Introduction to Oil Tanker and Gas Carrier Operations

Alexander Arnfinn Olsen

ROUTLEDGE

Introduction to Oil Tanker and Gas Carrier Operations

Introduction to Oil Tanker and Gas Carrier Operations introduces the mandatory minimum requirements for training and qualifications for masters, officers and ratings serving on-board liquefied gas tankers. It covers basic safety and pollution-prevention precautions and procedures, layouts of several types of liquefied gas tankers, types of cargo, their hazards and their handling equipment, as well as general operational sequence and liquefied gas tanker terminology.

The book is intended for officers and key ratings who have not previously served onboard crude oil or liquefied gas tankers as part of the regular ship's company. It covers the Level 1 training requirements prescribed by Regulation V/1, paragraph 1.2 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, STCW-95.

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Taylor & Francis
Taylor & Francis Group
http://taylorandfrancis.com

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Routledge
Taylor & Francis Group
LONDON AND NEW YORK

Front cover image: bob63/Shutterstock

First published 2025
by Routledge
4 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

and by Routledge
605 Third Avenue, New York, NY 10158

Routledge is an imprint of the Taylor & Francis Group, an informa business

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library

ISBN: 978-1-032-82400-0 (hbk)
ISBN: 978-1-032-82541-0 (pbk)
ISBN: 978-1-003-50504-4 (ebk)

DOI: 10.1201/9781003505044

Typeset in Sabon
by Newgen Publishing UK

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Preface

In the late 1920s, the transportation of liquefied gases in bulk began. In the very beginning it was the transportation of propane (C_3H_8) and butane (C_4H_{10}) in fully pressurised tanks. Around 1959, semi-pressurised ships entered the market and liquefied gas was now transported under lower pressure, which was made possible by lowering the temperature. By 1963, fully refrigerated ships for LPG, LNG and certain chemical gases wore in service, carrying cargo at atmospheric pressure. Liquefied gas is divided into distinct groups based on boiling point, chemical bindings, toxicity and flammability. The distinct groups of gases have led to several types of gas carriers and cargo containment system for gas carriers. The sea transport of liquefied gases in bulk is internationally regulated – regarding safety through standards established by the International Maritime Organisation (IMO), and these standards are set out in the IMO's Gas Carrier Codes, which cover design, construction and other safety measures for ships carrying liquefied gases in bulk.

This book is intended for officers and key ratings that have not previously served onboard liquefied gas tankers as part of the regular ship's company. It covers mandatory minimum training requirements prescribed by Regulation V/1, paragraph 1.2 of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, STCW-95, and includes basic safety and pollution-prevention precautions and procedures, layouts of several types of liquefied gas tankers, types of cargo, their hazards and their handling equipment, general operational sequence and liquefied gas tanker terminology.

The purpose of this book is to introduce the reader to the mandatory minimum requirements for training and qualifications for masters, officers and ratings serving onboard liquefied gas tankers.

Alexander Arnfinn Olsen
May 2024

Chapter 1

History of the oil and chemical bulk shipping industry

GENERAL

The technology of oil transportation has evolved in parallel with the oil industry itself. Although the use of oil as fuel reaches far back to prehistory, the first modern commercial exploitation of oils distilled from material extracted from the ground is credited to the Scottish chemist, James Young, who first manufactured paraffin (kerosene) in 1850 from coal and oil shales. In the early part of the 1850s, oil began to be exported from Upper Burma, then a British colony. The oil was transported in earthenware vessel to the riverbank, where it was poured into boat holds for shipping to Britain. In 1859 the US State of Pennsylvania became the unlikely birthplace of America's oil industry after the American industrialist Edwin L. Drake struck oil near Titusville. Initially producing around 10 barrels of oil per day, within two years the Titusville field was providing 3,000 barrels per day (480 m^3/d). The invention of oil refining led to the availability of kerosene as lamp oil, which has a clean combustion in contrast to then predominantly used whale oil. Due in part to overfishing, by the 1870s whale oil had become so expensive and hard to come that industrialists and merchants were forced to seek out alternative sources of fuel. This gap in the market was quickly filled with lamp oil, which would become known as "Pennsylvania kerosene." Break-bulk boats and barges were originally used to transport Pennsylvania oil in 40-US-gallon (150 litre) wooden barrels. But transport by barrel posed several problems. The first problem was weight: the standard empty barrel weighed 64 pounds (29 kilograms), representing 20% of the total weight of a full barrel. Also, the barrels tended to leak and could only be carried one way. Finally, the barrels themselves were expensive. For example, in the early years of the Russian oil industry, barrels accounted for as much as 50% of the cost of petroleum production.

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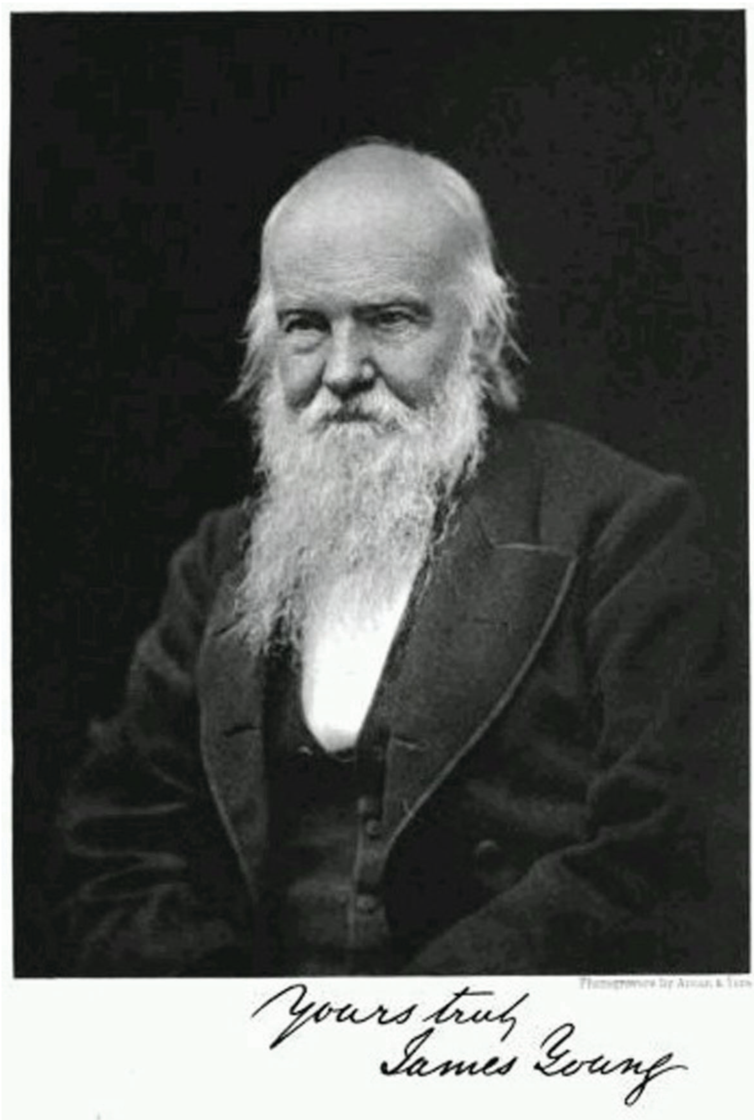

Figure 1.1 Scottish engineer and pioneer, James Young.

