APPENDIX R

HAZARDOUS MATERIALS TRANSPORT

Trucks for transport of hazardous materials

Stainless steel tanks for highway trucks

Corroded storage drum

Storage drums

APPENDIX R

HAZARDOUS MATERIALS TRANSPORT

MICHIEL P.H. BRONGERS[1]

SUMMARY AND ANALYSIS OF RESULTS

Corrosion Control and Prevention

Each year, approximately 2 billion metric tons of hazardous materials are produced in the United States. The amount of hazardous materials shipments is approximately 3 billion metric tons. Bulk transport of hazardous materials involves overland shipping by tanker truck, rail tank car, and specialized containers that are loaded on vehicles. Over water, ships loaded with specialized containers, tanks, and drums are used. In small quantities, hazardous materials require specially designed packaging for truck and air shipments.

The total cost of corrosion for hazardous materials transportation is at least $887 million per year. The elements of the annual corrosion cost include the cost of the transporting vehicles ($400 million per year), the cost of specialized packaging ($487 million per year), and the direct and indirect costs ($0.5 million per year and an unknown value, respectively) of accidental releases and corrosion-related transportation incidents.

According to the 1997 Vehicle Inventory and Use Survey (VIUS), there are a total of 403,000 trucks (including pick-up trucks) dedicated to hazardous materials transport in the commercial trucking fleet. Together, these trucks constitute only 0.55 percent of the total number (72.8 million) of commercial trucks. Hazardous materials trucks are responsible for 39.9 billion km (24.8 billion mi) of driven distance per year. In 1998, the Research and Special Programs Administration (RSPA) of the U.S. Department of Transportation (DOT) reported that 195,000 trucks (excluding pick-up trucks), 238,000 train cars, and 11,000 vessels (sailing under both U.S. and foreign flags) were dedicated to hazardous materials transport. The total cost to equip vehicles for corrosive hazardous materials was estimated at approximately $400 million per year.

The cost of hazardous materials packaging can be estimated by analyzing the replacement rates of steel pails and steel drums. In 1998, a total of 91.3 million new steel pails were produced with a total value of $290 million, and a total of 32.3 million new steel drums were produced with a total value of $684 million. Similar data for the last 10 years show that these replacement rates are typical. Two possible reasons for replacement of pails and drums are damage from handling and damage from corrosion. If it is assumed that 50 percent of the replacements are corrosion-related, then the cost of corrosion was $145 million for pails and $342 million for drums.

All accidental releases of hazardous materials during transportation must be reported to the U.S. DOT. Packaging failure was identified as the primary cause of 15 to 35 percent of all hazardous materials transportation incidents. Corrosion-related incidents are those accidental releases of hazardous materials where corrosion of the containers was identified as the root cause of the incident. In 1998, the corrosion-related incidents were approximately 1.35 percent of the total number of reported hazardous materials incidents.

The average direct cost of property damage in corrosion-related transportation incidents is only $0.5 million per year; however, the indirect costs of packaging failures are probably significant, although they go unreported. Indirect costs of corrosion-related incidents include the costs related to human injuries (average of eight injuries per year), fatalities (average of one death per 3 years), lost product (no data), and clean-up activities (no data).

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Summary of Issues

Increase consciousness of corrosion costs and potential savings.	The total cost of corrosion for hazardous materials transport is at least $0.89 billion per year. This total cost includes the cost of dedicated hazardous materials vehicles at $400 million per year and the corrosion cost of steel pails and drums at $487 million per year. The direct cost of hazardous materials transportation incidents is $0.5 million per year, while the indirect cost of hazardous materials transportation incidents is probably many millions of dollars.
Change perception that nothing can be done about corrosion.	No issue identified in current study.
Advance design practices for better corrosion management.	No issue identified in current study.
Change technical practices to realize corrosion cost-savings.	No issue identified in current study.
Change policies and management practices to realize corrosion cost-savings.	Adjust the U.S. Department of Transportation report form in order to gather more information about the long-term impact of corrosion, such as related hazardous materials incidents.
Advance life prediction and performance assessment methods.	No issue identified in current study.
Advance technology (research, development, and implementation).	No issue identified in current study.
Improve education and training for corrosion control.	No issue identified in current study.

