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Cooperative Research for Hazardous Materials Transportation: Defining the Need, Converging on Solutions -- Special Report 283 (2005)

Chapter: 2 Overview of Hazardous Materials Transportation

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Overview of Hazardous Materials Transportation

Background information on the transportation of hazardous materials shipments, the challenges involved in ensuring their safety and security, and the interrelated roles of government and industry in meeting these challenges is provided in this chapter.

TRANSPORTATION OF HAZARDOUS MATERIALS

The federal Hazardous Materials Transportation Act of 1975 (HMTA) and its reauthorizing legislation define a hazardous material as a substance or material that, if not regulated, may pose an "unreasonable risk to health, safety, or property when transported in commerce." In implementing the act, the Department of Transportation (DOT) has identified by name more than 3,000 materials subject to regulation. Thousands of unnamed materials are also covered by regulation because they are explosive, flammable, corrosive, infectious, or hazardous in other ways. The federal hazard classifications, along with example materials, are given in Table 2-1.

Excluding shipments by pipeline and oceangoing international tankers,[1] DOT has estimated from 1997 Census Bureau data that about 817,000

shipments consisting of 5.4 million tons of hazardous materials are made daily in the United States, which would total nearly 300 million

[1] Pipelines are a major mode for transporting petroleum products, accounting for about 45 percent of tonnage. Pipelines have characteristics that differ from those of other modes and are regulated separately. They have some commonality with fixed facilities. Likewise, tanker vessels are regulated separately by the U.S. Coast Guard. Statistics for pipelines and tankers are not reviewed here, although it is recognized that these modes may participate in cooperative research on hazardous materials transportation.

TABLE 2-1 Hazard Classes and Divisions with Example Materials

Hazard Class and Division	Name of Class and Division	Example Materials	Brief Description of Hazard
1.1 to 1.6	Explosives	Black powder, fireworks, rocket motors	Mass explosion, projection hazard
2.1	Flammable Gas	Propane	
2.2	Nonflammable, Nontoxic Gas	Compressed oxygen	Contents under pressure
2.3	Poison Gas	Chlorine	
3	Flammable Liquid Combustible Liquid	Paint, gasoline, diesel fuel	
4.1	Flammable Solid	Safety matches, Sterno	Readily combustible, self-reactive
4.2	Spontaneously Combustible	Calcium dithionite	Self-heating materials, ignite or heat when exposed to air
4.3	Dangerous When Wet	Calcium carbide	Reacts with water to yield flammable or toxic gas or becomes combustible

5.1	Oxidizer	Potassium bromate	Yields oxygen or fire potential
5.2	Organic Peroxide	Methyl ethyl ketone peroxide	Thermally unstable, burns rapidly, sensitive to impact
6.1	Poisonous Material	Pesticides	Toxic to humans
6.2	Infectious	Virus culture	
7	Radioactive	Cobalt-60	
8	Corrosive	Caustic soda	Damages skin on contact or corrodes metal
9	Miscellaneous	Heated liquid asphalt	

shipments and 2 billion tons of hazardous cargo per year (Table 2-2). On a tonnage basis, this was equivalent to about 18 percent of total freight shipped at that time. Since then, the amount of freight shipped in the United States has increased by roughly 5 percent, which suggests that annual hazardous materials shipments today are on the order of 2.1 billion tons.[2]

[2] According to the Census Bureau's 2002 Commodity Flow Survey preliminary report, 11.6 billion tons of freight was shipped in 2002, an increase of 4.4 percent from 1997 estimates (Census Bureau 2003, 14, 15; Census Bureau 1999). Although figures for 2003 and 2004 are not available, the committee conservatively assumes a total of 5 percent growth since 1998.

TABLE 2-2 Hazardous Materials Shipped in the United States by Mode, 1997–1998

Mode	Daily Shipments	Tons Shipped Daily	Ton-Miles Shipped Daily (millions)	Average Shipment Size (tons)	Percentage of Total Daily Shipments	Percentage of Tons Shipped Daily	Percentage of Ton- Miles Shipped
Truck	768,907	3,709,180	205	4.82	94	69	34
Rail	4,315	378,916	205	87.81	1	7	34
Water	335	1,272,925	187	3,799	0	24	31
Air	43,750	4,049	0.26	0.09	5	0	<0.01

Total	817,307	5,365,070	597	6.56	100	100	100

NOTE: The most recent years available for estimates are 1997 and 1998. Pipelines are excluded from calculations. The types of commodities shipped differ by mode. About 41 percent of truck shipments of hazardous materials are petroleum products, and most of the remaining 59 percent are chemical and allied products. Only about 10 percent of rail shipments are petroleum products, while 90 percent are chemical and allied products. Petroleum products account for more than 75 percent of waterborne shipments.
SOURCES: RSPA 1998; Census Bureau 1999, Table 1.

Hazardous materials make up such a large percentage of the nation's freight because they include many widely used commodities and products. Gasoline and other petroleum products are estimated to account for about 40 percent of all hazardous materials shipments and about three-quarters of the tonnage shipped (RSPA 1998, 1). Excluding pipeline and tanker traffic, more than two-thirds of petroleum tonnage is shipped by truck, mostly over short distances on distribution routes.

