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Australian Transport Safety Bureau

Derailment of train ST24

near North Melbourne, Victoria | 11 July 2014

Investigation

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Addendum

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Safety summary

What happened

On 11 July 2014, train ST24, a scheduled XPT passenger service, returning to Sydney Central Station from Melbourne Southern Cross Station, derailed at turnout MYD887 near North Melbourne station in Victoria. Turnout MYD887 was installed as part of the Regional Rail Link project. While certified for standard gauge revenue operations earlier that week, it had not been used by XPT services until the day of the derailment.

As a result of the derailment, there were minor injuries to some passengers and the train's crew, as well as damage to track and rolling stock.

What the ATSB found

The ATSB found that the derailment of ST24 occurred at a type 37 mixed gauge turnout (MYD887), as the wheelset of a carriage (probably XAM2176) transitioned from the standard gauge short stock rail onto the broad gauge switch blade through the transfer area. It was determined that there were design deficiencies of the type 37 turnout with respect to transfer area width, guard rail protection, and capacity of the tie bar to resist elongation, that contributed to the derailment.

Earlier that morning the same train, travelling from Sydney as ST21, derailed at a similar type 37 mixed gauge turnout (MYD882) but re-railed a short distance later. The train crew felt the train bounce but were unaware that it had derailed, so continued into Southern Cross Station. The incident was reported to operational staff and the track was being inspected at the time ST24 derailed at turnout MYD887.

Post-derailment, an examination of the type-approved design of the type 37 turnout determined that it was lacking, in that it had been assumed that the type 37 turnouts would perform safely in service based solely on the performance of a similar (type 29) dual gauge turnout, although there were significant differences between the two turnout types.

The ATSB determined that there were no maintenance deficiencies with train ST24 that contributed to the derailment.

What's been done as a result

V/Line has actively managed the redesign, alteration and validation of the type 37 turnout, to support the safe operation of standard gauge rolling stock having wheel rim widths of 127 mm, including a comprehensive review of contractual arrangements, testing and commissioning processes.

Safety message

Proposed infrastructure changes, including those put forward by contractors, need to be thoroughly assessed at the design stage to ensure that they meet all operational and safety requirements.

Once constructed, infrastructure needs to be rigorously tested as part of the commissioning process to ensure that the changes are safe and perform to the original design intent.

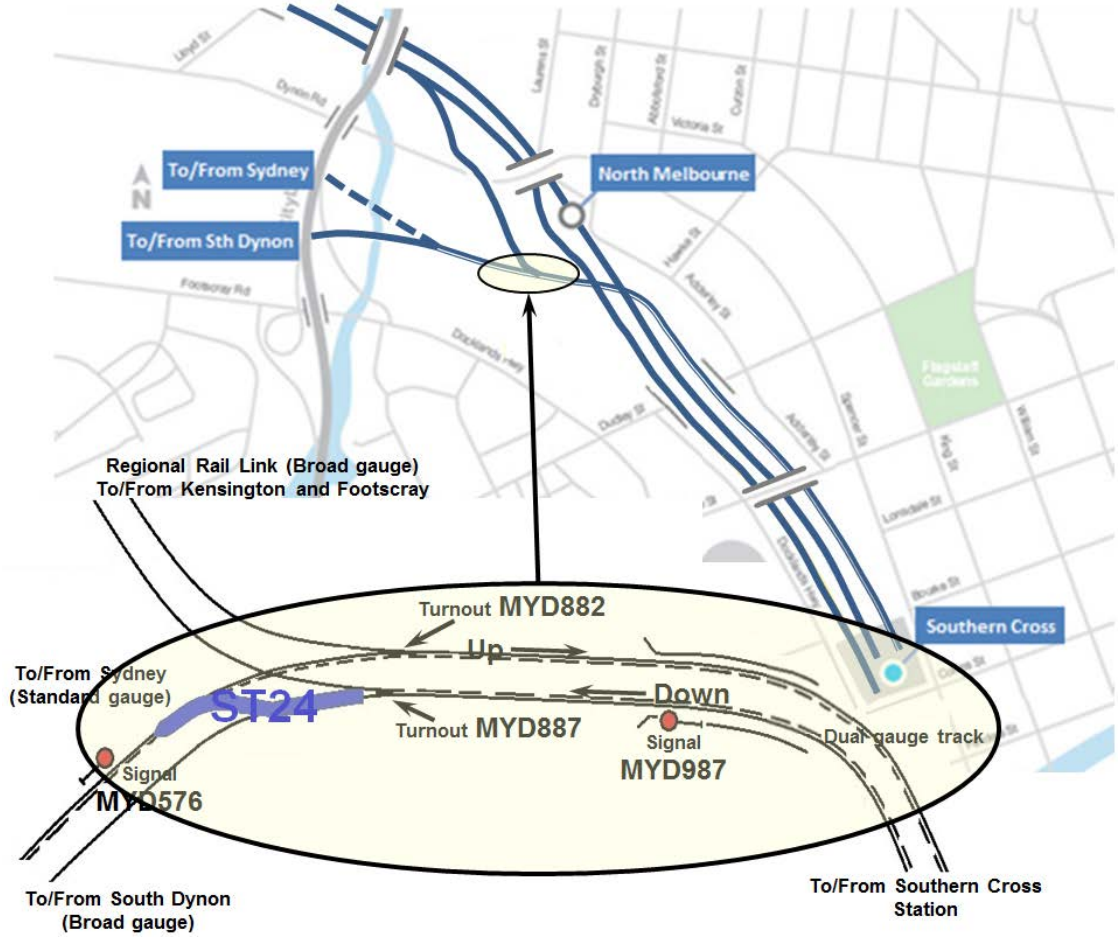
Contents

The occurrence

On the morning of 11 July 2014, scheduled XPT passenger service ST21 was travelling from Sydney to Melbourne. At Broadmeadows station (about 18 km north of the Melbourne CBD), a pilot boarded the train for the final part of the journey into Southern Cross station. The pilot was required to provide route familiarisation training for XPT drivers who were operating over a newly commissioned section of dual gauge track leading into and out of the Southern Cross station.

At about 0738,[1] train ST21 entered the dual gauge 'Up' flyover track (Figure 1) and passed over MYD882 (mixed gauge turnout), which was part of the newly commissioned track.

Figure 1: Location map near Southern Cross station



Source: Regional Rail Link with annotation by ATSB

As the train traversed the turnout at a speed of 8 km/h, it bounced heavily (Figure 2).[2] The pilot described it as 'a short sharp dip in the track, similar to a short deep bog hole (mud hole)' and explained that if the train hadn't kept rolling, he would have thought they had derailed. The pilot immediately rang Southern Cross number 1 signal box and reported the occurrence. Number 1 signal box advised that they would arrange for a track inspection. The train continued into Southern Cross, where it was fuelled and joined by passengers and new crew, in readiness for the return journey to Sydney as train ST24. While the report had prompted the scheduling of a track inspection, an examination of turnout MYD882 and the rolling stock had not occurred at the time train ST24 departed Southern Cross station.

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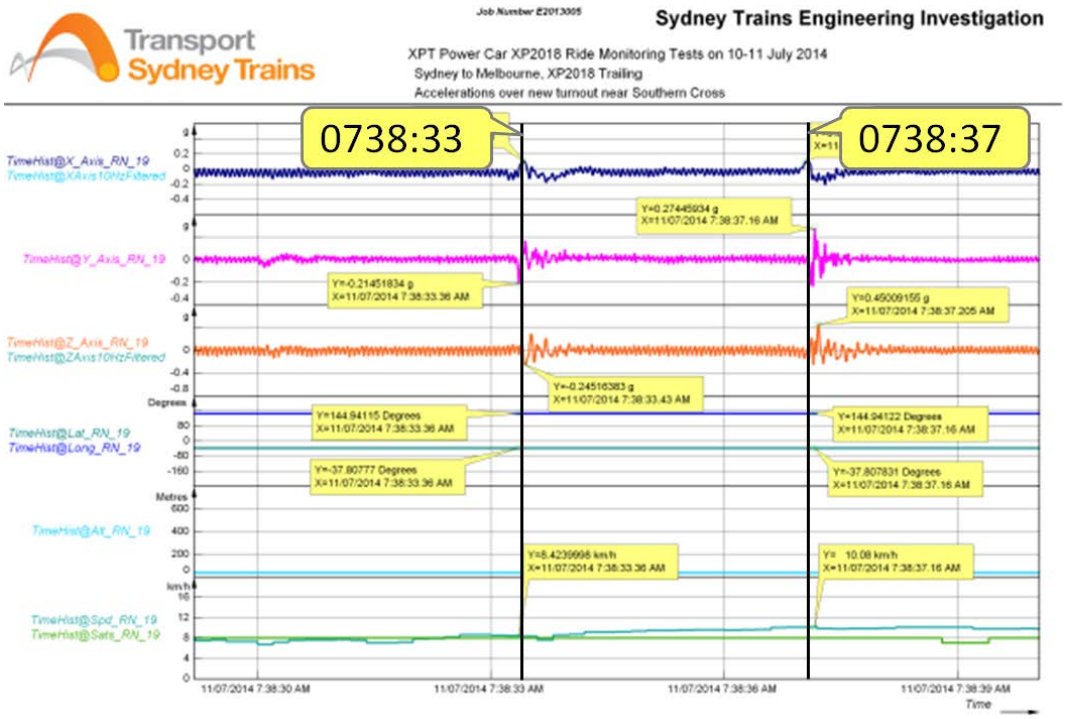
1 The 24-hour clock is used in this report and is referenced from Eastern Standard Time (EST).

