

Equipment explosion on an empty passenger train, 26 September 2019

Important safety messages

This accident demonstrates the importance of:

- ensuring that the risks associated with the potential failure of electrical capacitors are fully understood and mitigated.
- ensuring that routine maintenance and inspection activities take account of changes in equipment configuration.
- having processes in place to ensure that the intent of safety critical modification programmes is maintained when making changes during implementation.

Summary of the accident

At around 06:11 hrs on 26 September 2019, an explosion took place onboard train reporting number 5S33. This train, operated by XC Trains Ltd (Cross Country), was an empty coaching stock movement between Bombardier Transportation's maintenance depot at Barton-under-Needwood (near Burton-upon-Trent) and Birmingham New Street station. Evidence suggests that the explosion took place shortly after the train left the depot. No passengers were on the train at the time and the driver was the only member of staff aboard.

The driver was unaware of the explosion during the journey. Upon arrival at Birmingham New Street station, he had to transfer to the cab at the opposite end of the train. It was while he was walking through the train that he discovered the damage caused by the explosion, which had taken place within an electrical equipment case. The damage sustained included buckling to the inter-vehicle doors, detached covers from the equipment case and damage to the ceiling. The door between the vestibule and the saloon was blown off its runners. Fragments of safety glass from the glazed area of this door were found throughout the adjacent saloon seating area.

Train 5S33 was formed of three class 221 'Voyager' diesel-electric multiple units. The explosion occurred within an equipment case located in the vestibule area of coach 60982. This coach formed part of unit number 221132, the rearmost of the three units. The unit involved was taken back to the maintenance depot for investigation by Bombardier Transportation, the current maintainer and original manufacturer of the unit.



Damage caused by the explosion (left, photograph courtesy of XC Trains Ltd) and (right) the electrical equipment case. The explosion took place in the middle section of the equipment case shown in the photograph.

Cause of the accident

The explosion was caused by the failure of an electrical capacitor located in the middle section of the equipment case. A capacitor is a device which stores electrical charge. The failed capacitor generated hydrocarbon gases which mixed with air in the equipment case, and the mixture then ignited. The electrical equipment concerned is found on both the class 221 units and class 220 units and was supplied to Bombardier Transportation by Alstom.

The potential for these capacitors to generate explosive gases under specific failure conditions is a known phenomenon. A previous similar accident had occurred on 29 May 2005 on another class 221 unit.

Following the 2005 accident, Bombardier Transportation implemented modifications to both class 220 and class 221 units. These modifications were intended to increase the air flow through the equipment case and prevent any potential build-up of explosive gases from failing capacitors.

The first stage of the modification was to fit plastic spacers in five locations on the covers for the lower section and in eight locations on the cover for the middle section of the equipment case. These would cause the covers to 'stand-off' slightly from the equipment case frame, improving air flow. This modification was completed on all class 220 and class 221 units, including 221132, within seven days of the 2005 accident occurring.

The second stage of the modification was intended to allow air flow between the lower and middle sections of the equipment case. This involved providing holes between the sections so that air would be moved by an existing fan in the lower equipment section. Air could then pass out from the middle section through a new louvre which was fitted to the front cover.



Cover for the equipment case middle section without louvres



Cover for the equipment case middle section with louvres

However, as the second stage modification proceeded it was found that the modified trains were suffering reliability problems. This was due to water ingress affecting equipment within the middle section of the equipment case of non-driving coaches (comparable equipment cases on coaches with driving cabs have different air flow arrangements).

The second stage modification programme was stopped in 2006 to address these reliability issues. At the point when the programme was stopped 24 units, including 221132, remained unmodified. Units which had been modified had the holes between the lower and middle sections of the equipment cases sealed, but retained the louvred cover. However, the 24 unmodified units were not fitted with the louvred cover. This meant that only the stand-off spacers, fitted during the first stage modification, allowed ventilation of the middle section of the equipment cases on these units.

In May 2011 a special check was carried out to verify that the stand-off spacers on equipment case covers were correctly fitted and to ensure that the cover edges were clean. This check was instigated because of concerns that the spacers were being omitted after maintenance work, and that dirty equipment cover edges were impeding air flow. Bombardier Transportation reported to the RAIB that all class 220 and class 221 units were checked, and any rectification work found to be necessary was carried out.

Inspection of the damaged cover from the middle section of the equipment case on unit 221132 following the 2019 explosion showed that only two of the eight stand-off spacers were present. It is likely that the missing spacers were mislaid or otherwise not re-fitted following work that was done within the equipment case between the 2011 check and the 2019 explosion.

Following this accident, XC Trains Ltd issued National Incident Report (NIR) number 3610 to alert other users of similar equipment to the risks which it highlighted. Bombardier Transportation has reported that it has checked all class 220 and 221 coaches to ensure that spacers are fitted in accordance with the first stage of the modification. Bombardier Transportation are modifying the spacers such that they are permanently fitted to the equipment case covers (and therefore cannot be mislaid). A louvred cover has now also been fitted to the middle section of the equipment case on coaches which did not receive the modification as part of the second stage of the modification programme.

Each class 220 and 221 coach has one such equipment case. Within each case, Bombardier Transportation has identified eleven capacitors which have the potential to generate explosive gases. It is reviewing the risk which they pose before deciding on further actions to be taken.

Previous similar occurrences

[RAIB report 05/2018](#) covers the investigation of an explosion inside an underframe equipment case on a train at Guildford station. The accident at Guildford was also caused by the failure of a capacitor. The capacitor failed due to a manufacturing defect. It generated explosive gases, which then ignited. The explosion resulted in debris being ejected onto other platforms and a car park near the station. There were no injuries to passengers or staff.

As a result of the Guildford investigation, the RAIB recommended that UK train operating companies and the suppliers of rolling stock review the design of electric traction systems in their fleets to check that there are adequate safeguards in place to prevent similar potentially harmful explosions and address any shortcomings identified. The Office of Rail and Road has reported to the RAIB that this recommendation is progressing towards full implementation.