# HAZARDOUS MATERIALS SHIPMENTS

**Prepared by**

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Prepared by the Office of Hazardous Materials Safety

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***SUMMARY*:**

The Office of Hazardous Materials Safety presently estimates the number of hazardous materials shipments in the United States at more than 800,000 per day. Approximately 500,000 daily shipments involve chemical and allied products (SIC 28); about 300,000 involve petroleum products; and at least 10,000 other shipments involve waste hazardous materials, medical wastes and various other hazardous materials. Shipments are defined as equivalent to deliveries, and in most instances may be distinguished from the number of movements, trip segments, or other measures. The estimated number of *movements* associated with these shipments exceeds 1.2 million per day (Table 1).

**Table 1: HAZARDOUS MATERIALS SHIPMENTS MOVEMENTS and TONS [1]**

| Product Group | Daily Shipments | Daily Movements [2] | Annual Tons Shipped | Annual Tons Moved |
|---|---|---|---|---|
| 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 |
| **TOTALS** | **> 800,000** | **> 1,200,000** | **>3.1 billion** | **> 3.9 billion** |

While only about 43% of all hazmat *tonnage* is transported by truck, approximately 94% of the individual *shipments* are carried by truck. The air mode, while almost negligible in terms of tonnage, also has a share of individual shipments that greatly exceeds its percent of tonnage carried: less than 1% of all hazmat tonnage but about 5% of all hazmat shipments. In contrast, enormous amounts of hazmat tonnage are carried by rail, pipeline and water modes, and in some markets they are the only modes that haul hazmat products. Yet, the total number of shipments for all three of these bulk commodity modes is less than 1% (Table 2).

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

[2] Movements are defined in Section 3 and discussed further in Appendix C. They correspond to the movement of vehicles, rail cars, etc. that carry shipments, and in some cases they are equivalent to shipments.

## Table 2: HAZMAT SHIPMENTS, MOVEMENTS and TONS by MODE

| | Shipments | % | Movements | % | Tons Shipped | % | Tons Moved | % |
|---|---|---|---|---|---|---|---|---|
| | **CHEMICALS & ALLIED PRODUCTS** | | | | | | | |
| Truck | 445,218 | 90.3% | 830,761 | 89.36% | 808,662 | 55.52% | 894,452 | 37.30% |
| Rail | 3,723 | 0.8% | 11,169 | 1.20% | 335,070 | 23.00% | 1,005,210 | 41.92% |
| Pipeline | 34 | 0.0% | 34 | 0.00% | 127,500 | 8.75% | 127,500 | 5.32% |
| Water | 82 | 0.0% | 164 | 0.02% | 181,279 | 12.45% | 362,558 | 15.12% |
| Air | 43,750 | 8.9% | 87,500 | 9.41% | 4,049 | 0.28% | 8,098 | 0.34% |
| **SUBTOTAL -- a** | **492,807** | 100% | **929,628** | 100% | **1,456,560** | 100% | **2,397,818** | 100% |
| | **PETROLEUM PRODUCTS** | | | | | | | |
| Truck | 313,689 | 99.5% | 313,689 | 99.15% | 2,857,470 | 40.04% | 2,857,470 | 34.39% |
| Rail | 448 | 0.1% | 1,344 | 0.42% | 40,320 | 0.57% | 120,960 | 1.46% |
| Pipeline | 839 | 0.3% | 839 | 0.27% | 3,146,250 | 44.09% | 3,146,250 | 37.87% |
| Water | 253 | 0.1% | 506 | 0.16% | 1,091,646 | 15.30% | 2,183,292 | 26.28% |
| Air | - | 0.0% | - | 0.00% | - | 0.00% | - | 0.00% |
| **SUBTOTAL -- b** | **315,229** | 100% | **316,378** | 100% | **7,135,686** | 100% | **8,307,972** | 100% |
| | **OTHER HAZMAT** | | | | | | | |
| **Truck -- c** | 10,000 | 98.6% | 10,000 | 95.9% | 43,048 | 92.43% | 43,048 | 80.27% |
| Rail | 144 | 1.4% | 432 | 4.1% | 3,526 | 7.57% | 10,578 | 19.73% |
| Pipeline | - | 0.0% | - | 0.0% | - | 0.00% | - | 0.00% |
| Water | - | 0.0% | - | 0.0% | - | 0.00% | - | 0.00% |
| Air | - | 0.0% | - | 0.0% | - | 0.00% | - | 0.00% |
| **SUBTOTAL** | **10,144** | 100% | **10,432** | 100% | **46,574** | 100% | **53,626** | 100% |
| | **TOTAL HAZMAT** | | | | | | | |
| Truck | 768,907 | 93.98% | 1,154,450 | 91.88% | 3,709,180 | 42.94% | 3,794,970 | 35.27% |
| Rail | 4,315 | 0.53% | 12,945 | 1.03% | 378,916 | 4.39% | 1,136,748 | 10.57% |
| Pipeline | 873 | 0.11% | 873 | 0.07% | 3,273,750 | 37.90% | 3,273,750 | 30.43% |
| Water | 335 | 0.04% | 670 | 0.05% | 1,272,925 | 14.73% | 2,545,850 | 23.66% |
| Air | 43,750 | 5.35% | 87,500 | 6.96% | 4,049 | 0.05% | 8,098 | 0.08% |
| **DAILY TOTALS -- d,e** | **818,180** | 100% | **1,256,438** | 100% | **8,638,820** | 100% | **10,759,416** | 100% |
| **ANNUAL TOTALS -- f** | **298,635,700** | | **458,599,870** | | **3,153,169,300** | | **3,927,186,840** | |

" - " is negligible and, in some instances, might actually be zero.

