Report 00-118

express freight Train 520, Te Wera, 5 December 2000
express freight Train 920, Pareora, 6 December 2000
express freight Train 922, Shag Point, 6 December 2000
express passenger Train 601, Opapa, 8 December 2000
express freight Train 729, Ward, 14 February 2001
express freight Train 234, Te Kawa, 2 March 2001

derailments or near-derailments due to heat buckles 2000/2001

Abstract

This report examines 6 track heat buckle incidents that occurred in different localities throughout New Zealand in the summer of 2000/2001, 5 of which resulted in derailments. Safety issues identified by these incidents included:

- the need for training of track staff to ensure they recognise and respond to visible track defects
- the possible need to protect continuous welded rail, formed at an unknown neutral temperature, during hot weather
- the need to control tamping and lining to ensure track is not realigned leaving increased compressive stress in the rails
- the need to review the siting and trigger setting of heat sensors
- the practicality of the current Rule 176 regarding Caution signals for reduction of speed.

Five safety recommendations were made to the operator to address these safety issues.

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List of Abbreviations

C	Celsius
CWR	continuous welded rail
kg/m	kilograms per metre
km	kilometre(s)
km/h	kilometres per hour
lb/yd	pounds per yard
LE	locomotive engineer
m	metre(s)
mm	millimetre(s)
MNPL	Marton-New Plymouth Line
MSL	Main South Line
NIMT	North Island Main Trunk
PNGL	Palmerston North-Gisborne Line
POD	point of derailment
SOL	Stratford-Okahakura Line
t	tonnes
TPR	treated pinus radiata
Tranz Rail	Tranz Rail Limited

Data Summary

Rail Occurrence No.	Train	Date	Time	Km & Line	Locality
00-118	express freight 520	05-12-00	1520	47.35 Stratford-Okahakura Line (SOL)	Te Wera
00-119	express freight 920	06-12-00	1408	180.51 Main South Line (MSL)	Pareora
00-120	express freight 922	06-12-00	1640	307.62 MSL	Shag Point
00-122	express passenger 601	08-12-00	1440	137.40 Palmerston North-Gisborne Line (PNGL)	Opapa
	express freight 729	14-02-01	1410	267.50 Main North Line (MNL)	Ward[1]
01-103	express freight 234	02-03-01	1645	506.017 North Island Main Trunk (NIMT)	Te Kawa

Type of occurrences: derailments or near-derailments due to heat buckles

Injuries: nil

Damage: various track and wagon damage

Operator: Tranz Rail Limited (Tranz Rail)

Investigator-in-charge: R E Howe

[1] Details of this derailment were derived from an internal Tranz Rail report.

1. Introduction

1.1 During the summer of 2000/2001 a number of track buckles occurred throughout the Tranz Rail system, causing derailments or near-derailments. Because of commonality they have been combined in this report under occurrence number 00-118, originally allocated to the first incident at Te Wera on 5 December 2000. The incidents are summarised below:

- **00-118:** on Tuesday, 5 December 2000, the passage of Train 520 initiated a track buckle in continuously welded rail (CWR) track on the SOL near Te Wera resulting in the derailment of 7 wagons.
- **00-119:** on Wednesday, 6 December 2000, the passage of Train 920 initiated a track buckle in CWR track on the MSL near Pareora, which derailed the rear 2 wagons.
- **00-120:** on Wednesday, 6 December 2000, 2 wagons near the head of Train 922 were derailed in a speed restricted area on the MSL near Shag Point due to a heat buckle in CWR.
- **00-122:** on Friday, 8 December 2000 the LE of passenger express Train 601 reported a track buckle in CWR track on the PNGL near Opapa. The train had negotiated the buckle without mishap.
- **01-103:** on Friday, 2 March 2001, Train 345 derailed 8 wagons on heat-buckled CWR track on the NIMT near Te Kawa.

Another derailment occurred on Wednesday, 14 February 2001, when Train 729 derailed 14 wagons on heat-buckled CWR track on the MNL near Ward. Although the Commission did not open an investigation into this incident, the Tranz Rail internal report has been referred to as part of this report.

The factual information and analysis applicable to each incident are dealt with separately, followed by an analysis summary and common sections covering all findings and safety recommendations.

Continuous welded rail and track buckles

1.2 CWR track is formed by welding together adjacent lengths of rail to eliminate the bolted joints between them. It is a well-established worldwide practice and was first used in New Zealand in the early 1970s. The resulting length of rails can be measured in kilometres. Because there are no joints in the body of the rail, it is necessary to take suitable measures to compensate for the effects of temperature variations on the rail. In addition to specific requirements for the ballast, sleepers, and fastenings, it is essential that CWR is formed so that there is no stress in the rails at a defined rail temperature, usually called the "neutral temperature". At temperatures below the neutral temperature, there is a tensile stress in the rails, which is resisted by the fastenings of the rails to the sleepers, and the sleepers in the ballast. At temperatures above the neutral temperature, the stress is compressive and could cause buckling unless the rails and track are adequately constrained.

2. 00-118, Train 520, Te Wera, 5 December 2000

2.1 Factual information

Narrative

2.1.1 On Tuesday, 5 December 2000, Train 520 was a northbound express freight travelling between New Plymouth and Hamilton. The consist was a DFT locomotive hauling 15 loaded bogie wagons for a total tonnage of 699 t and length of 264 m.

2.1.2 The LE stated that at 1520 on approaching 47.35 km SOL the track ahead looked quite normal with "no bumps in it; no kick outs; it was virtually a perfectly smooth curve". He estimated he was travelling at about 50 km/h when he heard a "loud bang" underneath the locomotive followed by a "kick" at the rear end of the locomotive. He felt the train stretch as the slack in the couplings was taken up, and then surge forward. On looking back out of the cab window all the LE could see was dust. He immediately put the brakes into full service, and when the train came to a stop, examined his train to find it had parted between wagons 7 and 8.

2.1.3 Of the 8 wagons that had parted from the train, 6 had derailed, of which 3 had overturned. The derailment resulted in the replacement of 400 damaged sleepers and about 30 m of damaged rail.

2.1.4 Approximately 30 minutes prior to the derailment, two hi-rail vehicles of the track maintenance gang had travelled over the section of track to cross Train 520 at Te Wera. No track irregularities were noted at that time.

