RAILWAY INVESTIGATION REPORT
R02M0050

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
FREIGHT TRAIN NO. Q13711-13
MILE 38.85, BEDFORD SUBDIVISION
MILFORD, NOVA SCOTIA
13 AUGUST 2002

Railway Investigation Report

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Canadian National
Freight Train No. Q13711-13
Mile 38.85, Bedford Subdivision
Milford, Nova Scotia
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Summary

On 13 August 2002, at 1636 Atlantic daylight time, Canadian National freight train No. Q13711-13, travelling westward from Halifax, Nova Scotia, to Montréal, Quebec, with 112 loaded container platforms, derailed near Milford, Nova Scotia, at Mile 38.85 of the Bedford Subdivision. Seven container platforms from the last two five-pak container cars, and approximately 2.85 miles of track were damaged. There were no injuries and no dangerous goods involved.

Ce rapport est également disponible en français.

Other Factual Information

Canadian National (CN) freight train No. Q13711-13 (the train) departed Halifax, Nova Scotia, at approximately 1410 Atlantic daylight time,[1] travelling westward destined for Montréal, Quebec (see Figure 1). The operating crew consisted of one locomotive engineer and one conductor both located in the lead locomotive. They were qualified for their respective positions and met fitness and rest standards. As the locomotives passed Mile 42.60, a train-initiated emergency brake application occurred, bringing the train to a stop at Mile 42.90. After conducting the necessary emergency procedures, the train crew determined that seven container platforms on the last two five-pak container cars were derailed in an upright position on the right-of-way. There was approximately 2.85 miles of damaged track. A track buckle was noted at Mile 38.85 (see Photo 1).

[1] All times are Atlantic daylight time (Coordinated Universal Time minus three hours).

The train was 7540 feet long, weighed approximately 6230 tons, and was powered by two locomotives. The train consist comprised 33 loaded container cars, each of which consisted of one, three, four or five platforms, amounting to 112 platforms in total. A train safety inspection and No. 1 air brake test were performed before departure from Halifax and no exceptions were noted.

The Bedford Subdivision extends from Fairview Junction, Nova Scotia, Mile 5.0, to Truro, Nova Scotia, Mile 64.0. Train operations from Mile 15.6 to Mile 61.5 are controlled by the Centralized Traffic Control System authorized by the *Canadian Rail Operating Rules* and supervised by a rail traffic controller located in Montréal. The subdivision is predominantly single main track and handles both passenger and freight traffic. Approximately 15 million gross tons of traffic are carried over the track annually. In the derailment area, the track is located on a slight descending grade (0.5 per cent) in the direction of train travel. There is a reverse curve of approximately three degrees in each direction, with the initial point of derailment located within the exit spiral for the first curve (a right-hand curve).

The authorized timetable speed was 65 mph for passenger trains, and 50 mph for freight trains. Trains consisting of entirely intermodal equipment, whether loaded or empty, were authorized to operate at express speed, which was defined as 5 mph above the freight zone speed.

Recorded Information

The event recorder transcript indicated that, in the five-minute period before the emergency brake application, train speed varied between 57 mph and 46 mph, with the locomotive throttle in the No. 8 position and no dynamic brakes or air brakes applied. At a time of 1636:48, with the throttle in the No. 7 position and train speed at 45 mph, a train-initiated emergency brake application occurred. Train speed was recorded as 0 mph at 1637:29.

A review of recorded data from a wayside inspection system located at Mile 22.2 did not show any abnormal wheel bearing temperature, or dragging equipment, as the train passed this location. An inspection of the derailed cars did not reveal any indication of pre-derailment equipment defects.

Track and Site Information

The track structure consisted of 115-pound RE continuous welded rail (CWR) rolled and laid in 1989. The rail was secured with seven spikes per hardwood tie on 14-inch double-shouldered tie plates, and anchored every second tie. The crushed rock ballast was in good condition, with approximately 18-inch shoulders at the end of the ties and full cribs.