-- a Daily shipment subtotal is rounded to 500,000 in Table 1and in text.

-- b Daily shipment subtotal is rounded to 300,000 in Table 1 and in text.

-- c This figure is at least 10,000 and could range as high as 80,000 or more daily shipments. Waste hazmat, medical waste, various industrial products and other materials comprise this category. Virtually all shipments in the "Other" hazmat category are transported by truck. See Appendix G for detailed estimates within the "Other" category.

-- d Daily *shipment* TOTAL rounded to > 800,000 in Table 1 and text.

-- e Daily *movement* TOTAL rounded to > 1,200,000 in Table 1 and text.

-- f Annual tons *shipped* and *moved* are rounded to > 3.1 billion and > 3.9 billion in Table 1 and text.

## 1. BACKGROUND - INTRODUCTION:

Ensuring the safe transport of hazardous materials within the United States is primarily the responsibility of the U.S. Department of Transportation (DOT). Within DOT, the Research and 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 hazardous materials.

Hazardous materials (hazmat) shipment information plays an important role in RSPA's ability to achieve its mission. Developing cost-effective regulations and helping emergency responders plan for hazmat transport risks are among the activities that rely on information about hazmat shipments occurring in the U.S.

For the past decade, government and hazmat industry officials have used an estimate of more than 500,000 shipments to characterize daily hazmat traffic in the U.S.-- and implicitly the level of risk to the transport community and general public. That estimate was not unreasonable. A 1988 DOT (Volpe Center) study, for example, indicated some 546,000 daily shipments, consisting primarily of petroleum products and chemicals & allied products. [3] Other data sources suggested shipment levels of at least a similar order of magnitude. [4]

This brief report and its underlying analysis are an attempt to update the 500,000 daily shipment estimate. At the same time, the report introduces the concept of hazardous materials *movements*, with the intent of supplementing *shipment* data with a measure that conveys additional information about hazmat transport risk. The appendix materials identify component estimates, underlying assumptions, data sources, and other related information. Virtually all figures in both the text and appendix are estimates and could be rounded to nearest thousands, million, etc. Where precise figures are used, the intent is not to convey a false sense of precision, but rather to facilitate tracking the data and methodology used.

## 2. DEFINITIONS: Shipment, Movement.

**Shipment.** The definition of *shipment* used in this analysis is consistent with the Bureau of Census definition which uses the concept of an *individual delivery*. Instructions for the 1992 Commodity Flow Survey (CFS) note:

A "shipment" (or "delivery") is an individual movement of commodities **from** your

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[3] The Volpe study produced an estimate of 200 million annual shipments. That figure divided by 365 days = 546,000 daily shipments. The study covered truck only, but truck was accurately assumed to constitute the vast majority of individual shipments.

[4] The Bureau of Census Truck Inventory Use Survey (TIUS) figures suggest estimates of a similar magnitude. For example, TIUS indicated there were 340,000 trucks in 1987 belonging to the nation's total hazmat fleet: 99,000 hauling primarily petroleum; 47,000 hauling chemicals; 88,000 mixed; and 107,000 other. The 1992 TIUS study indicates 365,000 vehicles in the hazmat fleet. If it is assumed that some trucks deliver multiple hazmat shipments every day while other trucks are not used at all, a preliminary estimate of more than 500,000 daily shipments would not be unreasonable.

establishment **to** one customer OR **to** another location of your company (including a warehouse, distribution center, retail or wholesale outlet). A shipment uses one or more modes of transportation, including parcel delivery, U.S. Postal Service, courier, private truck, for-hire truck, rail, water, pipeline, air, and other modes.

Please note that for this survey:

A full or partial truckload can be considered **one** shipment **only** if all the commodities are destined for one buyer/receiver at one location. If the truck makes multiple deliveries on a route, **each stop is considered (at least) one shipment.**' (*emphasis in the original*, 1993 CFS, p. E-18)

This definition does have certain limitations, some of which are identified and discussed in Section 3. Overall, however, the definition provides a consistent and useful base line for analyzing freight traffic generally and hazmat traffic in particular.

**Movement**. We are unaware of any formal definitions of "movement" in the context of hazardous materials transportation statistics, but implicit meanings of the word seem intuitive. If a single container of freight is hauled by truck to a rail intermodal terminal; placed on a rail car and hauled 1,000 miles to a second rail intermodal terminal; and then placed on a truck for final delivery, that one *shipment* is presumed to entail three separate *movements*: 1) highway 2) rail, and then 3) highway again. Following that general schematic, we would define a movement of hazardous materials as:

*Transportation by a single vehicle, rail car, aircraft, vessel, or other mode from a point of origin to a point of either: a) transfer to another vehicle, train, aircraft, vessel or other mode or b) final delivery of the freight, whichever comes first.*

It should be noted that while a movement associated with a shipment and a movement associated with a vehicle (rail car, aircraft, etc.) are often the same, the relationship does not hold in all cases. For example, in the intermodal shipment just described, each *movement* of the shipping container does correspond with a separate truck or rail car movement.