2.1.5 The track ganger arrived at the site approximately 40 minutes after the derailment and recorded a rail temperature of 43°C. During repairs that day rail was cut out to relieve pressure and allow the track to be realigned. A temporary speed restriction was then imposed until the track could be destressed.[2]

Site information

2.1.6 The CWR track consisted of 1962, 91 lb/yd rail on 1977 treated pinus radiata (TPR) sleepers and rail anchored every fourth sleeper. All fastenings were tight. The ballast section was of clean crushed metal with a depth of approximately 250 mm below the sleepers. The ballast shoulders on both sides of the track in the area of the derailment extended up to about half the depth of the sleeper as shown in Figure 1. Evidence in the ballast section indicated that the sleepers had moved approximately 100 mm to the right at the point of derailment (POD) at 47.35 km SOL and 250 mm to the right at 4 m after the POD.

[2] Destressing was carried out as part of Tranz Rail's capital program and could be delayed for some time following reinstatement. Temporary speed restrictions remained in effect until destressing was achieved.

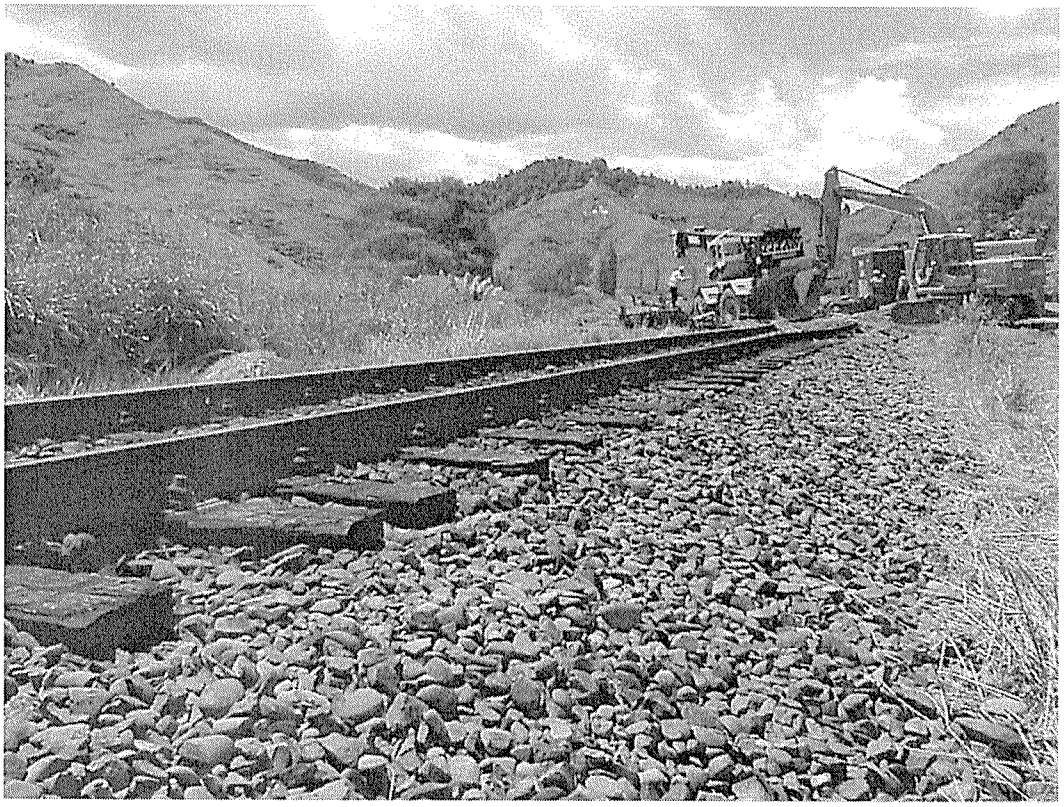

Figure 1
Typical ballast profile at 47.35 km SOL

2.1.7 The minimum new ballast section for CWR track, as stipulated in Tranz Rail's Code supplement CSP/55, for curves under 400 m radius was for the ballast shoulder to be heaped up 100 mm above the sleeper top for 450 mm outside the end of the sleeper and a minimum depth of 225 mm below the sleeper. Tranz Rail advised that the ballast profile, as distinct from the ballast depth, was also a minimum standard for maintaining existing track.

2.1.8 The track was formed into CWR and destressed by the mobile flashbutt welding crew on 12 December 1998 at a recorded rail temperature[3] of 32° C. Tranz Rail advised that there had been no observed or recorded track misalignment at the site since the formation of CWR.

2.1.9 The derailment occurred at the exit from a 240 m radius left-hand curve (in the direction of travel) with the wagons derailing to the inside of the curve. The speed curve board showing 55 km/h was up and in place. At the POD, wheel marks were recorded travelling across the head of the left-hand rail head over a distance of 2 m.

[3] The rail temperature at which track is destressed is termed the neutral temperature of the rail. Subsequent higher rail temperatures will induce compressive stresses in the rail and if these are excessive or lateral resistance is weak, track buckling may result. Rail temperatures less than the neutral temperature will induce tensile stresses in the rail. Destressing temperatures for CWR in New Zealand had historically been set to be within 15°C to 32°C with a nominal 27°C. However, the lower limit had been raised from 15°C to 23°C in 1987 and Tranz Rail had adopted a new standard destressing temperature of 38°C or greater in March 2000.

Track inspections

2.1.10 Tranz Rail advised that the last detailed track inspection over the area on 29 November 2000 did not reveal any track issues at the derailment location, although the track inspector did note that there was a ballast requirement for the area and this was recorded on the Track Log for the 47th km SOL as "Ballast required various areas." The track inspector commented that if any CWR showed an alignment fault, "we just monitor it or put a restriction up." His understanding was that the track had been destressed at 38°C, and not at 32°C as recorded in Tranz Rail records.

2.1.11 Both the track ganger and track inspector were unaware of any regular checks that were required to ensure that CWR was maintained to remain stable during hot weather. They were aware of other areas that were subject to heat speed restrictions but both understood that in areas that had been destressed, the problem of heat buckles was eliminated.

Heat speed restrictions

2.1.12 The Tranz Rail safety system to control the consequences of track buckling included the use of "heat 40" speed restrictions. These were dormant 40 km/h speed restrictions posted on defined sections of track considered susceptible to heat buckles and activated when required during hot weather. They could either be activated by Train Control following the triggering of a heat sensor alarm or by the local track staff based on local weather conditions. Their use was covered by semi-permanent Bulletin No. 843, a copy of which is attached as Appendix 1.

2.1.13 The derailment area was not considered to be susceptible to heat buckles and was therefore not listed as requiring any speed restriction in the event of hot weather. The stated reason for this was that the track had remained stable in the past, had been recently destressed and was known to hold good line and top.

