

InterCity Express Accident **June 3, 1998 in Eschede, Niedersachsen, Germany**

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The Inter-City Express (ICE) high-speed train operated by DB Fernverkehr derailed, and some of the railcars were thrown into the bridge piers of a roadway overpass. The accident killed 101 and injured 200 people. The direct cause of the accident was damage due to metal fatigue in a wheel rim of a two-part wheel. (Visit <http://nedies.jrc.it/index.asp?ID=216> for the press photo.)

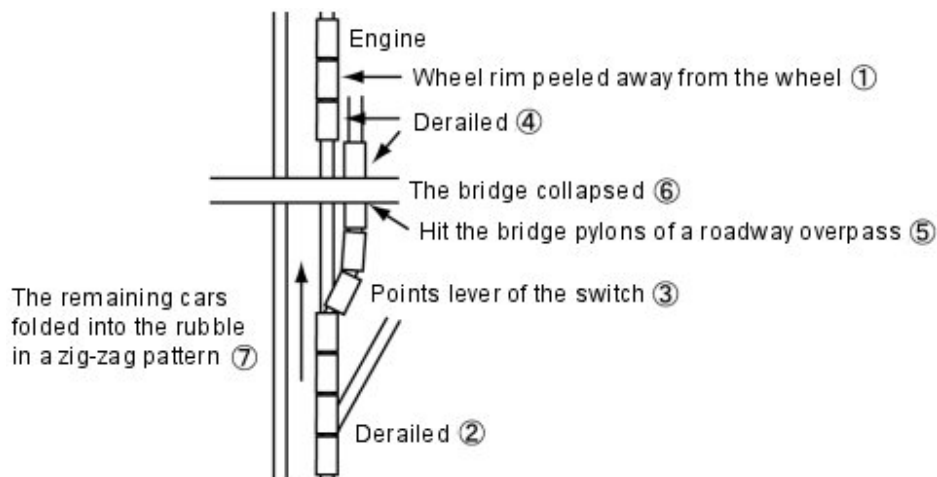


Figure 1. The InterCity Express Accident [4]

1. Event

The ICE high-speed train 884 was on the route from Munich to Hamburg, carrying 300 passengers. It derailed near Eschede in north-western Germany, and some of the railcars were thrown into the bridge piers of a roadway overpass (Figure 2). The accident killed 101 and injured 200 people.

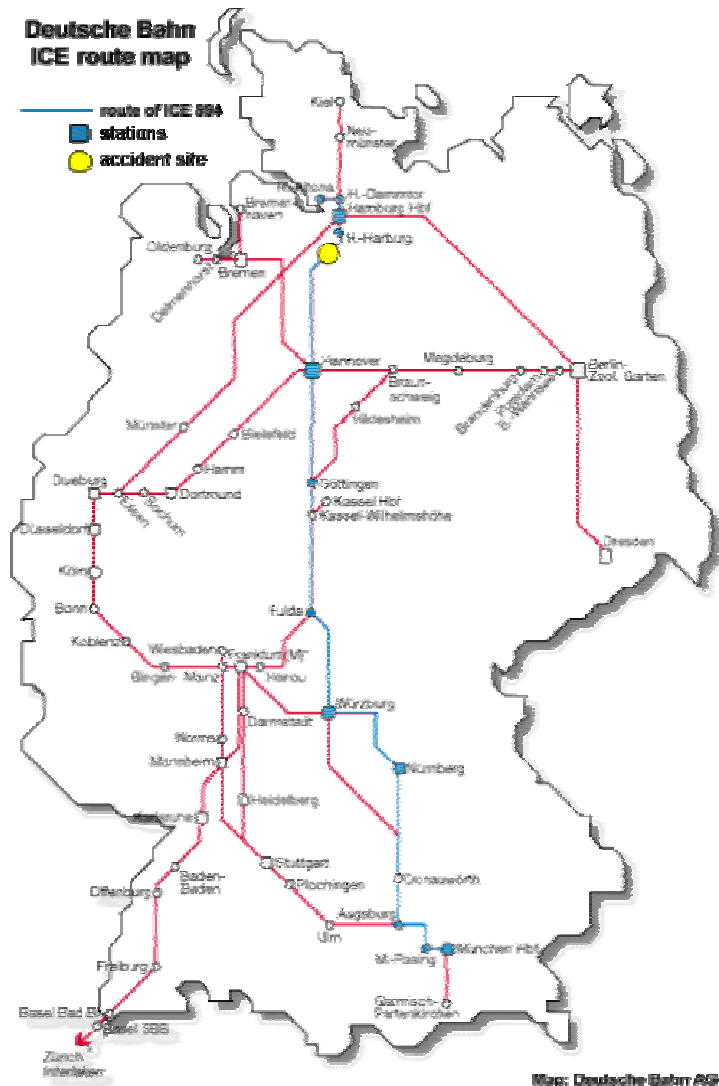


Figure 2. Accident Site [3]