DEVELOPMENT OF THE OIL INDUSTRY

The movement of oil in bulk was attempted in many places and in many different ways. Modern oil pipelines have existed in some form or other since at least 1860. The first oil tankers were two sail-driven tankers that were built in 1863 on the River Tyne in the north of England. The first ocean-going oil-tank steamer, the VADERLAND, was designed and built by the British shipbuilder, Palmers Shipbuilding and Iron Company, on behalf of the American-Belgian Red Star Line, in 1873. Despite her initial success, the vessel was soon curtailed by authorities who cited safety concerns. By 1871 the Pennsylvania oil fields were making limited use of oil-tank barges and cylindrical railroad tank cars similar to those in use today. In 1877, the sailing ship LINDESNÆS was converted to carry oil in bulk. The modern oil tanker was developed during the period between 1877 and 1885. In 1876, Ludvig and Robert Nobel, brothers of the Swedish chemist and philanthropist Alfred Nobel, founded Branobel (short for Brothers Nobel) in Baku, Azerbaijan. Throughout the course of the late 19th century, Branobel would become one of the largest oil companies in the world.

Ludvig Nobel was a pioneer in the development of early oil tankers. He first experimented with carrying oil in bulk on single-hulled barges. Turning his attention to self-propelled tankships, he faced a number of challenges. A primary concern was how to keep the cargo and fumes away from the engine room to avoid fires. The other challenges Nobel faced included allowing for the cargo to expand and contract in response to temperature changes and providing a method for ventilating the cargo tanks. In answer to these problems, Nobel signed a contract with the Swedish engineer and shipbuilder, Sven Alexander Almqvist in 1878, to design and build the world's first true type oil tanker. The result was the ZOROASTER, which sailed on its maiden voyage across the Caspian Sea from Baku, Azerbaijan, to Astrakhan, in southern Russia. The ship was built with Bessemer-process

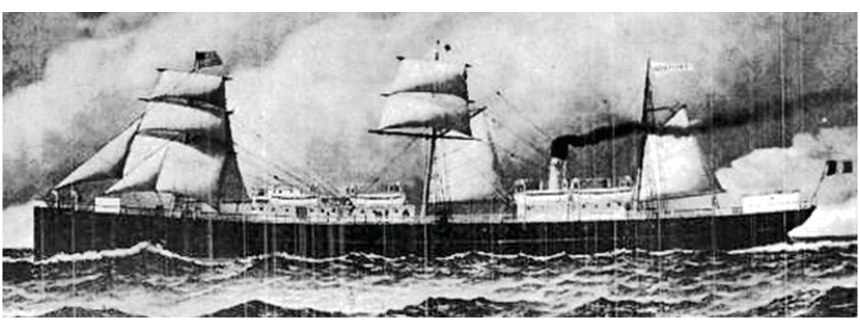

Figure 1.2 VADERLAND.

forged steel, while the petroleum holds were iron. One tank was positioned forward of the midship engine room and the other aft of the engine room. The ship also featured a set of 21 vertical watertight compartments for extra buoyancy. For its time, the tanker ship ZOROASTER was technologically advanced, being reinforced with ballast tanks to enjoy better balancing during navigation during inclement weather. The ZOROASTER measured over 55 metres (180 feet) lengthwise with a breadth of over 11 metres (35 feet), for a draft of about 3.5 metres (10 feet). Around 240 gross tons (1,760 barrels) of crude and kerosene could be ferried by the vessel between the provinces of Astrakhan and Baku along the River Volga and the Caspian Sea route. In October 1878 Nobel ordered two more tankers of the same design: the BUDDHA and the NORDENSKJÖLD. By 1900, the Caspian Sea was crossed by 134 units built in the same way, for a total payload of 48,848 tonnage.

Another important landmark in the advancement of tanker technology was achieved in the early 1880s, when German-British capitalists and naval engineers met at the Armstrong-Whitworth Works in Newcastle upon Tyne. The first oil tanker with integrated hull tanks capable of crossing oceans with relative safety, anticipating many of the modern schemes to be incorporated into ship design, was designed in 1884 by the British naval engineer Henry Frederick Swan. Built mostly of steel with a number of innovative safety systems and an independent pumping station, the 2,700-ton vessel was the first ship in which oil could be pumped directly into the vessel's hull instead of being loaded into barrels or drums: the first ship ever to sail with "oil to her skin." The GLÜCKAUF was powered by a 992-horsepower steam propulsor, providing 11 knots at maximum speed. In addition, the GLÜCKAUF also carried sails for backup. At 318-foot long, 37-foot beam and 19-foot draft, the GLÜCKAUF was equipped with 14 tanks arranged in seven separate compartments each divided longitudinally by a continuous bulkhead. The pumping system and expansion boxes could unload the ship in as little as 12 hours. Laid down on 25 November 1885, the GLÜCKAUF was launched on 10 June 1886, sailing on her maiden voyage from the Tyne on 10 July 1886, arriving in Philadelphia with a cargo of 2,880 tons of crude. Built for Wilhelm Anton Riedemann's shipping firm in Geestemünde, the vessel mostly operated as a tramp steamer on charter to the Standard Oil Company. The GLÜCKAUF remained in service from 1886 to 25 March 1893 when she ran aground in heavy fog on Fire Island, New York. After the GLÜCKAUF was lost, Standard Oil purchased the GLÜCKAUF's sister ships.

In 1903, the Nobel brothers built two oil tankers which ran on internal combustion engines, as opposed to the older steam engines. The VANDAL, the first diesel–electric ship, was capable of carrying 750 long tons (760 tonnes) of refined oil and was powered by three 120 horsepower (89

Figure 1.3 ZOROASTER.

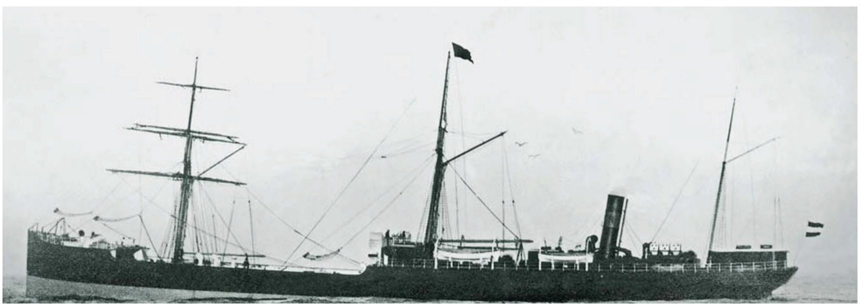

Figure 1.4 GLÜCKAUF underway.

kilowatt) diesel motors. The larger SARMAT employed four 180 horsepower (130 kW) engines. The first seagoing diesel-powered tanker, 4,500-ton MYSL, was built by Nobel's competitors in Kolomna, Russia. Nobel responded with the EMANUEL NOBEL and KARL HAGELIN, two 4,600-long-ton (4,700 tonnes) kerosene tankers with 1,200-horsepower (890 kilowatt) engines.