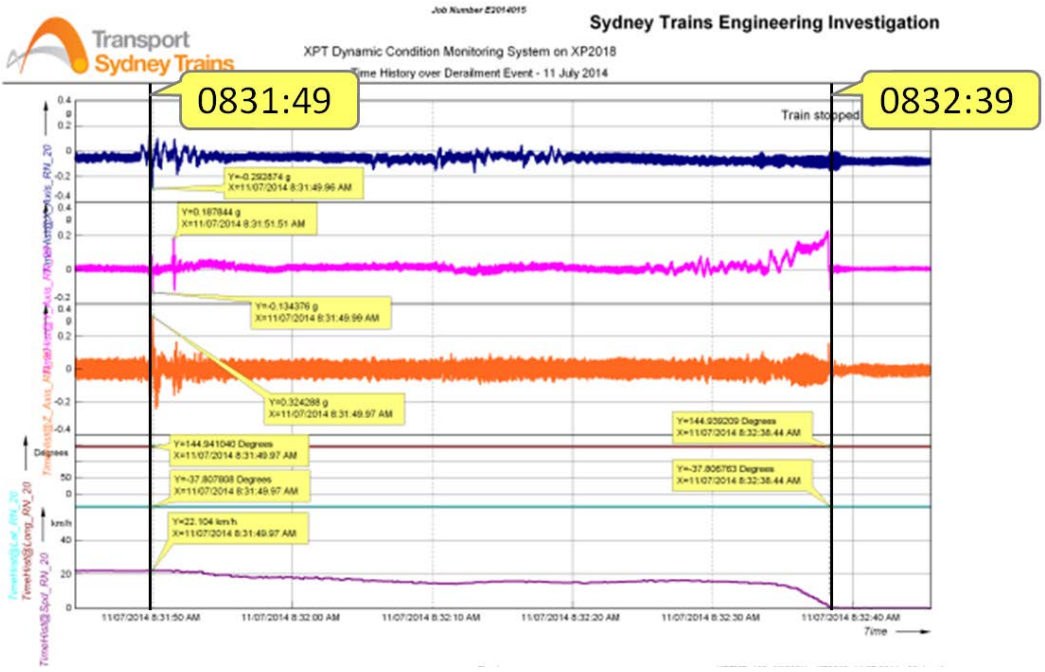
2 Graph at Figure 2 was derived from accelerometer measurements for evaluating ride quality of the XPT train services.

Figure 2: Accelerometer readings from XPT Power Car XP2018 at turnout MYD882



Source: Sydney Trains

Figure 3: Accelerometer readings from XPT Power Car XP2018 at turnout MYD887



Source: Sydney Trains

At about 0830, train ST24 departed Southern Cross and travelled along the dual gauge 'Down' flyover track on its return journey to Sydney. As the train approached signal MYD987, the driver observed a *clear medium speed* with 'S' indication.

To the driver, this meant that the route ahead was correctly set and that the train could traverse MYD887 (mixed gauge turnout) at the designated track speed of up to 25 km/h.

Shortly after 0831, as the train traversed the turnout at a speed of 22 km/h, the driver and pilot felt several large jolts (Figure 3), followed by a series of fault indications on the driver's display screen as the train came to a standstill.

Events post derailment

The pilot rang the train controller and advised that train ST24 had come to a stand on the flyover and had probably derailed. When the site was secured, the driver walked back along the length of the train to determine/report the extent of the derailment and damage (Figure 4). He reported that there was minimal damage to track but passenger carriages XL2229 and XAM2176 had derailed all wheels.

Figure 4: Train ST24 trailing power car XP2003 and derailed carriage XAM2176

Source: CITS

Recovery personnel were dispatched; they arrived shortly thereafter and commenced disembarking passengers. There were minor injuries to some passengers and the train's crew.

Investigators from the ATSB and the Chief Investigator Transport Safety (CITS) Victoria attended the site and began gathering/protecting perishable evidence, including site data, photographs, measurements, CTC[3] data logs and train data logs.

[3] Centralised train control – A system of remotely controlling the turnouts and signals at a number of interlocked stations, junctions and crossing loops in automatic signalling areas, from a centralised control room or signal box.

Context

Location

The derailment occurred at turnout MYD887 (Figure 1), located on a section of track that had been recently constructed as part of the Regional Rail Link [4] project. The project included extensive track reconfiguration and upgrades to the North Melbourne rail-over-rail flyover for improving access to the Southern Cross station. Turnout MYD882, where the driver and pilot experienced the heavy bounce when travelling towards Southern Cross station, was located adjacent to MYD887.

After construction, responsibility for the track was transferred from the Regional Rail Link City to Maribyrnong River Alliance (Alliance) to V/Line, who then provided both the infrastructure management and train control functions for this section of track, under a joint lease arrangement between VicTrack, Public Transport Victoria and V/Line.

Track Information

The track through the derailment site comprised a combination of broad gauge (1,600 mm), standard gauge (1,435 mm) and dual gauge track; that is, broad and standard gauge track having a common running rail. Turnouts MYD882 and MYD887 provided dual gauge rail access to and from Sydney/South Dynon, and broad gauge rail access to and from Kensington/Footscray. The turnouts were 50 kg type 37 mixed gauge turnouts.[5] The design of the type 37 turnout was based on an existing dual gauge turnout[6] design (type 29) in common use by the Australian Rail Track Corporation (ARTC).

The track work through this area was progressively remodelled in the period preceding the derailment, with the two turnouts MYD882 and MYD887 being installed in January 2014. From January 2014 until 8 July 2014, standard gauge rolling stock, including the XPT, operated exclusively (and bi-directionally) on the up track over turnout MYD882. During this period, turnout MYD882 was clipped[7] and used only by standard gauge trains. In July 2014, MYD882 was unclipped and the two turnouts were fully commissioned and made operational for both standard and broad gauge operations, with a certificate of acceptance being issued for both turnouts on 8 July 2014 – three days before the derailment.

During commissioning and acceptance testing, both broad and standard gauge trains were operated over the turnouts.

Train information

The XPT passenger fleet, operated by NSW Trains, had worked the Sydney to Melbourne route, which included sections of dual gauge track, for about 30 years. Train ST21, an XPT service, was operating from Sydney to Melbourne and returning to Sydney as train ST24. Train ST24 comprised leading (XP2018) and trailing (XP2003) diesel power cars operating in push-pull mode[8], four passenger cars, a buffet car, baggage car and sleeper car (Figure 5).

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4 The Regional Rail Link City to Maribyrnong River Alliance managed the project through this area. The Alliance comprised the Secretary to the Department of Transport (now the Secretary to the Department of Economic Development, Jobs, Transport and Resources), Abigroup Contractors Pty Ltd, John Holland Pty Ltd, Coleman Rail Pty Ltd, AECOM Australia Pty Ltd, GHD Pty Ltd, Metro Trains Melbourne and V/Line Pty Ltd.

5 The type 37 mixed gauge turnout has one dual gauge leg and one broad gauge leg.

6 The type 29 dual gauge turnout has two dual gauge legs.

7 Clip - A lockable clip for manually securing a point blade of the turnout to the stock rail.

8 For the XPT fleet, 'push-pull' mode means that the train can be driven from both ends and that both power cars provide tractive effort. In normal service the rear power car provides 'train supply' for lighting, air conditioning, buffet equipment, etc., in addition to tractive effort.

Figure 5: Train ST24 consist diagram

XP2018	XFH2104	XF2217	XF2210	XF2206	XBR2152	XL2229	XAM2176	XP2003
Power	Baggage	Passenger	Passenger	Passenger	Buffet	**Passenger**	**Sleeper**	**Power**

Direction of train travel

Power cars shown **bold**. Derailed passenger carriages shown **bold/blue.**

The first five cars behind the lead power car (XP2018) were built by Comeng. The sixth and seventh cars were built by ABB. The train had an overall length of 204 m and a gross weight of 460 t, with a maximum operating speed of 160 km/h.

Train crew information

The train was operated by a single driver, with hospitality staff catering for passenger needs. In addition, a pilot was assigned to assist the driver with route familiarisation over the newly commissioned flyover section of track.

The driver and pilot were appropriately qualified, and were medically fit for duty. Following the derailment, both the driver and pilot underwent drug and alcohol testing – the results of which were negative for both.

Based on an assessment of the occurrence and associated evidence, the ATSB found no evidence that the performance of the driver and pilot had been a factor in the derailment.

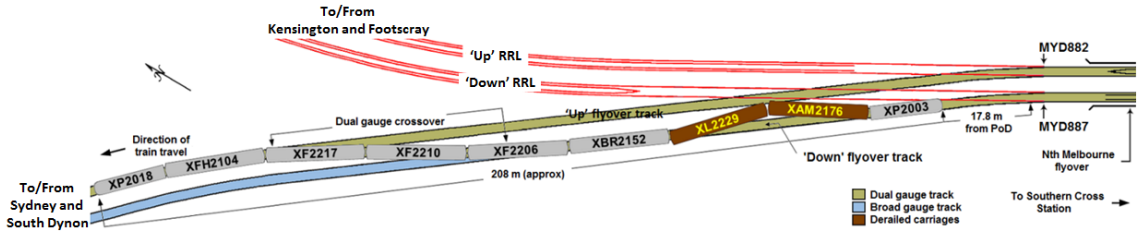
Environmental conditions

There was no evidence to suggest that weather had contributed to the derailment, with the meteorological conditions at the time being relatively benign (about 10°C with light winds).

Site observations

An examination of infrastructure near the derailment site (Figure 6) established that there was damage at turnout MYD882 on the up flyover track, and MYD887 on the down flyover track.