2.1.14 On the day of the derailment, 4 heat restrictions had been imposed between Stratford and Te Wera (0 km to 37 km SOL) by the track staff. They considered the heat was sufficient to warrant taking precautions in areas that had previously given alignment problems. Some heat speed restrictions had also been imposed on the Marton-New Plymouth Line (MNPL) as a result of the high temperatures being experienced.

2.1.15 There were no heat sensors installed on the SOL. The nearest was at Midhurst on the MNPL, 7 km north of Stratford and some 50 km from POD. This sensor, set at 40°C, was not triggered by the hot temperatures on the day. Tranz Rail advised that the initial trigger temperature for sensors was set at 40°C but this was subject to individual inspection and if areas were shown to be stable at temperatures higher than this then the trigger temperature was incrementally raised.

Locomotive event recorder

2.1.16 The locomotive event recorder was extracted following the derailment and confirmed a train speed of 51 km/h just prior to the LE's application of brakes.

Personnel

2.1.17 The track ganger had 23 years railway experience. He had spent 15 years in a thermit welding track gang, rising to leading welder, followed by 8 years in a shunting gang at Stratford. He had then applied for the position of track ganger, and after attending a one-week ganger training school was appointed. He had been ganger for 7 months.

2.1.18 The track inspector had 25 years railway experience with track gangs. He became a Grade 2 ganger at Stratford in 1980 and a Grade 1 ganger in 1986. He had been in charge of various production and track gangs before he was appointed track inspector in January 2000.

2.2 Analysis

2.2.1 The likely cause of this buckle was the passage of the train triggering lateral movement due to the substandard ballast profile providing insufficient lateral resistance.

2.2.2 Local track staff were not sufficiently aware of the CWR maintenance requirements necessary to ensure the stability of CWR track. They had assumed that because the track had been previously destressed it would require no further attention to resist buckling. In addition there was a misunderstanding over the neutral temperature of the rail.

2.2.3 There were no proactive measures in place to ensure CWR code requirements were maintained. Local staff believed it was appropriate to respond to any track misalignment which occurred. The area should have been reported as a weakness and been protected by a heat speed restriction until the appropriate ballast section was reinstated.

2.2.4 No other particular features were present to indicate track weakness.

3. 00-119, Train 920, Pareora, 6 December 2000

3.1 Factual information

Narrative

3.1.1 On Friday 6 December, Train 920 was a northbound express freight travelling between Dunedin and Christchurch. The consist was 2 class DX locomotives and 30 wagons for a total tonnage of 537 t and length of 604 m.

3.1.2 The LE of Train 920 stated that at about 1408 he was travelling north of Pareora at near his maximum permitted speed of 80 km/h when from a distance of about 90 m he "sensed a bit of a kick in the track" and felt a jolt as the locomotive passed over. He stated that the jolt did not unduly concern him, but he was aware of the possibility of a heat buckle. On looking back he noted a cloud of dust, and he immediately made a full service brake application and stopped the train. He walked back to the rear of the train and found that the last 2 wagons had derailed leading bogies.

3.1.3 The LE estimated that the initial kick in the track he observed would have been "only a few millimetres" and that the subsequent jolt was nothing more than he had experienced in normal track conditions. However when he walked back to where he thought the kick was he was surprised to find that the sideways movement of the track was about 400 mm.

3.1.4 The LE was aware of only one heat restriction that had been imposed on his route and that was at Ashburton, some 85 km away. He did not consider the day to be particularly hot and put this down to the coastal sea breezes that normally cooled the air. However, on exiting the cab after the derailment he was struck by the extent of the heat. The rail temperature as taken by the track gang when they arrived at 1530 hours (1½hours after the derailment) was 42°C and considered by them to be "not excessively hot."

Site information

3.1.5 The CWR track in the area of the derailment consisted of 1982, 50 kg/m rail on 1981 concrete sleepers. The fastenings were tight with no relative movement apparent between rail and sleeper. The CWR had been in place since the early 1980s and had not been destressed. The ballast consisted of clean crushed metal with at least 300 mm depth below sleeper and wide shoulders level to the top of the sleeper.

3.1.6 The derailment occurred on straight track on a 1 in 410 upgrade just after the train had passed over a ballast decked river bridge. The track inspector had inspected the area that morning. His report included:

> 180.51 Hole in track, down 20 mm

In his report to the track and structures manager on 20 December 2000, following the derailment, the track inspector included:

> At the 180.5 km I found a hole at the bridge end and estimated the track to be down 20 mm. There was no sign of any line in the track and no cant in or around the hole. I recorded the fault and took no further action. However I was talking to (the ganger) a short time later and mentioned the fault to him and he said that he would get it first thing the next morning.

3.1.7 A fault had also been recorded at the same metrage as a Priority 1 top fault of 20 mm by the EM80 Track Evaluation Car run on 14 June 2000, and was noted as being corrected on 1 July 2000.

3.1.8 Track measurements taken after the derailment at the POD at 180.51 km MSL showed that the track had buckled out to the right to a maximum of 315 mm over a distance of 20 m followed by a lesser 11 mm buckle to the left over 15 m.

3.1.9 In the process of realigning and straightening the track, the gang cut 42 mm out of the track immediately to the north of the track buckle. At the same time it was noted that there was a slight misalignment at 179.99 km (520 m to the north of the POD) and 25 mm was cut out there to relieve the pressure. Both localities were then protected by a temporary speed restriction until destressing could be arranged.

3.1.10 The track and structures manager stated that he considered that the track in the area of the derailment was one of the "best pieces of track" that he had, and that it had given no trouble in the 20 years it had been down even though it had been subjected to extremely hot weather during that time. He did not consider that the temperature on the day was excessively hot.

Heat restrictions

3.1.11 The area of the derailment was not subject to any "heat 40" speed restriction. The nearest heat sensor was at Herbert (97 km to the south and 8 km inland) and was set to trigger an alarm at 44°C and automatically advise Train Control so that heat speed restrictions could be imposed. It was not triggered on the day of this derailment.

3.1.12 There were no "heat 40" speed restricted areas activated between Oamaru and Ashburton by track staff on the day of this derailment.

Locomotive event recorder

3.1.13 The locomotive event recorder was extracted following the derailment and confirmed that Train 920 was travelling at 80 km/h when it derailed.

Personnel

3.1.14 The track inspector had 20 years railway experience, all of it based in Oamaru and including the derailment area. He had started as a track worker in a production gang, been ganger for 10 years and promoted to track inspector in February 2000. His area covered 275 km on the MSL.