When small package and less-than-truckload (LTL) shipments are consolidated, however, a single **vehicle** movement may incorporate the movement of numerous individual shipments. For example, an intermodal situation might involve a freight container with, say, 12 different pallets of bagged chemicals, with each pallet destined for a separate customer. In that same situation, the 12 pallets could have originated from a single origin point; been transported as a group of pallets aboard a single truck from the manufacturer to the rail facility; as a group while aboard a single rail car; and then, upon arrival at the destination railroad facility, as 12 individual pallets each distributed aboard a separate delivery vehicle. Each pallet or shipment was transported by two different vehicles and one rail car, or thus *moved* three different times for a total of 36 *movements.* Yet, the total number of vehicle and rail movements associated with these 12 shipments was only one truck, plus one rail, plus twelve subsequent truck movements for fourteen total *movements* (1+1+12 = 14), not thirty-six.

In Table 1 and elsewhere in this report, the estimates of hazmat movements correspond to the separate vehicle, rail car, aircraft or vessel movements associated with the shipments, not the

individual shipment movements themselves. For the preceding example, this report would consider the appropriate estimate of *movements* as 14, not 36. This concept of movement is discussed further in Section 3 and in Appendix C.

## 3. SHIPMENTS, DELIVERIES, MOVEMENTS and OTHER MEASURES:

How *shipments*, *movements*, and similar terms are defined greatly affects the estimates of those measures. The following schematics show how various shipment and mode configurations have different implications for estimating shipments, movements, vehicle trips, etc. This section is not suggesting that there is government or industry-wide agreement on the use of the terms. Rather, the schematics are presented to illustrate terminology and help show the basis on which the different measures are tallied (Figure 1).

Schematic #1 in Figure 1 represents a truckload (TL) operation, with material loaded at Point A, shipped directly to Point B, and unloaded at Point B. That operation can be viewed as one shipment, one delivery, and one movement.

### Figure 1: SHIPMENT and MOVEMENT SCHEMATICS

| SCHEMATIC # | | | No. of Shp | No. of Mov |
|---|---|---|---|---|
| # 1) | TL: | A ---------- Truck ---------- > B | **1** | **1** |
| # 2) | LTL: | A ---------- Pick-up Truck ---------- > B ---------- Line-haul Truck ---------- > C ---------- Delivery Truck ---------- > D | **1** | **3** |
| # 3) | Rail: | A ---------- Rail ---------- > B | **1** | **1** |
| # 4) | Truck/Rail: | A ---------- Truck ---------- > B ---------- Rail ---------- > C ---------- Truck ---------- > D | **1** | **3** |
| # 5) | Air Cargo: | A ---------- Truck ---------- > B ---------- Air ---------- > C ---------- Truck ---------- > D | **1** | **3** |
| # 6) | Air Package: | A ----- Van -----> B ----- Van -----> C ---------- Air ----------> D ---------- Air ----------> E ----- Van -----> F ----- Van -----> G | **1** | **6** |
| # 7) | Heat. Oil Del: | A ---------- Truck ----------> B ------- Tr -------> C ------- Tr -------> D ------- Tr -------> E ------- Tr -------> F | **5** | **5** |
| # 8) | Other "Milk" Runs: | A ---------- Truck ----------> B ------- Tr -------> C ------- Tr -------> D ------- Tr -------> E ------- Tr -------> F | **5** | **5** |

NOTES: Shp = shipments Mov = movements Tr = truck.

Schematic #2 represents a less than truckload (LTL) operation, where a shipment -- say 1,000 lbs. in size but technically any shipment less than 10,000 lbs.-- is picked up at Point A and transported locally to Point B where it is consolidated with other shipments; placed in long-haul carriage to Point C; and sorted at Point C for local distribution to Point D. The report's totals of more than 800,000 daily shipments and more than 1,200,000 daily movements, treat Schematic #2 as involving one *shipment* but three *movements*. (Schematics # 3-5 resemble #1 or # 2).

Schematic #6 represents the expedited shipment of a small package by air. Expedited air shipment operations typically utilize an air hub with a network of local and regional sort centers for ground pick-up and delivery. A package picked-up in the suburbs of a large metro area, for example, and intended for overnight shipment by air, is likely to be transported by small truck or van to a local or regional ground hub; subsequently trucked to the origin city's airport; flown to a hub airport; flown from the hub airport to the destination city's airport; trucked from that airport to the local hub; and trucked to the recipient. That one *shipment* would have six *movements* and one final *delivery*.

Schematic #7 shows yet another type of distribution pattern. For purposes of this analysis and report, an oil delivery truck used to distribute, for example, 2,000 gallons of heating oil to five different residential customers -- with each customer taking an average delivery of 400 gallons -- is considered to make five *shipments* and five *movements*. [5] This kind of distribution pattern, illustrated by the five deliveries in Schematic # 7, is sometimes referred to as a *milk run*. It is assumed that in a milk run situation, the number of *shipments*, *deliveries*, and *movements* are all equal.

Within the estimate of 315,229 daily hazardous petroleum product shipments, there are approximately 90,000 home heating oil (distillate) *milk run* shipments, 50,000 propane *milk run* shipments, and 30,000 lubricants *milk run* shipments. These amounts leave an estimated 145,000 shipments that are not milk runs. For Chemical and Allied Products (SIC 28), the extent of milk runs included in the data is not presently known. (See Appendix B for petroleum products shipment estimates.)

