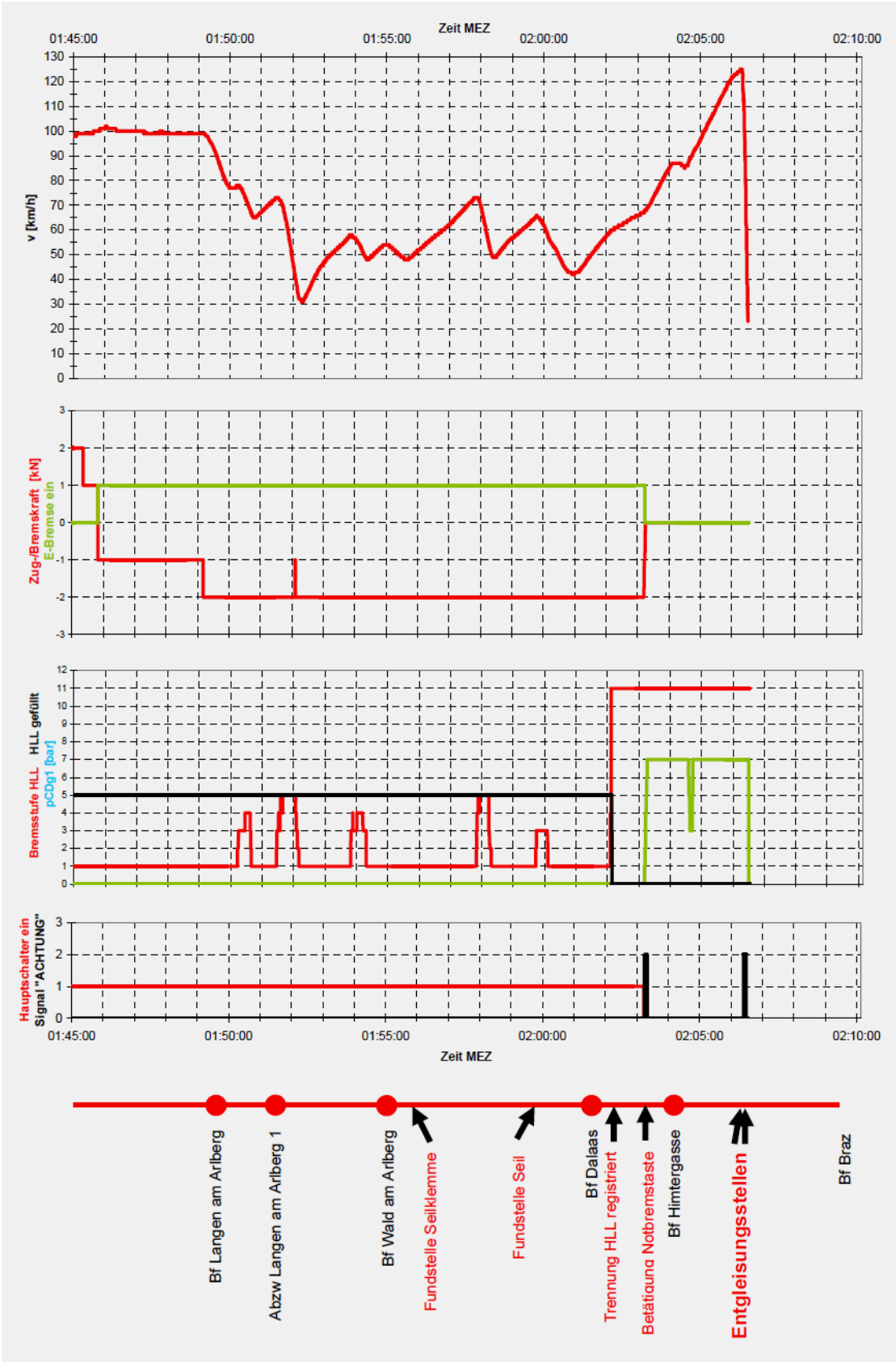


Figure 24 Time related analysis of data from the locomotive's recording device

7.4. Analysis of the temperature at train running checkpoints

Temperatures reached [by wheels and brakes] were assessed by fixed position measuring equipment; these records were made available to the Federal Accident Investigation Bureau by the infrastructure manager. No irregularities were noted at the installations in Wald am Arlberg (km 116.800) and Dalaas (km 120.550) stations. The temperatures were the same throughout the train. This means that all the wagons were exerting the same braking force.

```
Temperaturprofil
Datum:            03:00:19 16.06.2010     Achsen:                 68
Anlage:           Dalaas                  Geschwindigkeit:        62
Zugnummer:          46676                 Umgebungstemperatur:    18
Fahrtrichtung:    1
```

Temperaturprofil		Achsen	Axles
Datum	Date	Geschwindigkeit	Speed
Anlage	Installation	Umgebungstemperatur	Ambient temperature
Zugnummer	Train No		
Fahrtrichtung	Direction of travel		

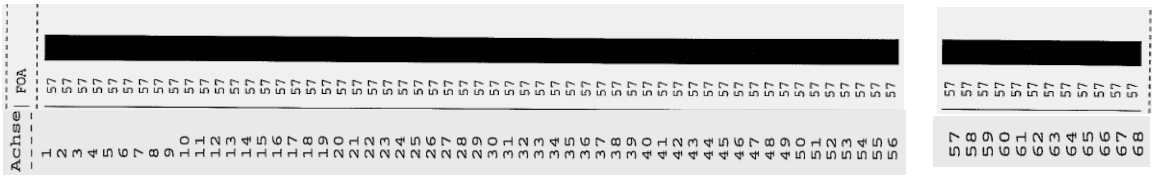


Figure 25 Report from the train running check point in Dalaas

7.5. Investigation of the technical aspects of the wagons in train 46676

The last technical examination of the wagons of train 46676 took place in Hegyeshalom station on 15 June 2010. This was a technical transfer inspection (in accordance with Appendix 9 GCU) and involved the wagons being examined for operational safety and suitability for traffic. No faults were recorded. The wagon examination record is attached as Attachment F.

7.6. General description of locomotive 1116 173-4

Locomotives of class 1116 are four-axle locomotives with two bogies. They are approved in Austria and run under the protected trade name of “Taurus”. They are equipped for electric traction using 15 kV AC at 16.7 Hz and 25 kV AC at 50 Hz. Loccomotives of this class are used for passenger and freight traffic and are approved in Austria and (although restricted to some classes) in the Czech Republic, Germany, Hungary and Switzerland.

Locomotive characteristics:

- Length over buffers 19280 mm
- Bogie pivot pitch 9900 mm
- Bogie pitch 3000 mm
- Minimum curve radius 120 m
- Tare weight 86 t (Mass in accordance with the Weights and Measures Act)
- Maximum speed 230 km/h

7.6.1. Braking equipment:

The locomotive is equipped with a graduated automatic air brake with an auxiliary braking function, an additional electro-pneumatic brake and a spring-loaded brake as the parking brake. To avoid severe thermal stressing of the wheels, disc brakes are used on the locomotive. For each wheel-set, two discs are arranged on one brake shaft. On each brake disc of each brake shaft the brake cylinder is spring loaded.
In addition, the locomotive has an electrodynamic brake (E-brake). On locomotives of class 1116, the E-brake is designed as a pure regenerative brake. Current converters together with the E-brake allow power to be returned to the system. The brake force of the E-brake is limited to avoid derailments.

7.6.1.1. Direct brakes:

The direct brakes are mainly used for parking and in shunting. The only operate on the locomotive itself. If they are employed whilst running at over 60 km/h, after 700 m a fault report is displayed, under 60 km/h this report is displayed after 45 seconds. To protect against thermal overstressing of the disc brakes, an automatic brake application is made after a further 60 seconds.

If the direct brakes are used in conjunction with the E-brake, the E-brake is reduced to a single stage (limitation of the total brake force).

7.6.1.2. Indirect brakes:

In indirect braking, the brake mechanism of the wagons is actuated in addition to that of the locomotive. Indirect braking is controlled via an electropneumatic brake valve installation under the control of the driver.

7.6.1.3. E-brake:

To avoid derailments, the maximum brake force for a service application of the E-brake is 150 kN or 100 kN for a speed of below 40 km/h. In push-pull working, the maximum E-brake force is 200 kN and as an assisting locomotive 240 kN.

If a rapid or an automatic brake application is initiated, the E-brake force in braking regimes P or G is limited to 80 kN. If a service application is being made before a rapid or automatic application is initiated, the available E-brake force of 150/100 kN is not reduced.

The brake cylinder pressure of the indirect brakes on the locomotive is reduced when the E-brake is effective. In E-braking, the traction motor is used as a generator in braking. If E-braking is activated, the electric motor switches over to become a generator and thus provides resistance which slows the system down rather than driving it.

This type of brake is less effective than mechanical brakes and operates solely as a regenerative brake. In that way, the electrical energy generated is returned to the grid via the overhead contact wire.

7.6.2. Failure of a traction motor

If a traction motor fails, the E-brake on it also becomes inoperable. However, in the case of the failure of one traction motor on a bogie, software ensures that the same E-brake force continues to be available as for a fully effective locomotive. The E-brake force missing is compensated by the remaining three traction motors.

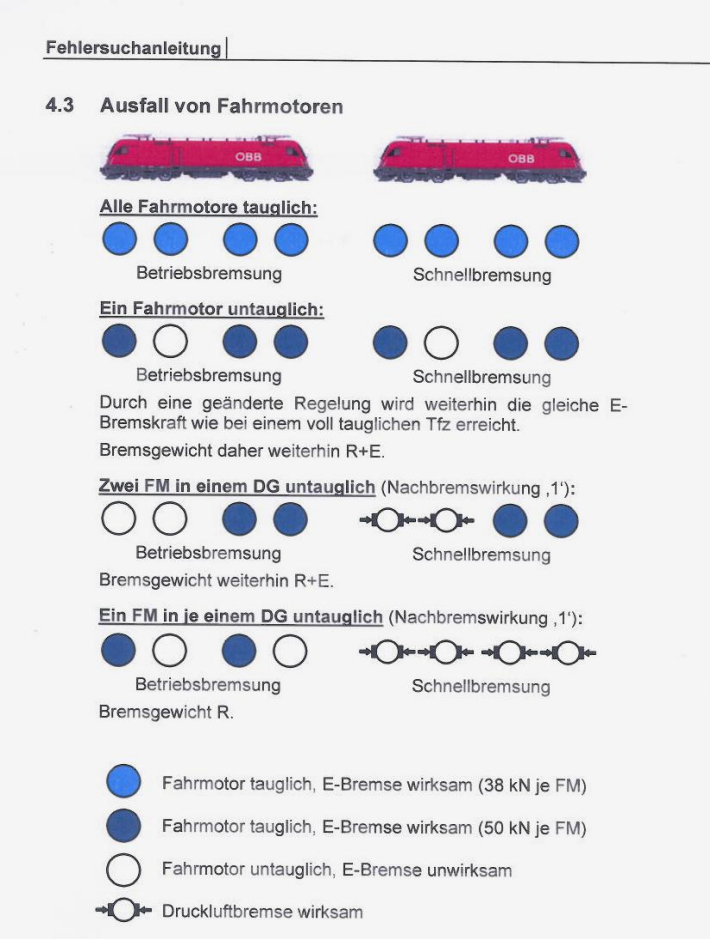


Figure 26 Effectiveness of the E-brakes (source: traction provider)