Other hazardous cargoes include basic industrial and agricultural chemicals such as pesticides, fertilizers, compressed gases, and acids. Many common household and consumer products are regulated as hazardous in transportation, such as paints, adhesives, batteries, cleaning solutions, and swimming pool chemicals. Shipments of hazardous wastes and radioactive materials used by the nuclear energy and medical industries are likewise subject to regulation. In short, hazardous materials are ubiquitous in the national economy. They are used not only by industry but also by consumers and businesses on a daily basis.

Carriers

Hazardous materials are transported by nearly all kinds of carriers and in many shipment sizes and forms of packaging. While some carriers specialize in the movement of hazardous materials shipments, many others that carry them do not.

The movement of hazardous cargoes is a normal part of the business of large railroads, barge operators, and shipping lines. The same is true of specialized carriers such as tank truck operators and other trucking companies that regularly move products such as paints, batteries, and cleaning chemicals. DOT estimates that about 45,000 carriers in all modes have equipment and operations dedicated to the transportation of hazardous materials (RSPA 2003). About 400,000 large trucks are dedicated

to hazardous materials service, including most tank trucks (RSPA 2003). About 115,000 railroad tank cars and more than 3,000 tank barges operating on the inland and coastal waterways are in hazardous materials service (TRB 1994, 47; RSPA 2003, 1; USACE 2002).

DOT further estimates that at least 500,000 carriers transport hazardous materials on an occasional or periodic basis (RSPA 2003). As a practical matter, most carriers move hazardous materials to one degree or another. Even trucking companies that specialize in small-package and less-than-truckload shipments regularly move hazardous cargoes. DOT estimates that while only 43 percent of hazardous materials tonnage is transported by truck, about 94 percent of individual shipments are transported by this mode because of the many small shipments (RSPA 1998, 1).

Table 2-2 shows a breakdown of hazardous materials tonnage moved by mode of transportation, excluding pipeline. Because shipments by rail and water tend to be heavier than shipments by truck, they account for major shares of hazardous materials traffic measured in this way. They also account for a much larger share of ton-miles of hazardous materials shipped, since water and rail shipments average much longer distances than shipments by truck. On average, the highways have the largest number of shipments, the waterways have the heaviest shipments, and the railroads move shipments over the longest distances. As a result of these modal differences, these three major modes of hazardous materials transportation each account for about one-third of ton-miles shipped, while the share by air transport (as would be expected) is negligible by this measure (Table 2-2).

Shipment Types and Sizes

Carriers specializing in the transportation of hazardous materials often move what are defined by DOT as “bulk packaged” shipments, which are single packagings exceeding 119 gallons for liquids, 882 pounds for solids, and 1,000 pounds for gases. Tank trucks, railroad tank cars, barge tankers, and intermodal tanks are forms of bulk packaging. Tank trucks typically hold between 2,000 and 10,000 gallons, railroad tank cars typically hold between 10,000 and 34,500 gallons, and barge tankers can hold several

hundred thousand gallons. Intermodal tank containers, which are transported on flatbed trucks and flat rail cars, can hold as much as 6,500 gallons. Bulk packaged shipments may also be shipped by truck in van-type trailers, on railroad flatcars, on flat barges, and in other nontank vehicles and containers. Many portable tanks, bins, and drums for transporting hazardous liquids and solids exceed 119 gallons or 1,000 pounds and are thus defined in the regulations as bulk shipments. Multiple bulk shipments are often transported in the same truck, rail car, or vessel.

A fairly small number of commodities constitute the vast majority of hazardous materials moved in bulk in terms of weight. Gasoline, diesel, and home heating fuel are the most common hazardous cargoes moved in tank trucks. About 125 commodities account for 90 percent of shipments moved by railroad tank car, but 6 of these—liquefied petroleum gas, caustic soda, sulfuric acid, anhydrous ammonia, chlorine, and fuel oil—account for more than half of tank car shipments (AAR 2002). Tank and dry barges are mainly used to carry many of these commodities.

"Nonbulk" shipments are packaged in boxes, drums, cylinders, and other smaller containers. They may range in weight from a few ounces to hundreds of pounds. Indeed, most products that are regulated as hazardous are shipped in nonbulk packagings. Compared with bulk shipments, nonbulk cargoes include a much wider range of materials. As noted earlier, trucks are the main means of transporting nonbulk shipments. Nearly all shipments moved by air are in nonbulk packaging. The fact that a vehicle contains nonbulk shipments does not mean that the total amount of material is small or insignificant. A single truck, for example, may carry several dozen shipments in nonbulk packages that together weigh tens of thousands of pounds.

The largest carriers of hazardous materials are oceangoing tanker vessels, which carry crude oil, petroleum products, chemicals, and liquefied petroleum and natural gas. The vast quantities of materials carried at one time in these vessels are of an entirely different scale than the amounts carried in a single rail car, truck, or barge. Oceangoing tankers vary widely in size and capacity. Even smaller vessels are capable of holding several million gallons, while the world's supertankers can carry tens of millions of gallons. These shipments and the vessels that carry them are regulated by

the U.S. Coast Guard (USCG) and are subject to statutory requirements different from those applying to shipments in bulk and nonbulk packagings discussed above. Containerships are also regulated by USCG; however, the intermodal containers that they carry—which can number in the thousands—are subject to DOT regulation since they are also carried by rail, barge, and truck.