The first derailed wheel marks were approximately 45 feet west of the initial indications of the lateral shift in the track structure (i.e. Mile 38.85). At that location, the track structure had shifted approximately 18 inches to the outside of the curve. There was no sign of any appreciable spike lift for the first 35 feet. Track destruction in the derailment zone precluded the identification of any signs of pre-derailment track conditions (e.g. rail creep). The train crew did not see or otherwise detect any problem with the track structure when the locomotives passed over that location.

Track Buckle Characteristics

A track buckle is a lateral shift of the track, and, as a phenomenon, has been extensively studied by the railway industry. It occurs when longitudinal compressive stresses building up in the rail[2] overcome the lateral resistance of the track structure. Most track buckles occur on curves. They are more likely to happen in the presence of one or more of the following factors:

- a weakened track structure;
- high compressive thermal rail forces;
- train vehicle forces; and
- poor track geometry.

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[2] The formula used to calculate the amount of compressive force in a rail is: temperature difference in degrees Fahrenheit X the rail's cross-sectional area in sq. in. X 195 lb/psi (thermal force constant) = the amount of force

A weakened track structure will prevail if ballast is missing from the cribs or ends of ties. If ballast is disturbed, such as after track work, the lateral stability of the track can be reduced by more than 50 per cent.

The action of a train on downgrades can increase rail creep and, consequently, the amount of compressive rail stress. Train vehicle forces can contribute to track buckling by exerting additional longitudinal forces during acceleration and braking. In curved sections of track, rolling stock equipment can contribute to buckling by increasing lateral wheel forces, especially on unstable subgrade. Track with no apparent visual indicators of track misalignment or buckling has been known to buckle ahead of, or beneath, a passing train.

Track Inspection and Maintenance

Employees performing track patrols relied on visual inspections to identify potential track buckle conditions. The portion of the track where the derailment occurred was inspected by a relief track supervisor on 11 August 2002, two days before the accident. The last previous inspection was 07 August 2002. During these two inspections, no exceptions in the general area of Mile 38 were identified.

A CN Track Evaluation and Service Test (TEST) car examined the Bedford Subdivision around 1100 on the day of the accident, several hours before the arrival of the train. No exceptions were recorded. Line and surface profile measurements through the reverse curve were within allowable limits.

Due to the alignment of the track in the derailment area, and the effects of train forces on the reverse curve, surfacing work was conducted every two years. Historically, the low side in these curves would settle. Frequent track surfacing was required to keep the proper superelevation. In 1999, surfacing work was conducted in the area in association with the installation of approximately 500 railway ties. The most recent surfacing work was a "surface lift,"[3] completed on 05 and 06 July 2002 from Mile 38 to Mile 40 using a track tamper and a ballast regulator.

Daily maximum temperatures at that time were 21°C (70°F). After surfacing was completed, train movements were temporarily protected with a slow order of 30 mph. Between the time of the last surfacing work and the accident, approximately 1 200 000 gross tons of traffic had passed over this location. This was well above the requirements of CN's standard practice circulars (SPCs) that require protection in most cases until the ballast is well compacted, thus providing adequate lateral resistance.

There had been no rail repaired due to breaks, or rail replaced, nor was there any rail destressing performed in these curves during the previous five years.

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[3] CN defines "surface lift" as the continuous raising of the track elevation with or without additional ballast and without raising the general elevation of the track more than 40 mm (1 ½ inches).

CN's SPC 3706 states that, during "rehabilitation ballasting" and "ballast lift" programs, if there are indications that rail stress is out of adjustment, destressing must be carried out in accordance with CN's Recommended Method 3205-0. Some of the warning signs of a "tight rail condition"[4] and the potential for a track buckling problem are:

- wavy rail;
- alignment defects such as short flat spots in a curve or kinks in tangent track;
- gaps or voids in ballast at the end of the ties;
- rail base not fully seated on the tie plates;
- rail creep;
- churning of ballast caused by tie movement; and
- longitudinal movement of a switch point.

