NATIONAL TRANSPORTATION SAFETY BOARD
WASHINGTON, D.C. 20594

Hazardous Materials Factual Report
August 24, 2005
DCA-05-MR-008

A. Incident Identification

Location:	Graniteville, South Carolina
Date and Time:	January 6, 2005; 2:40 a.m.
Hazardous Materials:	Chlorine
Carrier:	Norfolk Southern Railway Company
Shipper:	Olin Chlor Alkali Products
Transportation Mode:	Rail

B. Group Members

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C. The Accident

About 2:40 a.m. eastern standard time, on January 6, 2005, northbound Norfolk Southern Railway (NS) freight train 192P005 derailed after encountering an open switch and colliding with a parked train on a siding track, in Graniteville, South Carolina. The train was in NS non-signaled track warrant territory with a timetable speed of 49 mph. The 42-car train consisted of two locomotives, 25 loads and 17 empties, and had a crew of an engineer and a conductor. It originated in Macon, Georgia, was destined for Columbia, South Carolina.

About 7 hours before the accident, a local NS train, P22P005, had used the switch, which is near milepost (MP) 178.2, to enter an industrial siding track at that location. After servicing a local industry, the crew secured their train and departed the area around 7:00 p.m. The crew was transported by a van to their home terminal, where they cleared their track warrant at 7:53 p.m. No other trains had used the main track from the time the local train was parked in the siding until the arrival of the accident train. The engineer of NS train 192P005 initiated an emergency application of the brakes as his train neared the switch and siding. While in emergency braking, the train diverted through the open switch and onto the sidetrack, where it struck the parked local train locomotive. The two locomotives and the first 16 cars from train 192P005 derailed. The locomotive and one of two cars of train P22P005 also derailed. Included in the

derailment of train 192P005 were three cars of chlorine and one car of sodium hydroxide. A breach of a tank car of chlorine, the 9th car behind the locomotives, resulted in a release of chlorine gas (a poison gas). This prompted an evacuation of about 5,400 people within a one-mile radius of the site, which continued for at least 7 days. The NS engineer and eight other people were fatally injured by the inhalation of chlorine. The NS conductor and approximately 550 other people, and 5 firefighters, were transported to local hospitals with respiratory difficulties, with 75 of those persons admitted for treatment.

D. Hazardous Materials Information

The hazardous materials involved in the derailment were contained in tank cars. Five tank cars containing hazardous materials were derailed: 3 containing chlorine, 1 containing sodium hydroxide, and one containing a residue of an elevated temperature liquid. (The residue tank car had no significant damage.) The only hazardous material released was chlorine from a punctured tank car. (UTLX 900270)

Derailed Tank Cars

Four of the five tank cars that derailed were shipped by Olin Chlor Alkali Products (Olin), Augusta, GA. The three tank cars containing chlorine were SBLX 14146, GATX 17105, and UTLX 900270. The chlorine tank cars were the 6, 7 and 9 in the train behind the two locomotives. They were loaded between December 31 and January 4, 2005. The punctured car (UTLX 900270) finished loading on January 4 at 3:10 a.m. The recorded loading pressure for each car was 22 psi, which equates to a chlorine temperature of about –14º F. The cars each contained 180,000 lbs (about 13,827 gals)[1] of chlorine. According to Olin's MSDS, chlorine is a poisonous gas, an oxidizer and a marine pollutant. It has an IDLH value[2] of 10.0 ppm. It is toxic if inhaled. It has a vapor pressure of 114 psi at 77º F and a vapor density of 2.5 (heavier than air). Chlorine changes from a liquid to a gas at –29º F. It is miscible in water. It is considered corrosive because it forms hypochlorous acid and/or hydrochloric acid when reacted with water. (Appendices B-1 & C)

Photographs show that UTLX 900270 came to rest angled slightly to one side with the puncture opening extending below the midline of the resting tank. Measurements of the liquid level of the chlorine remaining in the tank made the day of the accident by emergency responders first on scene indicate that about 1/3rd of the product or 60,000 lbs (4,609 gals.) remained in the tank. The responders also noted that

[1] Calculations made using a specific gravity for chlorine of 1.56.