Figure 6: Site schematic



Source: CITS

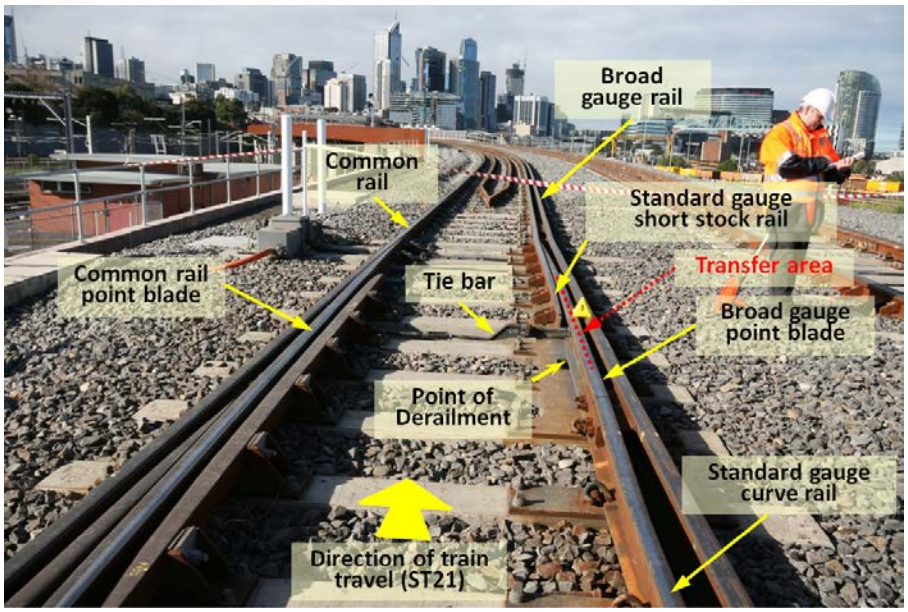
Turnout MYD882

Turnout MYD882, located on the up flyover track, provided for converging movements to access the Southern Cross station via the rail-over-rail flyover – dual gauge movements from Sydney/South Dynon (coming from the lower right in Figure 7) and broad gauge movements from Kensington/Footscray (coming from the lower left in Figure 7). Train ST21 was coming from Sydney/South Dynon and traversing turnout MYD882 when the driver reported that the train bounced heavily.

For a standard gauge train, such as ST21, the right wheels travel along the standard gauge curve rail (Figure 7) then transition onto the broad gauge point blade through the transfer area, before finally repositioning on the standard gauge short stock rail. By design, the gauge through the transfer area is wide, to allow broad gauge wheelsets to pass for trains coming from Kensington/Footscray and broad/standard gauge wheelsets to pass for trains coming from Sydney/South Dynon. For a standard gauge train (from Sydney/South Dynon), this results in reduced rim contact on the broad gauge point blade through the transfer area.

Inspection of turnout MYD882 established that several wheels from a train had derailed within the transfer area, dropping off the broad gauge point blade[9] into the four foot[10], before striking the tie bar, then re-railing on the standard gauge short stock rail.

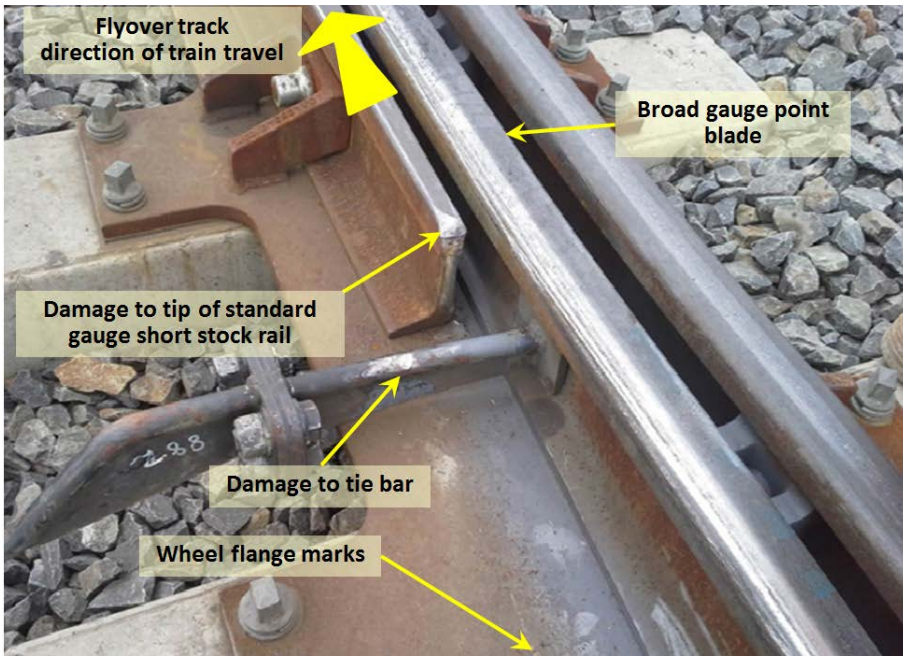
Figure 7: Turnout MYD882 located on the up flyover track



Source: CITS with annotation by ATSB

Damage to turnout MYD882 (Figure 8) primarily comprised bruising to the tie bar and tip of the standard gauge short stock rail. This damage probably occurred when the earlier inward bound service (ST21) traversed the turnout. This was about the time the driver reported rough riding (heavy bounce) through the turnout, and is consistent with XPT accelerometer data (Figure 2) which shows evidence of significant events at 0738:33 and 0738:37.

Figure 8: MYD882 showing damage to tie bar and tip of standard gauge short stock rail



Source: CITS with annotation by ATSB

[9] The machined pivoting or flexing running rail component of a turnout may also be called switch blade.

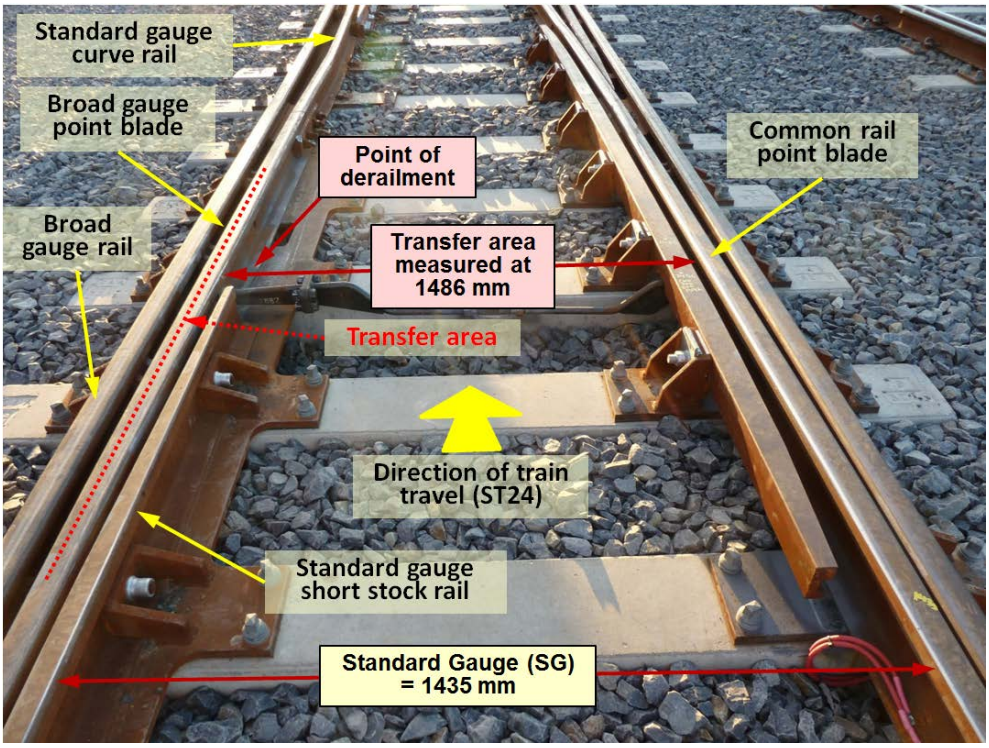
[10] The area between the rails of a standard gauge railway.

Turnout MYD887

Mixed gauge turnout MYD887, located on the down flyover track, provided for diverging movements – dual gauge to Sydney/South Dynon (going to the upper left in Figure 9) and broad gauge to Kensington/Footscray (going to the upper right in Figure 9). Train ST24 was diverging to the left, going to Sydney/South Dynon at the time of derailment.

For a standard gauge train, such as ST24, the left wheels transfer from the standard gauge short stock rail onto the broad gauge point blade before continuing on the standard gauge curve rail. Like MYD882, the gauge through the transfer area is wide by design, allowing broad gauge wheelsets to pass for trains going to Kensington/Footscray and broad/standard gauge wheelsets to pass for trains going to Sydney/South Dynon. For a standard gauge train (to Sydney/South Dynon), this results in reduced rim contact on the rail head through the transfer area.

Figure 9: Turnout MYD887 located on the down flyover track



Source: CITS with annotation by ATSB

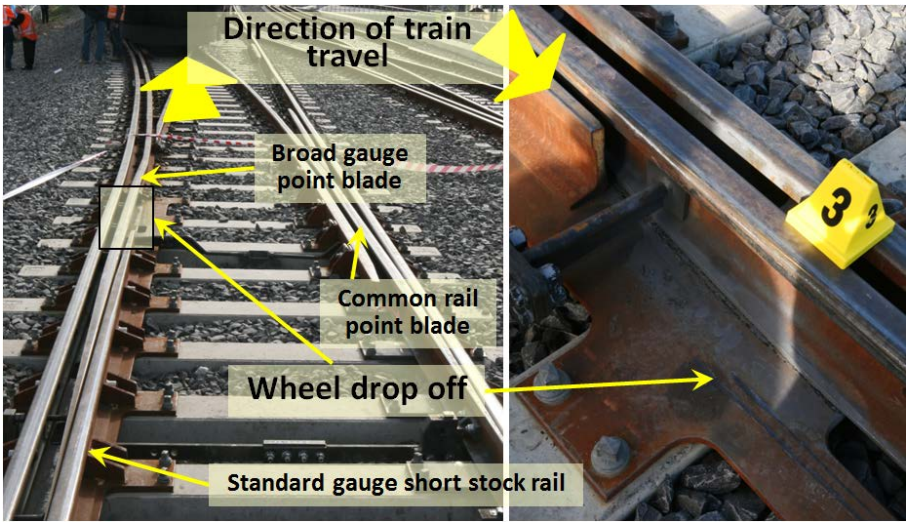
Examination of turnout MYD887 established that, as the left wheel(s) of a carriage(s) from ST24 transitioned from the standard gauge short stock rail onto the broad gauge point blade[11], a wheel, or wheels, dropped into the four foot. This is evident at Figure 10 (right side image), which shows bruising on the gauge face corner of the broad gauge point blade, and flange marks on the base plate at the bottom of the turnout.