Finally, it may be noted that trip segments, vehicle trips, vehicle loadings, load factors and other measures can be used to characterize hazmat or most any type of freight traffic. In Schematic #2, for example, the transportation from A to B, B to C, and C to D are generally referred to as separate *trip segments*. In theory, those three trip segments would also be referred to as three *vehicle trips*, although informally the total transportation from A to D might be considered by some as a single vehicle trip. In Schematic #7, the 2,000 gallon oil delivery truck is assumed to entail one *vehicle loading*, even though the vehicle makes five deliveries or shipments. Again in Schematic #7, the actual *load factor* (amount inside the vehicle) would be

different for every trip segment: 2,000 gallons on the trip from A to B; 1,600 gallons from B to C;

[5] The assumption is explicit in this report and implicit in the Census CFS data. We say implicit in the CFS data because, while it seems clear from the CFS survey directions that a shipper sending multiple pallets destined for multiple customers should treat those goods as multiple shipments, it is less clear that a local distributor of home heating oil would view a single 2,000 gallon heating oil run to numerous home owners as constituting "multiple shipments."

1,200 gallons from C to D, etc. Still other measures would depend on certain pick-up and delivery assumptions, as well as on other data. In Schematic #1, for example, it is possible to have a loaded *outbound* vehicle trip from A to B and an empty *return* vehicle trip associated with that single shipment. If the vehicle were completely full on the outbound and completely empty on the return, its *empty/loaded* ratio would be 50%.

## 4. SHIPMENT ESTIMATES as a PROXY for RISK.

Numbers of hazmat shipments, whether estimates or very precise tallies, by themselves provide only a partial look at the risks inherent in hazardous materials transportation. Ten shipments of one commodity, for example, might pose far greater risk than hundreds of shipments of another. Moreover, many other shipment characteristics and assumptions, besides commodity type, help determine the risks associated with any given hazmat traffic.

This report recognizes the limitations of hazmat shipment estimates by themselves as a proxy for risk. Consistent with that recognition, this section briefly discusses some of the many additional factors that would have to be examined, were a comprehensive analysis of hazmat shipment risk to be undertaken.

**Movements and Handlings**. It has already been suggested that hazmat *movements* provide a more detailed picture of the nation's hazmat traffic than shipment numbers alone. Data in Tables 1 and 2 and the schematics in Figure 1 show that estimated hazmat movements readily exceed the estimated number of shipments. To the extent each *movement* entails a change of vehicle or driver; a loading or unloading of material; or exposure to other workers and the general public at interim destinations that exceeds a shipment's exposure along its route, then *movements* do convey a more complete picture of risk than *shipment* numbers alone.

For some types of traffic, the concept of a *shipment* barely begins to portray the complex configuration of people, equipment and settings associated with that shipment. Results of a recent air carrier and freight forwarder study, for example, amplify just how complex a single air freight "shipment" can be, suggesting that even the tracking of *movements* does not fully characterize a single shipment's potential risk. Referring to a study conducted by Unisys Corp., one industry observer noted:

> "The Unisys study found the typical traditional air cargo shipment takes six days to reach the consignee, is handled 36 times, stored in six locations and generates 12 pieces of paper that must be processed." (Traffic World, 5/26/97, p. 51)

The Unisys study introduces yet another potential risk measure -- *handling*. It is not clear how a tally of "handlings" might compare with a tally of "movements" for any given set of freight shipments, and no formal attempt has been made in this report to estimate total *handlings* for the nation's hazmat traffic. Preliminarily, it would appear that there are at least two *handlings* for every one *movement*. The term is cited here, nevertheless, to indicate yet another dimension by which shipment risk analyses might be expanded.

**Annual Figures, Daily Peaks and Seasonal Peaks.** It is understood that in any seven day week most freight traffic probably occurs during the six days, Monday - Saturday. Thus, in terms of a snapshot of daily traffic in the U.S., using a 300-day year (representing 6, not 7, days per week) probably provides a more realistic picture and would increase daily estimates by about 14%. Moreover, it is important for emergency response planners who prepare local responders for incident risks to know that most daily traffic may be higher than 7-day per week estimates would suggest. However, to avoid a debate as to whether freight movement in the U.S. is a 7-day per week industry, this report uses the convention of a 365- day year.

In a similar way, seasonal flows of certain hazardous materials products can greatly affect actual daily levels of traffic. Home heating oil, for example, is delivered to far fewer homes in the summer months than during winter months. Thus, a more realistic picture of heating oil shipments might nearly double the deliveries in winter months while cutting summer daily estimates to near zero. No such adjustment has been made in this report, but the potential effect on peak daily estimates is herein noted.

**Shipment Quantity; Type and Condition of Infrastructure and Other Factors**. Generally speaking, the amount of material being transported affects its potential risk. One hundred pounds of material, for example, is usually less dangerous than one thousand pounds. It is true that a jerrycan (approximately five gallons) full of gasoline might be as risky as a full tank truck of gasoline because of careless bracing or driver indifference to the load. However, the relationship that large quantities are potentially more dangerous than small quantities generally holds true.

Type and condition of infrastructure affect risks. Two-lane rural roads typically have much higher accident rates than divided, multi-lane interstate highways. And similarly, interstate highway segments with narrow shoulders and damaged pavement are generally more risky than interstate segments without these problems.

Numerous other factors further characterize shipment risk. Driver/operator experience and skill level; condition of vehicles, and many other factors all contribute to the safety of hazardous materials transport. Thus, 800,000 daily shipments in the late 1990s might actually be safer than 500,000 daily shipments were in the 1980s. This report makes no judgement on that issue. Instead, to the extent that shipment and movement estimates themselves are instructive, this report attempts to improve the available estimates.