2. Course

9:00AM: The 14-car ICE train 884 was on the route from Munich to Hamburg, carrying 300 passengers. After stopping in Han over, the train made an emergency stop near Eschede in north-western Germany at around 9:00 am when the operator felt something was wrong with the train. After finding nothing particular, the train continued its journey northwards.

10:58: When the train was traveling 6km before reaching the roadway overpass at the speed of 200km/h, a wheel rim that was lining a wheel on an axle of the first passenger car (second railcar including the head car) broke, peeled away from the wheel, and punctured the floor of the car, where it remained embedded. (The survived stated that they heard a rattling noise a few minutes after the wheel rim broke.)

At 200m before the roadway overpass as the train passed over a track switch, the embedded wheel rim

slammed against the guide rail of the switch, lifting the axle carriage off the rails.

As the train passed over another track switch 120m ahead of the previous one, one of the derailed wheels struck the points lever, changing its setting. The rear axles of the car were switched onto parallel track, and the entire car was thereby thrown into the bridge piers of roadway overpass, destroying them completely.

At 10:59, one of the then derailed wheels struck the points lever of the second switch, changing its setting. The first passenger car was switched onto parallel track, and it was disconnected from the head car.

The second and the third passenger cars derailed deviating to the right from the track and continued traveling.

The first and the second passenger cars passed intact under the bridge, but the third passenger car was thrown into the bridge piers of a roadway overpass. The tearing of the wagon hitches caused automatic brakes to engage.

The engine (head car) came to a halt at 2km down the track without derailling after the automatic brakes were engaged. The operator realized that the passenger cars were disconnected from the engine.

The derailed first, the second and the third passenger cars came to a halt several hundred meters down the track from the roadway overpass. The fourth passenger car passed intact under the roadway overpass and rolled onto the embankment immediately behind it. This impact caused the roadway overpass to collapse as the second half of the fifth and the sixth passenger car were passing under the bridge.

The collapsed bridge flattened the rear part of car 5 and car 6 completely. The remaining cars all derailed and slammed folded into the rubble in a zig-zag pattern, as the collapsed bridge had completely obstructed the track. The vehicles parked on the collapsed bridge plunged into the pile.

3. Cause

- (1) A wheel rim that was lining a wheel on an axle of the first passenger car broke. (Direct cause)

In order to reduce costs and improve ride comfort, the ICE cars employed the wheel design that uses a rubber damping ring between a metal wheel rim and the wheel body. The wheel rim failed due to metal fatigue (Figure 1).

The ICE884 was one of the 60 first generation railcars of the older model, and it still had the wheel rims of the “wheel-tire” design at that time of the accident.

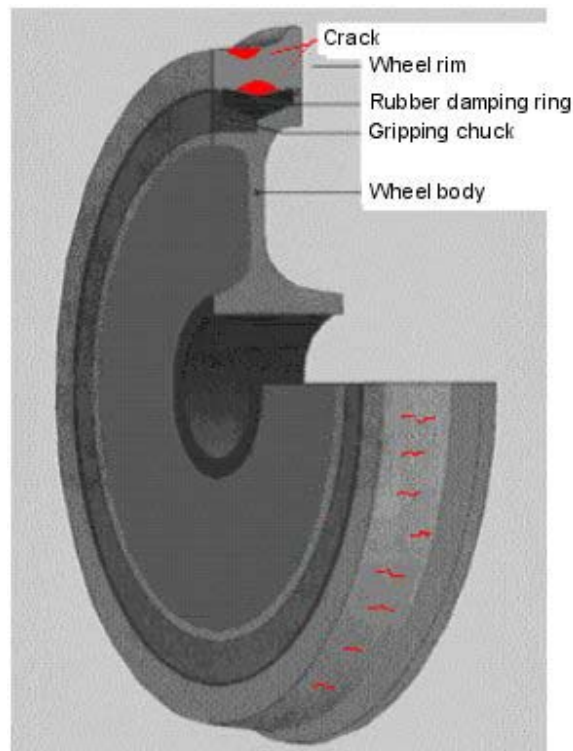


Figure 1. Wheel Design and Failure (Translated) [2]

- (2) Oversight of the maintenance crew: The maintenance crew did not follow the regulation.