Origins and Destinations

According to the U.S. Department of Commerce's Commodity Flow Survey, more than 14,000 establishments in the country are engaged in the manufacture of hazardous materials (Census Bureau 2003; RSPA 2003). DOT estimates that about 45,000 firms regularly ship significant quantities of hazardous materials and that another 30,000 are occasional shippers (RSPA 2003). These estimates do not take into account the multiple business locations of many shippers, which can result in many more shipping points.

Shippers of large quantities of hazardous materials include oil refiners, chemical manufacturers, and gasoline distributors. Among gasoline suppliers alone there are about 2,000 large bulk distributors, which ship to large manufacturers and utilities, and more than 10,000 local distributors, which supply individual gasoline retailers, farms, and filling stations. Shippers of smaller quantities of hazardous materials include hospitals, small manufacturers, and residential suppliers of home heating fuel.

Between the time a hazardous materials shipment leaves its place of origin and arrives at its final destination, it may pass through several modes of transportation and transfer points. The nation's ports serve as hubs for traffic moving by vessel, truck, and rail and are major transfer points for hazardous materials of all kinds. Rail yards and truck terminals are also major transfer points. Typically, tank cars pass through numerous yards and are switched among trains several times during their trips, which may take 1 to 2 weeks. The terminals of carriers that specialize in small-package and less-than-truckload shipments (including UPS and FedEx) are also major transfer points for nonbulk shipments. Bulk shipments by truck, especially in tank trucks, are less likely to involve a

transfer, because they are used to deliver partial loads to receivers and because trip distances tend to be shorter.

Receivers of hazardous materials shipments are even more dispersed and diverse than originators. Some are located where large quantities of hazardous materials are used in production, such as refineries, utilities, chemical plants, and factories. Hazardous materials shipments may be sent directly to their site of final use (e.g., blasting agents to a construction site) or to retail outlets (e.g., paint stores), hospitals, gasoline stations, and waste disposal sites. In the United States, more than 150,000 service stations and convenience stores receive regular shipments of motor fuel by tank truck (RSPA 1998).

ENSURING SAFETY AND SECURITY

Safety Challenge

Hazardous materials have been transported in large quantities since the rapid industrialization of the late 1800s. Ships, barges, and rail cars had long been used by the military to transport explosives, armaments, and other hazardous cargoes. However, the transportation of hazardous materials for commercial purposes did not grow markedly until after the Civil War. Demand for oil following its discovery in western Pennsylvania in the late 1860s led to increasing quantities of crude being transported long distances, first by horse and river barge and soon after by pipeline, tank car, and tanker ship (TRB 1993; Heller 1970; Newton 2002). By the start of World War I, significant amounts of hazardous materials were being transported on the nation's highways, waterways, and railroads. Tank trucks delivered gasoline and home heating fuel, steel tank cars were outfitted to carry dozens of petroleum products and chemicals, and steam-powered tankers and barges were carrying such cargoes on the inland and coastal waterways.

Concern over the safety of these shipments soon followed. Several spectacular railroad accidents prompted the railroads to create the Bureau of Explosives (BOE) in 1907 to serve as a "self-policing," standard-setting body for the shipment of hazardous materials by rail. Railroads began

demanding that shippers label hazardous shipments. A year later, Congress authorized the Interstate Commerce Commission (ICC) to regulate the transport of explosives and other hazardous cargoes. As one of its first actions in this area, ICC began formally approving design safety standards for railroad tank cars and other containers used for hazardous commodities. By the 1930s, Congress had extended ICC's authority to cover interstate motor carriers, and USCG and the Civil Aeronautics Board were given similar authority over the maritime and air transportation sectors, respectively.

The hazardous materials authority of ICC was transferred to DOT when it was created as a cabinet-level agency in 1966. DOT inherited a body of policies and regulations rooted in a number of statutes and implemented by a number of agencies. The regulations consisted of a piecemeal mix of voluntary and mandatory safety measures developed through decades of expert judgments and consensus building among shippers, carriers, and container makers (NTSB 1971). There was little consistency among modes in the rationale for the standards, most of which were adopted on a mode-by-mode and commodity-by-commodity basis over the course of many decades. Before 1968, no research funds were budgeted to support regulatory development. Data on the safety performance of hazardous materials transportation were seldom collected to assess risks and develop countermeasures. Instead, regulatory changes were often made in response to individual high-profile accidents.

A series of fatal tank car accidents beginning in the late 1960s was one factor prompting Congress to reform the federal hazardous materials safety program. The accidents generated public attention and calls for more concerted federal involvement in the safety process. In 1970, Congress passed the Hazardous Materials Transportation Control Act, which required DOT to collect information about hazardous materials incidents across all of the modes and to report annually on the activities and accomplishments of the various regulatory agencies responsible for safety in each mode. The act also withdrew or curtailed many of the reg-

ulatory functions delegated to the railroad industry's BOE and other industry groups. Initiatives for regulatory changes began shifting from the shippers and carriers to the regulators themselves. These developments

culminated in the passage of landmark legislation, the HMTA, which for the first time offered a consistent and coherent rationale for the federal regulatory program—"to protect the Nation adequately against risks to life and property which are inherent in the transportation of hazardous materials in commerce." In passing HMTA, Congress made it clear that the transportation of hazardous materials was to be regulated in a more consistent and systematic manner that conceptualized risks across modes and commodity types and with respect to hazards before, during, and after an incident. DOT placed this responsibility within the Office of Hazardous Materials Safety of the Research and Special Programs Administration (RSPA).

