Report 99-117

Express freight Train 230

derailment

Paraparaumu

6 July 1999

Abstract

On Tuesday, 6 July 1999, a loaded petrol wagon on Train 230, a northbound Wellington to Auckland express freight, derailed approximately 4 km south of Paraparaumu when a wheel on the leading bogie moved in on its axle. The brakes on the wagon had failed to release which caused the wheels to overheat. This overheating had been reported by a passing motorist and the train duly stopped just short of Paraparaumu, but not before the wagon had derailed. An incorrect tolerance fit of the wheel on the axle allowed the wheel to move inwards on the axle and derail the wagon. Safety issues identified were the absence of accepted engineering practices in fitting the wheel and inadequate checkout procedures. One safety recommendation was made to the operator.

The Transport Accident Investigation Commission is an independent Crown entity established to determine the circumstances and causes of accidents and incidents with a view to avoiding similar occurrences in the future. Accordingly it is inappropriate that reports should be used to assign fault or blame or determine liability, since neither the investigation nor the reporting process has been undertaken for that purpose.

The Commission may make recommendations to improve transport safety. The cost of implementing any recommendation must always be balanced against its benefits. Such analysis is a matter for the regulator and the industry.

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List of Abbreviations

km	kilometre(s)
km/h	kilometres per hour
kN	kilonewton(s)
kPa	kilopascal(s)
LE	locomotive engineer
m	metre(s)
mm	millimetre(s)
NIMT	North Island Main Trunk
Tranz Rail	Tranz Rail Limited
t	tonne(s)

Rail Incident Report 99-117

Data Summary

Train type and number:	express freight 230
Date and time:	6 July 1999, at approximately 1030 hours
Location:	43.86 km North Island Main Trunk (NIMT)
Type of occurrence:	derailment
Persons on board:	crew : 1
Injuries:	nil
Damage:	700 broken concrete track sleepers
Operator:	Tranz Rail Limited (Tranz Rail)
Investigator-in-Charge:	R E Howe

1. Factual Information

1.1 Narrative

1.1.1 On Tuesday, 6 July 1999, Train 230 was a scheduled express freight travelling from Wellington to Auckland. The train consisted of 2 locomotives (DX5074 and DC4156) hauling 44 bogie wagons, with a total weight of 1376 t and a length of 693 m.

1.1.2 At about 1030 hours, when the train was north of McKays Crossing at 41.8 km NIMT, a motorist travelling in the same direction as the train noticed sparks coming from the wheels of one of the petrol tanker wagons near the rear of the train. The sparks were reported as getting more intense and the motorist heard a “screeching” noise coming from the train.

1.1.3 The motorist used a mobile phone to contact an acquaintance who worked in the train control office of Tranz Rail and advise him of the situation. The locomotive engineer (LE) of Train 230 was immediately contacted, and he brought the train to a stop with the tail end of the train fouling the south end main line points at Paraparaumu at 47.58 km NIMT. Until the contact from train control the LE was not aware of any malfunction within his train.

1.1.4 An examination of the train at that stage revealed that the brakes on wagon UCA170 (the 38th wagon in the train) had locked on and all the wheels were overheated. The trailing left-hand wheel of the leading bogie had moved 116 mm in on its axle and derailed to the inside of the track. Figure 1 shows the extent the wheel had moved on the axle.

1.1.5 After the inspection, the train was pulled forward slowly for about 60 m to clear the main line turnout and free the loop at Paraparaumu for other train services. The Fire Brigade was called as a precautionary measure, but the wagon was intact and there was no sign of leakage.

