Gard Guidance on Freight Containers

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Preface

Knowledge and learning are key factors to achieve Gard's core purpose, which is to help our Members and clients in the marine industries to manage risk and its consequences.

I am very pleased to present our latest publication, the *Gard Guidance on Freight Containers*, which provides comprehensive information about containers as a means of cargo consolidation and effective transportation.

About 90% of international trade is moved by ocean-going ships and the vast majority of consumer and semi-finished goods are shipped in containers at sea. The suitability and quality of the containers themselves, as well as the knowledge and systems to ensure proper handling, stowage and securing of them on board, is crucial to achieve safe and efficient transportation. This has become even more pronounced with the tremendous growth in containership size and corresponding changes in container terminal operations and other parts of the logistical chain over the past two decades.

I am delighted that Mr. Jeroen de Haas, Managing Director of BMT Surveys (Rotterdam) B.V. accepted to be the lead author – a task for which he was found to be extremely well suited. Mr. de Haas holds, inter alia, an honors degree in Maritime Sciences from the University of Antwerp and is also a qualified maritime officer with combined qualifications as a deck officer and marine engineer. He has been active in the international surveying business for more than 25 years and has specialist knowledge in the safe and secure transport of containers. Apart from applying this knowledge in consultancy work, Mr. de Haas has provided expert evidence for tribunals and courts in several countries, as well as written numerous expert reports, loss prevention articles and given lectures and practical training courses to a wide array of stakeholders in the international shipping industry.

Again, this is a publication which is the result of a genuinely collaborative effort between external experts and Gard staff. I wish to thank all contributors that made this publication possible. A special mention to Geir Kjebekk and Alf Martin Sandberg who shared the vision of such a publication and have been deeply involved in seeing it through.

I hope this Guidance will be useful to those involved in the handling of containers, whether on board or ashore, as well as insurance practitioners who need a good understanding of the risks related to the carriage of containerised goods.

Arendal, January 2016

Rolf Thore Roppestad
Chief Executive Officer, Gard AS

Acknowledgments

I have received a significant amount of help and advice from many people in writing this Guidance. The result of their hard work is that the final text is significantly better than it otherwise would have been and I am very grateful for all their input and effort in sharing their knowledge, time and professional experience with me:

Geir Kjebekk, Master Mariner and Senior Adviser at Gard chaired the project and coordinated the review of the contents by many other experts at Gard, and provided invaluable input and advice. Geir is also the author of the book's last chapter on Container Insurance.

Alf Martin Sandberg, Senior Technical Adviser at Gard gave the manuscript a detailed, critical once-over based on his background as a former class surveyor and his time at Gard dealing with a wide range of technical and safety related matters – spanning an impressive career with over 40 years in the maritime industry. Alf is a person who does not take information at face value and through his attention to detail and challenging questions, he often found some of my errors and made me rethink what I was trying to explain.

Gert Uitbeijerse, Master Mariner and retired head of the Global Cargo Care and Research department at P&O Nedlloyd and later Maersk Line, and currently owner and consultant at Global Cargo Consultancy Management. Gert brought with him more than 40 years of unique experience from container shipping, which cannot be replaced by any form of written reference material. Gert not only conducted a critical review of the manuscript, but also provided unlimited access to his files and often pointed to additional sources and references.

The management and supervisors of ECT Delta terminal Rotterdam, in particular Philip Beesemer, Wim Luck and Jan Theeuwen. With no working experience from a container terminal, I felt extremely privileged being able to spend considerable time at the terminal to learn in detail about container operations. I was given the rare opportunity, as an external consultant, to be guided through every corner of the terminal and to carry out in-depth interviews with many of their professional staff. As a result, I have been able to complete the chapter on container operations with what, I believe, to be a rather unique insight and up to date information on the day-to-day operations at a modern container terminal.

Raymond Westdorp, planner at APM terminals who kindly read through the chapter on container terminal operations, providing valuable feedback from the point of view of a major terminal operator.

Mark van Kins, Operations Manager at CMA CGM (Holland) who provided much inside information on container operations from a container carrier's point of view.

Nico Blaauw, consultant and owner of Blaauw Container Service, for his advice on container regulations and his time spent in proof reading Chapter 6.

Onno van Rijswijk of the Dutch Customs Authority, for his advice on container security.

Furthermore, I'm grateful for the assistance and valuable advice of my colleagues at BMT who provided advice within their own particular areas of expertise:

Carlos Maenhout of BMT Surveys (Antwerp), MSc. in Naval Architecture and Marine Engineering from the University of Ghent and President of the Technical Commission of the International Association for Inland Navigation (IVR) for reviewing the chapters on inland navigation, ship's stability and naval architecture.

David Hurdle, of BMT Argoss and MSc in Fluid Dynamics from the University of Bristol, for reviewing the chapters on waves and ship motions.

Rob van Uffelen, Master Mariner and former manager of the dangerous cargo department at P&O Nedlloyd, and later Maersk Line, for reviewing the sections dealing with hazardous cargo.

In addition to the technical assistance that I have received, I would also like to thank the following people for their support and assistance and with whom I have worked very closely during the entire period of preparing this Guidance:

Special thanks go to Randi Gaughan of Gard (UK) Limited, who has proved absolutely invaluable in editing this manuscript specifically with regard to the language, style and consistency of the finished product.

Gerard 's-Gravendijk and Ria van der Graaf of strictly personal, who have done a splendid job in improving the readability of this book by creating clear illustrations and a professional layout.

Lastly, my sincere thanks to Gard for their patience, continued support and confidence in this project. I have a learned much and feel privileged to have been surrounded by so many knowledgeable people who have a real concern for their Members and genuinely care for safety and people, whether working on board a vessel or ashore.

Rotterdam, January 2016
Jeroen de Haas

Contents

The *Gard Guidance on Freight Containers* covers intermodal transport and the handling of containers in its widest form, both in terms of operations, geographical differences and the underlying technology. Although every attempt has been made to be as complete and correct as possible, there will be occasions or circumstances when containers are being handled or transported differently to that described in this book.

The first two chapters deal with the historical development of container shipping. This is a summary of information obtained from various books and articles published on this topic. For those interested in further reading and in learning the 'full story' of container shipping, some very interesting and worthwhile books are listed in the Bibliography.

Chapter 3 looks at transport networks and the various ways of shipping containers, which in addition to seagoing transport also includes barge, rail and road transport.

Container terminals are the pivotal points in container transport and hence a significant part of this book covers these operations. Particularly the chapters on Planning and Operations give an insight into the interaction between terminals and vessel operations, and how the planning is carried out.

Chapter 5 starts with a basic description of a container vessel. Today, many people working in the container business have little or no seagoing experience, and safety rules make it almost impossible to show people around a working vessel. Particular focus has further been placed on explaining what is meant by the vessel's 'operational envelope' and the factors which play a role in determining this operational framework which is particularly important for containerships. Towards the end of Chapter 5 is a summary as well as a discussion of the possible causes of typical containership related casualties.

Any Guidance on containers must contain a summary of the regulations covering transport, design and maintenance of containers. This is covered in Chapter 6.

This Guidance concludes with a chapter on container insurance and gives an understanding of the terms and conditions used in the insurance of the container box itself.

Throughout this Guidance you will also find side stories, or *box-stories*. These are sections which discusses a particular topic in more depth, outlines an individual's particular achievements or are anecdotal in nature.

Rotterdam, January 2016
Jeroen de Haas

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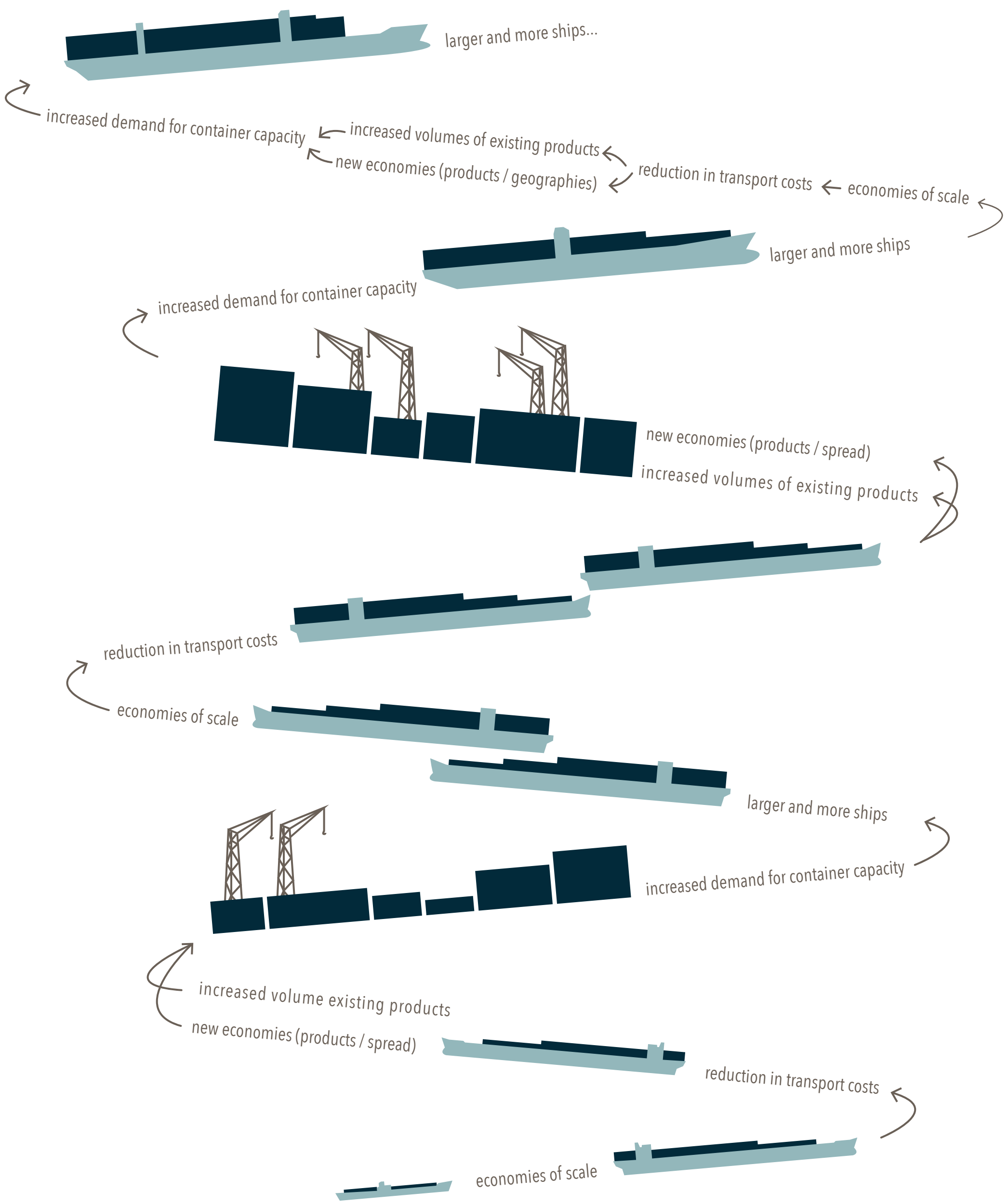
BOXTEXT / INSERTS

Introduction

The container could be described as a simple steel box designed to accommodate or carry cargo. However, the container conceals countless secrets unknown to many people. The types and sizes of the containers moving on our roads, railways and oceans are the results of a clever design, years of negotiations to reach an agreed standard and many decades of evolution to meet particular business needs.

In these days of truly globalised trade, it would be difficult to imagine how the world would look like if container shipping stopped tomorrow. Our lives would change dramatically; factories would close in a matter of weeks, some even days, due to a lack of supplies. Supermarkets and shops would be empty within a couple of days and modern economies would spiral into the deepest depression in recent history. The end result would be massive unemployment and nations descending into war over food and resources. In fact, the economic fate and destiny of mankind could be said to rest with one single piece of transport equipment, and that is the container. An article in The Economist on 18 May 2013 states that 'the container has been more of a driver of globalisation than all trade agreements in the past 50 years'. In fact, it is more than that. Through a constant process of expansion with a corresponding reduction in the cost of transportation, the container has become a self-accelerating machine which can no longer be stopped and which has become an indispensable part of our economy today.

Containerisation has made the shipping of goods affordable and whole industries have been able to relocate their factories to locations far from their customers. New types of cargo such as semi-finished



The self-accelerating container machine

products for assembly in low-cost countries in Asia entered the transportation chain. At the same time, shipping lines added new ports to their sailing schedules, which again fuelled the growth in transport volumes.

As a result, there was a need for increased capacity and with the assistance of new construction technology containerships became ever bigger. Through economies of scale, transportation costs could be reduced, which promoted further growth in volume, types of products transported and geographical spread.

In this way, over a period of 60 years, the container transport system has become to world trade what the circulatory system is to the human body. It is difficult to imagine the present level of international exchanges without a functioning intermodal container transport sytem. This system has proven to be a highly efficient and relatively safe and reliable means of transporting goods across the globe.

Definition

A container or cargo transport unit (CTU) is an article of transport equipment that is designed to be transported by various modes of transportation in such a way that no intermediate handling of the contents is required when being transferred from one mode of transport to the other and that at the same time meets certain size criteria and internationally accepted and agreed standards.

As most container standards have been developed by the International Organization for Standardization (ISO), the formal term for a shipping container is an ISO Freight Container. In this book, where reference is made to a container, this will always be an ISO Freight Container.

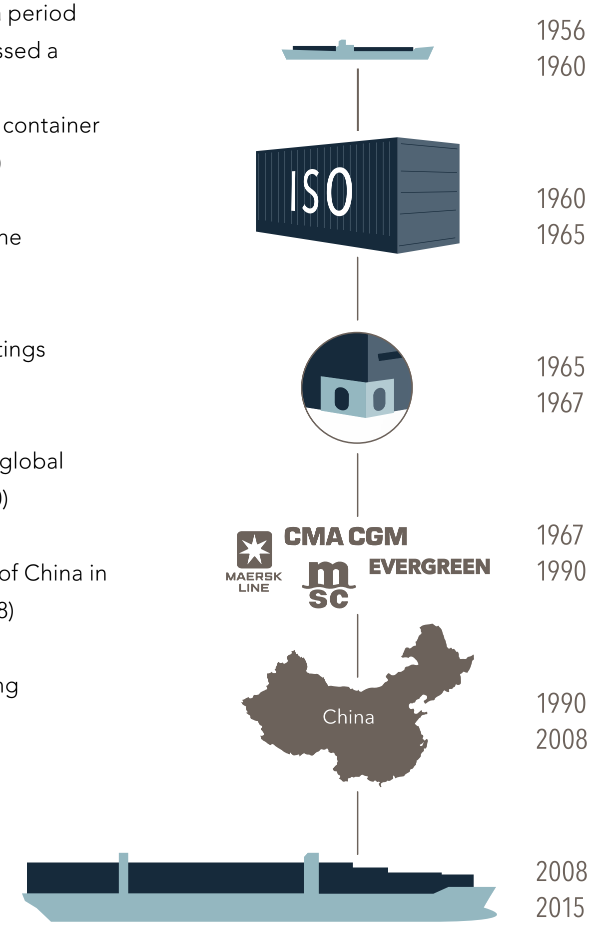
There are also many containers in circulation which are not ISO-classified. These are mainly used for domestic or regional purposes.

Chapter 1

History and development

The role of the container in today's transportation has evolved over a period of more than six decades and passed a number of milestones:

- Introduction of the intermodal container concept in the USA (1956-1960)
- Standardisation of the size of the container (1960-1965)
- Introduction of ISO corner castings (1965-1967)
- Adoption and integration into global distribution systems (1967-1990)
- Exponential growth and entry of China in the global economy (1990-2008)
- Global crisis and shift in thinking (2008-2015)



1.1

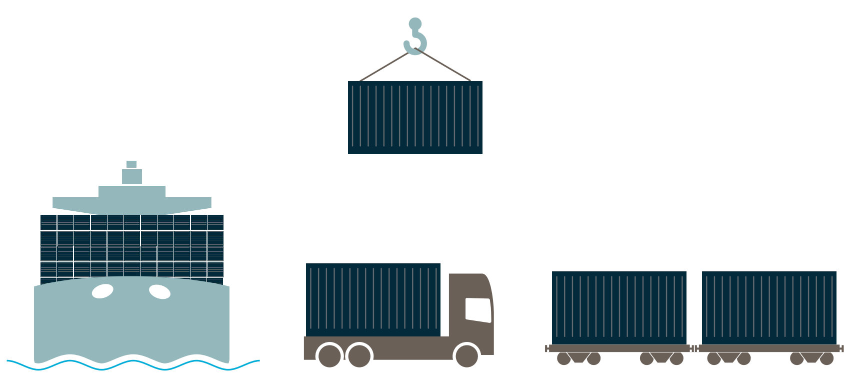
Introduction of the intermodal container concept in the United States (1956-1960)

The birth of container shipping and its initial development in the 1950's and 60's were mainly an American affair, led by two self-made businessmen, Graham Brush and Malcolm McLean.

Back in 1929, Brush founded a company called Seatrain to develop the carriage of railway freight cars overseas on specially designed ships. McLean, a trucking entrepreneur from North Carolina built his own motor freight company (McLean Trucking) and, after the Second World War, concentrated on the shipment of road trailers overseas, an idea which already came to him during his early days working as a truck driver (see *How the container seed was planted*).

McLean, being more focussed on in moving road trailers by sea, called his company Sea-Land, later becoming the largest container shipping company in the world.

In their book *The Box That Changed The World*, Arthur Donovan and Joseph Bonney provide a fine tribute to these American entrepreneurs: 'It is clear that containerisation as we know it today was being seriously considered well before Malcolm McLean was biding his time on the dock in Jersey City. But as Brush and McLean would have reminded anyone who is prone to stay in the world of ideas and abstract thinking, the people who actually make history are the doers, those who built things newer and better than what came before. Brush and McLean fit that category. They were innovators and entrepreneurs, men who earned a place in history by building more efficient systems for moving goods over land and sea.'



Intermodalism

How the (container) seed was planted

Malcolm McLean at railing, Port Newark, 1957

The idea that the 'big box' could be used economically and efficiently on a massive scale came from a once disparaged 'trucker' from North Carolina, named Malcolm Mclean. The idea that revolutionised cargo handling worldwide, and forever changed the nature of shipping, came to him one day back in 1937 at an American Export Lines pier in Hoboken, New Jersey.
'I had driven my trailer up from Fayetteville, North Carolina with a load of cotton bales that were to go on an 'American Export' ship tied up at the dock.
For one reason or another I had to wait most of the day to deliver the bales, and as I sat there, I watched all those people muscling each crate and bundle off the trucks and into the slings that would lift them into the hold of the ship. On board the ship, every sling would have to be unloaded by the stevedores and its contents put in the proper place in the hold. What a waste of time and money!
Suddenly it occurred to me: Would it not be great if my trailer could simply be lifted up and placed in the ship without its contents being touched?
If you want to know, that is when the seed was planted...'

From: Reminiscences on Malcolm Mclean by Capt. Richard T. Soper, Father of the modern containership and former operations manager at Sealand, during the Kinney Lectures in honor of Admiral Sheldon Kinney, February 2011. World Maritime University Inc.

Boxes similar to modern containers had been used for rail and horse drawn transport in England as early as 1792. Small containers with a standard size were also being used by the US government during the Second World War, which proved to be a quick and efficient way to load and distribute supplies. Also Seatrain used a system with boxcars as standard units.

What was new in the revolutionary ideas presented by Malcolm McLean was the belief that efficiency could be vastly improved through a system of 'intermodalism through containerisation' and his preseverance in taking these ideas into reality. He was by no means the inventor of the shipping container but his concept of containerisation as a means of reducing the cost of transport was very radical back in the mid 1950's.

Note
Intermodalism is a system where one container and its cargo can be transported with minimum interruption by different modes of transport from an initial place of receipt to a final place of delivery, without limitations as to the distance carried.
In practice this means that containers move seamlessly between ships, trucks, barges and trains. However, before achieving an intermodal transport system, ships, port terminals, trucks and trains had to be adapted to handle the containers.

Malcolm McLean converted the Second World War tanker POTRERO HILLS to a ship capable of handling containers. He rechristened the vessel IDEAL X and on 26 April 1956, the vessel made its maiden voyage from Port Newark to Houston in the United States. The vessel had a reinforced spardeck carrying 58 metal container boxes as well as 15,000 tonnes of petroleum in bulk and is known as the very first ship to carry standard size containers. By the time the ship had unloaded its cargo at Houston, the company was already taking orders to ship goods back to Port Newark in containers. McLean tried to sell the idea of container shipping to established shipowners in the United States, but they were more than a little sceptical to his ideas. This prompted him to become a shipowner himself and he, very appropriately named his company Sea-Land. Initially the containers were loaded together with a chassis. Later the chassis were left off, enabling the containers be stacked in multiple tiers.

Containership SS MAYAGUEZ IMO number: 2245546
Type of ship: Containership (previously GATEWAY CITY)
Year of build: 1944

Other companies such as Matson Navigation Company soon adopted the same approach and started a container service in the Pacific. The first vessel specifically converted to carry containers only was Sea-Land's GATEWAY CITY, which had its maiden voyage on 4 October 1957.

However, the container concept was only 'intermodal' as long as it was shipped under the umbrella of one shipping company. Due to differences in size and construction, the boxes were not interchangeable between different shipping companies and not compatible with the port handling equipment. As each company would need a large fleet of containers exclusively for its own customers, the next logical step was to standardise the container sizes.

Ideal X sets sail

On 26 April 1956, one hundred dignitaries enjoyed lunch at Port Newark and watched the crane place a container on the IDEAL X every seven minutes. The ship was loaded in less than eight hours and set sail the same day. McLean and his executives flew to Houston to watch its arrival at that port. 'They were all waiting on Wharf II for the ship to arrive and as she came up the channel, all the longshoremen and everybody else came over to look' one witness recalled. 'They were amazed to see a tanker with all these boxes on deck. We had seen thousands of tankers in Houston, but never one like this. So everybody looked at this monstrosity and they couldn't believe their eyes'.

For McLean, though, the real triumph came only when the costs were tallied. Loading loose cargo on a medium sized cargo ship cost USD 5,83 per tonne in 1956. McLean's experts calculated that the cost of loading the IDEAL X at 15,7 cents per tonne. With numbers like that, the container seemed to have a future.

IDEAL X (ships model) to indicate containers stowed on a spar deck above the on-deck tanker arrangement, here shown with 58 containers on deck

From: Marc Levinson. The Box, *How the shipping container made the world smaller and the world economy bigger*, Princeton 2006

1.2

Standardisation of the size of the container (1960-1965)

As early as 1960, international bodies recognised the potential of container shipping and they began discussions as to what the standard container size should be. The first containers used by Sea-Land were 35 foot ASA containers, i.e. containers constructed according to American Standards. Other companies had their own standard sizes, varying not only in length but also in width and height. Various US industry committees were established in order to reach consensus on container dimensions. This was a difficult process as existing shipping companies had already invested large sums of money in their own equipment.

Nevertheless, all recognised the need for standardised container sizes for containerisation to reach its full potential. The maximum container height was set at eight foot, so as not to conflict with height limits on United States highways.
The container width was mainly governed by the restrictions on the railways and was finally set at eight foot as well.

Years of negotiations took place on the most appropriate container size and finally on 14 April 1961, 10, 20, 30 and 40 foot boxes were announced as the standard lengths. Only containerships designed to carry these sizes could receive construction subsidies from the US government. In 1964, these dimensions were adopted by the International Organization for Standardization (ISO) and a world standard was born.

Interestingly, not a single container operated by the two leading shipping companies at that time, Sea-Land and Matson, conformed with this new standard.

20 foot and 40 foot container

Why are 20 foot and 40 foot the standard lengths?

The idea of standardising container lengths at 10, 20, 30 and 40 feet was introduced by Herbert Hall, the chairman of the Material Handling Section Committee (MH-5) during a presentation to an engineering society in 1957.
Hall knew little about the economics of using containers, but he was fascinated by the concept of arithmetic relationships – preferred numbers as he called it. He believed that making containers in 10, 20, 30 and 40 foot lengths would create flexibility. A truck equipped to carry 40 foot containers could also pick up two 20 foot containers, or one 20 foot and two 10 foot containers.*

Today, the two most commonly used sizes are the 20 foot and 40 foot container lengths.
The 20 foot container, referred to as a 'Twenty foot Equivalent Unit' (TEU) became the industry standard with cargo volumes and vessel capacity now measured in TEUs. The 40 foot container – literally 2 TEUs, became known as the 'Forty foot Equivalent Unit' (FEU). The 10 foot container appeared economically inefficient and was mainly used by the US Military and for off shore purposes. The 30 foot container also became less polular. These days, 30 foot containers are used mainly in the short sea trade for the carriage of bulk cargoes, owing to its optimal length, volume and weight ratio.

* From: Marc Levinson. The Box, *How the shipping container made the world smaller and the world economy bigger*, Princeton 2006

1.3
Introduction of ISO corner castings (1965-1967)

The agreement on standard container dimensions would promote intermodalism only to the extent that container operators now had clarity on the important issue of constructing their equipment. They could now consider their long-term investment programs without the risk of having their containers ruled out for reasons of non-compliance.

However, before the container could become readily interchangeable, one further standard design had to be agreed, namely the corner fittings used for lifting and securing the containers.

Each container is fitted with eight corners, four at the top and four at the bottom.

The four top corner fittings are used for lifting. The four bottom corner fittings are mainly used for securing the container to a road trailer, railway carriage or container foundation pad on board a vessel. Furthermore, both the top and bottom corner fittings or castings are used for applying the lashing hooks.

In the early days, each shipping company had its own patented design of container fittings. In 1965, ISO agreed the Sea-Land's design corner fitting as the international standard. It appeared, however, that the design could not pass the necessary strength tests and a new design was finally approved in June 1967.

ISO corner castings, top and bottom

1.4
Adoption and integration into global distribution systems (1967-1990)

Another important milestone for ships carrying containers became their deployment on the most important shipping route at that time, the North Atlantic crossing from New York to Europe. The first ship carrying containers across the Atlantic was the United States Lines' AMERICAN RACER. On 18 March 1966, the ship left Chelsea piers in New York with fifty 20 foot containers on board, all stowed in container cells below deck. Apart from containers, the ship also carried other break-bulk cargo.

One month later, on 23 April 1966, Sea-Land's FAIRLAND left Port Elizabeth in the USA. On board were 236 containers stacked above and below deck.

FAIRLAND's first port in Europe was Rotterdam where she arrived on 4 May 1966. Thereafter, the vessel called at Bremen. Before returning to New York, the vessel called at Grangemouth to load containers with Scottish whisky, one of the first containerised export cargoes from Europe to the US.

While AMERICAN RACER will thus forever hold the distinction of being the first container carrying merchant ship to cross

M.v. FAIRLAND on her maiden call at Rotterdam, discharging containers

the North Atlantic, FAIRLAND will likewise be identified as the first all-containership to link North America with Europe.

A year later, the container proved its efficiency in the Vietnam War. Every two weeks, a containership delivered some 600 containers with supplies and food in refrigerated containers to Vietnamese ports.

1968 and 1969 were the baby boomer years in container shipping. 43 container vessels were built each with a capacity of 1,000 TEU which was large for the time. Ship capacity soon increased to 2,000 TEU and in 1972 the first containerships of 3,000 TEU were completed at a shipyard in Germany.

Ready for take-off

After 1966, as truckers, shipping lines, railroads, container manufacturers and governments reached compromises on issue after issue, a fundamental change took place in the shipping world. The plethora of different container shapes and sizes that had blocked the development of containerisation in 1965 gave way to the internationally approved standard sized containers.

