RAILWAY INVESTIGATION REPORT
R97S0098

DANGEROUS GOODS LEAK

CSX TRANSPORTATION COMPANY AND
ST. LAWRENCE & HUDSON RAILWAY
INTERCHANGE TRACKS

CSX TRANSPORTATION COMPANY
CHATHAM YARD
CHATHAM, ONTARIO
07 OCTOBER 1997

Transportation Safety Board
of Canada

Bureau de la scurit des transports

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Railway Investigation Report

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CSX Transportation Company Chatham Yard Chatham, Ontario 07 October 1997

Report Number R97S0098

Synopsis

On 07 October 1997, at approximately 1220 eastern daylight time, a loaded pressure tank car containing butane was discovered leaking from the B-end centre sill area in the CSX Transportation Company interchange tracks in Chatham, Ontario. First responders immediately established a 100-metre exclusion zone, and an on-site command centre was set up. A subsequent evacuation from an area within a one-kilometre radius of the incident location included evacuating approximately 800 individuals from their homes for over seven hours. The situation was deemed to be controlled and safe at 2100, and product from the leaking tank was removed by 1210 the next day.

The Board determined that product from the tank car, having been subject to extensive repair and maintenance after a recent derailment and just returned to service, leaked from a through crack in the tank shell induced by a weld made during the installation of its protective jacket in 1980. The crack had been sufficiently tight not to have leaked for 17 years but may have been disturbed by the impact forces of the recent derailment.

Ce rapport est galement disponible en franais.

1.0 Factual Information

1.1 Background Information

At approximately 1220 eastern daylight time (EDT)[1] on 07 October 1997, a St. Lawrence & Hudson Railway (StL&H) employee noticed that tank car DCTX 33126, located in Chatham Yard of the CSX Transportation Company (CSX), was leaking product. The car contained 107,800 pounds of liquefied butane and was being inspected for interchange to StL&H. Frost was observed behind the bolster in the area where the jacket and stub sill meet at the tank car's B-end right side (BR location).[2] A small amount of product was escaping from a crack in the tank shell in the stub sill area.

A 100-metre exclusion zone was established around the leaking car; Canadian Pacific Railway[3] emergency response personnel quickly organized an on-site command centre. The tank pressure was closely monitored; the local fire department was at the site and intermittently sprayed the leaking car in order to cool the tank and lessen increased pressure attributable to daytime warming. Tank pressure was maintained at about eight pounds per square inch (psi). At approximately 1400, the fire department ordered the evacuation of 200 students from a nearby elementary school as a precautionary measure. At 1540, a state of emergency was declared by the City of Chatham's mayor, and about 800 individuals within an approximate one-kilometre radius of the leaking tank car were evacuated. A temporary emergency shelter for the displaced residents was established in a local community centre. At approximately 2100, after a thorough assessment of the situation by petroleum industry representatives and railway officials, provincial government emergency measures officials decided that the leak could be managed. As a result, the state of emergency was ended and the evacuation zone was reduced to the initial 100-metre radius area. This zone contained no dwellings or businesses, thus allowing those evacuated to return to their homes.

Transport Canada (TC) issued an estoppel certificate to allow the product to be transshipped to another tank car. Transshipping commenced at approximately 2355 and was completed at 1210 the next day. Car DCTX 33126 was then forwarded to the Procor Limited repair facility in Sarnia, Ontario, for inspection.

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1 All times are EDT (coordinated universal time (UTC) minus four hours) unless otherwise stated.

2 The B-end (B) of a rail car is the end on which the hand brake is mounted; the A-end (A) is the other end of the car. The denoted sides, left (L) and right (R), of the car are as seen from the B-end.

3 Parent company of StL&H

1.2 Dangerous Good

Liquefied butane, UN 1075, Class 2.1, is a flammable, compressed gas. Butane is easily ignited by heat, sparks, or flames. In concentrations with air of between 1.9 and 8.5 per cent by volume, it forms explosive mixtures. Butane is environmentally hazardous. It is also hazardous to one's health if inhaled, ingested, or if it comes into contact with the skin. Butane has a vapour pressure of 16.54 psi gauge at 21.1 degrees Celsius. During the day and evening of 07 October 1997, the temperature fluctuated between 15 and 20 degrees Celsius. The product was odorized to facilitate detection by smell.