As discussed in more detail below, the federal hazardous materials safety program continues to emphasize reducing risks to public safety. Judged in this way, the industry's performance is viewed as good by RSPA, which has observed that 99.995 percent of hazardous materials shipments are transported without incident (RSPA 2003). To be sure, the occurrence of fatalities and other significant consequences from hazardous materials incidents has fallen off markedly since the statutory changes and institutional reforms of the 1970s. In recent years, however, the elevation of other risk concerns, such as security and environmental harm, has expanded and complicated the role of the federal government in controlling the risks associated with hazardous materials transportation.

Safety Performance

Since passage of HMTA in 1974, federal law has defined a hazardous materials transportation incident as an unintentional release of a hazardous material from its package during transportation, which includes periods of loading and unloading and storage incidental to transportation. RSPA's Hazardous Materials Information System (HMIS) is DOT's main source of safety data related to hazardous materials transportation. The agency requires the reporting of an incident within 30 days, although the incident must be reported immediately if it involves a death, evacuation lasting 1 hour or more, or the need to alter the flight of an aircraft. Other federal agencies collect data pertinent to hazardous materials safety. The Federal Railroad Administration (FRA) maintains the Railroad

Accident/Incident Reporting System, the Federal Motor Carrier Safety Administration (FMCSA) maintains the Motor Carrier Management Information System, and USCG maintains the Marine Casualty and Pollution Database. However, RSPA's HMIS is the most widely used source of data on hazardous materials incidents.

In 2003, RSPA received 14,660 reports of incidents from carriers and shippers (Table 2-3). During the past decade, the number of incidents reported each year has fluctuated, with no discernible trend, between about 14,000 and 18,000. About 87 percent of the incidents reported during this period involved trucks, 7 percent air, 6 percent rail, and less than 0.1 percent water (Table 2-3). The vast majority (about 97 percent) of reported incidents can be characterized as having minor consequences— that is, they did not have any of the serious outcomes that require immediate reporting (Table 2-4). Incidents involving bulk shipments, which account for about one-fifth of reports, had nearly twice as many injuries and four times as much property damage as did reported incidents involving nonbulk shipments (Table 2-4). Gasoline was by far the most common material involved, as might be expected given the prevalence

TABLE 2-3 Hazardous Materials Incidents Reported to DOT, 1994–2003

	Mode				
Year	Air	Truck	Rail	Water	Total
1994	931	14,011	1,157	6	16,105
1995	817	12,869	1,155	12	14,853
1996	925	12,034	1,112	6	14,077
1997	1,031	11,932	1,102	5	14,070
1998	1,386	13,111	989	11	15,497
1999	1,582	14,953	1,073	8	17,616
2000	1,420	15,131	1,059	17	17,627
2001	1,081	15,909	899	5	17,894
2002	734	13,818	872	9	15,433
2003	748	13,154	751	7	14,660
Total	10,655	136,922	10,169	86	157,832
Percentage	6.8	86.8	6.4	<0.05	100.0

SOURCE: See hazmat.dot.gov/ for latest hazardous materials incident data from HMIS.

TABLE 2-4 Hazardous Materials Incidents and Consequences by Mode, Bulk and Nonbulk, 1994–2003

Mode	No. of Incidents	No. of Fatalities	No. of Injuries	Damages ($)
Air, total	10,655	110	202	2,042,118
Bulk	1	0	0	0
Nonbulk	10,654	110	202	2,042,118
Truck, total	136,951	97	1,941	338,136,186
Bulk	21,632	94	907	258,255,178
Nonbulk	115,319	3	1,034	79,881,008
Rail, total	10,169	3	1,332	166,791,761
Bulk	9,142	3	1,307	157,739,539
Nonbulk	1,027	0	25	9,052,222
Water, total	86	0	2	2,211,559
Bulk	45	0	1	576,378
Nonbulk	41	0	1	1,635,181
Total	157,861	210	3,477	509,181,624
Bulk	30,820	97	2,215	416,571,095
Nonbulk	127,041	113	1,262	92,610,529

SOURCE: See hazmat.dot.gov/ for latest hazardous materials incident data from HMIS.

of tank trucks on the highways. Together, gasoline, other flammable liquids, and corrosives accounted for 57 percent of serious incidents (RSPA 2003).

Ever since DOT has required the reporting of hazardous materials incidents, questions have arisen concerning the accuracy, completeness, and relevance of the data. The large number of reported incidents involving trucks stems in part from the many small, nonbulk shipments moved by this mode. Most of the reported incidents involve small leaks from drums and other nonbulk containers discovered during loading and unloading, with few, if any, consequences except for cleanup

expenses at the site. Even though most reported incidents do not involve serious consequences, the annual statistics reveal some highly costly and consequential ones. For instance, the 1996 figures include 110 airline passenger and crew fatalities from the crash of ValuJet Flight 592, which was caused by oxygen generators that caught fire. During the same year, chlorine gas escaping from a tank car damaged in a train derailment in Alberton, Montana, resulted in the evacuation of more than 1,000 people, more than 700 injuries, and 1 fatality. The 1998 statistics include the deaths of five people from gasoline that spilled and ignited during the unloading of a tank truck in Biloxi, Mississippi. The incident also resulted in the evacuation of 80 people and the closing of an Interstate highway. Because such major incidents are rare, they stand out and tend to dominate the safety data when they do occur.

