Transportation Safety Board
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Bureau de la sécurité des transports
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RAILWAY INVESTIGATION REPORT
R05H0013

MAIN-TRACK DERAILMENT

CANADIAN NATIONAL
FREIGHT TRAIN U-78631-04
MILE 113.35, KINGSTON SUBDIVISION
PRESCOTT, ONTARIO
04 JULY 2005

Canada

Railway Investigation Report

Main-Track Derailment

Canadian National
Freight Train U-78631-04
Mile 113.35, Kingston Subdivision
Prescott, Ontario
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Report Number R05H0013

Summary

On 04 July 2005, at approximately 1551 eastern daylight time, Canadian National freight train No. U-78631-04 derailed all 51 of its cars at Mile 113.35 of the Kingston Subdivision, while travelling eastward through the town of Prescott, Ontario. All of the cars last contained hydrocarbons. Two cars released a small amount of gasoline (UN 1203). There was no fire and there were no injuries. Approximately 2000 feet of main track was destroyed.

Ce rapport est également disponible en français.

Other Factual Information

On 04 July 2005, at approximately 1430 eastern daylight time,[1] eastward Canadian National (CN) freight train No. U-78631-04 (the train) departed Maitland, Ontario, Mile 122.7 of the Kingston Subdivision, destined for Saint-Romuald, Quebec.

The train consisted of 2 locomotives and 51 cars; the first 17 cars had last contained fuel oil (UN 1202) and the trailing 34 cars last contained gasoline (UN 1203). The train was about 3180 feet long and weighed approximately 2240 tons. The operating crew, a locomotive engineer and a conductor, met fitness and rest standards, were qualified for their respective positions and were familiar with the territory.

As the train approached Prescott, it was proceeding at 69 mph along the north main track with the throttle in position 8 and the brakes fully released. The crew observed a lateral deviation of the track at the east end of a turnout at Mile 113.36 and placed the throttle in idle. As the train was travelling over the lateral deviation, it experienced a train-initiated emergency brake application. The train came to rest at Mile 112.58 (see Figure 1). After initiating emergency procedures, the crew determined that all 51 cars had derailed, fouling the south main track.