3.1.15 The track and structures manager had 25 years railway experience in various track gang positions in a number of locations with the last 11 years in Dunedin as track and structures manager or equivalent. His area included all main line and branch track south of Temuka, a total of approximately 600 track km.

3.2 Analysis

3.2.1 The likely contributing factors to this derailment were:

- CWR formed at an unknown and low neutral temperature
- settlement of the track formation at the end of the bridge resulting in vertical movement of the track under load, thereby decreasing the ballast resistance, which allowed a small lateral track movement to develop into a buckle under the passage of the train.

3.2.2 Tranz Rail records showed that the length of track had been stable for years. Although the neutral temperature was unknown local track staff did not view this as significant in light of the stable history.

3.2.3 There were no other areas of specific weakness in the track structure.

4. 00-120, Train 922, Shag Point, 6 December 2000

4.1 Factual information

Narrative

4.1.1 On 5 December 2000, the local track inspector had noted problems with the alignment of the curve in the area 307.50 km to 307.75 km MSL, and because the recorded rail temperature was 39 °C he elected to safeguard the area with a temporary speed restriction of 25 km/h in accordance with Rule 176 (see paragraph 4.1.11). Train Control was advised accordingly and a Speed Restriction Advice was implemented at 1720 that day. Although Tranz Rail's Rule 176(c) required Caution signals to be posted they were not provided.

4.1.2 On Friday, 6 December, Train 922 was a northbound express freight travelling between Dunedin and Christchurch. The consist was a DX locomotive and 16 wagons for a total tonnage of 268 t and length of 251 m. The LE had been advised by Train Control of all areas where "heat 40" speed restrictions were activated and also held a Speed Restriction Advice for temporary speed restrictions under Rule 176, including the 307.50 km to 307.75 km length. Of 18 restrictions in place to Rule 176 on the MSL at that time, 9 were annotated as having no speed boards erected, including the derailment area.

4.1.3 As Train 922 was approaching the 308 km peg from the south at 1640, the LE was distracted as he listened on his train radio to details a ganger was giving to the train controller of a new heat speed restriction in the area. The LE was in the process of writing the details down, in anticipation of being formally advised, when on looking up he noted a misalignment in the track about 100 m to 150 m ahead. He immediately applied the train brakes then bled the engine brake off to keep the train stretched and thus have a better chance to survive a possible derailment. The LE considered the misalignment to be in the order of "inches" but very obvious.

4.1.4 The train stopped some 250 m past the misalignment with the leading axles on the leading bogies of the second and third wagons derailed

4.1.5 The LE stated that he was aware of the temporary speed restrictions for the day, which had been given him with the work order for the trip, but because he was distracted he missed seeing the kilometrage peg which would have allowed him to locate the unposted restriction.

Site information

4.1.6 The CWR track at 307.62 km, (the POD) consisted of 1980, 50 kg/m rail fixed to TPR sleepers and with rail anchors on every second sleeper. The ballast consisted of a mixture of crushed river-run metal and crushed stone. A large percentage of the river-run metal consisted of rounded stone. A large proportion of the ballast underneath the sleepers had become fouled. The ballast shoulder to the inside of the 400 m radius curve was 300 mm to 400 mm wide and level with the sleeper top, but the shoulder to the outside of the curve tapered off from the end of the sleeper.

4.1.7 Tranz Rail advised that the section of track had been destressed in 1997. They stated that records of the destress had not been located and although unclear as to the details it was likely that it was destressed to a neutral temperature of 27°C. The track had last been tamped on 17 May 2000.

4.1.8 The 400 m radius left-hand curve (in direction of travel) where the misalignment occurred was in a sidling cutting and on a 1 in 65 upgrade. Site measurements by Tranz Rail staff after the derailment showed that there had been a local track misalignment of 300 mm over a length of 15 m. The rail temperature recorded at the site at 1650 hours (10 minutes after the derailment) was 33°C.

4.1.9 The EM80 Track Evaluation car run on 14 June 2000 showed a good line and top in the area.

Locomotive event recorder

4.10 The locomotive event recorder was extracted following the derailment and confirmed a train speed of 67 km/h prior to entering the misalignment.

Speed restrictions

4.1.11 Tranz Rail Rule 176 required the following in relation to temporary speed restrictions:

> **176. (a) Caution Signals For Reduction of Speed -** When for any reason it is necessary to temporarily reduce the speed of trains the employee in charge of permanent-way or works staff at the defective place must arrange for the exhibition of Caution signals in accordance with the following:
>
> Temporary Speed Boards-
> (i) *Outer Speed Boards* - On a single line on each side of the defective place; on a double line on the side from which trains will approach;

In each instance the Board or Boards must be at least 1,200 metres from the inner speed board.
(ii) *Inner Speed Boards* - On each side of the defective place and 50 metres therefrom . .

(c) Advising Staff of Temporary Restrictions Imposed - When it is found necessary to temporarily reduce the speed of trains the employee in charge at the defective place must immediately -
(i) Arrange for the placing of Caution signals as directed in the preceding clauses;
(ii) Arrange for the appointment of Protectionmen who, until the speed restriction has been notified by train advice, must maintain two detonators on each rail, 10 metres apart and a little in advance of the Outer Speed Boards, and control the speed of trains by exhibiting Caution hand signals;
(iii) Advise particulars of the restriction to Train Control.
(iv) Advise particulars to the area officer concerned who must advise the Track and Structures Manager.

(d) Train Control when notified of a speed restriction in accordance with clause (c) must immediately -
(i) Arrange that until the restriction is notified by train advice, the Locomotive Engineers of all trains which will pass over the defective place are advised particulars;
(ii) Advise the Officer Controlling Train-running of the restriction and of the action taken . . .

(g) Protectionman to be appointed if Trackworkers Signals obscured – When Danger Signals or Caution Signals are not clearly visible to Locomotive Engineers owing to fog, falling snow, or other causes, a protectionman must be appointed to each such signal to stop approaching trains or to control their speed according to the nature of the signal which is exhibited.

In this particular incident the speed restriction had been notified by Speed Restriction Advice but Caution signals were not in place and the Speed Restriction Advice included this information. Track staff stated that it had been common practice for some years not to immediately advise LEs by Caution signals, and that at the time of the incident all of their Caution boards were in use. Tranz Rail's local management acknowledged the difficulty for the local 2-man track gang, which was responsible for 75 km of track, to cope with multiple restricted areas in hot weather as well as other priority demands and comment was made that it was also not practical to provide protectionmen to protect sites where Caution signals had not been erected.