In 1902 the 475 feet (145 metres), the seven-masted schooner, THOMAS W. LAWSON, was built as the largest pure sail tanker. Designed to carry coal, and oil in barrels from Texas to the East Coast of the US, the 5,218 GRT schooner was later fitted out as an oil tanker in 1906. She was sunk in a storm off the Isles of Scilly, UK, on 14 December 1907, with the loss of 17 out of 19 crew, including the ship's pilot.

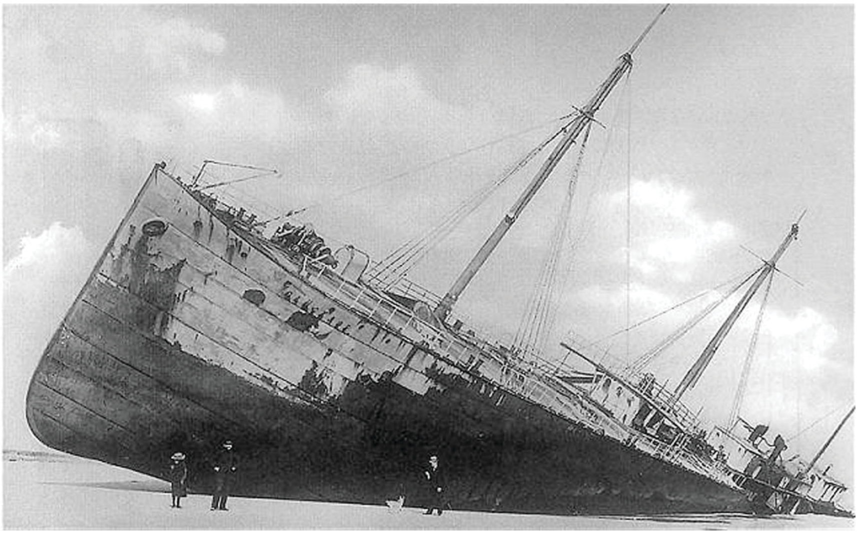

Figure 1.5 GLÜCKAUF grounded in heavy fog at Blue Point Beach on Fire Island.

Asian oil trade

The 1880s also saw the beginnings of the Asian oil trade to the East. The oil industry in Azerbaijan was the largest producer in the world at that time but was limited to the Russian market. To the west, John D. Rockefeller's Standard Oil Company dominated the world market. The idea that led to moving Russian oil to the Far East via the Suez Canal was the brainchild of two men: Marcus Samuel, and the shipowner/broker Fred Lane, who was the London-based agent for the De Rothschild Frères. Prior bids to move oil through the Suez Canal had been rejected by the Suez Canal Company as being too risky. However, Samuel approached the problem a different way. Instead of trying to force a ship through the Suez Canal, Samuel asked the company for the specifications of a tanker that it would allow through the canal. Armed with the canal company's specifications, Samuel tasked James Fortescue Flannery, ship designer for Bnito – the Caspian and Black Sea Oil Company, the Russian oil company of the Rothschilds – and ordered three tankers from William Gray & Company in Northern England. Named the MUREX, the CONCH and the CLAM, each had a capacity of 5,010 long tons of deadweight. In 1893 the Samuel brothers founded the Tank Syndicate together with Fred Lane and a consortium of Asian trading companies. In 1897 it was renamed the Shell Transport and Trading Company, forerunner of today's Royal Dutch Shell Company.

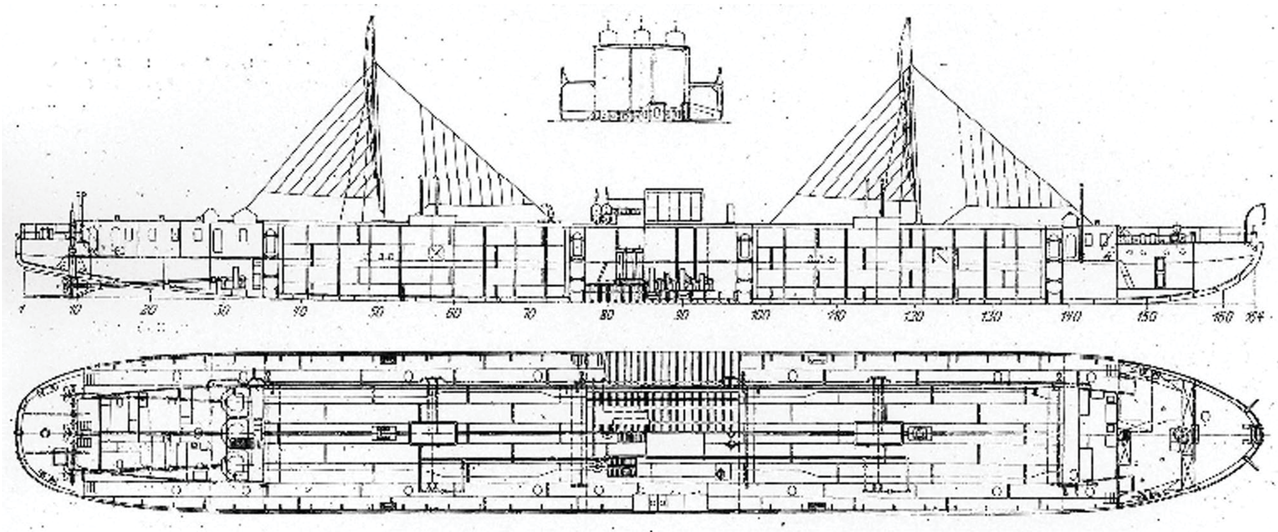

Figure 1.6 River tanker VANDAL (mechanical drawings), 1903.