Major hazardous materials incidents are usually investigated by the National Transportation Safety Board (NTSB). NTSB reports typically detail the circumstances of the incident and its aftermath, including the performance of emergency response. The reports attempt to identify factors causing and contributing to the severity of the incident. These investigations are helpful to DOT as it seeks remedies to problems and weighs needed changes in regulations and safety programs. NTSB, however, does not have the resources to investigate more than a handful of hazardous materials incidents each year.

Other Risks and the New Security Imperative

Hazardous materials regulation has long been focused on acute hazards, such as flammability, which pose a risk to the public when hazardous materials are accidentally released. This focus, however, has diminished over time as concern over other nonacute risks to human health and the environment has grown. During the 1970s, Congress called on the U.S. Environmental Protection Agency (EPA) to require the reporting of releases of certain environmental contaminants in specific quantities. DOT was subsequently required to regulate the transportation of these hazardous substances when they are shipped in quantities equal to or exceeding their reportable quantities.

More recently, concern over the risk of accidental releases has been joined by concern over intentional releases, especially the use of hazardous

materials shipments by terrorists to injure people or disrupt the economy. A particular concern is that shipments of certain hazardous materials—such as poison gases, flammables, and explosives—will be targeted or seized. Railroad tank cars passing through populated areas, tank trucks delivering gasoline to service stations, chemical and gas tankers at ports, and trucks carrying radioactive wastes are now viewed as candidates for terrorist activity. Whereas procedures to prevent the accidental release of hazardous materials may be beneficial in protecting against intentional releases, they may not be sufficient. It has become clear that

security concerns will require new risk calculations and possibly changes in how risks are managed.

Already, concerns about security have led to questions about the adequacy of packaging to withstand terrorist attacks and the advisability of allowing tank cars carrying toxic gases to be routed through urban areas. Some long-standing measures to communicate hazard information to emergency responders, such as the labeling of containers and the placarding of vehicles, have come under scrutiny as possibly aiding terrorists in identifying hazardous materials shipments (RSPA 2003).

Understanding and managing the full array of public safety, environmental, and security risks associated with the transportation of hazardous materials have become more explicit goals of both government and industry. During the past 3 years, DOT and industry have taken a number of steps to enhance the security of hazardous materials transportation. These steps include the development of guidelines to improve security awareness in the hiring of personnel, the conduct of on-site security reviews targeting shippers and carriers of very hazardous materials, and the evaluation of common hazardous materials routes from a security perspective. In passing the Marine Transportation Security Act of 2002, Congress required all ports and their users to develop comprehensive security plans and incident response capabilities.

Risk management involves not only preventing accidental and intentional releases of hazardous materials but also being ready to contain and mitigate the effects of incidents when they occur. The first responders to hazardous materials incidents are often local (county and municipal) law enforcement and emergency personnel. Consequently, the role of

firefighters, police, and other emergency personnel in responding to hazardous materials incidents is especially important. Much of the DOT regulatory and safety program is geared toward providing needed emergency response information—from requirements for placarding to the development and distribution of the *Emergency Response Guidebook*.

Emergency response is one example of how the private and public sectors at all jurisdictional levels must cooperate to ensure the safe and secure transportation of hazardous materials. In the following section, the roles and responsibilities of the sectors are described in more detail.

ROLES OF GOVERNMENT AND INDUSTRY

Because hazardous materials are so pervasive in commerce, it is not practical to describe all the roles of public and private entities in their efficient, safe, and secure movement. The focus here is on those roles pertaining directly to safety and security. Some vitally important roles, such as the provision of an integrated network of waterways by the U.S. Army Corps of Engineers and the building and operation of the nation's highway system by state departments of transportation, are not reviewed, although they are essential to the efficient movement of hazardous cargoes in commerce. The goal of the discussion that follows is not to provide a comprehensive review of government and industry roles in safety and security but to provide a general sense of how dispersed and interdependent these roles are.

Federal Agency Roles

Transportation Agencies

As described above, laws passed by Congress give the Secretary of Transportation primary responsibility for regulating the safe and secure transportation of hazardous materials affecting interstate commerce. This regulatory authority not only covers transportation activity directly but also extends to the handling, labeling, and packaging of hazardous materials by shippers and to the fabrication, reconditioning, repair, and

testing of shipping containers. The secretary has delegated the lead responsibility for developing the regulations to RSPA and its Office of Hazardous Materials Safety.

RSPA rulemaking covers two broad requirement areas: hazard containment and hazard communication. The first set of rules classifies materials according to their hazard characteristics and establishes material packaging and handling requirements. The second spells out how shippers and carriers must communicate these hazards through the use of placards, shipping papers, and package markings and labels. These communication requirements are intended to provide essential information about hazardous cargo to the public and emergency response personnel when incidents occur.