4.1.12 The track ganger reported that on the morning of the derailment he intended to go to the area and cut out rail to correct the alignment problem after first erecting speed boards at another misalignment at Herbert. However, he was called away to deal with a check rail in the Oamaru yard with derailment potential. He was able to get to the 307.5 km site at about 1500, at which time he considered it was too late to carry out any work to relieve the misalignment and felt that the unposted 25 km/h restriction would be sufficient to protect it until the next day.

4.1.13 On the day of the derailment all of the "heat 40" areas affected by high temperatures in the MS5 and MS6 gang lengths had been activated by the gangers. These included:

Length Gang MS5
278.15 to 279.00 km MSL between Herbert and Hillgrove

Length Gang MS6

315.95 to 317.85 km MSL	between Palmerston and Merton
320.20 to 320.65 km MSL	between Palmerston and Merton
321.70 to 324.10 km MSL	between Palmerston and Merton

Personnel

4.1.14 The track inspector concerned was the one referred to in 3.1.14 regarding the Pareora derailment, which occurred on the same day as this.

4.1.15 The ganger had 27 years railway experience, starting as a track maintainer in Oamaru. He was promoted to ganger in 1987, reverted to senior track maintainer in 1992 (restructuring) and was reappointed ganger in 1999. He was responsible for 71 km of track from 240.48 km to 311.53 km MSL.

4.1.16 The LE had 26 years railways experience, starting in Oamaru as a locomotive assistant and progressing through to a Grade 1 LE. He gained experience in a number of locations in South Island and had been based at Dunedin for the last 4 years.

4.2 Analysis

4.2.1 The ballast standard was inadequate. The ballast shoulder section was less than code requirements and the supporting ballast consisted of a significant portion of fouled and rounded material. Both of these factors would have contributed to a lowering of resistance to buckling.

4.2.2 The track weakness was recognised by the track inspector and an appropriate temporary speed restriction was arranged to protect it, but no Caution signals were erected. Had the LE observed the speed restriction it is likely that the derailment would not have occurred.

4.2.3 The local length ganger had a number of "heat 40" speed protected areas to attend to plus a hazard in the Oamaru yard. This delayed his intended remedial work at 307.5 km. However, this need not have necessarily prevented Caution signals from being erected as required by rule 176. Rule 176 was not clear as to the time span in which Caution signals were to be erected, but implied the following time sequence:

1. recognise a need for a temporary speed restriction
2. immediately erect Caution signals
3. arrange for protectionmen until a train advice could be issued
4. issue a train advice.

4.2.4 This implication in Rule 176 had been formally changed by the issue of Speed Restriction Advices that listed temporary speed restrictions in place with no Caution signals exhibited, a flexibility not covered in rule 176. Rule 176 (g) recognised the hazard associated with an LE not being able to see boards for some reason and required additional protectionmen to warn the LE of an approaching train, yet issuing Speed Restriction Advises to LEs telling them that Caution signals had not been erected was formally condoned. Putting details of sites without Caution signals on a train advice may reduce the hazard, but did not provide the level of protection and safety intended by Rule 176.

4.2.5 The effect of formally condoning temporary speed restrictions without Caution signals changed the practical time sequence to:

1. recognise a need for a temporary speed restriction
2. arrange a train advice
3. erect Caution signals up to a day, or days, later

as shown by the Speed Restriction Advice and track staff understanding, related to the 307.5 km site.

4.2.6 Since Rule 176 was introduced the Tranz Rail track organisation had changed. Track staff levels had dropped and smaller gangs now look after much longer gang lengths. In most cases it is now not practical to supply protectionmen, and they are seldom used in Rule 176 application.

4.2.7 The Commission has commented previously on the undesirability of safety rules which are not complied with. In this case non-compliance had been semi-formalised, and the non-compliance was the likely catalyst to the derailment. The safety system related to protecting temporary speed restrictions needs urgent review to ensure an effective warning is given to LEs, and Rule 176 requires amendment to reflect a practical procedure to achieve this.

5. 00-122, Train 601, Opapa, 8 December 2000

5.1 Factual information

Narrative

5.1.1 On Friday 8 December 2000 at about 1440, Train 601, the Napier to Wellington passenger express, passed over a reported track buckle at the 137.4 km near Opapa on the PNGL.

5.1.2 The LE stated that Train 601 was travelling at 70 km/h when he noticed a "heat buckle about 50 m ahead in a short straight between two curves". He estimated that the track had been displaced about 50 mm in an "S" fashion. He immediately closed the throttle and had only marginally slowed speed before the train passed over the buckle, causing the locomotive and carriages to "buck from side to side." After obtaining confirmation from the train manager that everything was all right he carried on to Opapa, where he stopped the train to make a visual inspection and contact Train Control before continuing. There was no damage.

Site information

5.1.3 The track in the area of the reported buckle consisted of 1968, 91 lb/yd rail in 38 m lengths, fixed to TPR sleepers and having rail anchors every fourth sleeper. All fastenings were tight. There was a full ballast section of clean crushed ballast.

5.1.4 The Tranz Rail track log indicated that the track had been destressed in 1995 but no neutral temperature had been recorded. The ganger had 5 years experience in the area and during that time had not had any problem with track movement during hot weather. The track had been tamped and lined in July 2000 and both the ganger and the track and structures manager considered that it had been pulled slightly "downhill"[4] thus increasing compressive forces in the rail during summer.

5.1.5 The buckle occurred at the entrance to a 400 m radius right-hand curve (in direction of travel). The curve was restricted to 70 km/h and posted accordingly.

[4] If in realigning a curve, it is repositioned to the inside of the original location ("downhill"), the radius is effectively reduced together with the total length of the curve. If the actual rail length is not shortened accordingly the compressive stress in the rail will be increased.

5.1.6 The track ganger who was called out to attend to the reported buckle was working 4 km away and did not think the weather was hot enough to warrant a special heat patrol. No rail temperature readings were taken. On arrival at the site shortly after 1500 he noticed "a weld sticking out about 40 mm" and immediately aligned it and placed a speed restriction on it. On Tuesday, 12 December, he returned and removed 50 mm from the rail to reduce the compressive stress and destressed the length.

5.2 Analysis

5.2.1 The misalignment negotiated by Train 601 had the potential to develop into a buckle capable of derailing the train, as evidenced by the need to reduce the compressive stress in the rail following the incident.

5.2.2 The Tranz Rail definition of CWR was any rail of length 40 m or more. The 38 m rails at this site (a commonly used length) were not classed as CWR and did not therefore come within the control measures applicable to the installation and maintenance of CWR required to avoid track buckles.