Fehlersuchanleitung	Instructions for detecting faults	Zwei FM in einem DG untauglich (Nachbremswirkung, 1)	Two traction motors on one bogie inoperative (stage 1 of graduated braking)
4.3. Ausfall von Fahrmotoren		Betriebsbremsung R+E	R + E service braking
Alle Fahrmotore tauglich	All traction motors operable	Ein FM je einem DG untauglich (nachbremswirkung,1)	One traction motor on each bogie inoperative (stage 1 of graduated braking)
Betriebsbremsung	Service brake application	Bremsgewicht R.	Brake weight R
Schnellbremsung	Rapid brake application	Betriebsbremsung	Service brake application
Ein Fahrmotor untauglich	One traction motor inoperable	Schnellbremsung	Rapid braking
Betriebsbremsung	Service brake application	Fahrmotor tauglich. E-Bremse wirksam (38 kN je FM)	Traction motor operative. E-brake effective (38 kN each motor)

Schnellbremsung	Rapid braking	Fahrmotor tauglich. E-Bremse wirksam (50 kN je FM)	Traction motor operative. E-brake effective (50 kN each motor)
Durch eine geänderte Regelung wird weiterhin die gleiche E-Bremskraft wie bei einem voll tauglichen Tfz erreicht. Bremsgewicht daher weiterhin R+E	The same E-brake force as for a fully operative locomotive is achieved by altering the settings. Brake weight continues to be R + E,	Fahrmotor tauglich. E-Bremse wirksam	Traction motor operative. E-brake effective
		Druckluftbremse wirksam	Air brake effective

7.6.3. Emergency brake button

Despite comprehensive monitoring and high safety standards, in extreme cases faults can cause problems with effective braking on the locomotive. In this event, the emergency brake button is to be operated in accordance with the locomotive's operating instructions.

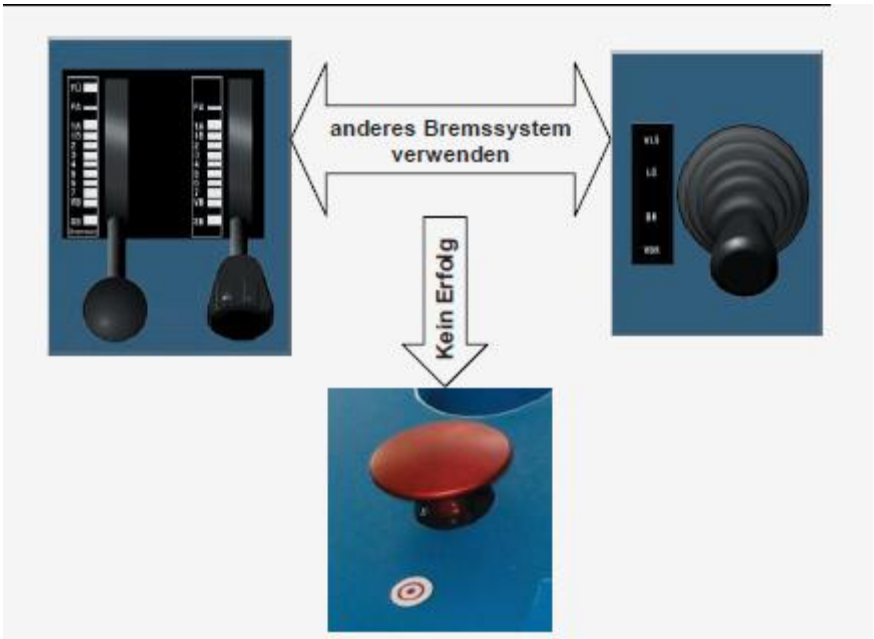


Figure 27 Emergency brake button (source: traction provider)

Anderes bremssystem verwenden	Use another braking system
Kein erfolg	No success

Operating the emergency brake button cuts off the supply of power to the anti-slip device and the magnetic retention valve of the indirect brakes. Hence the maximum braking effect of the air brakes is achieved and rapid braking initiated.
In addition, after actioning the emergency brake button, the master controller on the locomotive is switched off, the pantograph lowered and the "warning" signal (a long continuous tone) sounded as a warning.

7.6.4. Examination of locomotive 1116 173-4

The derailed locomotive was given a close inspection on site. After the derailment the locomotive rolled on to its side and came to rest close to km 129.116. Both bogies were separated from the underframe and the rear bogie was readily accessible. It was noted that on this bogie the disc brakes were hard on. Clear signs of discoloration through heat could be seen on the brake disks. This was a clear indication that the brakes on the locomotive had operated and of significant thermal stressing.

Figure 28 Brake discs on the rearmost brake shaft

In the cab, the position of the traction controller and the brake handle were documented. The speed and traction/braking controller were in position “0”.

Figure 29 Traction controller

The handle for the indirect brakes was in the “rapid braking” position, the handle for the E-brakes was in the “full brake application” position. The operating handle for the

direct brakes was in the central position and was not in the “complete release” position. That meant that the brake lever for the indirect brakes had also been operated.

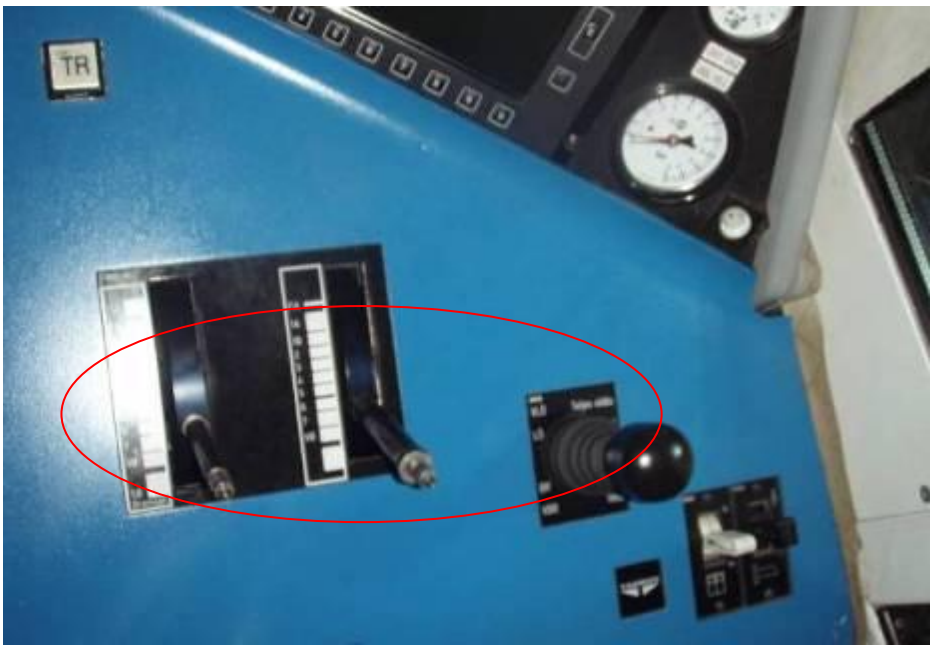


Figure 30 Brake handle

In addition, the log book and the written orders for train 46676 were recovered from the cab.
From the entries in the logbook it emerged that a traction motor on bogie No 2 (the leading bogie at the incident) on the locomotive had become defective on 27 May 2010 and had to be isolated. The defect on the traction motor meant that it was also unavailable as an E-brake. This shortage of E-brake force was compensated by software control of the other three traction motors so that 150 kN of brake force continued to be available (see point 7.6.2).

The bottom of the locomotive was visually examined in Bludenz station on 23 July 2010. The bottoms of both bogies were severely damaged by the derailment and by sliding over the embankment and road. That damage is to be regarded as the consequence of the derailment.

Figure 31 Bogie No 2

Figure 32 Bogie No 1

7.6.5. Overhaul and maintenance of the locomotive

In 2010, the locomotive went into accredited service workshops five times for maintenance and various activities. These took place on
19 January in Salzburg, 16 February in Villach, from 22 to 31 March in Linz, 5 May in Salzburg and 13 June in Vienna.

The defective motor was examined in the service workshop in Linz on 31 March 2010 and it was established that an intermediate circuit breaker was defective. Since a replacement part was not immediately available, the locomotive was left in service with three operative motors.

7.7. The wagons involved

The wagons derailed were flat wagons of the “Laaeks” type operated by a French wagon keeper with individual wheelsets (wagon units) and [two] decks to transport motor vehicles.

7.7.1. General vehicle data for wagon 23 87 437 2 372-4

Wagon 23 87 437 2 372-4 was built in January 2000. It is a two section double deck vehicle transporter wagon of type Laaeks TAL 497 A (wagon keeper’s type designation) with four individual wheelsets. The two half wagons of a vehicle each rest on two wheel sets (with a nominal diameter of 680 mm) via double suspension rings and parabolic springs. In the middle of the vehicle, these sections are permanently coupled with a strengthened screw coupling without a counterweight (Figure 33 Outline design Laaeks (source: wagon keeper) . In the middle of the wagon there are bridges which allow the complete loading platform to be driven over when loading or unloading. The lower bridge is at a height of 510 mm above rail level to provide the greatest possible height all the way along the lower loading platform.

