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1. LRV Car Shell Design

The car shell was originally designed to withstand stresses created from diagonal jacking and anti-climber compression. There is not a modern specification, nor was it considered in the historical design of the SD160, that covers a vertical load on the door portal. The accident scenario is not addressed for either car shells or doors in ASME RT or customer specifications for current builds. Siemens has experience with other impact load cases for side sills and window belts, but they are based upon automobile impacts.

The model simulation ran by Siemens did not reveal any plastic deformation of the door portal which is in line with visual inspections performed on the accident vehicle.

After visual inspection of the vehicle involved in the accident, review of the video's provided by RTD and analysis of the finite element model Siemens does not conclude that the car shell's performance contributed to the opening of the door. The loading on the car shell is not excessive enough to disable the integrity of the door system.

2. LRV Door System Design

The door system was designed to withstand an 890N (200 lbs_f) single load on a 930cm^2 (144 in^2) area per door panel located 50mm (1.97 in) from the leading edge and centered within the door height. This specification is taken from TREXLRV18r5aJun24.

After visual inspection of the vehicle involved in the accident, review of the video's provided by RTD and analysis of the finite element model Siemens does not conclude that the pole strike nor the car shell contract with the street contributed to the opening of the door or the passenger ejection.

3. Video Review

After reviewing the video's provided by RTD, the following significant incidents were noted from the file CoA Halo;

- At ~6:13:43.128 there is a significant vehicle impact on door 4 at the beginning of the derailment event that likely resulted in the damage seen to the under-car area of this door. It is realistic to assume that this event resulted in higher stress being seen by door portal number 4 than door 1 where the ejection occurred. It is known that the door leaf's at portal number 4 were not found to be compromised.
- At 6:13:44:378 door 1 appears to be starting to bow outward.
- At 6:13:44:911 door 1 appears to make the first contact with the ground
- At 6:13:45:044 door 1 appears to be disengaged from the bottom rollers

Siemens Industry, Inc.
Mobility Division;
Rolling Stock

7464 French Road
Sacramento, California
USA 95828

Tel.: +1 (916) 681-3000
Fax: +1 (916) 681-3116
www.usa.siemens.com/mobility

4. Passenger Impact Force on Door Portal

Siemens made the following calculation to determine the forces that could be expected as a result of the person impacting the door during the derailment.

Variables:

- f_{imp} impact force on door
- m_p passenger mass
- a_c centripetal acceleration
- a_p passenger acceleration
- g gravity (9.81 m/s^2) (32.2 ft/s^2)
- v_c vehicle velocity
- v_p passenger velocity relative to door at impact
- r_t track radius
- x_p passenger travel distance to door panel
- t_t travel time to door panel
- t_i impact time with door panel

Assumptions:

- m_p = 150 lbs (68.2 kg)
- v_c = 38 mph (17 m/s)
- r_t = 100 ft (30.5 m)
- x_p = 6 ft (1.83 m)
- t_i = 0.2 s

Calculation:

- First, finding the acceleration of passenger due to lateral acceleration and gravity,
  - $a_c = v_c^2 / r_t = 9.5\ m/s^2$ (31 ft/s^2)
- Combing with gravity,
  - $a_p = (a_c^2 + g^2)^{1/2} = 13.6\ m/s^2$ (44.6 ft/s^2)
- From Newton's law of motion,
  - $x = x_o + v_o t + at^2 / 2 = at^2 / 2$, if the frame of reference is located at the initial passenger location, ($x_o = v_o = 0$).
- So travel time, t_t, equals 0.54 seconds.
- Again, from Newton's law of motion, impact velocity is,
  - $v_p = v_o + a\ t = 7.4$ m/s (16.6 mph) ($v_o = 0$)
- From Newton's 2nd law,
  - $f = m\ a = m\ \Delta v / \Delta t$
  - $f_{imp} = m_p * v_p / t_i$ = (68.2 kg) (7.4 m/s) / (0.2 s) = 2 520 N (567 lbs_f)