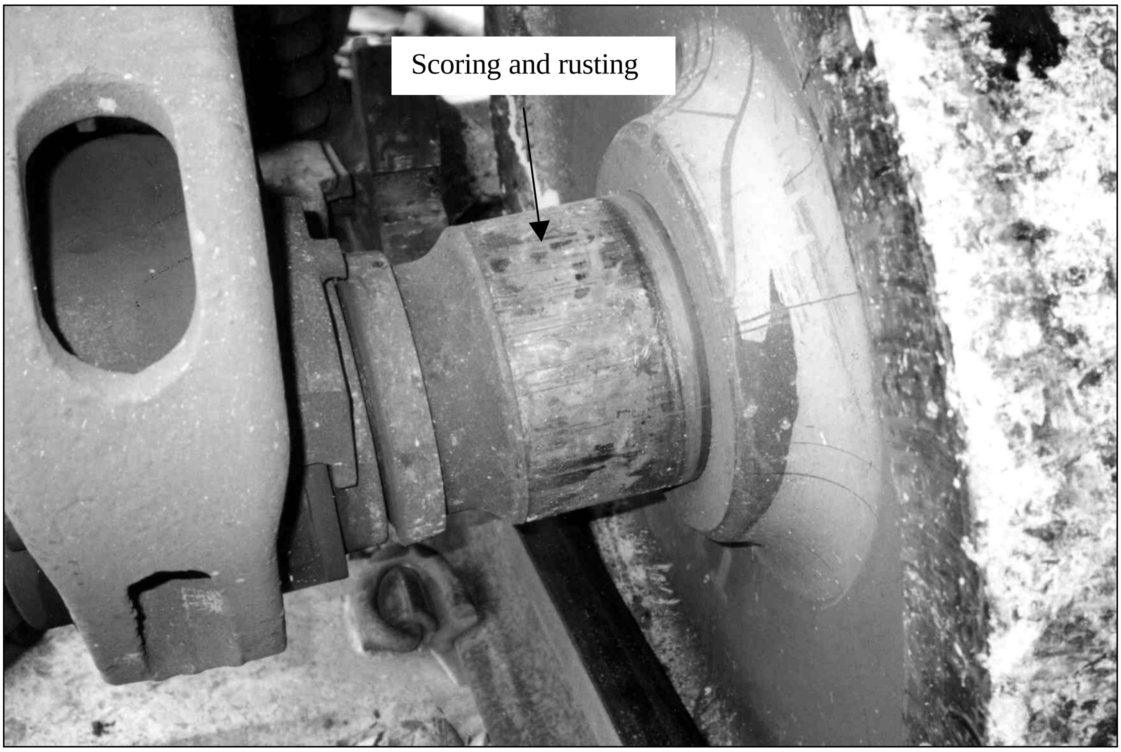


Figure 1
Wheel movement

1.2 Track damage

1.2.1 A track inspection following the derailment revealed the following:

- at McKay's crossing (at 41.8 km NIMT) there was a groove in the tar seal approximately 50 mm in from running edge of the left-hand rail indicating that the wheel had moved on the axle at that stage but was not derailed
- at Waterfall Road crossing (at 43.62 km NIMT) there was a similar groove in the tar seal about 100 mm in from the running edge of the left-hand rail
- at 43.86 km NIMT the left-hand wheel had dropped down off the rail and caused damage to the fastenings and sleepers as it ran in a derailed condition
- the left switch rail at the Paraparaumu south end main line turnout at 47.58 km suffered minor damage to the tip of the points from the derailed wheel. The wagon came to a stop approximately 160 m beyond the turnout points, having travelled 3.88 km in a derailed condition.