The *Railway Track Safety Rules* (TSR), Part II, Subpart F (V), state:

> In the event of fire, flood, severe storm, or other occurrence which might have damaged track structure, a special inspection must be made of the track involved as soon as possible after the occurrence.

At the derailment location, there were no warning signs or previous reports of the rail stress being out of adjustment. The surfacing work that had been performed was a surface lift, not a ballast lift,[5] the latter being more destabilizing to the track structure.

Effect of High Ambient Temperatures on Rail

Whenever the temperature of the CWR exceeds the neutral rail temperature[6] at which the rail was laid or last adjusted, longitudinal compressive forces are created, resulting in a tight rail condition. The tighter the rail becomes, the smaller the lateral force required to cause a track buckle. In 115-pound CWR, each increase of 8°F in the temperature of the rail increases the compressive stress in the rail by about 2200 pounds. A rail temperature increase of 15.5°C (28°F), which can occur on hot summer days, can create a compressive force of 61 425 pounds in a 115-pound RE rail. Neutral rail temperature can be modified by the amount of rail traffic, track maintenance activities (e.g. ballast cleaning or tie renewal programs), and extreme weather conditions, such as extraordinarily high or low temperatures.

The rail must be laid or adjusted at a temperature that will accommodate stresses caused by fluctuations in the temperature. The preferred rail laying temperature range in the area is 27 to 35°C (80 to 95°F). Railway Recommended Method 3205-0 required that additional safety measures be implemented when the ambient temperature exceeded the preferred rail laying temperature by more than 11°C (20°F), i.e. a temporary slow

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[4] "Tight rail condition" means a rail that is under high compressive stress.

[5] A ballast lift is the continuous raising of the track elevation by the use of additional ballast and where the general elevation of the track is raised more than 40 mm (1 ½ inches).

[6] Temperature at which CWR is stress-free (i.e. no compression nor tension).

order of 40 mph should be placed between the hours of 1100 and 2000, and a track patrol would be required between 1100 and 1700. Railway records indicating the temperature at which the rail was last adjusted were unavailable.

Environment Canada records from the nearest reporting station (Halifax Airport) show that, at the time of the derailment, ambient air temperature was 30°C (86°F), the winds were 25 km/h and the skies were clear. Between 10 August and 13 August 2002, the temperature had reached daily maximums of 27 to 30°C (80.6 to 86°F), the warmest temperatures of the summer up to that date. Several property owners who lived near the derailment location stated that local temperatures that day had reached 35°C (95°F). Local radio stations had reported similar temperatures elsewhere in the area. The rail temperature after the derailment was measured at 1700 to be 40.5°C (105°F). It is possible that rail temperatures prior to 1700 were higher, as the maximum ambient temperatures were recorded between 1500 and 1600.

Other Information

An examination of the TSB data for the years 1997-2002 indicated that there were 18 other occurrences involving a track buckle.

- In 84 per cent of these occurrences, a train derailment occurred in the second half of the train consist.
- In 74 per cent of these occurrences, the derailed cars were located within 15 cars of the end of the train.

As well as this occurrence, the TSB has been investigating two other occurrences (report Nos. R02D0069 and R02C0054). A brief explanation of these is provided in Appendix A.

New Technologies

Much research has been done, and is ongoing, to develop a non-destructive stress measuring system for CWR. Some examples are as follows – with further information in Appendix B:

- hand-operated hydraulic lifting frames with transducers and hand-held computers;
- rail stress monitors that measure and record longitudinal stress and temperature history;
- ultrasonic-based devices that analyse sound wave velocity;
- laser vibrometry that measures vibration amplitude with a laser in sections of rail only one metre long; and
- computer risk programs that analyse longitudinal, vertical and lateral forces as well as temperature.