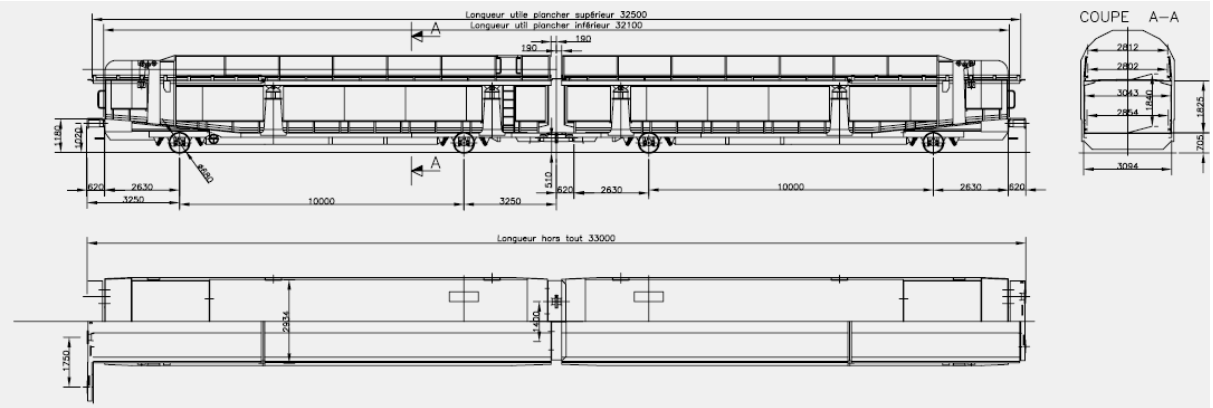


Figure 33 Outline design Laaeks (source: wagon keeper)

Characteristics:

- Length over buffers 33 m
- Wheel base 10 m within the sections of the wagon, 6.5 m between the sections of the wagon
- Minimum curve radius >75 m
- Tare weight 33 t (weight under the Weights and Measures Act)
- Line loading limit 23 t for lines of class “A”, “B” and “C” at Vmax 100 km/h
- Vehicle maximum speed 120 km/h when empty

According to the papers submitted for the approval of the wagons, they comply with the gauge set down in UIC leaflet 505-1 “Railway transport stock - Rolling stock construction gauge”.

7.7.2. Brake equipment

The wagon is equipped with an automatic through air brake of type SAB WABCO with brake blocks. This type of brake is approved for international traffic (in accordance with Appendix E of UIC leaflet 543 “Brakes - Regulations governing the equipment of trailing stock”). The brake performance is designed for the “P” (passenger train) brake regime (fast acting brake, brake cylinder fills in from 3 to 5 seconds and a release time of between 15 and 20 seconds) and for the “G” (freight train) regime (slow operating brake, brake cylinder fills in from 18 to 30 seconds and a release time of between 45 and 60 seconds). As a function of its length of 33 m, each wagon half is equipped with a distributor.
The brake weight of the air brake in the “P” regime is 39 t and that of the hand brake 20 t.

The main brake pipe is linked between the two sections of the wagon by brake hoses and brake couplings. The design of the wagon with the bridge in the middle dictates that a securing cable is used to provide safe support for the main brake pipe. A metal plate with two U-bolts is bolted above the brake coupling. A cable (length ≈ 970 mm, ∅ 6.42 mm, details from the construction drawings) is led through a loop on this metal plate. The cable passes over the screw coupling in an “O” form and is secured with a cable grip.

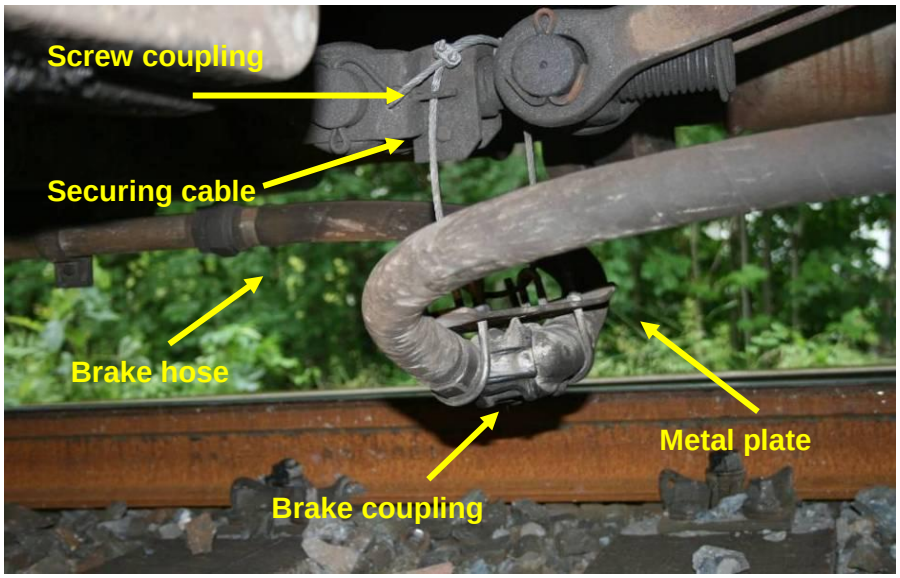


Figure 34 Brake coupling in the middle of the vehicle

According to the GCU Appendix 10, no part of the brake coupling system (whether connected or disconnected) must hang within 140 mm of rail level. This 140 mm dimension is a workshop dimension and must be adhered to in the maintenance of wagons in workshops.

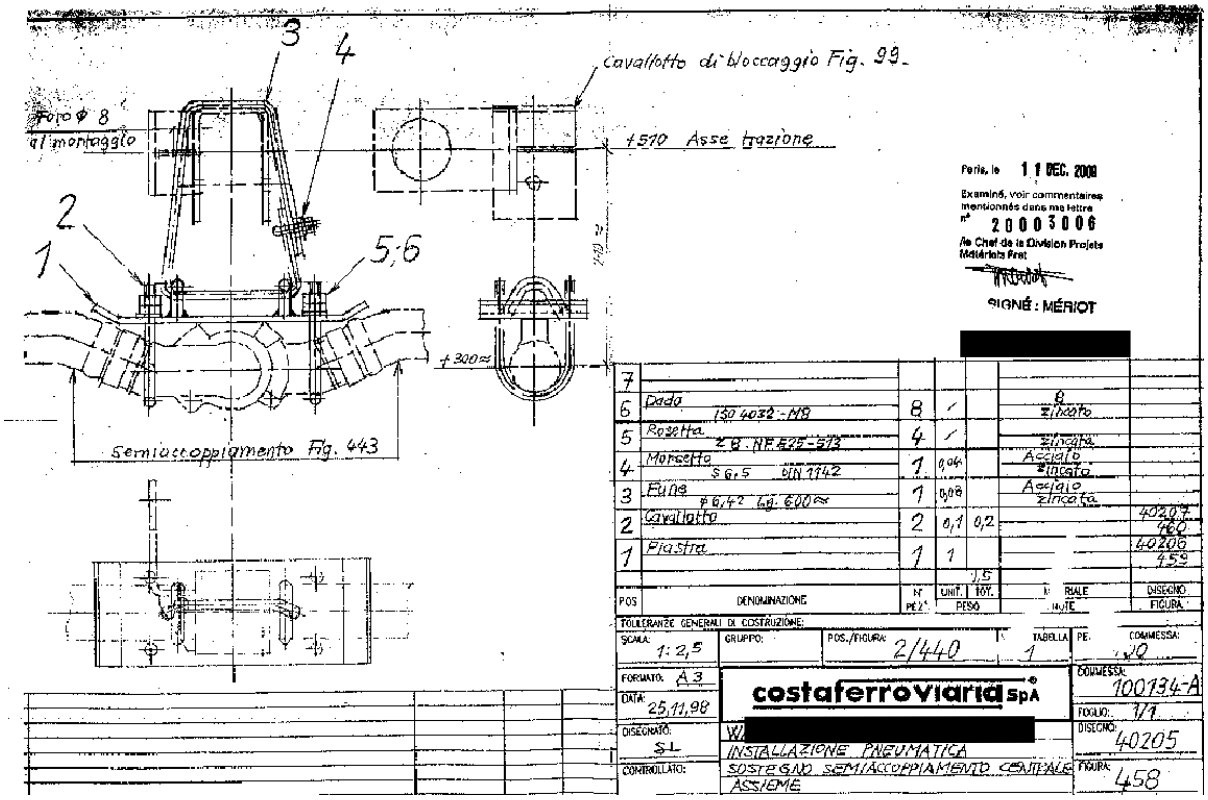


Figure 35 Design of the brake coupling in the middle of the vehicle (source: wagon keeper)

Differing ways of providing support for the hose were noted (see point 7.9) in on-site inspections of several wagons of the same type (23 87 437 2 type “Laaeks”).

7.7.3. Overhaul and maintenance of wagon 372-4

The last main overhaul of wagon 372-4 took place in a workshop (accredited to EN ISO 9001) in France in February 2006. The general overhaul was good for six years in accordance with the painted maintenance data. Subsequently, the wagon was employed on various traffic flows until March 2010. Amongst other flows, the wagon was used fifty-three times on the flow from Valenton (F) - Ciumesti (RO) – Valenton (F).

Between March 2010 and the end of May 2010, maintenance work was done on the wagon in a further workshop accredited under EN ISO 9001 and by the German Eisenbahn-Bundesamt) in France. In that maintenance work wheelsets 1, 2 and 4 were exchanged. The wagon left this workshop on 1 June 2010 and was sent empty to Ciumesti for loading. The first journey in loaded status was then from Ciumesti to Valenton on train 46676.

7.7.4. Examination of derailed wagon 372-4

The derailed wagon was examined on site. After the derailment, the front section of the wagon came to rest with the underframe on top and the rear section of the wagon ended on its side. All four wheel sets were separated from the underframe. It was possible to recover six of the eight brake shoes of the front section of the wagon. These were completely worn through in places.

Figure 36 Brake blocks of the front section of the wagon

Likewise, it was possible to recover six of the eight brake blocks from the following section of the wagon. These showed normal signs of use.

Figure 37 Brake blocks from the following section of the wagon (source: Bregenz Criminal Investigation Department)

In the following section of the wagon, the brake hose together with the coupling and metal plate was bent back (in terms of the direction of travel). The brake coupling was wedged in a 16 cm wide gap between the buffer beam and the covering of the spring element of the draft gear and hence the brake hose was kinked.

Figure 38 Brake coupling of the following section of the wagon

Noticeably, a new U-bolt was bolted to the metal plate on the brake coupling. This U-bolt showed no signs of rust or brake dust at all. This pointed unambiguously to maintenance work having been done on this brake coupling in the last workshop visit.

Figure 39 Metal plate with a new U-bolt

7.7.5. Securing cable and cable grip from wagon 372-4

A cable grip from the securing cable from wagon 372-4 was recovered on 17 June 2010 in Wald am Arlberg station at 116.633 km.

Figure 40 Cable grip

The securing cable from the brake coupling was recovered on 17 June 2010 in Dalaas station at 120.620 km. These components were assumed to have come from wagon 372-4.

Figure 41 Securing cable

The securing cable, cable grip and two specimens of securing cables for reference purposes with their grips were tested further in an accredited testing laboratory. Excerpts from the experts' report are shown in point [reference incomplete].

7.7.6. Screw coupling in the middle of the vehicle

The screw coupling was recovered by the Bregenz Criminal Investigation Department but examined in the Federal Office of Transport. In doing so, the three securing pins of the anti-rotation device were removed. No clear conclusions on the securing pins time in service could be drawn.

Figure 42 Screw coupling in the middle of the vehicle

Figure 43 Anti-rotation device

Figure 44 Securing pins extracted

7.8. Behaviour of the driver

After the impact on the brake coupling and its becoming wedged, the loss of air was signalled to the driver on the main brake pipe pressure gauge and the locomotive display. The braking which occurred automatically was supported by the driver making a rapid brake application from the locomotive. This complies with the provisions of DV M 26 Braking Regulations [Bremsvorschrift].