Leasing companies were now confident in investing large sums of money in containers and moved into this field in a big way, soon owning more boxes than the shipping lines themselves. Apart from Sea-Land which still used mainly 35 foot containers and Matson, which was gradually reducing its fleet of 24 foot containers, nearly all of the world's major shipping lines used compatible containers. Finally, it was becoming possible to fill a container with freight in Kansas City confident that almost any truck, train, port or ship would be able to move it smoothly all the way to Kuala Lumpur. International container shipping could now become a reality.

Marc Levinson. The Box, *How the shipping container made the world smaller and the world economy bigger*, Princeton 2006
From: *Marad International Container Services Offered by US Flag Operators*, January 1973

However, the container was still an unknown entity in global shipping and business, risks were relatively high as the technology was still unproven.

Between 1970 and 1980 container shipping grew exponentially, both in terms of volume and geographical reach. Connections were established between Japan and the US West Coast and Europe and the US East Coast. Still, the container business was mainly operated from the US. However, as from the mid-70's onwards, European shipping companies started to integrate container shipping into their business model as well. Indeed, one of the giants among today's largest container operators Maersk, only established the dedicated Maersk Container Lines in 1973. The 1,400 TEU fully cellular containership ADRIAN MAERSK was the first in a series of nine new vessels which made its first voyage in 1975.

Swiss based Mediterranean Shipping Company (MSC) was founded in 1970 and has developed into one of the world's major container carriers as has the Marseille based, Compagnie Martime D'Afrettement (CMA) which was founded in 1978.

A dominating player in the Asia to US West coast trade was Evergreen, who turned to container liner services in 1975. However, with 63 vessels in operation, capable of carrying 70,000 TEU, Sea-Land was still the largest shipping company in 1980.

By 1980, containerisation had been fully integrated in trade between Europe, South America and South East Asia, South Africa, Australia and New Zealand. In 1973, US and European containership operators carried some 4 million TEU. Ten years later, this had risen to 12 million TEU at which time containers also arrived in the Middle East, India, East and West Africa.

Containerisation was further boosted by several initiatives, mainly by connecting the ports and terminals to the hinterland.
In the US, land bridges were constructed at a height to allow double high stacking on railway carriages. In Europe, it was mainly the move to fast and scheduled container services in inland navigation which gave impetus to the containerisation process.

Containerisation also started to dramatically change the location and character of ports worldwide. Some of the established ports declined, whilst new emerged. The port of San Francisco, for instance, lost its position at the expense of the neighbouring port of Oakland, which became one of the largest ports in the US. In the United Kingdom, a similar fate was met by the ports of London and Liverpool. Meanwhile, the port of Felixstowe gained in importance. Complete new ports were built at strategic locations on north-south / east-west junctions.

In contrast to conventional break-bulk cargo ships, most containerships did not have onboard cranes. Container terminal facilities had to provide cranes as well as sufficient space to stack and store the containers on the dockside. Finger piers were no longer adequate and berths were redesigned to accommodate quick ship turnaround and more efficient dockside operations between the crane and the container storage areas.

On the European mainland, the port of Rotterdam emerged as a major gateway to serve the European hinterland, mainly because of its access to the hinterland and ability to receive deep draft traffic. Hamburg and Antwerp followed in its wake.

Prior to highly mechanised container transfers, crews of 20/22 longshoremen would be needed to stow break-bulk cargoes into the hold of a ship.
After containerisation, large crews of longshoremen were no longer necessary at port facilities, and the profession changed dramatically. With intermodal containers, the job of sorting and packing containers could be performed far from the point of loading onto the ships.

1.5

Exponential growth and entry of China into the global economy (1990-2008)

With the development of China into a global economy, a further boost was given to containerisation and to trade patterns as a whole. Freight costs, particularly when looking at the transport cost per unit, no longer represented the most significant cost aspect. As a result, factories could be located far from their customers. This paved the way for the container to become the preferred mode of transport in the development of Asia into the workshop of the world and to deliver to customers around the world a variety of new products.

Advanced refrigeration techniques in containers have made tropical products globally available, throughout the year

The shipping sector had to deal with a far larger variety of cargoes being carried overseas than ever before. With production and assembly locations considerable distances apart, large quantities of semi-finished products were carried in containers to be assembled elsewhere. For example, an assembly site in China would receive Japanese hair, Taiwanese plastics and American colourants in order to produce Barbie Dolls for shipment all over the world. In the carriage of food stuffs, a shift took place from the shipment of perishable goods in specialised reefer vessels to refrigerated containers. Whereas more than 60 per cent was carried in specialised reefer vessels in 1990, this had decreased to around than 30 per cent in 2015.

New techniques used to increase the shelf life of fresh produce saw supermarkets develop into global streetmarkets.

With the increasing volume of containers being carried by sea, the size of containerships also increased. In 1988, the first post-PANAMAX container vessels were delivered to APL. Until then, construction of containerships was mainly restricted by the width of the locks on the Panama Canal which were some 32.2 m wide. Once the PANAMAX restrictions had been broken, developments in ship size moved fast. The first 5,000 TEU ship was delivered in 1995 and the first 6,000 TEU ship in 1997. In 1998 the first 8,000 TEU vessels entered the market with the delivery of the Sovereign class series of containerships. In 2005, the EMMA MAERSK set a new landmark by raising the bar to 12,500 TEU.

In the period 1995-2008, considerable consolidation took place among containership operators which significantly changed the competitive landscape. The most notable mergers were Maersk's acquisition of Malcolm McLean's Sea-Land in 1999 followed by Royal P&O Nedlloyd in 2005. Through these acquisitions, Maersk Line became one of the major containership operators in the world today. Similarly, through a number of acquisitions, French liner company CMA CGM became a global force in container shipping whilst, remarkably, Mediterranean Shipping Company (MSC) of Geneva acquired its position through organic growth only.

Containerships and terminals were used to full capacity during the period 2000 to 2008 in order to meet the demand for container space. Shipping capacity even turned out to be insufficient on some trade routes and containers had to be left behind waiting for the next shipment. Freight and charter rates were rocketing and the revenues of shipowners and operators followed a similar path.

In order to meet the increasing demand, large new building orders were placed with shipyards in Asia, which were soon fully booked for years to come. No one at that time expected that, by 2008 the global economy would have collapsed and that for the first time since the introduction of the container in 1956, there would be a worldwide drop in container volumes.

1996	CMA (France) acquires previously state-owned CGM (France)
	Royal Nedlloyd (Netherlands) merges with P&O (UK)
1997	APL (Singapore) acquires NOL (Singapore)
	Hanjin (Korea) acquires DSR Senator Lines (Germany)
1998	CMA CGM acquires ANL (Australia)
1999	Maersk Line (Denmark) acquires SafMarine (South Africa)
	Maersk Line acquires Sea-Land.
2002	CMA CGM acquires MacAndrews (UK)
2005	CMA CGM acquires Delmas (France)
	Maersk Lines acquires Royal P&O Nedlloyd (UK – Netherlands)
2006	CMA CGM acquires OT Africa Line (UK)
2007	CMA CGM acquires Comanav (Morocco)
	CMA CGM acquires US Lines (USA)

Major acquisitions in the container shipping sector 1995-2008

1.6

Global crisis and shift in thinking (2008-2015)

At the beginning of 2008, the general topic at trade and container conferences was the failure of terminals to keep pace with the growth in the container trade which was doubling in volume every ten years. This picture had radically changed by September 2008 when a financial crisis in the Lehmann Brothers bank heralded the complete collapse of the international banking sector followed by global trade shortly thereafter.

A year later, in 2009, global container volumes had dropped dramatically and the same container terminals were now struggling to survive. In some ports such as Antwerp, whole terminals were closed, waiting for better times.

Remarkably, whereas the global economy remained in recession for the next 4-5 years, container volumes picked up again and most ports saw expansion during the years 2010-2013. The container industry was facing a new problem; how to deal with overcapacity and how to maintain sound and profitable freight rates. The solutions the industry came up with were larger vessels, slow steaming and new alliances.

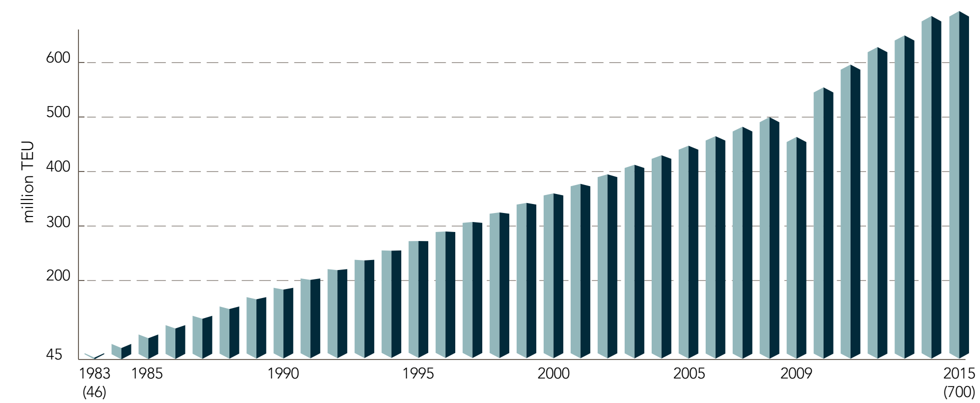
Slow steaming not only reduced the carrying capacity, which had a positive effect on freight rates, but also positively influenced the ever increasing fuel costs due to a lower consumption of fuel. Slow steaming also improved a company's carbon footprint, a new area of competition for shipping lines and associated modes of transport.

While Europe and the US were dealing with the crisis, the Chinese economy managed a 10 per cent year on year growth.

The new world's leading container ports such as Singapore, Hong Kong, Shanghai and Shenzhen were all there essentially to serve the Chinese export market. European or US ports would no longer appear on the list of the world's largest container ports.

In 2013, a new milestone was achieved in container shipping with the completion of the first 18,000 TEU container vessel, the MAERSK MCKINNEY MOLLER. This vessel was part of a series of new mega TEU carriers which would dominate the Asia – Europe trade.

By 2014/15, the international trade had to face yet another shake up the global economy, the slow down of the Chinese economy. Container shipping lines adapted to this new situation by reducing (and cancelling) their newbuilding orders and, yet again, looking for further consolidation and mergers.



World container throughput 1983-2015 (source Alphaliner)

Chapter 2

Evolution of containerships

The maximum size of a containership has increased from 58 trailer / container combined units in 1956 to nearly 20,000 TEU less than 60 years later. Building big and stretching the limits of shipbuilding have been the favoured options of the container shipping industry throughout the evolution of the containership. Today, new designs with even larger capacities are finding their way on to the drawing boards and into construction at shipyards in Asia. The only restrictions appear to be terminal capacity, ship's strength and the size and capacity of the main bottlenecks of global maritime traffic, i.e. the Panama and Suez Canal, and the Strait of Malacca.

Containerships can be grouped according to either their size, type or year of built. When it comes to size, the evolution of containerships has taken place in a number of stages. Traditionally, containerships were classified as 'generations', of which literature recognizes six generations, the last one being all ships with a capacity over 8,000 TEU. Later, other denominations such as Super Post Panamax, Post Panamax Plus, Post New Panamax, Ultra Large Container Ship, were used instead of 'generations'.

There appears to be no consensus in the industry for the classification of containerships, especially for the ships built after 2005. This book has extended the generations beyond the sixth one and also used the classification according to type of ship. The term 'generation' would suggest the different stages of ship-size succeed one another consecutively. This is, however, not the case. It is still well possible that in 2015 containerships of the fourth generation are built.

First generation (1956-1966)

The very first containerships were mainly converted break bulk ships or tankers. The very early containerships only could carry containers on deck; in the case of converted tankers, a spar deck was constructed. Shortly thereafter the tankers were replaced by former general cargo ships. Malcolm McLean acquired six of these vessels (known as 'C-2 freighters') from the US Navy and converted these to carry 226 containers, stowed in cell guides below deck and on hatchcovers above deck.

The first vessel of that series was the GATEWAY CITY which made its maiden voyage on 4 October 1957. These vessels were equipped with specially designed cranes to precisely lift and lower the containers in and out of the cell guides.

Keith Tantlinger, an engineer from Toledo, Ohio played an important role in McLean's company on the design of cell guides, cranes and locking systems; or as McLean said 'Tantlinger was the one who did the most to get containers on board ships'.

Later in the 1960's, more American shipping companies entered the container business and ships increased in size. A good example of the later first generation containership was the ELBE EXPRESS class series of containerships built at Blohm & Voss and deployed on the first North Atlantic service for Hapag-Lloyd-Container Linie. These ships generally had a capacity in the range of 700 to 1,000 TEU and a draught of approximately nine metres. The containers were carried to a maximum height of three tiers on deck and four tiers under deck.

ALSTER EXPRESS;
built 1968, 170 x 24.6 m, 736 TEU

ENCOUNTER BAY;
built 1969, 227 x 30.6 m, 1,578 TEU

SELANDIA;
built 1972, 274 x 32.3 m, 2,272 TEU

Sea-Land's SL-7 series, the fastest cargo ships ever built

In 1972-73, Sea-Land took delivery of a series of eight 1,900 TEU containerships built at the RDM shipyard in the Netherlands, at a cost of USD 32 million each. The ships were equipped with two steam turbines, capable of delivering 120,000 bhp. They had a service speed of 33 knots (61 km/hr), fast enough to sail around the world in 56 days, from New York to Rotterdam in 4.5 days, and from Oakland to Yokohama in just 5.5 days. The SL-7 series became the fastest cargo ships ever built.

These ships were designed at a time when fuel cost around USD 20 per barrel in 1980. When fuel prices skyrocketed and reached some USD 100 per barrel, they became financially unviable and were eventually sold to the US military.

SEALAND McLean from SL-7 series

Second generation (1966-1972)

Second generation ships had cell guides under deck and were the first purpose built containerships. The first such ship, was the KOORINGA, built in Adelaide, Australia in 1964 and deployed in a container service between Melbourne and Fremantle, the same year. The first purpose-built containership crossing the North Atlantic was the United States Lines' AMERICAN LANCER, delivered in 1966 and known to be first such ship bringing containers to Europe. The capacity of these vessels increased over the years and ranged between 1,000 and 2,500 TEU, mainly as a result of increased vessel length and width. Maximum stowage height on deck was three to four tiers. Typical containerships of this generation were the turbine vessels of the ENCOUNTER BAY class, owned by Overseas Containers Ltd., and built at the Howaldtswerke shipyard in Hamburg.

Third generation (1972-1980)

From 1972 onwards a new series of containerships entered the market. These ships were generally 32.2 m wide, the maximum width of the Panama Canal, hence the name Panamax containerships. The first Panamax containership was the LIVERPOOL BAY owned by Overseas Container Ltd. (OCL), whith a capacity of 2,961 TEU.

The accommodation unit on third generation containerships had been moved further forward on the ship's superstructure. This meant that containers could now also be stowed aft of the accommodation. Some ships came on the market with huge power plants and multiple screws. The SELANDIA and JUTLANDIA of the Danish East India Company were renowned for their speed and were equipped with three screws and three diesel engines,

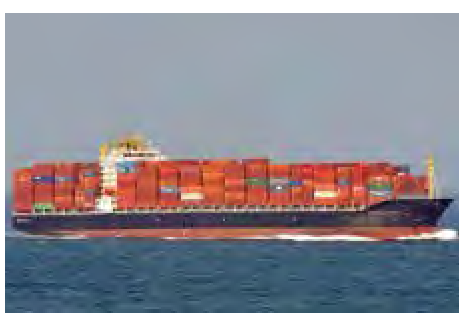
NEDLLOYD DELFT;
built 1982, 290 x 32.2 m, 2,952 TEU

delivering a total of 78,605 bhp thus achieving a maximum speed of 30 knots. The largest containerships at this time were the NEDLLOYD DEJIMA and NEDLLOYD DELFT, each equipped with steam turbines capable of delivering a speed of up to 28 knots, although normal service speed was generally 20-23 knots. Even faster was Sea-land's SL-7 series of which eight were built in the early 1970's (see insert *Sea-Land's SL-7 series, the fastest cargo ships ever built*). The number of containers on deck was relatively low compared to modern standards and the stacking height was limited to three tiers.

Fourth generation – Panamax Max (1980-today)

Fourth generation containerships were built with the largest dimensions capable of passing through the Panama Canal before its extension, but with an increased container capacity. The capacity of Panamax containerships increased in the mid-1980s and rose to some 4,000 TEU. Panamax-sized containerships have remained in favour with many shipping lines and increased load capacities have been achieved.

The ultimate fourth generation container class vessels, which are still being built today, can accommodate up to 4,950 TEU. With a beam of some 32.3 m, containers can be stowed in 13 rows across the deck. The higher container volumes were achieved by stretching the vessel's length to the Panama Canal limit of 294 m, and by decreasing the steel weight and increasing the deck stowage. The later versions of Panamax container vessels stowed containers up to seven to eight tiers high, making containers stowed on deck 70 per cent of the total capacity. These ships have typically a draught of 12.5 m.



Modern 4th generation (Panamax) container vessel, STADT COBURG;
built 2010, 247 x 32.2 m, 4,380 TEU

5th generation Post Panamax container vessels, APL's PRESIDENT TRUMAN and PRESIDENT KENNEDY;
built 1988, 275 x 39.4 m, 4,400 TEU

Fifth generation – Post Panamax (1988-today)

A new era began in containership design in 1988 when American President Lines (APL) ordered five C-10 class ships with a length of 260 m and a width of 39.4 m. The first ships delivered had a capacity of 4,300 TEU. Containers were stowed 15 across the deck and five tiers high. In the early 1990's, TEU capacity of these post-Panamax vessels rose to around 5,000-5,500 TEU. During this period, particular attention was paid to the efficiency of the loading and unloading operation and shipping lines such as Nedlloyd and Norasia, deployed open-top (hatch-less) containerships, where containers could be stowed 13 tiers high from the cargo hold. This system did not retain the interest from the market in the long term, but is still in use today in the short-sea and barge trade.

Sixth generation – Post Panamax Plus (1996-today)

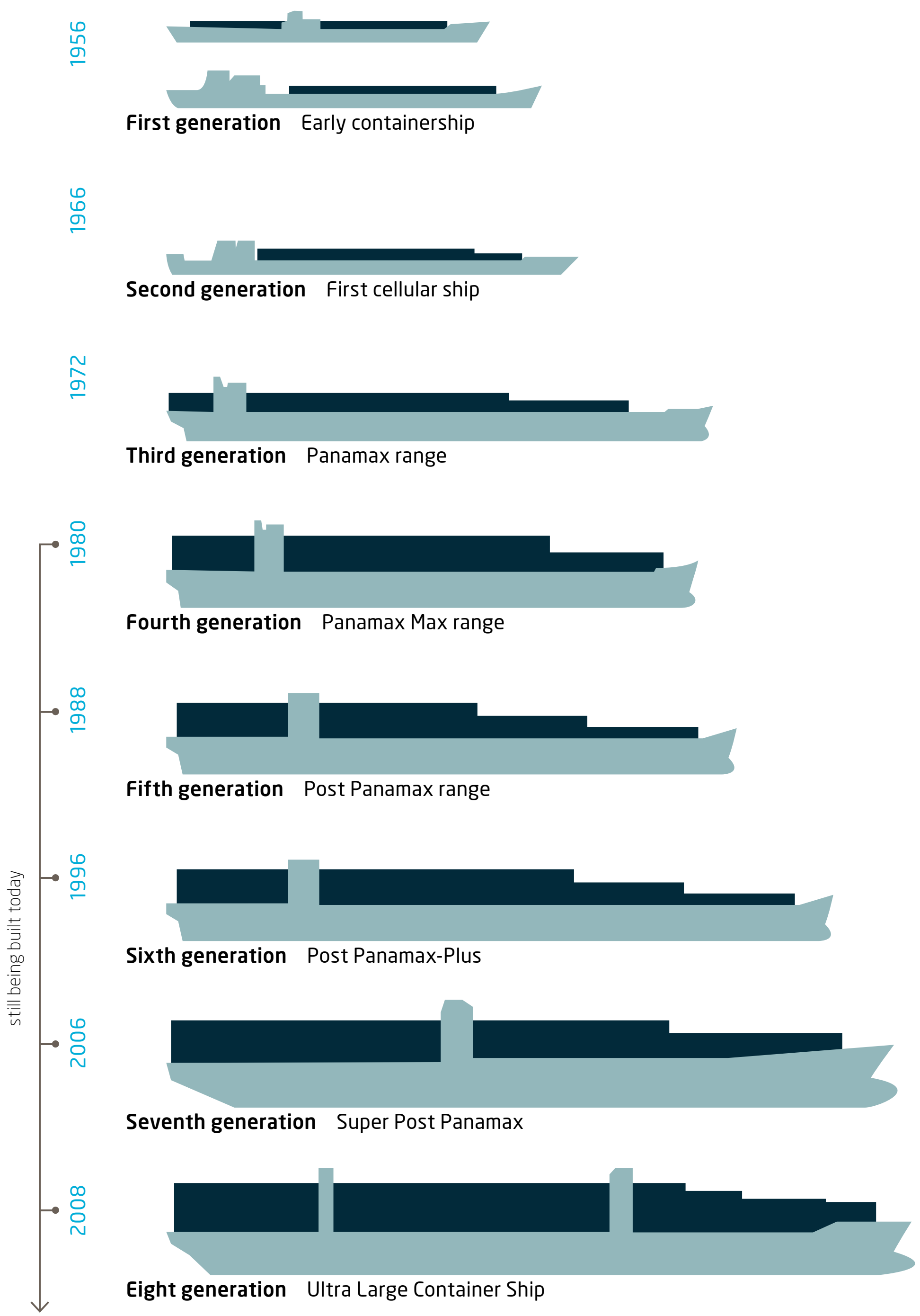
It was not until 1996 that a further new standard was introduced in container shipping with the launch of Maersk Line's REGINA MAERSK. The ship had a capacity of 6,000 TEU and a beam of 42.8 m allowed 17 containers to be stowed across the deck. For many years, a beam of 42.8 m remained the standard and ship capacity was mainly increased by extending the length of vessels to 350 m and increasing the stacking height of the containers on deck to seven to eight tiers. Subsequently, in 1997 / 1998, a series of 19 Sovereign Class vessels were launched, each with a capacity of 6,600 TEU.

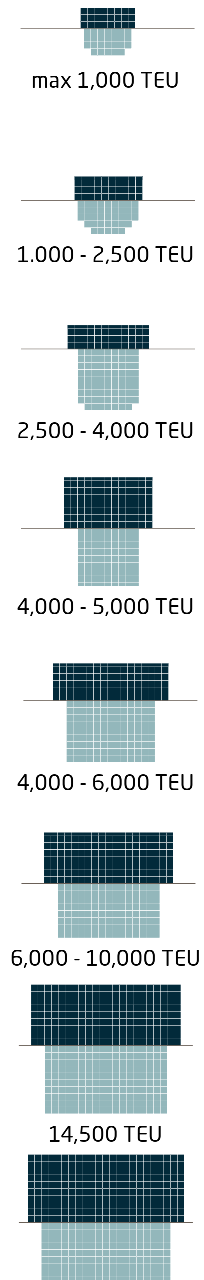
Early 6th generation container vessel, SOUVEREIGN MAERSK; built 1997, 347 x 44 m, 6,600 TEU

Late 6th generation container vessel, OOCL SX Class, OOCL EUROPE; built 2003, 323 x 42.8 m, 8,160 TEU

In order to optimise the stacking of containers on deck, ships were fitted with special lashing bridges. These bridges allowed the lashing to be anchored one or two tiers above main deck level.

Ship capacity continued to increase and by 2003, OOCL had breached the 8,000 TEU barrier with the SX Class series, of which 12 vessels were built. Interestingly, these vessels had a length of 323 m, some 44 m less than the SOVEREIGN MAERSK although it has an identical beam of 42.8 m. The increased capacity was mainly achieved through increased deck carrying capacity.





< 7/10 > number of rows across

3 stowage height on deck

4 under-deck

Year	Generation		length x width x draft	speed	stowage	rows across	on deck	under-deck
1956	**First generation**	Early containership	170/200 x 25 x 9	18.5 knots	max 1,000 TEU	< 7/10 >	3	4
1966	**Second generation**	First cellular ship	220 x 30 x 10	18.5 knots	1.000 - 2,500 TEU	< 10 >	3/4	5
1972	**Third generation**	Panamax range	290 x 32 x 12	23-28 knots	2,500 - 4,000 TEU	< 12 >	3/4	8/9
1980	**Fourth generation**	Panamax Max range	290 x 32 x 12	24.3 knots	4,000 - 5,000 TEU	< 13 >	7/8	8/9
1988	**Fifth generation**	Post Panamax range	275/320 x 40/43 x 14.5	24.2 knots	4,000 - 6,000 TEU	< 16/17 >	5/6	8/9
1996	**Sixth generation**	Post Panamax-Plus	350 x 44 x 14.5	25 knots	6,000 - 10,000 TEU	< 17 >	7/8	8
2006	**Seventh generation**	Super Post Panamax	390 x 56 x 15.5	24.5 knots	14,500 TEU	< 22 >	9	10
2008	**Eight generation**	Ultra Large Container Ship	395/400 x 54/59 x 16	19 knots	16,000 - 19,000 TEU	< 23 >	9/11	10

Seventh generation – Post New Panamax (2006-today)

A new generation of containerships arrived in 2006 when Maersk Line introduced the 15,500 TEU capacity, E-Class series. These vessels were generally described as Post-New Panamax class, as they were bigger than the expanded Panama Canal. With a width of 56 m, containers could now be stowed in 22 rows across the deck. The stacking height on deck increased to nine tiers and lashing bridges were raised to the second tier from the deck.

The accommodation structure on these ships is located approximately amidships, allowing containers to be stacked higher just forward and aft of the accommodation structure, whilst not conflicting with the IMO forward visibility regulations from the wheelhouse (see page 45).

Eight E-Class vessels were delivered to Maersk Line in total. Considerations such as the length of the propeller shafting system, hull stress and overall efficiency led to the development of yet another generation of containerships, built according to the ‘two island configuration’.

Eight generation – Ultra Large Container Ship (2008-today)

A complete new ship type was achieved by building containerships according to the two-island configuration: these ships were arranged with the navigation bridge deck forward of amidships and the after house located above the engine room aft of amidships. This configuration allowed the containers forward of the bridge to be stacked higher whilst still maintaining sufficient forward visibility. Aft of the bridge, containers could now be stowed to the maximum height over approximately 2/3 of the vessel’s length, leading to a considerable improvement in container capacity.

The first container vessel built according to this new principle was the MSC DANIELA (13,800 TEU) which was delivered in 2008. In 2012, CMA CGM launched its Explorer Class with the CMA CGM MARCO POLO (16,020 TEU) which became the largest container vessel in the world at that time.

7th generation container vessel, ELLY MAERSK; built 2006, 388 X 56.4 m, 15,550 TEU

Early 8th generation container vessel, MSC DANIELA; built 2008, 366 x 51 m, 13,800 TEU

Forward visibility requirements

Visibility from the navigation bridge must conform with IMO requirements in addition to any local requirements such as those for the Panama Canal etc. Measures such as reducing the vessel’s trim or, alternatively, changing the deck cargo stowage may be required to reduce the blind sector to within the stipulated limits.

A Panama Canal Authority (ACP) minimum forward visibility requirements

Vessels transiting the Panama Canal must comply with the following minimum visibility requirements for the navigation bridge, as established in the Maritime Regulations for the Panama Canal in OP Notice to Shipping No. N-1-2009,

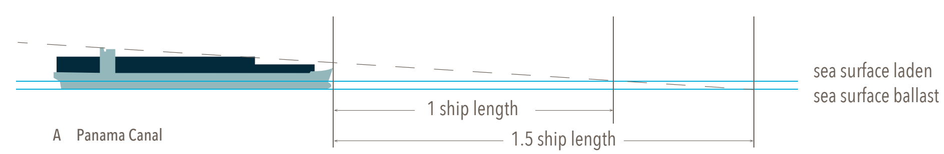
1 for laden vessels, the view of the water’s surface from any conning position on the navigation bridge shall not be obscured more than one (1) ship length forward of the bow, under all conditions of draught and trim.
2 for vessels in ballast (not laden), the view of the water’s surface from any conning position on the navigation bridge shall not be obscured more than one and one half (1.5) ship lengths forward of the bow, under all conditions of draught and trim.

