



TC class dental clinic trailer – wheel loss failure

Investigation report

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This report contains information which may be restricted under privacy requirements.

Some information contained in this report may be commercially sensitive.

Maintenance of failed units was not investigated.

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Executive summary

This investigation report relates to two separate wheel loss incidents that occurred July 2017 and July 2020. The affected TC class 2 axle simple trailers were supplied by Action Manufacturing to various District Health Boards (DHBs) as mobile dental clinics. A total of 23 trailers of the same design were built between 2009 and 2019. Heavy Vehicle Specialist (HVS) Certification for the drawbar and chassis rating were carried out during this time by two different Heavy Vehicle Specialist Certifiers (HVSCs). HVS Certification for the brakes was also carried out by two different HVSCs.

A report was received from the NZ Police CVST for the incident that occurred in July 2020. The conclusion from this made a number of assumptions on what caused the studs to be shearing off.

Waka Kotahi visited Action Manufacturing to discuss the incidents - what they had found and what was being done to assure safety of these trailers for use on the road. Waka Kotahi was informed by Action manufacturing that the vehicle components were compatible and rated appropriately but may have been impacted by other contributing factors. The manufacturer issued advice on pre movement checks, towing drawbar height and correct wheel torque procedure. The certifier had issued a letter confirming no issues were found with the axle/hub and rim combination. This letter also reiterated the tow coupling height and wheel fitting recommendation.

In June 2021 Waka Kotahi received a complaint from s 9(2)(a) against HVSCs 9(2)(a) and an investigation was initiated. The certification files were requested from HVSC s 9(2)(a) and Action Manufacturing were asked for information on specifications for the components used in the manufacture of these mobile dental units.

The files supplied by HVSC s 9(2)(a) were reviewed for both the drawbars and the chassis ratings. This confirmed that the HVS Certifications had been issued correctly for those aspects.

Component information supplied by Action Manufacturing was reviewed. Ratings of the individual components was confirmed. There was no information supplied that confirmed these components were compatible with each other.

The component suppliers and distributors were asked to confirm that the components supplied were compatible in combination with each other. This request ended with little to no response and compatibility was not confirmed. Further correspondence to be 'directed to a legal representative' was a common theme amongst those that did respond.

A vehicle inspection was carried out by Waka Kotahi on a non-incident dental unit trailer. This included wheel removal. This inspection identified some inconsistent ratings of wheel rims compared to the information supplied. There were also indications that the suspension may at times run out of travel. Some inconsistent mating marks between the wheel hub and the wheel rim was also identified. This highlighted a compatibility issue between the two components.

Findings into the root cause by Waka Kotahi were discussed with HVSC s 9(2)(a) and this was shared and discussed with Action Manufacturing. Computer modelling and analysis began to test these findings and were further explored by HVSC s 9(2)(a). The results from this analysis were concerning and were shared with both Waka Kotahi and Action Manufacturing. Work began between HVSC s 9(2)(a) and Action Manufacturing to explore a solution. A proposed solution was confirmed and communication with the trailer owners has now been made. The solution includes replacing the wheel studs and fitting a stepped spacer (to cover the hub recesses and provide an improved mating surface). This will include the fitting of a thicker higher rated rim option (still stud centric but with far less flexibility). Ordering of the parts to cover all the dental unit trailers has been confirmed by Action Manufacturing.

Introduction

In July 2021, Waka Kotahi NZ Transport Agency (Waka Kotahi) received a complaint from s 9(2)(a) Medworx Ltd related to dental clinic trailers (TC class, 2 axle simple trailers).

The complaint was against Heavy Vehicle Specialist Certifier (HVSC) s 9(2)(a) s 9(2)(a) requested an investigation into 'the fitting and certification of lug centric wheels to these heavy trailers'.

Two specific wheel loss failures from trailers supplied by Action Manufacturing, are referenced:

- Plate number U729P (7AT0H900X12677372) on 21 July 2017, near Cromwell
- Plate number W672B (7AT0H900X13551232) on 14 July 2020, in Tauranga.

Action Manufacturing has identified 23 unique production numbers of the same design as the two vehicles involved in wheel loss events. Chassis rating LT400 certificates and drawbar LT400 certificates were issued by HVSC s 9(2)(a) (7 units 2009-2011) and HVSC s 9(2)(a) (16 units 2011-2019). Brake certification was carried out by HVSC s 9(2)(a) (7 units 2009-2011) and HVSC s 9(2)(a) (16 units 2011-2019).

