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Rev. 01 - en

Analysis Report

SCI Denver

Denver VII

Project-No. 40004F1A

Customer SIEMENS NA

Project-Part Doors

System RLC-E2

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Revision History

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00	05.03.2019	Wagner T. Steinauer H.		
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1 Reference Documents

Doc. ID	Doc.No.	Äl (Index,..)	Title
01	T003565R03	2	Installation drawing
02	TREXLRV18r5aJun24	June 24, 2002	Transportation Expansion Project Light Rail Vehicles – Section 18 (Doors and Bridge Plates)

2 Definition

2.1 Abbreviations

RTD	Regional Transportation District
RLC	Reverse Locking - Classic system
MST	Mountain Standard Time
RH	Right hand
LH	Left hand
DL	Door leaf
PD	Production Date
S/N	Serial Number

door leaf, door leaves, door panels are used to id the same thing

3 Project description

3.1 Train Operator

RTD has 10 lines with 53 stations serviced by ~ 135 Siemens trains.

<http://www.rtd-denver.com/who-we-are.shtml>

- A** Union Station to Denver Airport Station
- B** Union Station to Westminster
- C** Union Station to Littleton - Mineral Station
- D** 18th & California Station to Littleton - Mineral Station
- E** Union Station to Lincoln Station
- F** 18th & California to Lincoln Station
- H** 18th & California to Florida Station
- L** 30th & Downing to 16th & Stout
- R** Lincoln Station to Peoria Station
- W** Union Station to JeffCo - Golden Station

Combined schedules

- C D** Southwest Line
- E F H** Southeast Line

Image 1: RTD Lines

3.2 Train

The trains are Siemens SD-160 trains. Each train consists of two cars, an A-car and a B-car and has three bogies (one on each end and one in the center between the two cars). A car diagram is included in Image 4.

3.3 Door system

The door system is a RLC system with a free width of 1200mm and a portal height of 2778mm.

Door 1 production:

LH DL	3T002930R28:	S/N D730238	PD: 10/2009
RH DL	3T002930R19:	S/N D720238	PD: 10/2009
LH Door leaf carrier	3T104329R20:	S/N 64/045	PD: 04/2010
Drive Unit	3T002741R76:	S/N 10100004	PD: 10/2010

3.3.1 RLC Components

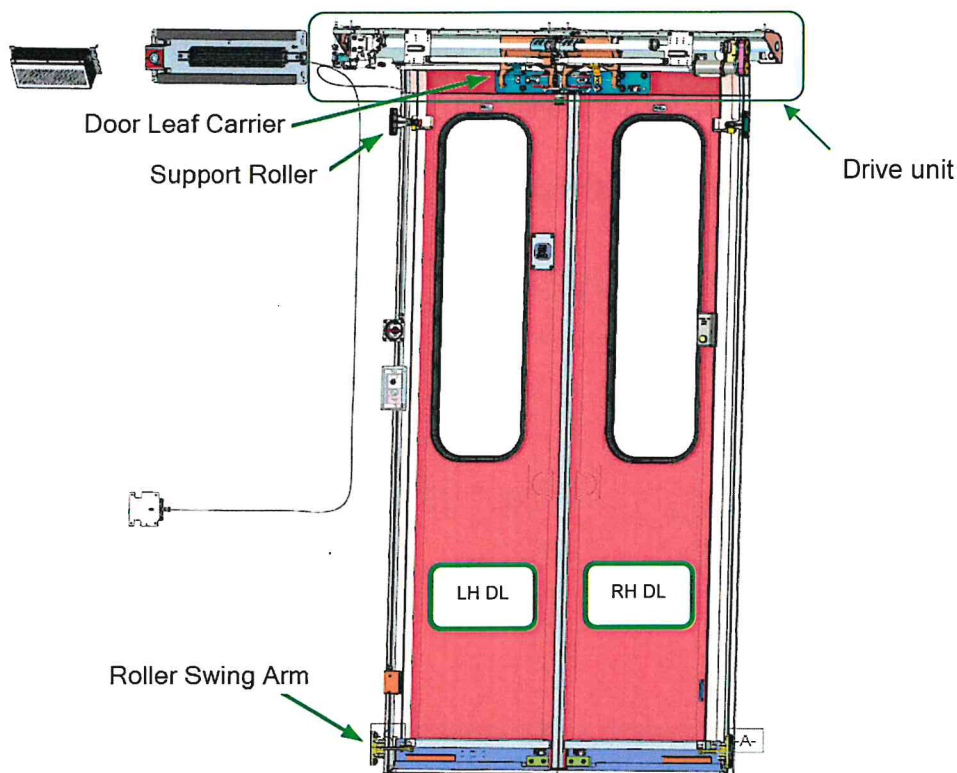


Image 2: RLC Components (symbolic image)