Quotation from DV M 26 Section 61(1): "*Drivers shall support every actuation of the automatic air brake by initiating a rapid brake application*" end of quotation.

The rapid brake application did not slow the train down since only the air brake on the first half-wagon and the E-brake and air brake on the locomotive were effective. The driver could not be aware of that situation. There was no way that the driver could pinpoint the cause of the defective braking of the train. In consequence, the driver tried to create effective braking by using the direct brakes on the locomotive (see Figure 30 Brake handle). That attempt was likewise without success.

To bring the train to a stop the driver operated the emergency brake button.
Operation of the emergency brake button complied with the operating instructions for locomotive (class) 1116.

7.9. Inspection of wagons of identical construction to type 23 87 437 2

An on-site examination took place on 23 June 2010 in Hegyeshalom station in conjunction with the Hungarian accident investigation bureau.

The on-site inspection consisted of a technical examination of the couplings of train 46676 (arrival in Hegyeshalom 23 June 2010 at about 09:15) composed of identical car transporter wagons of class 23 87 4372 xxx-x. The train running and technical parameters (number of wagons, loading status, trailing weight, and trailing length) of the train examined corresponded to the train of 16 June 2010 which was involved in the accident with only minor differences.

The following vehicle components and parameters in particular were checked:

- overall condition of the brake couplings;
- existence of a securing cable;
- type of securing cable and way it was implemented;
- type of cable grips and way they were implemented;

- routeing of the securing cable around the screw coupling;
- measures put into place for technical examination of wagons (in accordance with "Technical Work Instructions for Special Examination of Car Transporter Wagons of Type 2387 437x xxx-x" of 21 June 2010;
- checking of the distance between rail level and the lowest component of the brake coupling.

In the technical examination of the coupling points in the middle of the wagons, it was noted that in the case of 10 of the 16 wagons examined, the cable grips and securing cables were identical to the components recovered from wagon 23 87 437 2 372-4 involved in the accident to train 46676. On the remaining six wagons, various cable grips, sometimes with CE markings and various securing cables to secure the brake coupling were found. In addition, large differences were sometimes found in the measured distance between rail level and the lowest point on the brake coupling. The values measured extended from 160 mm to 280 mm above rail level.

Figure 45 Cable grip with CE marking

Figure 46 Securing cable with plastic sleeving

During the on-site inspection, the coupling of a nearby identical wagon of class 4371 was examined.
In doing so, it was noted that instead of the construction air-hose, brake coupling, metal plate, securing cable and so on, a continuous air-hose was used for the main brake pipe link between the two sections of the wagon. With that construction, if the train separated the air hose would be pulled from the main brake pipe and an automatic brake application initiated. A distance of 230 mm was measured between the rail head and the lowest point on the brake hose.

Figure 47 Wagon with a continuous brake pipe between the sections of the wagon

7.10. Stacking of objects on the track

7.10.1. ZSB 9

ZSB 9 “Keeping the track clear” is the set of regulations that cover the storage of objects in the area of the track. The general provisions are given in ZSB 9 and amongst other provisions, Section 2 “Minimum clearances” gives the mandatory clearances for stacking solid objects.

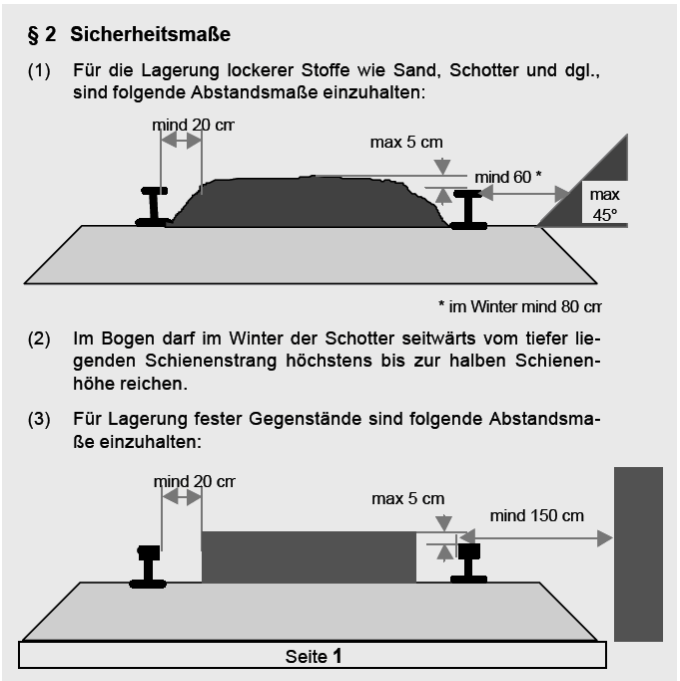


Figure 48 Excerpt from ZSB 9 (source: infrastructure manager)

§ 2 Sicherheitsmaßß	Section 2 Minimum clearance
(1) Für die lagerung lockerer Stoffe wie Sand, Schotter und dgl., sind folgende Abstandsmaße einzuhalten.	(1) For the storage of loose substances such as sand, ballast and so on, the following clearances are to be maintained:
Mind 20 crr – max	Minimum 20 cm – maximum
(2) Im Bogen dard im Winter der Schotter seitwärts vom tiefer liegenden Schienenstrang höchstens bis zur halben Schienenhöhe reichen.	(2) On curves, in winter ballast may only reach sideways from the lower rail to halfway up the higher rail.
(3) Für Lagerung fester Gegenstände sind folgende	(3) For the storage of solid objects, the following

Abstandsmaße einzuhalten.	clearances are to be maintained:

7.10.2. ZOV 48 [Handling and storage of permanent way materials]

Section A, General, point 1, third indent of ZOV 48 “Handling and storage of permanent way materials” (see Attachment B page 73) provides, inter alia, that permanent way materials are to be so stacked that the normal loading gauge (in accordance with ZOV 7 [Lineside structure gauge]) remains clear.

In Section B, Rails, it is laid down that “*on-site, as a rule rails are to be laid at the ends of sleepers. If exceptionally they have to be laid between the rails, suitable measures must be taken to ensure that the ends of the rails are always 30 to 50 cm away from the axis of the track*”.

These provisions in ZOV 48 apply to the storage of rails on-site and are designed to protect them from damage and to ensure they can be reused. In the case in point, the rails were intended to be scrapped and the work (changing the rails) between Braz and Wald am Arlberg stations was completed on 14 June 2010.

7.10.3. ZOV 7 [Lineside structure gauge]

Above and beside the track, the prescribed space must be left clear to permit vehicles to run safely. Table 7/2 of ZOV 7 “Lineside structure gauge and distance between the track centre lines” defines the dimensions of the clear space for standard gauge (1435 mm). This space to be kept clear begins 55 mm above rail level. (see Attachment A: ZOV 7 Table 7/2 loading gauge).

7.10.4. Stacked rails

The rails at 122.722 km were stacked for disposal in such a way that the normal loading gauge in accordance with ZOV 7 [Lineside structure gauge] was clear. The minimum clearance of a maximum of 50 mm above rail level to be maintained for the storage of solid objects in accordance with ZSB 9 was observed. The lateral minimum clearance to the running rails of at least 40 mm in accordance with ZSB 9 was not exceeded.

7.11. Vertical movement of stacked rails

After [receiving] the reasoned comments of the wagon keeper, measurements were made to determine the extent of vertical movement by the stacked rails when trains passed over them. Accordingly, the infrastructure manager installed a measuring system at km 122.722 between Dalaas and Hintergasse stations on the rails stacked in the middle of the track. It was used to measure and document the movement of the rails as trains passed overhead. In total 115 readings were taken.

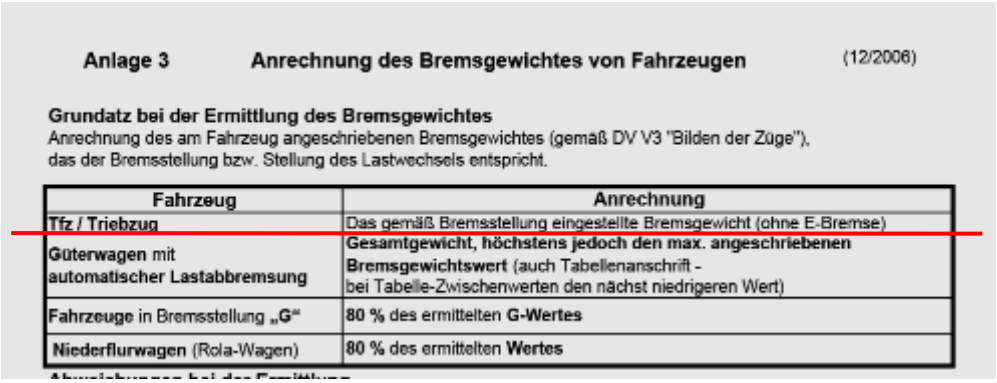
7.11.1. Results of the measurements

The largest vertical movement of a stacked rail was some 1 mm. Infringement of the loading gauge defined in ZOV 7 [Lineside structure gauge] can therefore be excluded.

The report on the measurements is included in the accident investigation report as Attachment 1.

7.12. Application of the brakes

Fundamentally all trains must be operated with adequate air braking. Only the braking effort of the air brakes is ever used for the brake calculation. All suitable brakes of a train are to be enabled. Dynamic brakes are always to be enabled if they are available but they may not be taken into account in the brake calculation. The brake weight is calculated in accordance with the infrastructure manager's DB 610 [Infrastructure manager's staff instruction for compiling train data]. The relationship between the brake weights and the total train weight is always given in hundredths, the brake percentage.
The braking performance of the air brake of a train must always be sufficient to bring it to a stop within the braking distance (specified by the infrastructure manager).
The brake percentages required for a train are shown in the headings in the infrastructure manager's timetable and must be available in the train. In the case in question a brake percentage of 69 % was required for train 46676 and 80 % available. Until the main brake pipe was separated, the train was adequately braked.



Anlage 3 **Anrechnung des Bremsgewichtes von Fahrzeugen** (12/2006)

Grundatz bei der Ermittlung des Bremsgewichtes
Anrechnung des am Fahrzeug angeschriebenen Bremsgewichtes (gemäß DV V3 "Bilden der Züge"), das der Bremsstellung bzw. Stellung des Lastwechsels entspricht.

