Study of the Ocean Transportation of Chemicals

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STUDY OF THE OCEAN TRANSPORTATION
OF CHEMICALS

BY

JOSEPH A. MEYERTOLEN

A MAJOR PAPER SUBMITTED IN PARTIAL FUILLMENT
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ABSTRACT OF OCEAN TRANSPORTATION OF CHEMICALS

The growth of the chemical industry over the past 30 years has contributed significantly to the increased volume of hazardous cargo transported by ocean vessels. The properties of some chemicals in commerce, particularly intermediate products, are such that their movement represents a risk to society in terms of environmental damage, bodily injury and carcinogenic effects that may not surface for years. This study traces the development of the ocean chemical transportation system with emphasis on the technology, management and regulatory regime that has evolved to control these risks. Selected incidents involving hazardous chemical cargoes are reviewed, highlighting the industry and government responses. The study concludes that the present risk management system is capable of supporting hazardous chemical transportation at sea with minimal risk, with two notable weaknesses: the shipowners reliance on the cargo owner’s selection of packaging and stowage for intermodal transport, and the impact of human error on the system of technological, managerial and regulatory controls. The study endorses the International Maritime Organization’s efforts to create a liability regime similar to that in effect for oil pollution liability.
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CHAPTER ONE

GENERAL INFORMATION AND BACKGROUND OF CHEMICAL TRANSPORTATION REQUIREMENTS

Introduction

The quantity of hazardous cargoes shipped at sea is increasing and is now estimated to account for greater than 50 percent of all cargoes shipped (Henry, 1985). The growth in the transportation of hazardous cargoes has taken place in the last 40 years, with chemicals accounting for a large portion of this increase. International concern over the risks inherent in the shipment of these cargoes has been reflected in conventions and resolutions sponsored principally by the International Maritime Organization (IMO), under the auspices of the United Nations.

In the spring of 1984, the IMO sponsored a conference on the Draft Convention on Liability and Compensation in connection with the Carriage of Hazardous and Noxious Substances by Sea (Draft HNS Convention). The conference ended without reaching consensus, but served to highlight the complexity of the issues involved in the carriage of hazardous cargoes, and the management of these risks.

Tragic incidents, such as the Union Carbide chemical release in Bopal India, serve to underscore the risks that are assumed daily, usually by an unsuspecting public. It is the intent of this study to provide a comp-
reprehensive review of one segment of the hazardous cargo population; chemicals. Armed with the necessary background information on the technology, market, and regulation of the transportation of chemicals, reasonable conclusions can be drawn and recommendations made concerning the International HNS Convention, and the international policy goals this treaty represents.

Purpose

The ocean transportation of chemicals is socially and economically necessary to modern man. Many of these chemicals represent a direct threat to human life, and can cause severe environmental damage if released. The Draft HNS Convention developed by the Legal Committee of the IMO is an attempt to establish international policy on liability and compensation in the event of such a release. Proponents of the HNS Convention cite the international liability regime established by the International Convention on Civil Liability for Oil Pollution Damage (CLC, 1969), and the International Fund for Compensation for Oil Pollution Damage (Fund Convention, 1971), as precedent for catastrophic incident recovery, and support a similar regime for hazardous and noxious substances. The insurance, vessel and cargo interests, however, concentrate on the differences between the carriage of oil and the carriage of hazardous cargo, which complicate the issues of assessing liability and more importantly,
liability limitation. In any event, the risks involved in the shipment of hazardous cargoes pose a significantly increased threat to human life than petroleum, including long term effects not immediately apparent. The liability vulnerability period is potentially longer and deeper than with petroleum products.

Concentration on the liability issues involved in hazardous cargo transportation seems to assume that tragic incidents will in fact occur. This assumption, on the surface, appears casual; accepted by knowledgeable persons familiar with the shipping of hazardous cargoes, including chemicals. It seems apparent that all risk cannot be eliminated.

**Hypothesis**

Without getting into quantitative risk analysis theory, this paper attempts to deal with the risks involved in the ocean transportation of chemicals from the political, technical, and managerial standpoint. Based on the theory that acceptance of risk is more dependent on confidence in risk management than on estimates of risk consequences, probabilities, and magnitudes (Starr, undated); it is imperative to understand the risk management system before addressing the liability question.

This paper describes in some detail the evolution of the ocean chemical transportation system and the
regulatory regime that manages it. The review is followed by an analysis of selected incidents which supports findings relative to the adequacy of these regulatory measures. Finally, this paper hypothesizes that in addition to the existing risk management system, an international liability and compensation regime is required.

**Background**

The emergence and growth of the chemical industry has had a profound effect on the economic and technical development of civilization in the Twentieth Century. Chemical products are found virtually everywhere, and in many forms; plastics, fertilizers, adhesives, to name a few (Gusman, VonMolke, Irwin, and Whitehead, 1980). Chemicals have played a pivotal role in the development of modern society, serving to enhance advances in agriculture, technology, and medicine. International trade of chemicals is of vital importance to the economic well-being of many countries, just as the chemical industry is dependent on access to world markets. The potential for expansion of their utility is practically unlimited, although the enthusiasm that characterized the early decades of the industry has been tempered by the emergence of health and environmental considerations.

About 50,000 chemicals are used commercially in the United States. Some of these are clearly hazardous and need to be handled in a suitably controlled manner so that
the user is protected. Others are toxic only after repeated exposure at levels too low to create untoward immediate effects. Still others can cause cancer, yet appear innocuous at the time of exposure and give no indication of their presence. In many cases, no one, including the manufacturer, may know if a chemical produces these long term effects (Guaman, VonMolke, Irwin, and Whitehead, 1980).

The introduction of chemicals into world commerce has been accompanied by governmental regulations. National and international laws govern the introduction, transportation, trade, application, and disposition of chemicals. Early laws dealt principally with localized safety and health considerations, while more recent legislation addresses broader environmental and public safety concerns.

The safe and economical transportation of chemicals and chemical products has been an evolutionary process, characterized by close industry and government cooperation. The technological base and entrepreneurial spirit have been important ingredients in its development, with human health and environmental considerations emerging as public issues in the shipment of chemicals, acting to complicate the purely economic and physical problems. The system resulting from these processes reflects a conscientious and timely incorporation of industry and public priorities, that strive to produce a
safe and economical ocean chemical transportation system.

**Chemical Categories**

From the industrial perspective there are three categories of chemicals: feed stocks, intermediates, and end products.

(a) **Feedstocks**: Most chemicals are synthesized from natural gas, air, and various ores as basic raw materials. These feedstocks are converted, through various processes, into intermediates or end products. Due to heavy reliance on petroleum products for raw materials, the transportation requirements for feedstocks are generally satisfied in the same manner as energy petroleum products.

(b) **Intermediates**: These are the products of chemical processing of feedstocks. They normally never reach a broad public, but are used as an ingredient for more specialized chemical or manufacturing processes. They are often sold between chemical companies and make up a large percentage of chemicals transported by sea.

(c) **End Products**: These are the specialized products of the chemical industry. They may be sold as an ingredient for a further manufacturing process, but are sometimes sold directly to consumers (Williams, 1973).
The transportation of chemicals of interest to this study is the distribution of intermediates and end products. In general, the intra- or inter-industry transport of intermediates represents the greatest challenges to the carrier; as intermediates are more valuable, more hazardous, and most susceptible to contamination (Williams, 1973).

Intermediates result from either mixtures of feedstocks or synthesized feedstocks. The discrimination between products of these processes is important in terms of the characteristics of the intermediate. Formulated blends or mixtures tend to exhibit composite characteristics of the component feedstocks. Synthesized products, however, may be totally different from the feedstocks used in reaction to create them. The complexity of intermediates is generally greater than feedstocks; fortunately, the volume of intermediates is generally less than that of feedstocks (Williams, 1973).

**Special Considerations**

The transport of intermediates requires extensive sanitation. The level of contaminants is measured in parts per million (PPM) for most of the chemicals where contamination by virtually any source could render the entire shipment useless for additional processing. This consideration effects transportation systems - particularly marine transportation - since seawater is a
ready source of contamination. The potential for contamination has been a principle industry concern in the development of marine chemical transportation systems (Holly, 1961).

There are other factors that have impacted the development of chemical carrying ships. The significant criteria are the characteristics of the products and the market in which they trade. Construction standards and safety features are based on the product's characteristics, such as flammability, toxicity, stability, and reactivity. Vessel size, capacity and cargo flexibility are based on the market, i.e., the supply and demand of product quantities on specific routes. As the chemical industry matured, the vessel that maximized flexibility in type and quantity of product has survived (Symon, 1981).

The business of chemical manufacturing involves processes that depend on a variety of transportation mediums. Distances between sources of feedstocks and initial processing sites, between primary and secondary processing sites, and between final processing sites and consumers combine to define the transportation component. This component is dynamic. During the early days of the chemical industry, short-term profit maximizing often meant reliance on less than ideal transportation networks, while long-term planning could minimize overall costs through efficient plant siting. Based on the parameters
of the particular chemical company, ideal plant sites were selected and trade routes and product quantities defined.

It is not intuitively obvious what the ideal plant location scheme should be. The cost of transporting large quantities of less sensitive feedstocks must be balanced against the cost of transporting lesser quantities of more sensitive intermediates and end products. Additionally, intermediates and end products move through a variable distribution system to secondary processors and consumers. The problem was particularly dynamic in the early years, as new discoveries created new opportunities, and more and more firms entered the business of chemicals.

An Overview

Industry pioneers were working with incomplete information. At the time, little was known about the cost of transporting sensitive chemicals and there was no industry record to analyze. Primary plant location was based on access to feedstocks, which in this country meant the U.S. Gulf Coast. Secondary processing plants were geographically dispersed among the industrial centers of the country, and sited near consumer markets. Initially the industry relied upon a land-based transportation system incorporating rail and truck modes. The expansion to tug and barge systems took advantage of intercoastal waterways and river systems, and allowed economies of scale to
effect the cost of chemical transportation.

Barge transportation was ideal for domestic distribution, utilizing the Mississippi River, and the intercoastal waterway to support deliveries of intermediates to the industrial centers of the east coast and middle America. The U.S. inland waterway system is the cheapest, safest, and most energy-efficient mode of transportation available for the movement of bulk products and, particularly, bulk hazardous materials (Brown, 1985). The transport of chemicals by barge is utilized extensively for domestic shipments in the U.S. and for international shipments within the European continent. The ocean transportation of chemicals in ships was an inevitable result of the greater distances, over open ocean, of international chemical trade between the U.S. and Europe, and to the Far East.

The chemical industry expanded to meet the demand of international markets developing in Europe and ultimately worldwide. This was not an overnight process, but grew slowly and steadily from the late 1950s. Figure 1 depicts a graphic representation of chemical waterborne traffic, foreign and domestic, in the United States between 1960 and 1984 (U.S. Department of the Army Corps of Engineers, 1985). Comparing the curves for domestic and foreign tonnage reveals three perceptible stages of development.
FIGURE 1

CHEMICALS MOVED BY WATERBORNE TRAFFIC
1960 - 1984

SOURCE: U.S. Department of the Army Corps of Engineers,
Waterborne Commerce of the United States Part 5
1960 - 1965: Greater and increasing domestic movement, and lesser and steady foreign traffic.


Figure 1 indicates that in late 1983, foreign chemical movement equalled and exceeded domestic movement. The figures do not differentiate between imports and exports in the foreign category, and are based on tonnage of product not value. They are indicative of chemical products transported, and provide insight as to the mode of transport. A great percentage of domestic transport was by barge, however, the vast majority of foreign transport was by ship. Therefore there was a clearly increasing amount of chemical transportation by ship developing in the middle 1960s that is still growing today.

In subsequent chapters, the development of the ocean chemical carrier and the national and international governmental regulations that have accompanied this development are explored. Additionally, the current issues that are shaping the ocean chemical transportation industry are also analyzed.
CHAPTER TWO
TECHNOLOGICAL DEVELOPMENT
AND THE GROWTH OF THE INTERNATIONAL MARKET

The evolution of economical ocean transportation of chemicals was an incremental process, paralleling the growth of the chemical industry itself. At any point in time, it is reflective of the industry’s ability to perceive international demand for chemical products along with development of foreign chemical manufacturing capabilities. The economics of the chemical market determine the products and quantities to be carried, which influences the choice of transportation mode. Today, chemical intermediates and products are transported through the marine environment in a variety of ways: chemical carriers, containers, tank containers, RORO vessels in tank trucks, LASH ships, and to a lesser degree, bulk and break bulk ships (Henry, 1985). Trends indicate the emergence of one type of transport as predominant, but considering the relative youth of the industry and the changes that have emerged thus far, the future is anything but certain.

The beginning of the chemical industry in the United States evolved between 1930 and 1955. During this period, the majority of chemicals transported in ships were packaged in drums or bottles, and shipped as break bulk cargo on liners (Cooperman, 1985). Limited bulk shipments were transported in deep tanks on liners as
liquid cargo. The first example of specialization for chemical carriage was in 1934 as the Marine Transport Lines (MTL) Inc. fitted two deck tanks onboard the SS MALCHASE specifically designed to handle an intermediate; caustic soda liquor (The Versatile Marine Dow-Chem, 1954). Although the MALCHASE was lost during World War II, MTL was quick to restore this capability with similar tanks installed onboard SS MARINE TRANSPORT.

The liner companies suited the needs of chemical manufacturers for product distribution, but the interindustry transport of intermediates appear to have inspired the move toward specialized bulk chemical ships (The Versatile Marine Dow-Chem, 1954). MTL continued to play a major role in this movement through a series of ventures with major chemical companies.

In 1949, Dow Chemical Company signed a long-term charter agreement with MTL for the exclusive use of the first modified chemical tanker. The SS MARINE CHEMIST, a modified T-2 tanker, was used by Dow for the transport of intermediates from Gulf ports to the east coast. She was fitted with double bulkheads between product tanks to prevent contamination and tank coatings to allow the carriage of caustic soda and glycol (Tanker To Transport Texas Chemicals, 1949). The availability of surplus WW II tankers was to stimulate other chemical companies to experiment with bulk shipment of intermediates. By the early 1950s, MTL was operating modified chemical tankers
for other companies, such as Union Carbide's SS R.E. WILSON (The Versatile Marine Dow-Chem, 1954).

The MARINE CHEMIST and the R.E. WILSON were representative of modified chemical tankers that served into the middle 1960s. This generation of ships ranged from 12,000 to 20,000 Deadweight Tons (DWT), and were usually fitted with segregation bulkheads dividing the cargo into three or four product tank groups. Often these groups were serviced by separate pump rooms, piping systems, and ventilation systems (Cooperman, 1985). Tanks within product groups could only be used for compatible cargoes, requiring pipe and pump flushing between transfer of different cargoes.