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SECTOR DESCRIPTION

This sector includes the transportation of hazardous materials (HAZMAT) other than of the transportation of hazardous gases and liquids by buried pipelines, which will be discussed as a separate sector (see Appendix E). The storage of HAZMAT is described in a separate sector as well (see Appendix G).

Bulk transportation of HAZMAT involves overland shipping by tanker truck and rail tank car and by specialized containers that are loaded onto vehicles. Over water, ships loaded with specialized containers, tanks, and drums are used. In small quantities, HAZMAT requires specially designed packaging for truck and air shipments. Table 1 lists primary areas of the HAZMAT transportation industries.

Table 1. Primary areas of the HAZMAT transportation and storage industries.

TRANSPORTATION MODE		LOADING / UNLOADING FACILITIES	TANKS AND CONTAINERS
LAND	Trucks	Manufacturers and Users	Tanker trucks
	Trains	Stations	Tanker train cars
WATER	Ships	Docks	Drums and movable tanks
AIR	Airplanes	Airports	Special containers

Background

The Hazardous Materials Transportation Act (HMTA) of 1974[(1)] authorized the U.S. Department of Transportation (DOT) to regulate the transportation of HAZMAT over land, sea, and air. Within U.S. DOT, the Research Special Programs Administration (RSPA) issues the Hazardous Materials Regulations (HMR) and provides training, enforcement, technical support, information, and policy guidance to protect the transportation community and the general public against the safety risks inherent in transporting HAZMAT.

In the last 25 years, the federal government has developed more regulations for HAZMAT transport. The regulations for workplace safety are given in the Occupational Safety and Health Act (OSHA).[(2)] The Code of Federal Regulations, 49 CFR 173,[(3)] contains the requirements for HAZMAT transportation, including the requirements for shipping, packaging container design, and labeling. The code defines nine hazard classifications assigned for distinct HAZMAT (see table 2).

Table 2. Hazard classifications assigned for distinct HAZMAT.[(3)]

CLASSIFICATION	MATERIALS
Class 1	Explosives
Class 2	Flammable and Compressed Gases
Class 3	Flammable Liquids
Class 4	Flammable Solids
Class 5	Oxidizers
Class 6	Poisonous Materials
Class 7	Radioactive Materials
Class 8	Corrosive Materials*
Class 9	Miscellaneous Hazardous Materials

*Includes materials corrosive to human skin.

Class 5 and Class 8 materials require shipping and storage containers that are resistant to corrosion to prevent internal damage. However, most of the materials listed in table 2 can become corrosive to a mild steel container when they are contaminated with moisture. Depending on the environment, materials from all nine categories must be shipped and stored in containers that are protected from external corrosion damage.

The Office of Hazardous Materials Safety (OHMS) and the Research and Special Programs Administration (RSPA) of the U.S. DOT reported[(4)] that there are at least 300 million HAZMAT shipments of more than 3.1 billion metric tons annually in the United States (see table 3 and table 4). While approximately 43 percent of all HAZMAT tonnage is transported by truck, approximately 94 percent of the individual shipments are carried by truck. Transportation by air, while almost negligible in terms of tonnage, also has a share of individual shipments that greatly exceeds its percent of tonnage carried. While less than 1 percent of all HAZMAT tonnage is transported by air, approximately 5 percent of all HAZMAT shipments are transported by air. In contrast, significant amounts of HAZMAT tonnage are carried by rail, pipeline, and water modes, and, in some markets, these are the only modes that haul HAZMAT products; yet, the total number of shipments for all three of these bulk commodities is less than 1 percent.

