RAILWAY OCCURRENCE REPORT

DANGEROUS GOODS INCIDENT

CN NORTH AMERICA
TANK CAR CGTX 20922
MILE 0.0, HALTON SUBDIVISION
TORONTO, ONTARIO
31 MARCH 1995

REPORT NUMBER R95T0092

Transportation Safety Board of Canada (TSB) investigated this occurrence for the purpose of advancing transportation safety. It is not the function of the Board to assign fault or determine civil or criminal liability.

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Summary

On 31 March 1995, at approximately 0115 eastern standard time, tank car CGTX 20922, a load of toluene, was found leaking at the CN North America (CN) MacMillan Hump Yard, Toronto, Ontario, during a routine inspection. Approximately 23 litres of product was released. There were no injuries.

Ce rapport est également disponible en français.

OTHER FACTUAL INFORMATION

Tank car CGTX 20922, owned by CGTX Inc., Montreal, Quebec, was loaded with about 130,000 pounds (60,000 kg) of toluene and was en route from Sarnia, Ontario, to Brampton, Ontario. While undergoing a routine car inspection, product was observed leaking from the weld between a brake cylinder mounting pad and the bottom of the tank. The product was leaking at a rate of approximately five drops per minute. Attempts made to secure the leak were unsuccessful and, as a safety precaution, operations near the car were suspended. The shipper was immediately notified and arrangements were made to transfer the product to another tank car. Once the transfer was successfully completed, the tank car was moved to CGTX Inc. in Montreal for repair.

Toluene, UN 1294, is a colourless flammable liquid with a flash point of four degrees Celsius (40 degrees Fahrenheit). The lower explosive limit of toluene vapours in a mixture with air is 1.27 per cent. The upper explosive limit for the same mixture is 7 per cent. Toluene is considered to be toxic. It affects the central nervous system and may cause hallucinations, distorted perceptions and motor activity changes. It has teratogenic and reproductive effects and causes bone marrow changes. Mutations have been reported as a result of exposure. It is also considered to be an eye and skin irritant.

Tank car No. CGTX 20922 was built to specification DOT-111A-1000W1 by Hawker Siddeley Canada Inc., Trenton, Nova Scotia, in 1970. It is a general purpose, unjacketed, non-pressure tank car designed to transport flammable liquids. The last tank and valve tests were performed in 1988.

The brake cylinder is bolted to a bracket, which is welded to two tubular supports welded to mounting pads that are in turn welded to the tank. The mounting pads are approximately six millimetres thick. The distance between the edge of the tubular bracket support and the edge of the pads is approximately 1.5 to 2.0 times the thickness of the mounting pad.

The manner of brake equipment support securement has been the subject of much study and change over the past 10 years. In 1986, a derailment and fire in Miamisburg, Ohio, USA, involving a tank car loaded with a flammable liquid, which failed at the weld between the brake support securement and the tank shell, led to a review of attachment specifications. In this instance, the tubular supports had been welded directly to the tank shell as had been allowed before 1971. In October 1987, the Association of American Railroads (AAR) ordered that all pressure cars or cars carrying dangerous goods be equipped with reinforcing pads at the attachment between the tank shell and

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This facility is now known as Trenton Works Ltd.

the tubular support by August 1988.

Cars built after December 1971 had required reinforcing pads to be 1/4-inch thick. The distance between the edge of these pads and the edge of the tubular support bracket had to be 1.5 to 2.0 times the thickness of the mounting pad.

In July 1992, the U.S. National Transportation Safety Board (NTSB) indicated to the AAR that they were observing instances where brittle fractures were occurring at areas in tank shells adjacent to the reinforcing pads. The NTSB was concerned about the quality of the welds, the lack of low-temperature performance of the steel used and the adequacy of the reinforcing pad thickness requirement (1/4 inch).

By March 1994, AAR standards had again been revised. The requirement for new cars now indicates that:

1) Pads shall not be less than 1/4-inch thick and shall not exceed the thickness of the tank shell to which they are welded by more than 15 per cent. Use of pads less than 7/16-inch thick shall be restricted to light structural applications.

2) Pads shall be attached by continuous fillet welds, except for venting provisions. The ultimate shear strength of the bracket-to-pad weld shall not exceed 85 per cent of the ultimate shear strength of the pad-to-tank weld. The pad-to-tank fillet weld leg size shall not exceed the tank shell thickness.