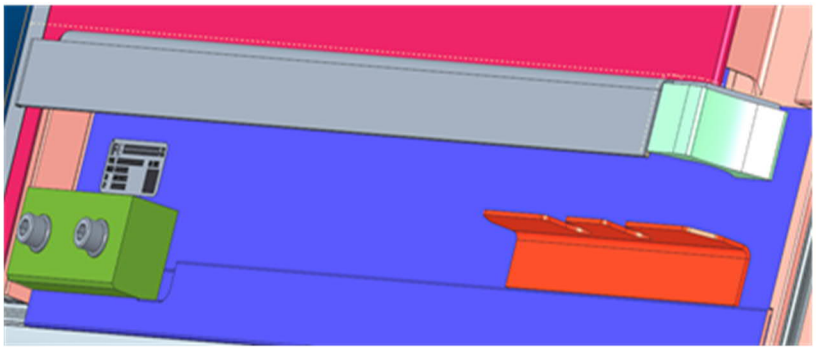
Result

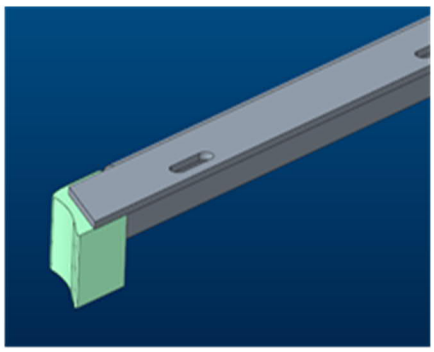
- Simple one-dimensional Newton mechanics, based upon certain assumptions, indicate that the impact to the door panel exceeds the specification and design values.
  - Door system design force = 890N (200 lbs_f) single load on a 930cm^2 (144 in^2) area
  - Calculated impact to door area = 2,520N (567 lbs_f)

5. Enhancement concept to Lower Guiding Rail

This enhancement concept has the possibility to withstand forces above the original design limit of 890N (200 lbs_f). Detailed engineering work has not been performed to evaluate what level of improvement over the original design specification could be obtained.

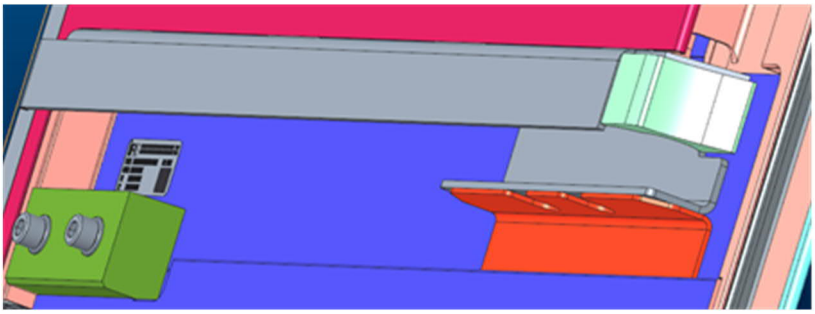
Old Guiding Rail

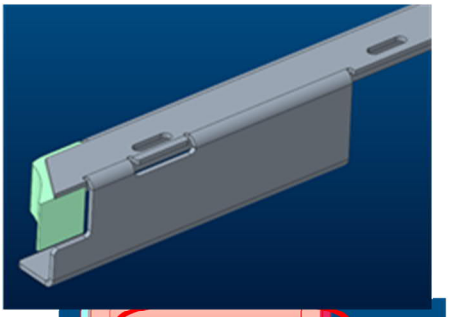




- Red bracket is bonded to door leaf
- This bracket delaminated during the accident, allowing the bottom roller to disengage from the lower guide

New Guiding Rail





- additional anti-lifting bracket installed onto door leaf
- the new bracket prevents the roller from falling out of the lower guide by capturing the rollers in the new bracket.
- It is anticipated that this new bracket would increase the design force that the door could withstand in a similar accident.