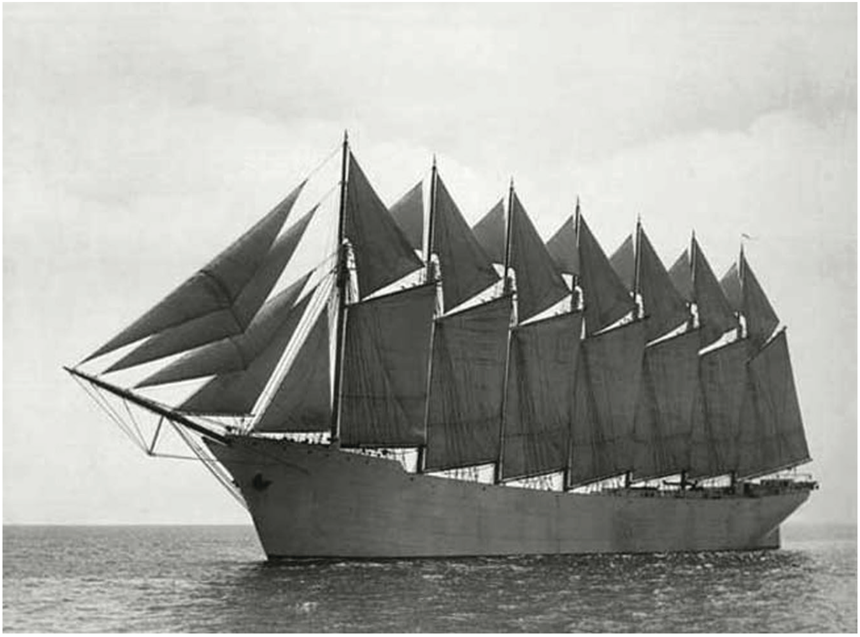

Figure 1.7 THOMAS W. LAWSON on her maiden voyage, 1902.

With facilities prepared in Jakarta, Singapore, Bangkok, Saigon, Hong Kong, Shanghai and Kobe, the fledgling Shell company was ready to become Standard Oil's first challenger in the Asian market. On 24 August 1892, the MUREX became the first tanker to pass through the Suez Canal.

In the meanwhile, in 1890, the Koninklijke Nederlandsche Maatschappij tot Exploitatie van Petroleumbronnen in Nederlandsch-Indie (KNMEP) ("Royal Dutch Company for the Working of Petroleum Wells in the Dutch Indies") – part of Royal Dutch Petroleum – was founded. In 1892 the company struck oil near Pangkalan Brandan on Sumatra, just some months before Samuel's kerosene arrived in Singapore. At first, chartered ships were used, but in 1896 KNMEP launched its first tankers, the BESITANG and BERANDAN. The threat of the Tanker Syndicate was reduced as the Dutch government excluded them from trading in the Dutch East Indies. By the time Shell merged with Royal Dutch Petroleum in 1907, the company had 34 steam-driven oil tankers. Standard Oil started building tankers the same way as Shell and by 1900 was the owner of a fleet of around 60 tankers.

Pivoting again to the west, from 1912 the Compañía Mexicana de Petróleo El Aguila ("Mexican Eagle Petroleum Company"), founded in 1909 by Weetman Pearson to develop the newly found Mexican oil fields, and later

Figure 1.8 Royal Dutch Petroleum dock in the Dutch East Indies (now Indonesia).

Figure 1.9 Steam tanker CONCH, built in 1892 by W. Gray & Co. Ltd, West Hartlepool.

nationalised in 1938 as Pemex, also started to build its own tanker fleet. They quickly adopted Joshua Isherwood's new longitudinal framing system which allowed for the construction of much larger ships using a simpler construction process. Prior to the outbreak of World War I, the company owned a sizeable fleet of 20 tankers. Despite being the world's number one oil

Figure 1.10 FALLS OF CLYDE, the oldest surviving American tanker and the world's only surviving sail-driven oil tanker

producer, Standard Oil did not participate directly in the newly discovered oil fields of Texas and Oklahoma, which gave rise to opportunities for new oil companies to emerge such as Gulf Oil and the Texas Fuel Company, later renamed Texaco. Avoiding the use of Standard Oil's pipeline system, they started using tankers to get their oil to the East Coast. In combination with the oil fields discovered in Mexico and Venezuela, this caused a rise in the demand for tankers, which provided opportunities for the first independent shipowners to enter the tanker market, such as the Norwegian shipowner Wilhelm Wilhelmsen, who launched their first tanker in 1913.

World War I and the interbellum period

The fleet oiler USS MAUMEE, launched on 17 April 1915, pioneered the technique of replenishment at sea (RAS). A large ship for the time, with a capacity of 14,500 long tons of deadweight, the USS MAUMEE began refuelling destroyers en route to Britain at the outset of World War I. This technique enabled the US and Royal Navy to maintain their fleets at sea for extended periods, with a far greater range independent of the availability of a friendly port. This independence proved crucial to the Allies victory in World War II. Underway replenishment was quickly adopted by other navies. One example of this is the Australian fleet oiler HMAS KURUMBA which provided underway replenishment services to Royal Navy from 1917 to 1919. During World War I, unrestricted submarine warfare caused a shortage of tankers. So much so, in fact, that the US ambassador to the UK, Walter Hines Page, wrote

> the submarines are sinking freight ships faster than freight ships are being built by the whole world. In this way, too, then, the Germans are succeeding. Now if this goes on long enough, the Allies' game is up. For instance, they have lately sunk so many fuel oil ships, that this country may very soon be in a perilous condition – even the Grand Fleet may not have enough fuel.

The French president, Georges Clemenceau, also wrote of the problem in a letter to US President Woodrow Wilson, in which he stated:

> Gasoline is as vital as blood in the coming battles…a failure in the supply of gasoline would cause the immediate paralysis of our armies.

In response, Wilson directed the US War Shipping Board to commandeer all US-registered merchant vessels and also took charge of all American shipyards. An unprecedented budget of US$1.3 billion was approved by the US Congress. As part of this package of aid, the largest shipyard in the world was built on Hog Island, which later became synonymous for the Hog Islander.[1] Between 1916 and 1921, 316 tankers were built with a total capacity of 3.2 million long tons of deadweight; in comparison to the entire world fleet before World War I, which was just above 2 million tons, this feat of human engineering was quite miraculous. In 1923 about 800,000 long tons were laid up, which gave enormous opportunities for speculators, such as Daniel Keith Ludwig. In 1925 Ludwig bought the freighter PHOENIX, installing tanks into the holds. These tanks were riveted instead of welded, which often leaked, resulting in an explosive mixture in the PHOENIX's hull. Sadly, an explosion killed two crew members and severely injured Ludwig. Following this incident, Ludwig became a strong believer in welding. In 1928, the 16,436-ton CO STILLMAN was built by the German shipbuilder Bremer Vulkan. The CO STILLMAN was notable for being the world's largest oil tanker at that time, a record she held throughout her 14-year career.

For most of the 1920s, the major oil companies continued to develop their fleets by building increasing numbers of tankers; however, many independent shipowners also started to invest in tanker fleets of their own. By the outbreak of World War II in 1939, some 39% of the global tanker fleet was in private shipowner's hands. This was partly due to the legacy of the

1929 Wall Street Crash, where the vagaries of the stock market led to a sharp drop in worldwide economic activity resulting in mass unemployment and dropping freight rates for tankers. Despite this, the tanker industry has avoided the "Conferences," cooperation agreements that predominate in the scheduled liner trade. Tanker chartering is cited by economists as one of the very few examples of "perfect competition" – i.e., the price is set purely by negotiation between the buyer and seller of the service without regulation of outside bodies or rules. This explains why when supply of tankers exceeds demand, there is nothing to stop the price negotiated by the customers – the charterers – being driven right down to the floor. The early 1930s was such a time for tanker owners and adversity led them to explore new ways to cooperate. One such example was HT Schierwater, a resident of Liverpool whose own produce brokerage had fallen victim to the 1929 Crash. After his business failed, Schierwater joined the British tanker owner, United Molasses, which later developed into Athel Line, working first in its Liverpool office and then in London.