3) Pads shall have each corner rounded to a one-inch minimum radius.

4) The distance between a bracket and the edge of the reinforcing pad to which it is attached shall not be less than three times the thickness of the pad.

There was no provision made to bring cars built before 1994 up to the current standard.

In the area of the leak, the car displayed evidence of heavy corrosion at both the weld joining the brake cylinder mounting pad to the bottom of the tank, and at the weld joining the tubular brake support to the brake cylinder mounting pad. A crack had developed at the weld joining the brake cylinder mounting pad to the bottom of the tank car, for approximately 270 degrees around the pad. The crack had penetrated through the tank shell for about 120 degrees along the weld.
A portion of the tank car, complete with the brake cylinder mounting pad and the tubular brake support, was cut out and sent to the TSB Engineering Laboratory for analysis. The TSB Engineering Laboratory (report LP 61/95) concluded that:

1) The leak was the result of a fatigue crack that developed at the toe of the circumferential weld joining a tubular support pad to the tank.

2) The fatigue crack had multiple initiation sites and an estimated minimum 30,000 load cycles would have been necessary to propagate the crack through the tank wall.

3) The quality of both welds (the pad-to-tank and the tubular support-to-pad) was judged to be inferior and may have contributed to the fatigue crack initiation process. A possible lack of post-weld stress relief may also have been a factor.

4) The construction material of the tank car satisfied the specification applicable at the time that the car was manufactured.

5) Since other cars of this design were found to contain similar cracks, it may be necessary to review the design methodology to prevent future failures of this type.

On 12 March 1995, tank car CGTX 20922 had received a pre-loading inspection by railway inspectors at the MacMillan Yard. At that time, defects were noted on the sill step and, once repairs were completed, the tank car went into storage. The car also received a pre-loading inspection by the shipper on 31 March 1995; no exceptions were noted.

As a result of this leak, CGTX Inc. embarked on an inspection program. They learned that the only cars susceptible to this problem within their fleet were those built by Trenton Works before 1982 and equipped with brake cylinder support tubes mounted on six-inch-diameter pads. They identified 1,937 such cars in their fleet: 906 general purpose, non-insulated cars, 694 general purpose, insulated cars and 337 pressure cars. By 09 November 1995, CGTX Inc. had completed inspections of 126 cars. Three cars were found with fractures penetrating through the tank car shell (including car CGTX 20922), 16 cars were found with cracks penetrating 1 per cent to 29 per cent of the thickness of the tank car shell and one car was found with a crack penetrating more than 50 per cent of the thickness of the tank car shell. All 20 cars were repaired or retired. CGTX Inc. analyzed the data (frequency of cracks, crack depth and car mileage) and estimated that shallow cracks grow at a rate of 1/64 inch per 100,000 miles and, therefore, would not progress to a critical depth during the anticipated life of the cars. CGTX Inc. indicated that any undetected shallow cracks do not represent a significant risk to the integrity of the cars. They are, however, continuing with the inspection program.

According to the information received from the current operator of the Trenton rail car manufacturing facility, there were 4,553 tank cars built to a similar design as car CGTX 20922. As indicated, 1,937

of those tank cars (42 per cent) were sold to CGTX Inc. and 2,616 (58 per cent) were sold to other parties in Canada, Mexico, Tanzania, Mali, Zambia, possibly the U.S. and/or other countries. At present, there is no information available to determine if any of the 2,616 tank cars have failed or are developing similar cracks. Such fractures would only be reported if they were found in Canada and then only if the cars were carrying dangerous goods.

A large number of these tank cars were built for pressurised service to carry liquefied compressed gases such as chlorine, propane, and anhydrous ammonia. By 09 November 1995, CGTX Inc. had inspected 26 pressurised service cars from their fleet, and found no cracks. Cars for compressed liquefied gases have thicker shells than those intended for non-pressurised (liquid) service.

ANALYSIS

A shallow crack had developed in the weld joining the brake cylinder mounting pad to the bottom of the tank. It was determined that the weld was of inferior quality. The crack slowly progressed over time until it eventually penetrated the bottom of the tank, allowing the product to escape.

It is apparent that cars built before 1994 that do not conform to the revised AAR standard are subject to this type of failure and that such failures have been well documented and frequent.

Routine pre-loading inspections conducted on the tank car did not reveal that a fracture had developed, even though the fracture was visible. Corrosion in the area of the fracture should have alerted inspectors to further examine the affected area.