Fahrzeug	Anrechnung
Tfz / Triebzug	Das gemäß Bremsstellung eingestellte Bremsgewicht (ohne E-Bremse)
Güterwagen mit **automatischer Lastabbremsung**	**Gesamtgewicht, höchstens jedoch den max. angeschriebenen Bremsgewichtswert** (auch Tabellenanschrift - bei Tabelle-Zwischenwerten den nächst niedrigeren Wert)
Fahrzeuge in Bremsstellung **„G"**	**80 %** des ermittelten **G-Wertes**
Niederflurwagen (Rola-Wagen)	**80 %** des ermittelten **Wertes**

Figure 49 Excerpt from Appendix 3 of DB 610 (source: infrastructure manager)

Anlage 3 Anrechnung des Bremsgewichtes von Fahrzeugen	**Appendix 3 Calculation of the brake weight of vehicles**
Grundsatz bei de Ermittlung des Bremsgewichtes	**Principles for determining the brake weight**
Anrechnung des am Fahrzeug angeschriebenen Bremsgewichtes (gemaßáDV V3 „Bilden der Züge"), das der Bremsstellung bzw. Stellung des Lastwechsels entspricht.	Taking into account the brake weight painted on vehicles (in accordance with DV V3 "Formation of trains") which corresponds to braking regime and load setting.
Fahrzeug	**Vehicle**
Tfz/Triebzug	Locomotive/motor coach
Güterwagen mit automatischer lastabbremsung „G"	Wagon with automatic load related "G" braking
Niederflurwagen (Rola-Wagen)	Low floor wagon (Rola-wagon)
Anrechnung	**Calculation**
Das gemäß Bremsstellung eingestelle Bremsgewicht (ohne E-Bremse)	The brake weight engaged in accordance with the braking regime (without E-brakes)
Gesamtgewicht, höchstens jedoch den max. angeschriebenen Bremsgewichtswert (auch	Gross weight, nevertheless not more than the maximum brake weight value painted (also tabulated

Tabellenanschrift- bei Tabelle-Zwischenwerten den nächst niedrigeren Wert)	values - for intermediate values use the next lowest value)
80% des ermittelten G-Wertes	80% of the "G" value determined
80% des ermittelten Wertes	80% of the value determined

7.13. Analysis of braking distance calculation using the "Minden Formula"

Berechnung des Bremsweges nach Mindener Formel
für P und/oder R gebremste Züge
Z 46676 nach Auftrennung der HLL

Bremsausmaß Tfz + 1 Wagenhälfte 1. Wagen:

Bremsgewicht Lok [t]	67
Bremsgewicht 1. Wagenhälfte [t]	20
Summe Bg [t]	87
Gesamtgewicht Zug Gg [t]	863
Bh [%] = (Bg / Gg) x 100	10

Parameter		gewählt	Anmerkung
v	Geschwindigkeit [km/h]	125	aus Registriereinrichtung
ψ	v-abhängiger Koeffizient [-]	0,98	aus Tabelle
c_1	Beiwert für λ [-]	0,97	aus Tabelle
c_2	Beiwert für i [-]	0,9	aus Tabelle
λ	Bremshundertstel [%]	10	errechnet
i	Streckenneigung [‰]	0	Gefälle mit negativem Operanden eingeben

Berechnung des Bremsweges aus der Geschwindigkeit

$$s = 3{,}85 \times v^2 / [\,6{,}1 \times \psi \times (\,1 + c_1 \times \lambda / 10\,) \pm i \times c_2\,]$$

s errechneter Bremsweg **5108 m**

Quelle; Dietrich Wende - Fahrdynamik des Schienenverkehrs - 1. Auflage
B.G. Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden 2003
ISBN 3-519-00419-4

Figure 50 Calculation of the braking distance using the Minden Formula

Berechung des Bremsweges nach Mindener Formel für P und/oder R gebremste Züge Z 46676 nach Auftrennung der HLL		Calculation of the braking distance using the Minden Formula for P and/or R braked trains. Train 46676 after separation of the main brake pipe	
Bremsausmaß Tfz + 1 Wagenhälfte 1. Wagen		Braking available: locomotive + half the first wagon	
Bremsgewicht Lok (t)		Brake weight: locomotive (t)	
Bremsgewicht 1. Wagenhälfte (t)		Brake weight first wagon half (t)	
Summe Bg (t)		Total brake weight (t) Bg	
Gesamtgewicht Zug Gg (t)		Gross weight of the train (t) Gg	
Bh (%) = Bg /Gg) x 100		Brake percentage Bh = Bg/Gg x 100	
Parameter	Parameter	Gewählt	Input
		Anmerkung	Remark
V ….Geschwindigheit (km/h)	V ….speed (km/h)	Aus Registriereinrichtung	From the recording equipment
Ψ…v-abhängiger Koeffizient (-)	Ψ…speed-dependent coefficient (-)	aus Tabelle	From the table

C1…..Beiwert für λ (-à	C1…..coefficient for λ (-)	aus Tabelle	From the table
C2….Beiwert für i (-)	C2….coefficient for i (-)	aus Tabelle	From the table
Λ….bremshunderstel (%)	Λ….brake percentage (%)	erechnet	Calculated
i…Streckenneigung (‰)	i…gradient of the line section (‰)	Gefälle mit negatiem Operanden eingeben	Gradient with a negative operator input

Berechnung des Bremsweges aus der Geschwindigkeit	Calculation of the braking distance from the speed
S errechneter Bremsweg	S calculated braking distance
Quelle; Dietrich Wende – Fahrdynamik des Schienenverkehrs – 1. Auflage B.G. Teubner Verlag / GWV Fachverlage GmbH, Wiesbaden 2003 ISBN 3-519-004194	Source: Dietrich Wende – Fahrdynamik des Schienenverkehrs [Dynamics of Rail Traffic] – first edition Publisher: B.G. Teubner Verlag /GWV Fachverlage GmbH, Wiesbaden 2003 ISBN 3-519-004194

The brake percentage for the configuration locomotive + the first half-wagon braked was calculated. Level track was assumed for the calculation of the braking distance. The calculation shows that train 46676 travelling at v = 125 km/h on level track would require some 5.1 km to come to a stop.

Using the Minden Formula to calculate braking distance also demonstrates that for the configuration locomotive + the first half-wagon braked no reduction in speed can be achieved on an average gradient of 14‰ and steeper.

7.14. Securing cable

The Federal Accident Investigation Bureau took a securing cable of identical design including the two cable grips from wagon 2387 4372 380-7 (eleventh wagon of train 46676) in Bludenz station on 23 July 2010 for further tests. The cable grips were opened and the cable undone to dismantle it.
A further securing cable was given to the Federal Accident Investigation Bureau by the infrastructure manager's staff. This came from wagon 2387 4372 379-9 (third wagon of train 46676). To recover this cable from wagon 379-9 it was cut through in one place. The cable was handed over with the two original cable grips still screwed up.

These components together with the cable and cable grips from wagon 2387 4372 372-4, recovered on 17 July 2010, were tested and reported on by an accredited test and inspection laboratory. The parts from the wagon involved in the accident (372-4) were visually examined and reported on. The reference components were examined visually and, in order to get comparable values, were subjected to tensile testing. The report was submitted to the Federal Accident Investigation Bureau.

7.14.1. Results of the tests on the cable

7.14.1.1. Interpretation of the visual findings concerning the damaged cable

Quotation from the report:

It was possible to establish from the visual examination of the damaged cable that it had been in use in various fittings and had been worn out by the scuffing and chafing of its fabric and the relative movements which are to be expected on vehicles. The consequent loss of tensile strength cannot be assumed to be a potential risk because of the low tensile strength required.

It could not be excluded that markings on the piece of cable originated from cable grips which have not held or only just held. Distorted areas, those that might be interpreted as having come from a firmly secured cable grip which had been pulled off, were not to be found.

7.14.1.2. Cause of the damage

Quotation from the report:

The measurements that were made and tests that were carried out allowed the following declaration to be made about the failure of the supporting sling for the brake hose:

There were no places with deformation damage on the damaged cable (of wagon 2387 4372 372-4) such as would have to be present if the cable grips used to create the sling were secured correctly and the sling were then to be forced open.

In particular, there was no damage to the clamping surface between the cable and the cable seating which would have arisen if the second end of the cable had been pulled out between the first end and the gripping plate. In the cable groove of the gripping plate of the cable grip there were likewise no signs of distortion from a braided cable being pulled out. From that it is to be concluded that properly tightened individual cable grips were not fitted to the damaged cable and naturally nor were the ends of the cable held by two tightened cable grips.

Presumably the cable ends were only placed loosely in the cable grips or the grips were only lightly tightened. Extended thread for nuts on the cable grip of the damaged cable corresponds to a clear space in the cable groove of up to 12.4 mm and shows that cable ends with approximately 2 x ø6.2 mm have enough space within this gap with slight or no pressure from the grip.
The following mounting conditions are presumed:

The individual cable grips were assembled using manual pressure and the nuts were likewise hand-tightened without using a spanner until there was resistance. Because of the restricted space and the friction the cable was able to support the weight of the brake hose (estimated as 10 kg) temporarily. Shaking movements made by the vehicle finally led to movement of the cable ends in the grip and ultimately to the supporting sling coming undone with the consequences we know.

7.14.1.3. Measures to avoid failure of the supporting sling

Quotation from the report:

Since in the current case the failure of the supporting sling into which the securing cable was formed would not have happened if two properly mounted cable grips had been present; the measures necessary may be limited to ensuring that there is greater certainty that the grips will be fitted properly.

We propose the following:

- *Severely damaged securing cables (for example, those with strands worn through at the bends and similar severe damage from corrosion) must be exchanged, even when the remaining cross-section is able to support the loads applied safely.*

- *In the checking processes after overhaul, a crude check of if the cable grips are screwed tight can be made by means of a simple load test (step on the supporting plate of the coupling). In any event, the sling must be in a position to support the weight of a person and the brake hose without problems. Loading is of course to be carried out in such a way as to be able to exclude injuries if the cable gives way.*

- *If used cable grips are to be re-fitted in the course of a general overhaul, there must be a check that the nuts still run properly on the threaded rods of the loops. Rods on which the nuts tighten too early because of a deformed threaded section must be rejected. Cable grips on which the nuts do not run properly are also to be rejected immediately.*

- *Each of the two nuts of the two cable grips should be tightened with a torque of about 3 Nm. In doing so, special care is to be taken to ensure that they are tightened in stages alternating between the threaded rods of a grip, so that both sides of the loop are equally tightened. Measuring the torque exactly is not necessary if the distortion of the cable in the area around the grip can be checked satisfactorily. The evaluation may be made by measuring a check dimension which provides the clear height in the cable groove by comparison with one tightened up with the correct torque. It is to be noted that this dimension may depend on the type of cable, even if the nominal diameter of the cables is 6 mm in both cases.*

- *Every supporting sling should always be supported with two cable grips even where the tensile forces do not require that. In that way the quality requirements on the individual cable grips can be kept modest.*

- *Collar nuts should also be used on cable grips which are designed to be used with them (wire rope grips in accordance with DIN 1142 or wire rope grip-1 in ac-*

cordance with EN13411-5) because the holes in the gripping plate sometimes require them. If it is not possible to manage an exchange in every case, special attention must be given to the condition of the cable and how it is deformed by the various cable grips. As an alternative, the use of nuts with suitable washers would be possible. The management of these multiple options on site rather argues against such an approach however.