The subdivision and segregation of cargo areas was an early response to one characteristic of the chemical market that has consistently influenced ship design; the demand for the transport of chemical intermediates and products in less than ship-load quantities. This means the employment of fewer multi-product ships meets the demand more economically than a greater number of single product tankers.

During this period, the liners were the primary vessels for the carriage of chemical products, while modified chemical tankers worked as industrial carriers supporting industry movement of intermediates. These trends continued until the 1960s, when two developments - working separately but in parallel - would converge to
change the ocean chemical carriage industry. The first was the emergence of purpose built chemical carriers that were designed from the keel up to incorporate specific design criteria. The second was the expansion of the chemical manufacturing industry to Europe and the Far East (Scuttling Tanker Rates, 1963).

**Purpose Built Chemical Tankers**

The first purpose built chemical tanker, the SS MARINE DOW-CHEM, was launched in 1954. She was a 16,000 DWT tanker, the product of a joint venture between two experienced chemical transporters; Marine Transport Lines Inc., and Dow Chemical Company. The tanker incorporated some unique cargo handling features and could carry up to eleven different cargoes at one time. The MARINE DOW-CHEM clearly manifested cargo diversity and quantity lessons learned from the MARINE CHEMIST. The MARINE DOW-CHEM stands as the first true chemical carrier; a class of vessel whose design has remained basically unchanged through thirty years of industry development, and whose concepts of construction were clearly reflected in both national and international regulations developed in the 1960s.¹

**Construction Features**

Reinforced cargo tanks; cargo tanks were designed to
carry products of higher density than petroleum product tankers. Crude oil has a Specific Gravity (SG) range of 0.85 to 0.95 compared to water at 1.00 SG. The MARINE DOW-CHEM’s cargo tanks were reinforced structurally to carry products of up to 1.62 SG.

Tank segregation: the MARINE DOW-CHEM utilized double bulkheads extensively for cargo segregation. Cofferdams (void spaces between adjacent tanks walls) were utilized to segregate each center tank from the tanks just forward and just aft. This is in contrast to conventional tanker construction, which utilizes a single bulkhead as both the after boundary of a forward tank, and the forward boundary of the after tank. Figure 2 presents the MARINE DOW-CHEM’s profile and deck plans with these cofferdams labelled.

Product segregation from the ocean was provided for by the installation of wing tanks surrounding all centerline tanks. The wing tanks were usable for nonsensitive cargoes or ballast water, or could be left dry to achieve the maximum in cargo segregation. All centerline tanks were constructed over a double bottom, which was configured to serve as ballast tanks when the centerline tanks were empty.

Tank Coatings

Two novel tank coating systems were used in the
FIGURE 2

DECK, CARGO TANK AND MACHINERY DIAGRAM
SS MARINE DOW-CHEM

SOURCE: "The Versatile MARINE DOW-CHEM"
MARINE DOW-CHEM. Both were specifically designed to protect sensitive cargo from iron-salt contamination.

Six cylindrical tanks in No. 1 hold were designed to transport hydrochloric acid. They were lined with a special rubber coating installed specifically for that cargo (Holly, 1961). This seems to be the only example of rubber coated tanks in service during the 1960s.

Tanks 6, 7, and 8 were specifically designed to handle a 73 percent solution of caustic soda. At that concentration, steam heating coils were required to maintain the product in the liquid state. Heated caustic soda has greatly increased corrosive properties which require special precautions. The MARINE DOW-CHEM was equipped with nickel clad steel tanks to take advantage of nickel's corrosive resistance. All associated pumps, piping, valves, and submerged structures (ladder rungs and heating coils) were made of solid nickel. The practice of using specialized construction materials for special products was new, and can be observed in modern ships incorporating extensive use of stainless steel tanks and fittings.

Cargo Transfer Systems

The MARINE DOW-CHEM presented a unique solution to the problem of cargo contamination within pump and piping internals. Selected cargo tanks were equipped with
separate cargo pumps and associated suction and discharge piping. Manufactured by the food division of the Peerless Corporation, these deepwell pumps consisted of maindeck mounted motors connected by shafting to the pump end in the bottom of the tank. This novel approach eliminated the need for cargo pumprooms and associated problems when handling toxic cargoes, and reduced system flushing requirements between cargoes. The deepwell pump design was another successful adaptation that would endure in the evolution of the modern chemical carrier.

**Developing The Overseas Market**

Up until the late 1950s the ocean transportation of chemicals was principally conducted by liners and modified tankers. The liners delivered products to consumers in Europe and the Far East, while the modified chemical tankers supported the flow of intermediates between primary and secondary processors concentrated in the U.S. The development of the chemical industry overseas was to present two profound impacts:

First, U.S. chemical products were in competition with local products which compelled a reduction in product transportation costs if U.S. manufacturers were to remain competitive.

Second, it opened an international market in chemical intermediates for which only a very limited
transportation system existed.

The practice of shipping chemicals in liners came under review as economizing measures were sought to maintain competitiveness in the overseas markets. At the time, overseas shipment of most intermediate chemicals in bulk on tramp vessels was not feasible due to the special sanitation and hazard features required. The stage was set, however, for a new service which would combine the economic advantages of tramp shipping with the special features of the modified and purpose-built chemical tanker.

The introduction of the "parcel" tanker into the ocean chemical transportation market was specifically designed to meet these service requirements. The competitive target for these vessels were the conference liners, who had traditionally carried chemical cargoes in both break bulk and deep tanks.

The Parcel Tanker Industry

In the late 1950s, European shipowners founded tanker companies to provide liquid cargo service of less than ship-load lots. The lots were colloquially referred to as "parcels." These vessels entered service capable of carrying a wide variety of cargoes, including: liquid chemicals, vegetable and animal oils, coconut and palm oils, syrups, and molasses. The high value commodities,
however, were liquid chemical intermediates, which drew these ships to the U.S. Gulf Coast, in pursuit of outbound chemical cargoes.

Parcel service was attractive as the market had the potential to bring economies of scale to the business of carrying chemicals. Two independent carriers, Parcel Carriers Inc. and Chemical Chartering Inc., were predominant by 1963. They offered rates between 10 and 50 percent below comparable liner tariffs. The highest discounts were available on most liquid chemicals, with progressively less savings on more corrosive cargoes (Scuttling Tanker Rates, 1963). Both lines offered scheduled services on a contractual basis for less than ship load lots, operating a mix of converted petroleum tankers similar to the MARINE CHEMIST, and purpose built ships like the MARINE DOW-CHEM. By 1964, Parcel Tankers Inc. operated four 17,500-ton vessels providing monthly service linking the Mediterranean, Northern Europe, the U.S. East Coast, Gulf Coast, Japan, Formosa and the Philippines (Scuttling Tanker Rates, 1963).

The long-term success of the parcel tanker industry was dependent upon their ability to secure liquid cargoes for the return voyage. Chemical products and intermediates were the mainstay on outbound runs, but the parcel tankers could not compete economically if inbound voyages were in ballast. Competing with the conference liners for liquid chemical outbound cargoes was
immediately successful because the liners did not have the capability to carry sensitive intermediates in bulk. The competition for inbound non-chemical cargoes was intense, because the liners were capable and had historically carried those same liquid cargoes.

Competing as independents on regularly scheduled runs the parcel carriers were susceptible to a variety of liner conference techniques which had the effect of reducing the economic advantage of bulk shipment. Dual rate schemes, and the use of "fighting" committees were employed to minimize independent competition.³

These techniques would have presented significant obstacles to the successful development of the parcel tanker industry. However, in 1958 - in the Isbrandtsen case - the Supreme Court of the United States ruled that the use of dual-rate contract systems as a "Predatory Device" was in violation of the Shipping Act of 1916 (U.S. Congress, House, Committee on the Judiciary, Antitrust Subcommittee, 1962). This ruling cast doubt on the validity of established U.S. liner industry pricing practices and encouraged further congressional investigation. The findings led to the 1962 amendments to the Shipping Act of 1916 and the federal bureaucracy that regulated the U.S. shipping industry. These well publicized events weakened the liner conferences hold on international shipping, and contributed to the market climate that fostered the successful development of the
parcel tanker trade.

The parcel tanker was designed to cater to the chemical industry, but its construction also made it ideal for the transport of vegetable, fish, and animal oils. Due to the combined effect of lower costs resulting from bulk carriage and the weakened position of the conference liners since the Isbrandtsen decision, the vegetable and animal oil market presented an ideal opportunity. Parcel tankers entered the Philippines coconut oil and Malaysian and Indonesian palm oil trades which provided profitable return cargoes to both the U.S. and Europe (Rogers, 1985). The lower cost of transportation and the opening of specialized service linking Europe and the Far East stimulated interest in new markets which would have been impossible under liner rates (Scuttling Tanker Rates, 1963). The subsequent industrialization of Far Eastern developing countries resulted in additional liquid exports, including refined palm oil products that demand sanitation and purity standards rivaling the most sensitive intermediate chemical.

The ability of the parcel tanker to carry a variety of liquid cargoes in small to medium quantities with a varied range of sensitivity characteristics was the key element in their successful development. The industry was profitable and flourished. The closure of the Suez Canal in 1967 increased the demand for crude oil tankers, thereby decreasing the profitability of purchasing and
converting standard oil tankers into chemical carriers. Ships added to the parcel trade after 1967 were predominantly new buildings, constructed to meet U.S. Coast Guard standards, and incorporating the technological features introduced in the SS MARINE DOW-CHEM.
CHAPTER THREE

THE MODERN CHEMICAL CARRIERS

The development of ocean chemical transportation technology in the 1950s and 1960s supported a rapidly expanding chemical manufacturing industry. Of the three principle types of vessels carrying chemicals; the industrial carrier, the liner vessel, and the parcel tanker, the latter was emerging as the principle carrier for the world's chemical cargoes.

Industrial Carriers

By 1970, chemical industry long-term planning included access to deep-water terminals as a critical factor in plant site selection, and modest sized industrial fleets were purchased to meet their own domestic processing needs (Bulk Transportation, 1968). Most major U.S. chemical companies owned or operated their own fleets at one time or another, but they seldom required more than two to four ships at a time, and generally relied on parcel tanker operators for their international shipments. It was also common for industrial carriers to contract out their excess space on the spot liquid bulk chemical market.

The outlook for the 1970s was optimistic. Both the chemical industry and the parcel tanker industry were forecasting continued growth in product movement. This enthusiasm grew despite the gradual dispersal of
traditional intermediate sources from the U.S. Gulf Coast to regional centers in Europe, Japan, and the U.S. Gulf Coast (Chemical Shipping: Parcel Tankers Plow Ahead Under Full Steam, 1972).

The Liners

The liners continued to command a share of the chemical market. The erosion of the power of liner conferences through the 1960s stimulated the search for service oriented initiatives to preclude further erosion of traditional cargoes, and to capture a market share of future cargoes. For the chemical industry, the liner services continued to play an important role in product distribution as the advantages of containerization were appealing (Big Boost For Simple Shipping, 1966). Chemical producers found initiatives such as liquid tank containers and dry-bulk container inserts could reduce freight rates as much as 12 percent over traditional break bulk methods, while reduced handling requirements cut contamination and damage losses. Although the resulting freight rates were higher than bulk shipment in parcel tankers, they supported timely shipment of orders when the only economic alternative was to wait until enough orders justified a parcel tanker shipment (Big Boost For Simple Shipping, 1966).

Other liner service initiatives were successful in regional markets. For example, Lykes Brothers Steamship
Company's LASH vessels supplied chemical barge delivery to overseas ports. This direct tie between the U.S. waterway system and overseas waterway systems has similar advantages to other intermodal services (Bulk Transportation, 1968). Roll-on roll-off operators, such as Trans-American Trailer Transport, provided direct link services between continental U.S. highway chemical delivery systems and overseas users (Down To The Seas In Roll-on Trailershps, 1970). The principle mode, however, remained container vessels in both standard packaged containers and liquid and dry bulk containers.

The Parcel Tankers

The parcel tanker business was a demonstrated success by 1968. Profits were high while chemical industry demand for space on these vessels exceeded supply. New entrants were attracted to the market, which served to increase competition and stimulate growth and change in the chemical industry itself. The U.S. Gulf Coast remained a principle supply source for intermediates, but the development of the chemical industry overseas opened new routes for the growing parcel tanker industry. European and Japanese primary processors were gaining larger and larger shares of regional intermediate markets, and emerging coastal chemical carriers from the Far East were competing for these new cargoes.

From 1958 to 1968, the parcel carrier business had
grown from four companies with nine ships to seven companies with 58 ships. Available tonnage had increased sixteenfold, while average ship size increased from 5000 DWT to 12,000 DWT (Chemical Ocean Going Tankers, 1968). The fleet was a mix of sophisticated parcel tankers and converted petroleum tankers, ranging in size from 1000 DWT coasties, to 30,000 DWT ocean vessels. The increase size of the new-built parcel tankers was a response to the emergence of competition between parcel carriers, as each sought to maximize advantage of the economies of scale. During this period prices on the spot shipping market were relatively high and major shippers were willing to sign up for high volume, long-term contracts. Parcel tanker operators, however, preferred to maintain a mix of long-term contract business and spot market work.

The ocean chemical transportation industry was maturing, and demonstrating characteristics that would shape the future of the industry. A shift in emphasis occurred around 1970 as technological advances gave way to business initiatives as the common denominator of the successful operator. The parcel tanker had competed successfully with the liners of the 1960s, based on technological differences which supported the transport of bulk liquid cargoes. The deciding competition during the 1970s would be between parcel tanker carriers, emphasizing lower operating costs, route selections, and convenience of service.
There were three significant political and economic developments that would impact the stability of the parcel tanker market through the 1980s; the closure of the Suez Canal, the IMO chemical code, and the oil crisis. The closure of the Suez Canal, from 1967 until 1975, is remembered for its impact on the transportation of petroleum products from the Middle East. Due to the dependence of chemical intermediates and products on petroleum feedstocks, the chemical industry was also impacted. The canal closure compelled the transport of Middle East oil around the continent of Africa, rather than through the Suez Canal to the Mediterranean and Europe. This had the effect of creating increased demand for petroleum tankers, and shipping prices rose sharply in response. Higher feedstock transportation costs meant higher prices at each link in the chemical production chain. The higher prices for intermediates and products created a reduced demand, which meant less volume of traffic in these cargoes. Reduced volumes in chemical traffic had minimal immediate impact on the parcel tanker market, as it was offset by the cross-over of some chemical carriers into the petroleum product business. The product carriers themselves could earn higher rates hauling crude oil around Africa, as the lengthened oil routes from the Middle East to European markets required additional ships to keep the pipeline full. Ultimately, the construction of Very Large Crude Carriers (VLCC) and
Ultra Large Crude Carriers (ULCC), with their accompanying economies of scale, would eliminate this market opportunity. Indirect effects of the canal closure also included increased operating costs in response to higher oil prices and greater ship construction costs, as shipyard order books were filled to capacity.