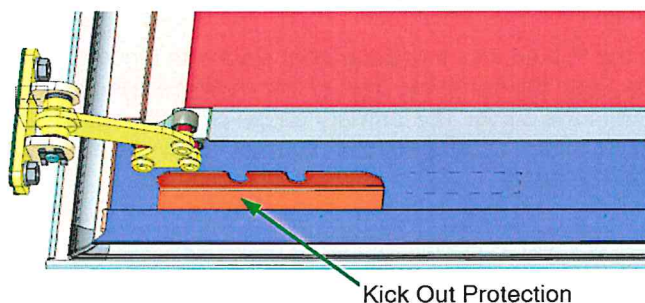


Image 3: RLC Components (Kick Out Protection)

3.3.2 Specification

The system was designed to withstand the requirements according to the project specification TREXLRV18r5aJun24 (890N single load on 930cm² per door panel located 50mm from the leading edge and centred within the door height).

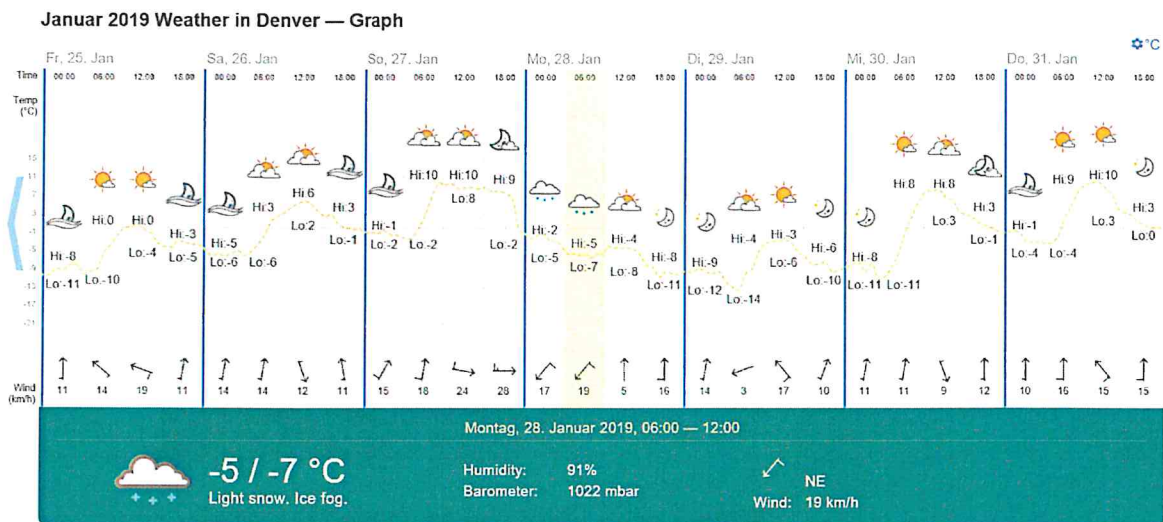
4 Introduction

4.1 Investigation reason

On 28.01.2019 at 7:15am MST a train on the R-Line derailed. During the accident a female passenger was ejected from the LRV and suffered serious injuries. Because an IFE door system was involved in the accident an IFE team went to Denver to investigate.

4.2 Weather condition

Light snow. Ice fog. -7°C. 19km/h NE wind. Source: <https://www.timeanddate.com/weather/usa/denver/historic?month=1&year=2019>



4.3 Accident description

Train 316 from the R-Line was travelling from Peoria to Lincoln, at junction Sable Boulevard and Exposition Avenue East, the complete train (2 car train) derailed and was sliding towards the rails of the counter direction in the curve. The primary cause of the derailment was that the LRV entered the curve at excessive speed according to RTD (max. allowed speed and speed records are not available for IFE at the moment).