The degree of danger caused by a fracture through the tank shell depends on the chemical makeup as well as physical characteristics of the product. In the case of a liquid, the fracture would lead to a slow, uneventful release of the product carried. However, in the case of liquefied compressed gases, the final step which changes a crack into a fracture may initiate a catastrophic failure of the whole tank. Further, a developing fatigue crack could be the point of origin of a brittle fracture. Such a brittle fracture may, under certain circumstances, lead to catastrophic failure of the tank.

A slow release of product from a tank car can be usually controlled so that the danger is limited. A catastrophic release of a load of compressed liquefied gas is an extremely dangerous event. In that case, up to 50 per cent of the released cargo could vaporise instantaneously, forming a dangerous and uncontrollable cloud.

The chemical identity and characteristics of the released product are very important. If the released cargo is, for example, liquefied

carbon dioxide, then the danger would be minimal. On the other hand, if the released cargo is a liquefied poisonous or corrosive gas, such as chlorine, an extreme risk to life exists even at a considerable distance from the point of release.

The CGTX Inc. inspection has revealed that none of the 26 pressure cars inspected was cracked. It should, however, be realized that the inspection of 26 cars out of a fleet of 337 represents a relatively small sample. Each operation of the brakes transmits a load through the brake support into the tank shell. The dissipation of this load is influenced by the thickness of the tank shell. One may speculate that, because the pressure cars have a thicker shell, they would either never develop fatigue cracks at all or only start developing them so late in their expected life that the progression to full fracture would not occur before the car is taken out of service. The result of a catastrophic release of a liquefied compressed gas, however, may be so serious that additional confirmation of the integrity of the pressure cars is warranted.

Considering the history of this problem and the measures taken over the years to constantly upgrade the installations, it may be appropriate to upgrade the existing fleet to the current AAR reinforcing mounting standards for new car constructions.

FINDINGS

1. Tank car CGTX 20922 was found leaking at the weld joining the brake cylinder mounting pad and the bottom of the tank car.

2. A fatigue crack had developed over time in an inferior weld joining the brake cylinder mounting pad to the bottom of the tank, leading to a complete fracture.

3. The original design of the brake cylinder mounting pad did not provide sufficient strength to sustain service loading.

4. Routine inspections did not detect the fatigue crack which would have been clearly visible.

5. CGTX Inc. is continuing to monitor the problem of fatigue cracking in tank cars similar to car CGTX 20922.

6. The fracture of a pressure tank car in a similar manner may lead to a catastrophic release of dangerous goods, and a confirmation of the integrity of such cars is warranted.

7. It may be appropriate to upgrade the existing fleet to current AAR reinforcing pad requirements for new cars.

8. All the owners of the tank cars similar to car CGTX 20922 may not be aware of the potential fatigue cracking problem.

CAUSES AND CONTRIBUTING FACTORS

The leak occurred as a result of a fracture caused by a fatigue crack in a weld joining the brake cylinder mounting pad to the tank car. The weld was of inferior quality and may have contributed to the crack initiation process. The original design of the brake cylinder mounting pad did not provide sufficient strength to sustain service loading. The clearly visible crack went undetected during routine pre-loading inspections.

SAFETY ACTION

Action Taken

Following this occurrence, the TSB forwarded a Rail Safety Advisory to Transport Canada (TC) alerting them to the issue of cracks in the welds joining brake cylinder mounting pads to the bottom of tank cars. The Advisory stated that TC might wish to consider a continuing inspection program of reinforcing pads on all tank cars built before the current AAR standard. It was also indicated that TC advise other applicable regulatory authorities of the details regarding the reinforcing pad welds.

In response, TC advised that:

i) the Federal Railroad Administration and TC are co-operating to seek solutions to the "reinforcing pad" weld problem;

ii) member railways of the AAR, which include CN, have begun to target suspect cars and should complete this review in 1996;

iii) the owner of the tank car involved in this occurrence will continue to inspect its fleet for fractures, cracks and other

possible defects; and

iv) regional TC safety officers will pay particular attention to problems inherent with reinforcing pad welds.

In addition, the owner of the tank car involved in this occurrence has undertaken to change all brake cylinder mounting pads on their pre-1982 built Trenton cars so that they will meet current AAR specifications.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board, consisting of Chairperson, Benoît Bouchard, and members Maurice Harquail and W.A. Tadros, authorized the release of this report on 14 August 1996.