Some of the new technologies allow the internal stresses in CWR to be remotely monitored, with alarm systems interfaced with evolving communications-based train control systems, or other wayside information systems in rail traffic control centres. These systems, tested and in use on several railways in the United States and in Europe, allow real-time monitoring of rail stress for the locations and the adjacent zones in the track where they are installed. When predetermined thresholds are reached, the resulting alarms allow immediate remedial action to be taken.

Analysis

Introduction

Although the train was travelling approximately 2 mph above the permissible express speed for a brief period of time, this was a relatively minor speed deviation and it is unlikely that it contributed appreciably to the accident. As the operation of the train otherwise met all company and regulatory requirements, and no defective equipment was identified, it is considered that neither the manner of train operation nor equipment condition played a significant role in this accident.

The Accident

The accident occurred at the hottest time of the day, during a period that saw the highest temperatures experienced in the area since the resurfacing work was conducted in July 2002. Given the extreme ambient conditions and the frequent surfacing work in this area, it is likely that the neutral rail temperature had been reduced; therefore, the higher-than-normal ambient temperature created higher-than-normal compressive stresses in the CWR. The frequent surfacing work also resulted in an excessive ballast depth that affected the overall stability of the track structure. When these factors were combined with the lateral force generated by the consecutive passes of rail car wheel sets in curved track, the factors commonly associated with track buckles were present. The forces exerted on the track structure by the moving train and the rail compression could not be contained by the ballast, allowing the track to shift out of alignment and buckle. The last two five-pak cars of the train travelling at express speed could not negotiate the misaligned track (18 inches) and derailed. The location of the track buckle in a curve on a downgrade is consistent with previous data on similar type track failures. Likewise, the track buckle, occurring under a moving train, derailing the end cars is typical of track buckle accidents.

Regular Track Inspection and Maintenance

There is no information to suggest that the frequent surfacing work was not performed in accordance with standard practice requirements and company procedures. Track inspections required by the TSR were performed as required, albeit two days before the accident and at lower ambient temperatures.

Track maintenance employees were aware of the favourable results of the inspection performed by the highly instrumented CN TEST car on the date of the accident. However, the TEST car had passed over the track around 1100, which was four to five hours prior to the highest ambient temperature conditions. The TEST car is not designed to detect harmful levels of compressive stress building up in the rails, and track buckling is an instability phenomenon that, in its initial stages, cannot always be identified by track evaluation measurements.

In the absence of any reports of the track stress being out of adjustment, and with few obvious physical signs of excessive rail stress on the date it was inspected, such as spike lift, anchor creep, tie movement or disturbed ballast, it would appear that track maintenance personnel had little indication that the rail needed destressing, and that future high ambient temperatures would negatively affect the integrity of the track structure in the area. This indicates that inspecting for physical signs of track degradation does not identify harmful levels of stress in undisturbed rail or track structure.

Inspection of Track During High Ambient Conditions

The need to fully control rail stress is evident by the amount of compressive stress that can occur in high heat conditions. The surfacing work was conducted at ambient temperatures that were 6°C (10°F) below the preferred rail laying temperature, and there was no indication that the line of the curve had been reduced; therefore, rail stress should not have been augmented by that procedure. However, ambient temperatures on the day of the derailment (which were in the mid-30s) and the rail temperature at 1700 (which was measured to be 40.5°C, or 105°F) were higher than normal. The rail temperature at the time of the accident exceeded the preferred rail laying temperature, increasing the compressive stress in the rail, thereby reducing the lateral force required to create a track buckle.

Railway safety measures, such as extra track patrols and speed restrictions, were not invoked as the ambient air temperature (approximately 35°C, 95°F) was not reported to have exceeded the preferred rail laying temperature by the required 11°C (27°C + 11°C = 38°C, or 100.4°F). It is noted that some railways require track patrols to be conducted at different ambient temperatures. For example:

- Canadian Pacific Railway's SPCs state:

  > During periods when the ambient air temperature is expected to be higher than 90°F (32.2°C), planned track inspections should be done during the heat of the day. . . .
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  > During periods when the ambient air temperature is expected to be high or when the temperature is rising rapidly (as in spring), additional track inspections may be required. . . .