1.3 Recent Trip History

1.3.1 Amoco Canada Petroleum Company Limited

Car DCTX 33126 was loaded at the L-4 loading rack of the Amoco Canada Petroleum Company Limited (Amoco) facility in Sarnia on 05 October 1997 during daylight hours. No weaknesses in loading procedures were evident. The tank car was given a pre-loading visual examination by two Amoco employees before being connected to the loading hose. Nothing abnormal was noted. The integrity of the loading process was verified using hand-held instruments and visual inspection. No leaking product was detected. During the post-loading inspection and placarding, no signs of escaping product were evident. The car was retrieved by Canadian National (CN) and stored at its Sarnia Yard on the same day.

1.3.2 CN and CSX Handling and Inspections

Railway inspections were thoroughly completed. At approximately 1730, 05 October 1997, car DCTX 33126 was given a visual inspection by CN personnel at the CN Sarnia Yard preparatory and was to be delivered to the CSX Sarnia interchange tracks. The tank car was not seen to be leaking product at that time. At approximately 1930, 06 October 1997, after CSX employees inspected the tank car to ensure that it was in good condition, car DCTX 33126 was accepted by CSX. At about 0700, 07 October 1997, after having been marshalled in train D724 for delivery to StL&H in Chatham, the tank car received a certified car inspection by CSX personnel with no exceptions noted. At about 1030, train D724 passed through Turnerville, Ontario (Mile 27.8 of the CSX Courtright Subdivision, about 10 kilometres north of Chatham), and was inspected as it passed by a CSX maintenance-of-way gang. No exceptions were noted. Later, at approximately 1210, 23 cars, including car DCTX 33126, were left in Chatham Yard where StL&H employees waiting to inspect the cars noticed that car DCTX 33126 was leaking.

1.4 Tank Car Information

Car DCTX 33126 was owned and managed by PLM Transportation Corporation (PLM) of Chicago, Illinois. It was built in 1966 to specification CTC-114A for anhydrous ammonia service by Davie Shipbuilding Ltd. of Lauzon, Quebec. The tank car was converted to CTC-114S specification by the addition of head shields and double-shelf couplers by Procor Limited, of Oakville, Ontario, in April 1980. The same facility converted the car to a CTC-114J specification with the installation of thermal insulation and a protective insulated jacket in September 1980. In December 1991, CGTX Inc.,[4] of Moose Jaw, Saskatchewan, made discharge pipe modifications and installed a manway to meet CTC-112J specification. At that point, the car was destined for liquefied petroleum gas service. Meanwhile, the stub sill inspection required by TC was carried out; a crack was observed in the A-end sill cope, and the welds in the sill flange area were noted to be poor. The crack was repaired, and the car returned to service. In September 1996, Procor Limited, of Oakville, repaired cracks in the centre sill plate area that were found during servicing (periodical valve testing and maintenance).

Eighty-six cars were built to this design by Davie Shipbuilding Ltd. and Hawker Siddeley, of Trenton, Nova Scotia. Another 2,600 cars were built in the United States by North American Tank Car Corporation, of Chicago. Later, the car became part of the fleet of GE Railcar Services Corporation, of Chicago. In December 1986, the car was acquired by PLM through its subsidiary, PLM Equipment Growth Fund, of Calgary, Alberta.

Tank car DCTX 33126 had derailed in the CN Saint John Yard, New Brunswick, on 18 April 1997. Subsequent to this derailment, the car was re-railed and shopped at Saint John, where the No. 1 and No. 2 wheel sets were replaced, and brake, running rigging, and safety appliances were repaired. The B-end centre pin was also replaced. The car was then directed, by its owner, to CGTX Inc., of Montréal, Quebec, for servicing, a centre sill inspection, and a required five-year safety valve retest.

PLM instructions to CGTX Inc. included a request for repairs of remaining damage caused by the derailment, an inspection, and corrective repair in accordance with Association of American Railroads (AAR) Interchange Rule 88B. PLM also specifically requested that the stub sill areas be inspected for weld undercuts.

The 13 May 1997 stub sill area repair facility inspection revealed two- to three-inch (50- to 75-mm) cracks in the stub sill pad-to-tank shell welds at the AR, AL, BR, and BL locations.

