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SIXTY-SECOND ANNUAL MEETING

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SYMPOSIUM

SAFETY IN THE TRANSPORTATION OF HAZARDOUS MATERIALS

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HAZARD EVALUATION AND ITS USE IN THE REGULATION OF HAZARDOUS MATERIALS TRANSPORTATION

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"Protection of operating personnel and the public in Bulk Transportation of Hazardous Materials is becoming increasingly complex. Existing classification systems and accident statistics are no longer sufficient as a basis for developing safety regulations and standards. With the rapid growth in size and variety of shipments, it is now essential that comprehensive hazard evaluations be made based on a good understanding of commodity properties, hazards, and disaster potential. Efforts to develop this technique for water transportation are discussed."

THE NEED FOR HAZARD EVALUATION

Texas City, Texas - On April 16, 1947 a cargo of ammonium nitrate fertilizer exploded in the hold of the GRANDCAMP. Five hundred and fifty-two people were killed and over 3000 people were injured. Property damages were in excess of $50,000,000.00.

Roseburg, Oregon - On August 7, 1959 a cargo of dynamite and nitro carbo nitrate, in a truck left unattended next to a lumber yard, exploded after the lumber yard caught fire. One hundred twenty-five people were injured. Property damages were in excess of $10,000,000.00.

Creve Coeur, Illinois - Shortly before midnight on August 1, 1961, a 4" discharge hose on an anhydrous ammonia barge ruptured, necessitating the evacuation of 13,000 people from the southern suburbs of Peoria, Illinois.

Dunreith, Indiana - On January 1, 1968, two Pennsylvania Railroad freight trains collided. Tank cars of ammonia, acetone cyanohydrin, ethylene oxide, methyl methacrylate, and vinyl chloride were derailed. The ethylene oxide exploded, and the methyl methacrylate and vinyl chloride burned. One tank car of acetone cyanohydrin ruptured spilling 20,000 gallons. A fire raged for two days. Fish kills extended for over sixty-five miles.

S.S. DANIEL PIERCE - On July 10, 1964, the S.S. DANIEL PIERCE, an old bulk petroleum carrier, took on a cargo of bulk concentrated sulfuric acid. Strange things began to happen. She hissed and whistled. Steam came from her cargo tanks. Welds leaked. Rivets fell out. She sank, across the harbor from her dock, three days later.

New Orleans, La. - On April 6, 1969, the M/V UNION FAITH collided with the towboat M/V WARREN DOUCET and tow. This was right at the foot of Canal Street in downtown New Orleans, just a few hundred feet from the Rivergate where we held a recent A.I.Ch.E. national meeting. Much of downtown New Orleans had to be cordoned off. The Mississippi River Bridge was scorched and had to be closed to vehicular traffic until its structure was examined. The cargo was crude oil, but what if it had been bulk chlorine, or anhydrous ammonia, or acetone cyanohydrin?

Why do we need hazard evaluation? Because each day we have a greater probability of chemical transportation disasters. Each day we produce more chemicals, and each day we move more chemicals.

(FIGURE 1)

As can be seen from the Figure production of organic chemicals has more than doubled in the period from 1958 to 1968, while the production of inorganic chemicals has almost doubled in the same period. By comparison, there has only been a fifteen per cent increase in population, even with the population explosion.

During the interval 1964 to 1967 the growth in chemical loadings was 25 percent or about 7 percent per year.

(FIGURE 2)

During the interval 1965 to 1968 the growth in the combined total of chemical imports and exports was 33 percent, or 8 percent per year.

With a greater absolute quantity of chemicals being moved in more individual movements there is a greater chance of an accident occurring. And with growing populous areas, there is a greater chance that some of these accidents will seriously involve the public.

WHAT IS HAZARD EVALUATION?

By the process of hazard evaluation we seek to minimize the probability of occurrence of an accident, and, failing that, to minimize the effects of the accident that does occur. The hazard evaluation system should properly contain a minimum number of categories and still be understandable; it must reflect multiple inherent hazards; it must specify degrees of hazards; and it must be somewhat quantifiable. These inherent hazards are determined by the physical, chemical, and toxicological properties of the cargoes. For instance, the toxicity hazard is related to vapor pressure, water solubility, LC_{50}, and LD_{50}, among others.