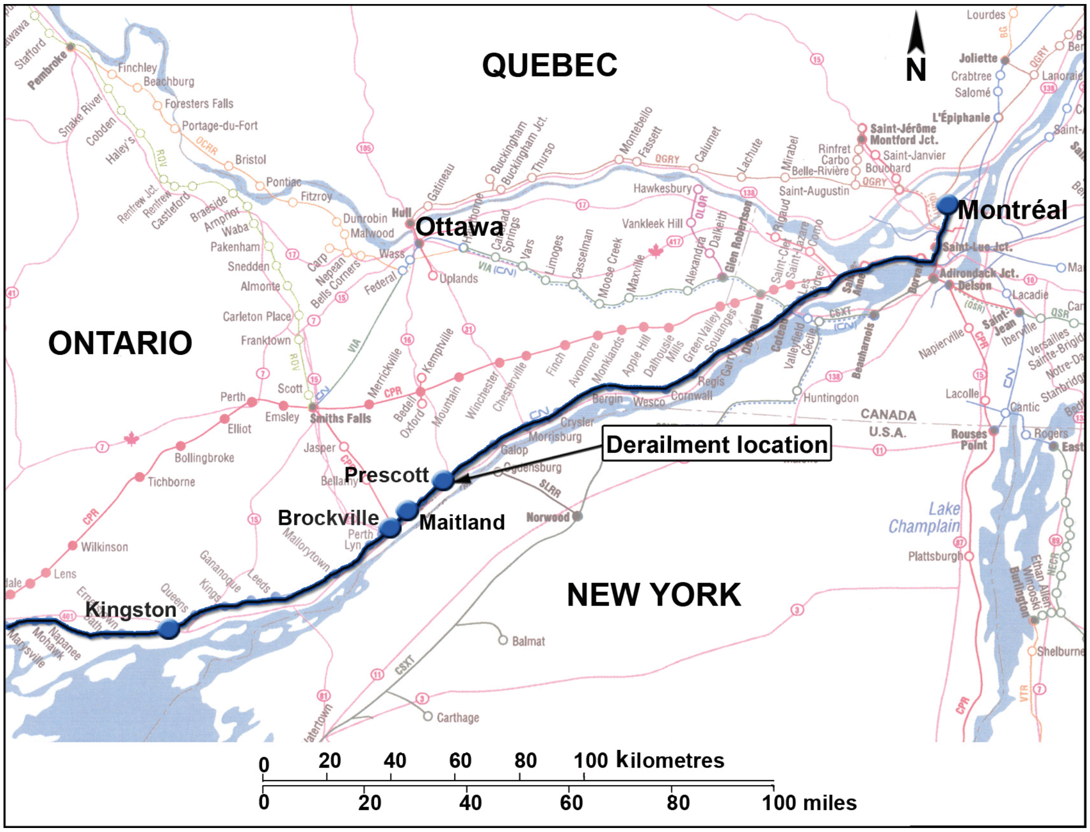

Figure 1. Derailment location

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

The Prescott Fire Department arrived on the scene within a few minutes, secured the perimeter and performed a site survey. Because all cars were residue tank cars and the damage was confined to the railway right-of-way, the fire chief, in consultation with the Brockville Fire Department, determined that the risk to the public was low and an evacuation of the surrounding area was not warranted. CN subsequently began the salvage and reconstruction operations.

Site Examination

The derailment zone extended between the turnout at Mile 113.36 and the crossing at Mile 112.95 (see Figure 2).

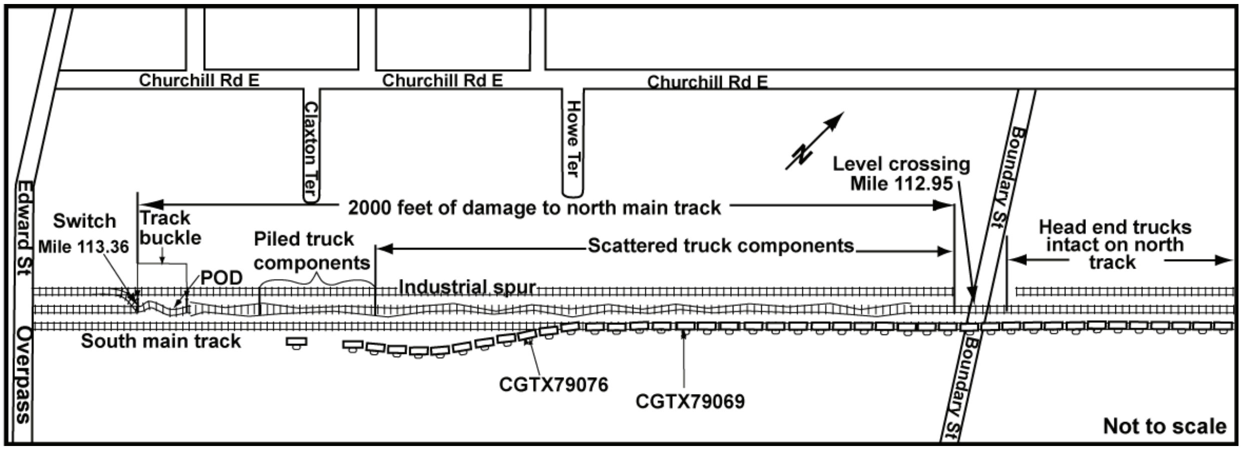

Figure 2. Derailment area diagram

In the vicinity of the turnout, the track had shifted laterally up to 24 inches. The shift began 24 feet west of the switch point and extended eastward in an "S" shape for 133 feet (see Photo 1). A mark was observed on the top of the south rail, approximately 60 feet east of the switch point. Two feet from the mark and extending eastward for 30 feet, the gauge-side spikes and the rail anchors exhibited impact marks. Damage to the track structure extended for approximately 2000 feet, up to the public crossing.