- One U.S. railway (CSX Transportation Inc.) requires trains to travel at 10 mph below the posted speed on days when heat orders are issued, i.e. days when the temperature is above 90°F (32.2°C) for two or more consecutive days, or if there is a temperature fluctuation of 40°F (22.2°C) or more in a 24-hour period.
- Similarly, another railway (Montana Rail Link) was noted to send out track inspection crews whenever the temperature was above 90°F (32.2°C), and speed restrictions were placed on trains.

Signs of the rail being under considerable compressive force would have been more apparent during inspections conducted when rail temperatures were at their highest (i.e. typically in the mid-afternoon to late-afternoon time period). Had a track patrol been conducted in the derailment area during these time periods using lower threshold temperatures (i.e. when temperatures exceeded 32.2°C (90°F) as opposed to 38°C (100°F) specified in CN's SPCs), it would have increased the probability of identifying the early signs (disturbed track structure) of a potential problem, allowing risk reduction measures to be taken to prevent a track buckle.

The need for additional special inspections contemplated by Subpart F (V) of the TSR is somewhat unclear. The TSR mention several cases where a special inspection should be carried out, but do not specifically mention "high heat" as one of the cases. One must infer high heat to be "an occurrence which might have damaged track structure." Somewhat similarly, CN's SPCs required special inspections to be made in relation to a threshold above the preferred rail laying temperature, as opposed to a direct reference to a maximum ambient temperature like some other railways. There are no specific criteria in CN's SPCs to guide employees as to what constitutes "high heat."

Given the absence of specific criteria for the inspection of track exposed to high ambient temperature conditions in the TSR, coupled with the maintenance crew's knowledge of the volume of traffic that had passed successfully since the last resurfacing work was conducted, and the favourable results of the CN TEST car examination, the crew did not inspect the track in the mid- to late-afternoon, the time at which signs of compressive forces would have been more apparent.

Identification of Rail Stress

The existing inspection methods largely rely on employees to inspect the track structure for any physical signs of a degradation in track structure integrity. To a knowledgeable employee, signs such as spike lift, or rail creep, can indicate the possible existence of a rail that has excessive compressive stress. These inspection methods have been used quite successfully for years but the track must be inspected at the right time of the day, and the employee must identify the physical signs of a tight rail condition. Employees normally have no tools readily available in the field to quantify their assessment. If employees cannot see any physical signs, they have no way of identifying the presence of harmful levels of compressive rail stress. Therefore, they are not likely to suspect that there is a potential problem, particularly if they have no information on the neutral rail temperatures for the sections of track that they are inspecting. Relying on visual inspections alone to identify the physical signs of track degradation does not provide the maximum safety margin as it does not allow the advance identification of harmful levels of residual compressive stress in undisturbed rail or track structure.

Also, it is a challenge for track maintenance employees to perform these visual inspections as, typically, broad geographic areas are affected by high heat conditions. Because employees must physically inspect all of this territory during the heat of the day, which is often limited in duration to a few hours, this makes the task all the more difficult. Visual signs that might indicate a risk of buckling are also indicators of other types of track defects, and they may not always be visible from a hi-rail vehicle moving at the speed normally used during track inspections. Because there is no easy method readily available to track maintenance employees to identify and assess the amount of stress in a rail, and due to the limited time periods available to cover the required territories when rail is at its maximum temperature, there is a risk that stressed rail (i.e. rail that is experiencing an abnormal amount of compressive stress) may go undetected and later cause an unsafe track condition.

Application of New Technologies

Because the new technologies described previously are still largely in a developmental stage, they are not in widespread use yet. They are intended to be used in a site-specific manner and are limited in their application as they require the pre-identification of high-risk locations. This occurrence highlights the vulnerability of track inspection methods alone to identify rail that is out of phase with its preferred rail laying temperature. Until such time as stress-measuring devices are regularly used to help track maintenance employees identify the amount of stress in a rail, the detection of unsafe levels of stress will rely largely on existing visual inspection methods that provide a lower margin of safety.