## 5. HAZMAT INDUSTRY PERSPECTIVE: Trucking, Vehicles and Tonnage.

**Prevalence of Trucking.** Although productivity and profits for the U.S. freight railroads have reached record highs nearly every year since deregulation by the Staggers Act in 1980, by certain other measures, rail transport in the United States actually peaked in 1929. That was the industry's high water mark in terms of employment, miles of track operated, share of the intercityn freight market, and many other measures. Today, while freight railroads remain a vital part of the nation's transport sector and overall economy, the dominant U.S. freight mode is truck. Although accounting for only about 25% of ton-miles and 45% of total tons moved

annually in the U.S., the trucking sector accounts for over 75% of freight revenues. And, in terms of hazmat shipment count, truck share is close to 94% of all hazmat shipments. Thus, for many measures of the freight market generally, and hazmat shipment estimates in particular, knowing the trucking sector role is key to understanding the broader industry.

**Number of Vehicles and Fleet Utilization.** The 1992 Truck Inventory and Use Survey (TIUS) indicates that approximately 60 million of the nation's 200 million vehicles are trucks, with the vast majority being personal use pick-up trucks. TIUS figures also show that some 16 million of the 60 million trucks, ranging from pick-ups and vans to heavy combination trucks, are involved in commercial transport activities (*business use*). Finally, the 1992 TIUS figures indicate about 365,000 trucks are in the hazmat fleet, implying that some 2.3% of the nation's commercial truck fleet is involved in hazmat transport (365,000/16,000,000).

The 1996 National Fleet Safety Survey, a report based on a study conducted by the Federal Highway Administration (FHWA) at various nationwide inspection stations, indicated that about 7.0% of the commercial truck fleet they surveyed were vehicles that transport hazardous materials. Because FHWA regulations generally exclude vehicles with a gross vehicle weight (gvw) under 10,000 pounds, however, the number of vehicles comprising the FHWA total commercial vehicle fleet is closer to 5-6 million vehicles. A figure of 7.0% suggests a 1996 hazmat fleet of some 360,000 - 420,000 vehicles -- not unlike the TIUS figure of 365,000.

Of the more than 800,000 daily hazmat shipments, approximately 770,000 are transported by truck (Table 2). Using a hazmat fleet size of 365,000 vehicles suggests that the average hazmat truck delivers just over 2.1 shipments per day. Given the industry's operating conditions, where one truck might be devoted to a single TL shipment for a period of one to three days, but trucks handling LTL and small package shipments might make several deliveries in a single morning, an average fleet utilization figure of multiple shipments per day is to be expected.

**Hazmat Tonnage Produced v. Tonnage Shipped.** The amount of hazmat produced (consumed) each year in the U.S. is close to 2 billion tons, while the amount shipped is closer to 3 billion tons. This relationship suggests that every ton, on average, is shipped 1.5 times. While the relationship holds for the hazmat industry as a whole, the ratio of tons produced/tons shipped is very different for Chemical & Allied Products than for Petroleum Products.

For Chemicals & Allied, the amount transported is apparently much less than the amount produced. The 1992 CFS shows 545,000,000 tons of Chemical or Allied products (STCC 28) transported in the U.S. For 1995, the Chemical Manufacturers Association (CMA) estimates 642,000,000 tons transported in the U.S. It is generally understood that for economic and/or safety reasons, major amounts of chemicals in the U.S. are "consumed" on plant-sites and converted into other products before they are *shipped* to other destinations. How high the initial production figure is unclear. One chemical industry source estimates that close to one billion tons of chemicals may actually be produced in the U.S., even though only some 642 million tons are transported (using the CMA figure). This suggests a ton shipped/ton produced ratio of only 0.64.

It is reasonable to assume that some or even much of the tonnage which is shipped includes tons (products) that are actually shipped more than once. It is even plausible that the original amount of SIC 28 tonnage that is eventually shipped -- and excluding those tons that are

not shipped -- could be as little as, for example, 320 million tons. This relationship would suggest: one billion tons produced = 680 million tons consumed on site + 320 million tons shipped off site. Once the 320 million tons were shipped, they would be reshipped for a total of 320 million x 2 = 640 million tons shipped. In this analysis and report, the estimates of tons shipped, i.e., the CFS 545 million ton figure and the CMA 642 million ton figure, are considered reasonably reliable data. What the estimate of tons *initially produced* might be is far less certain.

In contrast to chemical and allied product tonnage, petroleum product tons clearly involve, on average, multiple shipments of each ton produced. According to Department of Energy sources, The U.S. supplied about 18 million barrels of petroleum products per day in 1996 (Appendix Table B1). That amounts to a starting supply of nearly one billion tons annually. [6]

Some tons of petroleum products are shipped directly from ports of entry to end users/retail outlets. Tons distributed in that manner would be tallied as shipped once, delivered once, and moved once. Most petroleum products in the U.S., however, are shipped more than once. On average, each ton of petroleum products is shipped about 2.3 times, resulting in annual production of close to 1.0 billion tons but shipment of nearly 2.3 billion tons.

## CONCLUDING NOTES:

**Review and Recalibration.** This report deliberately uses the word "estimate." It does not presume to provide dispositive, unchallengeable "counts." It is well known, for example, that industries continually undertake operational changes to increase efficiencies, reduce risk, or both. In gasoline distribution, for example, the present trend is toward use of larger vehicles and fewer reshipments of product. Even as U.S. daily consumption of petroleum products has grown steadily from 17 million barrels per day in 1992 to close to 19 million barrels per day in 1998, the number of daily petroleum product shipments could be declining, depending upon corporate distribution and fleet utilization strategies. Thus, these estimates may be viewed as subject to continuing review and recalibration. Suggestions from industry and other knowledgeable sources regarding how to improve the underlying data assumptions and the accuracy of the overall estimates are welcome.