At this point however (wheels dropping into four foot), there was no evidence of wheel flange marks on the opposite side on the common rail point blade – suggesting that the right wheel had not derailed. It was not until about 1.3 m further along the track that there were wheel flange marks indicating that a right wheel(s) had climbed over the head of the right common rail.

The pattern of wheel markings indicated a mismatch between the wheelset dimensions and the track gauge through the transfer area, consequently requiring an examination of rolling stock wheelset dimensions and track gauge width through the transfer area.

[11] The design of dual gauge turnouts requires standard gauge wheels to traverse the broad gauge point blade for a short distance between the short standard gauge stock rail and the heel (or pivot point) of the broad gauge point blade.

Figure 10: Turnout MYD887 point of wheel drop and flange marks on turnout base plate



Source: CITS with annotation by ATSB

Examination of rolling stock

On 11 July 2014, the site inspection of rolling stock, including bogies, wheelsets and wheels determined that there were no obvious maintenance or compliance issues.

Figure 11: Photo – Derailed leading wheelset carriage XAM2176

Source: CITS with annotation by ATSB

The inspection also established that all wheelsets under the passenger carriages XL2229 and XAM2176 (Figure 11) had derailed. Bruising and damage to turnout MYD887 revealed that the derailment was initiated by one (or more) left wheels derailing to the right.

It was noted that the lead bogie of carriage XL2229 had derailed to the left. It was concluded that the lead bogie of carriage XL2229 derailing to the left was as a consequence of XL2229 (trailing bogie) and/or XAM2176 (lead bogie) derailing to the right, possibly accentuated by power car XP2003 operating in push mode.[12,13]

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12 Simon Iwnicki (2006) Handbook of Railway Vehicle Dynamics (pp 410 – 412).

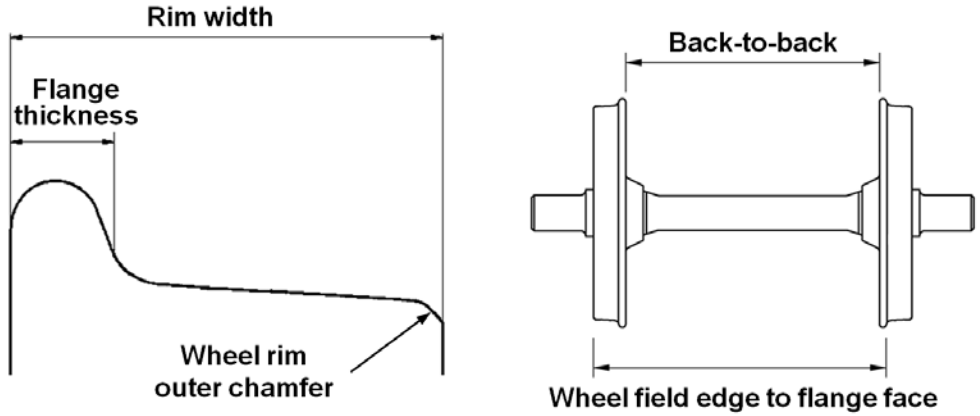
13 D.D. de Jong (2002) Running dynamics of long passenger trains in push/pull operation.

As a consequence, the investigation focused on the bogies and wheelset dimensions of XL2229 (trailing bogie) and XAM2176 (Figure 11 - lead bogie) for technical compliance.

Wheelset measurements

For rolling stock, the wheelset dimensions that are critical to ensure compatibility with track gauge are rim width, flange thickness and wheelset back-to-back distance (Figure 12). For a wheel to drop in between a track, the *wheel field edge to flange face* distance theoretically must be less than track gauge.[14]

Figure 12: Wheelset dimensions



Source: ATSB

The design and maintenance standards for rolling stock wheelsets and rolling stock wheels are documented in Australian Standard AS7517.3-2009 (Railway Rolling Stock Wheelsets Part 3) and AS7514.3-2010 (Railway Rolling Stock Wheels Part 3). AS7517.3-2009 prescribes back-to-back dimensions of wheelsets as 1,357 mm to 1,360 mm for standard gauge rolling stock. AS7514.3-2010 prescribes rim widths as 127 mm to 140 mm for both broad and standard gauge rolling stock wheels, and recommends a minimum flange thickness of 19 mm.

NSW Trains prescribes the following in-service flange thickness limits for its XPT services:

- New wheels and wheels that have just been machined or profiled should have a nominal flange thickness of 31 mm at the gauge point 10 mm above the wheel tread line.
- Wheels with a flange thickness below 23 mm are speed limited to 130 km/h.
- Wheels with a flange thickness below 21 mm when measured on the monthly schedule are not permitted to enter revenue service.
- Wheels with a flange thickness below 19 mm are not permitted to run.

V/Line, as the track manager, can impose additional restrictions for trains operating on their network. None were in force for XPT services at the time of the derailment and trains ST21 and ST24 (XPT services) had authority to operate on V/Line's network.

For the derailed carriages XL2229 and XAM2176, the bogies and wheelsets were comprehensively examined off site on 14 July 2014 at the UGL/Unipart Auburn maintenance facilities in New South Wales.

The examination established:

- Back-to-back dimensions for all wheelsets ranged from a minimum of 1358.25 mm to a maximum of 1359.54 mm.

[14] Note: The size of the wheel rim outer chamfer reduces the effective wheel rim width and therefore the effective *wheel field edge to flange face* distance.

- All wheels had a rim width of 127 mm.
- All wheels flanges exceeded 23 mm.

All wheels and wheelsets fully complied with, or exceeded, both the Australian Standards and NSW Trains mandated requirements for unrestricted running. It was established that of the wheelsets examined, the lead wheelset of the lead bogie of carriage XAM2176, while still compliant, had the narrowest field edge to flange face width. This leading wheelset was considered most likely to have derailed first, possibly accentuated by power car XP2003 operating in push mode.

Safety analysis

On 11 July 2014, train ST24, a scheduled XPT passenger service operated by NSW Trains, derailed at turnout MYD887 on the North Melbourne flyover track located just north west of the Southern Cross station in Victoria. While the lead wheelset of the lead bogie of carriage XAM2176 was considered the first to derail, it was subsequently shown to fully comply with engineering and operating requirements. As such, the investigation focused on the condition and characteristics of the recently commissioned track turnouts.

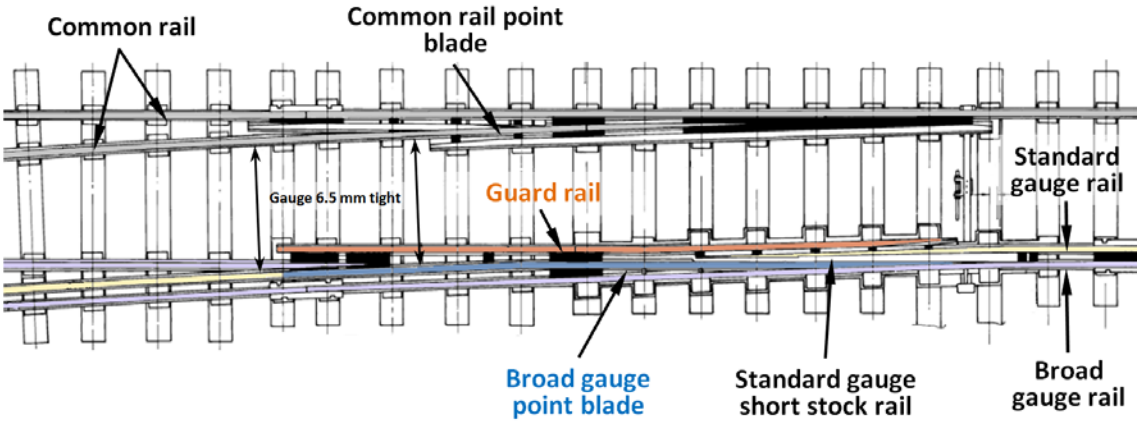
Type 37 mixed gauge turnout

The type 37 mixed gauge turnout has one dual gauge leg and one broad gauge leg.

The design concept for type 37 mixed gauge turnout was first envisaged by the South Australian Railways[15] (SAR) for use with 47 kg/m rail on timber bearers. The original SAR design (Figure 13 Drawing W33037/Appendix B) incorporated a set to give 6.5 mm tight gauge through areas of the turnout and guard rail[16] protection adjacent the broad gauge point blade.

Based on available information, the SAR type 37 turnout design was never used in operational service.

Figure 13: General schematic – SAR type 37 turnout (Drawing W33037 – See Appendix B)



Source: ARTC (SAR) with annotation by ATSB

Design of turnout MYD887 and MYD882

The two turnouts, MYD887 and MYD882, were designed and manufactured by Vossloh Cogifer Australia Pty Ltd (VCA). They are type 37 mixed gauge turnouts, however, the design was based on the Australian Rail Track Corporation (ARTC) type 29 turnout (Figure 14) which has two dual gauge legs and was specifically developed for 50 kg/m rail on concrete bearers.