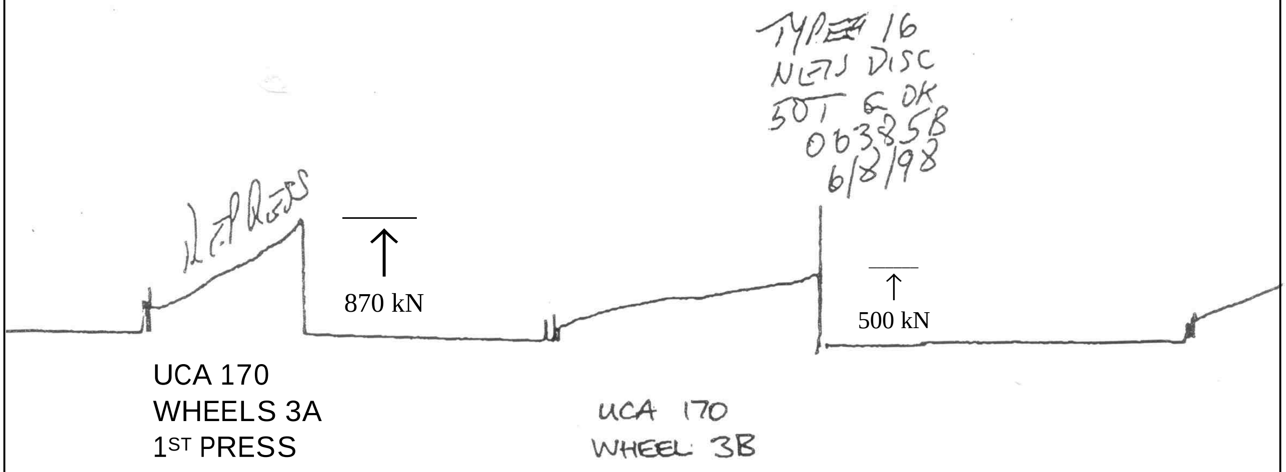
1.3 Examination of the failed wheel set

1.3.1 An examination of wagon USC170 at the Hutt workshops showed that all wheels had suffered from overheating. The wheels of the failed No. 3 axle were pressed off the axle in order to measure the internal and external dimensions of the components. Wheel 3A was the wheel that had derailed; wheel 3B was on the opposite end of the axle and had not moved on the axle.

1.3.2 The following measurements were supplied by Tranz Rail for the A and B ends of the axle (dimensions in mm):

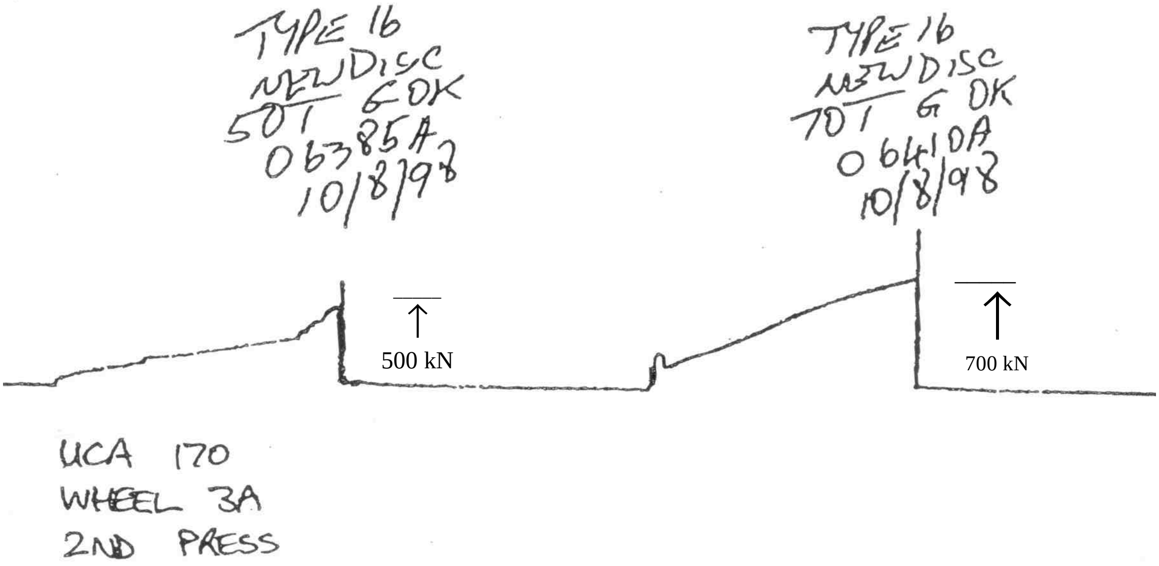
	side 3A	**wheel 3A internal**	**axle 3A external**
outside	@ 90°	196.76	196.66
	@ 0°	196.75	196.68
midway	@ 90°	196.57	196.80
	@ 0°	196.62	196.72
Inside	@ 90°	196.72	196.79
	@ 0°	196.72	196.75
Average dimension		196.69	196.73

	side 3B	**wheel 3B internal**	**axle 3B external**
outside	@ 90°	196.34	196.60
	@ 0°	196.34	196.67
midway	@ 90°	196.34	196.67
	@ 0°	196.34	196.63
inside	@ 90°	196.34	196.65
	@ 0°	196.37	196.65
Average dimension		196.34	196.64



Plot 1
First attempt to press wheel 3A (not successful)

Plot 2
Wheel 3B as fitted



Plot 3
Second attempt for wheel 3A as fitted

Plot 4
A typical plot of a correctly fitted wheel

Note The press was graduated in kN but for convenience graphs were annotated as 50T (for 500 kN)

Figure 2
Wheel pressing graphs

1.3.3 The area on the axle seat where the wheel had moved showed evidence of new surface rust plus older rust in the heavy scoring. Hand grind marks were also evident on the surface. Figure 1 shows the extent of scoring and rusting.