Car DCTX 33126 was returned to service in September 1997. The car was then moved to the Amoco facility for loading on 05 October 1997.

1.5 Post-occurrence Inspection and Testing

[4] In December 1999, the corporate identity of CGTX Inc. was changed to GATX Rail Canada.

After arriving at the Sarnia repair facility following the dangerous goods leak, car DCTX 33126 was cleaned, purged, and thoroughly inspected. Dye penetration testing was conducted on each corner of the stub sill, showing a through crack in the BR location. The cracking appeared to originate from a weld crater and followed a line under the car jacket spacer bar and reinforcing pad. The weld was very rough, uneven, displayed small blow holes, and showed signs of cavitation, undercut, porosity, and poor penetration. Recent good-quality welds were noted at the stub sill-to-reinforcing pad area at the BL and BR locations. A crack on the AR side was noted. It was also noted that the AL side had been air-arced[5] but not re-welded. Acoustical emission testing revealed cracking indications at the BR, AR, and AL locations worthy of follow-up examination. Low-quality welds at the tank strap and reinforcing pad at the BL, AR, and AL locations were also noted.

1.6 Tests and Research

A part of the stub sill and belly pad of tank car DCTX 33126, containing part of the head plate and first cylinder plate, was sectioned off and sent to the TSB Engineering Laboratory for examination.

The examination (Engineering Laboratory report LP 160/97) revealed that the tank car leak occurred at a crack in the shell in the car jacket spacer bar-to-tank weld at the BR location and concluded the following:

- The tank car leak coincided with a large pre-crack that measured 13.4 cm long and 17 mm deep. The leak occurred through a 10-mm-wide section of a wall.

- The overall pre-crack features were consistent with the entire crack having occurred in one single event, including the area where the leak occurred.

- The crack had existed for some time. The presence of a high-temperature oxide on its entire surface indicates that it most likely originated during welding of the spacer strap to the tank car plate when the car was fitted with an insulating jacket.

- Although the crack had been there for some time, it did not leak sooner because the through-thickness crack was very small (10 mm) and was supported in the stub sill area. The April 1997 derailment may have played a role in opening the crack sufficiently for leakage to occur.

[5] Molten steel blown out by compressed gas

- The weld joining the spacer strap to the tank car plate was of poor quality, as evidenced by the blow holes, lack of weld penetration, porosity, and undesirable martensitic microstructure where several secondary cracks were observed. Porosity suggests that the weld was made without pre-heat and was completed wet or without proper cleaning. The weld structure's overall microscopic appearance suggests that there had been no pre-heat or post-weld treatment.

- The recent weld made by CGTX Inc. appears to have had no effect on the existing pre-crack.

- The tank car plate material met the required AAR M128B specifications.

1.7 CGTX Inc.

The initial inspection of car DCTX 33126 at the CGTX Inc. Montréal facility on 13 May 1997 provided a maintenance cost estimate, valve testing, and repairs attributable to the April 1997 Saint John accident. Stub sill cracks at the AR, AL, BR, and BL locations were identified, and CGTX Inc. form QAF-1002A (the "Travel Sheet") and mechanical department form No. 39 (MEC-39) were completed. The presence of stub cracks was noted on both forms. A crack in the tank at the BR location was not noticed, nor was exception taken to the poor weld quality in the stub sill area tank jacket securement bracket. The repair and refurbishing of car DCTX 33126 commenced on 03 September 1997.

While the car was in CGTX Inc.'s Montréal facility, the four cracks in the stub sill were slated for repair. However, the post-occurrence inspection had disclosed that only the B-end cracks had been repaired, the AL crack had been air-arced but not welded, and the AR location had not received any attention.

The "Travel Sheet" and an MEC-39 form had accompanied the car through the shop and were duly initialled, as required by CGTX Inc. quality assurance (QA) protocol, indicating that required repairs were completed and inspections were conducted.

Two experienced welders qualified to AAR standards for tank car repairs had worked on the stub sill repairs. The B-end repair had been completed by a day-shift welder who made the repairs, reinstalled the tank jacket, and initialled the MEC-39 form specifying that he had completed and self-inspected the repairs. This employee indicated that he had not noticed any other crack in the BR location as he made this repair. The night-shift welder placed a check mark and his initials next to the location for the A-end repairs to indicate that he had completed and self-inspected the necessary repairs and then reinstalled the tank jacket. The night-shift welder was adamant that he had actually made the necessary repairs until shown pictures of the air-arced AL location, which he recognized.