The ARTC type 29 turnout had been certified for operational use in both South Australia and Victoria, so the type 29 turnout was used as the basis for the underlying design of the VCA type 37 turnout to streamline subsequent design and approval processes.

V/Line's subsequent provisional type approval of the VCA type 37 turnout was largely on the basis that design and componentry was substantially the same as the ARTC type 29 turnout. The main discernible change introduced by VCA with the type 37 turnout (Figure 15) was the removal the standard gauge point blade and associated (straight) rail section (Figure 14 – shown in orange).

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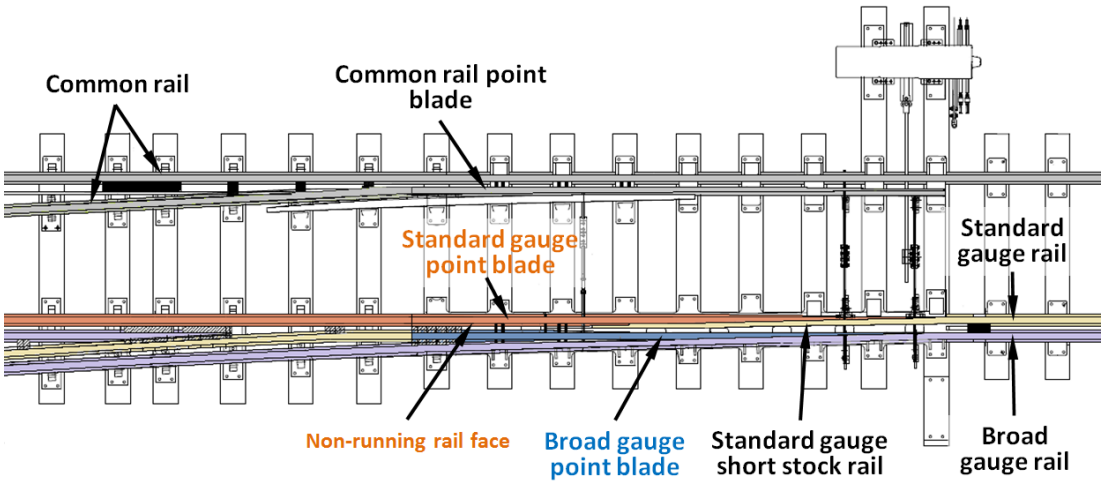
[15] The operations of the SAR (non-metropolitan railways) were vested in the Australian National Railways Commission (AN) by way of the *Railways (Transfer Agreement) Act 1975*. The lines operated by AN were subsequently transferred to the ARTC.

[16] A rail (inside or outside the running rail) used to restrain lateral movement of a derailed wheelset. Used to protect structures or control the lateral movement of the wheelset on bridges or in other higher risk situations.

This was because the track to Kensington/Footscray was broad gauge only – standard gauge was not required.

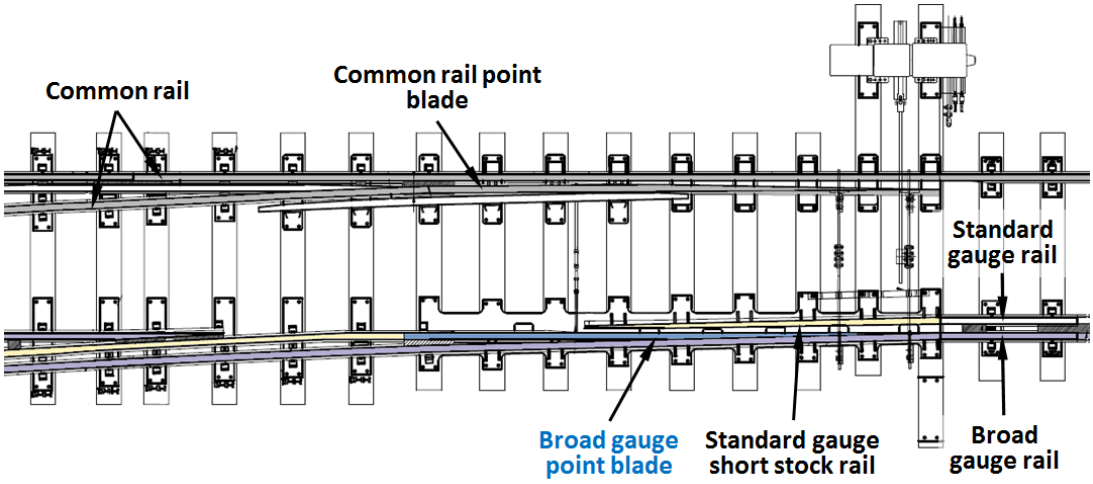
Figure 14: General schematic – ARTC type 29 turnout



Source: ARTC with annotation by ATSB

Post derailment measurements taken at turnout MYD887 established the widest point through the transfer area was 1,486 mm. This was 6 mm greater than the VCA design width of 1,480 mm but was probably gauge widening as a consequence of wheel(s) falling into the four foot.

Figure 15: General schematic – VCA type 37 turnout

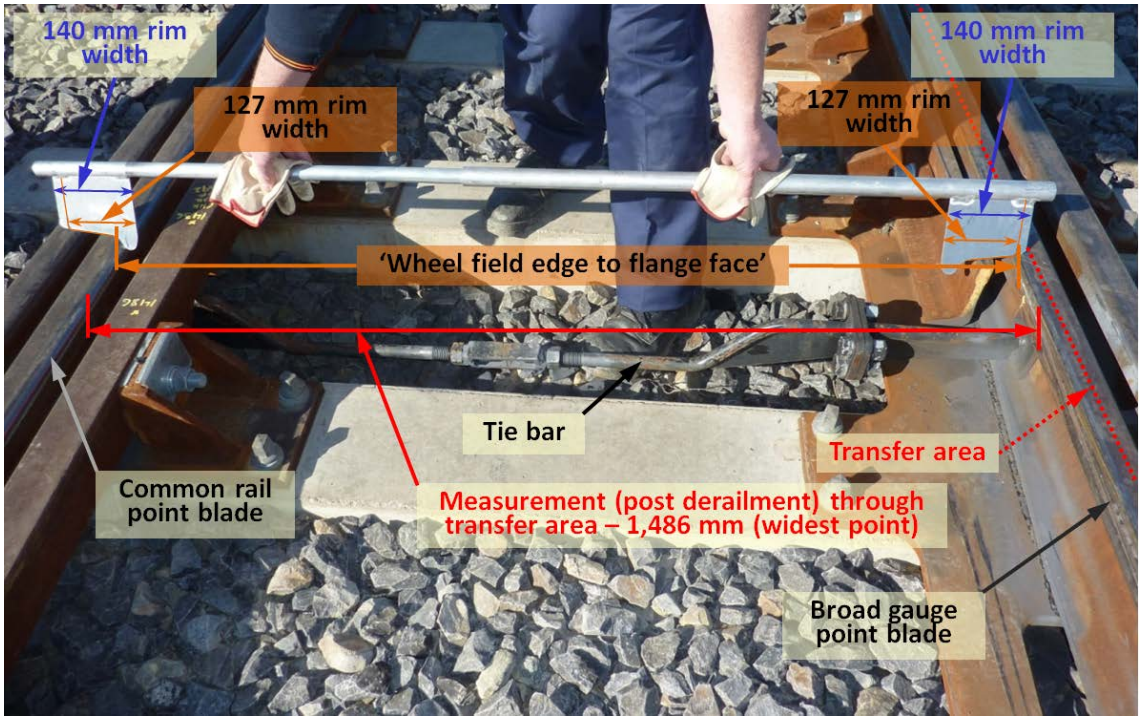


Source: VCA with annotation by ATSB

Overlaying a wheelset gauge on the turnout (Figure 16) through the transfer area clearly showed that a 127 mm wheel rim had marginal rim contact on the broad gauge point blade compared to a 140 mm rim. Post derailment computer modelling by VCA confirmed these observations.

As a result, when a 127 mm wheelset traversed the transfer area it imposed high forces on the left edge of the broad gauge point blade. Where the blade is insufficiently restrained, these forces would cause it to roll over and flex outwards (towards the broad gauge rail), increasing the likelihood of wheels dropping between the tracks. An examination of turnouts MYD882 and MYD887 established both trains had derailed as a result of wheelsets dropping in the four foot while traversing the transfer area. Subsequently, the investigation also established that the standard gauge test trains used during the commissioning of MYD882 and MYD887 had wheel rim widths of 140 mm and had traversed the turnouts without incident. XPT train ST21, returning to Sydney as ST24, had 127 mm rim widths which were not included as part of the commissioning process.

Figure 16: Turnout MYD887 transfer area with wheelset gauge overlaid



Source: CITS with annotation by ATSB

Further turnout examination

To better understand the mechanism of derailment, an examination of other in-service dual gauge turnouts ensued. This was done to identify any underlying differences between the VCA type 37 turnout and existing/in service dual gauge turnouts.

The examination established:

- Other dual gauge turnout types in service were narrower through the transfer area than the VCA type 37; in some cases by as much as 20 mm.[17] This meant that there was more wheel rim contact on the rail head, through the transfer area, for these turnout types when compared with the VCA type 37, and accordingly, there was less likelihood of a 127 mm wheelset dropping into the four foot.
- The tie bar shown at Figure 16 helps maintain gauge through the transfer area by preventing the broad gauge point blade flexing outwards (towards the broad gauge rail) during the passage of a train. The tie bar for turnouts MYD882 and MYD887 had been modified from an original ARTC design which used a straight rod, to a rod with a set. This was to remove an identified tripping hazard. While theoretical analysis indicated that the modified tie bar would be fit for purpose, post derailment physical testing and finite element analysis (FEA)[18] identified that the modified tie bar could elastically elongate by as much as 10 mm under typical operating loads and hence allow the broad gauge point blade to roll and flex outward.
- For the operational type 29 dual gauge turnouts (50 kg/m on concrete bearers, Figure 14) there was evidence, in a number of cases, of flange back contact wear on the non-running rail face of the standard gauge point blade.