Table 3. Daily and annual number of domestic HAZMAT shipments, movements, and tonnage shipped, specified by product group.[(4)]

PRODUCT GROUP	DAILY SHIPMENTS (quantity)	DAILY MOVEMENTS[2] (quantity)	ANNUAL SHIPPED (metric tons)	ANNUAL MOVED (metric tons)
Chemicals & Allied	500,000	900,000	0.53 billion	0.85 billion
Petroleum Products	300,000	300,000	2.60 billion	3.03 billion
Other	10,000	10,000	0.01 billion	0.02 billion
TOTAL	**> 800,000**	**> 1,200,000**	**> 3.1 billion**	**> 3.9 billion**

1 ton = 1,000 kg

Table 4. Daily number of domestic HAZMAT shipments, movements, and tonnage moved, specified by mode of transportation.[(4)]

TRANSPORTATION MODE	DAILY SHIPMENTS (quantity)	DAILY MOVEMENTS (quantity)	DAILY MOVED (metric tons)
Highway	768,907	1,154,450	3,794,970
Air	43,750	87,500	8,098
Rail	4,315	12,945	1,136,748
Water	335	670	2,545,850
TOTAL	**817,307**	**1,255,565**	**7,485,666**

1 ton = 1,000 kg

According to RSPA,[(4)] the amount of HAZMAT produced each year in the United States is close to 2 billion metric tons, while the amount shipped is closer to 3 billion metric tons. This relationship suggests that every ton of

[2] Based on the 1993 U.S. Census Bureau Commodity Flow Survey (CFS) shipment distribution data for standard transportation commodity classification (STCC) 28; 1995 CMA tonnage figures (SIC 28); 1995 U.S. EPA hazardous waste shipment and manifest data; 1996 U.S. DOE Energy Information Administration data; 1996 Waterborne Commerce Statistics; and 1997 BTS Air Carrier Traffic Statistics.

HAZMAT, on average, is shipped 1.5 times. RSPA reported a ratio of 0.64 for chemicals and allied products transportation, excluding other HAZMAT shipments.

Since the early 1990s, the federal regulations for transportation of small packages of HAZMAT have been performance-oriented, rather than specific about the shape of a container or about the packaging materials to be used. The specifications for larger packages are more design specific. To be able to operate in today's global marketplace, U.S. DOT has focused on harmonizing its rules and regulations with international standards.

In 1997, the Vehicle Inventory and Use Survey (VIUS)[5] reported that a total of 403,000 trucks, ranging from pick-ups and vans to heavy combination trucks (see figure 1), are in the commercial HAZMAT fleet (see table 5). This shows that 0.55 percent (403,000 HAZMAT trucks / 72.8 million total trucks) are involved in HAZMAT transport. Together, these HAZMAT trucks are responsible for approximately 39.9 billion km (24.8 billion mi) of travel per year.

Figure 1. Example of stainless steel tanks for road transport.

Table 5. Number of registered trucks transporting HAZMAT in 1997, as reported in the VIUS.[5]

HAZARDOUS MATERIALS CARRIED	1997 TRUCKS (x thousand)	PERCENT
Total Trucks Carrying Hazardous Materials	403.3	0.55
No Hazardous Materials Carried	71,182.8	97.78
Not Reported	1,214.1	1.67
TOTAL TRUCKS*	**72,800.2**	**100%**

*Values rounded to nearest thousand.

Table 6 lists the number of trucks used for each category of HAZMAT transport. The numbers of trucks listed in this table should not be confused with the 403,000 total trucks in the previous table, because many trucks can be used for multiple HAZMAT classifications.