Photo 1. Derailment zone showing the track buckle

All derailed cars came to rest on their side. The last car of the train, which had uncoupled, came to rest at Mile 113.28, and the other 50 cars remained coupled to the locomotives. The 1st to the 21st cars (from the locomotives) were located east of the crossing, fouling the south track, while their trucks remained intact on the rails on the north track. The 22nd to the 39th cars were also lying on the south main track, but their truck components were scattered over the north portion of the right-of-way (see Photo 2). The remaining cars came to rest skewed south of the tracks, while most of their truck components were piled up about 250 feet east of the switch point.

Tank cars CGTX 79069 and CGTX 79076 (the 35th and 42nd cars) released a small amount of gasoline and nitrogen vapours. All cars sustained moderate damage and were transferred to maintenance facilities for repair. There were no pre-derailment equipment defects noted on the cars that would have compromised the safe operation of the train.

Photo 2. Derailment site looking westward from the crossing

Temperature

Environment Canada records taken from a remote sensing station at Brockville (Mile 125.6), the closest weather station to the derailment site, showed the following maximum[2] and minimum ambient temperatures:

Date	Maximum Temperature (°C)	Minimum Temperature (°C)
27 June 2005	33.5 (92.3°F)	18.0 (64.4°F)
28 June 2005	31.5 (88.7°F)	21.5 (70.7°F)
29 June 2005	29.0 (84.2°F)	23.0 (73.4°F)
30 June 2005	29.5 (85.1°F)	17.0 (62.6°F)
01 July 2005	28.5 (83.3°F)	21.0 (69.8°F)
02 July 2005	25.0 (77.0°F)	12.5 (54.5°F)
03 July 2005	28.5 (83.3°F)	14.0 (57.2°F)
04 July 2005	30.5 (86.9°F)	18.5 (65.3°F)

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[2] The maximum temperature is commonly observed around 1600.

Track Information

The Kingston Subdivision extends from Dorval, Quebec (Mile 10.3), to Toronto, Ontario (Mile 333.8). Train movements are controlled by the Centralized Traffic Control System (CTC) and authorized by the *Canadian Rail Operating Rules*. In the area of the derailment, train movements were supervised by a rail traffic controller located in Toronto. The authorized timetable speed for freight trains was 65 mph.

The track through the derailment area is tangent. It consists of a double main track, oriented in an east-west direction. An industrial spur is located north of the main tracks. The rail on the north main track was Sydney 132-pound continuous welded rail (CWR), manufactured and installed in the late 1970s. The rail was laid on 14-inch double-shouldered tie plates secured with two spikes per tie plate. Newly installed ties had three spikes per tie plate. The rail was box anchored every tie for 200 feet west of the switch. East of the switch, the rail was box anchored every tie for 150 feet and box anchored every other tie beyond that. The ties were No. 1 hardwood ties and were in good condition. The ballast was crushed gravel and slag. The cribs were full and the shoulders were a minimum of 12 inches wide and were in good condition.

The track was classified as Class 5 track, according to Transport Canada-approved *Railway Track Safety Rules* (TSR). Track inspections were carried out twice weekly in compliance with the TSR requirements. During the last visual inspection, performed on the day of the occurrence at 0900, a broken joint bar was observed at the turnout at Mile 113.36 and replaced. The last geometry car inspection was performed on 06 May 2005, and the last rail flaw inspection was performed on 23 June 2005; no defects were found in the vicinity of the derailment.

A review of the railway records revealed that, between 25 June 2005 and 29 June 2005, a tie gang had changed out ties from Mile 111.0 to Mile 114.8. On 26 June 2005, they began working at Mile 111.6 at 2040 and completed their shift at Mile 113.36 at 0900, 27 June 2005. They changed out approximately 1200 ties; 414 of those ties were changed out between the crossing and the switch. The track was surfaced and the ballast was tamped and compacted with a dynamic stabilizer. A 25 mph slow order was placed on the track on the morning of 27 June 2005. On the afternoon of 29 June 2005, the track maintenance supervisor inspected the work area. He removed the slow order on the morning of 30 June 2005. All track maintenance operations were performed in accordance with Standard Practice Circular (SPC) 3300.