The Schierwater plan

Schierwater pioneered a plan to even the tanker supply-demand balance by cutting the number of tankers available to trade. The Schierwater Plan involved mothballing surplus tankers. The vessels that remained in trade would, from the expected higher freight returns, contribute 10% of their freight income to reward the owners of ships that had been mothballed. The Schierwater Plan was well received by the industry not least because the oil company charterers, concerned that the quality of the tanker stock should not fall due to underfunding, supported it and gave charter preference to ships entered into the scheme. The seeds of a cooperation between independent owners led to other opportunities to work together. On 28 February 1934, the International Tanker Owners' Association was inaugurated, with Schierwater appointed as its first Chairman to, in the words of shipowner Erling Næss:

> establish a medium for tanker owners to exchange information and opinions and to deal with the oversupply of tanker tonnage which depressed the market at the time.

The Schierwater Plan was the first such scheme of active cooperation amongst tanker owners to work. Although attempts were made to repeat its formula, no other scheme has enjoyed the same success. Whether its success was due to the participation of all parts of the industry, the forbearance of US anti-trust authorities or the recovery of economic activity and then the onset of World War II in 1939 is open to debate. Post-war, the massive reduction of tanker tonnage through sinking led to good times for tanker owners shipping oil from America and the Middle East to power the rebuilding of Europe. The Association was reassembled in 1949 by Schierwater and elected Reginald RS Cook of Hunting & Son, Newcastle, as its Chairman, a post he held until 1967. The Association continued to meet, but in times of prosperity, the meetings were more social than businesslike. Records show many involved dinners and golf matches between Britain and Norway. Despite the apparent success of the Schierwater Plan, there had been considerable doubts among some owners about its market effects. The continuing opposition resulted in the Association, which was the Plan's custodian, deciding in 1955 that a 76% vote of members in favour would be required to revive the mothballing plan.

In 1956, Egyptian President Gamal Nasser nationalised the Franco-British Suez Canal, leading to its closure and vastly increasing the length of tanker voyages from the Middle East oil wells to industrial Europe, and back again in ballast. Increased demand for tanker service brought good times but in 1957 the Canal opened again, now under Egyptian control, and the freight market again diminished. By 1962, after several years of poor freight rates, the Association was actively discussing a fresh mothballing plan modelled on Schierwater.

The international tanker recovery scheme

The international tanker recovery scheme was offered to owners and oil companies to improve conditions in the industry. The European oil majors British Petroleum (BP) and Shell were ready to back the scheme as the oil industry had backed Schierwater; however, this time the Americans were more reticent about joining the scheme. Nonetheless, the Association pressed on with the plan and at its peak in the summer of 1964 some 80 tankers (approximately 1.5 million tons of carrying capacity) were in lay-up under the scheme. However, the lay-up was short term and seasonal. By the winter of 1964/65, all the ships in lay-up left mothball and entered back into service. In 1967 the Suez Canal again closed only this time due to the Arab–Israeli War. Lay-up schemes were not the only objective of the Association. Erling Næss and Norwegian shipowner Jørgen Jahre promoted a Shipbuilders and Shipowner Collaboration Scheme in the 1960s to limit the construction of surplus tankers. European shipbuilders were ready to support the scheme; however, shipbuilders in the Far East, dominated by the Japanese, were too busy establishing themselves as the controlling force in world shipbuilding and were unwilling to back the scheme resulting in its failure to gather mass support.

Besides attempting to control the supply of tankers to manage surplus tonnage, the Association was active in attempts to harmonise safety requirements for tankers and to standardise equipment needs in different oil ports and terminals. This was before any international body for maritime affairs was established. The United Nations was only brought into being late in the 1940s. The Convention creating the Intergovernmental Maritime Consultative Organisation, the forerunner of the International Maritime Organisation (IMO), was drawn up in 1948 but not brought into effect until 1958/59. Shipping traffic was regulated by national rules and occasional bipartite treaties. The need for worldwide agreement on ship operation and equipment for a class of ship trading in a hazardous product was readily apparent to the Association. Following the stranding of the tanker TORREY CANYON on the British coast in 1967, and outcries about clean-up of oil spills and compensation for the victims of the maritime pollution, discussions started amongst tanker owners to form a voluntary agreement accepting liability and providing compensation funds, through insurance.

The International Tanker Owners' Association was active in these discussions which led to the creation of the Tanker Owners' Voluntary Agreement concerning the Liability for Oil Pollution, or TOVALOP. The International Tanker Owners' Association was headquartered in London, signifying the continued strength of the British merchant fleet. Its membership was international, but the leading positions were those of the British tanker owners Hunting's of Newcastle, Athel Line, P&O and Erling Næss' Anglo Nordic. Stewart Browne of Athel Line and Vice-Chairman under Reginald Cook continued to serve as Vice-Chairman until the Association closed in London. Jan Hudig, Jørgen Jahre and Erling Næss would later become chairmen in

Figure 1.11 TORREY CANYON, 1967.

Oslo, Norway. The Association worked closely with the leading bodies of British shipping and with the London-based oil companies. Indeed, when in the 1960s the senior manager in BP's shipping operations, Houston Jackson, retired from BP, he was signed to Hunting's and elected Chairman of the Association in succession to Reginald Cook. Many of the British members were liner companies with tanker departments or sections closely monitored by the UK Chamber of Shipping. This led the more specialist tanker owners to become restless and concerned that other interests were limiting the effectiveness of the Association. By 1967, the closure of the Suez Canal had rendered the recovery scheme unnecessary. The Association's agenda had therefore shrunk, and the opportunity arose for independent tanker owners to recreate the Association on finer lines and with more independence from other influences. Although some of the Association's members resisted, the Association was wound up in London. Largely inspired by Jørgen Jahre, INTERTANKO, the International Association of Independent Tanker Owners, opened in Oslo at an inaugural meeting on 21 October 1970.

Closure of the Suez Canal

The oil spill caused by the TORREY CANYON in 1967 led to wider public awareness about the environmental dangers of oil tankers. In response, the major oil companies united in 1970 to form the Oil Companies International Marine Forum (OCIMF), which became instrumental in the drafting and implementation of MARPOL 73. In 1968, the International Tanker Owners Pollution Federation was founded to indemnify the victims of tanker incidents. For tanker owners, the Six-Day War of 1967 was of greater importance. In response to Israel's victory, the Suez Canal was closed to international shipping until 1975. This had the effect of sending freight rates skyrocketing (1) because of the shortage of tonnage, and (2) because ships had to round the African continent and pass the Cape of Good Hope. To offset the costs of longer passages, shipowners started thinking about designing and building larger capacity vessels. Given the limitations of the Suez Canal were no longer relevant, the only governing factor was how big is too big! In only a couple of years, the size of tankers quadrupled to more than 500,000 long tons and there were even plans for tankers of 1,000,000 long tons. In 1969 the first ultra-large crude carrier (ULCC) was built.