Table 6. Number of registered trucks transporting HAZMAT in 1997, specified by HAZMAT classification, as reported in the VIUS.[5]

HAZARDOUS MATERIALS CARRIED		1997 TRUCKS (x thousand)
Class 1	Explosives 1.1 (formerly explosive A)	7.2
	Explosives 1.2 (formerly explosive B)	3.8
	Explosives 1.3 (formerly explosive C)	4.5
	Explosives 1.4 (formerly dangerous)	37.3
	Explosives 1.5 (formerly blasting agents)	22.7
	Explosives 1.6 (formerly dangerous)	25.3
Class 2	Flammable gas	115.3
	Nonflammable gas	83.0
	Poisonous gas	34.1
	Flammable	218.0
Class 3	Combustible	127.5
Class 4	Flammable solid	65.4
	Spontaneously combustible (formerly flammable solid)	41.4
	Dangerous when wet	47.4
Class 5	Oxidizer	90.8
	Oxygen	39.0
	Organic peroxide	46.5
Class 6	Poison (formerly poisons A and B, solids, and liquids)	70.9
	Keep away from food	49.6
Class 7	Radioactive	19.2
Class 8	Corrosive	159.2
Class 9	Miscellaneous hazardous materials	53.5
-	Hazardous materials not specified	40.6

In the previous paragraphs, an estimate of 403,000 HAZMAT trucks was given based on the 1997 VIUS.[5] However, in 2000, RSPA published data[6] regarding the dedicated HAZMAT fleet in the United States based on a long list of databases (see Appendix V of that report). RSPA reported that 195,000 trucks, 238,000 train cars, and 11,000 vessels (both under U.S. and foreign flags) are dedicated to HAZMAT transport. The RSPA numbers are smaller, but do not conflict with the VIUS data because VIUS includes small pick-up trucks and vans in its count.

Cost of Corrosion

No detailed information was found on the initial costs to equip a vehicle for HAZMAT transport or on the costs of operation and maintenance of HAZMAT vehicles. Dedicated HAZMAT vehicles are designed differently than regular trucks and are constructed using materials that are compatible with the HAZMAT contents; therefore, the cost of HAZMAT trucks is significantly greater than the cost of regular trucks. If it is estimated that $10,000 is the cost to equip one vehicle for HAZMAT transport and the average useful life per truck is 10 years, then the total cost of corrosion of HAZMAT vehicles is approximately $0.4 billion per year (400,000 trucks x $10,000 per truck every 10 years).

Shippers are required to report HAZMAT incidents to the U.S. DOT using the Hazardous Materials Incident Report DOT Form 5800.1 whenever there is an unintentional release of a HAZMAT. The information from all submitted forms is collected in the Hazardous Materials Information System (HMIS) incident database, which is maintained by RSPA and includes data reported by carriers over the past 30 years. Table 7 shows the number of, as well as the consequences resulting from, serious incidents for 1990 through 1998.(7) In 1998, there were roughly 15,000 reported HAZMAT incidents related to HAZMAT shipments, resulting in 13 deaths and 198 injuries.

On DOT Form 5800.1, the shippers are requested to give a description of the packaging failure for each incident. In addition to "vehicle collision," "improper loading," and several other checkboxes, there is an option to indicate "corrosion" as one of the contributing factors for the packaging failure. It is important to realize the difference between the contents of a package involved in an incident (corrosive materials were the contents in 35.7 percent of the 1998 incidents) and the root cause of an incident (corrosion was indicated as a contributing factor in 1.35 percent of the 1998 incidents).(8)

In general, the incident report gathers the hard "physical" costs associated with the damages generated by the spill, but not the intangible costs that we recognize as being associated with each incident. Such intangible costs may include the costs of executing paperwork and the lost time of production. Therefore, some types of factor can be added to the reported damages when looking at the overall impact cost of the incident.

For the current project, RSPA conducted a special query of the HMIS incident database. The results are included in table 7. As an example, the RSPA query(9) showed that in 1998, for 205 (1.34 percent) of the 15,322 incidents, corrosion was indicated as a contributing factor with a combined cost of $517,710. A total of 79 (38.3 percent) of these 206 corrosion-related incidents had a reported damage cost of $0, while 45 incidents had a cost between $0 and $100, and 81 incidents cost more than $100.