Conclusions

Findings as to Causes and Contributing Factors

1. Increased compressive stress in the continuous welded rail due to higher-than-normal ambient temperatures, in addition to an excessive ballast condition due to frequent surfacing, created the circumstances for a track buckle to occur.

2. The forces exerted on the track structure by the moving train and the rail compression could not be contained by the ballast, allowing the track to shift out of alignment and buckle.

3. Seven platforms from the last two five-pak cars of a train travelling at express speed could not negotiate the laterally misaligned track and derailed.

Findings as to Risk

1. Inspecting the track for physical signs of track degradation does not allow the advance identification of harmful levels of stress in undisturbed rail or track structure.

2. Additional railway safety measures, such as extra track patrols and speed restrictions, were not invoked as the ambient air temperature was not reported to have exceeded the preferred rail laying temperature by the railway-specified amount.

3. Because there is no easy method readily available to track maintenance employees to identify and assess the amount of stress in a rail, and due to the limited time periods available to cover the required territories when rail is at its maximum temperature, there is a risk that rail that is experiencing an abnormal amount of stress may go undetected and later cause an unsafe track condition.

4. In the absence of stress-measuring devices to help track maintenance employees identify the amount of stress in a rail, the detection of unsafe track conditions will rely largely on existing visual inspection methods that provide a lower margin of safety.

Safety Action

After the accident, Canadian National (CN) took the following corrective action in an area of 1.8 miles of the Bedford Subdivision, encompassing the reverse curve where the track buckle occurred:

- surveyed track geometry in the area;
- undercut the track to remove the excessive ballast conditions;
- removed some excessive superelevation; and
- destressed the rail.

On 29 August 2003, CN advised that it had also undertaken the following actions:

- Purchased three portable rail stress detection units (called VERSE) for undertaking spot checks of rail stress in continuous welded rail (CWR) territories. These units are highly accurate and can determine the rail neutral temperature to within 3°F; they have been issued to the CN field forces who are undertaking frequent spot checks targeting suspect locations.

- Revised its Standard Practice Circular (SPC) so that extreme heat inspections now commence when the ambient temperature exceeds 86°F (30°C). In addition, if conditions warrant, hot weather speed restrictions may also be implemented. With the new SPC on heat inspection, there is a specific temperature that acts as a guideline to employees, thus simplifying the instruction.

- CN contracted environmental services from a weather provider. With this new initiative, should the temperature exceed 30°C (86°F), a warning will be issued to the CN traffic control centres, the CN Weather Monitor Web site and the e-mail bulletin board site. This information is then relayed to the appropriate track forces. In addition, the Engineering Network operation officers monitor the Weather Monitor Web site and will contact either the general superintendent of engineering or the track supervisors to ensure that they are aware of the warning and the need to implement hot weather inspections and possible speed restrictions.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 13 November 2003.

Visit the Transportation Safety Board of Canada Web site (www.tsb.gc.ca) for information about the TSB and its products and services. There you will also find links to other safety organizations and related sites.

Appendix A – Other TSB Investigations Involving Track Buckles – Report Nos. R02C0054 and R02D0069

TSB Report No. R02C0054

On 23 July 2002, at approximately 1722 mountain daylight time, Canadian Pacific Railway southward freight train number 771-23 derailed 15 loaded tank cars at Mile 36.6 of the Red Deer Subdivision, near the town of Carstairs, Alberta. Three of the tank cars leaked about 200 litres of ethylene glycol. Highway 2A and adjacent roads were closed for a one-half mile radius around the derailment site. There were no injuries. The investigation identified deficiencies relating to track inspection and maintenance, use of dynamic brakes, employee training, as well as track buckle.