The adoption, in 1971, of the IMO Code for the "Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk" provided international standards for the parcel tanker industry. Traditionally, it had been international practice to apply new standards only to ships constructed after the standards had been adopted. However, due to port safety considerations, the chemical code called for the phased upgrading of existing chemical tankers to be completed by 1978 (Lakey, 1984). To the parcel tanker owners, this mandated major conversion, or scrapping, of 35 percent of the existing parcel tanker fleet by 1978 (Chemical Shipping: Parcel Tankers Plow Ahead Under Full Steam, 1982). The encouraging market picture that existed in 1971 influenced most parcel tanker operators to commit an to aggressive shipbuilding program in the 1970s.

The oil crisis was to be the most significant event impacting the parcel tanker industry in the 1970s. The reduced flow of feedstocks to the chemical industry resulted in increased demand which predictably led to increased prices. Instead of establishing a revised
supply/demand equilibrium, energy and feedstock consumers began to hoard petroleum as protection against even higher prices. This tactic was also prevalent among secondary and tertiary chemical processors as the demand for intermediates rose to fill existing storage facilities. The demand for parcel carriers increased correspondingly, resulting in freight rates in October 1973 that ran at levels up to 100 percent, and in extreme cases 150 percent, higher than 1972 rates (Hyde, 1973). The largest parcel tanker operator in the industry reported profits in 1974 that were 10 times higher than ever previously experienced (Stolt-Nielsen, 1984).

Facing the regulatory obsolescence of one third of the parcel tanker fleet because of the IMO chemical code, prudent owners ordered larger capacity, highly sophisticated parcel tankers. These new buildings, ordered during or after 1973, were at costs approaching three times the cost of a similar capacity ship contracted in 1970 (Hyde, 1973).

By the summer of 1975, the chemical production pipeline was full and storage capacity was full; the movement of intermediates slowed precipitously. The short-run hoarding was over, and the long-run market adjustments to higher feedstock prices surfaced, predictably, as decreased sales of products and intermediates. Producers drew required intermediates from stocks on hand, reducing the movement of these cargoes to a relative
trickle. By the summer of 1975, available chemical shipping capacity exceeded available cargoes, and rates fell sharply as carriers competed for the few cargoes remaining.

The Recession

The chemical shipping recession lasted from 1975 until 1979. The depth of the recession appears to have been aggravated by the timing of the three significant events just described: the higher construction costs resulting from the massive shipbuilding program following the closure of the Suez Canal, regulatory obsolescence of one third of the existing fleet by 1978, and higher operating costs and reduced cargo volumes caused by the oil crisis. The boom market of 1973 and 1974 had encouraged shipbuilding commitments and discouraged long-term contracts, leaving the ship-owner dependent upon a severely recessed spot market to make ends meet.

The recession was characterized by fierce competition which drove ship-owners to reduce operating expenses. Initiatives that were successful gained popular support throughout the industry, and in some cases influenced industry developments beyond the immediate recession. The most notable of these were:

Fuel Efficiency

New buildings were diesel-powered and designed to
burn less and cheaper grades of fuel. Fleet-wide speed reductions were implemented reducing consumption and stretching the available cargo over more ships (Chemical Ship Rates Seen At Bottom, 1975).

**Intermodalism**

Port costs were rising in response to higher labor and energy costs and out of environmental considerations. These environmental costs were indirect, resulting from port movement restrictions which limited chemical ship arrivals, departures, and berth shifts to hours of daylight. Additionally, the new sophisticated vessels were capable of off-loading their cargo at rates exceeding the capacity of many terminals to receive them. The terminal improvements envisioned when these ships were designed were delayed due to the impact of the recession on terminal revenues. Finally, these ships were often required to off-load at several terminals within one port, and at several ports in a geographic vicinity following each voyage. Freight rates would no longer support these long and increasingly expensive turnarounds.

The industry’s desire to trim port costs and reduce turnaround motivated large scale investment in shore terminal facilities. Company owned terminals translated into reduced turnaround time for vessels, as they are assured priority berthing and technologically compatible off-load facilities. The industry direction was clearly
Recovery

The recovery from the recession of 1975 through 1979 was a gradual process in response to increased trade flow in chemicals and reduced tonnage in the world fleet of chemical carrying ships. Improved economies developed during the recession in fuel consumption and reduced in port turnaround would remain as industry features in the 1980s.
Chapter Four
The Regulatory Regime: Cargo and Construction Standards

Regulation of the ocean chemical transportation industry is a national regime of flag state control, with strong influence by international conventions and resolutions. The international body for the coordination of shipping activities is the International Maritime Organization (IMO), which prior to 1982 was the Inter-Governmental Maritime Consultative Organization (IMCO). The convention which formed the IMO was adopted in 1948 but the agency did not become operational until 1959. Since then it has been the predominate international body addressing shipping issues. Due to strong support of the work of the IMO by the shipping nations of the world, the IMO's products, both conventions and resolutions, have had tremendous impact on the world shipping industry, even if not ratified or adopted by the flag state.

The chemical transportation industry is now regulated along three main thrusts: cargo controls, ship construction controls, and most recently pollution liability controls. This triad has developed incrementally, as the sophistication of cargoes and the ships that carry them have grown. The pollution liability regime is a general response to increasing environmental and public safety concerns since the 1960s, reflecting society's reaction to the increased volume of traffic in
hazardous cargoes.

This chapter traces the development of cargo and ship construction codes, including the International Maritime Dangerous Goods (IMDG) Code and the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (aka The Chemical Code).

Cargo Regulation

The regulation of dangerous or hazardous cargoes first appeared near the end of the nineteenth century, as the resources and products of the industrial revolution were being gathered and distributed on steam ships. Section 301 of the British Merchant Shipping Act of 1894 was titled "Dangerous Goods and Carriage of Cattle", and prohibited the transport of explosives, vitriol, lucifer matches, guano and green hides on vessels carrying passengers. Additionally Section 446 required shippers of specified hazardous cargoes and any other goods of a dangerous nature to mark the nature of the goods distinctly on the outside of the package and to give the master of the vessel notice as to their nature (Henry, 1985). The approach of this early legislation was to prohibit the carriage of hazardous cargoes on passenger ships, and to require labeling and notification of the hazardous nature of cargoes on all ships. The eventual disappearance of ocean going passenger vessels would obviate the impact of that portion of this precedent on
today's shipping market, but the identification and labeling of packaged hazardous cargoes has matured into the sophisticated international system in use today.

International law addressed the issue of hazardous cargo for the first time in the International Convention on the Safety of Life at Sea (SOLAS) of 1914. Although this convention never entered into force, it did establish international precedent for the concept of national responsibility over the identification and packaging of hazardous materials. Article 55 entitled Fire Protection, reads:

(1) The carriage, either as cargo or ballast, of goods which by reason of their nature, quantity, or mode of stowage, are, either singly or collectively, likely to endanger the lives of the passengers or the safety of the vessel, is forbidden.

(2) The government of each high contracting party shall, from time to time by official notice, determine what goods are to be considered dangerous goods, and shall indicate the precautions which must be taken in the packaging and stowage thereof (Wilson, 1914).

Note the apparent reference to reactivity between cargoes in use of the phrase, either singly or collectively. This aspect of the hazardous cargo regime increases in significance as product sophistication develops.

The SOLAS convention of 1929 was the second attempt at international regulation to deal with hazardous cargoes. Article 24 contained language very similar to the 1914 instrument, and was identical in its reliance on
national law for the identification, packaging and stowage of hazardous cargo. The principle difference between the two conventions was that SOLAS 1929 did enter into force in 1933 (Henry, 1985).

It is apparent from reading both SOLAS documents that the principle concern which influenced the attention toward hazardous cargo was the safety of the ship, its passengers and crew. At the time these conventions were drafted, the amount of hazardous cargoes in world commerce was relatively small, and the concept of environmental consequences had not surfaced. The incidents that motivated international action were focused on loss of life at sea, not on public safety or environmental concerns beyond the skin of the individual ship.

The reliance on national controls by the flag state to identify, package and stow hazardous cargoes resulted in a myriad of differing rules and regulations between flag states (Henry, 1985). As the quantity of these goods increased, more and more diversity emerged, particularly between the developed and developing states. In the late 1940s, the emergence of the chemical industry, with its unique cargo requirements, emphasized the need for international standards in the identification, packaging and stowage of hazardous cargoes (Henry, 1985). An additional factor, fueling the growing concerns of developed countries, was the competition presented by
flags of convenience shipping in the world market. The practice of registering vessels in foreign countries, to take advantage of lower operating cost and taxes, was gaining in popularity among U.S. ship-owners. Disparities in regulations, typically to the economic advantage of the Flag of Convenience (FOC) vessel, added tangible incentives to the movement towards international regulation.

Two international agreements in 1948 reflected the perceived need for increased cooperation in world shipping: the IMO convention, and the SOLAS 1948 convention.

The IMO Convention

Signed on March 6, 1948 in London by 20 states, the convention established the Inter-Governmental Maritime Consultation Organization (IMCO, hereafter referred to as IMO) for, inter alia, the following purpose:

(a) Provide machinery for co-operation among governments in the field of governmental regulation and practices relating to technical matters of all kinds affecting shipping engaged in international trade, and to encourage the general adoption of the highest practicable standards in matters concerning maritime safety and efficiency of navigation (Convention of the Inter-Governmental Maritime Consultative Organization, 1958).

The convention included an interesting article covering entry into force of the IMO. It required 21 states to accept the convention (only 20 states were
signatories), including at least seven of which had a total tonnage of not less than 1,000,000 gross tons of shipping each. It is unclear what the desired effect of this clause was, but it would take ten years for the instrument to enter into force, which it finally did on March 17, 1958.

SOLAS 1948

The SOLAS 1948 convention reflected an increased level of concern over the growth in international traffic of hazardous cargo. An entire chapter (Chapter VI) was devoted to the carriage of grain and dangerous goods, and reflected a distinctive shift in approach to hazardous cargoes, relative to earlier SOLAS treaties. It specifically identified nine categories of dangerous goods; a role which heretofore had been left to the national government to identify. The list included:

1. explosives;
2. compressed, liquified and dissolved gases;
3. corrosives;
4. poisons;
5. substances giving off inflammable vapors;
6. substances which become dangerous by interaction with water or air;
7. strong oxidizing agents;
8. substances which are liable to spontaneous combustion; and
9. any other substance which experience has shown, or may show, to be of such a dangerous character that the provisions of this regulation should apply to it.

Additionally, the convention added requirements for special precautions when carrying inflammable liquids and substances that are prone to spontaneous combustion.
These precautions were not specified, but were left to the national governments to determine. SOLAS 1948 was also the first international convention to require distinctive labeling, and notification to the shipper by classification categories provided in the convention (categories 1 through 9). The ship was then required to maintain a special list, setting forth the dangerous goods on board. Finally, the national government retained responsibility for regulating the packaging and stowage of dangerous goods (SOLAS, 1948).

The perceptible shift in international approach to hazardous goods was apparently not, in itself, sufficient for the convention delegates. Recommendation 22, of the SOLAS 1948 convention stressed the importance of international uniformity in the safety precautions applicable to the carriage of dangerous goods by sea. The Conference recommended further study of the subject, with the objective of drafting international regulations; and added that the study should include the question of marking dangerous goods by distinctive symbols and designs, so as to distinguish them according to their dangerous characteristics (Inglis, 1984). The SOLAS 1948 convention declared that:

1. Goods should be considered dangerous on the basis of their properties;
2. There was a need for international uniformity in the safety precautions; and
3. A marking system should be considered using distinctive symbols to indicate the kind of danger for each class of substance.
The resolution stated that further study should be undertaken with a view of drafting international regulations on the subject. Action on this recommendation would await the establishment of the IMO before being addressed (Inglis, 1984).

The first work specifically on the subject of dangerous goods was by a committee of experts established by the Economic and Social Council of the General Assembly of the United Nations (ECOSOC) (Henry, 1985). The committee of experts on the transport of dangerous goods considered the international aspect of the carriage of dangerous goods, by all modes of transport, and submitted its report in 1956. It relied heavily on existing national regulations and on work specifically done by organizations concerned with specific modes of transport. The aim of the effort was to achieve international uniformity to facilitate intermodal transport. The report provided a general framework into which existing regulations could be inserted and within which they could be developed (Henry, 1985). Detailed regulations were to be developed by organizations representing each specific transportation mode. For the marine mode, that organization was ultimately the IMO.

The IMO convention came into force in 1958, and the organization met for the first time in 1959. One of its first actions was to schedule the SOLAS 1960 conference for the following year.
In its treatment of dangerous goods, SOLAS 1960 expanded on the efforts to focus the regulatory regime that was initiated in SOLAS 1948. Chapter VII was devoted entirely to the carriage of dangerous goods, and reflected an increased level of specificity compared to earlier international treatments of the subject. Of particular note were the following regulations.

Regulation 1:

The regulation applied to all ships to which SOLAS 1948 regulations applied, except those excluded in the following applicability provision:

(b) The provisions of this chapter do not apply to ... particular cargoes carried in ships specially built or converted as a whole for that purpose, such as tankers (SOLAS, 1960).

This is an important provision for the ocean chemical transportation industry, for it was during the interim between SOLAS 1948 and SOLAS 1960 that the technological developments underpinning the future growth of the industry were made. This SOLAS 1960 provision, served as official recognition of the uniqueness of purpose-built bulk liquid chemical tankers like the MARINE DOW-CHEM (1954), and converted chemical tankers such as the MARINE CHEMIST (1949). Additionally, it emphasized that a gap was developing between dangerous cargo regulation for packaged or break-bulk chemicals, and the liquid bulk chemicals. SOLAS 1960 maintained the traditional reliance
on national governments to issue instructions on the packing and stowing of dangerous goods, however, Regulations 3 and 4 would provide specific considerations that the national regulations must address.