Table 7. Number of, and consequences resulting from, serious incidents involving HAZMAT transport for 1990 through 1998, as reported in the HMIS database(7) and the RSPA query.(9)

YEAR	TOTAL REPORTED INCIDENTS	NUMBER OF				AMOUNT OF PROPERTY DAMAGE	CORROSION WAS CONTRIBUTING FACTOR		PROPERTY DAMAGES IN CORROSION-RELATED INCIDENTS	
		SERIOUS INCIDENTS	FATALITIES	INJURIES	PERSONS EVACUATED					
1990	8,879	402	8	423	12,123	$32,353,276	142	1.60%	$289,710	0.90%
1991	9,110	403	10	439	10,502	$38,350,611	127	1.39%	$304,866	0.79%
1992	9,310	375	15	600	29,186	$35,164,057	150	1.61%	$517,388	1.47%
1993	12,830	357	15	627	18,237	$22,801,551	206	1.61%	$409,214	1.79%
1994	16,087	429	11	577	18,398	$44,185,413	216	1.34%	$5,966,850****	13.50%
1995	14,743	409	7	400	11,444	$30,903,281	233	1.58%	$456,957	1.48%
1996	13,950	464	120*	1,175**	19,556	$46,849,243	205	1.47%	$317,791	0.68%
1997	13,994	417	12	225	24,587	$33,393,504	210	1.50%	$536,746	1.61%
1998	15,322	429	13	198	9,181	$45,497,550	205	1.34%	$517,710	1.14%
Average	12,692	409	23	518	17,024	$36.6 million	188	1.49%	$1.0 million	2.60%
TOTAL	114,225	3,685	211	4,664***	153,214	$329 million	1,694	-	$9.3 million	-

*110 deaths were the result of a ValuJet incident in 1996.

**A single rail incident in Montana involving chlorine resulted in injuries to 787 people.

***In summarizing incident injuries for the biennial report, RSPA combines hospitalization (serious) injuries with minor injuries.

****In 1994, there was one rail incident involving arsenic acid liquid, with a total damage cost of $5,255,000 (Product Loss: $5,000, Carrier Damage: $250,000, Public/Private Property: $0, Decontamination/Cleanup: $5,000,000).

Limitations in HAZMAT Incident Data

There are two factors that could lead to low cost estimates for the incidents: (1) most incidents are small and (2) there are limitations to estimates of long-term impact because the information is collected immediately at the time and location of the incident.

The majority of the incidents reported to RSPA are minor and do not cause much damage or disruption. Even at 2 hours per incident (one for cleanup, one for reporting), the labor cost could be as low as $50, leaving $50 for materials lost or used during cleanup, for a total cost of $100 per incident. Since it was a minor spill and purely accidental, there may be no need for any managerial follow-up or corrective action such as safety training. To correct for small incident costs, (79 + 45) x $100 = $12,500 per year can be added to the $517,710 mentioned above.

The second reason for the low cost is the manner in which the information is collected. The question, as presented on DOT Form 5800.1, asks for the amount of loss or damages due to the HAZMAT as they relate to (a) Product Loss, (b) Carrier Damage, (c) Public/Private Property Damage, (d) Decontamination/Cleanup, and (e) Other. Most respondents do not take these types of costs into consideration when they are completing the form because the actual event descriptions do not correspond with the requested categories. Some costs may be under-reported since the forms are required within 30 days of the incident and the true costs may not be known until later. Additionally, the societal costs of evacuations, highway closures, lost work time, etc. are not reported on the incident report form; therefore, a cost correction factor could not be determined from this data.

Evaluation of HAZMAT Incident Reports

In March 2000, the U.S. DOT published a department-wide evaluation of the HAZMAT transportation programs.[(6)] The objective of that report was to document and assess the effectiveness of the department's HAZMAT transportation safety programs. The U.S. Coast Guard, the Federal Aviation Administration (FAA), the Federal Motor Carrier Safety Administration (FMCSA), the Federal Railroad Administration (FRA), and the Research and Special Programs Administration (RSPA) provided their input.

