Isle of Man Railways

Investigation Report

Derailment of Manx Electric Railway Tramcar number 16 on the 16th July 2021

I report for the benefit of the Chief Secretary the findings of my investigation into a derailment on the Manx Electric Railway that occurred on the 16th July 2021.

[redacted] CEng, FIMechE, FIET

29th August 2021

THE INCIDENT

Summary of the incident

On the 16th July 2021 a scheduled Manx Electric Railway passenger service formed of tramcar number 16 without a trailer car left Derby Castle for Ramsey at 17:40. In the vicinity of traction pole number 797 between Dreemskerry Farm and Lewaigue the car derailed to the land side at 18:40, all four wheels of the leading truck leaving the rails. The car came to a stop in a ballast shoulder with the front end leaning into the landside hedge just after pole number 799, the landside wheels were in the cess and the other two wheels were in the three foot hard against the landside rail.

The car was carrying 12 passengers, a conductor and the driver. Two passengers were seated on the drivers bench.

Figure 1. Car 16 following derailment

A track plan of the area is shown in Appendix 1

Events during the incident

A passenger who had been seated on the landside of the drivers bench was ejected from the car during the derailment and suffered a broken leg and bruising. All other passengers and staff were unharmed but shocked by the event.

The driver stated that on applying the brakes at the start of the descent to Lewaigue the brake action became rough followed by no brake and a bumpy ride until the car finally left the track.

Evidence at the site of the derailment showed that once the left hand wheel had climbed over the head of the rail the car ran along the landside rail on the traction motor casing. The right hand wheel then striking a check rails at Dreemskerry Farm occupation crossing and the second axle derailing.

Photographs of the derailment site are shown in Appendix 1.

Emergency Services attended the scene and the Police took initial charge of the investigation.

The car was recovered later that evening and towed to Laxey Car Sheds where it remained in quarantine until the formal investigation was begun.

External Circumstances

The incident took place during the hours of daylight.

The weather was sunshine with a low wind speed of approximately 5 mph in a northerly direction. The air temperature was approximately 25 degrees Celsius.

The previous few days had been dry with no rain.

The Driver

The driver of Car 16 was an experienced motorman who has over 40 years' experience driving tramcars.

The driver has an up to date certificate of competence to drive tramcars and signed for his Rule Book on 5 March 2020.

His driver's competence examination is up to date and expires on 31 December 2021. His medical expires on 9 May 2022.

The driver was tested for alcohol on the day of the of the incident and was verified as clear by a Police Officer.

The tramcar

Figure 2 Car 16 following recovery at Derby Castle Upper car shed. Showing damage to cow catcher and foot boarding

Car No.16 is an open crossbench ‘toastrack car’ built by G.F.Milnes in 1898.
It is fitted with ‘Brush D’ trucks and air brakes.
All axles are driven with four 25 hp traction motors controlled by General Electric K12 controllers.
The car has a maximum passenger capacity of 56 people.

Car No.16 was in operational condition; however, it is rarely operated outside enthusiasts’ events and days where additional capacity is required, operating 830 miles over the previous 12 months.

THE INVESTIGATION

Inspection of the Tramcar

The leading car truck was removed from the car body at Derby Castle for inspection and I am grateful to [redacted] and his team for their invaluable assistance in dismantling the car for inspection.

Prior to dismantling a full brake test was conducted, having temporarily sealed a leak in a brake pipe that had clearly been caused by the derailment. The brakes all functioned correctly and applied full braking force on the wheels.

Only two of the tyres on the car 'rang' when struck with a hammer. Hammer testing of tyres is a well established principle and is used to detect tyres that are cracked or no longer ductile.

The tyres were all worn well below any recognised limits. The tyres on the leading axle of the leading truck were an average of 25 mm thick with a loss of conicity across the tyre. The second axle tyres were approximately 28 mm thick, again with a loss of conicity.

There was a clear brittle fracture in the leading axle, left hand side tyre as shown in Figure 3 below:

The thin tyre and lack of conicity, together with witness marks from the wheel centre rotating within the tyre can clearly be seen.