Regulation 2:

The identification of dangerous goods was addressed similarly to the 1948 convention with some expansion of categories to recognize increased sophistication of dangerous cargoes:

- **Class 1** - Explosives.
- **Class 2** - Gases: compressed, liquefied or dissolved under pressure.
- **Class 3** - Inflammable liquids.
- **Class 4 (A)** - Inflammable solids.
- **Class 4 (B)** - Inflammable solids, or substances, liable to spontaneous combustion.
- **Class 4 (C)** - Inflammable solids, or substances, which in contact with water emit inflammable gases.
- **Class 5 (A)** - Oxidizing substances.
- **Class 5 (B)** - Organic peroxides.
- **Class 6 (A)** - Poisonous (Toxic) substances.
- **Class 6 (B)** - Infectious substances.
- **Class 7** - Radioactive substances.
- **Class 8** - Corrosives.
- **Class 9** - Miscellaneous dangerous substances, that is any other substance which experience has shown, or may show, to be of such a dangerous character that the provisions of this chapter should apply to it (SOLAS, 1960).

Regulations 3 through 7 deal with packing, labeling, documenting and stowing; these regulations identify areas that national regulations must address. The following examples are offered as indicative of the incremental standardization process as international law subtly focused the attentions of national law makers on specific issues.
Regulation 3:

(A) The packaging of dangerous goods shall be such a character that any interior surface with which the contents may come in contact is not dangerously affected by the substance being conveyed ...

(C) Receptacles containing dangerous liquids shall have an ullage at the filling temperature sufficient to allow for the highest temperature during the course of normal carriage.

Regulation 4:

Each receptacle containing dangerous goods shall be marked with the correct technical name (trade names shall not be used) ...

(A) Dangerous goods shall be stowed safely and appropriately according to the nature of the goods, incompatible goods shall be segregated from one another (SOLAS, 1960).

Although SOLAS 1960 was considerably more specific than any previous international regulation of dangerous goods, it still fell short of the expectations of attendees. The convention made specific recommendations (Recommendation 56) that:

(A) Contracting governments should adopt a unified international code for the carriage of dangerous goods at sea; and

(B) The organization should pursue its studies, in cooperation with the Committee of Experts, on such an international code ... and should cover, ...:

(i) packing;
(ii) container traffic; and
(iii) stowage, with particular reference to the segregation of incompatible substances (SOLAS, 1960).

With this recommendation, all doubt is removed as to the direction of international regulation of dangerous goods at sea, and the IMO had its mandate to develop a uniform...
The IMDG Code

The development and adoption of the IMDG Code by IMO is characterized by three principle features. First, it is a comprehensive treatment of the carriage of packaged dangerous goods, equally applicable to any mode of land or water transportation. Second, it is divided into two sections; a general regulatory section, which requires IMO assembly approval to amend; and a technical part containing the specifications relating to substances, which may be amended by a majority vote of the members of the marine safety committee of the IMO. This amendment feature allows the technical flexibility required to maintain currency of the code, without waiting for action by the bi-annual IMO assembly. Third, the code was designed to provide national governments a ready-to-adopt dangerous goods code to fulfill all requirements tasked by Chapter VII of the SOLAS 1960 convention. A summary of the substantive elements of the IMDG Code is provided in Appendix I.

The IMDG Code is a recommendation. Although it has been linked by footnote to the 1974 SOLAS convention, which is binding on parties, the adoption of the IMDG Code is still voluntary.
The United States and the IMDG Code

The United States was faced with a dilemma with the approval of the IMDG Code. National regulations for the labeling, packaging and stowage of dangerous goods for transport had been in existence since the early part of the twentieth century, and were well established and enforced across the country. To change systems would compel tremendous impact on the domestic transportation industry, the majority of which has no contact with ocean transport. The U.S. regulations are contained in the Code of Federal Regulations, Title 49, under the auspices of the Department of Transportation (DOT). The solution to this dilemma has been quite simple; the general approach taken has been to permit compliance with certain provisions of the IMDG Code in lieu of the corresponding domestic requirements. In 1976, the DOT regulations were amended to allow dangerous goods (except explosives and radioactive materials), which are being imported into or exported from the U.S., to be accepted and transported by vessel when classified, described, certified, packaged, marked, labelled and placarded in accordance with the IMDG Code (Henry, 1985).

Ship Construction Regulation

By the middle of the 1960s, the ocean transportation of liquid chemicals in bulk was an established and growing component of the shipping industry. The design and
operation of the early vessels developed with the support of the chemical industry in the United States, operating principally as U.S.-flag industrial carriers. The first chemical movements by water, however, were intermediate products carried in barges on rivers and on the inland waterway. The regulations governing bulk cargoes began in response to concerns over the transportation of bulk chemicals on the rivers and inland waterways, and later expanded to the ocean carriers as the technology and the market developed.

The Chemical Transportation Advisory Committee

The Shipping Act of 1936 gives the U.S. Coast Guard (USCG) the authority to establish rules and regulations for the design, maintenance, and operation of vessels carrying flammable and combustible liquid cargoes in bulk (Williams, 1983). In 1949, the American Petroleum Institute (API) and the Manufacturing Chemists Association (MCA) (Today the Chemical Manufacturers Association (CMA)) provided expert volunteers to support the USCG in preparing some standard rules and regulations for the bulk carriage of hazardous materials in tank barges. The API-MCA Ad Hoc Advisory Panel of 1949 would gradually evolve into the Chemical Transportation Advisory Committee (CTAC), which today provides voluntary assistance to the USCG in its rulemaking efforts (Lakey, 1984).

The appearance of foreign-flag chemical tankers load-
ing hazardous intermediates in U.S. Gulf Coast ports in the early 1960s generated concern over the safety of such operations. Although federal regulations for chemical barges were in development, no rules existed for chemical ships. As concern over chemical ship operations in U.S. ports increased, the Secretary of the Treasury directed a priority program to develop and implement rules to regulate U.S.-flag chemical ship and foreign-flag chemical ship operations in U.S. ports.

The ensuing effort, utilizing input from the Academy of Sciences and the API-MCA Ad Hoc Advisory Panel, resulted, in 1965, in the incorporation of Rules for the Carriage of Hazardous Cargoes into Title 46 (shipping) of the Code of Federal Regulations (CFR). Foreign-flag vessels operating in U.S. ports were made subject to this code under the jurisdiction of the Coast Guard Captains of the Port, pursuant to the authority of 33 CFR, Part 6 and in accordance with CFR, Part 124 (Code of Federal Regulations, Title 46, 1985). Effective 30 September 1965, foreign-flagged vessels operating in U.S. ports were required to obtain USCG Letters of Certification prior to loading hazardous cargoes.

The Chemical Code

The IMO became involved in chemical cargoes in 1967, when acting upon a proposal from the United States, the Maritime Safety Committee established the Subcommittee on
Ship Design and Equipment (Lakey, 1984). The subcommittee's terms of reference included the following:

... to consider the construction and equipment of ships carrying bulk cargoes of dangerous chemical substance, ... and to recommend suitable design criteria, construction standards and other safety measures to minimize the risks involved in loading, carrying and discharging such cargoes (Lakey, 1984).

The principle parties on the subcommittee were the flag states of chemical ship operators: the Federal Republic of Germany, Italy, The Netherlands, Norway, Sweden, the United Kingdom, and the United States. Virtually all participants operated vessels that were already complying with the U.S. regulations. The formulation of the Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk (The Chemical Code) was relatively swift, and was adopted in 1971 as assembly Resolution A.212(VII).

The Code addressed five main areas of chemical tanker regulation:

1. Cargo Containment:

Three levels:
Type I - cargoes having the greatest reaching effects beyond the immediate neighborhood of the vessel
Type II - significant hazard to ship and crew if released
Type III - remaining products covered by the Code

Containment standards, in terms of double bottom and distance of cargo tank from outboard skin of the ship, differed by type, being most stringent for Type I. Damage absorption criteria are applied to each type, to insure survivability following collision or stranding.
2. Cargo Segregation:

Applies standards for cargo separation in terms of; cofferdams, voids, separate piping systems and cargo ventilation systems. These features are utilized to insure isolation of highly reactive chemicals from each other.

3. Safety equipment and related considerations:

Requirements for ventilation of cargo handling spaces
Standards for electrical equipment
Standards for gauging of cargo tanks
Standards for fire protection
Standards for personnel protection.

4. Special Requirements:

This chapter extends the Code’s more general parts, to recognize the unusual hazards or properties of certain products, Ex: The extreme flammability of carbon disulfide.

5. Operating Requirements:

Contains various operating requirements including maximum cargo tank capacities for Type I and II cargoes (Lakey, 1984).

A more thorough review of the Code’s salient features is provided in Appendix II.

A notable effect of the Code was due to its application to existing chemical tankers as well as new tankers. This was not the normal procedure, as most other IMO instruments did not apply to vessels already in commerce. The Chemical Code was applied in a phased time program requiring immediate compliance in certain personnel protection areas, with up to six years for major ship modifications.
The primary intent of the MARPOL Convention is to control the discharge of polluting substances into the sea, its approach is twofold: prevention of accidental pollution, and control of operational discharges. Annex II of MARPOL 73/78 deals with pollution by substances other than oil, which includes chemicals. It is under Annex II that the Chemical Code is referenced, as the minimum construction and equipment standard to prevent the accidental discharge of chemical cargoes into the sea. (The control of operational discharges is covered in the next chapter; pollution and liability regulations.)

The significance of the Annex II reference to the Chemical Code lies in the establishment of the precedent of a voluntary IMO code becoming international law. The process proved easier to legislate than to effect, as it would take fourteen years for the Annex II provisions to come into force. The MARPOL 73 Convention established 1978 as the year the new regulations would be in effect. However, difficulties experienced by flag states in incorporating the Chemical Code into national regulations made that milestone unachievable. By 1978, it appeared the entire convention would be delayed entering into force because of Annex II.

In 1978, a second MARPOL 73 convention was called to consider the problem. The 1978 amendments allowed the treaty and its annexes, other than Annex II, to become
effective by 1983. Annex II was delayed for three years after the treaty entered into force (Henry, 1985). ANNEX II ultimately entered into force in 1987.

**SOLAS 1974**

This was the first SOLAS convention after the adoption of the IMDG and Chemical Codes. SOLAS 1974 was called in response to the backlog of amendments to SOLAS 1960 that had built up awaiting ratification. The steady increase in the membership of the IMO, meant that a higher number of ratifications was required to approve amendments, and by 1974, six such amendments were on the books, but not ratified (Bole, 1984).

As in SOLAS 1960, Chapter VII was devoted to the carriage of dangerous goods, and as originally ratified, SOLAS 1974 was virtually identical in text and function to the 1960 version (Bole, 1984). SOLAS 1974 was amended first in 1978 and again in 1981 and 1983. The 1983 amendments would have a significant impact on the status of both the IMDG and the Chemical Codes.

The 1983 amendments to SOLAS 1974 divide Chapter VII into three parts. Part A deals with the carriage of dangerous goods in packaged form or in solid bulk form. The amendment includes a footnote reference to the IMDG Code. Part B relates to the construction and equipment of ships carrying dangerous liquid chemicals in bulk, and Part C covers construction and equipment of ships carrying
liquified gases in bulk. Part B expressly incorporates the Chemical Code; transforming a voluntary code, into a mandatory requirement for party states (Henry, 1985).
CHAPTER FIVE

THE REGULATORY REGIME:
POLLUTION AND LIABILITY

Background

Since the TORREY CANYON stranding of March 1967, an international regime of law has developed to deal with issues arising from the pollution of the sea. This regime has focused on three general concepts, which have been endorsed, not only by the maritime states, but by the world community: intervention, compensation, and prevention.

Intervention

Intervention is the right of a coastal state to take positive action to protect its coasts from pollution caused by a maritime accident. This was the first of a series of ocean pollution issues addressed by the IMO following the TORREY CANYON disaster, and was prompted by the unprecedented actions of the United Kingdom — including bombing of the wreckage — taken in an attempt to alleviate the pollution threat (McDorman and Gold, 1984). It addresses the balance of traditional rights of mariners on the high seas, with the rights of a coastal state to protect its shoreline from ecological and economic damage. The conference dealing with intervention met in Brussels in 1969, and produced The International Convention Relating to Intervention on the High Seas in Cases of
Oil Pollution Casualties (The Intervention Convention) which entered into force in June 1975.

**Compensation**

The issue of compensation for pollution damages and clean up costs compelled international attention for the following reasons:

1. The high cost of damages and clean up, which could easily exceed the value of the ship and cargo involved in the pollution incident.

2. The jurisdictional issue involved in claims by a coastal state which has suffered economic damage from a vessel incident, which occurred on the high seas and involved ships and cargoes owned and registered in states other than the affected coastal state.

3. The prolonged time frame, often associated with maritime claims, between the occurrence and final award.

4. The issue of limitation of vessel owner liability which maintains that unless the incident occurred with the "actual fault or privity" of the owner, the claims against the vessel are limited to the value of the ship and cargo after the incident. (In the case of the TORREY CANYON this amount was less than $50.00).

The high value of the damages suffered by the United
Kingdom following the TORREY CANYON incident called for international action to create a regime of compensation for such damages. The IMO sponsored convention which adopted the Intervention Convention also produced the International Convention on Civil Liability for Oil Pollution Damage (CLC) in 1969. The convention sets the following precedent setting concepts:

1. It provides for strict liability (subject to a few, limited exceptions) on the registered owner;
2. It establishes a separate limitation amount exclusively for oil pollution damage which is approximately double the existing international standard for vessel owner liability;
3. It requires registered owners to insure their liability;
4. It insures that claims can be brought in states where oil pollution damage is suffered (McDorman and Gold, 1984).

The adoption of such a revolutionary instrument in such a short period of time was due to the level of public opinion arising from the TORREY CANYON incident, and stands as a tribute to the effectiveness of the IMO (McDorman and Gold, 1984). The instrument was not universally accepted, however, as it placed an undue burden on the vessel carrying oil, a burden that even the insurance industry expressed concern about their ability to underwrite. Some states argued that the liability
should be spread among other players in the petroleum market in addition to the vessel owners. The arguments were compelling inasmuch as the vessel owners were simply one link in a market chain of producers to consumers; a link that if made to bear the entire burden could break, which would be to the decided disadvantage of all energy consumers. The CLC convention ultimately passed with a compromise that the nations would meet again to discuss liability of the cargo interests, in the form of a Fund of some kind (McDorman and Gold, 1984).