1.4 Wheel set assembly

1.4.1 The wheels on the number 3 axle were originally assembled in Tranz Rail's Hutt workshops in August 1998. Graphical recordings of the axial force required to press each wheel onto the axle were made. Figure 2 is a copy of the original graphs for each wheel showing the increase in axial force as the wheels were pressed onto the axle. The horizontal axis represents the distance the wheel is pressed onto the axle and the vertical axis represents the axial force being applied as the wheel was pressed on.

1.4.2 There was no record of the axial force for the first press fit of wheel 3A to the axle, and the graphs had not been calibrated. However by scaling it could be established that with the wheel only about 63% on, the axial force was approximately 870 kN. Extrapolating the first press curve to a full press situation would equate to approximately 1220 kN.

1.4.3 The press-off force to move wheel 3B from the axle in the Hutt workshops following the incident reached 2400 kN to get the wheel started, reducing down to 300 kN near the completion of the removal. Both the mating surfaces were in good condition.

1.5 Tranz Rail wheel fitting requirements

1.5.1 Tranz Rail Wheelset Manual dated 10 June 1997 stipulated the following:

> Machining of Axles
> Axles will be finished machined to dimensions and tolerances indicated on the appropriate axle drawing. Every axle is to have a standard lathe centre to drawing Y42070 and these centres are not to be tampered with under any circumstances. All parts of axles shall be machined concentric. Journals and wheelsets shall be machined cylindrical.
>
> Axle surfaces shall be free of any abrupt changes in section.
> Wheelsets shall be ground or turned on suitable CNC lathes to between 0.4 and 0.8 micrometres. This also applies to seats for gears and/or discs.

1.5.2 Section 10 of Tranz Rail's Wheelset Manual gave details relating to preparation of axles and wheels, as follows:

> **3.1 Axles**
>
> The diameter of each wheel or gear seat is to be measured in at least three equally spaced planes to an accuracy of 0.01 mm and the average diameter is then to be calculated and recorded.
>
> Those diameters may be either parallel or tapered, in which case the taper shall not exceed 0.20 mm per 100 mm of axial length and shall give increasing interference in the direction of pressing on. . . .
>
> **3.2 Wheels, wheel centres and gears**
>
> The bore diameter of each wheel, wheel centre or gear should be measured the same way as for axles, i.e. in at least three equally spaced planes to an accuracy of 0.01 mm, and the average diameter is then to be calculated and recorded.
>
> Those diameters may be either parallel or tapered, in which case, as for axles, the taper shall not exceed 0.02 mm per 100 mm of axial length and shall give increasing interference in the direction of pressing on.

The wheel bore must be sufficiently smaller than the axle to enable the required mounting pressure to be obtained, as shown in Clause 4.1. . . .

4 Assembly of Wheelsets

4.1 Mounting interference allowance
Mounting forces must conform to those listed in the following table.

Wheel seat diameter (mm)	Minimum (kN)	Recommended (kN)	Maximum (kN)
191 to 200	700	880	1140

Note: The recommended interference for this application is 0.0012 mm per millimetre of wheel bore diameter. In practice, the actual permitted interference may vary from 0.001 to 0.0013 mm per millimetre of diameter.

The above desired mounting forces are based on 4.5 kN per millimetre of diameter with a variation of 20% under and 30% over. . . .

4.3 Pressing Procedure

The axle wheel or gear seat and the wheel bore, including oil injection groove, must have any sharp edges (high metal) removed.

Those surfaces must also be cleaned of any dirt or rust with kerosene and wiped out with a dry cloth to remove any traces of kerosene.

When both components are ready for assembly the Wheel Mount Compound is then to be applied.

The axle taper lead and at least 50 percent of the adjacent wheel seat or gear seat should be coated with LB-0749 Wheel Mounting Compound. . . .

The acceptable and unacceptable pressure diagrams are shown in Fig. 10-5. Any assemblies that produce unacceptable pressure diagrams must be stripped and reassembled.