Figure 3 Fractured tyre

Figure 4 shows the brake block and fractured section of the block. The fractured section was found about four pole lengths in advance of the point of derailment. The brake block was worn but was of adequate section to provide efficient braking.

Figure 4 brake block from the leading axle, left hand side together with section recovered from the track in advance of the point of derailment.

The axles were tested for equal wheel loading across the axles using a hydraulic weighing system. The leading axle had a 20% greater load on the left hand wheel, the second axle had approximately equal loadings.

The leading axle had 17 mm end float, which is excessive and requires further investigation once the wheelset is removed to fully understand why this is occurring.

The bolster beam vertical restraint bars were worn and had allowed the bolster beam to become locked horizontally to the left hand side. The witness marks clearly indicated that this was due to the derailment.

I noted that the bolster beam on the Brush trucks is uncontrolled laterally, unlike most other trucks that have lateral restraining springs.

The truck centre plate casting around the front face where the centre pin locates was fractured. This appears to be an historical fracture, possibly due to the flat centre plate that would not permit the truck to travel smoothly through vertical track curvature in combination with horizontal curvature.

The truck frame was checked for twist and only minor differences were recorded at the four corners.

The axle horns were slightly worn but well within tolerance.

Further photographs of the truck are shown in Appendix 1.

Inspection of the permanent way

The permanent way was thoroughly inspected between Dreemskerry and the derailment site. The line and level were found to be well within maintenance limits and no evidence of sleeper movement, indicating track buckles or twist was found. All the sleepers and fastenings were in good condition and held tight.

All the expansion joints were found to have the expected gaps for the ambient temperature and there was no evidence of fishplate joints being unable to move.

The permanent way had also been surveyed by a competent engineer and no faults were found.

The permanent way was in very good condition.

Inspection of evidential paperwork

Wheelsets

Drawings of the wheelsets from the 1930's show the design of the wheel centres and tyres, Figure 5 below:

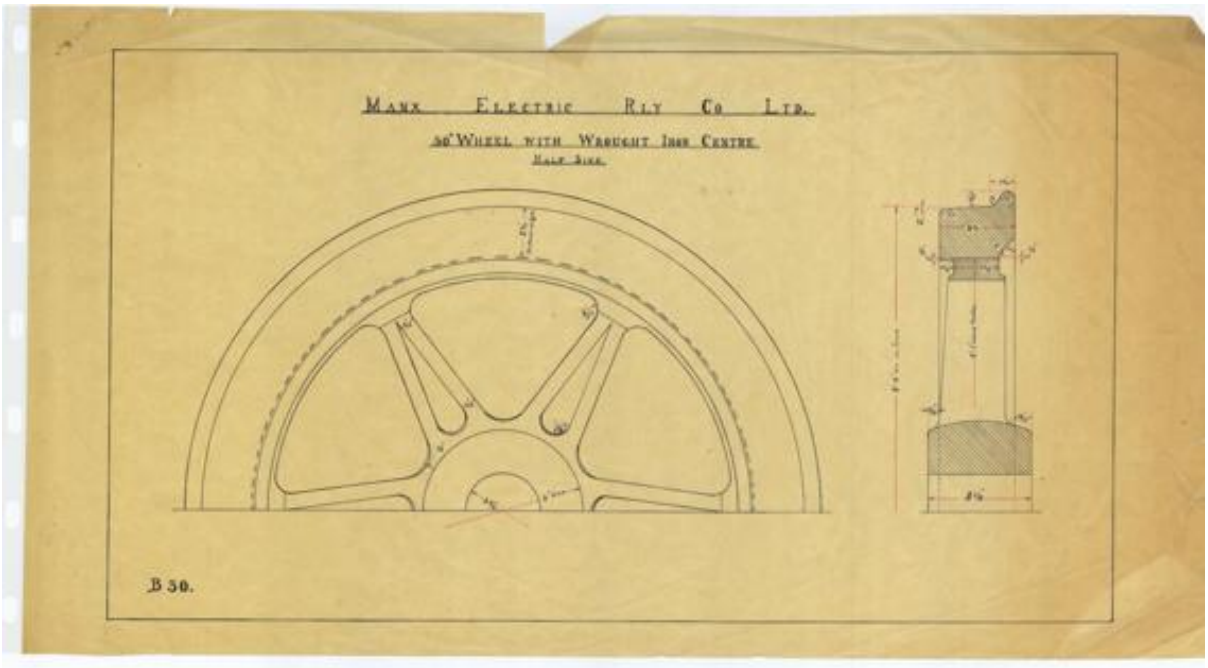


Figure 5 Tramcar wheel and tyre dimensions circa 1930

The design of the tyre registration on the wheel centre is unusual having sharp corners and potential stress raisers.

The drawing indicates that the tyre thickness when new was 2.5 inches (63.5mm).

The tyres on the leading axle of the leading truck were measured at 25mm thick. The tyres on the second axle were 28mm thick.

The best practice standard for wheelset treads and gauging is the former British Railways standard MT288, which gives a minimum scraping thickness for light weight vehicles of 30mm.

Speed data

The conductor of each tramcar carries a ticketing machine that accesses and records tramcar position and location data from geo-stationary satellites. The output data from the ticketing machine produces a speed profile for the journey, see figure 6 below that shows the final section of the journey on the 16th of July.

The speed output in figure 6 is in kph, the car derailed at 34kph (21mph).

From the full journey output data, it can be seen the car was consistently driven below the maximum speed limit of 25mph (40kph).