Form QAF-1002A is also used as an exit document for repaired cars and acts as a final inspection form. Car DCTX 33126 received a final inspection for release to the owner on 23 September 1997. The part of the form indicating that the stub sill area had been duly repaired and inspected for quality was initialled by the shop welding inspector. At this stage of the shop work, any repairs to the stub sill area would have been covered by the tank jacket and therefore not accessible for further inspection purposes.

1.8 Quality Assurance

1.8.1 Association of American Railroads Quality Assurance Program

The AAR's QA requirements are outlined in its *Manual of Standards and Recommended Practices*, section J (M-1003). The requirements of Canadian General Standards Board (CGSB) standard CAN/CGSB-43.147-97 also apply. Contractors such as CGTX Inc. are required to institute quality control to conform to AAR standards. To meet this end, contractors submit a copy of their quality assurance manual (QAM) for a review of adequacy and the facility itself is audited by AAR representatives.

Although inspection and test plan formats may suit the contractor's system, they must include inspection and test points and their relative position in the processing cycle. Plans must indicate subcontractor service areas; identify characteristics to be inspected, examined, and tested at each point; and specify the acceptance criteria and inspection and test points where measurement and test records are maintained. In addition, they must indicate mandatory hold points that require witnessing or verification of selected characteristics beyond which the work shall not proceed. Plans must also define or refer to how verification of compliance with process or procedures will be accomplished or documented. Process control is ensured in AAR QA by establishing workmanship criteria, ensuring that qualifications of personnel, procedures, and equipment comply with standards.

The CGTX Inc. Montréal facility was an AAR-certified facility and had been last subject to an AAR QA audit on 25 September 1997. AAR audits consisted of a review of documents to determine if QA requirements were met as described and filed with the AAR. The "Travel Sheet" and MEC-39 forms were scrutinized to ensure that work was being certified as complete and inspected as required. This audit disclosed several procedural shortcomings, which the company quickly remedied, and AAR certification was retained.

1.9 CGTX Inc. Quality Assurance Responsibilities

The CGTX Inc. QAM (*QAM-1002 Tank Car and Freight Car Repair and Maintenance*) outlined the QA responsibilities of company shop management, supervisors, and employees. QA requirements were delegated to each facility's QA representative. The CGTX Inc. Manager of QA delegated, in writing, certain QA functions to other personnel as operations dictated. In the CGTX Inc. Montréal shop, the Engineering/QA Coordinator served as the QA representative as delegated by the CGTX Inc. Manager of QA. The shop manager designated, in writing, individuals to perform the QA functions outlined in the QAM. Shop personnel carried out the day-to-day QA tasks on the shop floor.

The CGTX Inc. QAM dictated that the "Travel Sheet" be used to certify compliance to QA procedures associated with car repair. The "Travel Sheet" was initiated by the inbound inspector, and each item was to be certified as corrected by a responsible person when the work on that item was completed. No car was to be released into service unless the "Travel Sheet" was fully completed and certified by designated personnel.

All shop personnel were performance-qualified to AAR technical requirements and received regular training on shop procedures, including the use of the "Travel Sheet" and form MEC-39. In CGTX Inc. QA procedures, tank car repairers are responsible for performing the repair work and certifying that the repair has been conducted in compliance with technical standards. Both procedures are deemed completed upon initialling form MEC-39 opposite the listed repair or work requirement.

1.10 Thermal Insulation and Protective Jacket Installation

Although it has been established that Procor Limited, of Oakville, installed the protective jacket in September 1980, shop records of this conversion are not available. Procor Limited advised that, during the period in which the tank car was fitted with an insulated jacket, the shop QA standards were rigid, and any work on the tank shell would have been completed by experienced and qualified welders. In addition, Procor Limited advised that it was common practice to have all welds inspected by supervisory personnel. However, Procor Limited maintains such records for less than 10 years. Therefore, it could not be determined whether these practices were followed when car DCTX 33126 was re-fitted.