In 1971, the IMO sponsored the follow-on convention which resulted in the International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (the Fund Convention) of 1971, which entered into force in October 1978. The convention established the International Oil Pollution Compensation Fund (IOPC Fund) whose function is to reimburse those who have suffered oil pollution damage to the extent that they have been unable to recover their loss under CLC. The Fund has the effect of establishing a liability ceiling for the shipowner, which makes securing pollution insurance easier for the owner and much less risky for the insurer. The fund is supported by a levy on receipts for oil in party states, which effects a true sharing of the burden of oil pollution between cargo interests and ship interests.

Although the international compensation regime for
oil pollution did much to define and reduce risk, there were at least two areas that left vessel owners and cargo interests insecure: first, the regime did not provide compensation for expenses incurred in attempts to protect against damages from an incident; and second, many coastal states were not party to these conventions. From the perspective of vessels and oil interests, they were still liable for unlimited claim in these respects. They responded with industry sponsored compensation systems, which mirror the international regime, but are based on private funding; Tanker Owners Voluntary Agreement on Liability for Oil Pollution (TAVALOP), and the Contract Regarding an Interim Settlement of Tanker Liability for Oil Pollution (CRISTAL). Both are forms of self insurance clubs. The former is for vessel owners, and handles claims up to $70 million. The latter is for cargo owners and handles claims between $70 and $135 million. These figures are most impressive when viewed in comparison to the latest IOPC fund limit of $70 million, to be effective 1 December 1987 (This Week, 1986).

The bottom line in oil pollution compensation is that it is designed to support timely compensation for damages in an economically viable manner by sharing the risk among vessel owners, cargo owners, and of course, consumers. Consumers pay a higher price for the product, and are certainly the key element in the economic validity of the system.
Prevention

The international community turned its attention toward pollution prevention in 1973. This time the convention included the pollution of oceans by substances other than oil. The International Convention for the Prevention of Pollution from Ships was adopted in 1973 (MARPOL 73) and came into force in October 1983. Its approach to pollution prevention was more comprehensive than earlier conventions centering around six major types of pollution:

1. oil discharge from ships;
2. bulk, liquid or dry noxious substances other than oil discharged from ships;
3. noxious substances carried in packages or containers;
4. shipboard sewage;
5. ship generated garbage;
6. control of pollution through improved design, construction and equipment of tankers carrying oil and ships transporting other noxious substances in bulk (Mankabady, 1984).

Elements of this convention dealing with the Chemical Code were addressed in the preceding chapter; MARPOL 73/78 elevated the Chemical Code from a voluntary instrument to international law for party states. A detailed discussion on this convention's unique handling of substances other than oil - including chemicals - is contained in the next section.

International Pollution Law for Substances Other Than Oil

Of the three main areas of international pollution
legislation, prevention was the only area which considered substances other than oil from its inception. Legislation for the other two areas would be the subject of follow-on conferences.

MARPOL 73/78

The primary intent of the MARPOL Convention was to control the discharge of all polluting substances into the sea. The approach is twofold; prevention of accidental pollution and control of operational discharges. Most of the technical measures are contained in annexes to the convention which are as follows:

- **Annex I** - Oil;
- **Annex II** - Noxious liquid substances carried in bulk;
- **Annex III** - Harmful substances carried in packages (e.g., tanks and containers);
- **Annex IV** - Sewage;
- **Annex V** - Garbage.

Annexes III, IV, and V are optional, but governments ratifying the convention must accept Annexes I and II (Mankabady, 1984).

Annex II contains detailed requirements for discharge criteria, and measures for the control of pollution by liquid noxious substances carried in bulk. It applies to all tankers greater than 150 gross tons. The Annex divides substances into four categories, graded A to D, according to the hazard they present to marine resources, human health or amenities. Some 250 common cargoes are listed in these categories, and residue specifications
provided must be met prior to overboard discharge to the sea. In essence, the law restricts the pumping of category A products and certain category B and C products (those with high melting point and high viscosity characteristics) to diluted amounts totaling less than 1/30,000 of the amount of that cargo carried. Discharge of any residue is forbidden within 12 nm of land, or in water less than 25 meters (approx 82 ft) deep (Schultz, 1986).

The ability to meet these discharge requirements is a function of tank size and pump capability. All pumps will lose suction with some minimal level of product left in the tank. If the total amount of standing cargo, and the residue left on tank surfaces exceeds 1/30,000 of the total tank cargo capacity, then the residue cannot be pumped into the sea. The alternative for overboard discharge is to pump the residue to terminals ashore, which raises a host of complex disposal problems.

Parties to the convention are obliged to provide adequate facilities for the reception of residues at oil loading terminals. However, the convention does not address who pays for the disposal of these residues. Disposal is expensive; from the shipowners perspective the cargo owner should pay, the cargo owner feels that it is the shipowners problem and the terminal operator is in the middle. All are understandably reticent to accept responsibility for residues which are a considerable disposal problem. The economies of residue disposal are
complex, and differ from country to country. A scenario in which a parcel tanker sails from port to port amassing an assemblage of worthless residues which are expensive to dispose of, take precious import time to pump, and rob the vessel of revenue producing tonnage, excited a high level of concern among shipowners.

In 1973, just prior to the shipping recession of 1975-79, this law, combined with the adoption of the Chemical Code, spelled extinction for the older, less efficiently designed chemical tankers. Within years, however, the economic feasibility of achieving the conventions goals appeared harder and harder. This was the principle reason for the MARPOL Convention of 1978 which considered amendments to MARPOL 73. Although the convention resulted in changes in the approach to Annex I, Annex II was deferred until three years after Annex I entered into force (Mankabady, 1984). The delay in execution of Annex II provided states an opportunity to address the disposal responsibility issue.

The ultimate solution to the residue disposal problem was to avoid the collection of residues. If a vessel cannot meet the residue dilution requirements for category A and some category B and C products, it is simply barred from carrying those products (Schultz, 1986). In this way, theoretically, no residues will be required to be pumped ashore in the normal course of ship operations. All cargoes carried on parcel tankers can be flushed and
dumped outside 12 nm and in water greater than 25 meters.

**Intervention on the High Seas in Cases of Pollution by Substances Other Than Oil (1973)**

The Intervention Convention for substances other than oil addresses the issues of maritime states rights versus coastal states rights. It handles the legal issues in precisely the same way as the Intervention Convention for Oil Pollution, and was enacted in 1973 without major problem (McDorman and Gold, 1984). The convention entered into force on 30 March 1983.

**International Regulation of Civil Liability and Compensation for Damages Arising from Maritime Transportation of Hazardous and Noxious Substances Other Than Oil (HNS Convention)**

The HNS Convention is a proposed attempt to deal with the compensation issues of pollution by substances other than oil. Since its introduction in 1969 delegates have met several times, most recently in 1984, but have not yet agreed on a treaty. The goal of HNS is identical to the CLC and the Fund conventions; to provide an expeditious cure for damages caused by hazardous substance pollution, based on an economical sharing of the risk among more than one participant. The problems experienced translating the oil pollution regime into HNS are principally twofold (DeBievre, 1986).
Shipper Liability

HNS liability is intrinsically different than pollution liability. HNS includes environmental damages and economic consequences, but it also entails new risks outside the confines of the ship. These include: serious damage from fire, explosion, and toxicity which can lead to bodily injury and death claims; as well as carcinogenic claims that may not surface for years after the event. The convention reached basic tenants rather easily, including the concept of strict liability, but experienced difficulty in how to apportion the liability.

The following proposals have been considered so far:

I - Joint liability of shipper and shipowner;
II - Two tier system; primary to shipowner and residual to shipper;
III - Exclusive liability of shipowner;
IV - Exclusive liability of cargo producer;
V - Exclusive liability of cargo producer under product liability (DeBievre, 1986).

In 1984, it was clear that some sort of shippers liability was deemed appropriate. It was intended to take account of the fact that the damages from these cargoes result not only from ships misconduct, but also from the cargo carried (DeBievre, 1986). The difficulties involved in the detailing of shippers liability, were to be considerable. For example; from a vessel that may carry 40 different cargoes, owned by 40 different individuals, how do we identify whose cargo did the damage?

It was indeed the perceived practical difficulty of identifying satisfactorily the shipper for the purpose of civil liability ... which appeared to
seriously hamper ... progress on the finalization of the draft of the HNS Convention (DeBievre, 1986).

By the close of the convention most delegates were in favor of alternative II, with a compulsory cargo insurance scheme or fund available for the higher tier of coverage. Had other problems not developed with HNS, this was the scheme that most probably would have emerged.

**Types of Hazardous Cargoes**

In one sense the difficulties in describing what cargoes are hazardous are related to the shippers liability issue. The IMO legal committee had favored including only cargoes carried in bulk, excluding those in packaged form. This was based on the liability requirements to be levied on the shipper, and the problems anticipated to be experienced in attempting to identify all of the shippers of packaged and containerized goods. The inclusion of only bulk products would considerably limit the number of cargoes, and in that way facilitate the identification process. This proposal was met with strong disfavor by the convention delegates for the following two reasons:

1. Some products carried only in packaged form are actually a greater potential danger than most bulk products; and

2. It would place the liability burden on shippers who utilize bulk shipments, which would act as a disincentive for bulk shipment methods. This
was undesirable for most delegates considered bulk shipment safer than packaged or container shipment.

Another issue which caused difficulty was that experience has indicated that recently emptied petroleum cargo tanks contained, statistically, the most hazardous cargo of all - petroleum vapors. In attempting to deal with an example like petroleum vapors, the whole concept of shippers liability becomes very fuzzy. How do we hold a shipper liable when his cargo has been discharged and receipted for (DeBeivre, 1986)?

The HNS Convention was clearly not ready to address these issues to the satisfaction of the majority of delegates. It can be envisioned, however, that eventually the final draft will include bulk and packaged/containerized cargo; and will levy a fee on such shipments to support a general liability fund similar to the IOPC Fund. One thing is certain, the shipowner will continue to carry his share of the liability burden for the transportation of hazardous goods at sea.
CHAPTER SIX
ANALYSIS AND CONCLUSIONS

This study has endeavored to present a comprehensive treatment of the development of the ocean chemical transportation industry. The approach was intended to acquaint the reader with the technology, the management, and the regulatory regime which has evolved since the emergence of the chemical industry. This chapter discusses selected cases of hazardous cargo incidents that have occurred, and identifies the technological, managerial, or regulatory responses that have evolved to reduce the risk of reoccurrence.

Selected Incident Analysis

With the exception of accidents involving oil tankers there have been comparatively few major incidents at sea involving chemical cargoes. However, some of the incidents that have occurred, resulted in the worst disasters in shipping history (Inglis, 1984).

The cases that follow are considered representative examples of the risks involved in the ocean transportation of chemicals. The accompanying discussion provides reference to the risk management technique, if one exists, designed to preclude reoccurrence.

SS GRANDCAMP

The break bulk freighter SS GRANDCAMP caught fire and
exploded while loading a cargo of ammonium nitrates fertilizer in Texas City, Texas in April 1947. The explosion was of such force that it destroyed two light planes flying overhead and engulfed the SS HIGH FLYER also loading ammonium nitrates fertilizer, at a berth 200 yards away. The SS HIGH FLYER subsequently burned and exploded. 468 lives were lost, mostly as a result of the first explosion.

The proximate cause of the explosion was a fire that broke out in one of the ships cargo holds. The subsequent investigation revealed that the crew and longshormen were unaware of the hazardous nature of ammonium nitrates and used improper, as well as ineffective firefighting techniques. The substantial loss of life and property damage could have been avoided if the nature of the hazard had been realized. Ammonium nitrates were utilized extensively in the production of explosives during World War II. Following the war, this product was sold as an agricultural fertilizer. The cargo loaded onboard the GRANDCAMP was labeled "fertilizer compound," to take advantage of lower freight rates for fertilizer than for ammonium nitrates (Inglis, 1984).

The GRANDCAMP incident must have been a strong motivating factor behind the strengthened treatment of hazardous cargo classification and labeling by SOLAS 1948. Had this cargo been properly identified, and therefore recognized as hazardous, the response to the fire onboard
the GRANDCAMP would have been quite different.

A similar incident involving a fire onboard the SS OCEAN LIBERTY, also loaded with ammonium nitrate fertilizer, occurred in Brest, France during the summer of 1947. The local authorities had learned enough from the GRANDCAMP incident to tow the vessel out to sea where she then exploded with the loss of 21 lives. Shipboard firefighting efforts were severely hampered by toxic fumes and lack of knowledge.

These incidents illustrated two distinct aspects of the hazardous cargo problem; identification and response, both of which were acknowledged by the SOLAS 1948 Convention and ultimately addressed by SOLAS 1960 and the IMDG Code. Had these documents been available in 1947, the cargoes would have been identified as hazardous, marked accordingly, and the crews would have had information available as to the toxic hazard and the most efficient firefighting techniques.

SS MARINE SULFUR QUEEN

The SS MARINE SULFUR QUEEN disappeared in February 1963 while enroute from Beaumont, Texas to Norfolk, Virginia with a cargo of molten sulfur. The only trace of the vessel recovered were life preservers stenciled with the vessel's name. Thirty-nine lives were lost.

Although the cause of the disaster was never determined, there was considerable speculation that
linked the disappearance to the hazardous nature of the cargo. One New York Times report included a quote by a U.S. Coast Guard officer that if the sulfur had come into contact with water, the "ship would go up like an atom bomb" (Search for Tanker is Expanded in Vain, 1963).

Subsequent to the disappearance, a cooperative study was conducted by the Department of the Interior, the Bureau of Mines, and the Texas Gulf Sulfur Company (the owners of the SS MARINE SULFUR QUEEN's cargo). The resulting report quelled the water/sulfur reaction theory, and determined that an explosive risk existed through the formation of hydrogen sulfide and carbon disulfide gases in an enclosed space above the molten sulfur. The report recommended ventilation of molten sulfur tanks to avoid the build up of explosive gases (United States Department of the Interior, Bureau of Mines, 1963). Since the MARINE SULFUR QUEEN was equipped with tank ventilation systems, the report did not provide a reasonable explanation for the apparent suddenness of her loss. Even if the ventilation systems had malfunctioned, the gaseous explosions would have resulted in a molten sulfur fire, not the instantaneous destruction that was hypothesized. The special USCG Board of Inquiry could make no final conclusions as to the cause of the loss of the SS MARINE SULFUR QUEEN (Board Can't Explain Sulfur Ships Loss, 1963).

The studies that followed the loss of the MARINE
SULFUR QUEEN provide reliable data which was utilized by both industry and shipping management to enhance transportation safety of molten sulfur cargoes. Since 1963, molten sulfur has been transported by a relatively small fleet of industrial carriers - 11 ships in 1963, 8 ships in 1987 - without a major cargo related accident. As for molten sulfur's reactivity with water; the USCG Chemical Data Guide for Bulk Shipments by Water of 1982 states, "A major spill of liquid sulfur into navigable waters will solidify and sink, presenting no unusual hazard".