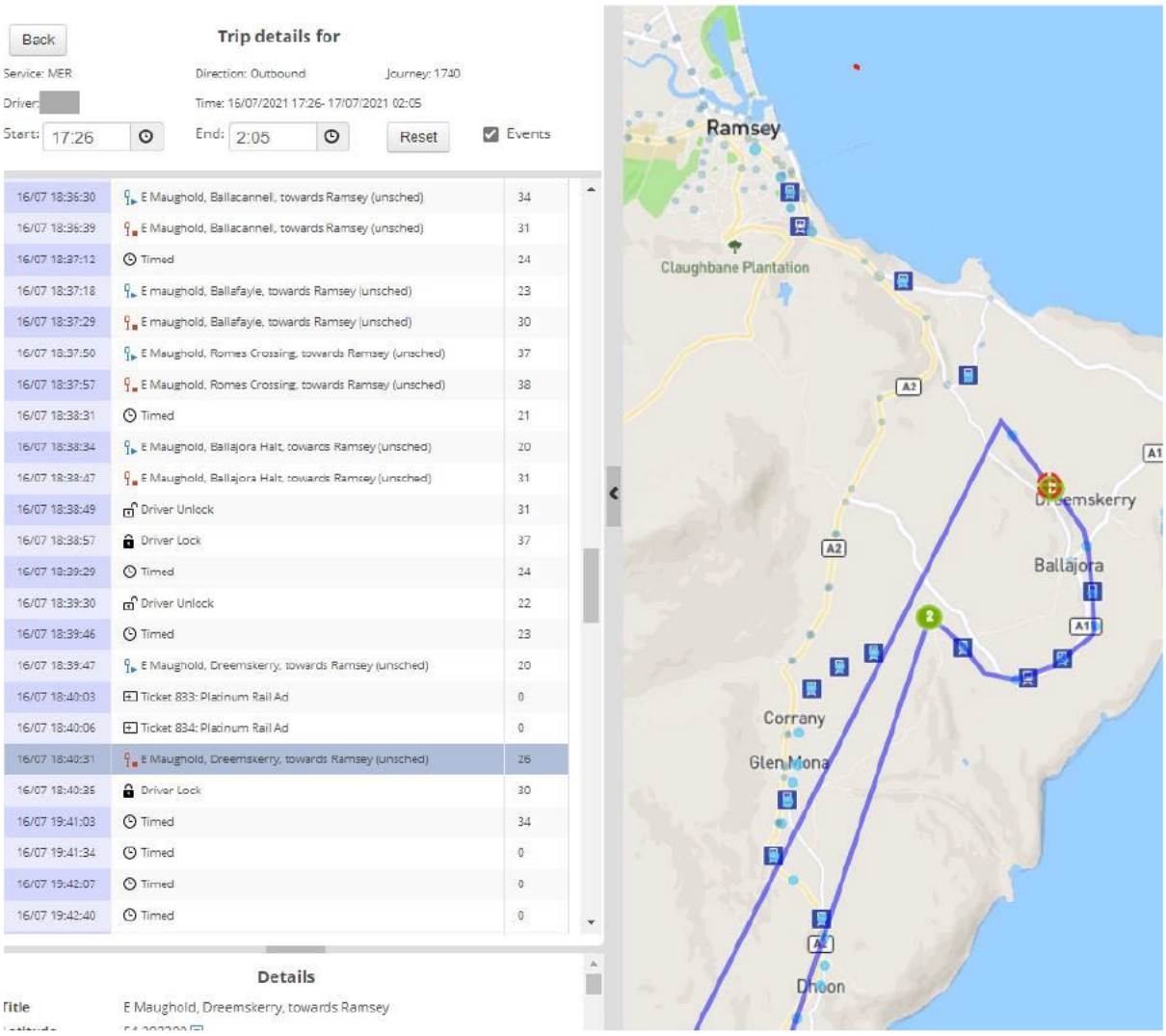
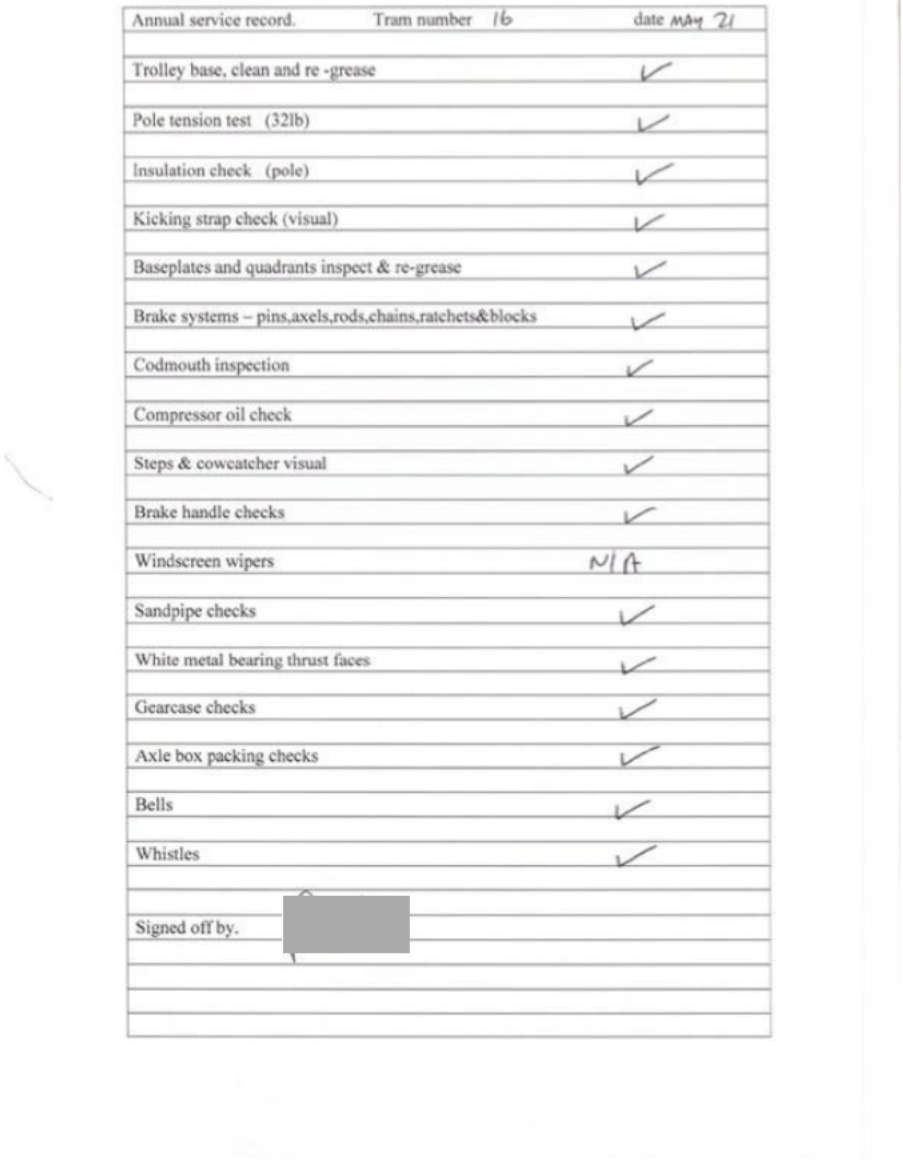