**1997 Commodity Flow Survey**. It may also be noted that preliminary data from the 1997 Commodity Flow Survey should be generally available some time in late 1998, with expanded, final figures available probably in late 1999. Those figures may indicate important changes or trends as to how many hazmat shipments are occurring in the U.S., as well as important information about product type, shipment size and mode of transport.

[6] Eighteen million barrels x 42 gallons x 7.15 lbs./2,000 lbs. x 365 days = 985 million tons.

# PREPARING HAZARDOUS MATERIALS OR WASTE FOR SHIPMENT

Many fabricators overlook the fact that they are governed by Department of Transportation (DOT) regulations whenever they ship off hazardous waste or transfer a drum of resin from one facility to another one -- even if it is just across the street. A brief overview is provided -- more detailed requirements can only be determined when the commodity to be shipped has been properly identified.

**Training:** Each employee involved in the shipment of hazardous materials, be it preparing the shipping paper or hazardous waste manifest to packaging and labeling the drum, must be trained on DOT requirements at least every three years.

**Preparing Shipping Papers:** All hazardous materials or waste must be correctly identified on the shipping paper. The DOT requires that all materials be properly identified according to descriptions from their Hazardous Materials Table. At a minimum, shipping papers or manifests must include:

- Shipper's name and address
- Consigne's name and address
- Basic description: Shipping name, hazard class, ID number, packing group -- in that exact order
- Weights and volume
- Total quantity, type and kind of package
- Emergency response information
- 24-hour emergency response telephone number
- Shipper's declaration -- stating that everything meets DOT requirements
- Page numbers
- Title and signatures

**Emergency Response Information:** The following information must accompany the shipping paper:

- Basic description and chemical names
- Immediate health hazards
- Risks of fire or explosion
- Immediate precautions to take in the event of an accident or incident
- Immediate methods for handling spills or leaks
- Preliminary first aid measures

This information can be provided by attaching an MSDS or ensuring that the transporter has a copy of the Emergency Response Guidebook.

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Many facilities use Chemtrec's phone number -- this number is only allowed to be used if you have registered with them!! You must ensure that the phone number on the paper will enable emergency responders to immediately access someone with a good understanding of the hazardous material being shipped and emergency procedures.

**Properly Pack and Prepare Containers for Transport:** All containers must meet the DOT's Performance Oriented Packaging standards (POPs). Packaging must be embossed with the proper UN code according to what is being shipped.

**Properly Mark and Label Containers:** All containers must be labeled with an approved hazard class label (4" x 4" diamond), proper shipping name, identification number and the shipper and consignee's name and address.

**Shipping and Placarding:** Any hazardous materials shipment weighing more than 1,000 lbs. in aggregate weight may only be hauled by a driver with a CDL license that contains a hazardous materials endorsement. The vehicle must be placarded on all four sides identifying the hazardous materials being carried.

Excellent overviews of the requirements and training material on Hazardous Materials Safety can be located at **http://hazmat.dot.gov/training.htm**.

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# HAZARDOUS MATERIALS REGISTRATION PROGRAM

As of July 1, 2000, the DOT has required *anyone* who offers a single shipment containing 1,000 lbs. or more of one or more classes of hazardous materials or hazardous wastes that require placarding to register with the DOT. Most Small Quantity Generators are going to be covered by this DOT program due to the fact that their Acetone waste stream often weighs more than 1,000 lbs. when it is being shipped off-site. The EPA's Hazardous Waste Manifest is the shipping paper which will indicate whether your facility should have registered or not.

- The registration year is July 1 to June 30 for each filing year.
- The annual registration fee for years beginning with 2003 – 2004 is $150 for each facility meeting the Small Business Administration's size standard for a small business and $300 for each facility that does not meet those standards.
- Copies of the registration statement and the certificate of registration must be kept for three years at your principal place of business and must be available for inspection.
- The requirement to register with DOT is based on a federal law. Federal, state, or local officials may impose penalties for failing to register or failing to meet the recordkeeping requirements.
- If you have failed to register in the past, you must file a registration statement and pay the appropriate fee for each year for which you need to register.

The DOT has an easy on-line registration system. This can be accessed at http://hazmat.dot.gov/register.htm. Questions about the Hazardous Materials Regulations can also be called into the Hazardous Materials Information Center at 800/467-4922.

***Please call the Composites One's Department of Health, Safety & Environment at 800/621-8003 for more detailed information on DOT requirements.***

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# HAZARDOUS MATERIALS TRANSPORTATION SECURITY

Anyone who offers or transports a single shipment containing 1,000 lbs. or more of one or more classes of hazardous materials or hazardous wastes that require placarding must have a security plan in place by September 25, 2003.

The security plan must include an assessment of possible transportation security risks for shipments and appropriate measures to address the assessed risks. At a minimum, the plan must include the following elements:

- **Personnel Security**. Measures to confirm information provided by job applicants hired for positions that involve access to and handling of the hazardous materials covered by the security plan.

- **Unauthorized Access**. Measures to address the assessed risk that unauthorized persons may gain access to the hazardous materials covered by the security plan.

- **En Route Security**. Measures to address the assessed security risks of shipments of hazardous materials covered by the security plan.

The security plan must be in writing and be retained for as long as it remains in effect. Copies of the plan must be available to employees who are responsible for implementing it. The plan must be revised and updated to reflect changing circumstances.