In view of the modest forces which the supporting sling must bear, it is not necessary to limit the apparently differing wire rope grips of nominal size 6 to a particular design. For the requirements of current use it is of relatively little significance if grips with M5 or M6 threads are used if they are properly screwed up and are working properly. In any event, to make the management of cable grips simpler in the future a gradual change to a single design (wire rope grip-1, nominal size 6.5 in accordance with EN 13411-5 Appendix A or a similar type of wire rope grip) might appear sensible. Nominal size 6 is not included in the European Norm.

8. Summary of findings and conclusions

The brakes of train 46676 operated faultlessly as was documented by the evaluation of the recording equipment on locomotive 1116 173-4. In the downhill journey there were a total of five applications of the air brakes between Langen am Arlberg and Dalaas stations. In each case the train slowed down in relation to the fall in air pressure.

The driver behaved in accordance with the regulations. The automatic braking which took place was supported by the driver making a rapid brake application from the locomotive. Likewise an attempt to get an effective brake with the direct brakes on the locomotive was made. The subsequent operation of the emergency brake button conformed to the operating instructions for class 1116 locomotives.

The defective traction motor on bogie No 2 was not relevant to the performance of the E-brake. Despite the defective motor, the maximum permitted E-brake force of 150 kN was available from the locomotive. By means of software management a brake force of 50 kN was available from each of the three functional motors. The E-brake is not a fundamental requirement to run a train. Hence the E-brake is also disregarded in brake calculations. The continuous air brake is however required as a braking system.

The construction of the brake coupling with a metal plate bolted over it and the positioning of the screw flange (the place where the main brake pipe joins the brake hose) in the underframe of the wagon allowed the brake coupling which had been pulled off to become wedged in the underframe of wagon 372-4. Because the screw flange is free-standing in the underframe, the air hose could be bent back by almost 180° at that point and hence compressed such that brake air in the following part of the train was prevented from escaping.

Figure 52 Kinked brake hose wagon 372-4

The wedged brake hose cannot be regarded as a consequence of the derailment. The shearing marks which begin at the exit from Langen am Arlberg station and the impact marks on the covers of the point mechanism in Wald am Arlberg and Dalaas stations may be regarded as important pieces of circumstantial evidence. These impact marks were no longer evident in Hintergasse station. The brake coupling must have been wedged under the vehicle in the position it was finally found at that point.

From the condition of the securing cable of wagon 372-4 it may be concluded that the cable had been used in various fittings. The new U-bolt on the metal plate of the brake coupling furthermore demonstrated that maintenance work had been done on that component. The Federal Accident Investigation Bureau did not investigate in which workshop that work had been done.

The insignificant pressure marks on the securing cable substantiated the inadequate purchase of the cable grip on the securing cable. Hence as a result of dynamic movement the brake coupling was able to fall below rail level and as a further consequence hit against point covers, decking and the rails stacked at km 122.722.

The rails stacked at km 122.722 were so stacked that the clearance of 50 mm above rail level (in accordance with ZSB 9) was respected. Vertical movement of more than 1 mm by the rails may be excluded according to the results of the measurements that were submitted. The loading gauge required in accordance with ZOV 7 [Lineside structure gauge] was respected.
The lateral minimum clearance to the running rails of at least 40 mm in accordance with ZSB 9 was not exceeded.
The fact that the whole brake coupling assembly was hanging too low after the failure of the securing cable made the impact of the brake coupling possible.

9. Other irregularities which did not contribute to the accident

9.1. Different information in the VzG [List of locally permitted speeds] and the Bsb [operating location description]

In the Bsb for Langen am Arlberg, Dalaas and Braz stations on section 10105 the details differ from those in the VzG:

The information in the Bsb for the position of the operating locations of “Langen am Arlberg station” and “Hintergasse station” does not agree with that in the VzG.

By taking account of the “kilometric adjustment -228 m” in the VzG of 19 October 2009 the kilometric distances for operating locations and features were altered by 228 m. When the Federal Accident Investigation Bureau made an arithmetical check the kilometric distance for the operating location “St. Anton am Arlberg No 1 automatic signal” agreed with the VzG but did not agree with the kilometric adjustment.

Operating location	Old kilometric distance	New kilometric distance should be	Kilometric distance in the VzG of 2010	Bsb details
St. Anton am Arlberg No 1 auto	km 101.586	km 101.358	km 101.586	km 101.568
St. Anton am Arlberg No 2 auto	km 104.760	km 104.532	km 104.532	km 104.760
St. Anton am Arlberg No 3 auto	km 108.372	km 108.144	km 108.144	km 108.372
Langen am Arlberg station			km 110.715	km 110.707
Hintergasse station			km 125.177	km 125.171

Figure 53 Table showing different information in the VzG and Bsb

9.2. Markings on the Laaeks wagon involved

According to the type plan, the wagon is designated as Laaeks.

The letter code “Laaeks” is not marked on the wagon (in accordance with UIC leaflet 438-2, point 5).

The letter code “k” is not defined in UIC leaflet 438-2 Appendix F4.

10. Cause

The cable grip on the securing cable of the brake coupling of wagon 372-4 was not properly secured. Because the cable grip had inadequate purchase on the securing cable, the brake coupling loosened by the relative movement of the whole brake coupling assembly as a result of dynamic movement fell below rail level and in consequence hit the rails stacked on the track.

The construction of the brake coupling with a metal plate bolted over it and the positioning of the screw flange (the place where the main brake pipe joins the brake hose) in the underframe of the wagon allowed the brake coupling which had been pulled off to become wedged in the underframe of wagon 372-4. Because the screw flange is free-standing in the underframe, the air hose could be bent back by almost 180° at that point and hence compressed such that brake air in the following part of the train was prevented from escaping.

The impact of the brake coupling that was hanging down and the subsequent wedging of the brake coupling in the vehicle underframe was the trigger for the brake failure which consequently led to the derailment of train 46676.

The absence of signs of distortion of the cable and cable grip allows forced opening of the supporting sling of the securing cable to be unequivocally excluded.

11. Comments considered

The comments received from people and bodies nominated by Section 14(1) and (3) of the Accident Investigation Act and involved [with the accident] have been incorporated in the accident investigation report subject to the following remarks or attached to the accident investigation report in their entirety (see Attachment G: comments received within the time limits, page 82.).

In the course of the final meeting on 27 May 2011, the legal advisor gave a workshop that is not named in the accident investigation report the task of making a comment on the report. A fourteen-day limit was set for this task.

11.1. Comments by the wagon keeper

The following points relating to the comments by the wagon keeper should be recorded:

Re 1. “Preliminary remarks on constitutional law”

The wagon keeper thought that the Federal Accident Investigation Bureau would be biased and not sufficiently independent. In response it might simply be remarked that in the context of their activities as an investigation agency, the staff employed in the Federal Accident Investigation Bureau are not bound by any instructions from outside the Accident Investigation Bureau and carry out their investigations independently in accordance with Section 4 of the Accident Investigation Act. There is no “dependence on closely related railway undertakings and infrastructure mangers” of any kind whatsoever. This has already been confirmed by the Volksanwalt [Ombudsman] who provided a detailed justification in the case of a similar complaint (Reference BD/197-VIN/08 of 14 July 2009 Volksanwaltschaft’s report). The text of the conclusion of the report reads that “no doubts about the legal conformity of the domestic statutory situation with Community or constitutional law can be raised because the independence of the staff members of the Accident Investigation Bureau is a given in the light of the clear phrasing of the statutory provision cited (Section 4(3)) taking into account the relevant legal precedents provided by the judgments made by the Constitutional Court”.

Re 2. “storage of used rails on the track in violation of the law”

2.1 “Preliminary remarks”

The wagon keeper expressed the view that “*had the used rails not been stacked in that area the accident would not have happened; at the most a brake hose hanging down would be noticed by the Swiss railway undertaking at the handover of the train in Bludenz station and remedied*”.

In response, it was established in the investigation that the brake coupling which was hanging too far below rail level made the impact against the stacked rails possible. There is no handover of trains to Swiss railway undertakings in Bludenz station or any wagon examination by them.

We will not comment further on the hypothetical statement by the wagon keeper that a Swiss railway undertaking would have noticed the hanging brake hose and remedied it.

Re 2.2 “Position of the used rails between the running rails”

The wagon keeper said “*actually the storage of the used rails contravened the regulations*”.

In response, it was established in the investigation that the storage of the rails **did not encroach upon** the normal loading gauge in accordance with ZOV 7 [Lineside structure gauge] (for details, see page 46, point 7.10.3 and page 71, Attachment A: ZOV 7 Table 7/2 loading gauge). This loading gauge was unobstructed for the safe running of railway rolling stock. On the contrary **railway rolling stock may not exceed the normal loading gauge**. The dimensions in ZOV 7 comply with international standards in conjunction with UIC leaflet 505-1 “Rolling stock construction gauge”.

The wagon keeper further expressed the view that under 2.2 “*seven used rails were stacked approximately parallel to and between the running rails and furthermore in such a way that the clearance was a maximum of 10 mm to the left and right hand side running rails. The track axis was completely blocked by used rails in which the front end of the used rails pointed exactly in the direction of travel*”.

Storage of the used rails was noted in the investigation and documented in the accident investigation report (see Figure 14 Stacked used rails and Figure 15 Point of impact).

Re 2.3 “Storage of the used rails in the light of ZOV 7 [Lineside structure gauge]”

In paragraph one, the wagon keeper objected that in accordance with ZOV 7 Table 7/2 the lateral minimum clearance for non-moving objects not secured to the running rails must be 15 cm.

In response, it should just be remarked that this minimum lateral distance in accordance with the regulations quoted (**"a"** in the following excerpt) is to be maintained outside the running rails (c.f. Figure 54 Excerpt from Table 7/2 ZOV 7 page 6).