Having identified and evaluated degrees of various hazards associated with any particular cargo, the next step is to interrelate those hazards with the engineering and operational aspects of the transportation mode. In that manner adequate controls can be provided to limit the hazards. For instance, in the case of highlv flammable or toxic commodities, containment of the evolved vapors becomes a matter of primary concern. Relief valves and materials of construction criteria would then be especially relevant.

IDENTIFICATION OF HAZARDS

The first step in the hazard evaluation process is the identification of the types of potential hazard that a given commodity presents to life and property. Who. or what, would be injured by a release of the commodity? People? Fish? Plants? Property? What kind of injury is sustained? For instance, in the human toxicity situation, is the effect cumulative? Is it delayed? Acute? How does the agent enter the body? By inhalation? Absorption? What are the critical dosages? The critical concentrations? What organs are attacked, the lungs, the skin, the eyes, the nervous system? Is the commodity a gas, a liquid, or a solid? What kind of property damage can the commodity cause? How will this damage be caused? By explosion? By fire? Can the commodity react with something else? Exothermically? Are the reaction products dangerous?

These hazards are identified without regard to the method of containment or handling. At this stage we are not yet concerned with how much damage the commodity can do. We are first concerned with knowing the properties of a commodity and tying these properties to hazards.

To be more specific, what is the nature of some of the hazards? First, let us consider chemicals that are gases, or that emit vapors or fogs irritating to the skin or to the mucous membranes of the eyes, nose, throat, and lungs. Here we are concerned, of course, with the health hazard, recognizing that chemical vapors vary in degree of toleration. An evaluation of vapor hazard would therefore be based upon the likelihood of developing injury, and the severity and permanence of that injury. Some chemicals, for example, would be rated as nonhazardous, as in the case of those which are nonvolatile or have vapors which are nonirritating to the eyes and throat. Other chemicals, with the highest hazard rating, would include those which are severe irritants, with vapors which cannot be tolerated even at low concentrations without causing eye or lung injury.

Another health hazard involves the tendency of chemicals, in liquid or solid state, to "burn" or irritate human skin. In this respect, some chemicals are practically harmless. At the opposite end of the hazard rating scale one would place the severe irritants, which cause second- and third-degree burns on short contact and serious injury if splashed into the eyes.

Another health hazard involves the possibility of poisoning, through inhalation, ingestion, or absorption. Some chemicals offer little or no likelihood of producing injury in this respect. Some others have threshold limits below 10 ppm and can be severely hazardous. Volatile chemicals producing toxic effects by inhalation are thought to be of most concern in bulk water transportation. Skin absorption is also of concern but less so because of lower probability of exposure. Chemicals which are toxic only by ingestion present a lesser hazard except in a few cases where severe injury may occur.

Chemicals would be rated as health hazards if they are anesthetics or narcotics or have a cumulative toxic effect, as well as if they are acutely toxic. The Coast Guard's primary concern, however, has been with acute rather than chronic or cumulative toxicity, and here acute toxicity has received greater weight in the evaluation process.

We have spoken so far to the health hazard. Water pollution characteristics of chemicals must also be considered. Hazard ratings in this case should reflect the degree of concern that arises when these specific chemicals are for any reason spilled or dumped into the water. A wide variety of problems may arise from such occurrences: water for municipal systems may be made unfit for human consumption; fish and other aquatic life may be killed; waters in streams or on beaches may be contaminated by oily, sticky, dark-colored, or malodorous materials which make them unfit for recreational purposes; or noxious odors or vapors may evolve from polluted water to contaminate the atmosphere in areas nearby. Thus, water pollution characteristics of chemicals should be considered in three ways: (1) human toxicity, (2) aquatic toxicity, and (3) aesthetic. Of these three factors human toxicity is the most important factor.