Between 29 June 2005 and the derailment date, 47 trains travelled over the north main track, pulling approximately 278 710 tons in the westward direction and approximately 50 810 tons in the eastward direction. On the afternoon of 30 June 2005, a westward freight train passed by the hot box detector at Mile 110.6 on the north main track at 1331, followed by westward VIA Rail Canada Inc. (VIA) train 65 at 1720. Before the accident on 04 July 2005, eastward VIA train 60 passed by the hot box detector at 1513. The crew did not report any track defects in the vicinity of the derailment.

A report entitled *Effects of Maintenance Operations on Track Buckling Potential*[3] states that track maintenance such as tie renewal or surfacing can "typically result in a 40% to 60% loss of lateral resistance." A dynamic stabilizer will "restore up to 60% to 80% of the original resistance, which is considered by most railway properties to provide adequate restraint against track buckling under most conditions." The report also shows that, after an additional 6 to 10 million gross tons of traffic, the track still has not fully regained its pre-maintenance lateral resistance. Another reference[4] indicates that, after a lifting and tamping program, it can take the passage of up to 20 million gross tons (with or without the use of a dynamic stabilizer) before the lateral resistance of the track reaches its full strength.

A properly designed and maintained track will withstand the compressive stresses that normally build up within CWR. Rail anchors, rail fasteners, tie plates, ties and ballast contribute to keeping the rail from moving longitudinally and laterally. However, when the track structure has been disturbed by track maintenance activities, such as tie renewal and surfacing programs, its lateral strength is reduced and its ability to resist buckling is lowered. After a work program, trains travel over the affected area at a reduced speed while the track is being compacted and recovering its strength. The compaction can be hastened with the use of a dynamic stabilizer.

When temperatures exceed 30°C (86°F), CN's Extreme Hot Weather Inspection Policy requires slow orders to be placed on sections of CWR track known to be susceptible to buckling and in areas where recent work has been performed. The policy also requires additional track inspections (hot weather patrols) to be performed between 1100 and 2000. There was no hot weather patrol performed on 04 July 2005. Furthermore, the derailment area was not considered susceptible to buckling as the required amount of traffic (according to SPC 3300) had passed over the track and there was no previous history of rail overstress during hot weather.

CWR is installed at a temperature within the preferred rail-laying temperature (PRLT) range, as close as possible to the PRLT. At the time of the installation, the rail is free of any tensile or compressive stress (neutral temperature). Whenever the temperature of the CWR exceeds the neutral temperature, longitudinal compressive forces develop, increasing as the temperature differential increases. Extremely high or low ambient air temperatures, mechanized track maintenance activities, and traffic-induced movements of the rail can cause a change or redistribution of the rail's internal stresses, thus modifying the neutral temperature. In general, the rail-neutral temperature decreases over time.

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[3] A. Kish, T. Sussmann and M. Trosino, *Effects of Maintenance Operations on Track Buckling Potential*, Proceedings of International Heavy Haul Association Conference, May 2003.

[4] E. T. Selig and J. M. Waters, *Track Geotechnology and Substructure Management*, Thomas Telford Publications, 2002.

The knowledge of the neutral temperature of the rail is critical to properly manage the risks of buckling when maintaining CWR. Much research has been done, and is continuing, to develop a non-destructive stress measuring system. However, most of these technologies are used in a site-specific manner and, therefore, are limited in their application as they require the pre-identification of high-risk locations. Consequently, they are not yet in widespread use. VERSE[5] (Vertical Stiffness Equipment) is one such non-destructive stress measurement system that is increasingly being used by railways.

The rail on the Kingston Subdivision near Prescott was installed in the late 1970s. The PRLT at the time was 21.1°C (70°F). In 2005, the PRLT in effect was 32.2°C (90°F) and the PRLT range was 32.2°C (90°F) to 46.1°C (115.0°F). CN's SPC 3205 (June 2004 version) required any newly laid rail that is installed outside the PRLT range to be destressed as soon as possible. There were no requirements to bring existing rail in compliance with the current SPCs, and there were no records showing that the rail in the derailment area had been destressed. The rail-neutral temperature before the tie replacement program was not measured. After the derailment, VERSE testing by CN showed that the rail-neutral temperature at various points along the Kingston Subdivision was between 18.3°C (65°F) and 21.1°C (70°F).