Background

Prior to receiving this complaint, Waka Kotahi became aware of the issue following the second wheel loss failure in 2020. At that time, conversations were held with s 9(2)(a) Action Manufacturing to understand what they'd found from their own investigations and what action was being taken as a result.

Early on in the investigation, Waka Kotahi was informed that the vehicle components were compatible and rated appropriately but may have been impacted by other contributing factors. Both the manufacturer and certifier involved issued advice on checking trailers before each use and then proceeded to investigate the root cause further.

Scope

During our investigation, it became obvious that this was a complex issue, with many parties involved.

While the primary focus remains on investigating the certification issued by the HVSC involved and the fitting of lug centric wheels (as per the complaint received), Waka Kotahi has extended the scope to look at the entire situation, from heavy vehicle certification to the manufacture of the vehicles in New Zealand to the component supply chain.

Inspections

Failed trailer inspections

Due to the historic nature of the incidents when Waka Kotahi became involved (the trailers involved were repaired and the fault couldn't be examined), the complainant provided the following:

HVSC s 9(2)(a) Inspection of U729P

A document referencing the 2017 wheel loss failure of U729P, was written by HVSC s 9(2)(a) s 9(2)(a). In this report dated 21/06/2017 and headed Wheel Loss, he makes the following observations:

1. The wheels are stud centred as opposed to hub centred
2. The broken studs show fatigue characteristics
3. The rim face has two embossed annuli as points of hub face contact
4. It appears that the rim is not hard-in at the wheel nuts
5. The rims outer annulus is suspended across two casting slots for about 25% of its circumference.

Also contained in this report are the following comments:

- Wheel studs on stud centred set-ups are prone to failure from loose wheel nuts. They are subject to cyclic stress from every wheel revolution and fail from fatigue quickly.

- The rim centre is subject to a primary stress from the clamping force of the wheel nuts. Both the centre face and across the slots through not being seated.

Email comments from HVSC s 9(2)(a)

There are two emails containing comments in reply to photos of the 2020 wheel loss failure of W672B. The email documents were written by HVSC s 9(2)(a). HVSC s 9(2)(a) has made comments on photos, but Waka Kotahi doesn't believe he carried out an actual physical inspection.

NZ Police Commercial Vehicle Safety Team (CVST) report

A report was completed by NZ Police CVST after being approached by s 9(2)(a). s 9(2)(a) informed the CVST of the incidents and his concerns. He requested the CVST weigh the trailers with the tow beam at different heights to establish how much weight is being placed on the rear axle. The CVST carried out an inspection which included weighing of the trailer. A report was completed as a result. The report included an assessment of the weights for each axle and determined from the assessment that there was no excess weight being placed on the rear axle even with the drawbeam/drawbar in the uppermost position (which it is unlikely to get to).

This report stated that they are of the view that the reason for the studs shearing could be:

1. The wheel nuts have not been torqued and re-torqued correctly
2. The wheel nuts may be too small for the wheel loading
3. The wheel does not fit closely over the hub therefore not supported by the hub
4. The mating surface between the wheel and the hub is not smooth or flat enough to provide sufficient friction allowing movement in the wheel
5. That the studs are too small in diameter
6. Wheel nuts over torqued (stretching the studs).

Waka Kotahi Inspection of other vehicles

On Thursday 23 September 2021, a trailer of the same type involved in the wheel loss failures was inspected by s 9(2)(a) (Heavy Vehicle Certification Officer) and Out of Scope (Vehicle Specialist) of Waka Kotahi at Temuka Primary School. The trailer (VIN 7AT0KG02X10103421) is operated by Canterbury District Health Board and had a hub odometer reading of 007388.2km when inspected. Photos taken during the inspection are below.

The first axle right side wheel and second axle left and right wheels were removed. Inspection of the wheels and wheel mounting was conducted to identify possible cause(s) for wheel loss on vehicles of the same type.