SS V.A. FOGG

The SS V.A. FOGG exploded and sank while enroute from Freeport, Texas to Houston on 1 February 1972. She carried three tanks of xylene, having just offloaded 22 tanks of benzene in Freeport. The benzene tanks were scheduled for cleaning during her transit to Houston. Thirty-nine lives were lost.

The vessel's wreckage was located on February 11, based on positions reported by pilot sightings of a dark mushroom shaped cloud on February 1st. Examination of the wreckage revealed that her cargo section was almost totally destroyed by explosions, while her engine order telegraph still indicated Full Ahead. The cause of the explosion has been determined, with some degree of confidence, to have been ignition of benzene vapors by an
electrostatic charge, probably emanating from an ungrounded stripping pump lowered into a cargo tank. Such a pump was found in the bottom of nr2 wing tank on board the V.A. FOGG (Williams, 1973).

The casualty to the V.A. FOGG was due to the violation of a well recognized and proven procedure for tank cleaning following offload of extremely flammable liquids. It is somewhat comforting to know that the V.A. FOGG would not be certified to carry such a product today.

The industry response to tank cleaning hazards has been largely technological. Improved tank design, placing the structural framework outside of the tank, dramatically reduces the amount of product residue remaining after offload. Use of stainless steel and improved coating systems make installed tank washing systems more effective, and have all but eliminated the need for tank entry between cargoes. Additionally, installed tank forced ventilation systems have proven most effective at removing all residue vapors, toxic and explosive (Symon, 1981).

Both industry management and the IMO recognize that technological solutions cannot substitute for crew training. Chapter V of the Chemical Code provides standards for crew training for various levels of supervision of board chemical ships. Required training includes fundamentals in ship/tanker knowledge, emergency procedures, specialized cargo handling, and
cargo characteristics.

**SS MONT LAURIER**

The French container vessel SS MONT LAURIER caught fire and was ultimately abandoned in the Atlantic, six lives were lost. The tragedy occurred in heavy seas when several plastic drums of Fixapret chemical resin popped their lids and leaked onto the trailer deck. The strong fumes and odors emanating from the chemical made clean up impossible. As the seas intensified, more drums of the resin broke loose and leaked, eventually covering the trailer deck and overflowing into adjacent spaces including the engine room. By evening of the second day, the cargo on the trailer deck shifted causing a 15 degree port list. A series of explosions occurred on the trailer deck overnight and the ship was abandoned the following morning (Inglis, 1984).

This case is an example of inadequate notification, packaging, and stowage. It is unclear from available accounts if the crew was aware of the hazard, but they were not prepared to deal with the situation once the chemical was spilled. The IMDG Code, had it been followed in this case, would have at least provided the crew with some warning as to the nature of the product, and safety precautions for clean up. It also appears that the packaging, in plastic drums, was inadequate containment for ocean transportation where ships movement
will predictably cause agitation and plastic drum compression.

**SS ASIA FREIGHTER**

This U.S.-flag container ship was abandoned in the Atlantic in November of 1974, following an outbreak of illness affecting the entire crew. Eventually the source of the illness was determined to be a loose cylinder of arsine gas (arsenic and hydrogen, \( \text{AsH}_3 \)) within one of the containers. No markings, notification or warnings had been supplied to the crew. Arsine is a colorless, flammable, extremely poisonous gas.

If the IMDG Code had been followed in this case, the arsine gas would have been identified as a poisonous gas (class 2.3), and the container would have been accompanied by a packaging certificate describing the bracing of the arsine cylinder.

The preceding two cases highlight one area of weakness with the present regulatory regime, particularly when intermodal container or roll-on roll-off cargo is involved. The vessel owner is dependent on the cargo owner for the proper packaging and stowage of the cargo container.

The IMO and the International Labor Organization (ILO) have produced guidelines for training in the packaging of cargo in freight containers, but the incentive remains strong for dockside inspection of the
contents of containers by experienced and qualified stevedors/boatswains. This is impractical for all containers, but possible for selected containers, for example; those containing hazardous cargoes.

If the vessel owner can be assured that all hazardous cargoes have been identified, his task of inspection and loading is made easier. The prudent master or owner should consider the properties of hazardous cargo while developing the ship's loading plan to minimize the hazards to the vessel and crew, and to facilitate jettisoning.

SS PUERTO RICAN

The SS PUERTO RICAN, a U.S.-flag parcel tanker, exploded and burned in October 1984, just outside the harbor of San Francisco California, with one life lost. The actual cause of the casualty cannot be established with certainty. The probable cause was leaking caustic soda cargo, which reacted with zinc chromate preservative to form hydrogen gas in a void space. This gas was possibly ignited by an electrostatic charge which led to a series of cargo fires and explosions (U.S. Coast Guard, Marine Casualty Report Tankship PUERTO RICAN, 1985).

The initial explosion destroyed the installed main deck fire fighting system, which delayed effective fire fighting response. Structural damage from the series of explosions was sufficient to cause the vessel to break in two when attempts were made to tow her away from land.
The stern section sank, the remaining section was recovered and ultimately scrapped. This event resulted in considerable environmental damage, the loss of life was minimized due to the rapid assistance which was provided by harbor vessels and the U.S. Coast Guard. If this incident had occurred on the high seas, the loss of life may have been much greater.

This casualty is most sombering because it occurred onboard a well managed and technologically capable vessel, that was fully certified by both USCG and IMO standards. The leak, which allowed the uncontrolled flooding of 2500 barrels of caustic soda into the void space, was traced to a one inch square gouge in the stainless steel cladding in a cargo tank. The gouge probably existed since the vessel was built in 1971. Successive cargoes of corrosive materials had eaten away the mild steel plate that backed the stainless cladding. The imperfection was hidden in the shadow of a ventilation system pipe bracket, and until shortly before this accident would probably have passed an air test.

The ships crew noted the apparent loss of caustic soda from the cargo tank prior to sailing from San Francisco, however, a physical inspection of the tank revealed no apparent problem, so the loss was written off as an ullage reading error. No soundings were taken or inspections conducted in the adjacent void because the crew mistakenly thought the void was under an inerting
blanket of nitrogen.

This incident, more than the others presented, is disturbing because it emphasizes the potential impact of human error on the regulatory and managerial regime onboard a technically capable vessel.

**Conclusions**

This study has endeavored to provide a review of the technology, management and regulatory regime which controls the risks involved in the carriage of chemicals, many of which are hazardous, on the high seas. Many of the concepts, procedures and techniques presented in this paper are applicable to all hazardous cargoes transported either as packaged or bulk commodities. The selected incidents presented in the preceding section provide the actual industry experiences on which the present risk management system is based, and highlight areas of deficiency for which future system improvements may or may not be forthcoming.

The following conclusions are offered which support a high level of confidence in the risk management system for the ocean transportation of chemicals:

1. The ocean transportation of chemicals is a highly competitive and professional business, which relies on concerned and capable management to assure safe and sanitary handling of hazardous chemicals. To a great extent, the
industries competitive base enhances the goals of safety and efficient handling.

2. The chemical transportation industry is technically capable of transporting dangerous cargoes with minimal risk within the limitations defined by competent regulatory agencies.

3. The chemical transportation industry is well regulated at both the national and international level; with an increasing degree of international compatibility in the following areas:
   a) identification, labeling and stowage
   b) ship construction standards
   c) pollution control, both accidental and operational.

4. The ocean transportation of chemicals is not risk free; the inherent properties of the cargo do not allow for human error without risk of pollution damage, bodily injury and death to those operating the vessel, and to the vicinity in which the vessel is operating and its inhabitants.

Based on these conclusions it is recommended that the IMO pursue the creation of an international liability regime, such as the proposed HNS Convention, to assure expeditious cure to injured parties and recovery for damages. Further, the instrument should apply to all
forms of hazardous cargo both packaged and bulk. Some form of cargo owner liability should be considered, particularly for packaged or containerized cargoes where the shipowner has no reasonable means of assuring seaworthy packaging and stowage.
NOTES

1. Ensuing discussion based on "The Versatile MARINE DOW-CHEM". Where other sources were utilized, appropriate references are provided.

2. It is interesting to note that in 1961 Dow and MTL teamed up again to build the second purpose built carrier, the SS LELAND I. DOAN. Although virtually identical to her predecessor, the use of cylindrical rubber coated tanks was dropped in favor of rectangular steel tanks with applied liquid coating systems for hydrochloric acid contamination.

3. Dual rate schemes, a classic conference device also called a deferred rebate; a payment made retroactively for the faithful use of conference vessels over a specified prior period. Fighting committees, a conference committee empowered to select "fighting ship" vessels from any of the conference liners, to sail on the same day and between the same ports as had been scheduled by an independent carrier at rates reduced sufficiently to secure the traffic.

4. For purposes of simplicity the title IMO will be utilized exclusively in this paper, with the understanding that prior to 1982 the title was actually IMCO.
NOTES

5. **Ullage**, a measure of a product in a container, based on the distance from the surface of the product to the top of the container.
APPENDIX I

THE IMDG CODE

The IMDG Code

In response to this recommendation, IMO formed a special Working Group made up of countries which had considerable experience in the carriage of dangerous goods. Preliminary drafts for each class were compiled by individual national delegations and then considered by the Working Group, taking into account the practices and procedures of a number of maritime countries in order to make the Code as widely acceptable as possible.

The resulting document was called the International Maritime Dangerous Goods (IMDG) Code and, after being approved by the Maritime Safety Committee, was adopted by the IMO Assembly in 1965.

The Code is designed to aid compliance with the requirements of Chapter VII of the SOLAS Convention, and to complement and supplement them. It was developed in close consultation with the UN Committee of Experts and took into account the recommendations prepared by them.

Although it is designed primarily for mariners, its provisions may affect industries and services from manufacturer to consumer. Manufacturers, packers and shippers should be guided by the advice given for terminology, packing and labelling. Feeder services, such as road, rail and harbour craft may also need to adopt, or at least to recognise, the provisions in respect of labelling and classification. Port authorities may use the Code to effect suitable segregation within loading, discharge and storage areas. Although the Code only applies to the ships covered by the SOLAS Convention, IMO considers that it is highly desirable that its requirements should be extended to other ships as well.

Since its introduction in 1965, the IMDG Code has undergone many changes, both in appearance and in content. By the middle of 1982, no fewer than 20 sets of amendments had been adopted (1). This process can be carried out relatively easily, since in 1965 the Assembly agreed that amendments "which do not affect the principles upon which the Code is based" could be adopted by the Maritime Safety Committee (MSC) alone.

The latest version of the Code is published in five loose-leaf volumes (in the English edition) so that amendments can be easily inserted. The Code is also published in French and a new Spanish edition will be produced shortly.

The first part of the Code consists of a general introduction. Chapter VII of the 1974 SOLAS Convention and Resolution 56 of the 1960 SOLAS Conference are both re-printed, followed by the classification of dangerous goods used in the Code and a description of standardisation of methods for establishing the flashpoint of substances (the flashpoint is the lowest temperature of a liquid at which its vapour forms an ignitable mixture with air and consequently gives a measure of the risk of formation of explosive or ignitable mixtures when the liquid or its vapour escapes from its packaging). The introduction goes on to describe methods of marking, identification, labelling and placarding, documentation and packing.
Also in the introduction are sections containing special requirements for freight containers and portable tanks and road tank vehicles; stowage and segregation; fire prevention and fire fighting. The final sections deal with the carriage of dangerous goods on roll-on/roll-off (Ro-Ro) ships; in limited quantities; and in shipborne barges on barge-carrying ships.

Annex I to the general introduction gives packaging recommendations and a glossary of packagings, with illustrations.

Following the general introduction, the Code then consists of a complete list of dangerous goods divided into nine classes. The classes are:

Class 1 - Explosives
Class 2 - Gases: compressed, liquefied or dissolved under pressure
Class 3 - Inflammable liquids
Class 4 - Inflammable solids, substances liable to spontaneous combustion and substances emitting inflammable gases when wet
Class 5 - Oxidising substances and organic peroxides
Class 6 - Poisonous (toxic) and infectious substances
Class 7 - Radioactive substances
Class 8 - Corrosives
Class 9 - Miscellaneous dangerous substances

Each class is preceded by an introduction which describes the properties and definitions of the goods and gives details of stowage and segregation (i.e. the degree to which goods should be kept separate from other dangerous substances carried on a ship). The class introduction also gives information concerning procedure which should be followed during loading and unloading.

Each class is identified by a distinctive label - some of which will be familiar to road users since they often appear on commercial vehicles which carry dangerous goods, such as petrol tank vehicles. Where appropriate, each schedule in the Code shows the label which should be affixed to a package.

Individual schedules in the Code follow a similar pattern. The substance's proper shipping name or correct technical name appears at the top left of the page. To the right of this, other vital information will be given, such as the serial number assigned to the substance by the United Nations Committee of Experts (its UN number); its chemical formula; explosive and flashpoint limits; and so on.

Other headings used in the Code include properties (such as its appearance); special observations; packing, and stowage. The schedule also shows the label or labels appropriate to the substance.
Class 1 - Explosives

These are among the most dangerous of all goods carried by sea and the precautions outlined in this class of the Code are particularly stringent.

The Class is divided into five divisions which present different hazards. The divisions are as follows:

- Division 1.1 Substances and articles which have a mass explosion hazard.
- Division 1.2 Substances and articles which have a projection hazard but not a mass explosion hazard.
- Division 1.3 Substances and articles which have a fire hazard and either a minor blast hazard or both, but not a mass explosion hazard.
- Division 1.4 Substances and articles which present no significant hazard.
- Division 1.5 Very insensitive substances which have a mass explosion hazard: the substances in this division are so insensitive that there is very little probability of initiation or of transition from burning to detonation under normal conditions of transport.

Class 1 is unique in that the type of packaging has a decisive effect on the hazard and therefore on the assignment of the particular division.

Goods in this class are also assigned to various Stowage Categories. Stowage Category I (Ordinary) covers goods which present relatively little hazard. Category II involves the provision of a magazine for stowage of such goods, and is itself divided into three groups. Stowage Category III is for pyrotechnics and Category IV for special items, mainly goods which contain both explosive and chemical agents which can evolve tear-producing or toxic gases.