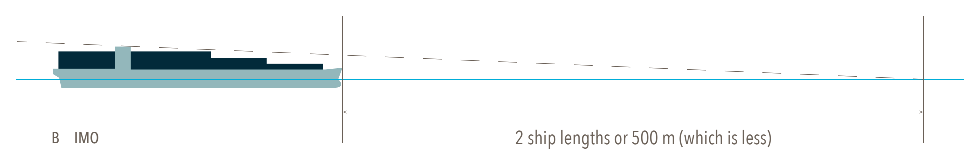
Vessels that fail to comply with the ACP’s minimum visibility requirements due to the presence of cargo, cargo gear, structures, or for any other reason, must inform the ACP of this visibility impairment at least 48 hours prior to arrival in order to properly schedule the transit and minimize any delays.

B Extract from SOLAS 1974 (as amended in 1998) Chapter V Regulation 22 – navigation bridge visibility

Ships of not less than 45 m in length, as defined in SOLAS regulation II/.12, and constructed on or after 1 July 1998, shall meet the following requirements:

From the conning position, the view of the sea surface shall not be obscured forward of the bow by more than the lesser of two ship lengths or 500 m (1,640 feet) from dead ahead to 10 degrees on either side of the vessel. Within this arc of visibility the blind sector caused by cargo, cargo gear, or other permanent obstructions must not exceed five degrees.





In 2013, a new landmark was set by Maersk with the delivery of the m.v. MAERSK MCKINNEY MOLLER (18,270 TEU).

The MAERSK MCKINNEY MOLLER stretched limits which had previously been deemed unbreakable. The launch of the vessel in August 2013 was the first in the series of so-called 'Triple-E class vessels', all with identical design and capacity. 20 Triple-E class vessels in total were on order at the Daewoo shipyard in Korea for delivery in 2014-2015.

The vessel's beam of 59 m enabled containers to be stowed 23 across the deck. Whilst the Triple-E vessels were actually only three metres wider and 11 metres longer than the EMMA MAERSK, they can carry some 2,500 boxes more. Included in the improved ship design was a stacking capacity on deck of 11 tiers and the new designs also provided increased cargo space under deck.

Radically new design features of the Triple-E class included measures to improve the ship's energy efficiency. The capacity of the main engines was reduced to optimise their performance at a target speed of 19 knots. This not only significantly reduced fuel consumption but also emissions per container. The company claimed that due to these environmental measures (including

CMA CGM MARCO POLO;
built 2012, 395 x 54 m, 16,020 TEU

MAERSK MCKINNEY MOLLER;
built 2013, 399 x 59 m, 18,270 TEU

a waste-heat recovery system) emissions per container on the Triple-E class vessels are 50 per cent lower than on other ships trading on the Asia-Europe route.

In 2014-2015 containerships with even greater capacity were delivered to other container shipping lines. By the end of 2015, the largest containerships in service were those from the Olympic Class owned by MSC (e.g. MSC OSCAR) with a total capacity of 19,224 TEU.

Container capacity, what you see is not what you get

Container capacity figures should be treated with some caution as the numbers may change quite considerably depending on the method of calculation used. Contrary to deadweight (DWT) capacity, which is regulated by specific rules, there are no strict rules for calculating TEU capacity.

Nominal TEU capacity. This is the container capacity usually listed on fleet data sheets and related statistics. This is also the number usually referred to in charterparties. Nominal TEU capacity is the maximum capacity of the ship according to its geometric capacity and is governed by the ship's dimensions, design, lashing and stacking limitations and compliance to meet bridge visibility regulations. As a result, this number is the reasonable maximum number of containers the vessel can carry. However, the capacity can be further increased by so-called 'blind sector loading', such as 'castle stowage', whereby additional containers are stowed with intermediate visibility gaps, in front of the bridge.

Effective TEU capacity. This number reflects the real carrying capacity of the ship, taking into account the specifics of the trade in which the vessel is operating. For instance, if the vessel is operating in a trade dominated by heavy boxes, the effective TEU capacity will be less. The same applies in trades where the majority are high-cube (9'6' high) containers or where draft restrictions apply for the ship.

TEU capacity at 14 metric tonnes. This is a derivative of the effective TEU capacity and reflects the ability to load a certain number of standard high (8'6') 20 foot containers, each container loaded with a homogeneous weight of 14 tonnes, taking into account draught limitations by freeboard rules, ship stability and a certain quantity of ballast and consumables on board.

Example: EMMA MAERSK may have a nominal TEU capacity of up to 15,000 TEU.
At 14 tonne homogeneous load, the capacity is 11,000 TEU. The official figure is 12,500 TEU, which includes a certain number of empty containers but in fact the vessel could load more than that.

Chapter 3

Container flows and transport networks

Introduction and terminology

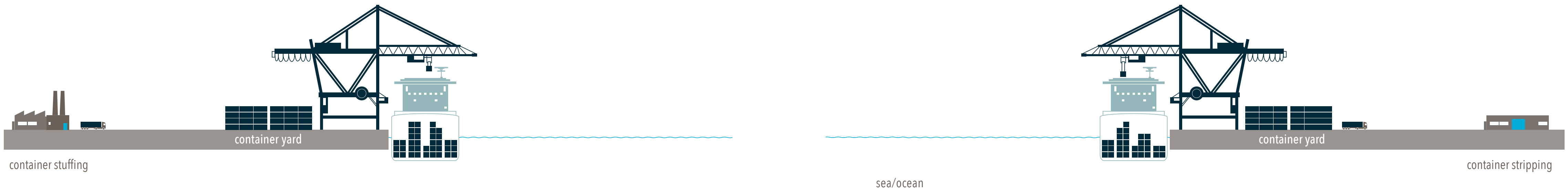
According to the World Shipping Council, approximately 90 per cent of today's global trade is carried by sea, of which some 50 per cent is carried in containers. The growth of container shipping in the last 60 years has been impressive and the volume and types of cargoes carried in containers are increasing all the time.

Globalisation would have been impossible without the full exploitation of the possibilities offered by the container. As already stated, the container's real importance does not lie in what it is – a simple steel box – but in what it makes possible: intermodalism, or the ability of the container to be carried by different modes of transport without having to handle the cargo at an intermediate stage.

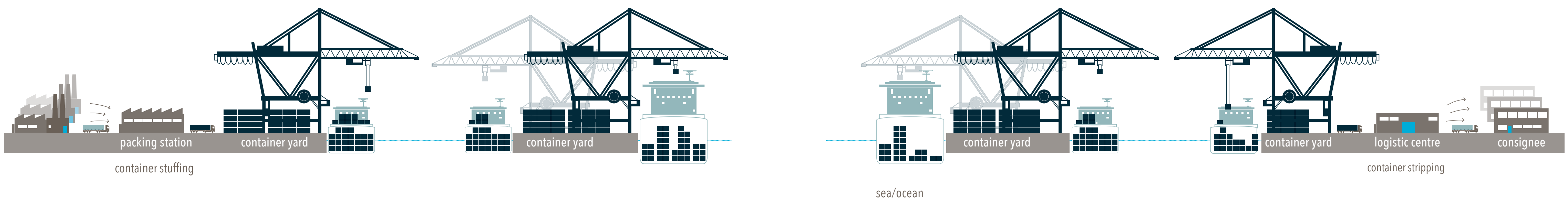
The cargo in the container may be a finished product shipped directly to a supermarket or retail store. Increasingly, however, the cargo in the container is just part of an end product and requires assembly further down the line. The types of cargoes carried in containers are almost unlimited; from unitised commodities (in general-purpose containers), to bulk cargoes (in bulk containers), liquids (in tank containers), perishables (in temperature-controlled containers), project cargoes and yachts (on flatracks) etc.

This chapter describes the various stages of the journey taken by the container; from the place of loading to its final destination, together with an explanation of the most relevant terms used in the industry.

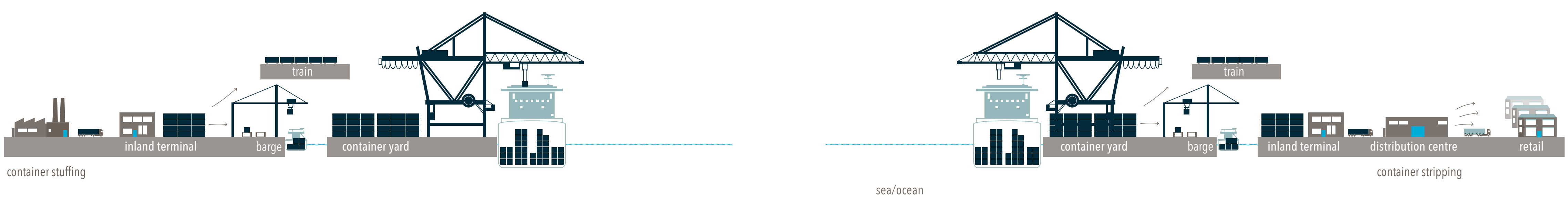
Deep sea, feeder and short sea services carry containers between ports located close to the open sea or to/from a port which has a connection to the sea by way of an inland waterway navigable by seagoing vessels. Once the container has reached its port of destination, it will be unloaded from the vessel at a terminal and will require further transport from the port. Further transport may involve only a short distance by road from the container terminal to a warehouse. Here, the cargo is unloaded from the container and transferred onto



Most basic container transport, direct shipment from shipper's premise or factory to receiver's warehouse (usually a so-called FCL/FCL-shipment)



Container transport, involving a container packing station and feeder vessels to connect a regional port to a container hub



Fully intermodal containershipment (truck, train, barge, ship) involving an inland terminal in country of origion and country of destination and a distribution centre for logistic service and delivery to retail shops a road trailer for further distribution, either as a whole or in parts. Similarly, cargo to be exported through the seaport undertakes the same journey but in reverse.

Containers destined for locations further away from the seaport may use other means of on-carriage, such as transport by rail or by barge using inland waterways (barging).

Hinterland

The inland region located behind a port and served by that port through a network of road, rail or barge connections is generally referred to as a port's 'hinterland'. Ports with a gateway function have a competitive advantage if they can efficiently serve a large hinterland. An inland region is not necessarily linked exclusively to one seaport and more than one seaport may serve a particular hinterland. A good example is the Ruhr area in Germany which is served by the port of Rotterdam as well as the Hamburg/Bremen port cluster and the port of Antwerp. Using the Danube and Rhine rivers, the Ruhr area may even be served by the port of Constantza in Romania.

Modal split

The percentage of freight using a particular type of transportation, e.g. ship, barge, train, truck is generally referred to as 'modal split'. In container transport, cost is often an important factor in the choice of preferred mode of transport. Carriage by ship or barge involves relative low transport costs and lower carbon footprints, but takes longer and is subject to unpredictable navigational factors such as weather and deviation. Transport by rail is faster, more regular but does not offer flexibility.

Connections with the Ruhr area from Rotterdam, Antwerp, Hamburg/Bremen and Constantza

Finally, carriage by road offers greater flexibility but is more costly and has a larger impact on traffic congestion and the environment.

On-time delivery

One of the most important requirements in transport today is on-time delivery of the shipped goods. Transport is considered an intrinsic part of the entire supply chain. Container transport operators have made on-time delivery possible through a system of fixed sailing schedules and berthing windows agreed with terminals. This has resulted in a different manner of stock control in warehouses; whereas warehouses would previously have had to maintain large volumes of stock, most of their stock is today floating at sea on board a container carrier.

Logistics management

Managing the supply chain in such a way that the right item arrives at the right time, at the right place, for the right price in the right condition to the right customer is known as 'logistics' and the services involved are rendered by a 'logistic service provider'.

The term 'logistics' comes from the military. For an army, it is an important element of military strategy to maintain its supply lines in the best possible way while, at the same time, disrupting the supply lines of the enemy. After all, an army without resources and transportation is defenceless.

In business, logistics management is the part of the supply chain that plans, implements, and controls the flow and storage of goods, services, and related information between the point of origin and the point of consumption to meet customer requirements.

Distribution centres form an essential part of supply chain management and containerised shipments. A distribution centre is located where a vast number of products are stocked. A typical retail distribution network operates with centres set up across a commercial market, with each centre serving a number of stores. Typical examples of such organisations are major retailers such as Wal-Mart, IKEA, TESCO etc., whose distribution centres are constantly supplied with tens of thousands products carried in containers from suppliers all over the world.

Aerial view of a large distribution centre

Carrier

In container transport, the term 'carrier' does not necessarily apply to the party who physically transports the goods from one place to another. Very often, an organisation has outsourced the transport and logistic services to a 'freight forwarder' or 'NVOCC' (Non Vessel Operating Common Carrier). A freight forwarder or NVOCC does not own or operate vessels; they may own containers or hire the container from a leasing company. An NVOCC is legally responsible towards the shipper for the transport of the containerised goods and accepts all liabilities as a carrier. However, the NVOCC acts as a virtual carrier and the actual transport is sub-contracted to a range of sub-carriers (shipping lines, railroad organisations, trucking or barge companies). The NVOCC carrier therefore acts as shipper towards the actual carrier.

The carrier responsible for the entire carriage is referred to as a 'multimodal transport operator' (MTO).

Freight forwarders were traditionally the agents of the shipper of the goods, but more and more, they have moved into a role as MTOs, accepting greater liability as carriers. Examples of large freight forwarders are Kühne & Nagel, FedEx and UPS.

Large sea carriers have also evolved into MTOs; they provide customers with a door-to-door service as well as logistic services. The sea carrier picks up the container at the sender's premises, usually located inland and delivers the same container to the receiver's premises, also usually situated inland, under one transport bill. In those instances, the sea carrier transports the container from a container yard at point A to the container yard at point B and nominates a sub-contractor for the land transport. The term 'carrier haulage' is a specific term to indicate that the shipping line is responsible for the land transport, as opposed to 'merchant haulage' where the shipper or the receiver is responsible for the land transport to or from the container yard.

3.1 Deep sea transport

Shipping networks and port connections

Intercontinental container shipping networks have emerged in recent decades. This development has supported the globalisation of production and consumption. From a logistics point of view, shippers require frequent direct services between their ports of preference. On the other hand, shipping lines aim to optimise their transport networks. This is usually achieved by utilising the space on board vessels in the best possible way (utilisation rate) and to operate the service at the lowest possible cost.

As it is both technically and economically impossible to establish direct shipping connections between every country, transport hubs have been established along the main global trading routes, particularly where east/west and north/south trading routes meet. At these points, containers can easily be transshipped from one vessel to another. This gives shipping lines greater flexibility to connect a range of ports around the world with the smallest number of vessels. Efficiency can be increased further when shipping companies participate in so-called 'alliances' with other shipping lines.

Long-distance (or intercontinental) transport of containers has developed very much along the lines of the 'hub and spoke' network system. Within this system, container traffic moves along spokes which are connected to hubs at the centre. Since the 1990's, many of these hubs have emerged particularly along the East-West trade lanes. Examples of such hubs are Singapore and Tanjung Pelapas in Asia, Dubai and Salalah in the Middle East, and ports such as Malta, Algeciras and Gioia Tauro in the Mediterranean.

Large liner ships call at large ports, usually located far apart, because each ship carries a huge volume of cargo. Smaller ports are serviced by feeder ships that cater to regional and niche markets. The term 'small' in the context of ships' sizes has become a relative concept; ships that were considered very large ten years ago, now act as feeder vessels in some trades.

Today's shipping networks are very complex and consist of many different sub-networks with regional connections. The combination of shipping alliances and vessel sharing agreements further promote flexibility and diversity of hubs and ports within each shipping network.

Service routes

Generally, container shipping may operate their deep-sea itineraries according to three types of service routes:

» End to end (or shuttle) services

» Pendulum services

» Round the World services

End to end services

The container vessels are scheduled back and forth between two continents and a range of ports are called on each continent. Examples are the Trans-Atlantic , Trans-Pacific services and Europe to Asia service. The advantage of end to end services is that ship size on these routes is only constrained by the navigational accessibility of the ports along the route. A disadvantage may be imbalance in container volumes between the two directions of the service.

Pendulum services

These services schedule vessels between three continents, with one continent acting as a central point (of fulcrum), linking either side of the pendulum swing. For example, a pendulum service may involve North America linking East Asia through Europe (or a European hub) serving as the fulcrum. The main advantage of this kind of service is better utilisation of the container space on board as container slots may be filled four times on the same voyage. Pendulum services can be arranged in many different shapes and can also be merged with end to end services.

Round the world service

This service ties the world's three trade corridors (i.e. Europe / Africa, North America and Asia) into one. The service can move either in a westward or eastward direction or in both directions. The main disadvantage of this type of service is that vessel size is limited by the dimensions of the Panama Canal which is included in a round the world services.

The flow of containerised trade across the globe is very much determined by the strategies of the individual liner companies and shippers' demand for certain types of services. Whether or not a port will be included in a liner network depends on a number of factors, such as the actual or expected density of the flow of trade, deviation from an existing network, political stability in the region, etc. Studies have shown that connection to such networks is important for the economic development of a region or even a country. The rapid development of an area often starts once local ports receive regular calls by a container liner service.

The Liner Shipping Connectivity Index (LSCI) captures how well countries are connected to global shipping networks. It is compiled by the United Nations Conference on Trade and Development (UNCTAD) and is based on five components of the maritime transport sector: the number of ships, container carrying capacity, maximum vessel size, number

of services, and number of companies deploying containerships in a country's ports. In 2004, the index value was fixed at 100 for the country with the highest index value (China). The index for a given year shows how well connected a country is, compared to China. The higher the score the more active that particular country is in the container trade. The index can give an indication of a country's developing connectivity over a given number of years.

The table below lists the 25 countries with the highest connectivity index value in 2014.

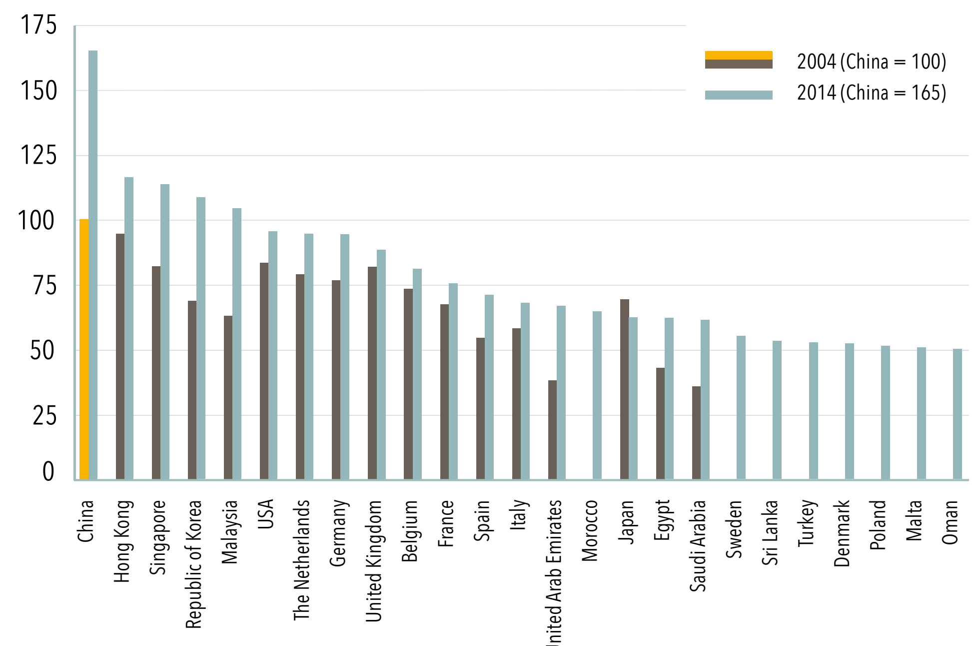
Container trade routes

There are nearly 500 liner shipping services providing regular scheduled services that enable goods to move between ports along the many trade routes crossing the globe.

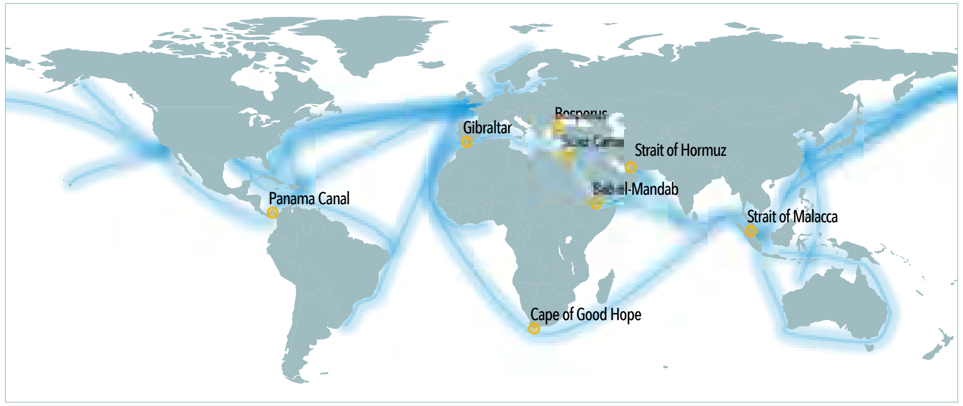
In terms of container volume, the most important connections are between Asia and North America (Transpacific Pendulum), followed by the Asia – Europe connection and Transatlantic Pendulum serving north-west Europe and the east coast of the United States. All of these are mainly east west freight movements.

Important north south connections have been established between the east coast of South America and Europe, between a range of ports in Asia Pacific but also between Australia and Asia Pacific and between North America and the east coast of South America.

With the future opening of the expanded Panama Canal (and possibly Nicaragua Canal), new liner services using larger



Top 25 connectivity index (source: UNCTAD)



World chart with most important container trade routes

container vessels will be established, to support higher volumes and more frequent east west connections, particularly between Asia Pacific and the east coast of North America. The realisation of port expansion plans in North America was necessary to make these ports accessible to very large container vessels.

Because of global trade imbalances, a large number of empty containers need to be transported by sea as well. There are approximately 2.2 times more full containers being transported from Asia to Europe than from Europe to Asia. A similar situation exists in the Asia to North America trade. A containership sailing from Europe or North America towards Asia carries half the load it carried on its way to Europe or North America. This large number of empty containers poses significant challenges to the liner companies in their logistic processes.

Important maritime passages

Maritime shipping supports some 90 per cent of global trade by volume and 72 per cent of its value. Clearly, an efficient and smooth running of this industry is very important. To connect continents around the world, maritime shipping depends on relatively narrow lanes of transoceanic passages which are of strategic significance.

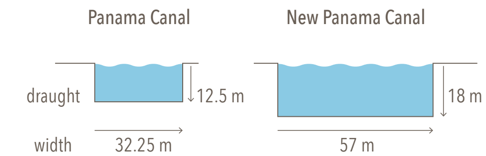
Since the beginning of shipping, the unique features of these main maritime passages have also placed important limitations on the design of ships, and the location of the navigable route. For example, the Panama Canal imposes restrictions on the width (max. 32.25 m) and draught (max. 12.04 m - upon request) of the design of (container) ships.

While ships continue to increase in size, the limitations on ship design created by two other important maritime passages must also be taken into consideration, namely the Suez Canal and the Strait of Malacca. These three passages are of vital importance to container shipping as they are the chokepoints in the flow of intercontinental container traffic.

Panama Canal

The Panama Canal connects the Atlantic Ocean with the Pacific Ocean, and runs from Cristobal on the Atlantic side to Balboa on the Pacific side. The canal consists of artificial lakes, several improved and artificial channels, and three sets of locks.

construction completed	1914
current owner	Panama Canal Authority (ACP)
length of canal	82 km
operational/ship design restrictions:	
	draught 12 m
	width 32.25 m
	length 295.4 m
locks	yes; Gatun locks (Atlantic side, Christobal) Miraflores and San Pedro locks (Pacific side, Balboa)
tolls	Yes, for containerships based on intake capacity: USD 72.00 per TEU, effective from 2009. A new toll rate applies as from April 2016.



New Panama Canal (since 2015)

New locks were constructed, which, together with the deepening of the access channels, allow ships with a maximum length of 366 m, a width of 57 m and a draught of 18 m to use the canal. The ships passing through these news locks are no longer positioned by locomotives but by tugboats.

Suez Canal

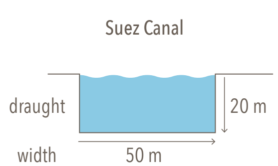
The Suez Canal is an artificial waterway connecting the Mediterranean Sea with the Red Sea. It is an open connection between Port Said at the Mediterranean Sea side and the Gulf of Suez.

Until July 2015, ships passing the Suez Canal had to sail in convoys with substantial waiting times as the size of certain sections of the Canal allowed for one-way traffic only. The Suez Canal expansion project added a new 35 km long shipping lane allowing for separated passing of ships in opposite directions. The existing section of the Canal was also deepened.

This increased capacity allows 97 ships to pass the Canal every day compared to 49 ships before the expansion project.
The waiting times decreased from 11 to 3 hours for most ships.

The expansion project was completed in one year and the New Canal was officially inaugurated on 6 August 2015.

construction completed	1869 (expanded in 1980, 2001 and 2015)
current owner	Suez Canal Authority (SCA)
length of canal	163 km
operational/ship design restrictions:	
	draught 20.0 m
	air draught 68 m
	width 50 m
	length unlimited
locks	no
tolls	yes; depending on the tonnage (Suez Canal tonnage) and number of container tiers on deck. Ranging from approximately USD 250,000 for a 4,000 TEU vessel to USD 650,000, for a 13,000 TEU vessel



Strait of Malacca

The Strait of Malacca is one of the world's most important shipping lanes.

The majority of maritime trade between Europe, India, the Middle East and Asia passes through this natural corridor.

The strait measures approximately 800 km in length and has a width of between 50 and 320 km. At Phillips Channel, just south of Singapore, the Strait of Malacca narrows to 2.8 km (1.5 nautical miles), creating one of the world's most significant maritime traffic junctions. In naval architecture, the term 'Malaccamax' is used to refer to the largest ship capable of passing through the 25 m deep Strait. The typical Malaccamax vessel used to be a bulker or a supertanker with a length of 330 m, a beam of 60 m and a draught of 20.5 m.

The latest generation of containerships has been built in accordance with the Malaccamax size requirements, but for reasons of safety and operational efficiency, and to make these ships capable of calling at several ports across the continents, the design draught of these ships has been limited.

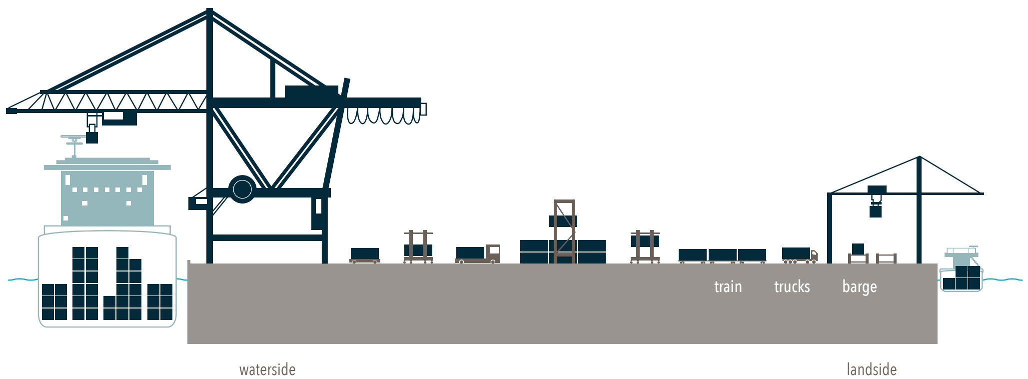
Deep sea container ports

The location of container ports is very much a reflection of how containerisation has changed the commercial geography of the world. Until the year 2000, the most important container ports were New York and Rotterdam, but with the emergence of the strong economies in the Asia Pacific region, a significant change occurred. In less than a decade, many container ports were established or further developed along the Tokyo – Singapore corridor. Today, with the exception of Dubai and the port of Los Angeles/Long Beach, the world's top ten container ports are all located in Asia Pacific. As of 2014, the port of Rotterdam, which is Europe's largest container port is twelfth on that list and New York twenty third.