The inspection identified:

- Rating and size stamped on wheel rim does not match information supplied. 16x7 & max 1180 Kgs stamped on inspected wheel rims; Information supplied states 16x6 3200LBS (=1451Kg)
- All removed wheel nuts felt tight when loosening
- The wheel rims did not appear to have full engagement with a flat face due to brake disc casting depressions
- The inner ring of the wheel rim was not making full contact with the disc surface, touch points at each wheel nut location
- The painted surface of the wheel rim had been expelled at the raised edges in contact with the disc
- There did not appear to be clean and uniform interface witness mark at the contacting areas, on either the disc or rim. Although it did not appear the wheels has been in operation whilst the wheel nuts loose
- Damage to the wheel stud threads and witness of thread contact on the wheel rims wheel stud holes was not more than what was considered normal from wheel removal and refitting
- Witness marks indicating the forward end of the spring rocker running out of travel were evident
- Differing brands of tyre were fitted to the vehicle and the right rear appeared to be a recently fitted tyre (Tyre single ratings ranged from 1150Kg to 1250Kg)
- Inconsistent witness marks at the wheel mounting surface contact points across the three wheels inspected

- The wheel mounting face of the brake disks have casting depressions to facilitate branding and wear limit markings. The brake disc casting depressions occupy sections of the wheel rim contact area and prevent the wheel rim's torque ring outer bead from making full contact with a flat mounting surface (as also mentioned in the supplied report by s 9(2)(a))
- Inconsistent wheel rim torque ring inner bead witness marks around the circumference of the wheel mounting surface contact area (on both the wheel rims and brake discs). This is most likely due to:
 - a damaged or poor-quality torque ring and or incorrect wheel nut torque; and
 - incorrect torque ring function due to areas of inadequate torque ring outer bead contact with the brake disc.

Improper interaction of a wheel's torque ring with its mating surface (the brake disc) may impact wheel retention performance.

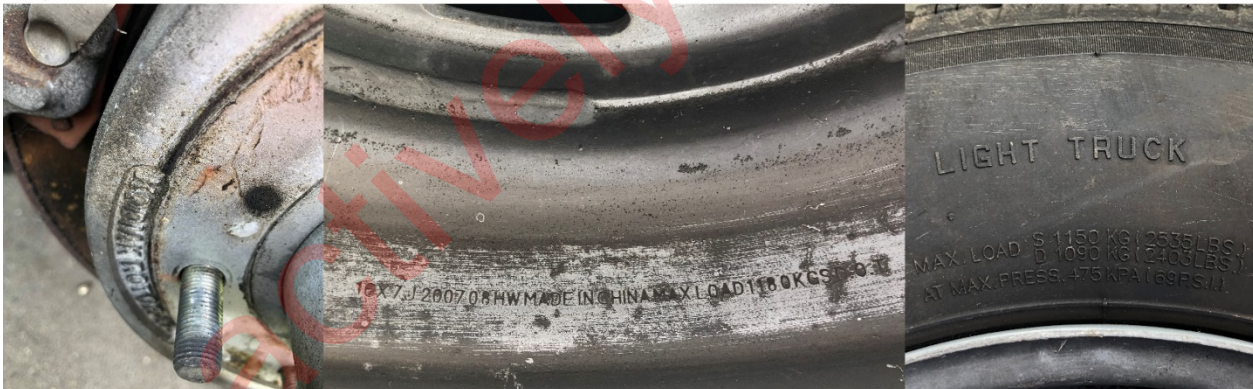
(Specific information regarding wheel mounting requirements and compatibility of components could not be obtained from the component suppliers despite best attempts by Waka Kotahi).



Wheel torque ring, interface (mounts towards brake disc)

Close up of wheel torque ring. Inconsistent witness marks evident.

Brake disc with wheel removed. Inconsistent witness marks and casting depressions evident



Close up of brake disc's wheel mounting surface. Witness mark from wheel rim and casting depression evident

Wheel rim stamped markings. max load rating evident (1180 KGS).

Fitted tyre marking. Max load rating of 1150 KG evident (single mounted)

Other inspections

The complainant also provided a report from s 9(2)(a) Metz Engineering (Tauranga) who independently inspected a similar trailer unit. The communication explains a number of findings with the wheel to hub/disc interface which align with the vehicle inspected by Waka Kotahi.

The report details an inspection where the brake disc was removed to inspect the disc to hub interface. A conflict caused by mismatched mounting dimensions which prevents the brake disc from correctly seating against the hub face is detailed.

Waka Kotahi contacted s 9(2)(a). He explained that in his opinion, disc fitment to the hub was contributory but was not the sole cause of poor wheel retention and he felt the wheel and hub assembly was not sufficiently robust for the vehicle's duty.