[2] The *IDLH (immediately dangerous to life and health) value* is an atmospheric concentration of any toxic, corrosive, or asphyxiate substance that poses an immediate threat to life, or would cause irreversible or delayed adverse health effects, or would interfere with an individual's ability to escape from a dangerous atmosphere. The Environmental Protection Agency uses 10 percent of the IDLH value when determining that a release has reached a level of concern for public exposure.

the B-end coupler of a steel coil car (CSTX 496430) was next to the puncture and had frost on its surface.[3] (Appendix E)

Olin also shipped tank car (GATX 58326) that contained 191,750 lbs (15,340 gals)[4] of a 50% solution of sodium hydroxide in water, a corrosive liquid. Prolonged contact with this liquid can cause permanent skin damage. (Appendices B-2 & C)

Westvaco Corp, De Ridder, LA shipped one tank car containing a residue of rosin, which is transported as an elevated temperature liquid. Rosin is solid at ambient temperatures and is not regulated by the U.S. Department of Transportation (DOT) as a hazardous material in its solid state. However, it is heated to above 212 degrees F to convert it from a solid to a liquid for loading and unloading. At these temperatures, the material is hot enough to produce thermal burns of human tissue. (Appendix C)

E. Tank Car Information

Review of Association of American Railroads (AAR) Certificates of Construction and Exhibit R-1's for the following tank cars, and post-accident examination revealed that each tank car was equipped with double shelf couplers and had the following:

Tank car SBLX 14146, (chlorine) was built in 1997 by Trinity Industries Inc. as a DOT specification 105J 500W tank car. The AAR Certificate of Construction is F-976026. The last periodic qualification was in February 2004. The tank heads were manufactured from 13/16-inch thick plate, and the shell was manufactured from 0.7874-inch thick carbon steel plate. Head and shell plates were normalized AAR specification TC-128-B. This car had a thermal protection system consisting of 2" of ceramic fiber against the tank, which was then covered with 2" of fiberglass. The AAR Certificate of Construction indicates that the 13/16" tank head, in combination with the insulation and the 0.1196 inch thick steel jacket meet the DOT tank-head puncture-resistance performance standards of 49 CFR 179.16, without head shields. The nominal water capacity of the tank was 17,368 gals. **Observed damage:** There was a severe dent and gouging in the lower half of the B-end head just to the right of middle. The dent had the size and was in a location that is generally associated with strike from another car's coupler. There was some flattening of the tank on the bottom and extensive damage to the jacket on the bottom and left side (from B-end). The A-end bolster was displaced on both sides. No breaches in the tank were observed. (Appendices A-1, H, & L)

Tank car GATX 17105 (chlorine) was built in 1979[5] by General American Transportation Corporation (GATC) under Build Order 10452. It was a DOT

[3] As the chlorine changes from liquid to gas at –29º F it freezes the water vapor in the air resulting in frost on nearby objeccts.
[4] Calculations made using a specific gravity for a 50% solution of sodium hydroxide of 1.5.

specification 105J500W tank car, originally built as a specification 105A500W. The AAR Certificate of Construction is F-783111. The last periodic hydrostatic test was in January 2000.[6] The tank heads were manufactured from 13/16-inch thick plate, and the shell was manufactured from 0.7874-inch thick carbon steel plate. Head and shell plates were non-normalized AAR specification TC-128-B. This car had a thermal protection system consisting of 4" of foam insulation covered with a steel jacket. The FRA stated that the 13/16" tank head, in combination with the insulation and 0.11 gauge steel jacket met the head protection requirements of 49 CFR 179.16, without head shields. The nominal water capacity of the tank was about 17,368 gals. **Observed damage:** There was a severe dent on the left side between the center of the tank and the A-end. It was just below the midline of the tank. There was a severe dent on the A-end to the left of the coupler and the coupler had been torn out. There were several dents in the jacket. The worst was on top between the B-end and the top fittings. No breaches in the tank were observed. (Appendices A-2, H & J)