Containerisation has also fundamentally changed the layout of shipping terminals and the reasons for their location. In particular the larger container vessels do not have onboard cranes, and consequently, significant onshore investment is required to provide cranes to load and discharge the containers. As the container itself protects the cargo from the elements, cargo warehouses are no longer required. On the other hand, ample storage space is required to store the containers on the dockside.

Global container carriers prefer to exercise some control over the terminal and its operations. Particularly in locations where they handle large cargo volumes, global container carriers operate their own terminals or even entire ports.

Container terminal Antwerp



In terms of ownership and access by users, container terminals may therefore be split into 'dedicated' terminals, the use of which is reserved for one single or a small number of operators, and common 'multi-user' terminals, which are open to any liner company with a contract with the terminal operator.

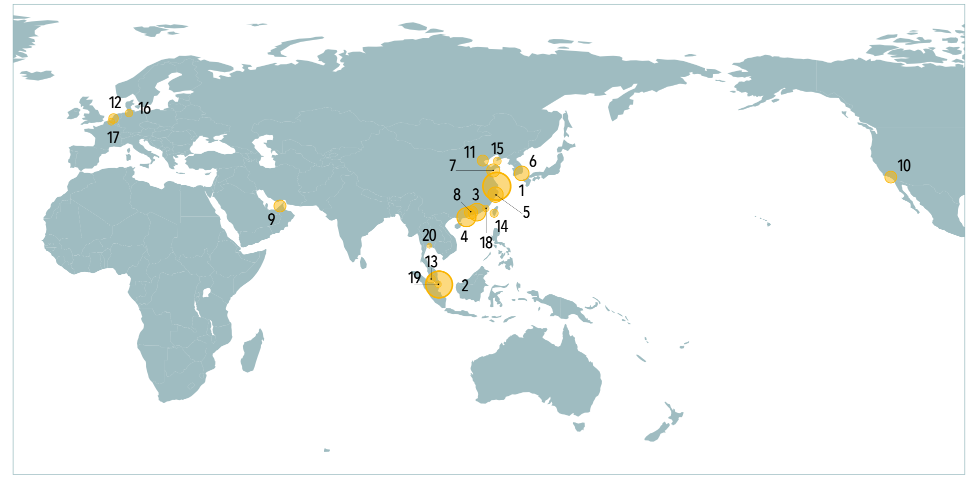
The four largest operators of container terminals in terms of container throughput are Hutchinson Port Holdings (HPH), China Merchants Holding Int. (CMHI), APM Terminals, Cosco Pacific, Port of Singapore Authority (PSA) and DP World. The terminals operated by these six companies handle approximately 40 per cent of the world's total container throughput.

Container terminals are divided into the waterside area, the storage yard and the landside area. The waterside area consists of a quay and apron for serving the vessels. The landside area consists of the hinterland servicing area for connections to barges, trucks and trains. The storage yard decouples the waterside from the landside area and is the area where the containers are stacked and temporarily stored.

A container terminal can serve as a place where containers are transhipped from one vessel to another vessel (the so-called 'hub function'). This function is usually used to link transport networks to each other. Only a very limited number of the containers arriving at these ports are destined for the country or place where the terminal is located. This is different from the so-called 'gateway' ports, which are especially equipped to serve a hinterland.

The connections to the hinterland can be in the form of rivers, lakes, canals, and rail or road systems. As a result, hub ports usually have large storage areas but limited or no connections with other modes of transport. Gateway ports place great emphasis on providing efficient connections to rail or barge terminals and access to road transport.

The function of a terminal or port may differ depending on the container carriers using the site; a port or terminal can be a hub for



1 Shanghai	35,300	6 Busan	18,700	11 Tianjin	14,100	16 Hamburg	9,800
2 Singapore	33,900	7 Qingdao	16,600	12 Rotterdam	12,300	17 Antwerp	9,000
3 Shenzhen	24,000	8 Guangzhou Harbor	16,600	13 Port Kelang	11,000	18 Xiamen	8,600
4 Hong Kong	22,200	9 Dubai	15,300	14 Kaohsiung	10,600	19 Tanjung Pelepas	8,500
5 Ningbo-Zhoushan	19,500	10 L.A./Long Beach	15,200	15 Dalian	10,100	20 Laem Chabang	6,600

World's top 20 container ports, measured by container throughput 2014, in 1000 TEU (source: Alphaliner)

one carrier but may be less significant for another carrier. For instance, Antwerp in Belgium is the main hub for MSC in Europe while it serves relatively fewer vessels from Maersk Line. On the other hand, Algeciras is the main European hub for Maersk Line, but is relatively insignificant in the MSC network.

With the deployment of the very large container vessels, nautical accessibility (water depth) and availability of space have become important factors in the selection of a port site within the shipping networks.

The table above presents the world's top 20 container ports, measured by 'container throughput'. Container throughput is the amount of cargo that passes through a port, and is measured in units of 20 foot containers (TEU).

The top three ports in the above list are highlighted below.

The port of Shanghai

Shanghai is probably the best example of how the Chinese economy established itself as an economic power in a relatively short period of time. In 1991, when the central government of China allowed Shanghai to commence commercial activities, container handling in the port was insignificant. Twenty years later, Shanghai became the biggest container port in the world, overtaking Singapore.

The port, which is a typical gateway type port, is situated in the centre of China's 18,000 km long coastline, where the Yangtze River flows into the sea. Through a network of inland waterways and rail connections, it serves the entire Yangtze River valley, one of the most densely populated areas in the world with a very high economic activity, mainly focussed on manufacturing and export of goods.

The port of Singapore

Singapore became the world's largest container port when it took over from Hong Kong in 2005. Singapore is a typical container hub; a large majority of the containers arriving at the port are transhipped to other ports.

Singapore is located on the southern tip of the Malay Peninsula, at the entrance to the Strait of Malacca, one of the world's most important marine traffic junctions.

The port is also the largest port in the world for the bunkering of fuel oil.

The port of Shenzen

Shenzhen is situated in the south of the Pearl River Delta in the province of Guangdong, China, and is one of the fastest growing ports and cities in southern China. The port acts as the economic hinterland connection for the nearby port of Hong Kong but has also developed into an important port for China's international trade.

Within 50 km of Shenzhen, are the ports of Hong Kong, Shekou, and Yantian, together representing what is probably the highest concentration of container activity in the world.

Inland ports and terminals

In most parts of the world, trucking is the predominant mode of transport between a seaport and its hinterland. Containers are picked up from the terminal for transport to the final receiver's premises either directly or indirectly, i.e. after transfer of the load from a warehouse onto a road trailer.

However, as the volume of cargo to be distributed increases, issues such as costs, energy consumption and delays due to congestion may provide sufficient incentives to set up an inland terminal.

Transport connections capable of handling larger number of containers in one movement are established between an inland terminal and a seaport. For example, one freight train can carry up to forty truckloads, whilst one barge can carry anything up to several hundred truckloads.

There are many different shapes, sizes and varieties of inland (or intermodal) terminals, and likewise, many different names are being used to describe this type of facility, such as:

- Inland clearance depot
- Container freight station
- Inland container depot
- Intermodal freight centre
- Logistics centre/freight village
- Inland freight terminal
- Inland port
- Dry port

The most common description is the term 'inland terminal'. The main features of an inland terminal are:

- it is an intermodal terminal – bimodal where two transport modes are concerned, or trimodal involving three transport modes
- it is situated inland
- it provides regular and reliable rail or barge connections from/to the seaport
- it offers the same ancillary services as are available at seaports and freight terminals, including:
  - storage of containers (buffer function for the seaport)
  - empty container storage
  - repair and maintenance of containers

- customs clearance
- warehousing, supply chain management
- distribution.

The concept of inland ports has developed particularly in Western Europe. Logistics zones, mostly with rail-based inland terminals, can be found in almost every region or close to any major city. This development was strongly supported by the liberalisation of rail services in Europe, especially in major sea ports such as Rotterdam, Antwerp and Marseille. In some ports, such as Basel, the majority of the containers handled are transported by barge. The largest inland port in Europe is Duisburg, Germany.

Several European inland ports are owned or operated by the same owner/operator as the seaport. Containers arriving at the seaport with an inland destination are carried by the terminal operator to the inland terminal under their own transport regime. This has created a situation where terminal operators have become carriers of containers, either by deploying their own transport equipment or by hiring equipment from others.

Largest inland port in Europe: Duisburg

Large numbers of inland ports can also be found in North America, where they are mostly referred to as 'load centres'. They service the ocean trade from and to ports in the Atlantic, the Gulf and Pacific areas. One of the world's largest inland ports is the port of Montreal in Canada.

In Asia, a large number of inland ports (over 2.000) are found along China's Yangtze and Yellow Rivers. The cities of Nanjing and Chongqing are two of the largest inland ports in China. In addition to these river-based inland ports, many rail-based inland ports are being established in China.

3.2 Short sea container transport

Deep sea container transport is the shipment of containers from one continent to the other, carried by very large containerships between major hub ports with smaller feeder vessels delivering the containers from these hub ports to smaller regional ports. The feeder vessels' own schedules tie in with those of the deep sea container vessels.

Since the early 1990's, a new type of container trade has been developing in parallel with and entirely independent of the deep sea container trade discussed above. This new transport segment is generally referred to as 'short sea container shipping', and its development has been particularly rapid in Europe. One of the main drivers behind this growth is the incentivising policy of the European Union, which sees a great number of advantages of short sea shipping compared to road transport which is often characterised by congestion, environmental issues, etc.

The term 'short sea shipping' is relatively new. The trade from which it originates has existed for centuries and used to be referred to as 'coastal trade'. In the United States it was also referred to as the 'marine highway' or the 'highway of the seas'.

In general, short sea shipping is seagoing trade, including the movement of cargo, mainly along a coast without transiting an ocean.

European short sea shipping

In Europe, short sea container shipping has mainly developed as a multimodal door-to-door transport concept for the carriage of intra-European cargo. It also includes destinations bordering the European Union.

The European Transport Policy has been promoting intermodal transport for the last 20 years. Aspects such as road congestion, environmental impact and sustainability against the background of a continuously increasing volume of goods were the main reasons for this policy. Various instruments were used by the European Union as well as its individual member states to bring the policy into practice, such as improving and financing current and new infrastructure, smoothing administrative bottlenecks (customs), and support for the providers of the transport services.

Over the years, many projects involving short sea shipping have been initiated throughout the European Union and various formal and informal networking groups have been established to further enhance

Short sea shipping connections in Europe

the growth of short sea container shipping in Europe. Some of these are:

TEN-T
Trans-European Transport Networks
The role of TEN-T is to support financially transport projects of common interest to the member states of the European Union. The projects aim to facilitate the mobility of goods and passengers within the EU. Its annual budget is approximately EUR 1 – 1.5 billion.

MOS
Motorways of the Sea (MOS)
The concept was first introduced in the White Paper on European Transport Policy of 2001, and aims to design logistics corridors based on short sea shipping similar in nature to the motorways on land.

ESPO
European Sea Ports Organisation
Founded in 1993, it represents port authorities, port associations and port administrations of the seaports of Norway and European Union member states. ESPO also has observer members in several neighbouring countries to the EU.

ESN
European Shortsea Network
ESN is a forum for co-operation between all the national short sea promotional centres, and is not exclusively for EU members. ESN provides information, and organises conferences and seminars, all aimed at promoting the role of short sea shipping in Europe.

European short sea shipping covers a very wide geographical area. It stretches from the Baltic states across Scandinavia and Iceland, via the United Kingdom, Ireland, and Western Europe to the Iberian Peninsula and the Mediterranean as well as to Northern Africa and the Black Sea.

The main European centre for short sea activities is Rotterdam, followed by Antwerp and Hamburg. Several terminals in Rotterdam operate containers exclusively for the short sea trade.

Most short sea shipping lines operate both in the short sea and in the feeder trade. This implies that ships in this trade call at several terminals in one port to pick up and/or deliver cargo from/to different transport chains.

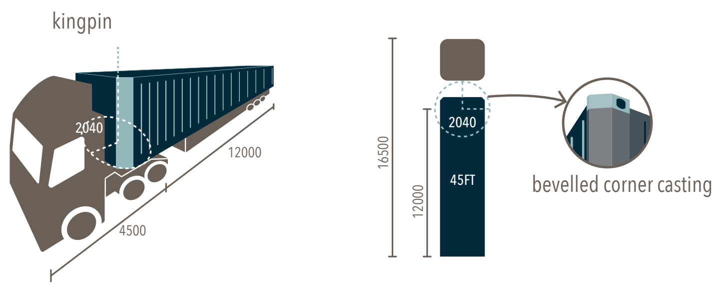
Short sea shipping is not bound by limitations in type and size of containers as is the deep sea shipping sector. The typical dimensions of containers in deep sea container transport are standardised 20, 40 and 45 foot long containers with a height of either 8'6" / 2.59 m (standard high) or 9'6" / 2.89 m (high cube). In the deep sea trade, the variation in container size is governed by ISO standards and mainly limited by the design of the vessel and the positioning of cell guides and container foundations on deck.

In the European short sea shipping sector a large variety of container types have been introduced over the years, mainly aimed at better adapting to the characteristics and dimensions of the cargo to be carried by the container. Containers with a length of 10, 21, 23, 27, 30 and 35 feet etc., can be seen on board a typical short sea type vessel, and many of these with an expanded external width of 2.50 m – so-called 'pallet wide' containers, or 2.55 m which are also known as 'over-wide' bulk containers. The pallet wide container was designed for better utilisation of the container space when loading pallets (see *The success of Europe's 45 foot intermodal container*).

The success of Europe's 45 foot intermodal container

One particular type of container has become very popular in the short sea shipping trade in Europe, and that is the 45 foot intermodal container. This is the longest container which can be carried by road within mainland Europe. As European short sea shipping is often a combination of sea and road transport, the restrictions on the largest size permitted for road transport must be taken into account. These restrictions are laid down in Council Directive 96/53/EC.

Council Directive 96/53/EC of 25 July 1996 has laid down the maximum permitted dimensions of certain road vehicles operating within Europe in both national and international traffic, and the maximum permitted weight in international traffic.



The Directive also states that the total distance from the kingpin of the container trailer to the aft end of the container should be no more than 12,000 mm. The standard 45 foot ISO container exceeds this maximum permissible length by 80 mm. An industry lobby working to have the 45 foot ISO container accepted by all European states failed, and it cannot, therefore, be carried by road everywhere in Europe.

Simply moving the 45 foot container 80 mm further forward will not solve the issue, as the same Directive states that, at the forward end, the container should be within 2,040 mm of the kingpin. As a result, a container was designed with a length of 45 foot but with the forward corner castings bevelled at an angle of approximately 45 degrees (see illustration above). This container construction complied with the EC Directive and made the container fit for road and sea transport in Europe.

Council Directive 96/53/EC also imposed restrictions on the maximum height of the trailer and container, which was limited to 4,000 mm. A standard road trailer can therefore carry a container with a height of 2,775 mm. A special trailer was designed with a so-called (lowered) 'gooseneck' chassis to accommodate the carriage of high cube containers with a height of 2.89 m.

Furthermore, in order to better align the width of the container with the standard pallet sizes used in the European trade (so-called 'EUR pallets' with a dimension of 1200 x 800, L x W), the internal width was increased from a standard 2.348 m. to 2.438 m.

The 45 foot pallet wide, high-cube container has gained so much in popularity in the European trade that it has become available with a large variety of options to meet particular trade requirements:

» the 45 foot curtain-sided container
» the 45 foot reefer container; including diesel electric power supply
» the 45 foot bulk container
» the 45 foot double door container (e.g. for the carriage of rolls of carpet)
» the 45 foot dry box with double load floor (e.g. for the carriage of cars)
» the 45 foot open-top container (e.g. for long/heavy objects exceeding the height of the container ceiling)
» the 45 foot dry box for hanging garments
» the 45 foot dry box with extra tall doors.

(source: Unit 45)

The large range of different containers carried in the European short sea sector created a need for a special type of vessel which could offer the carrier sufficient flexibility to stow, lash and secure the containers in a safe and efficient manner.

In the period between 2001 and 2008, a large number of ships were built to serve the growing short sea shipping business in Europe. A significant percentage of these new vessels for the short sea sector was built at the shipyard of Sietas in Hamburg-Neuenfelde, Germany. The most popular class was the Sietas 168 class, which had a carrying capacity of 862 TEU. The cell-guided cargo holds were designed without hatchcovers and the ships could carry both over-length as well as over-width containers. Later ships were designed with a larger carrying capacity, i.e. up to 1,400 TEU, which were referred to as 'Baltic Max' container vessels.

In Europe, short sea connections are also offered by the many ferry services between the continent and the United Kingdom, Scandinavia, etc.

Shipping connections were also established between seaports and inland ports such as Duisburg and Dortmund using hybrid vessels. These vessels are small enough to use inland waterways, while at the same time meeting flag state and classification society requirements for overseas voyages. Some navigation restrictions usually apply for these types of vessels, e.g. weather, distance from coast, etc.

Sietas 168 type containership for short sea, 862 TEU

Sietas 178 type containership for short sea, 1,400 TEU Baltic Max

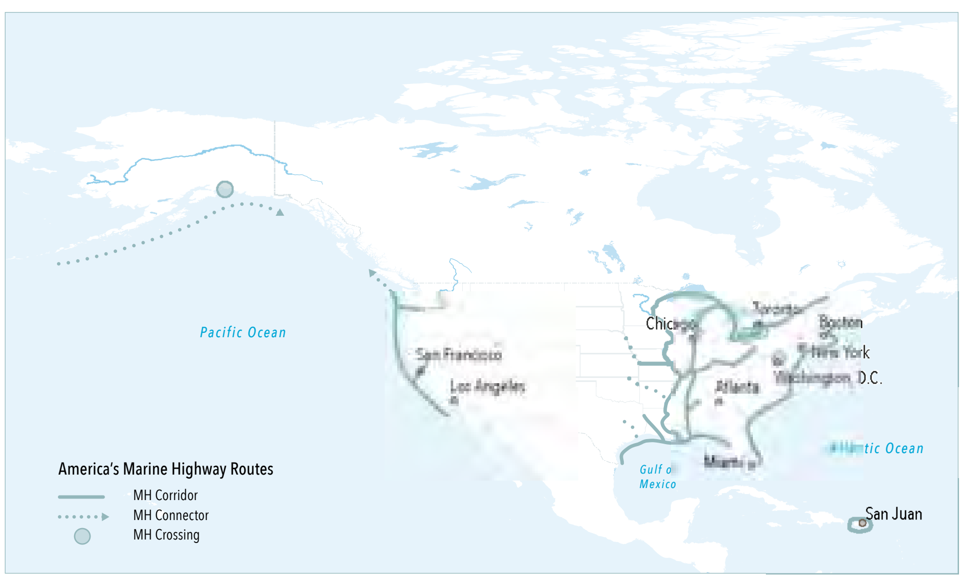
Short sea container shipping in North America

The majority of long-distance container transport in North America is carried by the railways, whilst road transport is the preferred option for shorter distances.

However, in 2007, America's Marine Highway Program was established under section 1121 of Energy Independence and Security Act and the United States Department of Transport, Maritime Administration (MARAD) is tasked with its execution. In 2012, the scope of the program was expanded by section 405 of the Coast Guard and Maritime Transportation Act.

The aim of the program is to 'integrate Marine Highway vessels and ports into the surface transportation system, in order to ensure reliable, regular, competitive and sustainable services'. As in Europe, these efforts are aimed at reducing landside congestion and air emissions and to produce other public interest benefits. America's Marine Highway System consists of over 40,000 km of navigable waterways. These include rivers, bays, channels, the Great Lakes, the Saint Lawrence Seaway System, coastal, and open ocean routes.

Marine Highway Routes are divided into corridors, connectors, and crossings. The corridors comprise long, multi-state routes that run parallel to major national highways. Connectors are shorter routes that serve as feeders to the larger corridors. Crossings are short routes passing through harbours or waterways as an alternative to much longer land routes.



Short sea shipping connections in North America (source: MARAD)

Cabotage laws and the Jones Act

Cabotage is the transport of goods or passengers between two points in the same country alongside coastal waters, by a vessel registered in another country. Most countries enact cabotage laws for reasons of economic protectionism, national security, or public safety.

The Jones Act, or the Merchant Marine Act of 1920, is a US federal rule that supports the promotion and maintenance of the American merchant marine. It regulates, amongst others, matters of maritime commerce in US waters and between US ports. Section 27 of the Jones Act deals with cabotage, i.e. coastal shipping, and restricts the carriage of goods or passengers between United States ports to US built and flagged vessels.

Some in the industry are of the opinion that short sea services in North America could be significantly increased if cabotage rules, tariff issues and duty aspects were removed. An example of such legislation is the Jones Act (see above), which prevents foreign registered carriers from transporting containers between ports in the US.

Short sea shipping in other areas

As described above, the concept of short sea shipping is to provide a door to door service between ports in the same country, region or continent without crossing an ocean. The vessels employed in these trades offer flexibility in terms of the variety of containers they can carry. As such, the short sea shipping trade has matured in Europe only. Programmes have been initiated in the United States to establish a similar type of trade to compete with road transport.

Coastal transportation of containers takes place on every continent in the world, but are mostly combined with feeder or (passenger) ferry services. The types and sizes of containers carried are similar to those carried by deep sea container services (20, 40 and 45 foot long). Frequent coastal services are maintained, for example, between South East Asia, China, Japan and Korea. In China, the port of Nanjing, which is situated some 200 km upstream of the Yangtze River has developed into China's busiest inland port and is the most important economic centre in China after Shanghai. The port of Nanjing offers many direct coastal services to other ports in the region.

Apart from coastal services, there is also inter-island traffic for the transport of containers in countries such as Indonesia and between the various islands in the Caribbean.

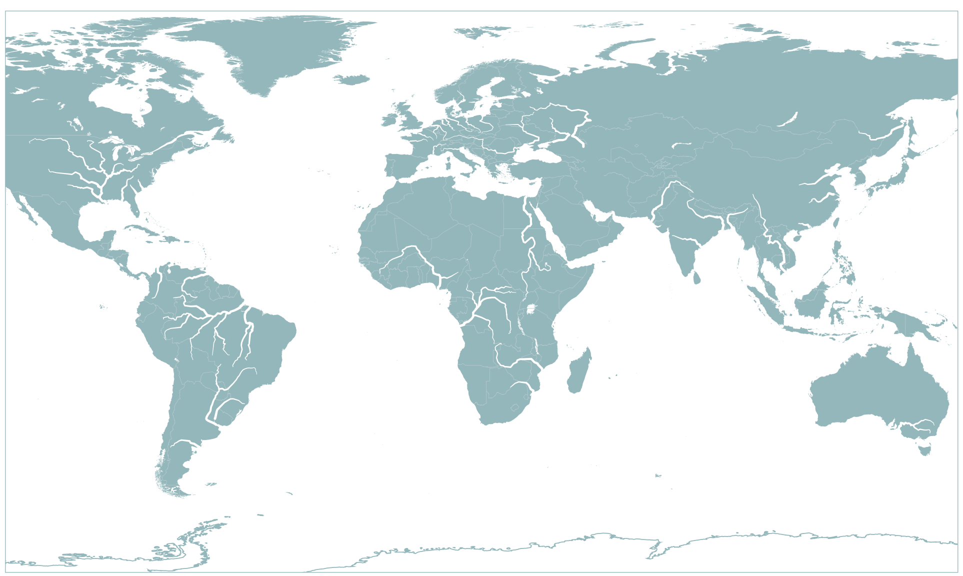
3.3

Container transport by barge

The term 'inland waterways' includes natural rivers, lakes, channels and man-made canals. The use of inland waterways to transport goods goes back to the early stages of the industrial revolution in the nineteenth century when barges were the only way to transport goods in larger volumes and at a cost that were not comparable to road transport. Many canals were built, particularly in England and the United States to transport goods between the industrialising areas. Later on, most of these canals were closed to commercial traffic as their size (width/draught) was too small to meet the demand for vessels with greater capacity. At that time, rail transport appeared to be a better alternative for transporting larger volumes of goods over longer distances.

During the first half of the twentieth century, barges were constructed with their own propulsion systems which introduced a period when inland navigation became increasingly important, particularly in Western Europe. New canals were built or existing canals were widened and deepened.

Some 50 countries have natural inland navigation networks that are a thousand km long or more. However, not all rivers can be used for transport purposes as too many navigational obstacles or seasonal differences allow access only during certain periods of the year. Furthermore, rivers are only suitable as a major transport connection if their direction of flow corresponds with the direction of the transport demand. For example, many rivers in Russia flow in a north-south direction, while the main demand for freight transport is east-west.



Overview rivers and inland waterways in the world

Significant inland waterways serving inland markets and used for container transport are, in particular, found in Western Europe, but also in North America (Mississippi River and The St. Lawrence/Great Lakes system) and the interior of China.

Inland navigation is focussed on serving geographic regions. The type of barges deployed on the various inland waterway systems worldwide, are unique to each region. The same applies to the rules and regulations these barges have to comply with. In contrast to international deep sea and coastal shipping, there is no regulatory system covering inland navigation shipping with a similar global coverage, e.g. IMO, SOLAS.

Inland freight vessels can be either self-propelled vessels, pushed barges operated by a push boat or towed barges operated by a towing vessel. Barges can be interconnected to form a convoy and, if not self-propelled, they can be operated by a push boat or towing vessel.

Pushed container convoy, Mississippi River

Self propelled container barge, Europe

Barge transport, port of Hong Kong

Ship to barge transfer, port of Hong Kong

Europe

The inland waterway network in Europe covers some 50,000 km of rivers and canals of which 50 per cent is accessible to barges with a capacity of 1,000 tons or more. In Europe, inland waterway traffic is mainly concentrated in Germany (7,500 km of waterways), The Netherlands (5,000 km), Belgium (1,600 km) and France (15,000 km).

When container shipping started to develop in Europe in the late 1960's, inland transport of containers was mainly by road. Rail transport became increasingly important at a later stage, for example to connect the German Ruhr area with the German ports of Bremerhaven and Hamburg.

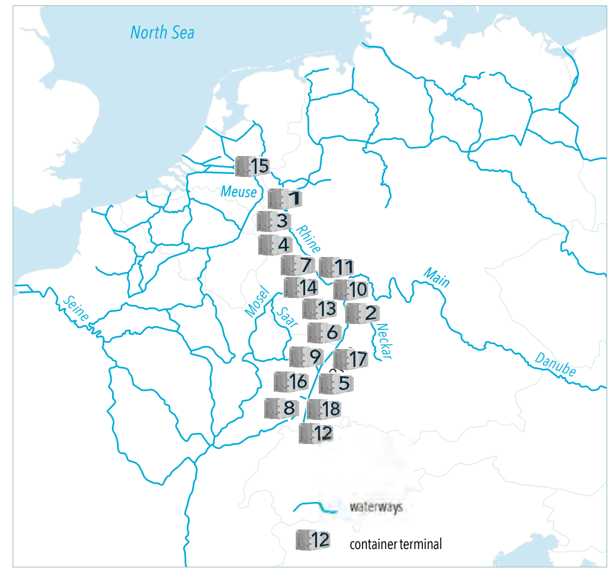
Overview of rivers and inland waterways in Europe

The most important European waterway system is the River Rhine and its tributaries. It connects the ports of Amsterdam, Rotterdam and Antwerp to inland destinations in Germany and Switzerland (Basel) over a distance of some nine hundred km. Barges up to 192 m long, 12 m wide and with a 4 m draught can travel from North Sea ports to Constantza in the Black Sea using the Main Donau Canal, a distance of some 3,500 km.