Investigation details

Heavy Vehicle Specialist Certifier s 9(2)(a)

Waka Kotahi requested complete certification files from HVSC s 9(2)(a) for certification of the two trailers that suffered wheel losses. The files supplied had details and information relating to the drawbar and chassis certifications.

The files contained:

- s 9(2)(a) calculations and notes
- design drawings
- information of advertised ratings for various components used to construct the trailers
- images
- chassis rating documentation
- administration documents.

Component ratings

Waka Kotahi confirmed that HVSC s 9(2)(a) certifications on these vehicles met requirements and were issued correctly.

Regarding the vehicle chassis rating, HVSC s 9(2)(a) identified the lowest rated component as part of assessing the vehicle to establish a rating.

The files contain individual component ratings and identifies a value of 1,150kg dictated by the fitted tyres. This is the lowest rated component. The determination made via the LT400 certificate issues a gross vehicle mass (GVM) of 4600 kg. This is equivalent to the lowest component rating; the vehicle's four single mounted tyres rated at 1150 kg per tyre (4x1150=4600). This is the rating identified on the notification of chassis rating document and is also identified in LANDATA.

The supplied documents used as part of defining the vehicle chassis ratings assume a uniform design load is applied across the chassis and the axle group load is equally distributed across the group. This is considered normal industry practice as certification is issued on empty trailers.

Waka Kotahi recognises that loading in these types of vehicles is weighted slightly to the right. However, some change in load distribution is expected (heavy vehicles are seldom loaded the same way every time) and is unlikely to have any meaningful impact on components.

Trailer manufacturer (Action Manufacturing)

Action Manufacturing produced a legal and compliant vehicle design.

All components individually were rated appropriately for their intended use. Some discrepancies in component rating were found between the vehicle Waka Kotahi inspected compared to those indicated in the documents supplied. However, all components were still appropriately rated eg wheel rim rating from vehicle inspection 1180kg, CM Trailer Parts documentation stated 1250kg, HTL wheel rim document and

stamping stated 3200lbs (1454kg), some documentation shows Kodiak TE2DIHK351 hydraulic disk hub (3500kg per pair) and other documents show Kodiak TE2DIHK251 hydraulic disk hub (2750kg per pair) fitted.

Axles and Wheels

The axles used were a heavy duty, light trailer axle supplied as hub assemblies that are appropriate for the weight ratings given to these trailers.

Early inspections and recent in-depth testing of the wheels and rims suggest there are issues with the compatibility of components even though they all were rated appropriately.

Action Manufacturing provided several operational and maintenance instructions/requirements for use of the dental trailer vehicles. We have assessed these and recognise the following:

Operation

Coupling height

A document provided by Action Manufacturing communicates a tow coupling height requirement for a level drawbar +/- 50mm and a design height of level being 570 -580 mm. It's noted that this height range was determined after the wheel loss failures occurred, as part of an exercise undertaken by the certifier and manufacturer to figure out what caused the failures. Hence no tow coupling height was displayed on the vehicles involved or inspected. This is supported by the NZ Police CVST when they carried out weight tests at different tow coupling heights. The test indicated that there is less than 5% difference in load transfer due to the 'swing-rocker' design used.

While tow coupling height may not cause any significant weight transfer, it does affect suspension travel. This would be mostly noticed and have a greater effect on uneven road surfaces or when traversing potholes.

Pre-movement check list

It is common for manufacturers and/or fleet operators to have pre-movement checklists. This is a good idea to ensure that the vehicle is roadworthy and safe to move. While most of the items on the list would be easy for an operator to check ie lights, some items would be unreasonable ie no movement in wheel or hub.

Maintenance

Maintenance instructions provided by Action Manufacturing may have been unclear or considered to be far beyond what is reasonably expected from vehicle owners and operators, but essential for service agents. Wheel torque on trailers is often overlooked with some service agents opting for power tools over things like torque wrenches.

A greater level of attention to maintenance may have picked up threading or wear of the wheel hub but it's unreasonable to expect owners to pull components apart during routine checks. Likewise, the Certificate of Fitness inspection checks tyre condition, hub and bearing play but doesn't involve invasive and in-depth wheel hub checks that would involve removal of components.

Trailer component suppliers

Information supplied by the trailer manufacturer states the hub, brake and wheel assemblies were procured from Brake & Transmission NZ Limited acting as stockists for C.M. Trailer Equipment Limited.