TSB Report No. R02D0069

On 03 July 2002, at approximately 1210 eastern daylight time, Canadian National southbound freight train number 353-21-02 derailed 14 cars at Mile 117.68 of the Joliette Subdivision, near L'Assomption, Quebec. There were no injuries and no dangerous goods involved. Approximately 1830 feet of main track, 660 feet of siding track, and a private crossing were destroyed. Other damage included the loss of 150 trees as well as water service to an adjacent tree nursery.

Appendix B – New Technologies for Measuring Stress in CWR

The following list contains some examples of the research that has been done, or is ongoing, to develop a non-destructive stress-measuring system for continuous welded rail (CWR):

- One system under test with CN in Western Canada was presented at the American Railway Engineering and Maintenance-of-Way Association (AREMA) conference in Washington, United States, in September 2002. The system comprises a hand-operated hydraulic lifting frame, a force transducer and a displacement transducer. The measurement systems are connected to a hand-held computer, are collapsible and portable. The stress-free temperature for a section of CWR is determined by analysing the force and deflection during a lift of 30 metres of unclipped, or unanchored, rail. Factors such as the rail temperature, rail profile, tie type, curve radius, along with site details, are entered into the computer, which then leads the operator through the measuring process. The rail is initially lifted to ensure no ballast is fouling the rail and that it is lifting freely from the pads, or tie plates. Three measuring cycles are completed and the rail is then re-fastened. On completion of the data collection, the measured data are transferred to the computer to calculate the neutral (stress-free) temperature. The whole process from arrival to site, assembling the equipment, unclipping the rails, measuring both rails, and leaving, is about one hour. Interestingly, the test results obtained revealed that the track was frequently not in neutral stress, and very often, the amount of stress in each rail was different, reinforcing the need for continued development of such technology.

- Another system, being marketed by Salient Systems, Inc. of Cincinnati, Ohio, United States, states that:

  > Research has shown that proactive, continuous measurement of longitudinal stress and neutral temperature at discrete locations along the rail provides the best early indication of emerging track problems. Salient has developed a technology called StressNet™ that serves as a comprehensive track safety and maintenance monitoring system. The system includes a strategic network of proprietary Rail Stress Monitors installed along the web of rail that routinely measure and record a region's longitudinal stress and temperature history. The data are then uploaded for analysis and reporting by the StressNet™ Data Management System.
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  > . . . applications for StressNet™ range from high maintenance or severe operating locations to curves, grades, new rail installation, repair plugs, bridges, and scales. They claim that nearly half of all track-caused derailments involve conditions that its technology may help to avoid.

- An ultrasonic device based on the stress-dependent velocity of sound waves in materials was tested by the Association of American Railroads (AAR) in the early 1990s and was described in AAR's research report R-779. The system required extensive calibration dependent on rail metallurgy.

- More recently, researchers are working at the University of Illinois on a project using laser vibrometry as another method to measure rail stress. A vibration of 100 to 200 hertz is introduced into the rail and a laser measures vibration amplitudes that are very small, measured in microns. When amplitudes are plotted, a sine wave of a particular wave length is seen and, from that wave length, stress can be inferred. It is thought that the process can be used on a piece of rail only one metre long, making it easier to use in a wider temperature range than the rail uplift method. Research and analysis is still ongoing with funding from the Transportation Research Board with field tests to come, possibly on a CN/IC rail line.

- Burlington Northern and Santa Fe Railway (BNSF) has developed a computer risk program for track buckling and has set up longitudinal force instrumentation sites around its system that measure longitudinal, vertical and lateral forces as well as temperature.

- Another method discussed is the use of concrete slab track instead of traditional ties and ballast. This type of track has been in use in Europe and Japan for more than 30 years and works well for high-speed passenger trains, but the challenge is to design and construct a track system that provides the required ride quality for high-speed passenger trains, and the strength to withstand 39-ton axle loads at freight train speeds. The Portland Cement Association is leading the research and a slab track installation is scheduled to begin on the FAST Loop in Pueblo, Colorado, United States, in 2003.