The world's largest super tanker ever built was constructed for Tung Chao Yung in 1979 at the Oppama Shipyard of Sumitomo Heavy Industries, Ltd. as the SEAWISE GIANT. This ship was built with a capacity of 564,763 DWT, a length overall of 458.45 metres (1,504.1 feet) and a draft of 24.611 metres (80.74 feet). She had 46 tanks, 31,541 square metres (339,500 square feet) of deck and was too large to pass through the English Channel. SEAWISE GIANT was renamed HAPPY GIANT in 1989, and then JAHRE VIKING in 1991. Between 1979 and 2004 she was owned by Loki Stream,

Figure 1.12 KNOCK NEVIS.

at which point she was bought by First Olsen Tankers, renamed KNOCK NEVIS and converted into a permanently moored storage tanker. Today, the Batillus class super tankers are the biggest ships ever constructed by gross tonnage.

Although the tanker fleet increased by around 12% annually in 1970, a shortage on tonnage remained. In 1973 this resulted in an enormous increase in new building orders, especially from oil majors that wanted to gain on the quicker deciding independents, who could ask enormous rates for their vessels. Where the existing tanker fleet comprised some 150 million long tons, in just a quarter of a year, tonnage of 75 million was ordered, although new build prices doubled. The increase in scale brought a new problem. Until then, the washing of tanks after cargo discharge was done by water. In December 1969 three tankers exploded during tank washing. The Dutch Shell tanker MARPESSA sank off the coast of Dakar and became the largest merchant vessel ever lost. The other two, the British Shell tanker MACTRA and the Norwegian KONG HAAKON VII sustained heavy damage but remained afloat. Shell investigated the incident and concluded that when water drops impact steel with high velocity, this generates static electricity that can cause explosions when combination with cargo vapours. This problem only became apparent with the large sizes of the tanks onboard very large crude carriers (VLCC).

Figure 1.13 MARPESSA.

Figure 1.14 MACTRA.

Figure 1.15 KONG HAAKON VII.

The solution was found by filling the cargo tanks with inert gas (IG), therein reducing the oxygen level such that the tank remains below the explosive limit of the cargo vapour. The use of IG is seen as the biggest step in increasing tanker safety. Ten years later however, 50 people were killed when the BETELGEUSE exploded at Whiddy Island in Bantry Bay. The Total tanker was still not fitted with IG. The vessel ENERGY CONCENTRATION did have this system, which prevented an explosion when it broke in two on 21 July 1980 during discharge at Europoort in the Netherlands. Washing with water in combination with a "Load on Top" system was replaced by crude oil washing (COW), a method developed by the British oil major BP. The advantages were cleaner tanks, no corrosive seawater in the cargo tanks and no discharges of polluted seawater overboard.

Era of the "super tanker"

Where the size of tankers had been more or less the same for 25 years, after World War II, they grew in size significantly, albeit initially slowly (Table 1.1). A typical T2 tanker of the World War II era was 162 metres (532 feet) long and had a maximum capacity of 16,500 DWT. In comparison, a modern ULCC can be as much as 400 metres (1,300 feet) long and have a capacity of 500,000 DWT. Several factors have encouraged

Table 1.1 Global tanker fleet 1957–1980

At year end	*Number of vessels in each tonnage class*			
	25–99 DWT	*100–149 DWT*	*150–199 DWT*	*>200 DWT*
1957	427	0	0	0
1958	568			
1959	715			
1960	826			
1961	892	2		
1962	989	4		
1963	1,092			
1964	1,226	6		
1965	1,303	15		
1966	1,395	34		
1967	1,446	59	5	2
1968	1,488	82	17	17
1969	1,535	96	30	61
1970	1,572	110	34	131
1971	1,600	125	37	200
1972	1,609	136	38	270
1973	1,656	150	41	357
1974	1,718	193	42	479
1975	1,714	241	47	588
1976	1,753	265	64	676
1977	1,580	279	76	712
1978	1,453	269	83	700
1979	1,435	304	45	699
1980	1,482	300	41	658

this growth. As discussed above, hostilities in the Middle East, which interrupted traffic through the Suez Canal, contributed, as did nationalisation of Middle East oil refineries throughout the 1960s and 1970s. Intense competition amongst shipowners also played its part. But apart from these considerations is the simple economic advantage that comes with larger vessels. The larger an oil tanker is, the more cheaply it can move crude oil, and the better it can help meet growing demands for crude products. It is worth noting that a similar evolution for container vessels has taken place since the mid-2000s. As of 2024, the largest container ships in service today are capable of stowing in excess of 23,000 20-foot equivalent ISO containers compared to the industry average of 5,000 in 2005. Whereas previously it was normal practice for the refinery of oil to take place near the well, this gradually moved towards the consumer location. Production in the Middle East developed, and the dominance of product tankers was replaced by crude oil carriers. Panamax tankers were built, soon followed by Aframax and Suezmax tankers.

After the war, it was expected that a large number of tankers would be laid up, which indeed happened. Despite the US Maritime Commission replacing the War Shipping Board, fraudulent activities are rampant. The Greek shipping magnates Aristotle Onassis and Stavros Niarchos used this time to buy tankers cheaply. The expected economic decline did not come, due in part to the Marshall Plan, with the demand for oil increasing to the point in 1947 that there was a shortage of tankers. Freight tariffs tripled overnight, enabling some to recoup their investment in as little as one voyage. Ludwig had started Universe Tankships in 1947 and began building larger tankers in his welding Shipyards. The BULKPETROL, boasting a massive 30,000 long tons, was the largest tanker to enter service at that time, though four of the five bulk class tankers sank, likely because welding technology was not yet fully understood. As larger ships could not be constructed in the yard at Norfolk, Virginia, Ludwig went to Japan where he introduced the concept of block construction at the Kure Naval Yard. Here, in 1952, the 38,000-long-ton PETROKURE was built. That same year, Onassis had a tanker of some 45,000 long tons built, with Niarchos following soon after. Both Onassis and Niarchos claimed to be the largest independent tanker owner in the world.