The press-on graphs give a graphic record of the operation which serves not only as a check on the quality of the output but also provides protection for the workshops if trouble develops later in service. . . .

4.4 Wheel Press Certification

Certification records, as well as pressure diagram records, must be kept at the press site and shall be made available to the Controller for inspection when requested . . .”

Tranz Rail’s Figure 10-5 is shown in Appendix 1.

1.6 Locomotive event recorder

1.6.1 Tranz Rail advised that the locomotive event recorder on the leading locomotive (DX 5074) was not working but they were able to extract the recorder from the second locomotive (DC 4156) following the incident. The clock recorder was not set correctly but a full set of train speeds was extracted and referenced to the deceleration of the train following the derailment.

1.7 Brake locking

1.7.1 An inspection of the train by the LE after it had stopped at Paraparaumu revealed that, while the handbrake lever on the wagon UCA170 was in the "off" position, the wheels were radiating heat, were "too hot to touch" and were all blue in colour.

1.7.2 Tranz Rail tests on the Westinghouse brake gear on the wagon following the incident showed that there was a loss of air pressure of 30 kPa per minute between the brake pipe and the triple valve and the triple valve would not release because of the leaks. The allowable maximum leakage under test was 15 kPa per minute.

1.7.3 Tranz Rail tests on the wagon after the incident also showed that the handbrake would not readily release as a result of partially seized hand brake rigging pins.

1.7.4 Wagon UCA170 had a brake service schedule 2 check (24-month periodic wagon brake service) on 9 July 1998 during which no faults were detected.

1.8 Staff and responsibilities

1.8.1 Tranz Rail advised that the inspection processes, duties and responsibilities of all parties involved in the fitting and certification of wheels prior to passout were:

I) Initial inspection of wheelsets by Team Leader, Bearing Group, to assess wheels and bearings.

II) Inspection by Team Leader, Heavy Machine Group, to decide on fate of wheels and bearings.

III) Tradesman, cylindrical grinding machine operator, checks axles for damage and passes or fails accordingly. Similarly, tradesman, boring machine operator, bores and measures wheel.

IV) Tradesman Press operator assembles wheelset and checks with gauges, referred to in the Wheelset Manual.

V) Team Leader, Heavy Machine Group makes random inspections of assembled wheelsets and press log.

1.8.2 At Hutt workshop the wheelpress was operated by any one of 7 tradesmen in the Heavy Machine Group. The least Heavy Machine Group experience within members of this group with wheel pressing as part of their duties, was 3 years. This was in contrast to the Hillside workshop practice, where only 2 dedicated staff were involved in pressing, each with over 20 years experience in this area.

2. Analysis

2.1 Brake locking

2.1.1 The handbrake lever to wagon UCA170 was in the off position when the train stopped at Paraparaumu. However, the hand brakes may still have been partially applied as a result of the stiffness in the rigging system, which may have contributed to the overheating.

2.1.2 The leaks found in the Westinghouse brake system on the wagon would have been sufficient in themselves to prevent the release of the air brakes. With a reduction in brake pipe pressure consistent with a medium to light application of train brakes, the leak would have been sufficient to prevent the necessary pressure build up to release the brakes again. The train event recorder indicated a number of areas where the train had to brake for restrictive curves heading north out of

Plimmerton. It is probable that the brakes on wagon UCA170 were constantly applied from around that time.

2.1.3 The sparks that the motorist observed just after the train had travelled through McKays Crossing were consistent with the brakes having been applied for a considerable time, thus overheating the wheel and brake blocks.

2.1.4 Train brake locking, while not common, happens often enough that Tranz Rail allow for such a contingency in rolling stock resilience. The heating of wheels due to locked-on brakes should not have influenced wheel/axle integrity.

2.1.5 From the locomotive event recorder output it was calculated that at the point of derailment the train was travelling at 72 km/h. As a result of the LE being advised of the sparks from his train he was able to apply the brakes approximately one kilometre from the south end main line points at Paraparaumu and reduce the speed of his train to 22 km/h before reaching the points.

2.2 Wheel fitting tolerances

2.2.1 A comparison of the average interference fit between the wheel bore and axle seat diameters on Side A (failed side) (196.73 - 196.69 mm = 0.04 mm) and the code requirement (between 0.196 and 0.255 mm) showed the interference fit was at least 0.156 mm too small.