An examination of the TSB database for 1999 to 2005 revealed that there were 17 occurrences where a track buckle caused a derailment on the main track. In 10 of those occurrences, track maintenance had been performed earlier in the spring or summer. It was determined that five of the occurrences took place when the ambient temperature had reached its highest level since the maintenance work had been completed.

Unit Tank Car Trains

The train was a unit tank car train comprised of 3 strings of 17 cars each. Each string of cars is permanently coupled with interconnecting hoses and related equipment that allow loading or unloading of the entire string from a single connection at one end. During the unloading process, nitrogen gas is used to push the product from the tanks through the interconnection hoses. The cars are equipped with double-shelf couplers designed to prevent them from separating in a derailment and puncturing an adjacent tank car.

In the 10 years preceding this accident, the TSB investigated four occurrences where unit tank car trains with double-shelf couplers have derailed and the cars overturned. Currently, a fifth such occurrence is being investigated:

- In 1995, 28 cars from a sulphuric acid unit train pulling 44 loaded tank cars derailed and spilled approximately 230 000 litres (51 000 gallons) of product; 11 of these cars rolled off their trucks (R95D0016).

- In 1999, 10 cars from a train pulling 68 loaded tank cars derailed; 4 of the derailed cars lay on their side, parallel to the track (R99Q0019).

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[5] Developed by AEA Technology Rail, it is a portable non-destructive measurement system that allows the stress levels in CWR to be measured.

- In 2002, a cut of 34 standing empty tank cars derailed in the Joffre Yard, near Québec, Quebec, after being contacted at one end by a yard movement. The struck tank car derailed, causing the remaining 33 cars to overturn (R02Q0041).
- In 2004, 10 cars from a train pulling 68 loaded tank cars derailed at Saint-Charles, Quebec; 4 cars derailed on their side (R04Q0026).
- In 2004, 18 cars from a train of 68 loaded tank cars derailed at Lévis, Quebec; 5 cars lay on their side, parallel to the track (R04Q0040 – ongoing investigation).

Analysis

Although the train was travelling approximately 4 mph above the permissible speed, it is unlikely that the overspeed contributed 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 the equipment condition played a role in this accident. The analysis will therefore focus on the lateral deviation of the track and the role of the double-shelf couplers on the severity of the derailment.

The Accident

The first wheel marks were observed on the rail head, spikes and anchors in the zone where a lateral deviation of the track was observed, ahead of the train. The lateral deviation, the S-shaped curve of the destroyed track, and the high ambient temperature on the day of the derailment suggest that the track was experiencing high compressive stresses, which led to track buckling.

On the day of the derailment, the ambient temperature climbed to its highest level since the slow order related to track maintenance had been removed (30 June 2005). After the passage of VIA train 60, during the hottest part of the day, when the thermal stresses would have reached their maximum, a lateral deviation was triggered east of the switch. Forty minutes later, as the locomotives and the first part of the accident train passed over the lateral deviation, the track shifted further out of alignment until the cars could no longer negotiate the buckled track and derailed.

In the 1970s, when the rail was installed, the PRLT, and hence the neutral temperature, was much lower than that in effect today. Since the rail-neutral temperature tends to degrade over time, it is likely that, before the track maintenance was performed, the neutral temperature had decreased below the PRLT, which would be consistent with CN's VERSE testing. After the track maintenance was performed, the predominantly westward movement of traffic caused the rail to creep and bunch up east of the switch, further lowering the neutral temperature in the area of the derailment.

The track maintenance work had been conducted in accordance with CN's Standard Practice Circulars. The track had been dynamically stabilized and a sufficient amount of tonnage had passed over it before the slow order was removed. Normally, these operations provide an adequate lateral resistance to track buckling, even though they do not totally restore the track lateral strength to pre-maintenance levels. However, due to the unusually low rail-neutral temperature, the recovered lateral strength, which would have been sufficient under most circumstances, was not able to counteract the track buckling forces generated by the large temperature differential and train dynamic action.