The first transport of containers by barge took place in 1980 when a company called Kieserling started a barge service between the port of Rotterdam and the inland port of Ginsheim Gustavsburg, situated where the River Rhine flows into the Main. Kieserling had agreed a contract for the carriage of containerised supply for the United States Army forces based in central Europe.
The containers from the United States were unloaded from ocean vessels in the port of Rotterdam, transported to Ginsheim by barge after which they were carried by truck to the US army depots.

In the wake of the accelerated growth of global container transport, inland transport by barge became increasingly important in Europe. Cross-border transport of containers by rail proved inferior compared to transport by barge. Rail systems in the various countries were often different and transport had to be carried on the same track as busy passenger traffic, which had priority over freight transport.

In the beginning there was limited experience with container transport using inland navigation barges. At that time, barge owners experimented by using dry bulk push barges and loading them with containers as high as possible. There were no rules and repeatedly barges capsized due to lack of stability. There was significant growth in container transport by barge between the ports of Rotterdam, Antwerp and several inland ports along the Rhine. The Rhine is one of the world's busiest inland waterways and millions tonnes of freight are carried on this natural waterway each year. In terms of capacity and operational accessibility, the Rhine can be divided into three sections:



		TEU
1	Duisburg	2,253,000
2	Mannheim	2,014,000
3	Neuss-Düsseldorf	658,000
4	Köln	557,000
5	Strassbourg	361,000
6	Germersheim	226,000
7	Bonn	178,000
8	Mulhouse Ottmarsheim	157,000
9	Wörth	121,000
10	Mainz	117,000
11	Koblenz	100,000
12	Basel	99,000
13	Ludwigshafen	85,000
14	Andernach	80,000
15	Emmerich	78,000
16	Kehl	66,000
17	Karlsrühe	54,000
18	Weil	25,000
		7,229,000

Rhine River with container ports and transport volumes (source: EICB)

The Lower Rhine - Rotterdam to Cologne - 350 km

This part of the Rhine can accommodate the largest self-propelled barges with a capacity of 500 TEU as well as push/tug combinations with six barges with a capacity up to 800 TEU. There are no locks on this part of the Rhine. The most important port in this section of the Rhine is Duisburg, Europe's largest inland port. The port has an annual turnover of approximately 110 million tonnes of cargo, including some 3.4 million TEU of containers (2014).

The Middle Rhine – Cologne to Karlsruhe – 330 km
The conditions on this part of the river are comparable to those of the Lower Rhine. There are no locks but restraints upstream of Mainz do limit the size of vessels.

The Upper Rhine – Karlsruhe to Basel – approx. 200 km
Vessel size and carrying capacity in this part of the Rhine are restricted by draught and a series of eleven locks with a maximum capacity of 110 x 11.40 x 2.50 m (length x width x depth).

The container carrying capacity of inland barges on the Rhine is also limited by the river's water level. When the Rhine has a high water level, the clearance below the bridges will be insufficient to permit four tiers of stowage. During dry periods and low water, draught is a limiting factor. Most of the specialised container barges in Europe have liftable wheelhouses, allowing the containers on deck to be stowed as high as stability and bridge clearance permits at any given time.

Most container traffic in North West Europe takes place between the ports of Rotterdam and Antwerp through the Scheldt Rhine

Container barge, Scheldt Rhine Canal

World's largest locks for inland navigation, Volkerak Locks, Netherlands

Canal. The Canal connects the Rhine with the River Scheldt and provides direct access to the various container terminals in these ports and has the world's largest locks for inland traffic, in terms of annual volume: the Volkerak locks. The locks' three basins measure 200 x 23.50 x 4.75 m (length x width x depth) each.

The transport of goods and containers by barge is heavily promoted by the European Union Transport Policy. Inland barge terminals have emerged all over Europe where there is sufficient navigational access. All import or export procedures can be completed at inland container ports. Congestion in the urbanised seaport areas can be avoided

classification	length	breadth	draught	air draft	tonnage	
I	38.5	5.05	1.8-2.2	4	250 - 400	
II	50/55	6.6	2.5	4/5	400 - 650	
III	67/80	8.2	2.5	4/5	650 - 1,000	
IV	80/85	9.5	2.5	5.25/7	1,000 - 1,500	
Va	95/110	11.4	2.5-4.5	5.25/7	1,500 - 3,000	
Vb	172/185	11.4	2.5-4.5	9.1	3,200	(convoy » 1 x 2)
VIa	95/110	22.8	2.5-4.5	7/9.1	3,200 - 6,000	(convoy » 2 x 1)
VIb	185/195	22.8	2.5-4.5	7/9.1	6,400 -12,000	(convoy » 2 x 2)
VIc	193/200	34.2	2.5-4.5	9.1	9,600 - 18,000	(convoy » 2 x 3)

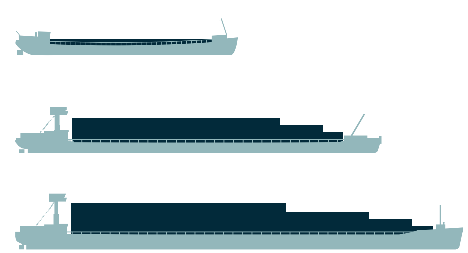
CEMT-classification, dimensions in metres (source: CEMT)

as well by delivering or picking up the container at an inland terminal.

In Europe, canal dimensions and barge types are strongly linked. Barges are classed according to the waterway they can safely transit and grouped into CEMT classes. (Conférence Européenne des Ministres de Transport/European Conference of Ministers of Transport). CEMT was founded in 1953 to co-ordinate European transport policies. In 2006, CEMT was renamed the International Transport Forum. It has its headquarters in Paris.

Within the framework of this classification, three typical container barges have been designed with capacities from 32 TEU to 500 TEU.

On the larger container barges, the containers are stowed six containers wide at most and five to six tiers high. There are no hatchcovers fitted on these container barges. The cargo holds may be fitted with cell guides extending above the hatch coaming. Only the containers which extend above the cell guides require securing. For barges which do not have cell guides, the usual practice in Europe is that only



length x width x draft	stowage
55 x 6.6 x 2.5	32 TEU
110 x 11.4 x 3	250 TEU
135 x 16.9 x 5.5	500 TEU

Different types of container barges

containers which extend above the coaming of the barge are secured. Stacking cones are applied between the container tiers to avoid sideward shifting of the containers. The practice of applying these stacking cones varies. On some barges all the containers above the coaming are secured; whilst on others only the containers stowed in the outboard rows are secured. Lashing elements such as twistlocks, which also have a vertical restraint, are not used onboard inland navigation vessels.

There are no strict regulations covering the lashing and securing of containers onboard inland barges. There is an increased risk of loss or shift of the containers when the barge makes a turning cycle, during periods of strong wind or when the barge heels over as a result of loss of stability (see also *Stability requirements for inland navigation vessels carrying containers*).

European rules and regulations covering inland navigation vessels

Various national regulations and European conventions apply to inland navigation vessels operating on waterways within Europe.

A leading role in the development and harmonisation of a legal and technical framework for inland navigation vessels in Europe has been taken by the Central Commission for the Navigating of the Rhine (CCNR). The framework, which in itself is only applicable to vessels navigating the Rhine, has become a technical reference point for the construction, operation and inspection of inland navigation vessels, irrespective of whether the vessels are intended for the Rhine or not. In several countries, the CCNR regulations have been adopted in national regulations.
The regulations were also the basis for the European Council Directive 2006/87/EC of 30 December 2006.

Other examples of European conventions applicable to inland waterways are:
» CLNI convention on the limitation of liability in inland navigation on the Rhine and elsewhere
» CMNI convention on the contract for the carriage of goods by inland waterway
» ADN agreement on the transport of dangerous substances by inland waterways
» CDNI convention on the treatment of waste produced during inland navigation.

Special stability requirements apply to inland navigation vessels carrying containers. These are set out in chapter 22 of The Directive 2006/87/EC (see insert).

Stability requirements for inland navigation vessels carrying containers

The provisions of Rule 22 of the EC Directive 2006/87/EC require the vessel to have on board an approved stability booklet, which should contain comprehensive information enabling the crew to check the stability of the vessel for each loading condition. The verification can be done manually or using special software.
For the manual method, the following steps need to be taken, using a simple calculation sheet:
» The skipper calculates the total weight of each container tier and multiplies that figure with the vertical centre of gravity for that container tier.

The vertical centre of gravity for each tier is a fixed number and can only vary with the container height (e.g. standard high or high cube containers). Where there is a mixed stowage of standard high and high cube containers, the vertical centre of gravity for high cube containers should be used.

Similar calculations are made for the ballast and fuel on board:
» On completion of the form, the skipper has established the KG value of the vessel. This KG value is the overall centre of gravity for the vessel in loaded condition.
» This KG value must be checked against the table of maximum permissible KG values which every vessel must have. There is a maximum permissible KG value for containers which are 'secured' and for containers which are 'not secured'.

The Rule states that 'containers shall only be considered to be secured if each individual container is firmly attached to the hull of the vessel by means of container guides or securing equipment and its position cannot alter during the voyage'. Consequently, this would imply that containers secured by stacking cones are considered 'not-secured'.

» The vessel complies with the regulation, and is sufficiently stable, if the KG value for the vessel in loaded condition is less than the maximum permissible value in the KG table.

North America

The inland waterways of the United States consist of more than 40,000 km of navigable waters. The majority of these waterways is situated in the eastern part of the country where the landscape is flatter and there is a higher rainfall. The most important waterways for inland traffic in the US are the Mississippi River System in the south and the Great Lakes system / St Lawrence Seaway in the northeast of the United States into Canada.

The most important waterways in the south are the Gulf Intracoastal Waterway (GIWW) and the very extensive Mississippi River System.

The Gulf Intracoastal Waterway is a 2,000 km long canal that runs along the Gulf of Mexico coastline from the southern tip of Texas to Florida. It was originally constructed to serve the Texan oil industry and to connect to ports in the Gulf of Mexico for the delivery of steel and construction materials. Today, it is the third busiest waterway in the United States connecting a large range of ports in the Gulf of Mexico with the inland waterway systems of the Mississippi and rivers in the state of Ohio. Further north, the Mississippi is connected to the Illinois Waterway, which continues to the Great Lakes Waterway and then to the Saint Lawrence Seaway into Canada.

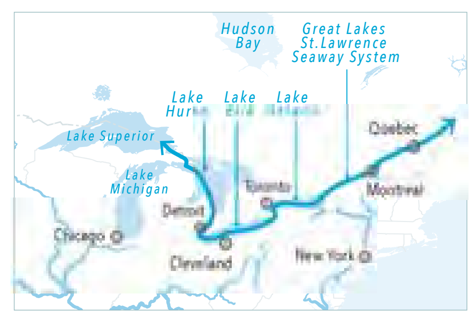
Inland navigation systems in the United States are mainly used for the transportation of agricultural products, which is highly seasonal and primarily focussed towards the end of the summer and autumn. The goods are transported on covered non self-propelled barges, which are lashed together and operated by a towage vessel or push boat. The number of barges in such a combination varies and

Most important waterways in the United States

ranges from four or six barges on smaller waterways up to over 40 barges on the lower Mississippi River between St. Louis and New Orleans.

Although the potential for intermodal container traffic is significant, the number of container freight movements in this river system is limited. One of the largest container barge operators in the area provides a weekly service between Houston and New Orleans and between New Orleans and Memphis. More irregular container services are also available between the Gulf ports and Pittsburg and Chicago, which involves transiting several locks.

US authorities are investing in plans to promote container barge transport in the United States. The building of the Louisiana International Gulf Transfer Terminal at the mouth of the Mississippi River is considered an important incentive to increase container barge traffic in the southern and central United States. The terminal will link ocean going traffic with short-sea and inland waterway services.



The Great Lakes St.Lawrence Seaway System is a deep-draft waterway running from the Atlantic Ocean to the Great Lakes, a distance of some 3,700 km

The most important waterways in the north and north east of the United States and Canada are the Saint Lawrence River, The Saint Lawrence Seaway and The Great Lakes System.

The first section is the 1,600 km Saint Lawrence River which provides direct access to the port of Montreal, Canada's second busiest port and reportedly the world's largest inland port in terms of intermodal container transfers. Montreal is unique in that the railway tracks are laid very close to the dockside. Freight locomotives transfer the containers to a large railway freight terminal nearby from where containers are carried by rail to eastern and western Canada as well as to the United States.

From Montreal, the Saint Lawrence Seaway proceeds to the Great Lakes via a system of canals, locks and channels. Ice conditions allow the Seaway to remain open for navigation from late March / early April to mid-December. The Seaway which was opened in 1959 is known as one of the most outstanding engineering achievements of the twentieth century. A total of fifteen locks bridge the 180 m height difference between Lake Erie and the Atlantic Ocean.

The locks each measure 233.5 m in length, 24.4 m in width and are 9.10 m deep. Hence the term 'SeawayMax', or the more commonly used 'Laker', is used for the type of vessel designed to meet these dimensions.

Ocean-going container vessels can travel as far inland as the port of Montreal. However, hardly any significant container traffic takes place further down the Seaway system towards the Great Lakes as it is faster to ship containers to the eastern and western seaports by rail.

In 2014, a new monthly Trans-Atlantic container service was established between the port of Cleveland on Lake Erie and Antwerp. Transit time for the service is 13 days.

There is no navigable river system on the east coast of the United States because of the Appalachian Mountains, which are located just a few hundred kilometres inland.

There are several major container ports on the west coast, such as Port Rupert, Vancouver, Seattle/Tacoma, Oakland and Los Angeles/Long Beach. However, there are no navigable inland waterways due to the Sierra Nevada and Rocky Mountains. The only exception is the Colombia River basin which provides access to the port of Portland, some 160 km inland. From Portland, container barge services can travel a further 600 km inland towards the state of Idaho.

The typical self-propelled inland container vessels, of which thousands are deployed on European waters, are not used on US inland waterway systems.

The most commonly used barge types in the US are barges used for agricultural products whereby the containers are stowed in a cargo hold. These barges can typically accommodate 48 40 foot containers, which can be stowed three wide, four long and four tiers high. Also barges with a capacity of 80-100 containers per barge are deployed on US inland waterways (see photo).

March 2014, first departure of combined general cargo, container service from Cleveland, bound for Antwerp

Containers on a push barge, USA

A fifteen barge combination could carry some 700 to 800 40 foot containers. On sections of the lower Mississippi where bridge height would allow five-high tier stackings, a combination of 42 two barge units could carry up to 3,000 40 foot containers.

Another method used is the so-called 'Container on Flat Barge' system, whereby containers are stowed in multiple tiers on a flat bottomed floating platform. Loading containers on such a flat bottom presents additional risks such as exposure to water/waves due to the low freeboard, stability issues, tow line failures, etc.

It is a requirement of the United States Coast Guard that operators of these barges have an approved Operations Manual. The Manual must contain procedures for the loading of containers and the need for stability calculations to be made prior to each voyage.

Containers on a flat barge, USA.

The three most important waterway systems in China

China

Rivers and inland navigation for the transport of people and goods have always played an important role in the Chinese economy. China has some 120,000 km of navigable inland waterways, with more than 4,000 inland ports and some 200,000 river vessels.

The three most important waterway systems in China are the Yellow River in the north, the Yangtze River in central China and the Xi River in the south. By far the most important waterway is the Yangtze River with a length of 6,400 km of which 3,000 km is suitable for navigation by vessels in excess of 1,000 tonnes.

Some three quarters of China's inland waterborne traffic takes place on the Yangtze River and its tributaries. The river flows from Tibet in the Himalayas through the heart of China's most populated areas before finding its way to the sea close to China's most important economic centre and the world's largest container port: Shanghai.

Other important cities and ports located on the Yangtze River are Nanjing – some 400 km from Shanghai, and Wuhan and Chongqing. Some of the most important inland container terminals are also located

Yangtze River

in these cities. Seagoing vessels with a draft up to 10 m can travel as far as Nanjing.

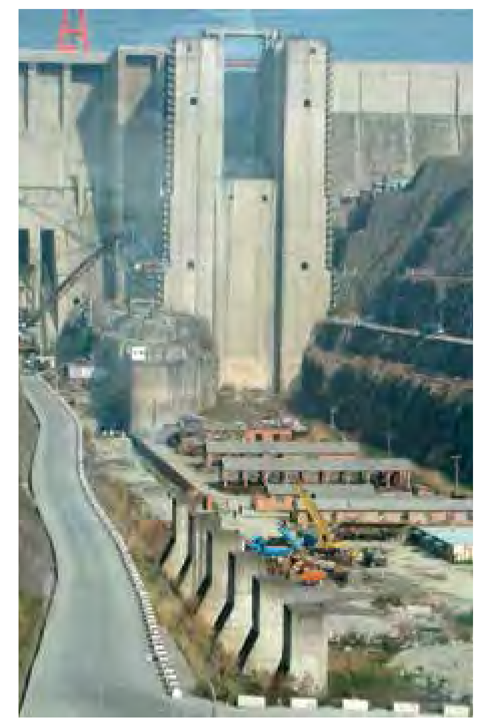
The Yangtze River is the number one river in the world in terms of cargo volume; over 1.2 billion tonnes of cargo, mainly dry bulk, were moved by ships navigating the river in 2014. The navigational conditions for barge transport on the river have improved significantly by the construction of several large hydraulic engineering works.

The Three Gorges Dam between Chongqing and Wuhan, including a ships' lock system, was completed in 2006. These locks are 280 m long, 35 m wide and 5 m deep and have an annual transit capacity of approximately 100 million tonnes. In addition to these locks, a new ship lift system is being built, capable of lifting/lowering ships up to 3,000 tonnes over a vertical distance of 113 m. The lift basin will be 120 m long, 18 m wide and 3.5 m deep. It will reduce the transit time through the dam from three to four hours using the lock system to approximately 30 to 40 minutes using the ships' lift. The lift was completed in 2015.

Locks on the Three Gorges Dam, Yangtze River

The largest and most advanced container terminal upstream of the Yangtze River is the Cuntan International Container Terminal in Chongqing, some 2,200 km inland from Shanghai. This terminal is an important inland freight hub in China with barge connections to Shanghai, rail connections to Shenzhen and close proximity to a large international airport.

Another major improvement project was the dredging of the Grand Canal, the world's longest. The canal runs for some 1,776 km from Beijing to Huangzhou, connecting the Yellow and Yangtze Rivers in eastern China. The project was completed in 2012 and significantly increased the Canal's transport capacity.



New ship's lift, Three Gorges Dam, Yangtze River

The importance of continuing to improve inland navigation is recognised by the Chinese government. In the five year plan for 2005-2010, the equivalent of EUR 1.5 billion was set aside for investments in the inland waterway system. This included improvements to the navigational accessibility of the rivers, implementation of traffic information systems and replacement of old tonnage.

The most commonly used container barges in China are self-propelled barges with a fixed, non-liftable wheelhouse, situated either forward or aft. The maximum stacking height on board these barges which resemble coastal vessels is three to four tiers.

Container barge transport on the Pearl River, China

Other areas

There are many other extensive river systems around the world, several of which have reasonable to good navigational accessibility. Only a few, however, are used for or have significant potential for inland container transport by barge.

Brazil

In South America, the Amazon and Paranagua Rivers are mainly used to transport agricultural and mining products. Significant levels of container transport take place on the Amazon River where deep-sea container vessels can travel as far as Manaus, which is located some 1,600 km inland. Several container lines offer direct services from Manaus to other continents.

The Brazilian Ministry of Infrastructure and Transport plans to increase the inland navigation's share of the domestic transport of containers. This will also include container transport by barge, which will be focussed on the Amazon and Paranagua Rivers as well as between the seaport of Rio Grande and the inland port of Porto Alegre.

Russian Federation

The Russian Federation has some 100,000 km of navigable inland waterways and over 100 inland ports. Most inland navigation movements take place in the European part of the Federation. The most important rivers for freight transportation are the Volga, Neva, Svir, Don and Dnepr and a range of canals connecting these rivers.

The Russian inland navigation fleet consists of some 15,000 freight vessels, of which the 1,100 river sea ships are particularly important. Winter conditions mean the rivers are only navigable during a certain part of the year. During the remainder, these sea-river vessels can also be employed offshore.

Road and rail transport dominate the freight transport market in the Russian Federation. Inland navigation transport is mainly for agricultural and mining products. Container transport by dedicated barge services is quite limited. There are intermodal container terminals also offering domestic barge transport in the Moscow area.

Container terminal in Moscow

South East Asia / Mekong

Another river system which has gained significance in the transportation of containers is the Mekong River in South East Asia. The river flows over a distance of 4,350 km from South China to Vietnam, through Myanmar (Burma), Laos, Thailand and Cambodia.

Due to seasonal rains and many bends in the river, navigation is difficult and only possible for smaller sized barges. Significant container transport by barge has developed on the lower part of the river, between the capital of Cambodia, Phnom Penh.

3.4

Container transport by rail

Containers are very important in the global transport of freight – not just in their capacity as cargo transport units, but more so due to their successful integration with rail, road and maritime shipping networks. Transport by land, rail and road are strongly interlinked. Rail is viewed as the long-distance volume-based haulier, while flexibility and the ability to transport individual consignments over shorter distances are achieved through road transport.

Primitive rail systems were already in existence in the 17th century and used to move materials in mines. The first proper rail transportation systems were only established in the early 19th century, with the introduction of the first steam locomotive in 1829. They were the product of the industrial revolution which, at that time, was sweeping across Western Europe and North America. Rail transport was, and still is today, the only way to move large and heavy freight volumes and large numbers of passengers at the same time on scheduled services. These advances were of great benefit during the industrialisation, and they fundamentally changed the way in which freight and passengers were moved by land.

Transport by rail remained the preferred way of moving bulk volumes of goods up until the Second World War. However, as roads improved and the road network grew in the years after the war, trucking companies became major competitors to the railways and gradually gained an increasing share of the market.
The transport of containers by rail has developed in the United States in particular, where it has become the way to move containers across the continent. The carriage of containers by rail in Europe developed some time after the US, but has over time gained an important share of land-side container transport.

Since 2000, both India and China have invested in dedicated container rail services and several major infrastructure projects to build more railways are underway or in the planning stages in these countries.

With some 225,000 km of track, the United States has by far the largest rail network in the world, followed by Russia (130,000 km), China (100,000 km) and India (65,000 km). The total extent of the rail network in the European Union is approximately 220,000 km.

United States

The US freight rail network is generally considered the world's largest and most efficient freight transportation system. US freight railroads account for approximately 40 per cent of intercity freight volume – this is more than any other mode of transport. US railroads are all privately owned, and are built and maintained by the railroads themselves. According to the Association of American Railroads, some USD 550 billion of their own funds were spent on locomotives, freight cars, tracks, bridges, tunnels, and other infrastructure between 1980 and 2013. There are a limited number of players in the American railroad business: CSX Transportation (former owner of Sea-Land), Canadian National Railway (US operations), Norfolk Southern Corporation, BNSF Railway, Canadian Pacific (US operations), Kansas City Southern Railway, and Union Pacific Railroad Company. Intermodal rail transport of containers is an important part of the business of each of these railway companies.

Malcolm McLean, the founding father of containerisation, had a clear idea of the opportunities that rail could offer. He saw containers as a way to integrate maritime and land-based transport into one transport chain. For this reason he called his shipping line Sea-Land and the company, which was initially set up as a shipping line, was sold to a railway corporation (CSX Tranportation) in 1986.

Marine transport of containers requires alignment with land carriage to be fully intermodal. Accordingly, McLean was equally active in rail and road transport. As in shipping – trucks, ships and railroads were all in the same business, namely that of moving freight from one place to another with as few transfers as possible.

At the time McLean started to consider land transport, it was recognised that, road transport was expensive and time consuming especially on longer distances. Railway corporations already offered an arrangement called 'Piggyback' or 'TOFC'

Trailer on flat car (Piggybacking)

(Trailer On Flat Car), a system whereby a road trailer, with container, is transported on a railway carriage. This method to transport freight by rail remained very common in American railway transport until the 1990's. After this time, intermodal freight transport moved towards so-called 'COFC' (Container On Flat Car), a system which had been introduced to American railway transport in 1936, but had become a common standard only in the 1980's.

Rail transport of containers in the United States started relatively late. One of the difficulties was the fact that the US railways

Deregulation of the US transport system

A significant reformation of the US transportation system took place between 1978 and 1980 by the passage of three major deregulation laws. These laws were the result of efforts by the Nixon Administration in the early 1970's to replace the regulatory structure that had existed since the Interstate Commerce Act of 1887.

Rail transport was deregulated by the Staggers Rail Act of 1980 (named after its sponsor Harley O. Staggers). The other two laws were the Airline Deregulation Act of 1978 and the Motor Carrier Act of 1980.
The Staggers Rail Act provided opportunities for rail operators to establish their own rates and their own contracts with shippers. The effect was increased competition between the operators and, over time, a considerable reduction of the freight rates. (According to a study by the Department of Transportation's Freight Management and Operations, costs and process were halved over a ten-year period).


US President Jimmy Carter signs the Staggers Rail Act, 14 October 1980

were heavily regulated and fragmented. At one point in time there were over 100 railway companies. Furthermore, the railway companies did not see a future in the transport of freight containers on their rail tracks. The situation changed in 1980, when Congress passed the Staggers Rail Act. Through this Act, the US railway system was substantially deregulated and opened up to competition.


Container on flat car

Interestingly, particularly the ship operators – lead by companies such as American President Lines (APL) and Sea-Land – pushed the development of intermodal (rail) transport of containers. They introduced a concept known as 'land-bridge', whereby the container was carried both on board a ship as well as on a railroad train as part of single shipment. For instance, containers from Asia Pacific with final destination New York would be discharged from the vessel at a port on the West Coast and then carried by train over land (bridge) to New York. The first service of this kind took place from the port of Los Angeles in 1977 and was offered by Sea-Land and the Southern Pacific Rail Road. Shortly afterwards, APL followed with a land-bridge service out of Seattle.
The Staggers Rail Act, together with the advent of the container shipowners becoming involved in railway operations, marked the beginning of a new era in container rail operations in the United States. The traditional stringent practices with respect to schedules, right of way and interchange with other railroads were abandoned, which allowed containership companies to exercise greater control over their landside operations. At the same time, a shift was observed from railway-owned rolling stock to large fleets of railway cars owned and operated by containership companies. By the end of the 1980's, hundreds of dedicated container trains – often over a mile long – were deployed between ports on the West and East Coast. A new industry standard for the carriage of containers by rail was introduced in 1977. This new concept was known as 'double-stack', a system whereby the containers were carried two-high on railway carriages. To facilitate the introduction of this new technology, a new type of railroad car was created – the 'well car'. Again, Malcolm McLean, the founder of Sea-Land, played an important role in the development of the double-stack and the construction of well cars (see box story *McLean on his way to the White House).* After several years of development, the first all double-stack train left the port of Los Angeles heading east in 1984. The concept proved successful,

McLean on his way to the White House

Sea-Land people had been meeting with executives from the Southern Pacific, but the railroaders kept insisting that the floor of a conventional flatcar precluded transporting containers one atop another, as McLean wanted to do. One day McLean and his wife and children were invited to a reception at the White House, and they travelled to the capital from northern New Jersey aboard a Pennsylvania Railroad train. As they were walking along the platform at Washington Union Station, McLean noticed that a considerable amount of permanent equipment hung below the floor level of the cars, especially steam pipes and brake hoses that were connected to each other below the couplers of the cars. Getting down on his hands and knees, McLean crawled beneath the cars to estimate how high above the rails this equipment rode, and he determined that it cleared by a mere three inches. Armed with this information, Sea-Land people renewed their efforts with the Southern Pacific, and the world's first double-stack container car, Southern Pacific No. 513300, turned out by the American Car and Foundry Company, a joint effort by Sea-Land and Southern Pacific.