In developing these rules, RSPA consults with the modal agencies within DOT, which are most familiar with the operations and environ-

ments of their respective modes. These agencies—most notably, the Federal Aviation Administration (FAA), FRA, and FMCSA—have primary responsibility for enforcing carrier compliance with the regulations through inspections and penalties. Each modal agency has inspectors versed in hazardous materials regulation. FRA's Office of Safety Enforcement employs several hundred inspectors, about 20 percent of whom are trained hazardous materials specialists. FRA inspectors cover shipper and receiver facilities, rail yards and lines, and tank car manufacturing and repair facilities. In contrast, FMCSA has only a handful of inspectors, because it has arranged for states to assist with motor carrier inspection and enforcement activities. The agency has helped in the training of state inspectors to familiarize them with federal hazardous materials regulation. In the case of marine transportation, the March 2003 transfer of USCG from DOT to the newly created Department of Homeland Security (DHS) complicated the delegation of enforcement authorities for hazardous materials shipments. Nevertheless, USCG has retained responsibility for enforcing DOT hazardous materials regulations in the maritime sector.

Many shippers use more than one mode of transportation to move their hazardous cargoes. Hence, RSPA is responsible for enforcing compliance by shippers. It also has primary responsibility for enforcing compliance by

manufacturers, repairers, and reconditioners of most kinds of containers, including intermodal containers. The agency is responsible for working with international standard-setting bodies to ensure that federal rules are compatible and consistent with international standards. RSPA usually carries out this responsibility with assistance from the relevant modal entities. For example, it works with USCG and the International Maritime Organization on marine transportation and with FAA and the International Civil Aviation Organization on air transportation.

Both RSPA and the individual modal agencies have various outreach programs to inform the regulated industries and state and local authorities about the federal requirements and what to do in the event of a hazardous materials incident. RSPA develops and publishes the *Emergency Response Guidebook*, which is provided to state emergency management agencies for distribution to local responders. It contains basic hazard identification and response information for those who are first to arrive

at the scene of a hazardous materials incident. RSPA also assists state and local authorities with enforcement and compliance training through the Transportation Safety Institute. DOT's modal agencies have similar outreach programs to the public and private sectors. As an example of the latter, FRA works with railroads, as part of its Safety Assurance and Compliance Program, to identify systemic safety issues, including issues pertaining to hazardous materials transportation, and to develop and implement plans to address them.

As noted earlier, NTSB conducts independent investigations of hazardous materials transportation accidents to determine probable causes and recommends corrective measures to DOT, other government agencies, and industry. Although NTSB does not have enforcement or regulatory authority, it monitors the actions taken in response to its recommendations, submits comments to DOT and other federal agencies on rulemakings, and testifies before Congress on matters related to hazardous materials transportation safety. It also conducts periodic special studies of multiple accidents to determine recurring safety problems.

Other Federal Agencies

Besides USCG, other federal agencies outside DOT have regulatory, enforcement, and related responsibilities pertaining to the transportation of hazardous materials. EPA designates certain materials as hazardous substances that are potentially harmful to human health and the environment if they are released in specific quantities. These designated substances are regulated by DOT in transportation. EPA also requires generators of hazardous wastes to keep track of shipments of these wastes by maintaining detailed manifests of their movements from origin to disposal.

The U.S. Department of Energy is responsible for carrying out the federal government's spent nuclear fuel and high-level radioactive waste disposal program. It has been transporting spent nuclear fuel for several decades as part of its research, defense, and cleanup missions. Most notably, its Office of National Transportation is responsible for planning and carrying out the multidecade program to transport spent fuel and high-level radioactive waste to a geologic repository. Federal standards for the design and performance of packages used for certain shipments of radioactive materials, including spent nuclear fuel, are set by the independent Nuclear Regulatory Commission.

Several other cabinet-level departments have notable responsibilities. The Department of Defense is responsible for establishing requirements governing the movement of most hazardous cargoes for military purposes. Within the Department of Labor, the Occupational Safety and Health Administration (OSHA) is responsible for regulating hazardous materials used and stored in the workplace, which has implications for transportation. The safety of transportation workers handling hazardous materials is within OSHA's purview, although some of these responsibilities are handled by DOT through memoranda of understanding between the two departments. OSHA has set package marking and labeling requirements for materials it has designated as hazardous in the workplace. It requires employers who use or store these materials in the workplace to maintain Materials Safety Data Sheets (MSDS), which contain emergency response information. MSDS are familiar to many emergency responders, who use them at both fixed-site and transportation incidents.

One way in which these varied roles and functions of the federal agencies are coordinated is through the National Response Team (NRT). NRT consists of 16 federal agencies with interests and expertise in various aspects of emergency response to hazardous materials incidents. EPA and USCG lead NRT, which acts as a national planning, policy, and coordinating body. In that capacity, NRT coordinates federal emergency response capabilities. Among other NRT member agencies are the Federal Emergency Management Agency, the Department of Agriculture, the Department of Health and Human Services, and the National Oceanic and Atmospheric Administration.