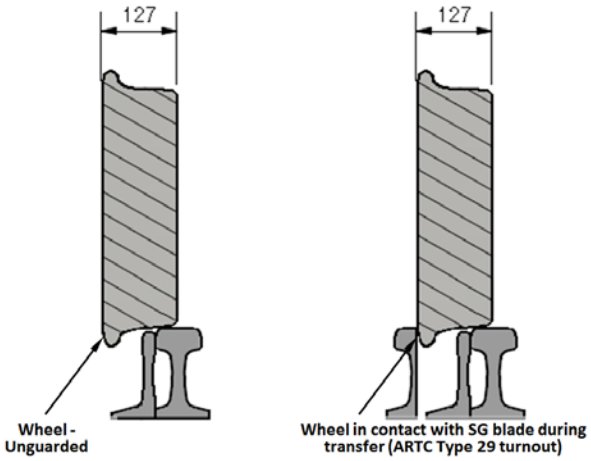
  Although the standard gauge point blade was not designed as a guard rail (Figure 17), it is possible that it has provided some assistance in guarding and may have in some cases prevented trains from derailing. While the width of the transfer area is critical for a train to

[17] Largest differential existed for a type 30 turnout – 47 kg/m on timber bearers.

[18] FEA as applied in engineering is typically a computer model of a material or design that is stressed and analysed for specific results. It is used in new product design, and existing product refinement.

safely negotiate a turnout, the removal of the standard gauge point blade, without providing guard rail protection, meant that the left wheel of a vehicle (carriage) could work off the broad gauge point blade and fall into the four foot. As such, it was evident that the removal of the standard gauge point blade without incorporating fixed guard rail protection (type 37), was probably a design oversight that increased the likelihood of the derailment of trains operating with 127 mm wheelsets.

Figure 17: Comparison of VCA type 37 and ARTC Type 29 wheel transfer zones



Source: VCA with annotation by ATSB

Conclusion

The design of the VCA type 37 turnout with respect to transfer area width, guard rail protection and capacity of the tie bar to resist elongation were all areas of design deficiency that contributed to the derailment of train ST24 on 11 July 2014.

Contract documentation and approval process

The supply of the turnouts by VCA was pursuant to the Services and Supply Umbrella Agreement (Umbrella Agreement) between MTM and VCA. V/Line, as the relevant authorised rail operator was required to give type approval to the turnouts designed by VCA.

While the Umbrella Agreement contract documentation included general conditions, a cost schedule (supply and delivery of turnouts), a generic technical specification and drawings / photographs, the specification 'Design, Manufacture and Delivery of Tangential Turnouts, Fabricated Points and Crossings' did not include:

- A technical specification for dual gauge turnouts and crossovers in addition to broad gauge tangential turnouts and crossovers.
- Any guidance as to design for standard gauge operation, including limits for gauge widening.
- Details or requirements for rolling stock types or wheel profiles and sizes.
- A requirement for a wheel transfer study and
- Performance measures (Clause 9.0 of the specification noted this as 'To be negotiated').

Provisional approval of the VCA type 37 turnout, by V/Line, was largely documented in a checklist titled 'V/Line Type Approval VLP157'. This document included an Executive Summary, Type Approval Checklist Infrastructure (NIFO – 1310.1 | Revision 01), suppliers documentation, clarifications, drawings and risk assessment.

In provisionally accepting the VCA type 37 turnout, V/Line undertook a compliance validation audit, the results of which are recorded in the document Type Approval Checklist – Infrastructure (NIFO – 1310.1 | Revision 01). An extract, item 1.0 of the document, is shown in Figure 18.

Figure 18: Extract from Type Approval Checklist – Infrastructure: Item 1.0

Item #	Check Item	Supplier's Evidence / Reference Document – Page & Section	Compliance Yes or No	V/Line Review & Comment	V/Line Acceptance for Provisional Type Approval
1.0	**Meets the Standards, Regulations and Project Brief**				
1.1	Is a Design for the system or item included with the submission?	P5/1	YES	CROSSING WORK LAYOUTS FOR EACH DESIGN	Y
1.2	Has the System/Item been designed in accordance with accepted engineering standards (V/Line, VRIOG RISSB, Australian standards)?	P7/2	YES	COMPLIES BUT NOT LIMITED TO PTCV, IUC, ORE, BR, AREMA, ARTC NSW STANDARDS, ARTC COP AND AUSTRALIAN STANDARDS	Y

Source: V/Line

Examination of the checklist at item 2.0 (Figure 19) of the same document established that V/Line accepted the VCA type 37 turnout based on the in-service performance and history of similarly designed dual gauge turnouts. However, there were notable design changes inherent in the VCA type 37 turnout, and importantly, the type 37 turnout had not been used in operational service. While the VCA type 37 turnout was based on an in-service design (type 29), the parties involved had not appreciated the subtleties of the design changes from the type 37. Further, as the specification provided by MTM under the Umbrella Agreement did not identify rolling stock likely to operate over the turnouts, including rolling stock with 127 mm wheel rim dimensions, V/Line was not alerted to the risk that might arise in operating such rolling stock over MYD882 and MYD887.

Figure 19: Extract from Type Approval Checklist – Infrastructure: Item 2.1 and 2.2

Item #	Check Item	Supplier's Evidence / Reference Document – Page & Section	Compliance Yes or No	V/Line Review & Comment	V/Line Acceptance for Provisional Type Approval
2.0	**Use in comparable Railway Systems**				
2.1	Is the item approved for use in comparable systems? Have details been provided?	P9/3 & p13/7	YES	ARTC NETWORK – SA AND VIC V/LINE INSPECTED THE SIMILARLY DESIGNED DG TURNOUTS INSTALLED IN GHERINGHAP AND MISSING LINK PROJECTS	Y
2.2	Does the item have a proven record in other rail systems under comparable operational conditions?	P9/3 & p13/7	YES	SEE ITEM 2.1	Y

Source: V/Line

The checklist at item 3.0/4.0 (Figure 20 – Item 3.2) shows that V/Line recognised the need for vehicle interoperability, in that all authorised rolling stock could safely operate over the VCA type 37 turnout. However, a review of the column 'V/Line Review & Comment' does suggest that, prior to and during the provisional type approval process, the possibility of trains having 127 mm rims (including the XPT) operating over these turnouts was not referenced/appreciated. This was also evident in that none of the trains used during the testing and commissioning phase of the turnouts had 127 mm rimmed wheels.

It was considered likely that, had this oversight in the design documentation/validation phases been picked-up prior to or during the provisional approval process, then trains with 127 mm rimmed wheels would have been included in the testing program and the deficiency with the VCA design would probably have been identified.

It is also likely that V/Line would have required that VCA demonstrate the safe operation of the turnout using an appropriate computer modelling/wheel transfer simulation.

Figure 20: Extract from Type Approval Checklist – Infrastructure: Item 3.2 and 4.1

Item #	Check Item	Supplier's Evidence / Reference Document – Page & Section	Compliance Yes or No	V/Line Review & Comment	V/Line Acceptance for Provisional Type Approval
3.0	**Interoperability with existing systems**				
3.2	Confirm compatibility with wheel rail profiles, speed, configuration, track maintenance vehicles and tools	P10/4 & P7/2	YES	V/LINE TRAINS CURRENTLY RUN ON DG TURNOUTS IN GHERINGHAP	Y
4.0	**Form (the system or item submitted for Type Approval must have the correct requirements to fulfil the intended function) and be Fit for purpose in existing systems.**				
4.1	Is the item compatible with current railway operational requirements?	P11/5	YES	V/LINE TRAINS CURRENTLY RUN ON DG TURNOUTS IN GHERINGHAP	Y

Source: V/Line

Conclusion

The MTM contract documentation and specifications did not identify notable engineering constraints such as rolling stock types (wheel profiles/wheel rim width). It was also evident that the V/Line approval process lacked robustness, in assuming that the VCA type 37 turnouts would perform safely in service, based on the design and performance of the type 29 turnout. The V/Line approval process also did not recognise the need to test/commission the VCA type 37 turnout with all applicable rolling stock types – in particular trains with a 127 mm wheel rim.

Response to the initial derailment at turnout MYD882

The ATSB investigation found that train ST21 (later returning to Sydney as ST24) had derailed at turnout MYD882 in a similar manner to ST24. However, because of the direction of travel, train ST21 immediately re-railed on exiting the turnout – leading to the driver's report of a heavy bounce.

When train ST21 traversed MYD882, the pilot was extremely concerned. He reported the occurrence to Number 1 signal box; they advised that they would arrange a track inspection. At the time that train ST24 subsequently departed, maintenance staff were inspecting the track just east of the derailment site (closer to Southern Cross station), having probably had insufficient time to complete a comprehensive inspection of the MYD882 turnout.

Had the inspection of turnout MYD882 and the train wheels been carried out prior to allowing train ST24 to depart, it may have alerted engineering staff to the earlier derailment event. Questions may have thus arisen as to the potential for a similar risk on the adjacent MYD887 turnout, which in turn, may have prompted a more comprehensive inspection of the train and track before ST24 departed.

Findings

From the evidence available, the following findings are made with respect to the derailment of the XPT passenger train ST24 on 11 July 2014. These findings should not be read as apportioning blame or liability to any particular organisation or individual.

Safety issues, or system problems, are highlighted in bold to emphasise their importance. A safety issue is an event or condition that increases safety risk and (a) can reasonably be regarded as having the potential to adversely affect the safety of future operations, and (b) is a characteristic of an organisation or a system, rather than a characteristic of a specific individual, or characteristic of an operating environment at a specific point in time.