2.0 Analysis

2.1 Introduction

Car DCTX 33126 leaked from the stub sill area within three days of being loaded for the first time after undergoing required extensive repair and maintenance following a derailment. It was originally suspected that either a faulty repair or continuing stub sill cracking problems typical of this tank car design had precipitated the leak. When the leak area was examined, it became apparent that neither was the case. The tank car's history had mandated certain upgrades, repairs, and re-qualifications. The results of these activities warrant detailed discussion.

2.2 Consideration of the Facts

2.2.1 The Leak

Considering the presence of stray odours and noise from plant equipment, the inspection and leak monitoring system at the Amoco loading dock would not likely have detected a minor leak such as seen in car DCTX 33126. However, inspectors in Sarnia Yard would have noticed the frost's development and smell. Similarly, the maintenance-of-way gang at Turnerville would have probably noticed the frosted area. Therefore, car DCTX 33126 probably did not begin to leak until some time after the approach to or arrival in Chatham.

The nature of the crack indicates that it had existed in the form of a closed through crack for a considerable time. The existence of a through crack that does not leak, although rare, is a well-documented phenomenon. The physical evidence also indicates that the crack was a one-time event that was initiated at the 1980 installation of the protective jacket. Therefore, the crack was sufficiently tight so as not to leak during normal service loads for 17 years. It appears that, only after experiencing an extraordinary event such as the Saint John derailment, the crack opened to the extent where it could leak. It is probable that the buff and draft forces applied to the car at or near Chatham Yard on delivery were sufficient to prompt escape of the product.

The stub sill inspection at the CGTX Inc. Montréal facility revealed the stub sill cracks at the A and B locations, but the crack was not noticed in the tank shell near the stub sill crack at the BR location. At that time, the crack would have been hidden by oxidation and tank insulation debris and was likely not detectable by unassisted visual means. The crack was also outside the typical cracking location for this tank car type—an area that would tend to escape close scrutiny. The car also underwent a centre sill inspection in 1991, at which time the crack also went unnoticed. Therefore, the crack was not visible and was in a location virtually undetectable to the naked eye.

The tank car was hydrostatically pressure-tested to 340 psi in 1991, over 10 years after the crack was produced; this test did not reveal the crack. It would seem that current visual inspection methods and pressure testing cannot always ensure tank car integrity. The effectiveness and validity of such tests is therefore questioned.

2.2.2 Quality Assurance

The CGTX Inc. QA methodology followed AAR and CGSB requirements. However, CGTX Inc.'s system, which relied on self-inspections, allowed a tank car with identified cracks in a safety-sensitive area to leave its shop unrepaired. While the cost-effectiveness of a self-inspection system is appreciated and shop morale is enhanced when employees have ownership of their own work, this incident has shown that such systems are not without safety risk.

Most repair items are subject to casual visual scrutiny throughout the repair process; complete omissions would be apparent to supervisory personnel. Therefore, in most instances, the supervisory personnel are aware that the work has been done and are merely attesting to the employee's known (and certified) professional competence when signing off outbound inspection forms such as the CGTX Inc. "Travel Sheet." However, when the work area is hidden immediately after the repair and no second pair of eyes attests to the quality and completeness of the work, a secondary line of defence is removed.

The two other Canadian companies certified by the AAR to repair tank cars have QA procedures based on the same AAR and CGSB requirements but require that the shop foremen visually ensure that stub sill repairs have been made and initial alongside the repairer. This procedure reduces the likelihood that a tank car could be certified as having had the stub sill repaired when in fact it had not been repaired. Therefore, it would seem that both the AAR and CGSB QA requirements are not sufficiently prescriptive with respect to the exact procedures required for the repair and inspection of jacketed tank cars.

The quality of the jacket spacer bar weld was not consistent with the work of an experienced and qualified welder. It would be expected that such a weld would also attract a welding inspector's attention. Thus, it would seem that QA on the shop floor at the time of the spacer bar application did not serve its intended purpose since no exception was taken to a low-quality weld, resulting in the return to service of a tank car with a crack in the tank.

2.2.3 Emergency Response

The first response was timely and effective. Railway and petroleum company experts and provincial and municipal authorities managed their respective responsibilities in a professional and cooperative fashion. The product's relatively low vapour pressure, moderate temperature, and ability to manage the rate of leak by water spray mitigated the danger and was properly assessed by these individuals.

The liquefied butane was leaking from a location on the tank car whose tank shell had been compromised. Such a leak presented a risk to public safety and warranted an evacuation of the surrounding area until the danger had been evaluated by experts and determined to be at a level acceptable to the authorities.