**Security Awareness Training:** No later than the date of the first scheduled recurrent required hazmat employee training after March 25, 2003 (no later than March 24, 2006) must now include training that provides an awareness of security risks associated with hazmat transportation and methods designed to enhance transportation security. There must also be a component covering how to recognize and respond to possible security threats. New employees must be trained within 90 days after employment.

**In-depth Security Training:** By December 22, 2003, each hazmat employee must be trained concerning the security plan and its implementation. Security training must include:

- Company security objectives
- Specific security procedures
- Employee responsibilities
- Actions to take in the event of a security breach
- Organizational security structure

Guidelines and training material may be found on the DOT's website at **http://hazmat.dot.gov/hmt_security.htm**.

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The table on the following pages lists the 9 hazard classes, basic definitions, and a few examples of hazardous materials for each class. Click on the *49CFR Reference* link to view the DOT full definition.

# Material Classification

**There Are Nine Hazardous Material Classifications.**

## Class 1 - Explosives

Reference 49CFR173.50 (Definitions)

There are 6 sub-divisions for explosives based on the type and severity of explosion. Materials or devices in Class 1.1 present a mass explosion hazard, while Class 1.6 applies to very insensitive explosive articles that do not present mass or projectile explosion risks. Some examples of Class 1 items are air bag inflators, ammunition, gun powder, water-activated contrivances, liquid propellant, primers, jet fuel and fireworks. Some explosives are forbidden from being offered for commercial transportation.

## Class 2 - Gases

Reference 49CFR173.115 (Definitions)

There are three types of gases - flammable, poisonous and compressed. Examples of flammable gases are certain aerosols, starting fluids, butane, propane, acetylene and cigarette lighters. Examples of poisonous gases are carbon monoxide, chlorine, nitric oxide, hydrogen and anhydrous ammonia. Compressed gases may be neither flammable nor poisonous but are packaged in a manner so that the absolute pressure is 40.6 psi or greater. Compressed gases can include liquefied gas, cryogenic gas, asphyxiate gas and oxidizing gas, also including compressed air and airbag inflators.

## Class 3 - Flammable Liquids

Reference 49CFR173.120 (Definitions)

The number of materials that qualify as flammable liquid is large. Flammable liquids are generally defined as "liquid having a flash point of not more than 60.5 C (141F). This class also included combustible liquids which are liquids that do not meet the requirements of any other hazard class, and has a flashpoint above 60.5 C (141F), but below 95 C (200F). Examples of flammable liquids can include gasoline, diesel fuel, kerosene, crude oil, methanol, paint, adhesives, certain medicines and rosin oil. Although there are no class subdivisions, flammable liquids fall into three packing groups which are determined by both flash point and initial boiling point.

## Class 4 - Flammable Solids

Reference 49CFR173.124 (Definitions)

In general there are three types of materials that qualify as flammable solids. 1: certain types of desensitized explosives. 2: certain self-reactive materials (materials that are thermally unstable and can undergo strongly exothermic decomposition without air) and 3: readily combustible materials such as certain metal powders, or materials that can cause fire through friction (such as matches) or that have an accelerated burn rate. There are two types of spontaneous combustible material...pyrophoric and self-heating material. Material that is dangerous when wet is material that is liable to become spontaneously combustible if in contact with water.

## Class 5 – Oxidizers

Reference 49CFR173.128 (Definitions)

Oxidizers are materials that may, generally by yielding oxygen, cause or enhance the combustion of other materials. The hazardous materials regulations generally defines organic peroxides to be any organic compound containing oxygen in the bivalent O-O structure and which may be considered a derivative of hydrogen peroxide, where one or more of the hydrogen atoms have been replaced by organic radicals. There can be some overlap between qualifying as a Class 5.2 organic peroxide and a Class 1 explosive, and when this occurs the material must generally be classified as a Class 1 explosive. There are seven different organic material types, Types A - G, in descending order of hazard risk presented, with type A being banned from commercial transportation.

## Class 6 - Toxic and Infectious Substances

Reference 49CFR173.132 & 134 (Definitions)

The hazardous material regulations define poisonous material as any material, other than a gas which is known to be so toxic to humans as to afford a hazard to health during transportation, or if the material is presumed to be toxic to humans because of animal testing with respect to oral toxicity, dermal toxicity, or inhalation toxicity.

Arsenic, arsenic compounds, copper-based pesticides, tear gas, anti-knock compounds, trichloroethylene, and 1,1,1-trichloroethane are examples of Class 6.1 poisonous materials. The biohazard materials from Class 6.2 include infectious substances, diagnostic specimens, biological products, and regulated medical wastes. There are a number of exceptions and exclusions associated with Class 6.2, and in some cases compliance with OSHA regulations can be substituted for compliance with the hazardous materials regulations.

## Class 7 - Radioactive Material

Contact the Department of Radiation Protection

The hazardous materials regulations define radioactive materials as any material having a specific activity greater than 70 Becquerel (Bq) per gram. The specific activity of a radionuclide is the activity of the radionuclide per unit mass of that nuclide. The specific activity of a material in which the radionuclide is essentially uniformly distributed is the activity per unit mass of the material. Articles or instruments, such as clocks, electronic tubes or apparatus that have radioactive material in gaseous or solid, non-dispersible solid form as a component part of the article or instrument are subject to regulation as Class 7 radioactive materials. There are however, fairly broad exceptions for articles or instruments containing radioactive material as a component part when certain packaging formats are used, and certain radiation measurements can be satisfied. For questions about shipping radioactive materials, please contact the Radiation Protection Department.