5.2.3 The main catalyst to this misalignment appears to have been the increased compressive stress developed as a result of downhill movement during tamping. A combination of such downhill movement and compressive stress due to hot weather has the potential to cause similar misalignments, and possible buckles, in rails less than 38 m in length, down to and including bolted 12.8 m track. This is the first non-CWR track buckle notified to the Commission in 8 years. However, the length of the 38 m rail makes it more vulnerable to temperature, and particularly vulnerable on curved track. In view of this low incidence no recommendations have been made regarding non-CWR track. However, it would be prudent for Tranz Rail to monitor the buckling behaviour of 38 m rail on curves, and initiate appropriate defences if this apparently isolated incident became more prevalent.

6. 00-103, Train 234, Te Kawa, 2 March 2001

6.1 Factual information

Narrative

6.1.1 On Friday, 2 March 2001, Train 234 was a northbound Palmerston North to Auckland express freight. The consist was an EF class electric locomotive and 23 bogie wagons for an all-up weight of 808 t and length of 365 m. The train carried a mixture of loaded and empty wagons.

6.1.2 At about 1645 Train 234 was approaching the 506 km (approximately 1 km south of Te Kawa) at 80 km/h when the LE observed a buckle to the right side in the track ahead at the entrance to a left-hand curve. On sighting the buckle the LE stated that he gradually applied the train brakes and at the same time left the locomotive with some power on to prevent bunching of the train.

6.1.3 The LE was able to bring Train 234 to a stop 500 m beyond the buckle. On checking his train he found that 8 wagons through the train length had derailed axles on the leading bogies. In addition, the last 2 wagons had parted from the rest of the train, leaving a gap of 20 m. The LE observed a maximum track displacement of approximately 300 mm to the outside of the curve.

6.1.4 The LE did not consider the day was particularly hot, and cooler than when heat speed restrictions had been previously applied in that area.

6.1.5 Approximately 200 damaged sleepers had to be replaced as a result of the derailment. There were no injuries.

Site information

6.1.6 The derailment occurred at 506.017 km in the body of a 500 m radius left-hand curve with an authorised and posted curve speed of 80 km/h and on an up grade of 1 in 183. A track buckle had occurred from 506.003 km to 506.023 km with a maximum shift of 310 mm at 506.013 km.

6.1.7 The CWR track in the area consisted of 1979, 50 kg/m rail fixed to a mixture of 1974/94 concrete sleepers. There was a full ballast section of clean, crushed metal.

6.1.8 Tranz Rail advised that the track was last destressed in October 1998 to a neutral temperature of 32°C. The track had last been machine tamped and lined on13 February 2001 (3 weeks prior to the derailment) at a rail temperature of about 31°C.

6.1.9 The rail temperature taken at the site one hour after the derailment was 37°C. Tranz Rail advised that a track heat sensor at a site 2 km north of the derailment recorded a temperature of 35°C at 1500. The sensor had been set to trigger at 40°C. The ganger stated that the rail temperature at Kopaki, where he was working, was 37°C, with overcast sky and threatening rain so he had no particular concern regarding the possibility of heat buckles. He had inspected the track the previous day and found nothing defective in the area.

6.1.10 After clearing the derailed wagons, 30 mm was cut out of the rail in the straight prior to the curve so that the track could be realigned and repaired and a temporary speed restriction was imposed.

6.1.11 Offset meaurements[5] from the track centre-line to the concrete pole traction overhead supports in the derailment curve, but outside the buckled length, were measured following track reinstatement and compared to the datum values with the following results:

Kilometrage	Datum offset	Actual offset	"downhill" movement
506.051	3.040 m	3.142 m	102 mm
506.089	3.025 m	3.112 m	87 mm
506.127	2.985 m	3.000 m	5 mm
506.165	2.960 m	3.040 m	80 mm

Locomotive event recorder

6.1.12 The locomotive event recorder was extracted following the derailment and showed that the train had been travelling at 74 km/h when the brakes were applied. Light use of the throttle was recorded while braking.

Personnel

6.1.13 The ganger had 20 years railways experience, progressing to senior track maintainer before being appointed as ganger in early 2000. His 85 km gang length was from Kopaki (455 km NIMT) to Hamilton (540 km NIMT). For all of his railway time he had been based at Te Kuiti.

[5] Measurements were fixed to the concrete pole supports giving the original offset from the pole to the track centre and the height of the overhead power wires from rail levels. Although primarily to locate the traction overhead they were also intended as a datum for ensuring alignment was maintained for CWR.

6.2 Analysis

6.2.1 The likely catalyst to buckling was track disturbance due to tamping. The fact that the curve had been tamped and lined 3 weeks prior to the derailment, and that in relation to the bench marks on the traction overhead poles was up to 102 mm "downhill", indicated that the effective neutral temperature may have been progressively lowered over time due to "downhill" movement of the curve during maintenance. There was no evidence that the datums were being used to locate the track.

7. Train 729, Ward, 14 February 2001

7.1 Introduction

7.1.1 The Commission did not open an investigation into this incident. Information has been derived from Tranz Rail's internal report to determine any commonality with the 5 track buckles for which investigations were opened.

7.2 Factual information

Narrative

7.2.1 On Wednesday, 14 February 2001, Train 729 was a southbound express freight travelling between Picton and Christchurch on the MNL. It consisted of 2 DX locomotives and 27 wagons for a total weight of 794 t and length of 464 m. It was crewed by 2 LEs, one of whom was learning the route.

7.2.2 The LE at the controls stated that at approximately 1410 when about 3 km south of Ward, and as the train started to descend a grade and negotiate a left-hand curve, he noticed an "S"-shaped heat buckle in the track ahead. Train speed was about 70 km/h and the LE immediately applied a minimum brake reduction to ride through the buckled area of track.

7.2.3 The 2 locomotives and the first 4 wagons negotiated the buckled track without derailing but of the remaining 23 wagons 14 were derailed. Nine of these wagons ended up on their side.

Site information

7.2.4 The derailment occurred at 267.50 km MNL in the body of a 500 m radius left-hand curve (in the direction of travel).

7.2.5 The CWR track in the area of the derailment consisted of 1966, 91 lb/yd rail on a mixture of 1970/1990 TPR sleepers. The fastenings were reported as being tight. The ballast was recorded as being clean crushed river gravel. The ballast section was stated as meeting Tranz Rail Code requirements and photographs of the area immediately after the derailment confirmed this.