Not so lucky, though, was the man who was en route to a White House reception. His little inspection tour in Washington Union Station put a big hole in Malcolm McLean's trousers – he called him his 'britches' – and when he arrived at 1600 Pennsylvania Avenue shortly afterward, the man was anything but the last word in sartorial splendour.

From : Brian J. Cuhady, Box Boats How Container Ships Changed the World, Fordham University Press, 2006. Quoted from: Malcolm McLean interview, McLean Foundation Oral History Collection however, before double-stack trains could move from west to east, the overhead clearance of many railway passages had to be adapted. Today, more than 70 per cent of intermodal containershipments in the United States is carried on double-stack trains.

The main seaports on the US west coast are Los Angeles / Long Beach in the south and the Seattle / Tacoma region in the north, with Oakland located halfway in between. From these ports, daily services are available to destinations inland and on the east coast. Large inland container terminals have been built near cities such as Chicago, Detroit and Kansas City, where east-west and north-south connections meet.

Double stack on well car

Major container railroad connections in the United States — source Dr. Jean-Paul Rodrigue, Dept. of Global Studies & Geography

Average transit times on the main routes are (source: websites of various railway companies):

Los Angeles – New York	7 days
Los Angeles – Miami	8 days
Los Angeles – Chicago	4 days
Chicago – New York	3 days
Kansas City – New York	4 days
Vancouver (Canada) – Chicago	6 days
Prince Rupert (Canada) – Chicago	4 days

Trans-Pacific transit times out of Pusan, Korea range between nine days for Prince Rupert and up to twelve days for Los Angeles. Accordingly, a voyage from Pusan to New York, using the most efficient land bridge connection, could take some 17-18 days and is therefore a reasonable alternative to the Panama Canal, if only taking transit times into account.

Europe

Rail transport of containers only becomes economically viable when large volumes can be transported over long distances, with as few intermediate transfers as possible. There are 51 countries in Europe and travelling a few hundred kilometres in any direction usually involves crossing one or more borders. Therefore, Europe had a number of specific issues to overcome before efficient container rail services could be established. The European Union played an important role in resolving these problems and in creating an environment whereby cross-border traffic could be accomplished without too many difficulties. In the 1970's and 80's, the European rail market was dominated by state-owned railway companies offering international services. However, as there was no single organisation responsible for cross-border traffic, when the train reached the border station, the unit had to be transferred to the railway company operating in the neighbouring country.

With the liberalisation of rail traffic within the European Union, smaller rail service providers entered the market and a new type of service, referred to as 'rail-road combined transport', became available. These services included container traffic between a seaport and an inland terminal (or vice versa) or long distance transport of consumer goods between various parts of Europe. On these combined transport trains one can find ISO freight containers, (semi-) trailers or a typically European load unit known as a 'swap body'.

Swap body

A swap body is a regional transport containment of a permanent character designed for road and rail transport within Europe and complying with European standards. (UNECE definition) Swap bodies are generally 2.5 m or 2.55 m wide and are subdivided into three length categories:

Class A: 12.2 to 13.6 m long (maximum gross mass 34 tons);
Class B: 30ft (9.125 m long);
Class C: 7.15, 7.45 or 7.82 m long (maximum gross mass 16 tons).

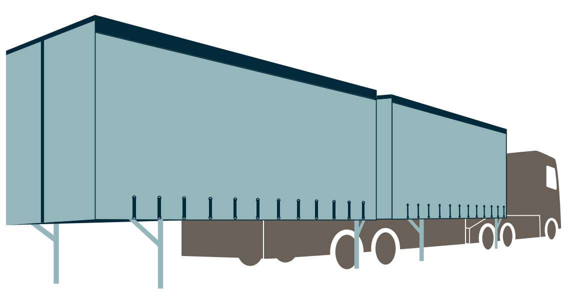
For all swap bodies, bottom container castings are fitted at the same intermediate distances as on a normal ISO shipping container. This allows the swap body units to be placed on the same types of trucks, trailers and railroad cars as the ones designed for ISO shipping containers. The overall dimension of a swap body may be different from an ISO container, which results in the bottom fittings not always being located at the corners of the swap body.

The width of a swap body is usually 2,50 or 2, 55 m in order to allow two EUR pallets (80 x 120 cm) to be placed next to each other without leaving empty space. The other advantage of a swap body is its relative light weight and the consequential cost saving in fuel consumption during transport. There are stackable and non-stackable swap bodies.

Non stackable swap bodies only have bottom fittings and require lifting by the bottom frame, usually by means of grappler arms which are inserted into the four recesses in the bottom structure. More and more stackable swap bodies come on the market and these have top fittings as well, enabling the same kind of handling with standard freight container handling equipment.

In terms of stack ability and strength, a swap body differs substantially from an ISO freight containers and is therefore not suitable for overseas transport on board a regular container vessel. Swap bodies are regularly carried on board short sea vessels, in Europe.

Swap bodies are subject to European Normalisation standards such as EN 283 (testing), EN 284 (non-stackable swap bodies, class C dimensions and general requirements) and EN 452 (class A swap bodies, dimensions and requirements) as well as EN 13044 (coding, identification and marking).



The introduction of combined rail services was a turning point in European rail traffic, and was further improved once issues such as flexibility, transit time, punctuality and cross-border issues had been addressed by the railway operators. Clearly, in order to be competitive, European rail transport had to offer at least the same level of service as did road haulage. This was accomplished by offering scheduled block-train services with high quality rail logistics.

Note

'Block (or unit) train service' is a point-to-point service for a complete train, usually for one customer, the opposite being 'wagonload service' whereby single wagons for various customers are assembled in one train.

Container block trains (also known as 'container shuttle services') are mainly used in hinterland container traffic between the seaport and an inland container port. Today, these shuttle services are mostly operated by the seaport terminals themselves and / or one of their subsidiaries. An example of such a company is European Rail Shuttle (ERS), which was established in 1994 by a consortium formed by Maersk Line, NS Cargo, Sealand, P & O Containers and Nedlloyd. The company provided regular railway services between Rotterdam, Germany, Austria and Italy. In 2013, Maersk Line, who in the meantime had acquired the other shipping companies in the joint venture, sold ERS to Freightliner UK. Today, several private railway companies operate on European railways providing regular container services between the major seaports and a large number of inland container ports.


Betuwe route, Netherlands

In Europe, most container transport by rail uses the same very busy tracks as passenger trains. In 2007, a 160 km long dedicated freight track, the Betuweroute, was completed between the port of Rotterdam and the German border. With a total cost of EUR 4.7 billion, it is Netherlands' most expensive infrastructure project ever. The Betuweroute has been built for double-stack container transport, although these are not in use at this moment in time.

As electrification of the railway system in Europe predates the double-stacking concept, the overhead cabling is too low to accommodate a double-stack. Many bridges and tunnels are also too low for double-stacking, and adapting the height of these to accommodate taller freight trains would be far too expensive. Another obstacle for further expansion of container transport by rail in Europe is the lack of uniformity of the track gauge (the width of the track). Spain, Portugal and the former Soviet Republics operate a broader gauge compared with other European countries. Funds are being provided by the European Union to connect the rail systems in these areas to the rest of Europe.

India

Containers were carried in double-stack arrangement for the first time out of APM's container terminal at Pipavav, India in 2006. In contrast to the United States, where most long haulage routes are operated by diesel locomotives, India has opted for electrification of the freight railways. With a distance of 7.45 m between the cabling and the tracks, India has the highest overhead wiring in the world. This height allows for the carriage of two tiers of high-cube containers on a normal flatcar. Double-stack container transport is also planned for the Dedicated Freight Corridor Project, connecting Delhi with Mumbai in the west and Kolkota in the east.

China

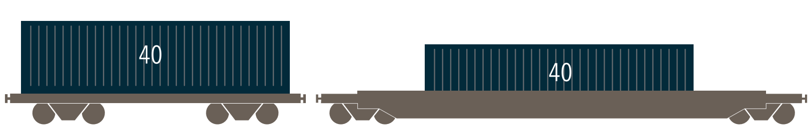
Double-stack container transport was introduced in China on the rail track between Beijing and Shanghai in 2004. The Chinese railway system is in the middle of significant expansion, not only for passenger transport but also for freight

Double-stack container transport in India: containers loaded on normal flatcars

and containers. In future, China will have a complete network of inland container terminals interconnected by rail shuttle services. Several of these tracks will be able to carry double stacks as well.

Technology

Containers may be carried on flatcars or well cars on the railway. A well car, also known as a 'double-stack car' or 'stack car', is a railroad car designed to carry containers used in intermodal freight transport. With a normal flatcar, the wheels are positioned directly underneath the flat bottom. On well cars, the wheels are positioned at the fore and aft end of the carriage allowing the cargo platform to be closer to the rails. The well car makes it possible to load containers in a double-stack arrangement wherever the loading



flatcars   well cars

gauge provides sufficient space. In double stacking, the top container is held in place either by a bulkhead built into the car, or by inter-box connectors. The vertical centre of gravity is a major aspect in double stack transport of containers, as it determines the stability of the car load. It is particularly important in connection with high side wind loads and the corresponding maximum permissible speed (centrifugal forces). The use of well cars has a positive effect on the centre of gravity and allows the carriages to travel at higher speeds compared with flatcars. The use of well cars is also more secure as it prevents the container doors from being opened during the railway journey.

Track gauge is an important feature. It is the distance between the rails on a railway track, and is measured between the inner faces of the load-bearing rails. Many different track gauges are used worldwide. The most common is the standard gauge of 1.435 m, which is found on 60 per cent of the world's railway tracks, for example in North America, China, Australia, the majority of Europe, and North Africa.

US double stack of 53 foot containers in a well car

The widest track gauge is used in India and is 1.676 m – it provides greater stability, hence allowing for a higher speed, e.g. 100 km/hr when carrying high-cube containers in double-stack arrangement on normal flatcars.

Well cars range in size to accommodate the standard sizes of containers i.e. 2 x 20 foot or 1 x 40 foot (12.19 m), 48 foot (14.63 m) and 53 foot (16.15 m) containers. There are also 45 foot (13.72 m) and 56 foot (17.07 m) well cars. If the well is smaller than the container being loaded, the larger container may be placed on top of the smaller container.

Common configurations are 1 x 40 foot container stowed on top of 2 x 20 foot or 45, 48, 53 foot containers stowed on top of a 40 foot container. For this purpose, containers longer than 40 feet have additional ISO container posts at 40 foot length (see photo). The size of the well is usually clearly marked on the side of the car.

Well cars are mostly constructed as units of multiple cars (three or five), connected to each other by articulated connections or a drawbar. At the extreme end of each unit is a coupler to connect it to the next unit. This coupler is usually a so-called 'AAR' or 'Janney coupler'. These loose couplings are necessary to enable the train to go around bends. Furthermore, the couplings are also an aid in starting heavy trains, since the transmission of power from the locomotive to the train operates on each car successively.

Couplings and connectors should also be designed in such a way that they reduce the impact of 'slack action' as much as possible. Slack action in railway terms is the length of free movement of one car before it transmits its motion to an adjoining coupled car. When the train is set in motion, this slack is gradually let out when cars begin to roll one at a time. With long trains, as used in the US and Canada, where freight trains can be several kilometres long, some units may be moving uphill while others are moving downhill at the same time. In such circumstances, slack is constantly let out and taken up, and this causes a significant fore-aft shock effect to the container and its cargo. Freight trains are known to have divided as a result of such slack action.

Accelerations / weight limits

Similar fore-aft forces also occur during shunting operations. Excessive impact loads and accelerations, up to seven times gravity acceleration of 9.81 m/s^2, may occur during shunting. For this reason, cargo in the containers must be properly secured against these very significant fore-aft forces. The maximum permissible weight for a railway car is generally in the order of 8 mt per metre of train length, and approximately 22.5 mt per axle. For example, a four-axle 40 foot container car can take 90 tonnes. The railway car itself generally weighs between 20 and 25 mt. Since a container's weight is limited to 32.5 mt for a 20 foot container and 34.0 mt for a 40 and 45 foot container, single stacking does not exploit the full load capacity of the railway car. Weight considerations are, however, important when double-stacking is involved.

In Europe, flatcars are commonly used for the transport of containers. These specialised container cars have an open-bottom frame with securing equipment (hinged locking pins) at intermediate distances, meeting standard container sizes. Two-axle (L-type) container cars are designed to carry two 20 foot or one 40 foot container. The four-axle (S-type) cars can carry three 20 foot containers, one 40 foot plus one 20 foot container or two 30 foot containers (see photo below).

2 x 30 foot bulk containers stowed on a four axle S-wagon car

3.5 Road transport of containers

Road transport by truck is the dominant mode of transporting freight in developed countries. This is particularly so for local and short distance transport, where there are little or no suitable alternatives. Road transport is fast, flexible and available almost everywhere, although this has an effect on transport costs, air quality and traffic congestion.

Only very rarely are shipping containers used in road transport when trucking is the only mode of transport, for example a point-to-point carriage over land. For this type of road transport, vehicles such as box trailers, tautliners and road tanks are used. Refrigerated and insulated box trailers are also available for transport of perishable goods.

In the intermodal transport of containers, trucks are used during the first and last stages of the transport, i.e. between the container yard and the client's warehouse, or vice versa. In most container ports, there are distribution and storage centres nearby, where containers are loaded (stuffed) and unloaded (stripped). The short transport by road between the container yard and these distribution centres is usually referred to as 'drayage'.

40 foot container on a 3-axle road trailer

History and development

The road transport of freight first developed when small combustion engines were installed in freight trucks. In 1915, MAN delivered the first diesel operated truck, which was succeeded by the first direct injection diesel engine in 1924. An efficient road infrastructure was needed to be able to move quickly from one place to another. The first modern motorway with road segregation, overpasses and restricted accesses was built in Germany in 1932 between Cologne and Bonn. After the Second World War, there was a period of rapid development of road transport systems in North America, Europe and Australia followed by other continents. In the United States, probably one of the most important achievements was the completion of the American Interstate Highway system in 1956. The purpose of the road network was to serve the national economy and to support the movement of army troops. The motorways were even

US Interstate Highway system

European E-road system

designed in such a way that they could act as air strips in an emergency. In total, some 70,000 km of four to six lane motorways were built between 1950 and 1975 and linked all major US cities.

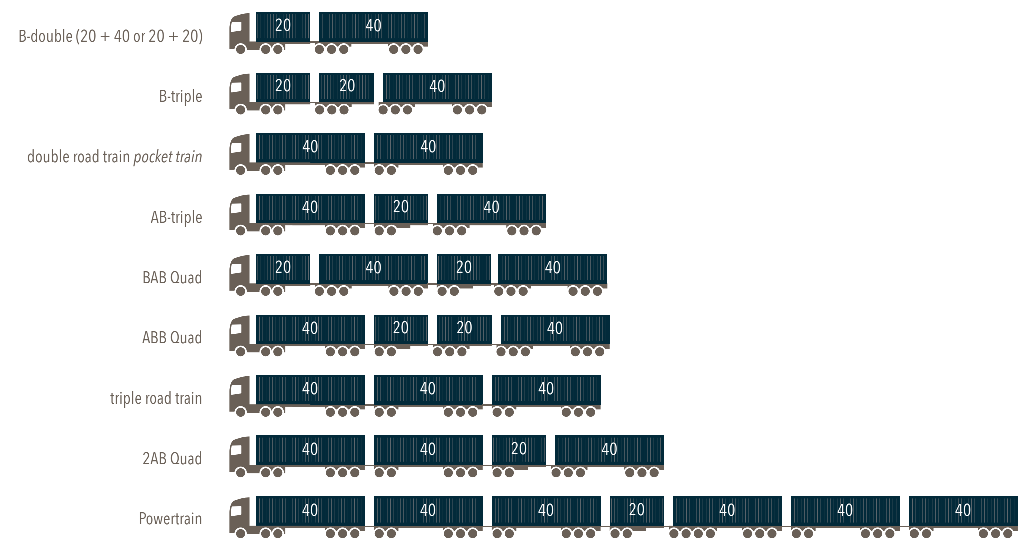
By 1980, most industrialised countries had a national motorway system and the work began to establish regional motorway networks. Examples are the Trans African

Highway, the Asian Highway and the European E-road networks.

In China, the building of a national network of expressways was started in 1989. Twenty years later, some 80,000 km of expressway had been completed. In 2011, the length of the Chinese road network surpassed that of the US Interstate.

States, where they are known as 'turnpike doubles' or 'Rocky Mountain doubles'. More commonly, road trains are referred to as an 'LCV (Long Combination Vehicle)' and can be found in several different arrangements.

'Powertrains' are the largest road trains operating in Australia and worldwide. This combination, however, only operates



Australia relies heavily on road transport, also for long distance transport. There are no inland waterways and the rail systems have not been sufficiently developed to transport large volumes of freight. The road train concept is therefore a typical Australian solution. A road train consists of a tractor unit pulling two or more trailers. Australia permits the world's largest and heaviest road-legal vehicles on its roads, with configurations weighing up to 200 tonnes and over 50 m in length. Road trains can also be found in Canada and the United

on private property such as mining grounds and not the public highway and are therefore not subject to legislation.

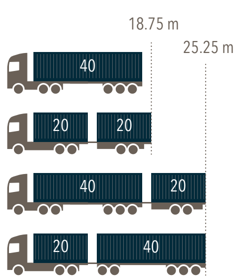
In most European countries, the standard has been for a long time a maximum length of 18.75 m. The longer combinations previously permitted in Sweden and Finland resulted in a discussion when these countries joined the European Union in 1980. A compromise was reached to allow an increased vehicle length (maximum 25.25 m) and weight (maximum

Typical US 3-axle truck, pulling a 2-axle semi trailer

European cabover truck with three axles, pulling a 3-axle trailer with 40 foot container

60 tonnes) across the EU on the condition that the standardised European Modular System (EMS) was used. Each country was subsequently free to introduce the EMS (or EuroCombi) at its own discretion. Denmark permitted use of the EMS on some parts of its road network in 2008. The Netherlands followed in 2011 and some parts of Germany in 2011. Trials are currently (2015) ongoing in Belgium.

The definition of the EMS can be found in EC Directive 96/53. The remaining European countries continue to have a maximum length of 18.75 m with a maximum weight of 40 tonnes, or 44 tonnes in case of a 40′ ISO container.



European Modular System (EMS)

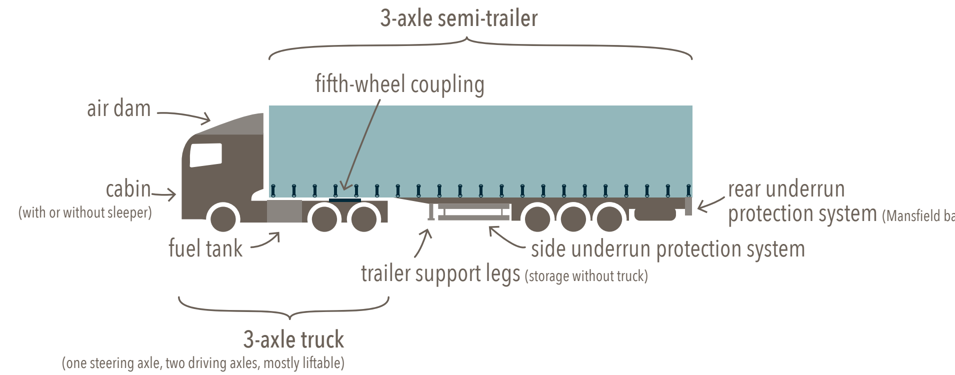
The overview below shows some common configurations including the EMS configuration, which allow the transport of 3 x 20 foot or 1 x 20 foot and 1 x 40 foot container at the same time.

Technology

A road transport combination comprises a truck (powered vehicle) and a trailer (unpowered vehicle). The tractors, or powered trucks, typically have two or three axles. One of the rear axles on a three axle truck can be liftable. Trucks built for hauling heavy cargo may have as many as four or five axles, although these are not common in container transport.

In North America and Australia, most tractors have a forward engine, one steering axle, and two drive axles. The driver and the sleeper cabin are located behind the engine.

The Cabover or flat nose truck is more common in Europe and some other parts of the world, where there are more restrictions on truck lengths. Cabovers offer greater manoeuvrability and better overview



for the driver, but accessing the engine requires the cabin to be tilted. Conversely, conventional (US type) cab tractors offer the driver more comfort and better protection in a collision.

A trailer can be either a full trailer or a semi trailer, the only difference being the presence of a front axle (or dolly) on the full trailers. There are far more semi-trailers than full trailers in use, except in the case of multiple trailers in one road combination (e.g. road trains).

A semi-trailer is normally equipped with legs, called 'landing gear', which can be lowered to support the trailer when it is uncoupled from the tractor.

Fifth wheel coupling

Container trailers (chassis or Skeletal trailers) are available in many different versions and sizes. Modern container chassis can be adjusted in length, to accommodate 20 foot, 40 foot, 45 foot or longer containers. Each corner of the container is secured to the chassis by means of twistlocks, which are fixed to the trailer. Full trailers are usually equipped with a draw bar which can be coupled to a truck. The most common type of coupling used on semi-trailers is the so-called 'fifth wheel coupling'. This coupling provides a link between a semi-trailer and the towing truck, or between the dolly and the leading trailer. The coupling consists of a kingpin, (a steel pin on the front of the semi-trailer), and a horseshoe-shaped coupling device on the rear of the towing vehicle. The fifth-wheel coupling on most tractor trucks is adjustable and can be moved fore and aft to optimise weight distribution over the rear axle of the truck. 25 per cent of the total trailer load should ideally rest on the fifth wheel coupling.

Maximum permissible dimensions for road transport units differ by country or even by state (US). A maximum permissible height of 4 m prevails in most European countries. Hence, high-cube containers 2.89 m high, are carried on gooseneck chassis, which reduces the overall height to an acceptable level. In the United Kingdom, the standard minimum clearance over every part of the carriageway of a public road is 16 feet 6 inches (5.03 m). In the United States, the maximum gauge is 4.11 m (13.5 foot). In most Australian states the maximum gauge is 4.3 m.

Weight is usually limited to nine tonnes on a single axle or 18 tonnes on tandem axles. In the United States, 80,000 lb (36,000 kg) is the maximum permitted weight of a single truck trailer. A special permit is required for heavier weights. In the United Kingdom, the weight limit is 44 tonnes. The heaviest permitted weight for a single semi-trailer (50 tonnes) anywhere in the world can be found in the Netherlands.

Road accidents

Every year there are thousands of road accidents involving container trailer loads. The most common and very dangerous accident is the container overturning, usually as a result of one or a combination of the following factors:

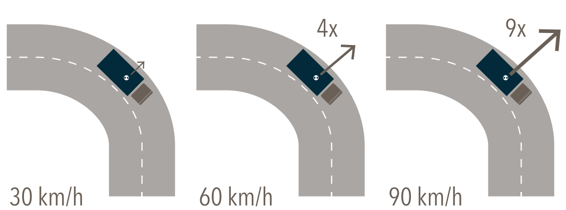
Container road accident

Side wind

Trucks transporting containers are particularly susceptible to aerodynamic forces. This can be the effects of side wind or other passing vehicles.

Speed and cornering forces

The centrifugal force is affected by vehicle speed and the angle of turn. In other words, the faster the vehicle is going and/or the tighter the turn, the more likely the driver is to lose control of the vehicle causing the vehicle to roll over. Centrifugal forces occur during cornering or evasive manoeuvres. Speed has a squared effect to the overturning force and may therefore dramatically impact the ability to control the vehicle. For instance the overturning force at a speed of 60 km/hr is four times the overturning force at a speed of 30 km/hr. At 90 km/hr the overturning (or centrifugal) force will be nine times that of 30 km/hr. See illustration below.



Jane Mansfield and trailer safety

Many people know Jane Mansfield (1933 – 1967) as an American actress, nightclub entertainer, singer, and an early Playboy Playmate. In the 1950's she became one of Hollywood's most famous sex symbols. Most people, however, are not aware that her name became connected with an important safety device on road trailers. Her sad death explains how the story began:

Late on 28 June 1967, Jane Mansfield together with her three children Miklos, Zoltan and Mariska, her partner Sam Brody and their driver Ronnie Harrison left Biloxi, Mississippi in a Buick Electra 255, heading for New Orleans, where she was scheduled to appear in an early morning television interview.

On 29 June at approximately 2:25 in the morning, on US Highway 90, east of Rigolets Bridge, the car crashed into the rear of a road trailer and the top of the car was sheared off when it went under the truck. Police reports state that the three adults in the front seat were killed instantly; whilst the children, sitting in the rear, survived the accident with only minor injuries.

The death certificate stated that the immediate cause of Mansfield's death was a 'crushed skull with avulsion of cranium and brain'.

After her death, the US National Highway Traffic Safety Administration (NHTSA) recommended that road trailers be equipped with a rear underride guard. The bottom rear edge of a road trailer is almost at head level of a person in a car, where the car's windshield is the only, and insufficient, protection. A strong assembly hanging down from the bottom of the rear edge of a semi-trailer would prevent cars from sliding under the trailer. Today, most trailers are equipped with this type of bar, which is known as the 'Mansfield bar'.

In addition to rear underride guards, a Side Underrun Protection System (SUPS) is also required on most trailers and trucks may also be equipped with a Front Underrun Protection System (FUPS). These additional safety measures provide protection in an oblique or side collision. Following a high number of fatalities in car crash incidents, underride protection systems on trucks and trailers have become mandatory in most countries.

Stability of the vehicle

There are many factors affecting the stability of the trailer. Some of these are:

Poor load distribution

This particularly applies to the transport of containers as the cargo inside the container is not visible to the truck driver. If the load in the container is too off centre (longitudinally as well as transversely), it will have a negative impact on the stability and cause the trailer load to bend over dangerously. Too much weight on the coupling may lead to a so-called 'motor boating effect'. Too much weight on the rear of the towed vehicle will have a similar effect, resulting in an uneven pressure distribution over the length of the truck-trailer combination.

Load securing

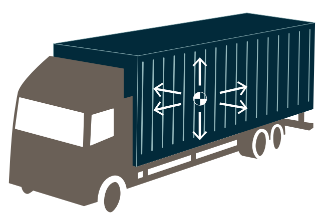
Numerous incidents have been caused by improper or no securing of the cargo inside the container.

Centre of gravity

The trailer load's centre of gravity is the sum of the centre of gravity of the empty trailer and the centre of gravity of the cargo loaded in the container. When carrying high-cube containers, a gooseneck chassis may not only assist in reducing the overall height of the trailer load but also to lower the centre of gravity.

Construction of the trailer

This includes wheel and axle alignment, brake calibration, position and number of axles. The more axles a trailer has, the more stable the trailer unit will be.



Chapter 4
Container terminal operations

Any movement of freight involves terminals in one way or another. Even the simplest form of freight transport – the dispatch of a postcard – requires assembly (the central post box) and distribution through a network of regional and national post centres (terminals) before arriving at its final destination.

With the exception of freight large enough to be shipped individually, e.g. a heavy lift unit, goods will be consolidated and travel in batches or units, for example a trailer load, a ship load, or a freight container. The processes of assembly, dispatch, and the transfer to other modes of transport take place at terminals. Terminals are, therefore, critical links in the transportation chain. Depending on their function and location, each terminal requires specific equipment and accommodation to handle the specific types of freight involved.