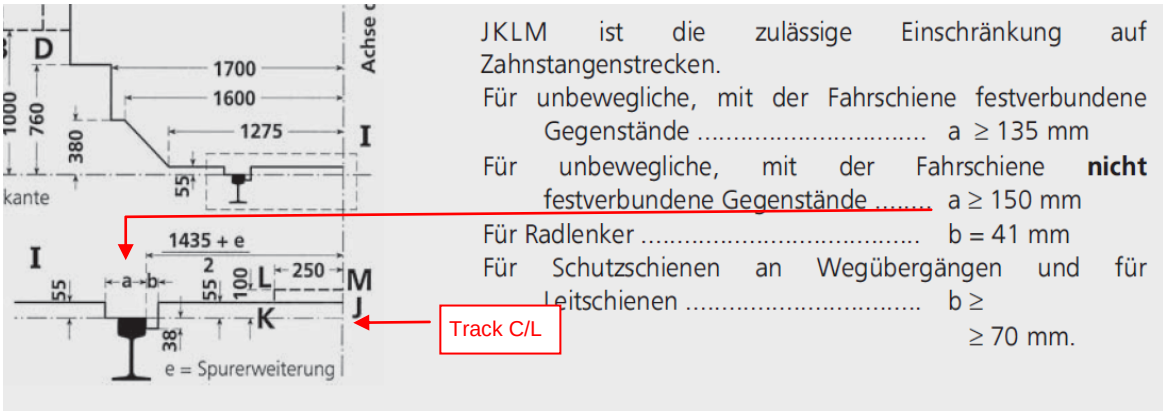


Figure 54 Excerpt from Table 7/2 ZOV 7

JKLM ist die zulässige Einschränken auf Zahnstangenstrecken.	JKLM is the permitted encroachment on sections fitted with rack rails.
Für unbewegliche, mit der Fahrschiene festverbunden Gegenstände 0000a135 mm	For non-moving objects attached to the running rails ... a ≥ 135 mm
Für unbewegliche, mit der Fahrschiene **nicht** festverbundene Gegenstände	For non-moving objects **not** attached to the running rails a ≥ 150 mm
Für radlenker	For check rails... b = 41 mm
Für Schutzschienen an Wzgübergängen und für Leitschienen,	For check rails on level crossings and other types of check rail.

In the second and fifth paragraph, the wagon keeper objected "*in addition, it has not been established that the loading gauge above rail level was maintained. It is well known that if rails are stacked between the running rails that they can lift slightly above rail level at their ends (to the extent that they are not secured at the ends – which seems not to have been the case here) because of oscillation, vibration and air currents from the passage of trains*" and "*it may be conjectured that since the stacked rails were not secured they could move in such a way that at the moment the train passed over they moved slightly upwards and hence the safe clearance above rail level was no longer maintained …*".

This comment was considered and appropriate tests and measuring train runs commissioned. The results are considered in the accident investigation report and attached as Attachment 1.

In the third and fourth paragraph, the wagon keeper quotes from the parallel criminal investigation run by the Bludenz District Court "*on the underside of locomotive 1116 173-*

4 clear signs of an impact with a fixed object were noted and this fixed object must have been across the direction of travel. These markings were on the side and exactly in the area in which markings could also be noted on the stacked rails. The investigation bureau seems not to have followed up this evidence".

This comment was considered and the damage to the locomotive was documented in the accident investigation report. The damage to the underside of locomotive 1116 173-4 was considered to be damage from the derailment and its consequences. Had the stacked rails (at km 122.722) caused this damage to the locomotive, the ends of the rails would have been significantly more damaged or would have demonstrated significantly greater signs of impact (see Figure 14 and Figure 15 on page17).

Re 2.4 "Storage of the used rails taking ZSB 9 [Keeping the track clear] into account"

This comment was considered and safety recommendation **A-20/2011** adopted in the final accident investigation report in order to lay down a standard set of regulations for stacking of rails on or around the track.

Re 2.4 "Storage of the used rails in conformity with ZOV 48 [Handling and storage of permanent way materials]"

In response to the comment made by the wagon keeper on the provisions and dimensions in ZOV 48 and stacking of rails in accordance with these regulations to the effect that the storage of these rails was contrary to the regulations, we would point to point 7.10.2 page 46 of the accident investigation report (ZOV **48**) which describes the purpose of ZOV 48, i.e. the protection of stacked rails from damage so that they can be re-used. The used rails stacked in this case were intended for scrapping and not for re-use and stacked before removal.

In the final accident investigation report, an appropriate safety recommendation has been adopted in order to lay down a general regulation for the storage of rails on or around the track.

Re 3. “Technical condition of locomotive 1116 173-4”

Re 3.1 Failure of a traction motor

The wagon keeper objected to the Federal Accident Investigation Bureau’s remarks that “*all the attempts that the driver made to apply the brakes had “no effect at all” (Preliminary Report page 39, point 7.8, second para.)*” as being technically illogical and not comprehensible.

An alternative phraseology was adopted for the effectiveness of the braking in the accident investigation report.

Re 3.2 Brake force required and its reduction, consequences of the failed traction motor

In response to the claims made by the wagon keeper, we would remark that no account is to be taken of the E-brake force theoretically possible from locomotives of class 1116, since in accordance with the relevant regulations E-brake force is **not** a fundamental requirement for a train to run. The maximum permitted E-brake force of locomotive 1116 173-4 for train 46676 was limited to 150 kN since the train comprised exclusively single axle wagons. This 150 kN brake force was applied by the locomotive despite the failure of the traction motor. An E-brake force of 240 kN is only permitted for trains exclusively composed of bogie wagons which have an assisting locomotive.

Increasing the E-brake force to **300 kN is not possible**. Increasing the E-brake force from 150 kN to a maximum of 240 kN by means of the locomotive display is possible from **both cabs** but in the case in point was **not permitted**. The maximum permissible E-brake force for train 46676 was 150 kN since the train comprised exclusively single axle wagons. Increasing the E-brake force in the case in point could have led to the wagons in the train becoming lock-buffered and in consequence could also have led to derailment.

Re 3.3 Safety recommendation

The wagon keeper's recommendation to amplify the safety recommendations so that in the case of a loss of pressure in the main brake pipe without the train separating, the driver should manually over-ride the limitation of the brake force so that the locomotive reaches the maximum possible brake force of 300 kN was not pursued because of the risk of derailment. The current regulation for limiting brake force on class 1116 locomotives will be maintained.

Re 4.2 Mistaken assumption of a divided train

The phraseology that loss of air "in principle means a divided train" is covered in DV V3 §94 para 7. Quoting from DV V3 "*… every sudden drop in pressure in the main brake pipe must be assumed to be a divided train until the cause is clarified.*"

In this situation, it was not possible for the driver to clarify the exact cause of the loss of air.

Re 4.3 Application of automatic braking

It was established in the accident investigation report that the brakes came on automatically but for the reasons stated in the report that was not enough to bring the train to a halt. Concerns about the failure of the air brakes are considered in detail in the accident investigation report.

Re 4.4 Circumvention of SIFA (remark: vigilance device)

The vigilance device was in no way circumvented by the driver and there were no signs to suggest that SIFA was not working. The failure of the air brakes (for reasons stated in the accident investigation report) meant that SIFA, which also makes use of the air brakes, could only have a limited effect. The brake force from the locomotive and the first half-wagon was not enough to bring the train to a stop on the gradient.

Re 4.6 Inappropriate operation of the emergency brake button

The driver operated the emergency brake button in accordance with the operating instructions for the locomotive; see point 7.6.3 on page 32.

Re 4.7 Safety recommendation

The wagon keeper's proposal to supplement the safety recommendations to provide that in the event of an air loss in the main brake pipe without a divided train that the driver manually overrides the limitation on the E-brake force so that the locomotive could exert the maximum possible E-brake force of 300 kN cannot be pursued for technical reasons. Once the automatic brake is applied on the locomotive by a loss of air in the main brake pipe, it is no longer possible for the driver to change the E-brake force manually.

Re 5 Checks made on train 46676 on handover

This comment was considered and the wagon examination record in accordance with the GCU Appendix 9 is attached to the accident investigation report as Attachment F.

Re 8.1. Contradictory information on the brake percentages

The entry "Bhmax" is an abbreviation used in DB 639 and means brake percentage required. The abbreviation was adopted in Section III of the accident investigation report. In the book timetable, the "Bhmax" value shows the **maximum** brake percentage required for a train running at the timetabled speed to come to rest within the shortest braking distance.

Re 8.2. Contradictory information on maximum speed

The VzG [List of locally permitted speeds] shows the maximum permitted line speed on individual sections of line. The book timetable containing the relevant speed information remains the authoritative source for the maximum speed of a train.

Re 8.3 Holding the speed of a train with the E-brake

The steep section proper begins in Langen am Arlberg station and ends in Bludenz station. This was correctly stated in point 3 of the accident investigation report.
The section from St. Anton am Arlberg station to the exit from the Arlberg tunnel in Langen am Arlberg station has a maximum gradient of 16 ‰. On this section the speed of the train could have been held with the E-brake.

From Langen am Arlberg station to Dalaas station, the line has a gradient of up to 32 ‰. The E-brake alone was no longer adequate on this section and the driver also used the air brake.

Re 8.4 Signs of the impact of the allegedly hanging brake coupling

The Federal Accident Investigation Bureau's search for evidence took place from 16 to 17 June 2010. It involved a search of the line between Hintergasse station and Langen am Arlberg station for clues. Inter alia, the section from Langen am Arlberg station to the Blisadona Tunnel was searched for signs of impact, the securing cable and the cable grips from wagon 372-4 with the help of the authorities.

The still fresh marks of impacts found during the search for evidence were recorded photographically and documented in the accident investigation report. The marks of the impact on the plastic decking were clearly visible at that time. They were not covered in brake dust and therefore could be unambiguously associated with the incident.

Re 8.5 Sites at which the securing cable and the cable grips were found

The following illustrations make it easier to understand the technical reasons why the sites at which the securing cable and the cable grips were found were more than four kilometres apart.

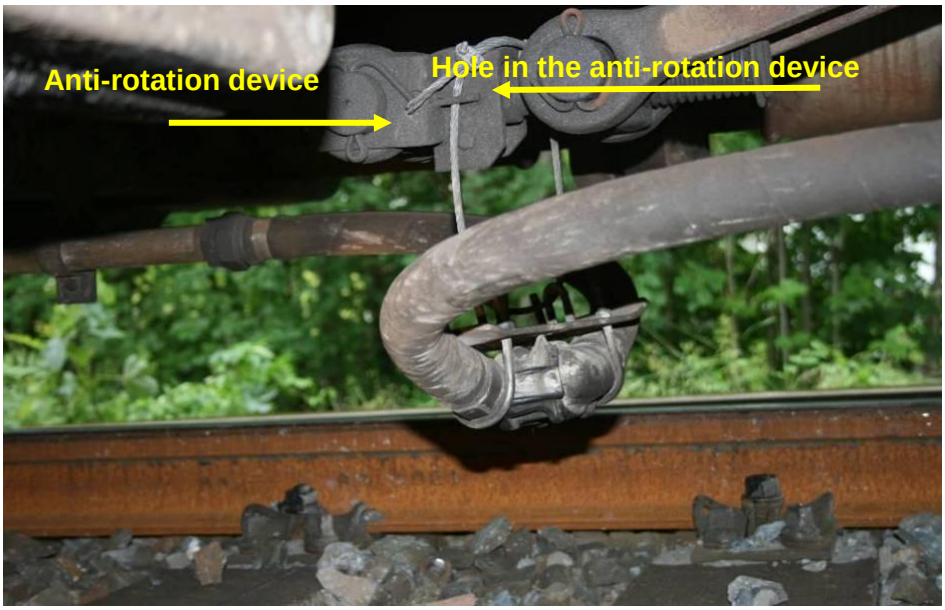


Figure 55 Anti-rotation device

Figure 56 Hole in the anti-rotation device – detail

After the cable grip fell off at km 116.633, the securing cable itself just hung loosely in the hole through the anti-rotation device in the coupling spindle and the loops in the metal plate until it was completely pulled out in Dalaas station.