According to Der Spiegel (news magazine), the derailed cars underwent a periodic maintenance by a computer on the previous night. The Munich Maintenance Center examined the external diameter of each wheel and sleeve thickness using an acoustic sensor. While the permissible error was 0.6mm, one of the wheels of the derailed car had 1.1mm of error. The maintenance crew did not replace or repair the wheels, assuming that the given value would only affect on the ride comfort.

- (3) Insufficient failure detection system

The ICE train did not have a system installed to detect wheel failure and bring the train to an emergency stop. Japanese bullet trains are equipped with a system for alerting the train operator about wheel deformation and failure during the operation so that the operator may manually activate the emergency brake. They also have a temperature sensor so that frictional heat in wheels exceeding 140 degrees C will cause automatic brakes to engage.

4. Immediate Action

Die Bahn (German Federal Railways) commissioned the Fraunhofer Institute to determine the cause of the accident. All 59 railcars with the same “wheel-tire” design underwent complete overhaul after the accident.

5. Countermeasure

By the end of June 1998, the 59 railcars of the first generation ICE had their wheels replaced with the single-cast wheels equipped in the second generation ICE.

6. Summary

The ICE once had the advertising statement “Travel twice as fast as vehicles and half as fast as aircrafts”. It had carried more than 120 million passengers since 1991. Approximately 27 million people used the ICE in 1997, which was 30% of all long distance travelers. Until this accident, it was believed that Deutsche Reichsbahn (Germany National Railways) had taken sufficient safety measures on its services. After the development of a new wheel design, two-part wheels were installed in the ICE trains that were previously equipped with single-cast wheels. This change in wheel design led to an accident.

7. Knowledge

- (1) A change in a product entails risks in safety.

Product development always requires some changes in design, production and the inspection method. The developers tend to pay attention to the improvement and forget about the tradeoffs.

It is important to assess the possible tradeoffs in the development and required efforts to minimize the damage. The developers must abandon a new design, if an improvement cannot compensate the shortcomings that come with it. In particular, a careful consideration and review are required before making a change in a proven product. The product's positive evaluation given over the years is a proof of its good quality.

- (2) It is easy to ignore regulations and inspection standards.

- (3) Sensors are effective in picking up things that are unable to be detected by humans.

8. Background

The ICE opened as a new land-based high-speed public transportation for Germany in 1991. The first generation ICE trains were equipped with single-cast “monoblock” wheels ideal for safe cruising at high speed. Once brought into service, however, metal fatigue and non-circular deformations on the monoblock wheel design could uncomfortable resonance and vibration at cruising speed.

In order to resolve the problem and improve the ride comfort, engineers decided to employ a two-part wheels design (VSC Bochum84) ideal for safe cruising up to 284km/h. The wheel rim of the two-part wheels, 91cm in diameter and 13cm in thickness, consisted of a wheel body surrounded by a rubber damper and then a metal wear rim. This wheel design was also effective in reducing the maintenance costs as replacement of the wheel rim fixes problems such as metal fatigue and cracks.

The DB started the production of new wheels in 1992 and replaced the wheels of the ICE trains to two-part wheels. The new wheel design brought into service was proved successful at resolving the issue of vibration at cruising speeds. The number of ICE passengers increased constantly and it tripled in 5 years since 1992.

A new air shock absorber became available in 1997. The DB found it effective in resolving the issue of vibration at cruising speeds in the ICE trains equipped with monoblock wheels, and decided to install monoblock wheels to the ICE trains. Replacement of wheels started from the second generation ICE trains in production. In 1998, 44 trains had new monoblock wheels.

9. On the Side

The “wheel-tire” design was originally developed for streetcars traveling at significantly lower speeds. Its relatively simple structure had been employed successfully in streetcars, eliminating resonance and vibration at cruising speed. The “wheel-tire” design had neither been tested nor been in service at high speed. The accident may have simply exposed the characteristics of rubber; its relatively inferior wear and abrasion resistant properties.

References

- [1] Nikkei Mechanical Online, <http://nmc.nikkeibp.co.jp/kiji/t536.html>
- [2] ICE Train Accident in Eschede, <http://www.ndt.net/news/2000/eschedec.htm>
- [3] Danger Ahead! Feature, <http://danger-ahead.railfan.net/features/eschede.htm#top>
- [4] Masayuki Nakao (2005) *1000 Scenarios of Failure*, Morikita Shuppan Co., Ltd.