Although the safety of goods in Class I can best be assured by stowing them separately, in practice this can rarely be done. To ensure that they are stowed as safely as possible, the substances in the class are arranged in twelve compatibility groups. These are lettered from A to L (the I is missing) and the letter S.

The compatibility groups and classification codes are shown below:

<table>
<thead>
<tr>
<th>Description of substance or article to be classified</th>
<th>Compatibility Group</th>
<th>Classification Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary explosive substance</td>
<td>A</td>
<td>1.1 A</td>
</tr>
<tr>
<td>Article containing a primary explosive substance and not containing two or more independent safety features</td>
<td>B</td>
<td>1.1 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2 B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.4 B</td>
</tr>
<tr>
<td>Description of substance or article to be classified</td>
<td>Compatibility Code</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------</td>
<td>--------------------</td>
<td></td>
</tr>
<tr>
<td>Propellant explosive substance or other deflagrating explosive substance or article containing such explosive substance</td>
<td>C 1.1 C 1.2 C 1.3 C 1.4 C</td>
<td></td>
</tr>
<tr>
<td>Secondary detonating explosive substance or black powder or article containing a secondary detonating explosive substance, in each case without means of initiation and without a propelling charge. Articles containing a primary explosive substance and containing two or more independent safety features</td>
<td>D 1.1 D 1.2 D 1.4 D 1.5 D</td>
<td></td>
</tr>
<tr>
<td>Article containing a secondary detonating explosive substance, without means of initiation, with a propelling charge (other than one containing an inflammable or hypergolic liquid)</td>
<td>E 1.1 E 1.2 E 1.4 E</td>
<td></td>
</tr>
<tr>
<td>Article containing a secondary detonating explosive with its own means of initiation, with a propelling charge (other than one containing an inflammable or hypergolic liquid) or without a propelling charge</td>
<td>F 1.1 F 1.2 F 1.3 F 1.4 F</td>
<td></td>
</tr>
<tr>
<td>Pyrotechnic substance, or article containing a pyrotechnic substance, or article containing both an explosive substance and an illuminating, incendiary, lachrymatory or smoke-producing substance (other than a water-activated article or one containing white phosphorus, phosphide or an inflammable liquid or gel)</td>
<td>G 1.1 G 1.2 G 1.3 G 1.4 G</td>
<td></td>
</tr>
<tr>
<td>Article containing both an explosive substance and white phosphorus</td>
<td>H 1.2 H 1.3 H</td>
<td></td>
</tr>
<tr>
<td>Article containing both an explosive substance and an inflammable liquid or gel</td>
<td>J 1.1 J 1.2 J 1.3 J</td>
<td></td>
</tr>
<tr>
<td>Article containing both an explosive substance and a toxic chemical agent</td>
<td>K 1.2 K 1.3 K</td>
<td></td>
</tr>
<tr>
<td>Explosive substance or article containing an explosive substance and presenting a special risk needing isolation of each type</td>
<td>L 1.1 L 1.2 L 1.3 L</td>
<td></td>
</tr>
</tbody>
</table>
Description of substance or article to be classified | Compatibility | Classification Code
--- | --- | ---
Substance or article so packed or designed that any hazardous effects arising from accidental functioning are confined within the package unless the package has been degraded by fire, in which case all blast or projection effects are limited to the extent that they do not significantly hinder or prohibit fire fighting or other emergency response efforts in the immediate vicinity of the package | S | 1.4 S

NOTES: 1. The descriptions are intended to be mutually exclusive except for a substance or article which qualifies for Compatibility Group S. Since the criterion of Compatibility Group S is an empirical one, assignment to this group is necessarily linked to the tests for assignment to Division 1.4.

2. Articles in Compatibility Group D or E may be packed together with means of initiation provided that the hazard of causing an explosion of the article is virtually eliminated in the event of accidental operation of the means of initiation.

3. Articles in Compatibility Group D or E may be fitted with their means of initiation provided that the means has a safety device to interrupt the initiation in the event of accidental operation.

In addition to the name and UN number the individual schedules in Class 1 also give the substance’s or article’s division and compatibility group. This information must also be shown on the label which goes on the package. The schedule also shows the substance’s or article’s stowage category.

Class 2 - Gases

Gases carried on board ships have very varied properties and come in different forms. They may be compressed liquefied at ambient temperature under high pressures; dissolved under pressure in a solvent, which is then absorbed in a porous material; or liquefied by refrigeration. They may be for example poisonous, corrosive, inflammable, supporters of combustion (oxygen), or a combination of all or some of these. Some are much lighter than air (hydrogen) while others are much heavier (carbon dioxide). Lighter gases will tend to disperse more quickly should a leak occur, while the heavier gases will tend to accumulate close to the ground.
The Code gives general information concerning the properties of gases, packing, stowage, segregation and fire precautions.

The schedules include the UN number, the chemical formula, and for inflammable gases, their explosive limits. The latter refers to the amount of gas required to make a quantity of air explosive. The wider the explosive limit range, the more hazardous the gas, as there is the possibility of an explosion over a large range of concentrations. An example of such a gas is acetylene whose lower explosive limit (LEL) is 2.1% and upper explosive limit (UEL) is 80%. This means that a mixture of acetylene in air can become explosive when quite dilute up to high concentrations.

The schedule goes on to describe the gas's properties, any special observations, and details of packing and stowage.

There are three sub-classes: inflammable gas (2.1), non-flammable compressed gas (2.2), and poisonous gas (2.3).

Class 3 - Inflammable liquids

This class deals with liquids which give off an inflammable vapour at or below 61°C (141°F); some liquids may be included in other classes because of other dangerous characteristics.

The class is divided into three sub-classes according to flashpoint. Class 3.1 consists of liquids with a low flashpoint of below -18°C (0°F); class 3.2 consists of liquids with an intermediate flashpoint of -18°C up to but not including 23°C (73°F); and class 3.3 consists of liquids with a high flashpoint of 23°C and above up to 61°C (141°F).

The Code refers to the various methods which can be used to establish the flashpoint of liquids. Liquids with low flashpoints are more hazardous than those with higher ones, and thus the requirements for low flashpoint liquids are more stringent.

The introduction to the class includes information on packing, stowage, segregation and fire precautions.

Individual schedules are arranged in the three sub-classes referred to above starting with class 3.1. The schedule includes the substance's name, UN number, chemical formula, explosive limits and flashpoint.

Other information comes under similar headings to those which appear in other classes of the Code, i.e. properties, (special) observations, packing and stowage.

Substances in this group are also assigned to a packaging group which is determined by the degree of danger presented. Packing Group I includes liquids presenting great danger, Group II medium danger and Group III minor danger. A similar system of assigning goods to one of three packaging groups is used in other classes of the Code, with the exception of Classes 1, 2 and 7.

Generally speaking, water is unsuitable for fighting inflammable liquid fires. The Code recommends either the use of water as a fine spray, or the use of foam which forms a scum on the burning liquid surface making the access of oxygen difficult.
Class 5 - Oxidising agents
  - Organic peroxides

The class is divided into two sub-classes. Class 5.1 deals with oxidising substances which, although not necessarily combustible themselves, have the potential to increase the intensity of a fire by giving off oxygen (a supporter of combustion) which is present in the structure of all oxidising agents. Therefore, the use of fire extinguishers which act by excluding oxygen from the fire, will not work with these materials. Class 5.2 includes organic peroxides, most of which are combustible.

Class 5.1: Oxidising agents

The fact that all substances in this class give off oxygen when involved in a fire creates obvious fire-fighting difficulties. Some substances may also be sensitive to impact, friction or a rise in temperature. Others may react vigorously with moisture, increasing the risk of fire.

Oxidising substances should be kept away from combustible materials, e.g. spilt oil, oily rags, sawdust, which may catch fire and burn explosively. The use of sawdust on ships for absorbing spillages must not be used for Class 5 substances and, in fact, it is better replaced with an inert absorbent such as vermiculite.

Most oxidising substances react vigorously and sometimes explosively, with strong mineral acids. For example, sodium chlorate reacts violently with sulphuric acid giving off a toxic gas.

Since the use of a fire extinguisher such as carbon dioxide may be ineffective with oxidising materials because they give off oxygen, the Code recommends the prompt use of large quantities of water as being the best means of controlling this type of fire.

This class includes ammonium nitrate fertilisers, hydrogen peroxide, copper chlorate and lead nitrate.

Class 5.2: Organic peroxides

In addition to being oxidising agents, most substances in this class are also liable to explosive decomposition. Most will burn rapidly and are sensitive to heat. Some are also sensitive to impact or friction. To reduce this sensitivity to a safe level they are carried in a solution, as a paste, wetted with water or with an inert solid.

Violent decomposition may be caused by traces of impurities such as acids, metallic oxides or amines. This decomposition may give rise to toxic or inflammable gases.

Organic peroxides can be particularly dangerous to the eyes. Immediate medical attention is necessary following contact.
Some organic peroxides begin to decompose at low temperatures and it is therefore necessary to transport them in a refrigerated unit. Should the cooling unit suffer a breakdown and the temperature rises above a certain value, rapid decomposition of the peroxide will occur which could lead to an explosion if not checked. It is good practice to transport two such units in tandem, each half loaded, so that transfer can be effected to a working unit should one break down.

The general introduction and the introduction to the class contain information concerning temperature control with specific temperature requirements given on the schedule.

Packages containing organic peroxides should be moved away from the seat of a fire or jettisoned otherwise an explosion may result. If this is not possible, packages should be sprayed with large quantities of water from a safe distance. Even when the fire has been extinguished, packages containing organic peroxides should be treated with great care as they may explode violently at any time.

Some organic peroxides require subsidiary hazard labels such as Class 1 (explosives) or a Class 3 (inflammable liquid).

Class 6 - Poisonous (toxic) and infectious substances

The Class is divided into two sub-classes. These are Class 6.1 - Poisonous (toxic) substances and Class 6.2 - Infectious substances. Substances in Class 6.1 may cause death or serious injury if swallowed, inhaled or absorbed by skin contact. They are arranged into three packaging groups, in descending order of risk. The introduction to the class shows how this grouping is determined.

Fire-fighting precautions are basically the same as those given for Class 3 (inflammable liquids) but because of the high risk of poisoning through fumes, the Code states that ships carrying poisonous substances should always carry protective clothing and self-contained breathing apparatus.

If a spillage occurs involving toxic substances - such as liquid pesticides - decontamination should be carried out by trained staff wearing suitable clothing and equipment.

Class 6.2 includes substances containing disease-producing micro-organisms. These substances contain micro-organisms or their toxins which are known or suspected to cause disease in animals or humans.

The labels required for the various substances in the class vary according to the substance's properties. Most are required to carry the 'poison' label, but some carry a label indicating that the substances is harmful to foodstuffs. In addition, further labels may be required, depending upon the substance's properties.
Class 7 - Radioactive substances (materials)

The provisions of this class are based upon the principles of the International Atomic Energy Agency's Regulations for the Safe Transport of Radioactive Materials, 1973 (as amended). They offer guidance to shipowners and others handling packages in ports and on ships without necessarily consulting IAEA regulations.

Basically, there are two types of packing for radioactive materials, A and B. The former used for substances of lower radioactivity, the latter for higher levels of activity. Type B packing has to undergo very stringent tests which include a drop test, fire engulfment at 850°C for half an hour, and total water immersion, without suffering significant radiation leakage.

The practical unit of measurement of radioactivity for transportation purposes is the Transport Index, which simply described is that amount of radiation measured at 1 metre from a package. On a ship the maximum quantity of radioactive material permitted in any one location is determined by its transport index, which must not exceed 50, separated by 6 metres from any other radioactive material. The total for a ship must not exceed 200.

The chemical hazards associated with some radioactive materials far exceed those due to the radioactivity. For example, uranium hexafluoride, \((\text{UF}_6)\), has little radiation hazard, but if a spillage occurs will evolve a highly corrosive and toxic gas (hydrogen fluoride). Apart from bearing a radioactive hazard label, uranium hexafluoride must also bear subsidiary labels of 'Corrosive' and 'Poison'.

A substance is regarded as being radioactive if it emits more than 0.002 microcuries of radiation per gram of material.

Packing, labelling and placarding, segregation and other requirements vary according to the radioactivity of the material as indicated above. Radioactive substances are divided into three categories, depending upon radiation levels, category I white being the least dangerous. Category II and III labels are printed in yellow and white for additional emphasis. Category I white label has the wording 'Principal Radioactive Content' and 'Activity of Contents ... Curies' across the front. In addition to this, Category II and III labels have the wording 'Transport Index this Package'.

Class 8 - Corrosives

Substances in this class can damage living tissue and materials, in some cases very severely. Some of them give off irritating or harmful vapours and others are toxic or give off toxic gases. Some are inflammable or give off inflammable gases under certain conditions.

Some corrosives, alkalis such as sodium hydroxide, attack metals such as aluminium and zinc and dissolve them, others will corrode iron or steel. Glass is corroded by fluorides.

Water can also affect some substances by making them corrosive, by liberating gases and in a few cases by generating heat.

In view of these differing properties, packing and stowage are extremely important. The substances
are divided into three packaging groups (group I being the most dangerous). The introduction to the class gives detailed information on the types of packaging to be used.

Most fires involving corrosive substances can be dealt with by any extinguishant, including water, although those which are inflammable should be dealt with in the same way as substances in Class 3 of the Code and care should also be taken in view of the high risk of poisoning through fumes.

Class 9 - Miscellaneous dangerous substances

This class includes substances which, for various reasons, do not come within any of the other classes. Because their properties are so varied, the individual schedules usually include detailed information on stowage, labelling, packaging and other information.

Substances in this class include aerosol dispensers, some ammonium nitrate fertilizers, asbestos, and safety matches.

Medical First Aid Guide for use in accidents involving dangerous goods (MFAG)

The MFAG was developed in close co-operation with the World Health Organisation and the International Labour Organisation.

It is intended as a supplement to the International Medical Guide for Ships (IMGS) although issued as a separate publication.

The Guide was first adopted by the Maritime Safety Committee in 1972. In December 1981, the Sub-Committee on the Carriage of Dangerous Goods completed what virtually amounts to a complete revision of the Guide. The new version was adopted by the MSC at its forty-sixth session in April 1982.

The advice in the MFAG refers not only to the substances listed in the IMDG Code but also to those in Appendix B of the Code of Safe Practice for Solid Bulk Cargoes.

It is intended to provide the advice necessary if chemical poisoning is to be diagnosed and treated within the limits of the facilities available on board ships.

It covers such matters as diagnosis of poisoning; first aid; the complications of poisoning; general toxic hazards; emergency treatment; chemical tables, including indexes; and a list of medicines.