Re 8.6 Replacement of the brake coupling by a continuous pipe

It is not possible to understand the objection to the length of the continuous hose, and for a continuous brake hose the support mechanism would no longer be required. The associated safety recommendation will be justified in more detail in the accident investigation report to underline the necessity.

11.2. Comments by the BMVIT [Austrian Ministry of Transport]

11.2.1. Comment by Section IV/SCH2

Re 4. Paragraph concerning the safety recommendation to modify the emergency brake button

The safety recommendation to modify the emergency brake button was deleted.

11.2.2. Comment by Section IV/SCH4

Re 3. Subsidiary wagon type code “k”

Appendix F4 of UIC leaflet 438-2 is the authority for wagon type codes in the accident investigation report. Code letter “k” is not defined in that appendix.

Re the comments on safety recommendation 12.1, 12.2 and 12.3

Whether this safety recommendation could be relevant to other vehicles with low loading platforms was not examined. The safety recommendation for the vehicle type in question was made more specific to highlight the necessity.

Re the comment on the safety recommendation to modify the emergency brake button

The safety recommendation to modify the emergency brake button was deleted.

11.3. Comments by the traction provider

The comments by the traction provider were considered and the safety recommendation for the emergency brake button was deleted.

11.4. Comments by the railway undertaking

In Section II, the List of the Regulations was supplemented by adding the ZSB [Supplementary Provisions to the Signalling and Operating Regulations] and DG 610 was corrected to DB 610.
In point 3, Description of the Incident, another formulation for partial brake test was chosen.
In point 7.7.2 Brake equipment, “operation of the brakes” was changed to “performance of the brakes”.

12. Safety recommendations

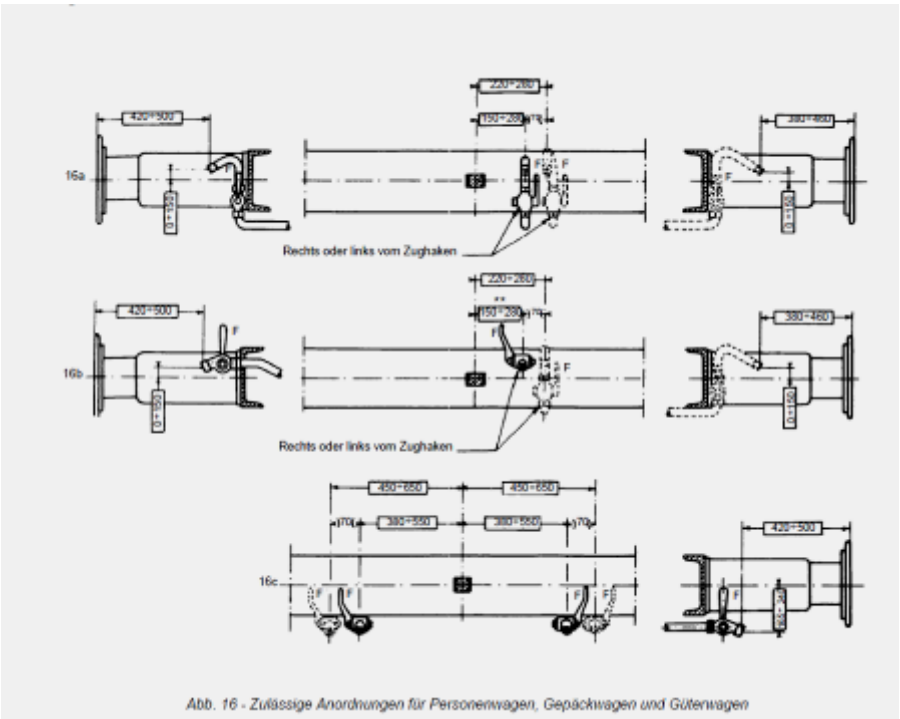
In accordance with Article 25(2) of EU Directive 2004/49/EC r*ecommendations shall be addressed to the safety authority and, where needed by reason of the character of the recommendation, to other bodies or authorities in the Member State or to other Member States. Member States and their safety authorities shall take the necessary measures to ensure that the safety recommendations issued by the investigating bodies are duly taken into consideration, and, where appropriate, acted upon.*

The safety recommendations issued by the Federal Accident Investigation Bureau Rail Section as immediate measures in **GZ: BMVIT-795.204/0001-II/BAV/UUB/SCH/2010** in accordance with Bundesgestzblatt No 123/ 2005 Accident Investigation Act Section 16(2) are replaced or supplemented as appropriate by the following safety recommendations:

Annual serial number	**Safety recommendation**	**ad-dressed to**
A-17/2011	For car transporter wagons of type **23 87 437 2** xxx-x which have that or a similar design of linkage and suspension of the brake coupling between the two wagon halves, ensure that until this class of vehicle can be rebuilt • the brake coupling is suspended and secured safely (two cable clips fitted, cable clips firmly secured, undamaged cable and securing loop), • safe support is provided for the brake coupling, • a minimum distance of 140 mm is provided between the rail level and screw coupling components, brake coupling components and the support system. These features should be checked by means of special examinations of the wagons in question in the vehicle owner's [=keeper's?] servicing workshops. Until the special examinations are complete, the wagon owner should organise checking of these features in service, for example when loading or unloading. Safety recommendation A-58/2010 is withdrawn.	**NSA** **Vehicle keeper** **ERA**
Annual	**Safety recommendation**	**ad-**

serial number		dressed to
A-18/2011	For car transporter wagons of type **23 87 437 2** xxx-x which have that or a similar design of linkage and suspension of the brake coupling between the two wagon halves, until this class of vehicle can be rebuilt, it is recommended that: – severely damaged securing cables, for example, those with strands worn through at the bends and similar severe damage from corrosion, must be replaced even when the remaining cross-section is able to support the loads applied safely. – In the checking processes after overhaul, a crude check of if the cable grips are screwed tight can be made by means of a simple load test (step on the supporting plate of the coupling). In any event, the sling must be in a position to support the weight of a person and the brake hose. Loading is of course to be carried out in such a way as to be able to exclude injuries if the cable gives way. – If used cable grips are to be re-fitted in the course of a general overhaul, there must be a check that the nuts still run properly on the threaded rods of the loops. Rods on which the nuts tighten too early because of a deformed threaded section must be rejected. Cable grips on which the nuts do not run properly are also to be rejected immediately. – Every supporting sling should always be supported with two cable grips even where the tensile forces do not require that.	**Wagon keeper** **ERA**

Annual serial number	Safety recommendation	ad-dressed to
Further to A-18/2011	– Each of the two nuts of the two cable grips should be tightened with a torque of about 3 Nm. In doing so, special care is to be taken to ensure that they are tightened in stages alternating between the threaded rods of a grip, so that both sides of the loop are equally tightened. Measuring the torque exactly is not necessary if the distortion of the cable in the area around the grip can be checked satisfactorily. The evaluation may be made by measuring a check dimension which provides the clear height in the cable groove by comparison with one tightened up with the correct torque. It is to be noted that this dimension may depend on the type of cable, even if the nominal diameter of the cables is 6 mm in both cases. – Collar nuts should also be used on cable grips which are designed to be used with them (wire rope grips in accordance with DIN 1142 or wire rope grip-1 in accordance with EN13411-5) because the holes in the gripping plate sometimes require them. If it is not possible to manage an exchange in every case, special attention must be given to the condition of the cable and how it is deformed by the various cable grips. As an alternative, the use of nuts with suitable washers would be possible. The management of these multiple options on site rather argues against such an approach however. These points are to be actioned by the vehicle keeper providing appropriate workshop instructions to the workshops responsible for servicing in each case. *Justification: these actions should exclude the failure of the supporting sling of the securing cable.*	**Wagon keeper** **ERA**

Annual serial number	Safety recommendation	ad-dressed to
A-19/2011	For car transporter wagons of type **23 87 437 2** xxx-x which have that or a similar design of linkage and suspension of the brake coupling between the two wagon halves, it is recommended as a medium term measure to replace the brake coupling between the two sections of the wagon by a through air pipe without a coupling. *Justification: Because the screw flange is free-standing without a cut-off cock in the underframe, the brake-hose can be bent by some 180° at this point and thus compressed so that no brake air can escape. This vehicle-specific construction deviates from the normal constructional characteristics defined in UIC leaflet 541-1. See the diagram below (source: UIC leaflet 541-1 Appendix B2) and Figure 34 Brake coupling in the middle of the vehicle on page 37.* *The following diagram is also shown in Attachment E to the* accident investigation report.  *Abb. 16 - Zulässige Anordnungen für Personenwagen, Gepäckwagen und Güterwagen* Safety recommendation A-59/2010 is withdrawn.	**Vehicle keeper** **ERA**

Annual serial number	Safety recommendation	ad-dressed to
A-20/2011	ZOV 48 [Handling and storage of permanent way materials] and ZSB 9 [Keeping the track clear] covering stacking of rails for scrap and re-use on and around the track should be aligned as appropriate with ZOV 7 [Lineside structure gauge] to create a single set of regulations.	**NSA** **Infra-struc-ture manager**

The safety authority and other authorities or bodies or, when appropriate, other Member States to which recommendations have been addressed, shall report back at least annually to the investigating body on measures that are taken or planned as a consequence of the recommendation. (EU Directive 49/2004/EC, Article 25(3).

This accident investigation report is being sent to:

Organisation/function
Driver of train 46676
Authorised representative of the wagon keeper
Infrastructure manager
Railway undertaking
Traction provider
Staff representative
Federal Ministry of Transport, Innovation and Technology
Public Prosecutor's Office Feldkirch
European Railway Agency
BMWFS – Clusterbibliothek [Federal Ministry for Science and Research library??]

Vienna, 8 August 2011

Leader of the Investigation:

Signed by Ing. Johannes Piringer

Leader of the Investigation:

Signed by Erich Landl

Attachments:
Attachment A: ZOV 7 Table 7/2 Loading gauge
Attachment B: ZSB 9 Keeping the track clear
Attachment C: Excerpt from ZOV 48 Handling and storage of permanent way materials
Attachment D: Analysis of the recording equipment
Attachment E: UIC 541-1 Appendix B.2 Arrangement of air-brake connections
Attachment F: Wagon examination record
Attachment G: Comments received within the time limits
Attachment H: Report on the tests on the cable
Attachment I: Results of measurements on the stacked rails