The Hazardous Materials Program Evaluation (HMPE) team analyzed all 13,950 incident reports for 1996 to determine their root cause. In table 8, the RSPA values, which were generated from the incident report forms that are filled out by HAZMAT shippers, are compared with the HMPE values, which were estimated by the team members, who all had inspection backgrounds. The HMPE team concluded that a larger percentage (34.6 percent) of the incidents are attributed to packaging failure than are indicated by the RSPA values (15.4 percent).

Table 8. Distribution of HAZMAT incident causes, as determined by RSPA and HMPE and reported in a 1996 RSPA-HMIS incident remarks subsystem report.[(7)]

CAUSE	**RSPA-DETERMINED CAUSE**	**HMPE-DETERMINED CAUSE**
	% of Total	**% of Total**
Human error	80.7	61.0
Packaging failure	15.4	34.6
Vehicle accident/derailment	2.4	2.6
Other	1.5	1.8
TOTAL	**100%**	**100%**

AREAS OF MAJOR CORROSION IMPACT

RSPA's Office of Hazardous Materials Safety (OHMS) published a list of the Top 50 hazardous materials in a 1998-1999 summary of HAZMAT transportation incidents.[8] The corrosive materials that were most often involved in HAZMAT incidents in 1998 included sodium hydroxide solutions, basic inorganic liquids, hydrochloric acid solutions, acidic inorganic liquids, phosphoric acid, caustic alkali liquids, acidic organic liquids, potassium hydroxide solutions, sulfuric acid, cleaning liquids, hypochlorite solutions, basic organic liquids, liquid amines, and ammonia solutions.

Internal Corrosion

Internal corrosion of tankers usually only requires mitigation when an oxidizer (Class 5) or a corrosive material (Class 8) is transported. Internal corrosion from settled contamination is limited because of high throughput and product movement during transportation. Internal corrosion of tankers can be a problem during long periods of storage if they are not cleaned properly first.

In 1998, the value of shipments of new steel pails totaled $289.8 million and the value of shipments of new steel drums was $684.2 million (see table 9).[10] The quantity of new steel pails was 91.3 million (average $3.17 per pail) and the quantity of new steel drums was 32.3 million (average $21.19 per drum).

Table 9. Summary of shipments of steel pails and drums from 1989 to 1998, as reported by the U.S. Census Bureau.[10]

	STEEL PAILS			**STEEL DRUMS**		
	QUANTITY (x thousand)	**VALUE ($ x thousand)**	**AVERAGE $ / PAIL**	**QUANTITY (x thousand)**	**VALUE ($ x thousand)**	**AVERAGE $ / DRUM**
1998	91,341	$289,768	$3.17	32,293	$684,242	$21.19
1997	88,940	$279,449	$3.14	34,107	$722,101	$21.17
1996	60,443	$200,681	$3.32	34,334	$706,084	$20.57
1995	71,896	$162,992	$2.27	33,279	$685,499	$20.60
1994	86,478	$208,406	$2.41	34,857	$681,972	$19.56
1993	85,899	$202,460	$2.36	33,474	$672,948	$20.10
1992	76,794	$178,850	$2.33	33,336	$632,616	$18.98
1991	72,645	$180,408	$2.48	33,970	$668,692	$19.68
1990	75,242	$195,669	$2.60	36,388	$701,615	$19.28
1989	80,693	$205,834	$2.55	35,966	$667,024	$18.55

Two possible reasons for replacement of pails and drums are damage from handling and damage from corrosion. If it is assumed that 50 percent of the replacements are corrosion-related, then the cost of corrosion in 1998 was $145 million for pails (50 percent of $290 million) and $342 million for drums (50 percent of $684 million).

Shipping containers, such as drums and pails, can suffer internal corrosion damage and failure when corrosive materials are shipped. Normally, internal corrosion is not a problem when materials are shipped from the manufacturer because the proper container material is used and the container materials are normally transported in a relatively short period of time. However, contaminated or corrosive materials can cause failures when stored beyond the material's shelf life. The corrosion failure of drums containing hazardous waste tends to be more of a problem. Typically, the problem occurs when wastes are mixed or when waste is contaminated and stored in containers made of non-compatible materials (see figure 2).