7.2.6 The rail had been destressed in 1996 to a neutral temperature of 32°C and rail anchors had been applied by box anchoring 1 in 4 sleepers. No rail temperature had been recorded on the day of the derailment because of a faulty gang thermometer, but a local Ward resident recorded an air temperature of 37°C. The day was also notable for its lack of wind.

7.2.7 The detailed Track Inspection Report of 26 October 2000 recorded poor line and top on the curve, cant excesses and mud spots. A 40 km/h speed restriction was recommended and the area was to be tamped. The curve was reported as "not being one of the better curves in the area" and requiring regular tamping.

7.2.8 The track was last tamped on 10 December 2000, some two months prior to the derailment. The rail temperatures recorded while tamping were between 30°C and 32°C. During tamping evidence of mud infiltration into the ballast underneath the sleepers was found in several locations. Following the tamp, a 40 km/h speed restriction was imposed until 9 February 2000, some 5 days before the derailment, to allow the track to stabilise.

"Heat 40" speed restrictions

7.2.9 There were no heat sensors in the Ward area. The nearest was at 314.5 km MNL, between Vernon and Blenheim, some 47 km away, which was set at 42°C and not triggered on the day. However, the high temperatures being experienced on the day were sufficient for staff to activate all the areas on the MNL that were subject to "heat 40" speed restrictions. There were 10 such areas between Hapuku (201 km MNL) and Picton (342 km MNL).

Locomotive event recorder

7.2.10 The locomotive event recorder confirmed that the train was travelling at 66 km/h at the time of the brake application.

Personnel

7.2.11 Tranz Rail advised that all local staff associated with track inspection and maintenance in the Ward area were appropriately qualified and experienced with years of local knowledge of the area.

7.3 Analysis

7.3.1 With a recorded air temperature of 37°C at Ward on the day, the rail temperature at the derailment site could have exceeded 50°C and placed a higher than normal compressive stress in the rail.

7.3.2 The site was known to be unstable in terms of holding good line and top. Mud infiltrating into the ballast underneath the sleepers would have encouraged pumping (vertical movement of the track under load) and reduced sleeper resistance.

7.3.3 It is likely that maintenance work since destressing in 1996 had resulted in downhill track movement and an effective lowering of the neutral temperature.

7.3.4 In the circumstances the area should have been protected by the use of a discretionary "heat 40" restriction when temperatures were high.

8. Analysis Summary

8.1 A review of the common features associated with these 6 incidents showed:

- 5 occurred on CWR and one on track not classed as CWR
- 2 involved buckles occurring under the train
- 4 had a local weak track characteristic, but only one (Shag Point) had a temporary speed restriction applied
- 3 involved track that was at an unknown neutral temperature

- 3 involved track sites that had been disturbed by tamping and lining shortly before the incident, which may have resulted in movement of track downhill
- none of the sites had been identified as a potential weakness to be activated under "heat 40" speed restriction conditions
- none of the areas around the 6 sites had "heat 40" speed restrictions activated due to triggering of heat sensors, although 3 areas had been activated by local staff.

8.2 Arising from these common factors are the following safety issues:

- the need for training of track staff to ensure they recognise and respond to visible track weaknesses
- the possible need to protect CWR at an unknown neutral temperature until such time as it can be destressed. In this regard the progressive raising of the lowest effective neutral temperature from 15°C to 38°C shows that Tranz Rail had recognised the need to reduce compressive stress. This places even more importance on protecting sites at an unknown neutral temperature
- the need to control tamping and lining to ensure track is not realigned with increased compressive stress
- the need to review the number, the siting and the trigger setting of heat sensors to improve the protection of weak sites.

Four of the safety recommendations made in Section 10 address these issues.

8.3 The progressive raising of the lowest permitted neutral temperature from 15°C to 38°C has decreased the possibility of track buckles. However, it has increased the possibility of tension failures (pull-apart or rail failure) during cold weather. This applies particularly to points of lesser strength, such as in aluminu thermic (or "thermit")[6] site welds and rail defects. Tension failures in areas where failure is not detected electrically, such as areas under track warrant control, present a particularly high risk. The Commission has no reason to doubt either the technical justification for raising the neutral temperature, or the factor of safety of track at low temperatures, and has made no recommendations in this area. However, it would be prudent for Tranz Rail to satisfy itself that recent changes to neutral temperature have an acceptable effect on the susceptibility of rail to tensile failure in cold weather, if such has not already been done.

9. Findings

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

00-118, express freight train 520, Te Wera, 15 December 2000

9.1 The ballast section was less than that required to ensure stability of CWR.

9.2 Key local staff did not appreciate the significance of the ballast section deficiency.

9.3 A "heat 40" speed restriction should have been activated on the weak ballast section during high temperatures.

[6] Site welds formed by igniting a powder mix in a crucible to reduce heavy metal oxides by aluminium. The molten mix in the crucible is tapped to flow into a mould around the 2 rail mends with sufficient heat to fuse the parent metal.

9.4 The Tranz Rail safety system had not identified the potential weakness of this area and ensured appropriate restrictions were in place during hot weather.

00-119, express freight train 920, Pareora, 6 December 2000

9.5 A possible triggering effect of the low spot in the track profile just off the bridge end on CWR that had not been destressed was not appreciated by local track staff.

9.6 Historical site stability was seen by Tranz Rail staff as being more important than the specific weakness present at the site.

00-120, express freight train 922, Shag Point, 6 December 2000

9.7 The likely cause of the derailment was Train 922 travelling over a known weak section of CWR track at excessive speed.

9.8 Although the track weakness had been identified and protected the required process of advising LEs of the restricted speed by Caution signals was not followed.

9.9 The format of Speed Restriction Advices showed it was common and accepted practice not to immediately advise LEs by Caution signals, contrary to the intent of Rule 176.

9.10 The current Tranz Rail track gang structure and manning level means it is often impracticable to comply with the intent of Rule 176.

00-122, express passenger train 601, Opapa, 8 December 2000

9.11 A misalignment developed during hot weather in non-CWR curved track that had possibly been placed in increased compression by tamping some months previously.

9.12 The Tranz Rail safety system had not recognised the potential weakness of this area and ensured appropriate restrictions were in place during hot weather.

01-103, express freight train 234, Te Kawa, 2 March 2001

9.13 Track which had been disturbed by tamping and likely realignment had insufficient buckling resistance.

Express freight train 729, Ward, 14 February 2000

9.14 A known weak track length had been recently disturbed by tamping and had insufficient buckling resistance.

9.15 The Tranz Rail CWR safety system had not recognised the potential weakness of this area and ensured appropriate restrictions were in place during hot weather.