Brake & Transmission NZ Limited (trailer components retailer)

An email was sent to **s 9(2)(a)** Brake & Transmission NZ Limited requesting information on mounting requirements and ratings for the supplied wheel, tyre, and hub components.

No response was received

C.M. Trailer Equipment Limited (trailer components wholesaler)

Several emails requesting information on mounting requirements, compatibility and ratings for the supplied wheel, tyre and hub components were exchanged. On 22 September 2021 **s 9(2)(a)** advised:

“ALKO are a supplier of vehicle components only and we make no recommendations relating to fitment, or operation. I am unable to provide any evidence without knowing the specifics about this situation.

Our organisational guidelines will be to refer this matter to our legal representatives thereafter.”

Tompkins Wake (legal representative for C.M Trailer Equipment Limited)

An email was received from s 9(2)(a) Tompkins Wake advising he was acting on behalf of C.M. Trailer Equipment Limited and would revert once he had “an opportunity to review the correspondence and be fully briefed”.

A follow up email was sent when no response arrived and an out of office reply was received.

Kodiak Brake Products, LLC (wheel hub and brake manufacturer, Texas, USA)

A query was sent to Kodiak Brake Products (wheel hub manufacturer) requesting information on any requirements for wheel compatibility, no response was received.

HLT (HK) Cooperation Limited (wholesale wheel manufacturer or supplier, Hong Kong)

A technical drawing of a wheel rim was supplied by Action Manufacturing (vehicle manufacturer) together with information about the vehicle’s components. The drawing is identified with the branding HLT. The reference of HLT likely refers to Hong Kong based HLT (HK) Cooperation Limited; additional information regarding the company could not be easily located. Further information regarding wheel mounting requirements in order to ensure performance and justify rating from its manufacturer was not pursued.

Operation and maintenance of the vehicles

These vehicles were designed to be manoeuvred into tight spaces and should cope with the additional fatigues and pressure. Ongoing maintenance is critical for these vehicles, particularly given the use and difficulty in operating them, but invasive checks shouldn’t be required often.

It’s difficult to completely dismiss operation or maintenance of a vehicle from being part of the cause as this is not something that can easily be investigated. However, in these instances, it appears vehicle operation is not the root cause of the issue.

Independent specialist advice

On 27 September 2021, a meeting was held with s 9(2)(a) Elite Wheel Company. s 9(2)(a) explained the key concepts and common pitfalls that can cause steel wheel mounting issues and wheel stud or nut faults. s 9(2)(a) viewed photos of the trailer wheels and hubs inspected on 23 September and made the following comments:

- The steel wheel torque ring profile (centre area around the wheel stud holes) is a common design, although not all rims on the market are equal
- Steel wheel torque rings are prone to damage caused by over tightening which can permanently deform the torque ring profile. This leads to failure and can be a cause in situations where the wheel nuts loosen during operation
- Wheel centre spigoting (hub centric) is often not employed with steel wheels used at the lighter end of the market
- The mounting face of the wheel hub must be clean, flat and the correct dimension to accommodate the inner and outer contact points of the wheel torque ring.

Recent test analysis

After conducting conversations and receiving documents that formed the base of the investigation (as detailed above), HVSC s 9(2)(a) decided to undertake in-depth analysis at his own cost to help determine root cause and possible solutions.

The analysis involved running tests on full revolutions of the wheel to analyse the rim and hub combination. The testing is very involved and takes time to run so Waka Kotahi held off finalising this report to allow time for results to arrive.

Given that standards and requirements were all met by the parties involved, and several conflicting pieces of expert advice were received, including this testing in the investigation report was deemed critical to finding a resolution.

Results

The testing clearly shows that the rim flex is inducing a fatigue load into the studs. The load is approximately 50% higher in the studs at the hub slots. This in turn reduces the stud life by a factor of 3 over the remaining bolts.

When a side load is applied to the rim (to simulate cornering), the rim flex is increased considerably and the fatigue into the studs gives them a very short life. This compares with what was seen in the dental trailer units that experience wheel loss failure.

Solution

The solution includes:

- replacing the wheel studs
- fitting a stepped spacer (to cover the hub recesses and provide an improved mating surface).
- fitting of a thicker higher rated rim option (still stud centric but with far less flexibility).

Test results from the solution

The result of this analysis improves the stud life from 2996kms to 409,000kms. Some failures occurred at around 1500kms, being 1/2 of what the analysis shows, but the relationship between the two should hold true. This would give the new design a life 205,000kms.