Figure 2. Storage drums for short-term storage can suffer both internal and external corrosion if they are stored for longer periods of time.

External Corrosion

In the transportation industries, external corrosion of tanker trucks and rail car-mounted tanks is a consideration. Both general and pitting corrosion from the atmosphere and splash water from the roadway or rail bed can affect the tank's structural integrity and tightness. This problem is particularly severe in areas of the country with chloride sources such as road salt or airborne marine atmosphere, and high concentrations of airborne industrial pollution. The common mitigation technique involves painting of the tanks.

CORROSION CONTROL

Corrosion control methods for tanker trucks and rail car-mounted tanks include linings and corrosion allowances for internal corrosion. In cases where corrosive materials are to be transported, corrosion-resistant alloys are used. In extreme cases, rubber bladder tanks have been used on flatbed trailers or rail cars. External corrosion is controlled with coatings and designs that minimize crevices. For example, crevice corrosion can be prevented by placing a horizontal tank with a circular cross-section on legs, thereby avoiding direct contact with other surfaces.

CASE STUDY

Hydrochloric Acid Leak in Train Tanker ($30,200)

This case study illustrates the direct cost of a failed liner in a train tanker containing a corrosive liquid. In addition, this case study shows what type of problems can be encountered and how different agencies work together to remediate a HAZMAT incident. The information reported here was taken from a single HAZMAT incident report from the HMIS database.[7]

On May 21, 1998, a chemical transportation safety manager of a large railroad company was contacted by a car foreman in Colton, CA, who reported that a train tank car was leaking from the bottom portion of the car. The manager drove to the Colton receiving yard, located the tank car on a yard track, and observed the tank car leaking a steady stream of product, estimated to be 30 to 38 L (8 to 10 gal) per hour, from the center bottom portion of the car. The billing information for this car showed that the car was not fully loaded and that the contents were a residue. The leak appeared to be at the weld that attaches the protective skid plate to the bottom of the tank car. The San Bernardino, CA, Fire Department was notified due to the toxic nature of the product vapors. Arrangements were made with the train company's HAZMAT emergency response contractor, who responded with a team of people and equipment to assist in remediation of the problem.

Due to the location of the tank car in the receiving yard, access was limited, which required moving the tank car. As there was a hospital directly north of the receiving yard, it was determined that the tank car would have to be moved east, which would place the tank car adjacent to the main switching yard. The highway patrol closed Interstate 10 and the Ceder Avenue overpass while the tank car was being moved, which was accomplished by 6 a.m. The area where the tank car was to be placed and the repair shop were evacuated. Once the tank car was placed, an entry team removed the valving from the product liquid line on the top of the car and placed a containment system to capture the leaking product underneath the car. During this process, the leak at the bottom of the car stopped and restarted several times. A vacuum truck was brought in and set up with a PVC "stinger" to access any free product through the tank car's liquid line. No product was obtained during this process, which further confirmed that the tank car liner had failed. It appeared that the liquid was between the tank liner and the tank shell.

Several attempts were made to putty the weld at the side plate, which only resulted in the leak moving to other areas of the weld. At this point, arrangements were made with a local tank car repair shop to receive this car. The repair shop had a containment pit that would accommodate the leaking tank until it could be purged. A makeshift containment system was constructed under the tank car to prevent any further spreading of product during the move. The tank car was then moved as a single unit with a yard switch engine and was sent to the containment area by 11 p.m. Two 208-L (55-gal) drums of free product were captured during this event. The waste and a batch of contaminated soil were delivered to a facility for proper disposal.

The total reported cost for this HAZMAT incident was $30,200. This cost was the direct cost incurred by the train company, and probably included the cleanup costs and repair costs for the tanker car. However, the indirect costs related to the actions taken by the fire department, the police department, and the lost time of the travelers on Interstate 10 were not included in the total cost.

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