Contributing safety factors

- Train ST24 derailed at turnout MYD887 as the wheelset of a carriage, probably XAM2176, dropped off the broad gauge point blade into the four foot while traversing the transfer area.
- **The design of the VCA type 37 mixed gauge turnouts (MYD882 and MYD887) was such that they were not suitable for use by rolling stock with a 127 mm rimmed wheel. [Safety issue]**
- **The VCA type 37 turnout design and V/Line's provisional type approval process did not fully identify the subtle design changes inherent with the VCA type 37 turnout in determining testing, commissioning and validation needs. [Safety issue]**
- **The physical testing and commissioning regime for the VCA type 37 turnout did not require the use of standard gauge trains with 127 mm rimmed wheels. [Safety issue]**

Other factors that increased risk

- **Contract documentation and specifications within the *Umbrella Agreement* were generic and did not specify the intended purpose of the type 37 turnout. [Safety issue]**
- **V/Line's processes for responding to the report by the driver of train ST21 did not limit or prevent the subsequent movement of train ST24 before checks had been carried out to identify and assess any potential track and/or rolling stock issue(s). [Safety issue]**

Other findings

- All wheel and wheelset dimensions for the derailed rolling stock that were critical for compatibility with track gauge were within the requirements specified in the Australian Standards, and considered fit for purpose for operation on the V/Line network.

Safety issues and actions

The safety issues identified during this investigation are listed in the Findings and Safety issues and actions sections of this report. The Australian Transport Safety Bureau (ATSB) expects that all safety issues identified by the investigation should be addressed by the relevant organisation(s). In addressing those issues, the ATSB prefers to encourage relevant organisation(s) to proactively initiate safety action, rather than to issue formal safety recommendations or safety advisory notices.

All of the directly involved parties were provided with a draft report and invited to provide submissions. As part of that process, each organisation was asked to communicate what safety actions, if any, they had carried out or were planning to carry out in relation to each safety issue relevant to their organisation.

Safe transition of dual gauge turnouts (Preliminary report)

During the investigation of this occurrence, the ATSB released preliminary report RO-2014-013 on 25 September 2014. The preliminary report identified the following safety issue:

Number:	RO-2014-013-SI-01
Issue owner:	V/Line and NSW Trains
Operation affected:	Rail: Infrastructure and Rolling stock.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

Inherent to the design of many dual gauge turnouts is a region of reduced wheel rim contact on the broad gauge switch blade (rail head) through the transfer area. In circumstances where the switch blade is insufficiently restrained, and where the passing train has a narrow (127 mm) wheel rim width, there is an increased risk of derailment.

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-016

V/Line is currently actively managing the redesign, alteration and validation of the type 37 turnout to support restoration of standard gauge, 127 mm rim width services.

Office of the National Rail Safety Regulator (ONRSR) – Safety Alert

The Office of the National Rail Safety Regulator has independently reviewed this occurrence and identified the higher risk of derailment through the wheel transfer area of some mixed and dual gauge turnouts for rolling stock having wheel rim widths of 127mm. ONRSR has issued an industry wide Safety Alert (RSA-2014-03) shown at Appendix A

ATSB comment:

While the ATSB is satisfied that the action proposed by V/Line will adequately address this safety issue in the context of type 37 turnouts, it is considered appropriate that all rail transport operators should be made broadly aware of the increased derailment risk in operating trains with narrow (127 mm) rimmed wheels through similar dual gauge turnouts.

ATSB safety advisory notice to: All rail transport operators

Action number: RO-2014-013-SAN-01

The Australian Transport Safety Bureau encourages all relevant rail service operators and rail infrastructure managers to note the circumstances of the derailment outlined in this report, and to undertake an examination of all dual gauge turnouts under their control, to ensure that all authorised rolling stock can safely transition the turnouts.

Design of turnouts – MYD882 and MYD887

Number:	RO-2014-013-SI-02
Issue owner:	V/Line
Operation affected:	Rail: – Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

The design of the VCA type 37 mixed gauge turnouts (MYD882 and MYD887) was such that they were not suitable for use by rolling stock with a 127 mm rimmed wheel.

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-011

V/Line is developing technical and performance requirements for all crossing work, including dual gauge. This will include:

- Minimum Wheel/rail cover requirements;
- Performance requirements for fixed spreaders and gauge retention mechanisms;
- Performance requirements for flange back guarding/checking mechanisms; and
- Desirable and absolute limits for design gauge.
- These will be issued to projects and external suppliers prior to receiving designs or type approval applications for review.

ATSB comment in response:

The ATSB is satisfied that the actions proposed by V/Line will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by V/Line had not yet been fully implemented.

Provisional type approval process

Number:	RO-2014-013-SI-04
Issue owner:	V/Line
Operation affected:	Rail: – Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

The VCA type 37 turnout design and V/Line's provisional type approval process did not fully identify the subtle design changes inherent with the VCA type 37 turnout in determining testing, commissioning and validation needs.

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-013

V/Line is developing a comprehensive safety in design process which will be integrated with the type approval process within our Safety Management System. The safety in design process will be mandated for all design of systems and products in compliance with:

- Rail Safety National Legislation;
- Safe Work Australia guidelines; and
- Worksafe Victoria guidelines.

ATSB comment in response:

The ATSB is satisfied that the actions proposed by V/Line will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by V/Line had not yet been fully implemented.

Testing of turnouts MYD882 and MYD887

Number:	RO-2014-013-SI-05
Issue owner:	V/Line
Operation affected:	Rail: – Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

The physical testing and commissioning regime for the VCA type 37 turnout did not require the use of standard gauge trains with 127 mm rimmed wheels.

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-015

V/Line's Safety Management System will be updated to ensure that all projects, irrespective of whether they are delivered by internal or third parties, comply with V/Line Testing and Commissioning requirements and procedures as documented in NIPR-2690 "Infrastructure Commissioning". NIPR-2690 "Infrastructure Commissioning" will be updated to provide further specific requirements for operational testing.

ATSB comment in response:

The ATSB is satisfied that the actions proposed by V/Line will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by V/Line had not yet been fully implemented.

Contract approval process

Number:	RO-2014-013-SI-03
Issue owner:	V/Line
Operation affected:	Rail: – Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

Contract documentation and specifications within the *Umbrella Agreement* were generic and did not specify the intended purpose of the type 37 turnout.

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-012

V/Line is developing a comprehensive safety in design process which will be integrated with the type approval process within our Safety Management System. The safety in design process will be mandated for all design of systems and products in compliance with:

- Rail Safety National Legislation;
- Safe Work Australia guidelines; and
- Worksafe Victoria guidelines.

ATSB comment in response:

The ATSB is satisfied that the actions proposed by V/Line will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by V/Line had not yet been fully implemented.

Inspection of turnout MYD882 and train wheels

Number:	RO-2014-013-SI-06
Issue owner:	V/Line
Operation affected:	Rail: Infrastructure.
Who it affects:	All rail transport operators throughout Australia.

Safety issue description:

V/Line's processes for responding to the report by the driver of train ST21 did not limit or prevent the subsequent movement of train ST24 before checks had been carried out to identify and assess any potential track and/or rolling stock issue(s).

Proactive safety action advised by: V/Line

Action number: RO-2014-013-NSA-014

Following V/Line receiving any rough ride report over a dual gauge turnout, V/Line will immediately halt all standard gauge services until the rough ride report has been investigated. This includes inspection of both the track and the relevant rolling stock.

ATSB comment in response:

The ATSB is satisfied that the actions proposed by V/Line will, when implemented, adequately address this safety issue.

Current status of the safety issue:

Issue status: Safety action pending

Justification: At the time of this report release, the safety actions advised by V/Line had not yet been fully implemented.

General details

Occurrence details

Date and time:	11 July 2014 – 0835 EST	
Occurrence category:	Serious incident	
Primary occurrence type:	Derailment - Running Line	
Location:	North Melbourne 2 km north west of Southern Cross station	
	Latitude: 37° 48.419' S	Longitude: 144° 56.341' E

Train details

Train operator:	NSW Trains	
Registration:	ST24	
Type of operation:	Passenger	
Persons on board:	Crew – 5 (6 including pilot)	Passengers – 193
Injuries:	Crew – 6 (Minor)	Passengers – 10 (Minor)
Damage:	Minor	

Sources and submissions

Sources of information

The sources of information during the investigation included the:

- Metro Trains Melbourne
- NSW Trains
- Regional Rail Link Authority
- The Australian Rail Track Corporation (ARTC)
- V/Line
- Vossloh Cogifer Australia Pty. Ltd

References

AS7517.3-2009 (Railway Rolling Stock Wheelsets Part 3)

AS7514.3-2010 (Railway Rolling Stock Wheels Part 3)

D.D. de Jong (2002) Running dynamics of long passenger trains in push/pull operation

RISSB National Guideline - Glossary of Railway Terminology

Simon Iwnicki (2006) Handbook of Railway Vehicle Dynamics (pp 410 – 412)

Submissions

Under Part 4, Division 2 (Investigation Reports), Section 26 of the Transport Safety Investigation Act 2003, the ATSB may provide a draft report, on a confidential basis, to any person whom the ATSB considers appropriate. Section 26 (1) (a) of the Act allows a person receiving a draft report to make submissions to the ATSB about the draft report.

A draft of this report was provided to the Australian Rail Track Corporation, NSW Trains, the Office of the National Rail Safety Regulator, Regional Rail Link City to Maribyrnong River Alliance (CMR), VLine, Vossloh Cogifer Australia and train crew.

Submissions were received from the Australian Rail Track Corporation, NSW Trains, the Office of the National Rail Safety Regulator, Regional Rail Link City to Maribyrnong River Alliance (CMR) V/Line, Vossloh Cogifer Australia and train crew. The submissions were reviewed and where considered appropriate, the text of the report was amended accordingly.