Finally, the security of the nation's hazardous materials freight has become a major concern since the terrorist attacks of September 11, 2001. DHS, along with its Transportation Security Administration (TSA) and Bureau of Customs and Border Protection, is taking a more prominent role in ensuring hazardous materials security. TSA was created by the Aviation and Transportation Security Act of 2001, which gave the agency comprehensive powers to identify security threats in all modes of transportation and to take actions to address them. The Homeland Security Act of 2002 gave DOT authority to prescribe regulations for "the safe

transportation, including security of hazardous materials in intrastate, interstate, and foreign commerce."[3] DHS and DOT therefore work together on many security issues pertaining to hazardous materials transportation. In particular, the two departments are examining enhanced security requirements for the rail transportation of hazardous materials that pose a toxic inhalation hazard.[4]

Roles of State and Local Governments

In the regulation of hazardous materials in transportation, federal rules preempt most state and local requirements. State and local governments cannot make requirements that unreasonably burden interstate commerce, reduce the overall safety of the transportation system, or interfere with the uniformity of federal regulatory standards (for instance, by developing different placard symbols). States and localities can limit movements of hazardous materials on public highways for clear safety

reasons (e.g., to restrict movements on certain bridges or in tunnels). However, they have limited authority to impose permits and fees for hazardous materials transportation or to adopt hazardous materials regulations that differ from those of the federal government.

Traditionally, states had more freedom to regulate the intrastate transportation of hazardous materials. However, DOT has long encouraged states to adopt regulations compatible with federal regulation, first under the State Hazardous Materials Enforcement Development Program and later under the Motor Carrier Safety Assistance Program (MCSAP) and the Cooperative Hazardous Materials Development Program. In 1997, Congress made the federal hazardous materials regulations fully applicable to intrastate transportation, and conflicting state rules were thus preempted.

State and local governments are responsible for enforcing federal hazardous materials regulations, especially those pertaining to truck transport. The federally funded MCSAP, which is administered by FMCSA, has strengthened state enforcement efforts by providing funding for

[3] See discussion of agency roles in the *Federal Register*, Volume 60, No. 157, Aug. 16, 2004, pp. 50988–50994.

[4] *Federal Register*, Volume 60, No. 157, Aug. 16, 2004, pp. 50988–50994.

this activity. MCSAP encourages states to conduct more frequent roadside and terminal safety inspections to ensure that federal (and state) requirements, including federal hazardous materials regulations, are being complied with. Historically, states have had less authority to enforce hazardous materials regulation pertaining to railroads, but changes in FRA provisions have given states more latitude to enforce the federal regulations. FRA has agreements with a number of states to conduct railroad inspections under federal authority.

State and local governments respond to hazardous materials incidents. The first responders are often local police and fire units, who may be warned of a hazardous material only by the presence of placards. Most local emergency responders are trained to recognize placards and take initial protective measures, but only a fraction are trained at the highest level of competence for dealing with threatened or actual hazardous materials releases. Metropolitan communities are more likely to have

specialized teams trained and equipped to handle hazardous materials accidents than are rural areas. Some states have therefore established hazardous materials response teams to assist in major emergencies, with planning and coordination handled through state emergency management agencies.

To aid state and local governments in preparing for hazardous materials emergencies, Congress established the Hazardous Materials Emergency Preparedness (HMEP) grant program in 1990. The grants are used by state and local authorities to develop and implement emergency plans, train public employees to respond to incidents involving hazardous materials, and determine flows and patterns of hazardous materials transported in their jurisdictions. Since 1993, state and local governments, as well as territories and Native American tribes, have been awarded about $100 million in grants. The grants are funded through registration fees collected from carriers and shippers of hazardous materials. The HMEP grant program and registration fee are discussed in more detail later in this report.

Industry Roles

The safety of hazardous materials transportation hinges on shippers and carriers fulfilling their respective roles. The role of shippers is especially important. Most shippers have compelling economic reasons to ensure the safe movement of their cargoes. Large shippers may tender and receive hundreds of bulk shipments and thousands of nonbulk shipments each day in their plants and distribution facilities. A single chemical plant, for instance, may have multiple loading and unloading areas for trucks and rail cars; these vehicles must be efficiently and safely loaded and unloaded to keep the plant in operation. Even minor incidents can be disruptive and costly. Consequently, most shippers of large quantities of hazardous materials have active safety programs to monitor the condition of the vehicles and containers that carry their products and to ensure that they are securely loaded and readied for transport.

Most DOT rules pertaining to hazardous materials transportation are directed toward shippers, which are responsible for ensuring that shipments are properly classified, named, packaged, marked, and labeled.

In addition, shippers must ensure that their shipments are accompanied by shipping papers with instructions on emergency response. With few exceptions, shippers are required to provide a 24-hour telephone number that can be used by emergency responders to obtain information about the hazardous shipment.

Trucking companies, railroads, and other carriers must abide by the rules governing the safe handling of hazardous cargoes, the routing of certain shipments, maintenance and inspection of vehicles, and temporary storage of hazardous materials en route. For instance, federal rules govern the positioning in the train of rail cars carrying hazardous materials. As noted earlier, carriers must report incidents and releases involving hazardous materials to DOT.