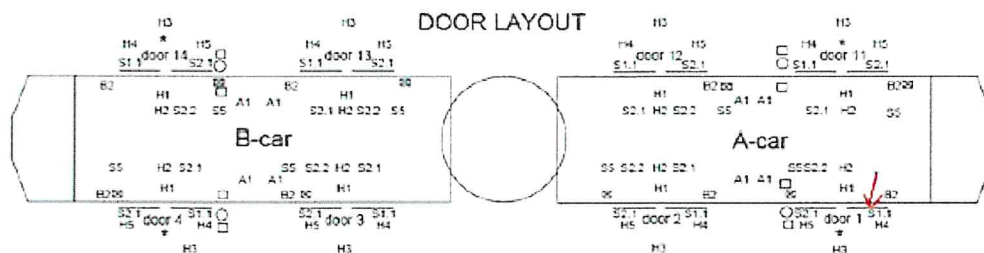


Image 4: Car Diagramm

The front car (B car) was caught in the rails of the counter direction; the end car (A car) was sliding
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over the rails. During the derailment the train tipped on an angle and was sliding only on its outer wheels (train side of Door 1) and all lower door portal structure on this side.

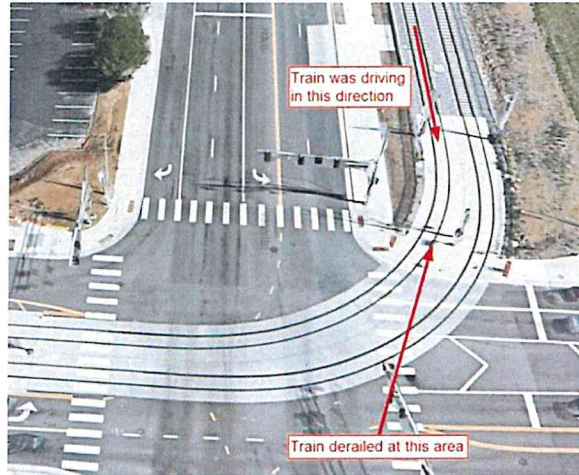


Image 5: Accident location

Pictures and videos (security camera) of the accident exist, but are not able to be shared with IFE at this time. RTD has not confirmed if IFE will be given access to this material.

It can be assumed that there were two significant impacts to Door 1. The first impact was the collision of the door leaf with the threshold (see Image 18: Threshold with mark of door leaf) caused by the derailment of the train. Due to the derailment and tilting of the train a passenger was forced down, impacting the door leaf.

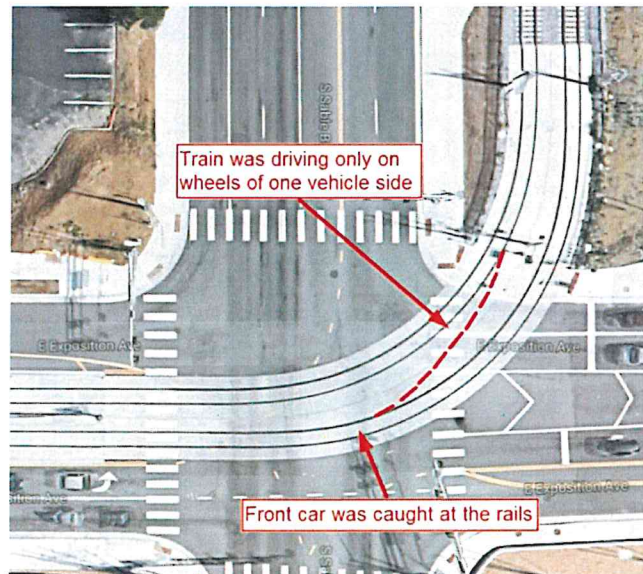


Image 6: Sliding traces during first impact



Image 7: Stairs at door 1

There was a second impact on Door 1 which is assumed to happen when the end car was sliding over the rails. The lower member of the door portal was bent to the inside of the vehicle during this impact it had direct contact with the street.