3.0 Conclusions

3.1 Findings

1. Product loading system, practices, and railway operating and car inspection procedures played no role in the incident.

2. The product leaked through a pre-existing, undetected crack in the tank shell that developed from a September 1980 low-quality weld on a car jacket spacer bar-to-tank shell attachment.

3. The crack was likely disturbed from its tightly closed, non-leaking state by the derailment in Saint John Yard.

4. The crack was in a location such that unassisted visual detection during regular maintenance procedures was not likely.

5. Tank pressure testing in 1991 did not reveal the presence of the crack. The effectiveness and validity of such tests is therefore questioned.

6. A "self-inspection system" is not a fail-safe quality assurance (QA) methodology for safety-sensitive repairs to tank cars in dangerous goods service.

7. The Association of American Railroads and Canadian General Standards Board QA standards are not sufficiently prescriptive to ensure that safety-sensitive repairs to tank cars in dangerous goods service are properly completed.

8. The emergency response was timely and effective.

9. The leaking tank car presented a risk to public safety, and an evacuation of the surrounding area was warranted.

3.2 Cause

Product from the tank car, having been subject to extensive repair and maintenance after a recent derailment and just returned to service, leaked from a through crack in the tank shell induced by a weld made during the installation of its protective jacket in 1980. The crack had been sufficiently tight not to have leaked for 17 years but may have been disturbed by the impact forces of the recent derailment.

4.0 Safety Action

4.1 Action Taken

4.1.1 Transport Canada and the Railway Industry

On 01 December 1997, a Rail Safety Information Letter was forwarded to Transport Canada (TC) outlining the circumstances of the incident. In response, TC advised that, on 22 October 1997, it had a second car from this series (DCTX 33116) opened for inspection. Cracks were found in the weld area of the tank shell-to-stub sill connection, prompting the inspection of the 68 remaining cars.

The 68 cars were captured by way of Association of American Railroads Maintenance Advisory MA-45 dated 28 October 1997. The car owner, PLM Transportation Corporation, also issued a special instruction requiring that the inspection include a thorough examination of the tank strap-to-reinforcing pad areas. No cracks were identified at these locations. One of the cars was no longer in service. The inspection program found that 23 of the 67 cars had reportable cracks (one to five each). The cracks varied in size from 1.3 cm (0.5 inch) to 15.2 cm (6 inches). TC is satisfied that all the tank cars have now been repaired as required or scrapped.

CGTX Inc. has changed QA procedures and implemented double inspection of safety-critical repairs at its repair facilities.

4.1.2 Tank Car Testing Change

On 01 September 1998, amendment schedule No. 23 to the *Transportation of Dangerous Goods Regulations* came into force, replacing section 73.3 (“Qualification and Maintenance of Tank Car Tanks”) by part 80 (“Continuing Qualification and Maintenance of Tank Cars”). As part of this change, section 73.31 was amended to remove the requirement for hydrostatic testing of
fusion-welded tank cars. New inspection requirements have been introduced that are specifically designed to detect weld defects. Test methods to determine that the welds are in proper condition include dye penetration, radiology, magnetic particle, ultrasonic, and optically aided visual inspection. Hydrostatic testing is being phased out and is no longer authorized for non-insulated, non-jacketed tank cars. A similar change has been made to the Federal Railroad Administration (United States) requirements.

This report concludes the Transportation Safety Board’s investigation into this occurrence. Consequently, the Board authorized the release of this report on 01 August 2000.

Appendix A - Glossary

A	the non-hand brake end of a rail car
AAR	Association of American Railroads
Amoco	Amoco Canada Petroleum Company Limited
B	the hand brake end of a rail car
CGSB	Canadian General Standards Board
cm	centimetre
CN	Canadian National
CSX	CSX Transportation Company
EDT	eastern daylight time
L	left, as seen from the hand brake end of a rail car
mm	millimetre
PLM	PLM Transportation Corporation
psi	pound per square inch
QA	quality assurance
QAM	quality assurance manual
R	right, as seen from the hand brake end of a rail car
StL&H	St. Lawrence & Hudson Railway
TC	Transport Canada
TSB	Transportation Safety Board of Canada
UTC	coordinated universal time