2.2.2 A comparison of the average interference fit between the wheel bore and axle seat diameters on Side B (196.645 - 196.345 mm = 0.300 mm) and the code requirements showed that the interface fit was at least 0.045 mm greater than the maximum interference fit.

2.2.3 From the above figures, both wheels were outside the tolerance fit required by Tranz Rail codes; the A side too slack, and the B side too tight.

2.3 Wheel pressing requirements

2.3.1 Section 4.1 of Tranz Rail Wheelset Manual stated that for the diameter of axle used, the force to achieve the press fit required should be between 700 and 1140 kN with a desirable force of 880 kN. Both wheels were ultimately pressed on using only 500 kN and were therefore well short of the recommended levels.

2.3.2 A comparison of the press fit graphs in Figure 2 with those in Appendix 1 shows that while the general profile of the graph for wheel 3B fits the “No. 1 – Ideal”, wheel 3A clearly fits the “Unacceptable” force fit diagrams. The significance of the force fit diagram for wheel 3A was that there was not a linear build-up of force as the wheel was pressed on and it was only over the last 25 mm of travel (of a total of 194 mm) that the maximum force was achieved.

2.3.3 The interference force fit of wheels on axles is not an exact science, with a number of factors influencing the actual force that is required to achieve the press fit. While the extent of the interference fit is the governing feature, this can be influenced by the type of lubricant used, the smoothness of the mating surfaces, and whether there is any pick-up of surface steel during the press. The 3A end of the axle showed heavy score marks which indicated that there had been considerable pick-up of metal during the first pressing resulting in a final high press load of approximately 870 kN with only 63% of the travel (Figure 2, plot 1).

2.3.4 The hand grind marks on the surface of the scored axle was probably the result of the press fit operator attempting to smooth the pick-up burrs after the wheel had been removed in preparation for a repress. The use of a hand grinder to attempt the required fit, and the re-use of the heavily scored axle, showed a lack of adherence to documented procedures and a lack of tradesman expertise in this operation.

2.3.5 The dimensionally over-tight fit of wheel 3B to the axle did not relate to the lower than recommended force required to press it on (i.e. 500 kN as compared to the code minimum force fit of 700kN). This variation could be accounted for by the type of lubricant used. Modern "locking" lubricants can significantly reduce the press-on force (all other things being equal) and after standing for some days can tend to lock the surfaces together. While press-off forces always tend to be much higher than the equivalent press-on force, the significantly higher press-off force of 2400 kN for this wheel reflects the variations that can result using modern lubricants.

2.4 Quality control

2.4.1 The three-tier checking hierarchy within the Hutt workshops did not detect the faulty axle at either the repress stage, or at the substandard press fit, or in the analysis of the wheel fit force diagrams. The lack of a dedicated experienced workforce on the wheel press at Hutt workshops (when compared with Hillside workshops) may require more detailed manuals and closer supervision of the staff, to ensure that their limited experience is allowed for.

3. Findings

Findings are listed in order of development and not in order of priority.

3.1 Train 230 was being operated normally prior to the incident.

3.2 Wagon UCA170 derailed as a result of a wheel moving in on its axle.

3.3 The movement of the wheel on the axle was initiated by heat produced from locked-on wagon brakes.

3.4 Correctly assembled wheel sets should not move under expected brake locking temperatures.

3.5 The wheel moved on the axle due to the failure to meet tolerance specifications and press-on force requirements.

3.6 The procedures and supervision to maintain quality control at the Hutt workshops was not commensurate with the limited experience of staff fitting wheels to axles.

4. Safety Actions

4.1 Since the incident Tranz Rail have carried out an inspection of all wheel pressing practices at both Hutt and Hillside workshops to ensure that correct procedures were being followed.

4.2 Tranz Rail advised that since the incident they have initiated an upgrade of the wheel press work manual to take account of more modern techniques and practices, including lubricating advances, and to give more detail to staff involved in assembly consistent with their experience and competency.