10. Safety Recommendations

10.1 On 26 June 2001 the Commission recommended to the managing director of Tranz Rail that he:

10.1.1 carry out specific training to ensure key track staff are aware of the vulnerability of sites that have an unknown neutral temperature, and the site deficiencies that justify inclusion of sites in "heat 40" lists (020/01)

10.1.2 quantify lengths of CWR that have an unknown neutral temperature and ensure they are assessed, and protected where appropriate until destressing can be arranged (021/01)

10.1.3 introduce alignment control procedures to ensure maintenance tamping does not result in an effective uncontrolled lowering of the neutral temperature of the rail (022/01)

10.1.4. quantify the effectiveness of heat sensors at current settings to protect areas of weakness in hot weather, and if necessary lower the trigger levels of sensors in areas where buckling is occurring well below current settings (023/01)

10.1.5 amend the Engineering Rules to ensure adequate warning of temporary speed restrictions is given to LEs in a practical, effective and auditable manner until such time as the appropriate warning boards have been erected. (024/01)

10.2 On 16 July 2001 the managing director of Tranz Rail replied:

020/01: Tranz Rail accept this recommendation. Specific system wide training for track staff was carried out in March 2001. This training will be repeated in September 2001.

021/01: Tranz Rail accept this recommendation. These sites have been identified during a recent survey carried out to assist preparation of the de-stressing programme and to reconfirm sites requiring "heat 40" speed restrictions.

022/01: Tranz Rail accept this recommendation. This is currently under investigation.

023/01: Tranz Rail accept this recommendation and is included in training referred to above.

024/01: Tranz Rail is currently reviewing the Engineering Rules and related processes applicable to the provision of adequate warning for temporary speed restrictions. The review is expected to be complete by the end of September, at which time Tranz Rail will decide whether or not to implement the recommendation.

Approved for publication 11 July 2001

Hon. W P Jeffries
Chief Commissioner

Appendix 1

WELLINGTON

BULLETIN NO. 843 (2 pages)

(Semi permanent)

Tranz Rail

29 November, 2000

CANCELLATION

Bulletin No.841 (Semi-permanent) dated 29 November, 2000, re Special Temporary Speed Restrictions is CANCELLED.

NOTE: Where a paragraph is marked with a vertical line and the print is italic this indicates either it is a new instruction or if it was a previous change a further change has been made.

SPECIAL TEMPORARY SPEED RESTRICTIONS

Commencing FORTHWITH and continuing until further advised the following instructions will operate:-

Speed restrictions for various sections of track which could be at risk for possible misalignment during the following summer months will be included on separate speed restriction Bulletins as the conditions for their operation will be different to that provided for in a normal speed restriction situation.

1. Each restriction will have special outer speed boards erected. These 40km/h Speed Boards with their associated C and T boards will remain uncovered at all times and will be erected at positions as specified in Rule 126. These boards will have the facing side painted yellow with the word "HEAT" and the maximum speed to be run indicated in black, these letters and figures will be shadowed in yellow reflecting material.**The C and T boards at these restrictions shall have yellow reflectorised tape located on the outer edges of the boards to distinguish them from ordinary C and T boards. Rule 76(e) is modified accordingly.** - Where ordinary speed boards need to be used this will be notified on the special temporary speed restriction area Bulletin.

2. The restrictions will only apply on a daily basis when the Ganger for each length advises Train Control. Either ALL the restrictions within each Ganger's length will apply or none at all. The speed restrictions will normally remain in operation until 2100 hours unless Train Control is otherwise advised by the respective Ganger in charge.

3. In areas where the special temporary speed restrictions operate LOCOMOTIVE ENGINEERS MUST CALL TRAIN CONTROL BETWEEN 1100 HOURS AND 2100 HOURS EACH DAY to ascertain which restrictions are in force, this includes when entering each Train Control area. A space will also be provided on the special temporary speed restriction area Bulletin for Locomotive Engineers to identify the restrictions which will apply.

Exception-For Locomotive Engineers working multiple units in the Wellington and Auckland suburban areas, and the special temporary speed restrictions are in operation Train Control/Authorities will fax a Bulletin with the updated relevant details to the Platform Co-Ordinator, Wellington, Paekakariki Tranz Metro, Officer in Charge Upper Hutt, Operations Supervisor, Auckland station , or Travel Services Officer, Papakura as the case may be; in addition the Auckland suburban bulletins will also be faxed to the Service Co-ordinator/Team Leader, Westfield. At these locations bulletins are to be attached to the notice/clipboard concerned.

IT WILL BE THE RESPONSIBILITY OF THE LOCOMOTIVE ENGINEERS WORKING MULTIPLE UNITS TO CHECK THE NOTICE/CLIPBOARD BEFORE EACH JOURNEY(unless local instructions advise otherwise). Rule 21 is modified accordingly.

NOTE: At Auckland station the staff may need to advise Locomotive Engineers working multiple units not breaking their journey of any speed restrictions which have been recently notified to ensure they are aware of the restriction.

Continued on page 2..BKG..

BULLETIN No.843 - Continued
(Semi-permanent)

WELLINGTON 29.11.00

SPECIAL TEMPORARY SPEED RESTRICTIONS - continued

4.Train Control Responsibilities are:-
*Train Control is to have a fresh copy of these Bulletins available each day and the relevant details completed when advice is received from the respective Ganger. As each train is advised of restrictions in force, Train Control will record the details on the Train Control diagram.
*ENSURE LOCOMOTIVE ENGINEERS REQUIRED IN CLAUSE 3 TO CALL TRAIN CONTROL BEFORE STARTING THEIR JOURNEY HAVE RECEIVED THE CURRENT SPECIAL TEMPORARY SPEED RESTRICTION INFORMATION.
*IF ANY TRAIN IS ENROUTE AND IN A SPEED RESTRICTION AREA AT THE TIME THEN TRAIN CONTROL MUST ADVISE THE LOCOMOTIVE ENGINEER/S CONCERNED.
*WHEN THROUGH TRAINS ARE RUNNING INTO A TRAIN CONTROL AREA, TRAIN CONTROL MUST ENSURE THE LOCOMOTIVE ENGINEER IS AWARE OF THE CURRENT SPECIAL TEMPORARY SPEED RESTRICTION AREAS.

5. Terminal Managers are to ensure that sufficient copies of each applicable Bulletin are provided to Locomotive Engineers so as to ensure that a fresh copy is available each day for Locomotive Engineers to endorse particulars of restrictions in force.

BK GORDON.
NETWORK CONTROLLER