Figure 6 Ticketer graphical output (note: the graphical output is only showing the journey between Ballacannell and the point of derailment, the two straight blue lines should be ignored.)

Inspection records

An annual service sheet had been completed and dated May 2021 see Figure 7 below:

There were no records of wheelset inspections, suspension inspection or any measurements taken for wheelset dimensions, wheel weights, brake shoe thickness, air pressure and holding time and braking performance.



Annual service record. Tram number 16	date MAY 21
Trolley base, clean and re -grease	✓
Pole tension test (32lb)	✓
Insulation check (pole)	✓
Kicking strap check (visual)	✓
Baseplates and quadrants inspect & re-grease	✓
Brake systems – pins,axels,rods,chains,ratchets&blocks	✓
Codmouth inspection	✓
Compressor oil check	✓
Steps & cowcatcher visual	✓
Brake handle checks	✓
Windscreen wipers	N/A
Sandpipe checks	✓
White metal bearing thrust faces	✓
Gearcase checks	✓
Axle box packing checks	✓
Bells	✓
Whistles	✓
Signed off by. [redacted]	

Figure 7 tramcar 16 inspection record

IMMEDIATE CAUSE OF THE DERAILMENT

The immediate cause of the derailment was a broken wheel tyre on the left hand side of the leading axle of the car that was prevented from rotating by the brake block whilst the right hand tyre continued to rotate leading to significant lateral forces that allowed the left hand wheel to climb over the head of the rail thereby derailing the leading axle.

The tyre had suffered a brittle fracture over its complete width allowing it to move on the wheel centre. The fracture had probably occurred when the wheel struck an expansion joint on leaving Dreemskerry. When the brake was applied on the following gradient the brake shoe struck the fracture and was itself fractured by the rotational force. The brake shoe was then held by the crack in the tyre and the tyre rotated on the centre. The broken section of the brake block had been found some four pole lengths in advance of the point of derailment.

ROOT CAUSES

A tyre that was worn below acceptable limits leading to hardening of the steel and lack of ductility.

The tyres and axles had not been inspected prior to operation nor had they been hammer tested.

The car shed maintenance staff had no access to wheelset standards or measuring equipment, other than a back-to-back gauge.

There were no Vehicle Maintenance Instructions for the maintenance staff to follow.

There was no professional engineering oversight of the condition and maintenance of the cars.

DISCUSSION OF CAUSATION AND CONSEQUENCE

The primary control measure for the safety of any rail vehicle is the thorough inspection of wheelsets on a periodic basis. This inspection includes examination and measurement of wheel treads using gauges that clearly indicate to maintenance staff when critical parts of the wheelset have reached a safety limit. Some applicable limits and examples of gauges are set out in British Railways Standard MT288. [redacted] will need to define acceptable maintenance and safety limits for wheelsets used on the Manx Electric Railway.

Had the wheels been hammer tested for ringing prior to the journey it is highly probable that tyres that were no longer ductile would have been detected.