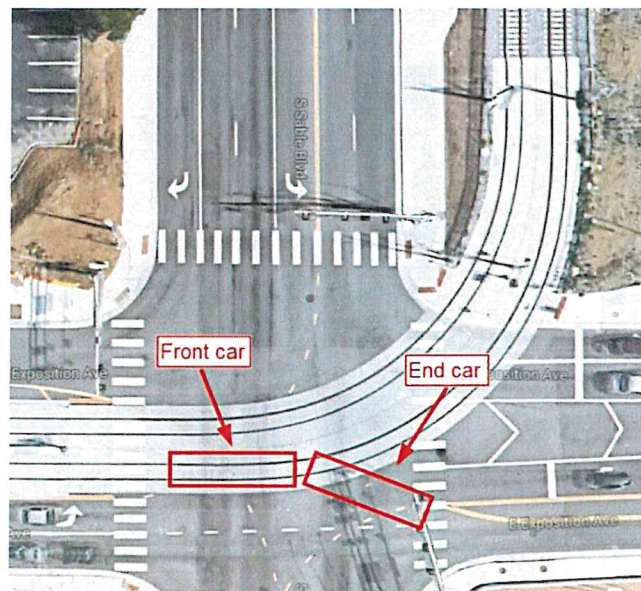


Image 8: A-CAR sliding over rails

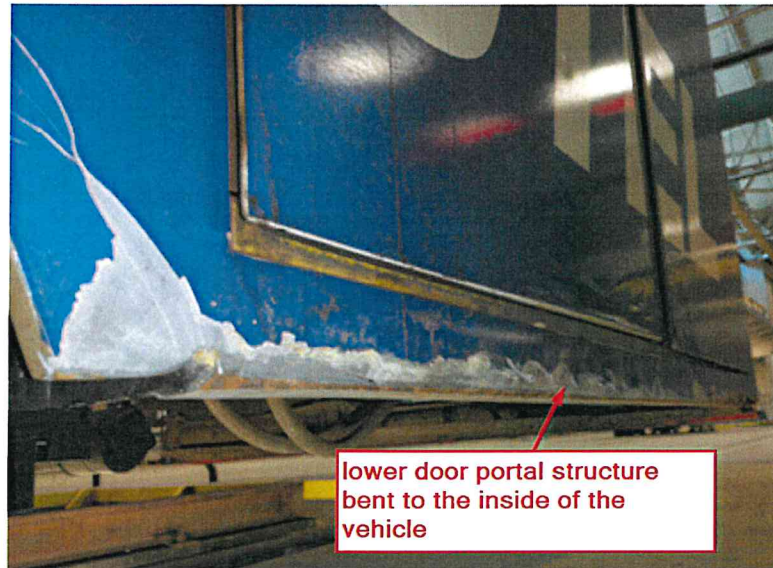


Image 9: Threshold of door 1

5 Consequences of the accident

- The right door leaf of Door 1 rotated counter clockwise (view from outside) and pushed the support roller to the end of the elongated holes



Image 10: Threshold - Lower door leaf

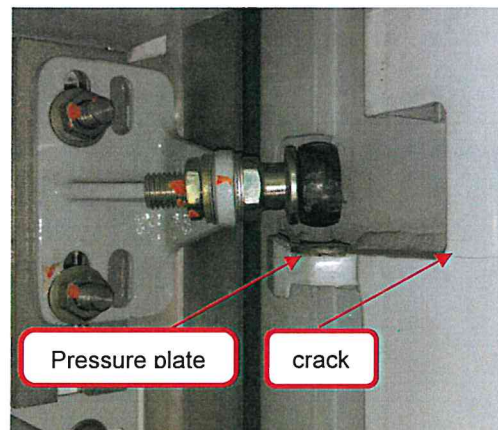


Image 11: Support roller with elongated holes

- Door leaf and door leaf carrier were twisted and collided with the upper sealing frame

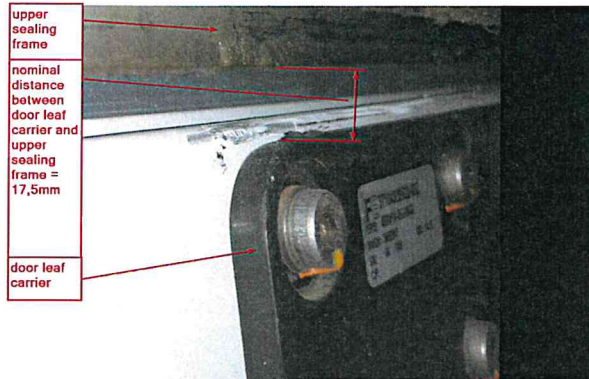


Image 12: Scratches on door leaf and carrier



Image 13: Bending on sealing frame

- Lower bracket (kick out protection which is installed to prevent vandalism by passengers) was ripped off by the roller swing arm



Image 14: kick out protection



Image 15: Bonding area of kick out protection on left door leaf of doorway #1 vehicle 316

- The door leaf was lifted out from the roller swing arm and therefore had no guiding in the lower area anymore.