Tank car UTLX 900270 (chlorine) was built in 1993 by Union Tank Car Company. It was a DOT specification 105J500W tank car, originally built as a specification 105S500W. The AAR Certificate of Construction is A-937060-A. The last periodic qualification was in July 2004. The tank heads were manufactured from 53/64-inch thick plate, and the shell was manufactured from 0.777-inch thick carbon steel plate. Head and shell plates were of normalized specification AAR TC-128-B. This car had a thermal protection system consisting of insulation, 2" of ceramic fiber against the tank and then covered with 2" of fiberglass. This car was equipped with ½-inch thick full head shields. The nominal water capacity of the tank was 17,300 gals. **Observed damage:** The tank had a puncture and tear on the right side near the middle slightly toward the A-end of the tank. The puncture was about halfway up the tank. The opening was 34 inches long and had a maximum of 5 inches in width. The area around the puncture was crushed inward and there are severe dents on either side it. The dents in the tank shell around the crack ranged from 15 to over 20 inches in depth. The puncture will be described in detail in the metallurgical factual. The left side of the tank had some flattening and there is a dent on the shell near the A-end head weld at about 2 o-clock. (Appendices A-3, H & I)

Tank car GATX 58326 (sodium hydroxide solution) was built in June 1980 by ACF Industries, Inc. as a DOT specification 111A100W1 tank car. The car was originally stenciled with car mark and number OLNX 21156. In August of 1989, the car mark and number was changed to GATX 58326. The AAR Certificate of Construction is

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[5] The certificate for construction shows the approval date of 1978; however, General American management stated that the lot of tank cars constructed under that approval was fabricated in three sub-lots. The sub-lot that included this tank car completed fabrication and testing in 1979.

[6] In accordance with Title 49 CFR section 180.509(l), tank cars with metal jackets or thermal protection systems were not required to have performed the periodic qualification inspections found in Part 180, Subpart F until July 1, 2000. Prior to that date periodic hydrostatic tests were performed to requalify tank cars.

A-791056-A. The last periodic hydrostatic test was in January 1998. The tank heads and shell were manufactured from 7/16-inch thick carbon steel plate. Head and shell plates were non-normalized ASTM specification A-515 grade 70, except the center section of the shell is non-normalized AAR specification TC-128-B. This car has a total of 6" of fiberglass insulation. The nominal water capacity of the tank was 16,100 gals. **Observed damage:** There was extensive jacket damage and the jacket had been torn from almost 1/3 of the tank on the B-end. A severe dent was observed in the shell near the A-end on the left side (from the A-end). The top of the car was dented in near the A-end. The coupler and draft gear were missing from the A-end and the stub sill was bent upwards. No breaches in the tank were observed. (Appendices A-4, H & K)

F. Postaccident Actions

The chlorine escaping the punctured tank car (UTLX 900270) vaporized causing the temperature of the chlorine in the still tank car to fall below its boiling point reducing the amount of chlorine escaping. Because the punctured chlorine tank car was in the middle of the pile of derailed cars the emergency responders could not readily work on that car. Work began on the outer cars. The tank car containing the sodium hydroxide car (GATX 58326) was unloaded into a frac tank and pulled out by January 9. Also on January 9, by 3 a.m., a polymer patch was inserted into the opening in the punctured tank and a vacuum was pulled on the tank to control the amount of chlorine escaping. The chlorine vapor removed from the tank during the vacuum process was released in a sodium hydroxide solution to neutralize it. Construction began on a permanent lead patch.

At 9:30 a.m. on January 10 the punctured chlorine car was rotated so the puncture was upright. This disturbed the liquid chlorine in the tank and caused a delay in efforts to unload other tank cars. At 12:10 p.m. emergency responders began unloading the chlorine from tank car SBLX 14146. About 7:00 p.m., plans for the lead patch were dropped and construction of a steel patch began.

By 2:00 p.m. January 11, SBLX 14146 was unloaded. At about 2:45 p.m., tank car GATX 17105 was righted to facilitate unloading and SBLX 14146 was moved from the immediate area of the site. At 3:00 p.m. the first bolts for the steel patch were attached to the punctured tank car (UTLX 900270).

On January 12, at 1:10 a.m., responders began unloading tank car GATX 17105. At 9:30 a.m. the steel patch was in place on the punctured tank car and unloading was started. Because the punctured tank car had extensive damage, the chlorine remaining in this tank car could not be pumped out in its liquid phase like the three other unbreached tank cars. This chlorine in this tank car had to be vaporized and pumped as a gas from the tank, and then bubbled through a sodium hydroxide solution held in a separate tank. Bubbling through the sodium hydroxide solution converted the chlorine to a relatively safe and easily transportable liquid bleach solution. However this process was much

slower than unloading chlorine in the liquid phase and would take several days. By 2:10 p.m. the second tank car was unloaded and work was started on the third tank car (GATX 58326).