Rail-Neutral Temperature

On high temperature days, locations with a low rail-neutral temperature are subjected to high thermal stresses and are more susceptible to buckling, particularly when the track has been disturbed or when unusual train forces are applied. The increase of the PRLT on the Kingston Subdivision to 32.2°C (90°F) and the requirement to destress newly laid rail, installed with a neutral temperature below the PRLT range, ensure a higher neutral temperature and, consequently, reduce the level of thermal stresses and the risks of track buckling. However, the requirement of destressing does not apply to rail installed in the past at a temperature below the current PRLT. Since this rail is known to have, in some locations, a measured neutral temperature as low as 18.3°C (65°F), these locations, which are susceptible to track buckling, may be overlooked.

Extreme Hot Weather Inspection Policy

The Extreme Hot Weather Inspection Policy requires that hot weather patrols be conducted and slow orders be placed on the track when the ambient temperature exceeds 30°C (86°F). As the maximum ambient temperature on the day of the derailment was only 0.5°C (0.9°F) above that temperature for a short time, it was not practical to conduct the hot weather patrol and, consequently, no patrol was initiated. Had a patrol been initiated, the derailment area would not have been inspected, nor protected with a slow order because it was not considered to be susceptible to buckling, even though it had an unusually low rail-neutral temperature.

Knowledge of track structure strength and rail-neutral temperature is critical to identify areas susceptible to buckling and to take appropriate action. Weaknesses in the track structure can be visible and easily recognizable; however, rail-neutral temperature measurement is more cumbersome and is limited in its application because it is site specific. As the hot weather patrols cannot always effectively detect areas of track susceptible to buckling, rail-neutral temperature measurement remains the most promising method to fulfil that role, despite its limitations.

Double-Shelf Couplers

In this occurrence, the double-shelf couplers functioned as designed: all but one car remained coupled together and no tank heads were punctured. Double-shelf couplers have been effective in preventing tank head punctures. However, they may also increase the number of cars derailed, particularly when empty tank cars are involved. Since these couplers remain interlocked, they are capable of transferring high torsional forces; therefore, one overturning car can initiate the roll over of adjacent cars, increasing the severity of derailments. While this sympathetic roll-over phenomenon has occurred in both loaded and empty tank cars, it was observed that loaded cars were less likely to be affected. The weight of the loaded cars acts as a stabilizing force to counteract the torsional force transmitted through the double-shelf coupler.

Findings as to Causes and Contributing Factors

1. As the locomotives and the first part of train No. U-78631-04 passed over a lateral track deviation, the track shifted further out of alignment until the cars could no longer negotiate the buckled track and derailed.

2. The low temperature at which the rail was laid, the degradation of the rail-neutral temperature over time, and the westward creep of the rail caused by the preponderance of westward train movements after the maintenance program resulted in an unusually low rail-neutral temperature just east of the switch.

3. Due to the unusually low rail-neutral temperature, the recovered lateral strength of the track, which would have been sufficient under most circumstances, was not able to counteract the track buckling forces generated by the large temperature differential and train dynamic action.

Findings as to Risk

1. While current Canadian National Standard Practice Circulars require newly installed rail with a neutral temperature below the preferred rail-laying temperature range to be destressed, there is no such requirement to address rail installed in the past. Consequently, locations susceptible to track buckling may be overlooked.

2. Areas susceptible to track buckling might remain undetected and, hence, not protected, even though an Extreme Hot Weather Inspection Policy is in effect.

3. Double-shelf couplers have been effective in preventing tank head punctures. However, they may also increase the number of cars derailed, particularly when empty tank cars are involved.

Other Finding

1. As the hot weather patrols cannot always effectively detect areas of track susceptible to buckling, rail-neutral temperature measurement remains the most promising method to fulfil that role, despite its limitations.

Safety Action

Canadian National (CN) issued a notice to its engineering staff, providing them with additional information on identifying locations of track in need of being destressed. In addition, the notice re-emphasized the requirements of CN's Recommended Methods 3205-0 (Destressing Continuous Welded Rail) and 3205-1 (Handling of Failures in Continuous Welded Rail).

CN issued another notice to its engineering staff describing the accident and providing revised procedures for destressing rail at fixed track locations.

This report concludes the Transportation Safety Board's investigation into this occurrence. Consequently, the Board authorized the release of this report on 29 May 2006.

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