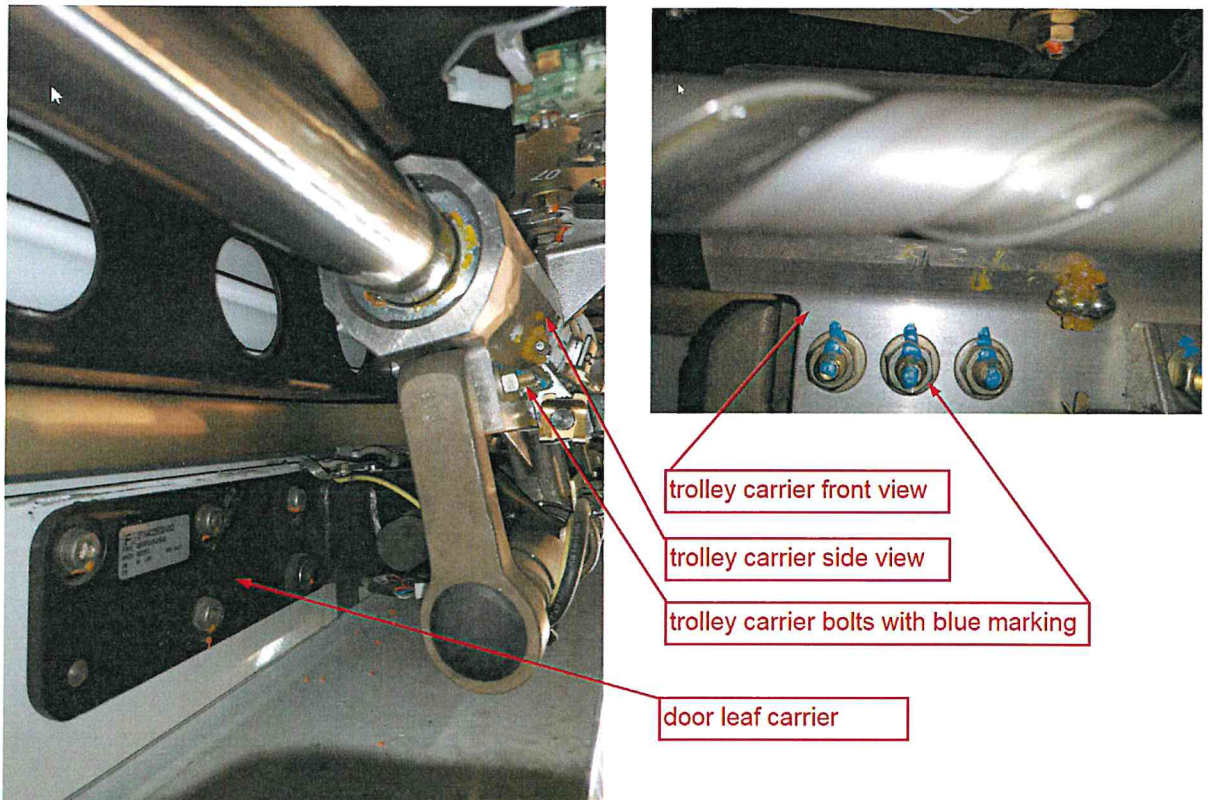


Image 16:
Lifted out roller swing arm

Due to the above described consequences of the accident a part of the passenger's leg was exposed outside of the train, got trapped between threshold and street and was severed. When the leg was trapped between threshold and street the passenger was pulled out of the train through the gap between threshold and the left door leaf (view from inside; see also Image 7)

6 Additional findings on Door 1

- No plastic deformation of the portal could be measured. (height, diagonal measurement)
- All mounting bolts of the drive unit were still in position (screw marking not cracked), only the marking of the left door leaf mounting bolts was cracked.
- Bolt markings on the trolley carrier were not cracked



- Door leaf guiding rail did not show any indication of movement due to the accident
- Even though the paint of the door leaf was cracked under the left door leaf carrier and at the pressure plate (see image 11) there was no deformations visible (flexible bending)
- The lower left door leaf area showed plastic deformation because of the collision with street