5. Safety Recommendation

5.1 On 3 April 2000 the Commission recommended to the managing director, Tranz Rail Limited, that he:

5.1.1 give increased consideration to the need for procedures and supervision which take account of the competency and experience of staff employed in all safety critical areas to ensure effective quality control. (018/00)

Approved for publication 12 April 2000

Hon. W P Jeffries
Chief Commissioner

Appendix 1

Tranz Rail Mechanical Engineering Page 10-9

Wheelset Manual: *10 Wheel Press Instructions* Effective Date: 10 June 1997

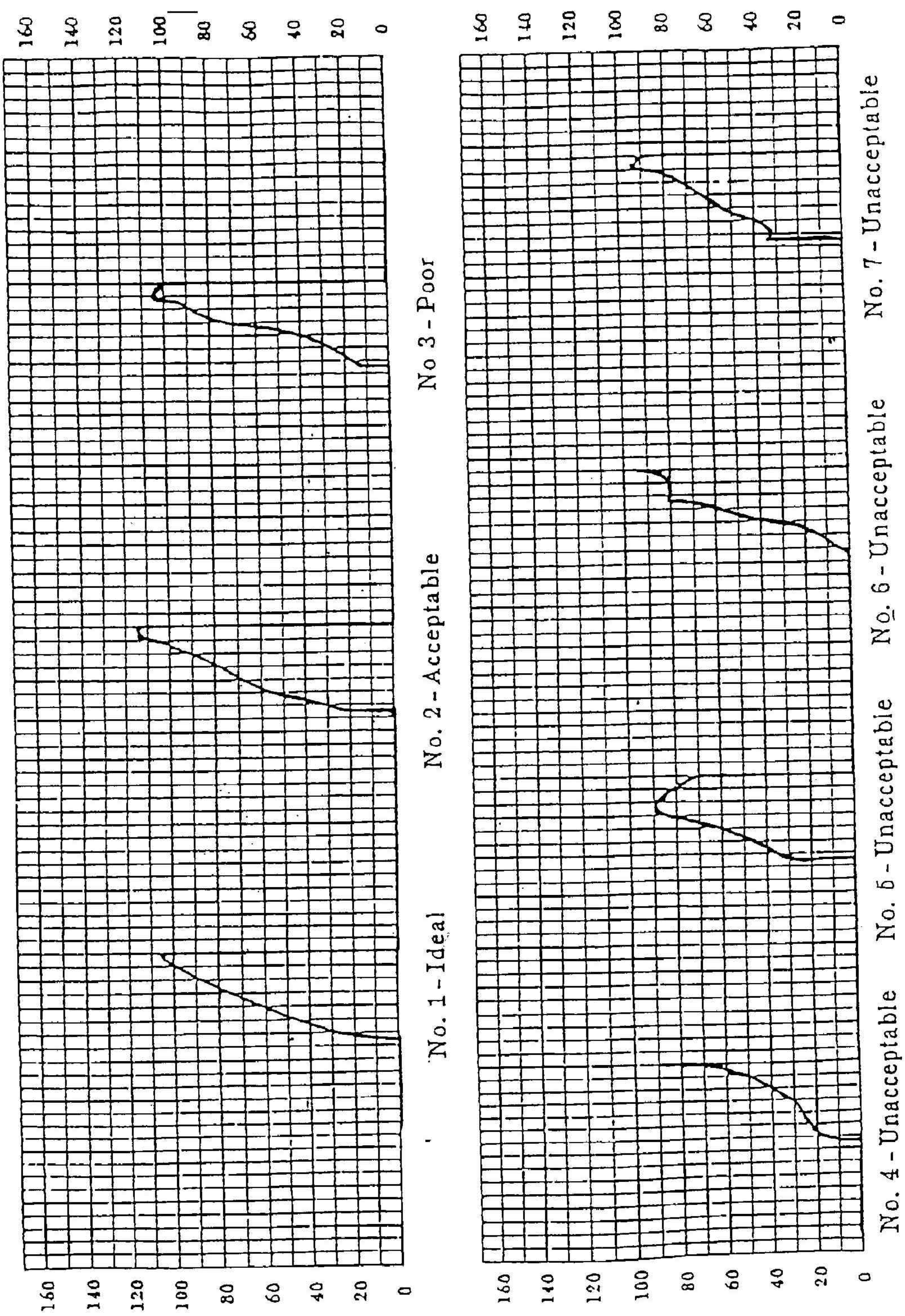


Figure 10-5. Wheel fit force diagrams.