Australian Transport Safety Bureau

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; fostering safety awareness, knowledge and action.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to fare-paying passenger operations.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

Purpose of safety investigations

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

Developing safety action

Central to the ATSB's investigation of transport safety matters is the early identification of safety issues in the transport environment. The ATSB prefers to encourage the relevant organisation(s) to initiate proactive safety action that addresses safety issues. Nevertheless, the ATSB may use its power to make a formal safety recommendation either during or at the end of an investigation, depending on the level of risk associated with a safety issue and the extent of corrective action undertaken by the relevant organisation.

When safety recommendations are issued, they focus on clearly describing the safety issue of concern, rather than providing instructions or opinions on a preferred method of corrective action. As with equivalent overseas organisations, the ATSB has no power to enforce the implementation of its recommendations. It is a matter for the body to which an ATSB recommendation is directed to assess the costs and benefits of any particular means of addressing a safety issue.

When the ATSB issues a safety recommendation to a person, organisation or agency, they must provide a written response within 90 days. That response must indicate whether they accept the recommendation, any reasons for not accepting part or all of the recommendation, and details of any proposed safety action to give effect to the recommendation.

The ATSB can also issue safety advisory notices suggesting that an organisation or an industry sector consider a safety issue and take action where it believes it appropriate. There is no requirement for a formal response to an advisory notice, although the ATSB will publish any response it receives.

Appendices

Appendix A – ONRSR safety alert RSA-2014-03

Safety Alert

OFFICE OF THE national rail safety regulator

NOTICE TO RAIL TRANSPORT OPERATORS

RSA-2014-03 Date Issued: 20 August 2014

SUBJECT

Operational interfaces between Rail Infrastructure Managers and Rolling Stock Operators – mixed and dual gauge turnouts

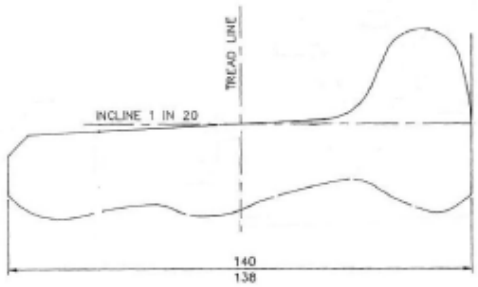
ISSUE

On 11 July 2014 a standard gauge interstate passenger train derailed in a facing movement while attempting to negotiate the diverge leg of a Type 37 mixed gauge (1435mm / 1600mm) turnout.

The derailment occurred at the wheel transfer area approximately midway along the point blade of the turnout. The train wheelsets had a rim width of 127mm.

Due to the design of the wheel transfer area of some mixed and dual gauge turnouts, rolling stock with wheelsets of 127mm rim width are at higher risk of derailment than wheelsets of 140mm rim width.

Similar mixed gauge and dual gauge (1435mm / 1600mm) turnouts are used elsewhere on Australian rail networks.



ANZR1 Wheel Tread Profile

Both Rail Infrastructure Managers (RIMs) and Rolling Stock Operators (RSOs) have rail safety duties under the Rail Safety National Law and obligations to manage, so far as is reasonably practicable, the safety of the operator's railway operations. These duties include:

- Ensuring they have an appropriate documented set of engineering standards and procedures, and operational systems, safety standards and procedures to cover the following, and, if relevant, the interface between any 2 or more of the following:
  a) rail infrastructure
  b) rolling stock
  c) operational systems.

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- Managing the risks associated with their railway operations, including at the rolling stock / track infrastructure interface (including the wheel / rail interface) which may be managed jointly through track access agreements or similar type agreements.
- Ensuring they have procedures for ensuring that changes that may affect the safety of railway operations are identified and managed, including consultation with all affected parties.

As a result of this occurrence, and pending the outcome of formal investigations into the incident, the ONRSR recommends all relevant RIMs and RSOs operating standard gauge rolling stock over mixed gauge and dual gauge turnouts undertake the following:

1. RSOs to contact any relevant RIM of the network they operate on that has dual gauge operations to determine if your rolling stock operates over mixed gauge and dual gauge turnouts.

    a. RSOs to ensure they are operating in accordance with the route access standards and track access agreement (or similar documents) as defined by the RIM.

    b. RSOs to check their rolling stock fleet to ensure they are operating the correct wheelsets (in particular, wheel rim widths and wheel profiles) in accordance with the RIM's requirements.

    c. RSOs to ensure no changes are made to the operational configuration of their rolling stock such as changes in operational routes, introduction of new or modified rolling stock or changes to wheelset configuration (in particular, wheel rim widths and wheel profiles) without first confirming that the changes will continue to meet all requirements of the RIM.

2. RIMs to review the design of the wheel transfer areas of all mixed gauge turnouts. The review should focus on:

    a. Turnout designs similar to Type 37 mixed gauge turnouts (including Type 27, Type 28 and Type 38 mixed gauge turnouts).

    b. Ensuring wheel transfer designs are suitable for the operation of all rolling stock including the operation of wheelsets with 127mm rim widths.

3. RIMs to notify all RSOs affected by any relevant changes implemented as a result of undertaking step 2 above.

4. RIMs with mixed gauge turnouts similar to Type 37 mixed gauge turnouts (including Type 27, Type 28 and Type 38 mixed gauge turnouts) to inspect and adjust the turnouts as required to ensure the correct wheel transfer.

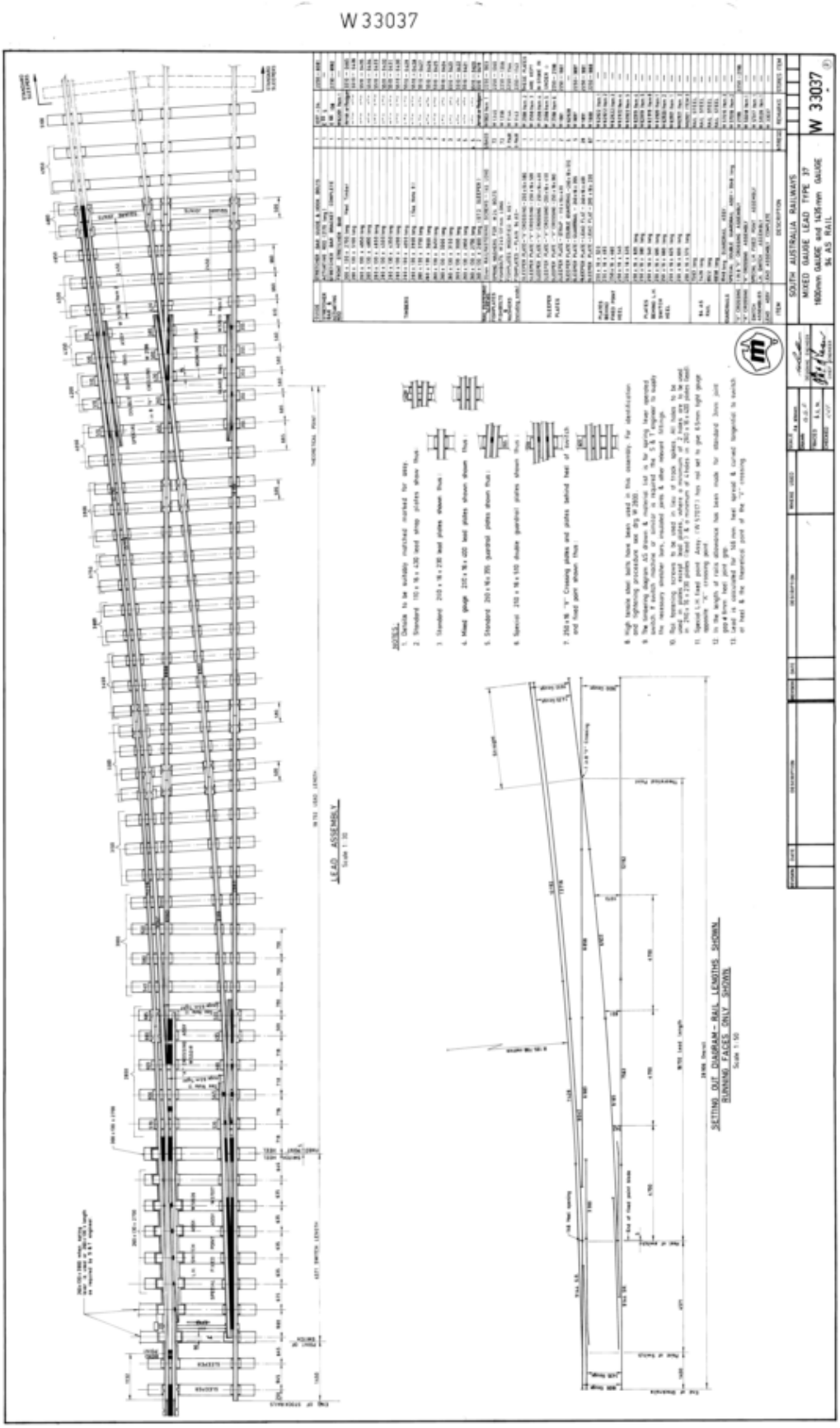
Additional information and updates regarding this safety alert may be provided in the future based on the outcomes of investigations currently underway.

For further information please contact Geoff Bell, Infrastructure Safety Engineer within the Victorian Branch of the ONRSR via e-mail geoff.bell@onrsr.com.au or phone (03) 9655 8954.

THIS ADVICE IS EFFECTIVE IMMEDIATELY

Peter Doggett
Executive Director National Operations

Appendix B – South Australian Railways (SAR) - Mixed Gauge Lead Type 37 (Drawing W33037)



Australian Transport Safety Bureau

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Investigation

ATSB Transport Safety Report
Rail Occurrence Investigation
Derailment of train ST24
near North Melbourne, Victoria, 11 July 2014

RO-2014-013
Final – 14 May 2015