The obvious unit of freight in container transport is the container itself with its capacity constrained by either volume or weight. At terminals known as 'multi modal container terminals', the container may be transferred between different modes of transport, e.g. rail, road or barge. This is particularly the case where the terminal serves as a gateway to a hinterland. Terminals may also serve as points of interchange between the same mode of transport, for example where the terminal acts as a central hub. Container terminals which do not have a maritime link are known as 'dry ports', where containers are transferred from trucks and barges to railway carriages and vice versa.

The container terminals' clients are the shipping lines. They pay the terminal an agreed fee for every container loaded or unloaded from the vessel. At the same time, shipping lines demand that terminals handle a minimum number of containers per hour. These and many other aspects of terminal operations are agreed between the shipping line and the terminal and set out in the terminal service contract.

An important section in these contracts deals with the terminal's commitment to reserve, long before the vessel arrives, a berthing space for the vessel on a certain date and for a certain period of time – a so-called 'berthing window'.

In terms of exclusivity and ownership, container terminals may be divided into 'multi or common user terminals', which serve any shipping line, and 'dedicated terminals' offering exclusive rights to shipping lines. This exclusivity may only apply to a part of the terminal and for a certain period of time. Shipping lines may also own and operate terminals themselves, particularly in locations of significant strategic importance to the shipping line.

This chapter describes how containerisation has changed the function and layout of ports and terminals, and gives an insight into the processes at a modern container terminal and the complexities of storage, shipping, stowage planning, loading and unloading of a vessel as follows:

- History and development
- Terminal owners and operators
- The function of a container terminal
- Layout of a modern container terminal
- Terminal equipment
- Planning and operations.

4.1 History and development

The word terminal comes from the Latin 'terminus', which means the end or final part, and suggests the end of a transportation line. In shipping, and container shipping in particular, terminals have an intermediate function in moving containers from one ship to another, or from a ship to another mode of transport. Historically, ports developed at the most navigable upstream parts of rivers or in locations where rivers came together. Cities such as London on the Thames, Antwerp on the Scheldt, or New York on the Hudson River owe much of their current status as major global cities and ports to their location.

In those early days, there were few requirements for navigable access, and sites easily achieved status as a port or harbour. Ports which had to cope with tidal waters created enclosed docks accessible through lock gates.

Dry cargo was shipped in the form of break bulk and ships had to stay in port for several days or even weeks to load and unload the cargo; this required a sufficient number of berths being available. Ports were typically constructed with finger piers to achieve a maximum number of berths within the port area. As ships had their own cargo gear and transfer times were lengthy, quays could

New York Lower Manhattan . East River piers circa 1931. Typical pier construction as was common prior to containerisation

be relatively small. Warehouses located immediately adjacent to the dockside meant that goods were only exposed to the elements for a very short period of time.

The shift from break-bulk to containers led to a fundamental change in the construction and siting of terminals. This was especially so in the late 1960's, when containerships were built without on-board cranes. The terminal where the ship intended to berth had to provide the equipment to load or unload the containers. The rate at which containers were loaded and discharged was much faster than the trucks could handle. Therefore, a buffer of container storage space was needed ashore. Quayside warehouses were no longer needed as the container itself provided enough protection. Accordingly, ports which entered into container handling had to completely redesign their port structure. Locations like New York and Hamburg reshaped their existing port areas while, for example, Rotterdam shifted its container operations towards the coast and built it on land reclaimed from the sea. With the further globalisation of the world trade, large container ports were needed at the junctions of north/south and east/west trade routes. These ports had a transhipment function only.

Historically, two ports have led the way in the development of container ports and terminals. The first major development took place in the late 1950's (and early 1960's), when New York and nearby Newark battled over the location of the construction of the first dedicated container port in the area. The second such development was in 1980 when Rotterdam-based Europe Combined Terminals decided to move their container operations from the city of Rotterdam to the coast and opened its Delta terminal, the world's first automated terminal, in 1985 (see also *Port Newark Elizabeth Marine Terminal and ECT Delta Terminal; leaders in the development of container terminal operations*).

With the size of vessels increasing, there was a corresponding growth in the demand for ports and terminals to handle these larger vessels as well. These new vessels created new challenges for the terminals, particularly regarding water depth and the size of quay cranes. The investment required to build new terminals or to adapt existing terminals to the new standards became so large that many terminal owners sought alliance with or ownership by foreign investors to be able to afford these investments.

Due to 'call-size' (the volume of containers handled during one port call) and the need for storage space ashore, terminals handle much greater peak loads than ever before. A normal port call of a very large container vessel involves the exchange of some 5,000 TEU (loading and discharge), however, there have been instances where over 10 to 15,000 TEU have been transferred during one port call. The trend is for current container volumes to be handled by fewer, but larger terminals, capable of handling ultra large container vessels and with the required navigational accessibility.

Port Newark Elizabeth Marine Terminal and ECT Delta Terminal; leaders in the development of container terminal operations

Port Newark Elizabeth Marine Terminal

On 15 August 1962, the Port Authority of New York opened its Elizabeth Marine Terminal, considered to be the world's first container terminal, at the port of Newark.

The New York Port Authority was created in 1921 from the merger of the ports of New York and New Jersey, who had been fighting for many years between themselves over the jurisdiction rights on the Hudson River. The new port agency was tasked with developing and modernising the entire port district. The nearby port of Newark received particular attention, as by 1951 it had become one of the world's most modern terminals with 21 berths and a 35 foot (10.7 m) deep channel to accommodate the largest ships at that time. On 26 April 1956, the terminal was the location of a landmark in the carriage of containers, when Malcolm McLean's IDEAL X was loaded for its first voyage carrying standard freight containers, destined for Houston. At that time, McLean had already struck a deal with the port agency to build a completely new container port just south of Newark, which was to become the new Port Elizabeth. In fact, this new terminal instigated the demise of the port of New York. Marc Levinson writes as follows in The Box:

'Then (1955) came the most aggressive move of all. On December 2 1955, New Jersey governor Robert Meyner announced that the Port Authority would develop a 450-acre tract of privately owned tidal marsh just south of Port Newark. The new Port Elizabeth, the largest port project ever undertaken in the United States, was planned

New York and the Bayonne Bridge

eventually to accommodate twenty-five oceangoing vessels at once, enabling New Jersey to handle more than one-fourth of all general cargo in the Port of New York. Previously, the Port Authority had shown little interest in Elizabeth's marshlands. McLean's idea of putting truck trailers on ships changed that view entirely. Now, port planners foresaw a resurgence of coastal shipping, and the new Port Elizabeth would have ample wharf and upland available for the proposed use of large shipping containers on specially adapted vessels. There might not even be a transit shed, the most expensive part of pier construction. The first containership had yet to sail, but the Port Authority was making clear that the future of container shipping would be in New Jersey, not in New York.'

Today, the Port of New York and New Jersey is the third largest port in the United States in terms of volume (tonnes), after the Port of New Orleans and the Port of Houston.

Any development of the Port of Newark is considerably hampered by the fact that the Bayonne Bridge only allows a maximum air draught of between 46 and 48 m, which is not sufficient for the largest container vessels. In May 2013, a USD 1.3 billion project was started to increase the navigational clearance to 65 m, with completion aimed in 2017.

ECT Delta terminal

Ten years after its birth in the United States, containerisation found its way to Europe. The director of the Rotterdam Port Authority, Dr. F. Posthuma, recognised containerisation's enormous potential at the port of Rotterdam. Sea-Land chose Rotterdam as its centre of activities in Europe, influenced by Posthuma's good relationship with McLean. In 1967, a consortium consisting of Dutch Rail and four stevedoring companies, founded a new company to handle the new container business: Europe Combined Terminals (ECT). In order to facilitate further growth in its container operations, the ECT opened its Delta Terminal in 1985, near the sea and some 50 km from the city of Rotterdam. Many were of the view that the new terminal was too far away from the existing port area, however, the move appeared successful and ECT's business continued to grow. The terminal expanded further in 1993, with the opening of the world's first automated terminal. Further expansion took place in 1999 and 2003 with the opening of the automated Delta Dedicated East and West terminals. In 2008, the opening of ECT's Euromax terminal was the next step in the development of terminal automation, and it became one of the most environmental friendly terminals in the world.

Many terminal operators around the world followed ECT's example of situating their terminals closer to the sea or sufficiently close so as to allow access without the need to pass through locks. Automation was introduced at many terminals around the world, particularly in countries with high labour costs.

Further innovations in container terminal operations, particularly with regard to energy saving and reduction of carbon emissions, have been introduced at Rotterdam's new terminals at Maasvlakte 2, which opened in 2015.

4.2 Terminal owners and operators

The investments involved in constructing and operating container terminals are very significant, require strategic planning and a long term view. Furthermore, operating a container terminal requires capacity in terms of funding, knowledge of ship handling, logistics management and data processing. This combination makes that container terminal operators are usually part of large international consortia of which a limited number are operating on a world-wide basis.

Based on their container throughput in 2014, the six largest container terminal operators are:

- Hutchinson Port Holdings (HPH)
- China Merchants Holding Int. (CMHI)
- APM Terminals
- Cosco Pacific
- Port of Singapore Authority (PSA)
- DP World.

(*source: Lloyds List/company's annual reports*)

Looking at background, organisation and constitution, container terminal operators can be divided into three categories:

Terminals with a typical stevedoring background

These companies were originally founded as stevedoring companies and, at a certain moment in history, diversified into container handling. Examples are HPH, PSA (Singapore), HHLA and Eurogate (Germany).

Financial holdings/investment companies

These are investment banks, pension funds and wealth funds that consider the container terminal sector a valuable source for generating revenue. The majority are shareholders and do not get directly involved with the management of the terminal leaving this to the (existing) operator of the terminal. Examples are DP World from Dubai and Port America.

Terminals linked with container shipping companies

These terminals were set up by container shipping companies expanding into terminal operations in order to exercise greater control over this important part in the container transport chain. Examples are APM Terminals (AP Moller), Cosco Pacific and TIL (MSC).

Productivity rates of ports and terminals

The productivity of a container terminal or port is the average of the gross moves per hour for each vessel's call.

The definition of gross moves per hour for a single vessel call is the total number of container moves (loading, discharging and repositioning) divided by the number of hours the vessel is at berth, for the period between all lines fast and all lines off. The method of counting moves may vary between ports and terminals but the following is a common method:

discharge or load	1 x 20'/40'/45'	= 1 move
restow in the same bay	1 x 20'/40'/45'	= 1 move
discharge, land and restow	1 x 20'/40'/45'	= 1 move
out of gauge	1 x 20'/40'/45'	= 3 or 4 moves
hatchcover handling on board		= 2 moves
hatchcover handling to shore		= 3 moves
twinlift	2 x 20' units	= 2 moves
tandemlift	2 x 40' units	= 2 moves

In 2014, the US based JOC Group produced a white paper on port and terminal productivity, based on a survey of 150,000 port calls at 483 ports and 771 terminals. They ranked ports and terminals according to the average number of moves per hour per ship during 2013. The port with the highest productivity was Tianjin, China averaging 130 moves. The terminals with the highest productivity were the APM Terminal in Yokohama, Japan and the Tianjin Xingang Sinor Terminal in China, with 163 moves each. The survey indicates that Asian ports are far more productive when compared with their European and American counterparts. The APM Terminal at Port Elizabeth (New Jersey) was the highest ranked terminal in the Americas with 104 moves. The Euromax Terminal at Rotterdam was the highest ranked European terminal with 100 moves.

Whilst there are no official records, the Westport Terminal at Port Kelang Malaysia claims to hold the world record for the most container moves in one single hour. In March 2010, they achieved 734 container moves in one hour over the 9,572 TEU CSCL LE HAVRE, using nine cranes at a time.

ranking	port	moves	ranking	terminal	moves
1	Tianjin (China)	130	1	APM Yokohama	163
2	Qingdao (China)	126	2	Tianjin Xingang Sinor	163
3	Ningbo (China)	120	3	Ningbo Beilun Second	141
4	Jebil Ali (UAE)	119	4	Tianjin Port Euroasia	139
5	Khor al Fakkan	119	5	Xiamen Sonyu	132
6	Yantian (China)	108	6	Tianjin Five Continents	130
7	Xiamen (China)	106	7	Ningbo Gangji	127
8	Busan (S. Korea)	105	8	Tianjin Port Alliance	126
9	Mawan (China)	104	9	DP World, Jebil Ali	119
10	Shanghai (China)	104	10	Khor al Fakkan	119

Ranking of world's most productive port and terminal, average container moves per ship, per hour, all vessel sizes (2013).
source: JOC Group

4.3

The function of a container terminal

Handling and storage

The primary function of a container terminal is to handle and move containers one way or another. This is the primary function of every container terminal around the world, irrespective of whether it is a marine or an inland terminal. The practical impossibility of directly transferring containers between vessels or between trucks, barges, trains and vessels are an integral part of container terminal operations. Direct transfer between vessels would require the transhipment vessels, as well as trucks, trains and barges to all arrive at the terminal at the right time and in the right order, and containers would need to be unloaded from these in the same sequence as they are loaded on board the vessel. This is simply impossible. Therefore, container terminal operations can only be executed in an efficient manner if the containers can be placed in temporary storage at the terminal. This is referred to as the 'storage buffer'.

The amount of time a container remains at the terminal is referred to as the 'container dwell time'. Terminals prefer to limit container dwell time as much as possible, as too many containers at the storage yard complicates the logistic processes. After all, a container terminal is not a warehouse, but is built to handle as many containers as possible in the shortest possible time.

On the other hand, the terminal provides secure and relatively inexpensive storage for shippers, receivers and shipping lines. Terminals, therefore, provide fixed time periods during which shippers can deliver their export containers to the terminal. The point in time from which shippers can deliver the containers to the terminal in advance of the vessel's arrival is known as 'the cargo opening time'. This varies from terminal to terminal, but a cargo opening time of some eight to 10 days prior to the vessel's estimated arrival is not unusual. The terminal would ideally prefer that import containers which have been discharged from the vessel are picked up as soon as possible. A two to three day storage period at the terminal is usually included in the cost of the container handling. Thereafter, the terminal charges a daily storage rate.

Empty containers are a separate category of storage and separate areas may be set aside at the terminal to store empty containers for each shipping line. However, in most instances, and especially at very busy terminals, empty containers are stored at designated empty container depots just outside the terminal itself. At these empty container depots there are also facilities for inspection, repair and cleaning of the containers.

Container stripping and stuffing

Facilities for regular loading (stuffing) and unloading (stripping) of the container may be available at the terminal, albeit this will mostly be only at the smaller or medium-sized terminals. The larger terminals do not usually have the space to carry out such operations on a regular basis, and will only facilitate stuffing and stripping of containers if alllowed by the Custom status of the terminal and/or in an emergency; for example, if the container has been damaged and can no longer be transported.

Administrative functions

Document check and verification

Container terminals exchange a vast amount of information and documentation with their users. Every day, mostly 24/7, they are in contact with shipping lines, local agents, trucking companies, barge and rail operators, Customs, etc. This particularly applies to terminals with a gateway function, where various modes of transport meet.

For the terminal to operate as efficiently as possible, it is important that all the information delivered to the terminal is correct and accurate. For example, if the transport document shows that the container delivered to the terminal is a 20 foot container, but is in fact a 40 foot container, this will lead to complications during the automatic container stacking and stowing on board the vessel. The same complication, with an additional safety risk will arise if the weight of the container as declared on the transport document provided by the trucking company, is different from that stated in the booking form supplied by the shipping line. Container weight and container weighing will be dealt with further in Chapter 6. Efficiency of stacking containers in the yard also depends on the correctness of the information about the next mode of transport (e.g. rail, barge, truck or ship)

Container inspection

At the terminal, the container crosses several 'lines of responsibility' each requiring an assessment of the external condition of the container. These lines of responsibility are crossed where the container enters the terminal. This can be either at the quayside or at the entrance gate to the terminal. In practice, the container will be inspected as soon as it is landed on the quay. This inspection usually entails a check for any damage to the container, as well as the integrity of the container seal. The container will also be checked for any leakage or spillage of cargo. Containers which have been declared to contain hazardous cargo, are checked for the presence of the required IMO placarding on the outside of the container.

A special type of container is the refrigerated containers. These containers are stored in a special area of the container yard where they can be connected to a power supply. The temperature of these containers must be checked regularly to verify that these are in line with the carriage instructions.

Similar inspections take place at the container gate. At some of the more sophisticated terminals, cameras with 'Optical Character Recognition' (OCR) are installed at the entrance gate to identify the arriving container by its unique 7-digit reference number. Seal status, direction of the door, container damage and IMO labels can also be detected. If the system finds any irregularity with the container, the security systems can automatically prevent the container from entering the terminal. It is good practice by the terminal to send a damage or non-compliance report to the client as soon as an irregularity has been found. This gives those involved an opportunity to rectify any errors.

Data control and verification

It would not be in anyone's interest if transport companies send their haulage equipment to the terminal to pick up a container if the container is not yet available, has been blocked for transport, has not been cleared by Customs, or does not yet have the necessary documents. This would not only incur unnecessary costs for the transport company, but would also create congestion and inconvenience at the terminal gate. Terminals have, therefore, often a system in place whereby the transport companies can verify that these issues have been resolved before sending their haulage equipment to the terminal. These systems vary from a simple line of communication to a complete online computer system, where all the relevant parties can log on, enter clearance codes, and check whether the container is ready for collection.

Automatic container inspection at the terminal gate

Stowage planning

Terminals play an important role in the completion of the preliminary and final stowage plans for each vessel calling at the terminal. In the past, these plans were created by the ship's officers but, due to logistic reasons, this task has been transferred to the planners at the terminal, who work in close co-operation with a stowage co-ordinator at the offices of the shipping line. The process of preparing the stowage plan is described in more detail later in this chapter.

4.4
Layout of a modern container terminal

The purpose of a container terminal is to safely and efficiently load and discharge vessels and to accomplish a smooth transfer between the various modes of transport. The terminal will only function efficiently if the layout of the terminal has been designed in such a way as to ensure that all operations are in alignment with each other.

Each container terminal has its own specific layout, concept of container handling, and its own equipment.

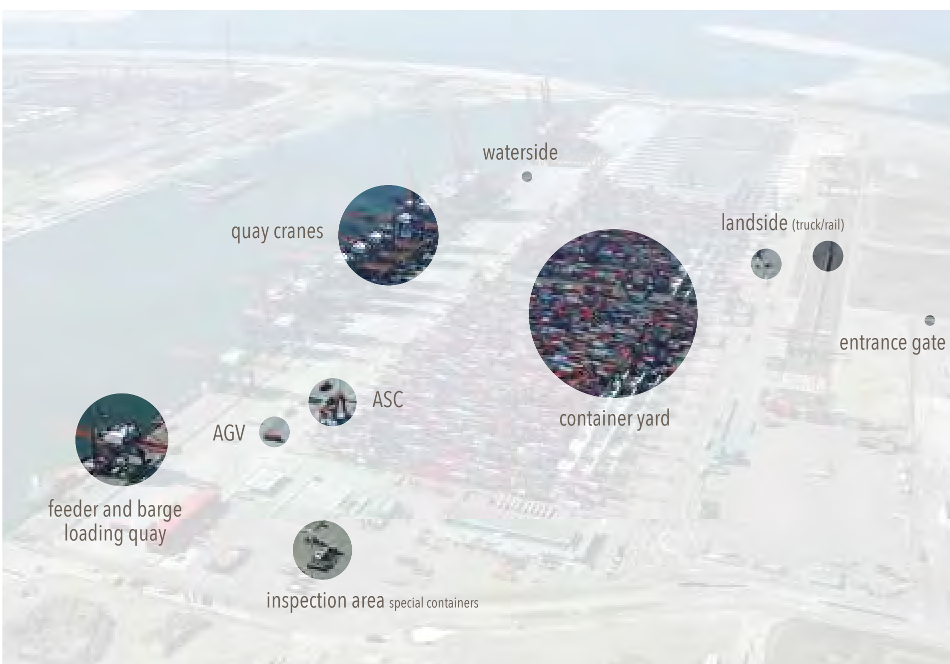
In general, the layout of a container terminal serving as a transhipment hub is different from that of a typical gateway terminal. A transhipment terminal will have maximised the container storage, as containers may have to stay at the terminal for a longer period of time. The landside operation on the other hand will be minimal, as only a few containers will have an inland destination. For example, the Malta-based container hub Malta Freeport will only handle a few import and export containers destined for the island itself. The vast majority of the containers arriving at the port are destined for transhipment onto other vessels.

A gateway terminal will focus on having an efficient landside operation. The purpose of the terminal is to serve more than one transport mode, and to have an efficient internal transport system to shuttle containers between the container stacks and the landside operation. Nevertheless, the general layout will be more or less the same at each location.

A marine container terminal can generally be divided into three areas:

1 The 'waterside area' with quay wall, apron and cranes to load and discharge ships and barges.

  Most modern containerships are gearless. The loading and discharge of containers are carried out at large terminals with specialised gantry cranes. These cranes can traverse the length of the quay on a rail track. Between the rail track and the quay wall may be a road used by terminal personnel and visitors to gain access to vessels. This road may also be located behind the gantry crane. The trolley of the container gantry crane is passing over this road. At the landside, the containers are picked up/landed in a section of the container yard where vehicles drive between the container cranes and the container storage yard.



2 The 'storage area' or 'container yard' where the containers are stored temporarily and which links the water- and landside operation.

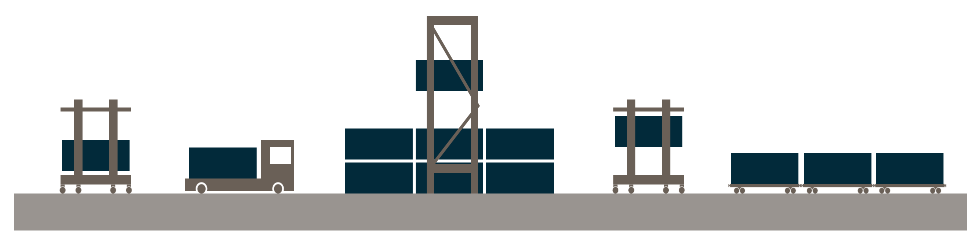
The container yard is located at the centre of the terminal and occupies most of the space at the terminal. A storage capacity of 30,000 to 40,000 containers is not uncommon.

Containers may be stacked ashore in blocks or lanes. 'Block storage' is used in conjunction with yard cranes. Each position in each block is identified by its bay, row (lane) and tier position. 'Lane storage' is used where straddle carriers are used to store the containers in the yard.

The stacking height for block or lane stowage varies with the lifting capacity of the yard's cranes or straddle carriers. Straddle carriers and yard cranes usually lift to a maximum of four tiers high. The highest storage density can be achieved using yard cranes with approximately 1,100 TEU per hectare as opposed to approximately 750 TEU per hectare for straddle carriers. In some locations with a high storage density, e.g. Hong Kong, bay racks are used where containers can be stowed up to 12 tiers high.

A less common system is 'storage on trailer chassis' which is particularly popular in the United States. This system requires a significant storage area and is therefore only found at terminals with limited container throughput.

When containers are stacked in the yard not every container is readily available to be picked up by the yard equipment. Where the container at the base of the stack is needed, the containers stowed on top must be removed first. This involves unproductive moves (reshuffles) in the yard. The terminal obviously wishes to keep the number of reshuffles to a minimum and this places certain demands on the storage strategy, the type of equipment in the yard and, most importantly, the decision whether or not to automate the storage system.



Lane storage involving straddle carriers

3 The 'landside area', where containers are delivered or leave the terminal by road, rail or barge.

The landside operation is where the terminal interacts with the connections towards the hinterland. At the end of the container stacking area, straddle carriers or yard cranes load containers onto chassis or railway carriages. Barges are loaded further away from the stacking area. This may also be the case for dedicated rail centres. Special vehicles, such as 'multi-trailer units', are used to shuttle between the container stacking area and the rail / barge loading areas.

US: Container storage on chassis

4.5 Terminal equipment

Handling systems found in container terminals include a quayside handling system for loading and discharge of vessels and barges, a transport system, and a storage yard system.

Each terminal will use its own type of equipment based on differences in operation, size and construction of the terminal. Furthermore, the systems will differ between terminals due to their different manufacturers.

This section therefore provides a general overview of the equipment used at container terminals. A general distinction can be made between terminals which are automated and terminals where all (or part of the) equipment is operated by drivers. The areas of the terminal which lends themselves most to automation is the stacking area, the transport between the stacking area and the quay cranes, and the transport between the stacking area and the loading platforms for trucks and rail transport. A few terminals operate with remotely operated gantry cranes for loading and discharge of vessels.

The benefits of automation are reduced labour costs, reduced emissions and, most importantly, a more consistent performance of the terminal as a whole. Shipping lines operate a scheduled service, and they are best served by a reliable and consistent performance of the terminal in the loading and discharge of their vessels. Automation, however, completely changes the operation and data processing at the container terminal and requires very significant investment.

Gantry or ship to shore crane

Quay cranes

Different terms are used for quay cranes at container terminals. The most commonly used term is 'ship-to-shore (STS) crane', although the term 'gantry crane' is more common. In the United States, the term 'portal crane', or more commonly 'portainer' is used. This was the trademark of the very first container cranes built by Paceco Inc. in 1959 but has since that time become the generic term used for this type of cranes. In this book, quay crane denotes a rail mounted crane consisting of a supporting framework with a container spreader device that can traverse the length of a quay, and which is known in the industry as a 'gantry crane'.

It should be noted that some terminals also use multi-purpose, mobile harbour cranes, which can be fitted with a container spreader. These cranes, however, have limited capacity in terms of reach (usually they can serve ships up to 13 containers wide) and are slower than gantry type quay cranes. In view of their limited use at modern container terminals, this type of crane will not be further considered here. Gantry type quay cranes move on rails running parallel to the quay wall. The positioning on a rail system means that quay cranes cannot pass each other and the sequential order of the quay crane positions along the quay wall cannot, therefore, be changed.

The crane driver is located in a cabin just above the spreader. From his position in the cabin, the driver controls all movements of the crane and spreader.

The loading/unloading mechanism of a gantry type quay crane is a trolley which runs over the boom of the crane. In its backreach position, the trolley hangs above the storage area at the container yard. In the outreach position, the trolley hangs above the vessel. The part of the container crane which hangs above the water is hinged and can be moved into a vertical position to clear the area for navigation.

The driver's cabin is located in the trolley itself which is equipped with a steel wire operated container spreader to lift/lower the containers. The spreader is fitted with a standardised twistlock mechanism which locks into the four upper corner castings of the container to be lifted. Telescopic beams in the spreader allow easy adjustment from a 20 foot container length to 40/45 foot container lengths.

From his position in the cabin, the driver has to lower the spreader on top of the container to be lifted. Flipper arms are fitted at each corner of the spreader to help position the spreader onto the container. Once the spreader is fully lowered in the correct position, the spreader's locking devices engage and the container can be lifted. To ensure proper connection at each

Gantry crane driver cabin

Container spreader with flipper arms

corner of the container, sensors are fitted in the spreader allowing the locking device to engage only if the spreader is resting on the container. A signal in the cabin tells the driver when all four locking devices are engaged. Similarly, sensors, both on the spreader and in the driver's cabin, prevent the lifting of 2 x 20 foot containers in a 40 foot spreader.