The SINCLAIR PETROLORE that Ludwig had built in 1955 was at 56,000 long tons, not only the largest freighter in the world, but also a self-unloading ore–oil carrier, the only one of that type ever built. It exploded on 6 December 1960 near Brazil. The likely cause being cargo leakage in the double bottom, which resulted in the largest spill until that time with an estimated 60,000 tons leaking into the South Atlantic. In 1956 the UNIVERSE LEADER of 85,000 long tons was built just before the Suez Crisis started with the seizure of the PANNEGIA. Within ten years, tanker sizes had quadrupled. In 1958, Ludwig broke the 100,000-long-ton barrier with the construction of the UNIVERSE APOLLO. This behemoth displaced 104,500 long tons, a 23% increase from the previous record holder, UNIVERSE LEADER. Not to be outdone, in 1962, Niarchos had the 106,000-long-ton SS MANHATTAN built. This was the largest merchant vessel ever built in the US. It was converted to have ice breaking capabilities in 1969 and was the first commercial ship to cross the Northwest Passage. Although the voyage was a success, a second attempt to cross the passage in winter proved impossible. Combined with numerous environmental concerns, the project was cancelled, and the Trans-Alaska Pipeline System built instead.

In 1966 the 206,000 long ton IDEMITSU MARU was the first VLCC to be built, followed shortly after in 1968 with the first ULCC, the UNIVERSE IRELAND. In as little as 20 years, the size of tankers had increased tenfold.

Oil crisis and consolidation

On 10 October 1973, the Yom Kippur War began, igniting the 1973 oil crisis, tripling oil prices to US$10 per barrel and halting economic growth. Newly build ships sometimes went straight from the yard to lay-up. The situation worsened when the Suez Canal was reopened in 1975. Just when the situation began to improve in 1979, the Iranian Revolution caused the second oil crisis, causing oil prices to rise to US$30. Ships were sometimes sent to the breakers after being in service for only ten years. It took until the end of the 1980s before many shipowners say any profits being made in oil transport. In 1979, World-Wide Shipping of Yue-Kong Pao, with a fleet of 204 vessels, many of them tankers, was the largest shipping company in the world with a tonnage of 20.5 million. Within five years, however, he had sold some 140 vessels. In 1980, Ludwig had built or acquired the largest fleet after Pao and CY Tung and was widely regarded the richest man in the US.

In 1976, the Intervention Convention was used for the first time when the US Coast Guard took on the salvage of the ARGO MERCHANT, although the vessel was in international waters. This was the first time the monopoly of the Flag State was challenged. The EXXON VALDEZ oil spill saw the introduction of legislation requiring tankers to have a double hull, a measure that was not universally seen as the best solution by all naval experts. Where a double hull should (in theory) minimise the consequences of a vessel grounding, Concordia Maritime developed an alternative approach with the Stena V-MAX, a VLCC fitted with two propellers, two rudders and two

Figure 1.16 During the salvage of the ARGO MERCHANT, the Intervention Convention was used for the first time.

Figure 1.17 STENA VICTORY, a V-MAX, approaching LOOP from anchorage.

redundant engine rooms. The key benefit being that a single fault would not result in a loss of steering, therein reducing the chances of grounding. That being said, the sheer size of VLCCs and ULCCs limits their sailing area and available ports. In the US, Louisiana Offshore Oil Port (LOOP) is the only facility that is able to handle VLCCs. To overcome this, ULCCs and VLCCs often anchor offshore before lightering to smaller tankers that are able to reach the destination port. The largest oil terminal in operation (as of 2024) is the Ras Tanura Oil Terminal in Saudi Arabia.

Emergence of the ultra-large crude carrier (ULCC)

In 1999 the Greek Hellespont Steamship Corporation ordered four double-hulled super tankers to be built between 2002 and 2003. These sister ships, the HELLESPONT ALHAMBRA, HELLESPONT METROPOLIS, HELLESPONT TARA and FAIRFAX, were sold to the Overseas Shipholding Group and Euronav in 2004. Renamed the TI class, and currently registered as the TI ASIA, TI EUROPE, TI OCEANIA and TI AFRICA, are as of 2024 the world's four largest working super tankers. Each of the four sister ships has a capacity of over 441,500 DWT, a length overall of 380.0 metres

Figure 1.18 EXXON VALDEZ.

(1,246.7 feet) and a cargo capacity of 3,166,353 barrels (503,409,900 litres). The first ULCC tankers to be built for some 25 years, they were also the first ULCCs to be double-hulled. To differentiate them from smaller ULCCs, these ships are sometimes given the V-Plus size designation. In February 2008, the owners of the TI AFRICA and TI ASIA began converting both vessels into stationary floating storage and offloading (FSO) units. The TI AFRICA and TI ASIA were anchored at the Al Shaheen Oil Field near Qatar in 2009.

With the exception of the pipeline, the tanker is the most cost-effective way to move oil today. Worldwide, tankers carry some 2 billion barrels (3.2×1,011 litres) of crude oil each year, with an average residual cost of only US$0.02 per gallon at the pump.

DEVELOPMENT OF THE CHEMICAL AND PRODUCT TANKER

In the years following World War II, a series of chemical industries sprang up along the US Gulf Coast. These new industries relied on Texas oil and gas fields and Louisiana sulphur mines to provide the raw chemical feedstocks. Initial plant production figures were insignificant compared with today's mammoth outputs, thus enabling shipments to be made to consumers

Figure 1.19 HELLESPONT ALHAMBRA (now TI ASIA).

along the Atlantic Coast in drums, portable tanks and railroad tank cars. Throughout the 1950s, however, demand for chemicals quickly increased and more extensive and sophisticated means of transport were required. For a while dry cargo ships with deep tanks were able to supplement existing methods of transport but the appearance of hazardous new chemicals which had to be shipped in large batches made it apparent that a new type of sea-going vessel was required. The first chemical carriers were converted war-built T2 tankers. By realising the significance of cargo segregation, the tank layouts in the earliest of these conversions enabled the simultaneous carriage of several hazardous and incompatible cargoes. The first of the new breed was the 9,073 gross tonnes RE WILSON, which was converted for the Union Carbide and Carbon Corporation in 1948. The RE WILSON was fitted with a double bottom and deep well pumps, unique for such ships at that time. Her centre tanks allowed the carriage of nine different chemicals, while petroleum products of moderate density, such as kerosene, could be carried in the ship's wing tanks. She entered service in January 1949 and shuttled regularly from the Gulf Coast ports to New York, except for a period of about 18 months in the mid-1950s when she carried chemicals from Texas City to Los Angeles and San Francisco. The RE WILSON operated successfully until 1971 when she was scrapped in Spain. Not all the US' chemical tankers began life as T2 tankers though; one such vessel was the Texan. Built in 1946 as a C4 cargo vessel, she was converted and lengthened in Japan in 1954 to an ore/oil vessel and in 1957 the ore holds were converted to carry 14,000 tonnes of chemicals. These vessels operated regularly between the Gulf and West Coasts until January 1975 taking chemicals out to the West Coast and returning home with between 7,000 and 8,000 tonnes of lube oil and other clean petroleum products. This was the genesis of the parcel tanker trade. Parcel tankers are smaller sized vessels which carry small lots of liquid chemicals or "parcels," usually on a regular service. Parcels may be anywhere from a few hundred to a few thousand tonnes each; they can be of any of a multitude of products; and they could be loaded and or discharged at any one of several ports along an established route.