Many large shippers and carriers have specially trained emergency response teams that can assist in the response to a hazardous materials incident. The chemical industry maintains a mutual-aid network of emergency response teams (known as CHEMNET) that can be deployed in a few hours to assist carriers and local emergency personnel in responding to chemical emergencies around the country. The American Chemistry Council, the trade association for chemical manufacturers, maintains a 24-hour hot line known as CHEMTREC. Emergency responders can obtain hazard information and technical guidance from this hot line by giving the name of the product and nature of the emergency. CHEMTREC can also establish a communications link between the responders on the scene and the shippers, if the shippers are known.

Industry also has a role in promoting hazardous materials transportation safety through research, education, and training. As an example, the Association of American Railroads' (AAR's) BOE monitors and responds to incidents and works with shippers to ensure proper packaging of hazardous materials shipments. AAR oversees the setting of design standards for railroad tank cars. It also operates the Transportation Technology Center, Inc., in Pueblo, Colorado. The center, which receives some of its research funding from FRA and other DOT agencies, can conduct full-scale equipment tests and is often used by industry and government to test tank car designs, components, and construction

materials. It also coordinates classroom and field training on hazardous materials emergency response.

Several joint activities merit mention because they illustrate the industry's cooperation in promoting the safe transportation of hazardous materials. Since 1970, AAR and the Railway Supply Institute have cosponsored the Tank Car Safety Research and Test Project to identify and understand accident-caused releases from tank cars. The information derived from this research program has led to a number of changes in tank car design and operations to dramatically improve safety performance. Another example of a cooperative effort is the Transportation Community Awareness Emergency Response (TRANSCAER) program. Supported by shippers, carriers, and their trade associations, TRANSCAER promotes transportation safety by assisting communities in preparing for and responding to hazardous materials transportation incidents.[5] These efforts include assisting local communities with emergency response training and planning, participating in exercises to test the plans, and maintaining a dialogue with state and local authorities to keep emergency contacts and plans current.

Another means by which industry cooperates in the promotion of hazardous materials safety is through the Dangerous Goods Advisory Council (DGAC). DGAC, which has more than 100 shipper and carrier members, provides hazardous materials training and information to facilitate compliance with federal rules and the following of good safety

[5] TRANSCAER sponsors are the American Chemistry Council, the AAR Chemical Educational Foundation, National Tank Truck Carriers, Inc., and the Chlorine Institute.

practices in general. Another example of a public–private cooperative effort is the Commercial Vehicle Safety Alliance (CVSA), which seeks uniformity in commercial vehicle inspections and enforcement activities. CVSA operates several safety-related committees, including a hazardous materials committee comprising state enforcement personnel, motor carriers, and federal officials. The committee provides technical expertise related to hazardous materials transportation in an effort to reduce

incidents and encourage uniformity and consistency in the application of the regulations.

Box 2-1 provides a summary listing of many of the entities having important roles in ensuring the safe and secure transportation of hazardous materials.

BOX 2-1
Entities Involved in Ensuring the Safe and Secure Transportation of Hazardous Materials

FEDERAL: REGULATION, ENFORCEMENT, AND RESEARCH

Department of Transportation
Research and Special Programs Administration[a]
Federal Railroad Administration
Federal Motor Carrier Safety Administration
Federal Aviation Administration
Federal Highway Administration
Bureau of Transportation Statistics
National Highway Traffic Safety Administration

Department of Homeland Security
United States Coast Guard
Transportation Security Administration
Bureau of Customs and Border Protection
Federal Emergency Management Agency

Department of Energy
National laboratories

Nuclear Regulatory Commission

Department of Defense
U.S. Army Corps of Engineers

Occupational Safety and Health Administration

Environmental Protection Agency

National Transportation Safety Board

STATE AND LOCAL: INFRASTRUCTURE, EMERGENCY RESPONSE, AND ENFORCEMENT

State emergency planning management offices
Local emergency management offices and committees
State and local police
Local firefighters
State, regional, and local hazardous materials response units
State highway, railroad, and transportation agencies
State and regional airport and marine port authorities
State environmental protection agencies

PRIVATE COMPANIES: OPERATIONS, INFRASTRUCTURE, PRODUCTION, AND USE

Carriers: truck, railroad, pipeline, barge, maritime (about 45,000 dedicated; about 500,000 occasional)
Shippers (about 45,000 regular; about 30,000 occasional)
Receivers: farms, disposal sites, refineries, factories, retailers, hospitals

INDUSTRY ASSOCIATIONS: STANDARDS, TRAINING, AND EMERGENCY RESPONSE

Dangerous Goods Advisory Council

Commercial Vehicle Safety Alliance

Association of American Railroads
Bureau of Explosives
Tank Car Committee

Railway Supply Institute
RSI–AAR Tank Car Safety Research and Test Project

American Chemistry Council: CHEMTREC, CHEMNET (with shippers)

American Trucking Associations

National Tank Truck Carriers, Inc.

NOTE: This list is intended not to be comprehensive but to summarize the organizations and entities identified in Chapters 2 and 3. Several international organizations not listed here, such as the United Nations, also serve in various standard-setting and educational capacities.

[a] As noted in the Preface, Congress has passed legislation dividing RSPA into separate administrations for research activities and hazardous materials and pipeline regulatory functions.

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Abbreviations

AAR Association of American Railroads

NTSB National Transportation Safety Board

RSPA Research and Special Programs Administration

TRB Transportation Research Board

USACE U.S. Army Corps of Engineers

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