A table from the MFAG is reproduced below as an example.

General Information

These chemicals are all corrosive, but they vary in the degree of their severity. They may cause severe chemical burns.
SIGNS AND SYMPTOMS

Skin Contact
There will be redness and irritation. Strong acids cause chemical burns with severe pain.

Eye Contact
There is redness, irritation and pain. Chemical burns may occur.

Inhalation
Weak acids and low concentration of strong acids produce a cough, tightness in the chest and shortness of breath. High concentrations of any acid may cause breathlessness with frothy sputum (pulmonary oedema). Bronchitis or pneumonia can occur.

Ingestion
Weak acids will give a burning sensation in the mouth with nausea and vomiting. Strong acids can produce severe vomiting with blood. Perforation of the gut can occur.

Emergency Procedures

As no operation is 100% safe no matter how closely regulations are followed, there is always the danger that an accident will lead to an emergency. The Medical First Aid Guide gives information on how personal injuries should be tackled, and IMO has also developed Emergency procedures for ships carrying dangerous goods. These contain information designed to protect the ship as well as those on board.

The substances which appear in the IMDG Code are all listed in the general index which gives the product's UN number; its Emergency Schedule number (EmS), Medical First Aid Guide (MFAG) Table number; and the number of the page on which it appears in the IMDG Code.

By looking up the substance in the index it is a simple matter to ascertain the appropriate emergency schedule. The schedules take the various classes of the IMDG Code and divide the various substances contained in each class into sections. These give information on special equipment which should be carried; emergency procedures; emergency action in case of fire or spillage (remedial action may vary depending on whether the substance is stowed on deck or below deck).

An example (Emergency Schedule 8-05) is given on the following page.

An introduction gives general guidance on dealing with emergencies and particular guidance is given on the emergency schedules.
Under Section 2 (special emergency equipment), for example, the procedures point out that specialised equipment normally available on land is not likely to be available at sea. The EmS (Emergency Schedules) therefore recommend essential equipment which should be carried. Under Section 4 (emergency action) the document states: "In general, the recommendation is to wash spillages on deck overboard with copious quantities of water ... disposal of spilt dangerous goods overboard is a matter of judgement by the master, bearing in mind that the safety of the crew has priority over pollution of the sea."

The emergency schedules currently in use were approved by the MSC in December 1980 and circulated to IMO Member States in March 1981. They replaced schedules adopted in 1979.

(1) Early in 1982, amendments to the Code were approved. They include changes to the general introduction and various other sections as well as the introduction of substantial new schedules. See the changes in M Notice 1032.

(2) Flammable has the same meaning.

(3) See The Ship Captain's Medical Guide 21st ed. published by HMSO. From 1984 it is proposed that it should be a statutory requirement for this official manual to be carried in all British ships.

**EMERGENCY SCHEDULE 8-05**

**CORROSIVE SUBSTANCES, COMBUSTIBLE**

<table>
<thead>
<tr>
<th>Special Emergency Equipment to be carried</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective clothing (boots, gloves, overalls, headgear)</td>
</tr>
<tr>
<td>Self-contained breathing apparatus</td>
</tr>
<tr>
<td>Spray nozzles</td>
</tr>
</tbody>
</table>

**EMERGENCY PROCEDURES**

West protective clothing and self-contained breathing apparatus when dealing with SPILLAGE or FIRE.

**EMERGENCY ACTION**

<table>
<thead>
<tr>
<th>SPILLAGE</th>
<th>On deck</th>
<th>Under deck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wash overboard with copious quantities of water</td>
<td>Collect spillage, where practicable, (using absorbent material for liquids) for safe disposal.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>FIRE</th>
<th>Use water spray</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batten down, use ship's fixed firefighting installation. Otherwise adopt action as for &quot;on deck&quot;.</td>
<td></td>
</tr>
</tbody>
</table>

First Aid - See IMO Medical First Aid Guide (MFAG)
<table>
<thead>
<tr>
<th>UN No.</th>
<th>Substance or Article</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1779</td>
<td>FORMIC ACID</td>
<td>) Turn ship off wind</td>
</tr>
<tr>
<td>1940</td>
<td>THIOGLYCOLIC ACID</td>
<td>)</td>
</tr>
<tr>
<td>2028</td>
<td>BOMBS, SMOKE,...</td>
<td>)</td>
</tr>
<tr>
<td>2262</td>
<td>N,N-DIMETHYLCARBAMOYL CHLORIDE</td>
<td>)</td>
</tr>
<tr>
<td>2565</td>
<td>DICYCLOHEXYLAMINE</td>
<td>)</td>
</tr>
</tbody>
</table>
APPENDIX II

CODE FOR CHEMICAL SHIPS

The Subcommittee on Ship Design and Equipment held its first session in January 1968. From their first discussions, it was evident that international safety standards were needed. It was also clear that the standards should be based upon a concept of total integrity and reliability of the cargo containment system. This is because release of the products could lead to widespread pollution of the sea and atmosphere with attendant injury to crew members, innocent people, and property. In order to deal with the complexities of chemical transportation, the Subcommittee established a special Ad Hoc Working Group to develop the standards. Initially, this Group consisted of representatives from Norway, the United Kingdom, and the United States. The Group was later joined by representatives from the Netherlands, the Federal Republic of Germany, Italy, Sweden and others. Industry groups which have observer status at IMO, such as the International Chamber of Shipping, also assisted with the work.

The standards for chemical tankers were developed over a three year period in which time 10 meetings of the Ad Hoc Working Group were held. They were adopted in 1971 as Assembly Resolution A.212(VII) - "Code for the Construction and Equipment of Ships Carrying Dangerous Chemicals in Bulk". In doing so, the Assembly invited all governments to give effect to the Code as soon as possible.

Additionally, the Subcommittee (and the Ad Hoc Working Group) prepared other recommendations which pertain to chemical tanker safety. These included "Interim Recommendations for Existing Ships Carrying Dangerous Chemicals which are Liquid at Ambient Temperatures and at Atmospheric Pressure" and "Recommendation on the Training and Qualifications of Officers and Crews of Ships Carrying Hazardous or Noxious Chemicals in Bulk".

The Code is based upon a philosophy of relating cargo containment features of ship design, construction, and operation to the hazards and physical properties of the various chemicals covered by the Code.

The following discussion highlights the various chapters of the Code.

Chapter I - General

Chapter 1 contains important information concerning the application and scope of the Code. The scope limits the Code’s application to tankships which transport bulk cargoes of dangerous chemical substances. These are defined as products which have significant fire hazards in excess of petroleum products, and products which have significant hazards in addition to or other than flammability. (As a result of the MARPOL Convention, the scope of the Code will be expanded to include water pollution). Table I is a listing of products which were evaluated and determined to meet the above criteria. Many other products were also evaluated and determined not to be within the scope of the Code. They are listed in Chapter VII of the Code. The United States National Academy of Science Hazard
Evaluative System was used as a basic guide for evaluating whether a product was within the scope of the Code. Hazard evaluation systems developed in Norway and the United Kingdom assisted in making these definitions.

The Code applies only to cargoes which are liquids at normal temperatures. Liquefied gases were excluded so that the Code could be completed in a more timely manner. (As will be discussed in a later section, a separate Code was prepared for gas carriers).

The Code applies to both existing and new chemical tankers. Previously, it had been the practice to apply newly developed standards to ships constructed after the standards had been adopted. Because of the port safety considerations, it was agreed that an upgrading of existing chemical tankers should comply with the Code. A phased time period was developed for existing ships to comply with the various standards. Compliance with requirements for personnel protection was expected immediately, while up to six years was permitted in order to comply with those involving major ship modification, e.g., installation of a double bottom, etc. Also, it was acknowledged that full compliance might not be possible in all cases; therefore, certain types of dispensations were permitted.

Chapter II - Cargo Containment

This chapter contains features of major significance to the design of ships. For the first time, measures to prevent the cargo from release were incorporated into ship design standards. Recognising the probability that damage resulting from collision or grounding could lead to uncontrolled release of the cargo, three degrees of protection for the cargoes were developed. The degrees of physical protection, or 'ship types', define the location of the cargo with respect to the ship's side and bottom and the extent to which a ship should be capable of remaining afloat after damage. The assignment of ship types to the various cargoes takes into account the nature and severity of the product's hazard to the environment should it be released. The more severe requirements are imposed against the more hazardous substances.

The highest standard of physical protection, Type I ship, is required for those substances considered to have the greatest environment hazard, i.e. if released, the cargo would have wide reaching effects beyond the immediate neighbourhood of the ship. Tanks containing Type I products are required to be located inboard from the ship's side a distance equivalent to $1/5$ the ship's beam. The tank's bottom must also be located above the ship's bottom a distance equal to $1/15$ the ship's beam. Further, a Type I ship must be able to survive certain defined damage anywhere in its length, including the engineroom, and remain in an upright stable condition.
A Type II ship is required to transport those cargoes which would present a significant hazard to the ship and crew if released. The release of a Type II cargo would not have the same far-reaching effects as a Type I product. Type II tanks must be located at least 760mm from the ship's side and above the bottom of the ship a distance equivalent to 1/15 the ship's beam. This tank location provides cargo protection against low energy collisions and groundings which often occur to ships in port.

The survivability requirement for a Type II ship is based upon ship length. A Type II ship over 150 metres in length must meet the same survival requirements as a Type I ship. Type II ships less than 150 metres in length must be able to withstand the defined damage anywhere in the cargo area and, separately, withstand flooding of the engineroom.

Type III ships are required for the remaining products covered by the Code. Type III ships are very similar to the petroleum product tanker, i.e., a single skin tanker, although it is significant to note that they are required to meet a higher standard survivability than is required for an oil tanker.

Cargo Segregation

Many of the chemicals which are transported on chemical tankers will react violently if accidentally mixed with other chemicals. Therefore, the Code requires that incompatible cargoes be physically separated on the ship by a cofferdam, void space, or mutually compatible cargo. Similarly, the piping and tank vent systems for incompatible cargoes must be completely separate. The Code does not specify which products are reactive; however, this information is available from other sources, e.g., the U.S. Coast Guard.

Chapter II also develops in detail additional requirements on the location and arrangement of the accommodation space, machinery spaces, cargo pump-room, cargo piping and hose, tank vent systems, tank gauging systems, etc.

Chapter III - Safety Equipment and Related Considerations

One of the major objectives of the Code is to make each chemical ship a safe working environment for its operating personnel. A chemical ship is alive with various operations, such as transferring cargo, cleaning tanks and other similar operations, each of which presents hazards to the vessel's personnel. Within Chapter III are the following major sections:

1. Requirements for ventilation of cargo handling spaces.
2. Standards for electrical equipment.
3. Standards for the gauging of cargo tanks.
4. Standards for fire protection.
5. Standards for personnel protection.
Chapter IV - Special Requirements

Chapter IV contains special requirements which extend the Code’s more general parts. This is to recognise the unusual hazards or properties of certain products. These special requirements are grouped into three subject areas as follows:

Individual Cargoes - This section contains specific requirements which address unusual hazards or characteristics of certain products. For example, the extreme flammability of carbon disulfide is addressed with special requirements for eliminating sources of ignition.

Groups of Products - This section draws special attention to hazards of certain groups of products. For example, monomers have a tendency to polymerise under certain conditions. This tendency can be controlled by introducing small amounts of an inhibitor into the liquid cargo. The special requirement for the monomer group of products deals with the proper inhibition of those cargoes.

Construction and Equipment - This series of special requirements directs attention to the need for certain types of equipment and/or materials of construction when designing ships to carry certain products.

Chapter V - Operating Requirements

This chapter is mainly a summary of the various operating requirements contained in other parts of the Code. When the chapter was prepared, the International Chamber of Shipping was preparing a comprehensive safety guide for chemical tankers which would supplement the Code. Therefore, the chapter was purposefully kept brief.

One operating requirement is of major significance. It establishes cargo size limits for Type I and II ships. The limits are as follows:

"The quantity of a cargo required to be carried in a Type I ship should not exceed 1250 cubic metres in any one tank."

"The quantity of a cargo required to be carried in a Type II ship should not exceed 3000 cubic metres in any one tank."

There was considerable debate over whether size limits should be imposed on chemical tankers. Some delegations were of the opinion that cargo size limits should be determined by national authorities based upon local conditions. Others felt that the Code’s success depended on its containing internationally agreed cargo size limits. Much of the discussion centred upon the likely effect of a particular limit. As recorded in the Code’s preamble, it was finally decided to include the above limits as “holding figures” on the condition that further in-depth studies would be conducted. It is perhaps worthy to note that the Subcommittee had previously developed the formula for limiting the size of cargo tanks on crude oil tankers. That formula was subsequently incorporated into the 1969 Amendments to the 1954 Convention for Prevention of Pollution of the Sea by Oil and the MARPOL Convention.
Chapter VI - Summary of Minimum Requirements

Table 2 is an extract from the "Summary of Minimum Requirements". Chapter VIII serves as the vital link for communicating the Code's requirements. However, what is more significant is that the "Summary of Minimum Requirements" represents a systematic approach to considering the hazard potential, the physical properties of the products in their transported state, and the various degrees of containment. At the time of the Code's preparation, full agreement could not be reached on a single hazard evaluation system and criteria for relating the hazards to the various degree of containment included in the other chapters. Instead, each respective delegation utilised a different system. Remarkably, agreement was reached rather quickly on the requirements for the products. More recently, guidelines for evaluating new products have been developed and are being used when amending the Code. The guidelines are available from IMO.

Impact of the Chemical Code

Prior to 1968, most of the 'chemical tankers' were petroleum product tankers which had been converted to carry chemicals. The degree of conversion varied considerably. In most instances, the 1968 chemical tanker was a single skin tanker which had some modification to the piping and venting systems, but little else. In a few cases, the tanker had been modified extensively by installing a double bottom, independent stainless steel tanks and separate pumping, piping and venting systems for each tank.

Because of its application to existing ships, the Code has impacted each of the 1968 tankers. By 1983, most of the 1968 tonnage has been either scrapped or placed in other service. The fleet has more than doubled in size during the 1968-1983 time frame, and now the average age is approximately 7 years. The Code has, of course, impacted each of the new ships. A sophisticated fleet now exists which consists mainly of double skin Type II ships.

The Code has also had a beneficial impact upon national administrations. The Code has been implemented by 12 countries and is applied on a voluntary basis by 9 other countries. The countries are listed in Table 3. Ships with proper Code certificates are now accepted by many countries that were previously applying unilateral regulations. Other countries are requiring that chemical ships meet the Code as a condition of entry into their ports.
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