The earliest parcel tankers, like early chemical tankers, were conversions based on petroleum product tankers built in the late 1940s and early 1950s. These ships had been laid up after the post-Suez collapse in 1957, as they were deemed uncompetitive compared to the larger, newer vessels. As the international trade in chemicals was developing rapidly; however, shipowners realised the potential of having smaller volume tankers and were willing to invest money on a small amount of conversion work to prepare these vessels for time charters to keep them employed. Conversion work usually entailed adding a few bulkheads to provide smaller tanks, coating some of the tanks with zinc silicate, installing additional pumps and pipelines to provide segregation and, if necessary, adding a second pump room. At the time daily running costs were low (between US $2,000 and US $3,000 were common for 12–18,000 DWT parcel tankers), enabling low time charter rates (as low as $3.00 per DWT per month). It was these low freight rates combined with efficient handling of difficult and hazardous products which gave the parcel tanker trade its initial boost. In the early 1960s typical rates were averaged around US $8.00–$10.00 per tonne on the US Gulf to Rotterdam route and between $14 and $18 per tonne on the US Gulf to Japan route. There is little doubt that the artificially low rates provided by the worldwide parcel tanker services had a catalytic effect on the growth of the chemical industry. These low freight rates, however, have at times come back to haunt the parcel tanker operation as they have never truly reflected the actual cost of ship construction or replacement. At the time, the charter rates that were paid for these ships as parcel tankers did not include the amortisation of any capital element. As a result, some operators requiring replacement tonnage in later years were hard pressed for capital funding. As the first purpose-built parcel tankers appeared in the early 1960s shipbuilding prices were still comparatively low. At this time, the European petrochemical industry was slowly recovering from the war, and so it was left to US chemical manufacturers to supply the bulk of European customers. In addition, the world trade in edible oils, lubricating oils and inorganic chemicals was expanding. This led to several operators deciding to get enter the parcel tanker sector. The first purpose-built ships incorporated the main characteristics of the early converted parcel tankers in addition to several novel technologies. More bulkheads were included in the cargo spaces to provide the ship with upwards of 40 tanks. Many ships incorporated a variety of coatings on a single vessel to ensure compatibility with a wider range of cargoes. Stainless steel tanks, to enable vessels to carry corrosive cargoes requiring a high degree of product purity, were fitted to many vessels. Other features included installing heating coils or ducts and sophisticated safety, alarm and IG systems.

The types of products that parcel tankers transport in bulk, i.e., chemicals, edible oils, lubricating oils and solvents, necessitated trade patterns. In general terms, chemicals produced in the US, Japan and Europe, which incidentally are also the main market for these chemicals, are also required in South America, South Africa, Australia and the Indian Ocean region. Therefore, only the difference between output and demand is moved by sea between individual countries. Since the parcel tanker acts as a buffer to balance the petrochemical plants output programme, no long-term consistency can be expected regarding the movement of any one product. Edible oils are produced either in the agricultural areas of the Western Hemisphere or in the tropical areas of the Far East and Africa. Consumption is centred in developed countries which do not produce the raw materials necessary for making soap, cooking fats, margarine, etc. Hence, there is a consistent flow of products such as soya bean oil, palm oil, beef and mutton, tallow, coconut oil and so forth, from the producing areas into Europe, the US and Japan. Lubricating oils and solvents are manufactured in the refining centres of the world and are widely distributed to countries which may have a low consumption which would not warrant local manufacture. Patterns of loading enormous quantities at one port and discharging small quantities at several remote ports are common. Unlike chemicals, a consistent pattern can be seen with lubricant and solvent movements. Parcel tankers are influenced by global trends more than any other sector of shipping. The closure of the Suez Canal in 1967 with its doubling of the voyage distance from the Persian Gulf quickly drove rates upwards. Parcel tanker operating costs, which had increased at about 6% annually during the early 1960s, jumped 50% between 1969 and 1971 and have consistently climbed at almost 12% per year since then. In addition, many operators switched to the lucrative long-distance clean and dirty petroleum products trades.

The IMO's requirements for double-bottomed, double-skinned vessels, individual cargo tank venting, containment of slops and ballast and approved stowage of an extensive list of commodities have further pushed up the construction and operating costs for parcel tankers. As a result of price increases, the price of bunkers has escalated and has become a major part of the operating cost. During 1974 the freight rates for parcel tankers began to reflect these cost increases. Although the tanker market collapsed in the first few months of that year the parcel market stayed firm with rates finally covering ship replacement, i.e., US Gulf to Rotterdam rates reached US $75 per tonne and US Gulf to Japan rates increased to US $150 per tonne. By late 1974, however, the worldwide recession resulting from the increased oil prices finally hit the international chemical market, while fats and oils formed unusual new trade patterns. During the period 1974–1978 freight rates remained low causing operators major financial problems. This was especially felt by those companies that had just commenced large building programmes. In 1978 the MARPOL Code was fully implemented having been ratified in 1972. This meant that shipowners who had not used the preceding six years to upgrade their pre-1972-built ships would be heavily penalised. In the last quarter of 1978, an unexpected uptick in the parcel tanker sector returned. From September 1978 to early 1979, rates soared, reaching two to three times those of six months earlier. Those companies that could engage in the spot trade operated very profitably, while other operators with a year's contract of affreightment only enjoyed the tail end of the boom. That said, the boom was short lived. The world recession, together with continuing overcapacity, returned the sector to low rates and subsequently low revenues. Since the brief period of reasonable freight rates that occurred between 1978 and 1979, the parcel tanker owner has had precious little to be optimistic about, with overheated competition and surplus capacity. During this period substantial upgrading of the parcel tanker fleet meant that vessels underwent significant modernisation through the adoption of increasingly sophisticated technology. This, of course, was extremely costly. The late 1983 price for a 35,000 DWT parcel tanker capable of more than 50 cargo segregations was in the region of US $40 million in the Far East, and more in Europe. At the MariChem Conference in Hamburg in 1983, it was universally accepted that parcel tanker operators would need better returns if they were to remain competitive.

To qualify this assertion, the example of a 30,000-DWT parcel tanker was used operating on a transatlantic route between Rotterdam, New Orleans, Houston, Texas City, before returning to Rotterdam via Antwerp. With 13 days of port time, and 30.3 days at sea, the entire round journey would take an average of 43.3 days. With an average daily cost of US $25,500 at sea and US $20,650 in port, the total cost of the voyage, including port expenses, was calculated at US $1,121,100. With a westbound ballast leg and a 100% cargo load coast bound, the vessel would require an average freight rate of more than US $38 per tonne to merely break even. A cursory look at the figures above demonstrates the actual rates paid throughout 1983 were well below this figure. Demonstrating the way that costs have steeply rising, the Conference noted that a similar sized ship of an equivalent age on such a voyage in 1976 would have required a freight rate of only US $27 per tonnes to cover its operating costs. Stanelift's conclusion