One passenger statement given voluntarily after the incident considered that speed was a contributory factor in the derailment and others stated that speed may be a causal factor. In addition to examining the speed records from the ticketer machine a test run was undertaken with a tramcar having the same Brush trucks without dampers

and a similar axle end float. The car was driven up to a speed of 26mph, (measured by a GPS speedometer) at which speed the ride quality was uncomfortable together with a perception that the car travelling dangerously fast. At 20mph the ride quality was reasonable, but the perception of speed was still enhanced. The open environment of a toast rack car does lead to a much higher perception of speed and drivers confirmed that even though there are no speedometers they are very much aware of approaching the 25mph speed limit. I do not consider speed to have been a contributory factor nor did it enhance the consequences of the derailment.

It was clear that a ballast shoulder had rapidly halted the progress of the derailed car and demonstrated the benefits that such a shoulder can bring, especially on exposed sections of the route where a derailment could result in a trajectory down a significant drop.

ACTIONS UNDERTAKEN SINCE THE INCIDENT

All tramcars and trailers with composite tyred wheels were withdrawn from service pending an engineering assessment of their ongoing operational life.

PREVIOUS RECOMMENDATIONS

I had previously recommended in 2019 that Vehicle Maintenance Instructions should be produced for the Manx Electric Railway vehicles:

'Vehicle Maintenance Instructions (VMI) have been produced for the Snaefell cars which represent good practice and should ensure that ad hoc maintenance is a thing of the past. The VMI system should now be introduced on the MER and Steam Railway together with suitable recording systems as soon as practicable. It was encouraging to note that maintenance and repair is also subject to photographic record, building a proper understanding of the asset.

is currently assessing asset management systems with a view to introducing a software-based system across all railways to understand the assets and properly plan maintenance and renewal. '

I noted that the production of VMIs had begun and a draft unfinished copy was held by the maintenance team at Derby Castle.

RECOMMENDATIONS

All recommendations are directed to [redacted]:

1. Steel gauges for measuring tramcar wheel profiles should be procured Staff should be thoroughly trained on wheelset inspection and the use of relevant gauges. Maintenance and safety limits for wheelsets used on the Manx Electric Railway must be defined (Some applicable limits and examples of gauges are set out in British Railways Standard MT288).
   This recommendation should be completed as soon as reasonably practicable

2. The results of a thorough wheelset inspection should be recorded in suitable varying detail on the annual inspection record sheet, periodic inspection record sheet and the daily fitness to run sheet for all vehicles used on the Manx Electric Railway.
   This recommendation should be completed as soon as reasonably practicable

3. A competent engineer should be assigned to Derby Castle Car Sheds to review the condition of the cars and trailers, continue the production of suitable and sufficient Vehicle Maintenance Instructions that include maintenance and safety limits, mentor and train the maintenance team and take responsibility for the safety of the rolling stock. An engineer should be available on an on-call basis to also provide advice to motormen should a tramcar fail in service.
   This recommendation should be completed as soon as reasonably practicable

4. All vehicles on all the railways that have composite tyred wheels should be subject to a daily wheel tap. *This should begin with immediate effect.*

5. A survey of the seaside cess and all other locations, where a derailment would result in a potential trajectory down a significant drop, should be undertaken to ensure that there is a suitable restraining ballast shoulder.
   This should be conducted within 3 Months

6. Consideration should be given to the fitment of discrete speedometers and discrete forward-facing cameras to the tramcars. Cameras are an invaluable assistance in the investigation of incidents, especially at level crossings. Evidence from cameras would have rapidly eliminated many of the potential causes that had to be examined during this investigation.

APPENDIX 1

Extract from Manx Electric Railway track plans showing the position of pole 800.
Car 16 stopped between poles 799 and 800.

PHOTOGRAPHS OF THE DERAILMENT SITE

Just after the point of derailment showing marks from the motor case on the left hand rail head and scoring marks on sleepers from right hand leading wheel.

Right hand leading wheel contacted the check rails at the occupation crossing for Dreemskerry Farm. Second axle derails.

PHOTOGRAPHS OF THE TRAMCAR

Marks on motor casing from contact with the rail head

Cracked tyre and witness marks of rotation.

Broken centre casting. Note also poor maintenance practice of using washers instead of correct length studs on traction motor reaction springs.