In the early morning of January 13, the three unbreached chorine tank cars had been unloaded, placed on railroad flatcars, and moved from the site. They were held on the Warrenville siding for inspection until 10 p.m. that evening when they were moved to Augusta yard. Subsequent cleaning and purging would be done at the Olin plant in Augusta over the following several weeks.

On January 18, between 11 and 11:30 p.m. the punctured tank car (UTLX 900270) was unloaded. On January 19, the punctured tank car was cleaned and purged on site. It was then loaded on a flat car and moved to the Augusta yard the following morning (January 20).

G. Shipper Information

Olin Corporation is a manufacturer concentrated in three business segments: metals, chlorine/alkali products and ammunition. The metals include copper and copper alloy sheet, strip, foil, rod, welded tube, and fabricated parts; and stainless steel and aluminum strip. The chlorine/alkali products include chlorine, sodium hydroxide (caustic soda), sodium hydrosulfite, hydrochloric acid and bleach products. The ammunition products include sporting ammunition, canister powder, reloading components, small caliber military ammunition and industrial cartridges. In 2003, Olin posted sales of approximately $1.6 billion. The company has approximately 5,700 employees and manufacturing locations throughout the United States.

Augusta Plant Description—The Olin Augusta plant produces chlorine, sodium hydroxide, sodium hypochlorite (bleach), hydrogen, sodium hydrosulfite, hydrochloric acid, and dilute sulfuric acid. The plant has been in operation since 1965 and has about 80 employees. (Appendix D)

H. Regulations and Standards

The following chart shows the primary tank cars, the proper shipping name, hazard classification, identification number, and packing group specified by the DOT for each hazardous material involved in the derailment (Title 49 Code of Federal Regulations (49 CFR) section 172.101). The chart also shows the Environmental Protection Agency's reportable quantity for spills of each hazardous substance, in pounds, and identifies those materials defined as marine pollutants (**MP**) by DOT.

Shipping name (Tank Car Specs.)	Hazard Class (Secondary hazard)	ID NO.	Packing Group	RQ in lbs Mar Pol
Chlorine (DOT 105)	**2.3 Zone B (8)**	**UN1017**	**-**	**RQ= 10 MP**
Sodium Hydroxide, Solution (DOT 111)	**8**	**UN1824**	**II**	**RQ = 1000**

49 CFR section 173.31(b)(1) requires, in part, that all tank cars conforming to a DOT specification or being used for the transportation of a hazardous material be equipped with a coupler vertical restraint system (shelf coupler, see section 179.14). Section 173.31(b)(3) requires, in part, that tank cars transporting a Class 2 (including division 2.3) material, have a tank-head puncture-resistance system (head shields or equivalent, see section 179.16). Section 173.31(b)(4) requires, in part, that tank cars transporting a Class 2 material have thermal protection or an insulation system that meets the specific criteria for thermal conductance. This section references section 179.18 which requires tank cars to have sufficient thermal protection so that there is no release of lading, except through the pressure relief device, when subjected to a pool fire for 100 minutes, and a torch fire for 30 minutes.

Section 174.85 restricts the classes or divisions of hazardous materials that may be placed next to each other in a train. The section divides the hazard classes and divisions into 4 groups. Each of the materials involved in the derailment in Graniteville, South Carolina, were placed in Group 2.[7] Group 2 hazardous materials are permitted to be placed next to each other in a train. (Appendix E)

James E. Henderson
Hazardous Materials Group Chairman

[7] Group 2 includes Divisions 1.3, 1.4 1.5 (Class B and C explosives), Class 2 (compressed gas; other than division 2.3, PG I, Zone A poisonous gas), Class 3 (flammable liquid), Class 4 (flammable solid), Class 5 (oxidizing), Class 6 (poisonous liquid; other than division 6.1, PG I, Zone A poisonous liquid), and Class 8 (corrosive) materials.

LIST OF APPENDICES