Conclusions

This was not a straightforward investigation and the complaint against the HVSC couldn't be treated in isolation of the end to end supply chain.

This investigation was made more complex by the fact that information came from a large number of sources, with varying levels of review conducted (inspections of involved vehicles, 'like' vehicles, photos taken from the failure and many verbal/email discussions. In investigations such as this one, Waka Kotahi cannot take alleged information into account and must make decisions based on factual information gathered.

1. Certification was issued correctly

Addressing the complaint itself against HVSC s 9(2)(a), Waka Kotahi found he issued certification correctly and the components used were rated appropriately.

It is common practise to issue certifications across 'like' vehicles based on the same components and design being used repeatedly. Waka Kotahi has no concerns with the process of issuing the trailer certification, nor the certification itself.

Waka Kotahi held an outcome discussion with HVSC s 9(2)(a) and no further action is required.

2. The manufacturer met their legal obligations

Extending the investigation to the manufacturer, Action Manufacturing, Waka Kotahi determined that they met their obligations under law and there were no issues with the design of the vehicles. It appears that maintenance information provided with the vehicles is overzealous and complicated and this is a factor that Action Manufacturing should consider for future reference.

Action Manufacturing quality control processes may need to be reviewed to ensure that component compatibility is appropriate.

3. Conflicting information should have been addressed earlier by parties involved

HVSC s 9(2)(a) didn't inspect the trailers post failure so it's impossible to get a direct account from him.

What became clear during the Waka Kotahi investigation is that he should have been involved with physical inspection of the failed units from the beginning. Waka Kotahi is unable to comment on why this didn't happen but is raising it as a learning.

Waka Kotahi also believes that s 9(2)(a) testing analysis should have been conducted earlier, particularly as concerns had been raised about the components and their compatibility.

4. The components used, while independently rated appropriately, were not compatible on this vehicle

Results from the recent testing conducted by HVSC s 9(2)(a) confirms fault lies with the wheel rim and wheel hub components. While these were purchased, installed, and certified as meeting requirements, they have failed once extreme fatigue stresses were applied.

It's very hard to predict this failure. Vehicle manufacturers purchase components in good faith – they are not expected to test every component bought - this is impossible. Likewise, HVSCs are not required to conduct in-depth testing on every component combination used.

Unfortunately, the component manufacturers and suppliers have not engaged with Waka Kotahi during this investigation and are not regulated parties. Waka Kotahi is unable to determine if this type of failure has occurred elsewhere. Waka Kotahi will engage with these suppliers through their legal representatives to establish this and determine the risk and any further actions that may need to be explored.

Waka Kotahi acknowledges that Action Manufacturing has ordered replacement components as per the solution and has contacted the vehicle owners advising this solution.

5. Operation of the vehicle

During this investigation the operation of these trailers had to be explored. It is accepted that tow coupling height can be a factor, however this was not communicated on the vehicle. Therefore, it is unreasonable to expect an operator in the field to know any specific requirements outside of the normal safe towing guidelines.

The rating of a component should always have a factor of safety built into it. Therefore, it's acknowledged that any possible minor overloading is ok and should not create failure of a component.

Operation of vehicles in the New Zealand environment is often met with a number of challenges like tight winding roads and harsh conditions. These dental units were built to be located and service schools and communities around NZ in both urban and rural environments. It's accepted that they should be built to be able to withstand tight and often difficult manoeuvring. It's unreasonable to expect that all locations will be easy, flat and straightforward.

Waka Kotahi acknowledges that the actions of operators of these vehicles in moving them around the country should not be attributed to the wheel loss incidents. The fault is related to component compatibility and not the way they are operated.

Recommendations

1. Although manufacturers are not regulated by Waka Kotahi, a general statement should be issued to industry. It should cover the purchasing of components and their compatibility and suitability during the manufacture or repair of vehicles and the importance of how this needs to be checked. This could likely be done through the industry alert process.
2. Waka Kotahi to discuss certifier and manufacturer roles in failure situations with HVSC s 9(2)(a) and Action Manufacturing including level of involvement required and will communicate this to the rest of industry.
3. Vehicle failures due to heavy vehicle components occur infrequently and Waka Kotahi can be informed via a number of channels and parties. As part of continuous improvement, Waka Kotahi will develop a framework for investigation, including when involvement is required and who within Waka Kotahi should be involved.

Proactively Released