## Class 8 - Corrosives

Reference 49CFR173.136 (Definitions)

Liquids or solids that cause full thickness destruction of human skin at the site of contact within a specified time period, and liquids that can have a severe corrosion rate on steel or aluminum qualify as Class 8 corrosive material under the hazardous materials regulations. Numerous industrial and consumer products qualify as Class 8 corrosive items, including certain wet and dry batteries and alkali battery fluid, certain dyes, formic acid, hydrochloric acid, nitric acid, mercury and devices containing mercury (such as thermometers and electron tubes).

## Class 9 - Miscellaneous

Reference 49CFR173.140

One of the most common materials in use at University Park that falls into this category is the use of ***dry ice***. The shipper is responsible for supplying the dry ice and the shipping container, however if needed EHS can assist with locating proper containers. This classification can also be used for materials that present a hazard but do not fall within the guidelines of any of the other classifications. Examples would be any material that has an anesthetic or noxious property that could interfere with the duties of a flight crew member during transportation by air, asbestos, chemical kits and equipment containing hazardous materials. Class 9 serves as a "catch-all" for a wide variety of items that do not fall within the specific definitions of the other classes. When in doubt, ask an EHS representative.

If your material meets the definition of a hazardous substance or marine pollutant, and the material is not listed in the Hazardous Materials Table and does not meet any hazard class, the material is regulated as a Class 9 *Environmentally hazardous substance (liquid or solid), n.o.s. (not otherwise specified)* which is listed on the 49CFR 172.101 Hazardous Materials Table.

Manufacturers and suppliers are required to provide Material Safety Data Sheet (MSDS) for their products. On newly formatted MSDS's, Section 14 is dedicated to Transportation Information. Review the MSDS, container labels, and prior shipping documents carefully for reference to "UN" numbers.

In addition to the DOT regulations mentioned above, by reference, the transportation of hazardous materials is also regulated by the International Air Transportation Association (IATA) which oversees the transport of hazardous materials by almost all airlines. Other carriers such as FedEx, UPS, Yellow Freight, USPS etc. are also bound by these regulations, and may have their own more stringent restrictions.

By following the procedures outlined here, you can:

Ensure that your package arrives intact and on-time without regulatory delays.

Avoid costly non-compliance penalties. (penalties are levied against the shipper)

Rest assured that all individuals who come into contact with your package will know what it is, and how to safely handle it.

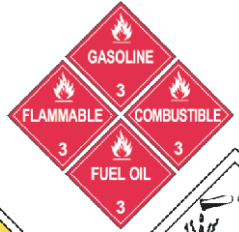
If you are unsure if the material you wish to ship is regulated, contact EHS at 865-6391 and they will answer your questions.

# Nine Classes of Hazardous Materials

**Class 1: Explosives**
Divisions: 1.1, 1.2, 1.3, 1.4, 1.5, 1.6


**Class 2: Gases**
Divisions: 2.1, 2.2, 2.3


**Class 3: Flammable Liquid and Combustible Liquid**




**Class 4: Flammable Solid, Spontaneously Combustible, and Dangerous When Wet**
Divisions 4.1, 4.2, 4.3


**Class 5: Oxidizer and Organic Peroxide**
Divisions 5.1, 5.2



**Class 6: Poison (Toxic) and Poison Inhalation Hazard**


**Class 7: Radioactive**


**Class 8: Corrosive**


**Class 9: Miscellaneous**


**Dangerous**

Revised 06/05

**Federal Motor Carrier Safety Administration**

**U.S. Department of Transportation**
**www.fmcsa.dot.gov**

# Reporting Hazardous Materials Information

## ACCURATE REPORTING SAVES LIVES

**Data you collect is used to calculate risk assessment, determine response methods, and develop regulations. Vehicles carrying hazardous materials are required to carry shipping papers containing the HM Class and ID number (or name). Your Accident or Collision Report/Supplement may ask the following hazardous materials questions (exact wording will vary by State):**

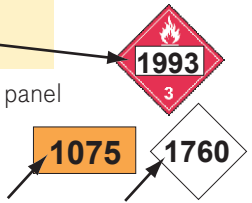
### 1. DOES THE VEHICLE HAVE A HAZARDOUS MATERIALS PLACARD? YES ● NO ○

Placards should be on all four sides of the vehicle. For containers with bulk packages inside, if the required ID# marking is not visible, the transport vehicle must be marked on each side and each end.


Some Common Placards

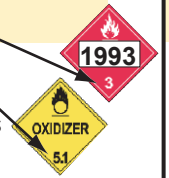
### 2. ENTER THE FOUR-DIGIT NUMBER (OR NAME) FROM THE PLACARD 1 9 9 3

The four-digit number may be on an orange panel or a white "square-on-point" panel. If no four-digit number appears on the placard, enter the Placard Name.




### 3. ENTER THE HAZARDOUS MATERIALS CLASS NUMBER FROM THE BOTTOM OF THE PLACARD 3

The Class Number can be a one- or two-digit number with a decimal in the middle. **5.1** It is critical for identifying and studying various types of hazardous materials involved in traffic crashes.




### 4. WAS HAZARDOUS CARGO RELEASED?

YES ● NO ○

The intent of this question is to determine whether any of the **placarded material** was released or escaped from its transport container into the environment. Fuel or oil carried by the vehicle for its own use is NOT considered cargo and should not be reported in this section.

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