Image 17: Plastic deformation on left door leaf

- Door panels were in contact with the lower member of the door portal during the first impact of derailment

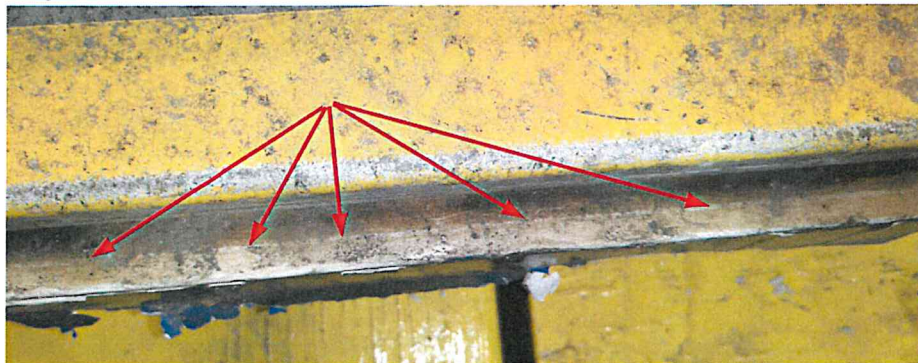


Image 18: Lower member of the door portal with mark of door leaf

- The grounding wire of the left door leaf was cut-off when door leaf carrier and sealing frame were in contact.
- Diagnostic codes of door control unit were downloaded. No findings related to the accident.

7 Other findings on train 316

- All thresholds on the left side of the train made contact with the street and rails, most of the weld seams on the lower side of the thresholds were broken.



Image 19: Threshold Door 1



Image 20: Right portal side of threshold doorway #4- broken welding seams

- The second wheel on the front wheel has a flat spot due to sliding over the street



Image 21: Flat spot on wheel

- Damage on the top of the end car due to collision with the light pole.

Rear view
mirror ripped
off during
collision with
the pole.



Image 22: Top of end car

- Damage of the car body and rain water gutter above Door 1

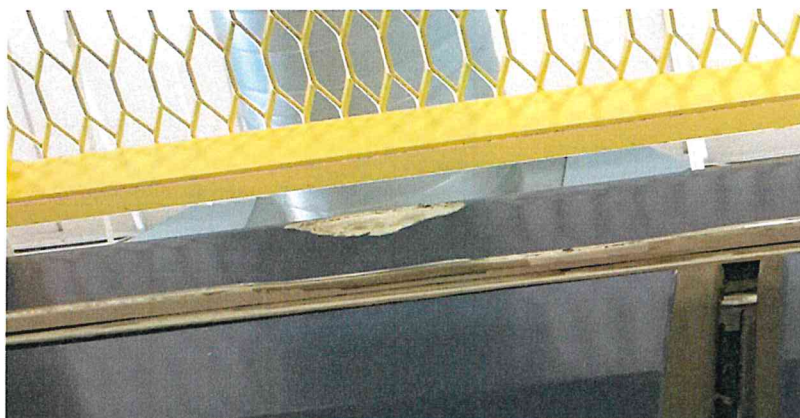


Image 23: Scratch above Door 1

- Collision of end bogie with underframe structure



Image 24: Damage on tank



Image 25: Measurement traction motor

- Support rollers on all other doors were found in an incorrect position. It was not possible to evaluate if the parts moved due to the accident because the marking of the bolts and parts was insufficient. Only the left door leaf of Door 3 has a cracked bolt marking which was sufficient to conclude that the movement was due to the accident. The support roller on Door 3 has no contact with the pressure plate anymore.
- Generally, it could be observed that on all left door leaves of the left train side (in driving direction) and all right door leaves of the right train side there was no contact anymore between pressure plate and support roller.

8 Conclusion

The used door system was designed according to the project specification TREXLRV18r5aJun24 (applied specification for Denver VII).

According to RTD the accident happened due to too excessive speed. The observed damages on the train and on the door system caused by the accident lead to the conclusion that the resulting forces of the accident were far over the door system limits and are not included in any specified load case (see 3.3.2).

9 Next steps/ open points

Investigations on the train are still ongoing. Siemens will get in contact with IFE NA (Brent Jones) as soon as any update is available. Siemens requested IFE to investigate if there are any design improvements possible to avoid similar accidents.

Siemens to determine if there has been an update.