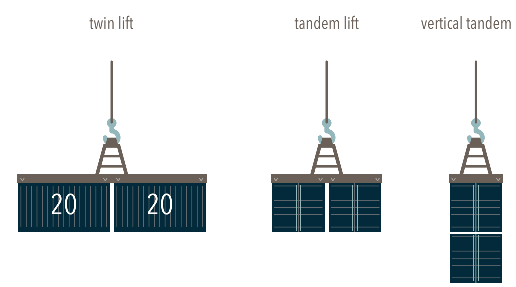
Twin lift

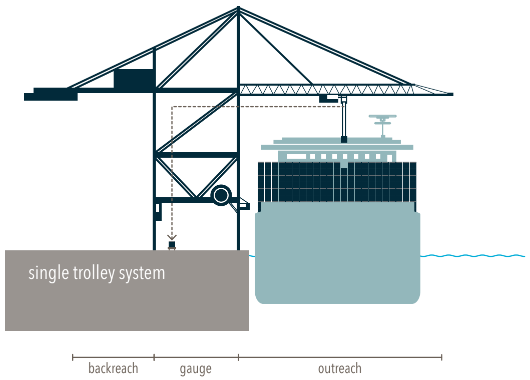
Tandem lift

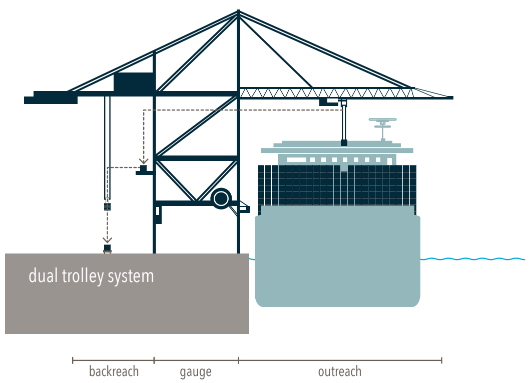
Crane and spreader devices are now available which allow containers to be lifted in horizontal tandem, vertical tandem or twin lift arrangement.

Conventional container gantry cranes have a single hoist with a single spreader lifting a single 20 foot, 40 foot or 45 foot container.

A special spreader can be fitted which allows 2 x 20 foot containers to be lifted at one time. This way of lifting, whereby 2 x 20 foot are lifted end-to-end in a 40 foot spreader, is referred to as a 'twin lift'. A 'tandem lift' is the lifting of two (or three) containers side by side. There are two systems for tandem lifts; a single hoist system with one set of falls connected to a special single headblock with two (or three) spreaders, or two main hoists each operating a single spreader, and working in parallel on the same trolley. A 'vertical tandem lift' (or in port jargon 'Piggy backing') is the lifting of two containers locked one above the other in one operation. The safety of this operation very much depends on the integrity of the devices locking the containers together and is not allowed in every port in the world.







Gantry cranes can be divided into 'single' and 'dual trolley cranes'. A single trolley crane transports the container in one move from its stowage position on board to the quay or onto a terminal vehicle. A dual trolley gantry crane consists of a main trolley which moves the container from the vessel onto a platform. From there, a second trolley moves the container onto the quay.

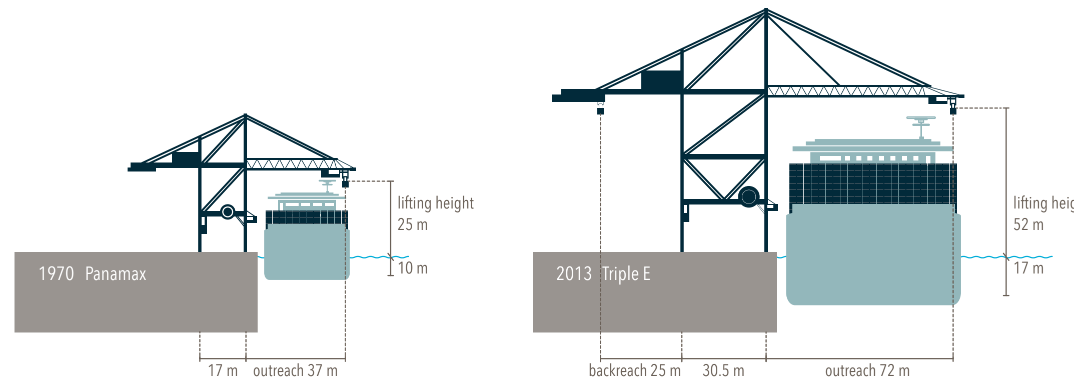
Modern container gantry cranes must not only be capable of handling the largest vessels (see insert), the increased volume of container traffic also demands quicker transfers to and from the ships. Modern gantry cranes are therefore equipped with many features to improve efficiency, such as:

» Precision vehicle positioning (to align vehicles on the quay in an optimal position for loading or unloading)
» Cameras for better visibility and remote control
» Pendulum motion control to eliminate the effects of wind and container inbalance
» Automatic container landing systems, for precise motion control of the container during landing on the terminal vehicle
» Automatic track control. The spreader follows set paths along the trolley to automatically position the spreader above the container stacks. The driver takes over during the last few metres before the spreader is lowered onto the container or into the cell guides.

Some recently built container terminals, such as APM and Rotterdam World Gateway (RWG) at Maasvlakte 2 and the Dubai-based Jebil Ali T3 terminal, deploy container gantry cranes which are no longer operated by crane drivers located in the cabin, but are instead remotely controlled by an operator in the terminal building. Crane manufacturers have developed a range of concept designs which can increase the crane's rate of handling containers.

Bigger ships call for bigger and smarter cranes

Increasing the capacity of containerships has not only been a challenge for naval architects and classification societies. Crane manufacturers have had to keep pace with these developments as well. The increased container capacity of ships was mainly achieved by increasing the width of the vessel and the stacking height of the containers stowed on deck. Consequently, lifting height and outreach of the gantry beam had to become larger as well. In addition, heavier and larger cranes also impose increased requirements on the strength of the quay wall.



Transport equipment at the terminal

Once the container has been unloaded from the vessel, it needs to be taken to the container stacking area, where it will remain for a certain period of time. The vehicles used for the transport from the quay to the yard fall into two categories.

The first group comprises vehicles which provide horizontal transport only, and which do not have lifting capacity. These vehicles can be either (multi-)trucks with a container chassis operated by truck drivers, or unmanned automatic guided vehicles (AGV).

AGV

AGVs are robotic vehicles that drive along predefined loop-type paths with transponders in the ground. These vehicles can either be operated by a diesel motor or can be electric or both, i.e. a hybrid. The vehicles have a loading capacity of 60 to 70 tonnes, and are capable of carrying one 40 foot, one 45 foot, or two 20 foot containers. Some AGVs have a liftable platform, enabling the vehicle to lift and place containers independently on transfer racks in the interchange zone in front of the yard-stacking cranes.

The road at the terminal used by the AGVs is divided into a small grid. Before an AGV can enter that grid, it has to be allocated the path so that no other AGV can drive in the same area at the same time. This way, collisions between AGVs within the network are avoided. In addition, sensors are fitted at the front and the back of an AGV, which immediately switch off the engine if the AGV hits, or is hit by, another object. An overview of all the AGV movements can be seen on the screen in front of the quay operator located in the terminal building. As soon as an AGV fails, it can be remotely steered to a separate area where technicians can locate and repair the fault. If the engine fails on an AGV, a truck can be connected to the AGV to pull it to the inspection area. Experience from operating automated terminals has shown that for the optimum operation of the terminal, at least eight AGVs should be connected to one quay crane. Therefore, a terminal operation with six quay cranes should deploy some 50 AGVs.

The second category is the 'straddle carrier system', also called a 'shuttle carrier' or 'van carrier'. The vehicle consists of a metal frame with a telescopic spreader suspended within the frame. The vehicle usually drives on four wheels located either side of the frame. The frame itself is in the shape of an upside down U, which allows the carrier to drive over the container and to lift the container between the frame legs, up to three or four container tiers high. This allows the straddle carrier to pick up the container from the quay or truck chassis and

Straddle carrier

to place it directly into the container yard, or vice versa. Straddle carriers are mostly operated by a driver located in a cabin at the top of the frame. The work orders for the carrier drivers appear on a screen in the cabin in a sequential order. Once a work order has been accepted by the driver, it disappears from the top of the list and a new order heads the list. In 2005, the Patrick Autostrad Terminal in Brisbane, Australia, became the first terminal with a completely automated straddle carrier system. The terminal had opted for the straddle carrier system instead of the AGV system to ensure a consistent container throughput, as they were of the view that the AVG system was less flexible and more at risk of failure.

Terminal storage equipment

The simplest form of container storage is 'storage on chassis'. This system is particularly popular in the United States. The typical yard chassis consists of a simple steel frame with guides to allow easy and correct positioning of the container on the chassis. In its parked position, the chassis is resting on support legs. The chassis is often referred to as a 'MAFI trailer', which has become a generic term but which was

originally the name of one of the terminal chassis manufacturers.

Mafi

Special yard tractors are used to shuttle the containers and chassis from their parking position on the terminal to the gantry cranes.

For transport on public roads, the trailers must have additional features such as a twistlock system to lock the container to the chassis.

The terminal equipment used to stack containers can be divided into three different groups:

» Reach stackers, container lift trucks and forklift trucks
» Straddle carriers (see previous Chapter)
» Yard cranes

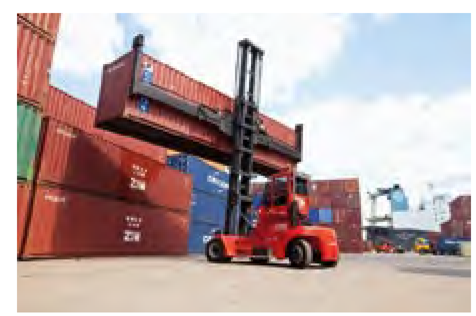
Reach stackers, fork lift trucks and container lifting trucks are all rubber-tyred vehicles powered by a diesel engine or a hybrid diesel-electric engine and used to lift fully loaded containers. The vehicles differ from each other in the way they lift the containers and the stacking height capacity.

Forklift trucks lift containers by inserting the prongs into the forklift pockets in the container's base frame.

Reach stackers (top pickers) have a telescopic arm with a spreader device attached to the top of the arm which lifts the container using the top corner castings. Reach stackers are capable of stacking containers up to five tiers high.

Forklift truck

Reach stacker



Container lift truck

Container lift trucks (side pickers) can only lift containers vertically. For that purpose, the trucks have a telescopic lifting frame in front of the vehicle. The containers are lifted through the side apertures of the top corner castings. These trucks are particularly popular at empty container deports where containers need to be stacked 6-8 tiers high.

All the above types of container stacking equipment are used mainly in smaller ports, container logistic sites or container depots. They are very flexible and can be used for both transport and stacking. Reach stackers are also used to load and discharge barges.

Larger container terminals, however, prefer to use another type of equipment for container storage, namely 'yard cranes'. Firstly, more containers can be stowed within a given area when using yard cranes. The yard crane system is also much safer as there is less traffic in the storage area. Furthermore, yard cranes lend themselves to a high degree of automation which is particularly important in countries where labour is expensive.

Rubber tired gantry

A yard crane consists of a steel portal frame, a trolley and a spreader. The crane drives on either rubber tyres (RTG – rubber tired gantry) or moves on a rail system (RMG – rail mounted gantry).

Automated container handling in the storage yard

During the last 25 years, improved sensor and navigation technology has made it possible to operate automatically container handling equipment, using very sophisticated computer controls systems. The first type of automated container handling equipment was the rail mounted gantry cranes, now commonly known as 'Automatic Stacking Cranes' (ASC). The first ASC, together with unmanned AGVs, were installed at ECT's Delta Terminal in Rotterdam in 1993. In 2002, HHLA's CTA terminal in Hamburg implemented a similar technology. Since its first introduction in 1993, some 30 terminals have introduced ASCs and their use have become the norm at new large container terminals in Europe, Asia and America.

The latest ASC designs can stack up to five containers high (with one container passing)

Automatic Rail Mounted Gantry (ARMG), or: Automated Stacking Cranes (ASC)

and span eight to twelve containers wide. The container block can be several hundred metres long and can be served by one or more ASCs. Where there are multiple ASCs in one container block, the ASCs can all be of the same height, in which case they cannot pass each other, or can be of different heights, in which case they can pass below each other. This latter configuration can be found at the CTA and CTB terminals in Hamburg.

There are two different layouts used in the construction of storage yards operated by ASCs; the 'end-loading' and the 'side-loading system'.

The end-loading ASC yard (E-ASC) has container blocks perpendicular to the quay. This system is particularly seen in automated terminals in Europe, e.g. Rotterdam, Hamburg, Algeciras and Antwerp. Containers are only handled at the two ends of the storage block; one end serving the waterside (usually by trucks, AGVs or straddle carriers). The other end serves the landside for loading container onto trucks, railway carriages or multi-trailer systems. There is no traffic in the yard when using the end-loading system.

The side-loading system has the container blocks positioned parallel to the quay. This system is mainly favoured in Asia. The ASCs in the side-loading system are cantilevered (C-ASC). Trucks drive into the container stacking area in a side-loading system, through lanes running parallel to the container blocks. ASCs pick up the

ASCs in end loading system

containers from the trucks. The end-loading system is considered less flexible in its ability to handle peak loads at either the land or waterside end and for this reason many terminals opt for the side-loading system. A combination of the end and side-loading system is in use at Thamesport, UK.

ASCs receive their work orders directly from the terminal operation system. These work orders come in batches which means those responsible for terminal planning can prepare each batch based on the latest real-time information received and any future information can be included in subsequent batches.

The sequence of stowing and stacking containers in the yard is a highly computerised process, whereby the operation system continuously looks for optimisation. In container storage terms, optimisation means the smallest amount of reshuffles (or shifters) during the loading of the vessel. Since trucks do arrive at the terminal in an entirely random order which will be different to the sequence in which the containers are to be loaded on board the vessel, the ASCs will carry out reshuffles during periods of less activity.

The container storage will now have been prepared in such a way that only a small number of reshuffles will be necessary during the loading operations of a vessel.

ASCs must be equipped with advanced observation (CCTV), positioning (transponders, laser, infrared) and communication systems to automatically report the status of the crane and any possible technical failures of the machinery.

Container terminal equipment, for those who like abbreviations

A wide variety of container handling equipment is available, each type with its own abbreviation. Each type of equipment has a unique functionality and may be used together with complimentary equipment within the same system. Below is a list of the most commonly used abbreviations:

AGV	Automated Guided Vehicle. Robotic vehicles that drive between the gantry cranes and the stacking area and are controlled by a network of electric wires or transponders in the ground
ALV	Automated Lifting Vehicle, an AGV that can both load and unload
ASC	Automatic Stacking Crane
TTU	Terminal Tractor with Trailer Unit
MTU	Multi Trailer Unit (terminal tractor with several trailers) also known as 'MTS - Multi Trailer System'
RTG	Rubber-Tyred Gantry crane (mostly used in conjunction with straddle carriers)
ARTG	An automated RTG
RMG	Rail Mounted Gantry crane
ARMG	An automated RMG (also referred to as an 'ASC')
OHB	Overhead Bridge Crane
SC	Straddle Carrier
ShC	Shuttle carrier
STS crane	Ship to Shore crane (usually a gantry crane)
ECH	Empty Container Handler (front loaders capable of up to 9-high stacking ashore)

4.6 Planning and operations

Different container terminals have different processes and procedures in place for the planning and execution of their operations.

These differences may depend on the type of equipment used at the terminal, but the differences can also be of an historic and/or cultural nature. For example, terminals located in high cost countries will move more quickly towards automation.

An example of this, is as already mentioned, the fact that Asian countries favour the side-loading system in a storage yard whereas European yards favour the end-loading system.

Container terminal operations are very complex compared with many other similar operations due to the high level of uncertainty at almost every stage of the planning operation. These uncertainties are inherent in shipping, but also in transport in general. Vessels may be delayed because of bad weather or operational delays in a previous port. At the terminal, during the execution of an operation, technical equipment can suddenly fail and this can lead to rescheduling of the operations. The terminal can suffer congestion during peak times because of conflicts between terminal operations and, as a result, the performance of a quay crane may be less than initially planned. If this is the case, the terminal will have to reschedule its operations in order to meet the vessel's planned departure time.

All these uncertainties mean that container terminal operations are very dynamic processes where plans continuously need to be rescheduled and decisions need to be taken to adjust to the actual real-time situation.

The terminal operation system (TOS) is the beating heart of a modern container terminal and is designed to quickly deal with any real-time changes. The TOS is a software package offered by a dozen different manufacturers to the market in many different versions, and capable of adding software modules covering various other operations. It is important that plans and messages are interchangeable and can be read by every computer system at the terminal to achieve efficient operation and to communicate efficiently with other parties in the transport chain.

Apart from internal communication, container terminal operators conduct a high volume of communication with a wide range of external parties such as shipping lines, local agents, freight forwarders, trucking,

UN / EDIFACT

In shipping, as in many other sectors of industry, documents and data are exchanged electronically between different companies, in accordance with internationally agreed standards.

By definition, Electronic Data Interchange (EDI) is the transfer of structured data, by agreed message standards, from one computer system to another without human intervention. The files carry the extension .edi after the message description. There are several EDI standards although the standard recommended by the United Nations UN / EDIFACT (Electronic Data Interchange for Administration, Commerce and Administration) is the only international standard. All EDIFACT messages are based on the ISO standard 9735, which was adopted in 1988. Accordingly, all computers used in a shipping environment and have been installed to deal with electronic data exchange, should support EDIFACT-type messages.

The following are the most frequently used EDIFACT messages in communication with container terminals:

BAPLIE (Bayplan / stowage plan Occupied And Empty Locations message).
Bayplan message from the terminal to the ship operator, to the ship and, if required, to the next terminal

COPARN (COntainer Pre-ARrival Notice)
Container announcement message (loaded or empty) from the carrier to the terminal

COPRAR (COntainer PRe-ARrival) message
The loading and / or discharge instruction from the carrier to the terminal

COARRI (COntainer ARRIval) message
Loading / discharge report from the terminal to the carrier

MOVINS Stowage instruction from the ship operator to the terminal

COREOR (COntainer REelease ORder)
Container release message for full and empty containers from the carrier to the terminal

CODECO (COntainer DEparture COnfirmation)
Gate in / gate out movements from the terminal to the carrier

rail and barge operators, customs etc. To achieve uniformity and efficiency, all parties use the UN internal standard for electronic communication, called 'EDIFACT'. (Electronic Data Interchange For Administration, Commerce and Transport). These messages are recognised by the file extension .edi. (see also above).

This chapter will now deal with the following two processes which are important to every marine container terminal:

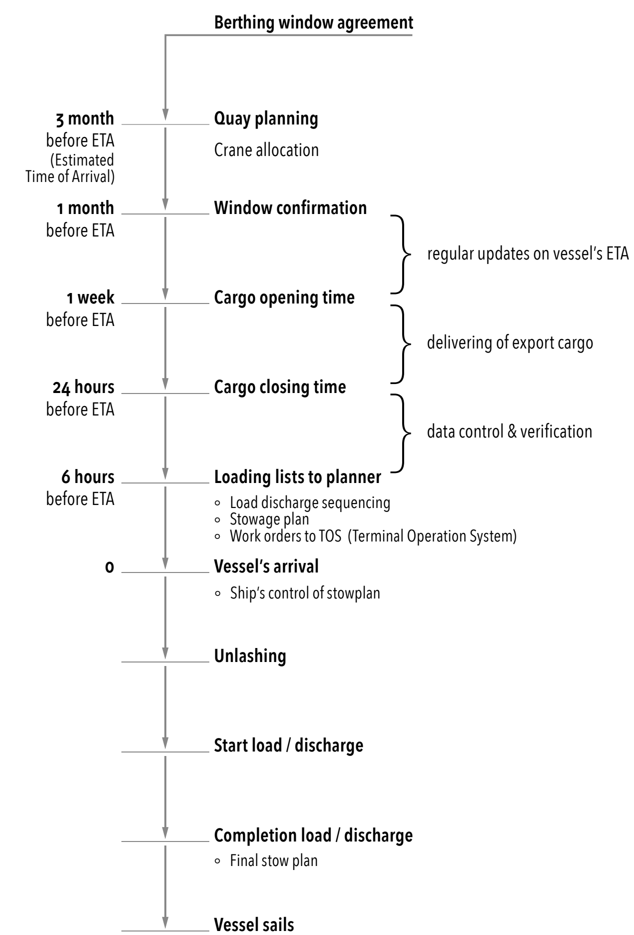
» the ship planning process – berth allocation, crane and resource planning
» the preparation of the container stowage plan.

These processes are outlined as they would be at typically large container terminals in north-west Europe. The container yards at the terminals in question are fully automated as well as the transport between the container yard and the quay cranes. The annual throughput ranges between 2 and 4 million TEU and there is a full range of intermodal connections to inland Europe. The planning departments operate a 24 / 7 service in five work shifts. Where time frames are mentioned, these will be applicable to these particular terminals only and may be different at any other terminal.

Ship planning – berth allocation, crane and resource planning

This is the process which assigns vessels to a certain section of the quay wall, taking into account the vessel's dimensions, location of mooring points, expected service times, etc. It is the terminal's quay

Ships planning procedure (indicative)



planner, who is part of the terminal's resource planning department, who handles these planning issues and stays in contact with the shipping line and the vessel's local agent.

The allocation of a berth starts a long time before the expected arrival of the vessel. Nearer the date of the vessel's arrival, crane sequences and labour resources will be involved in the planning process as well.

We will now deal with the various stages of the ship planning process.

Berthing window agreement

Large container vessels operate regular schedules that are agreed a long time in advance. A typical liner service runs weekly schedules with berthing on a certain day each week. The weekly service can be provided by one single liner operator, or by a pool or alliance of operators. The latter being the most common arrangement today.

Long-term planning is important for liner operators to enable them to provide their customers with scheduling information well in advance and to contract with terminals at scheduled ports along the route. The contracts with the terminals provide the liner operator with a degree of guarantee that a berth will be available when the ship arrives. At the same time, the advance planning allows the terminal to plan the resources available (quay space, labour, and equipment) for a longer period of time.

The terminal service contracts entered into between the liner operator and the terminal state a predefined berthing window, as well as the length of time the liner operator is allowed to be delayed. A typical contract allows the vessel to arrive two to four hours late. Depending on the terminal's other berthing commitments, consideration may have to be given to rescheduling the vessel's berthing time if the vessel is delayed, or, alternatively, to skip the port call all together.

Timely arrival of the vessel is also important for the planning of the operations at the stacking yard. The terminal usually allocates mooring berths well before the first export containers arrive at the terminal. The terminal would ideally like to have as short a distance as possible between the containers at the yard and the vessel, and will therefore place the export containers as close as possible to the vessel's intended berth. If for one reason or another the ship arrives after the allotted time, she may have to divert to another berth. This will incur significant costs (and additional work) for the terminal as the containers will have to be moved over a longer distance to be loaded onto the vessel.

The ship's name is usually not mentioned in the berthing window clause contained in the terminal service contract; only the ship's dimensions and estimated call size, i.e. number of containers to be loaded and discharged.

The table below is an extract from a typical berthing window plan, agreed between the terminal and the liner operator.

Art. 1 Vessel's details / trade

trade	nominal capacity (TEU)	L.O.A. (metres)	maximum number of containers abeam	maximum draft	vessel operator	number of vessels operated
Alliance X	6,600	305	16	14.50	container line x	9

Art. 2 Berthing window plan

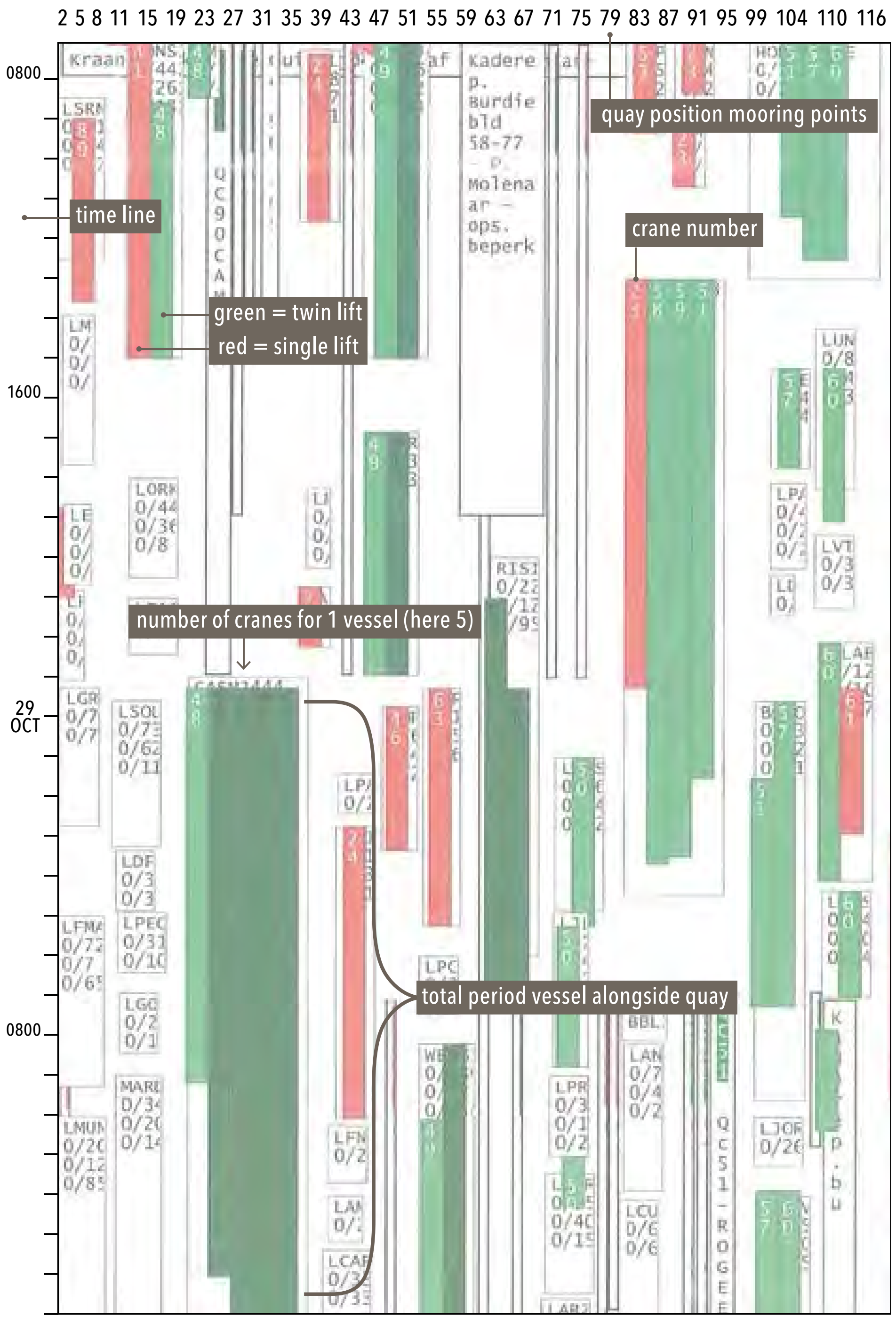
trade	call size (TEU)	contractual berthing window	dedicated berth
Alliance X	2,500 load / 2,500 discharge	Wednesday 22.00 – Friday 22.00 hrs.	alfa berth

Quay planning

Approximately three months before the expected arrival of the vessel, the quay planner books the intended quay position (length) and allocates a number of cranes to the vessel. Quay positions are indicated by the bollard positions. The decision on berth allocation takes into account the vessel's technical requirements and the technical restrictions at the intended berthing place, such as air draught, water draught, outreach of the crane, etc.

The service contract between the shipping line and the terminal also stipulates a berth production. This is the average number of containers per hour which the terminal has to handle during the vessel's stay at the terminal. A typical berth production for a large container vessel is 100 containers per hour. On the basis of this figure, the quay planner estimates the number of quay cranes that needs to be allocated to the vessel. For a crane productivity of 20 containers per hour, this would be 5 quay cranes. A section of the stacking area, and a number of ASCs, will be automatically connected to the berthing location.

Once the number of cranes that will be needed has been established, the quay planner will also know the expected length of stay of the vessel at the terminal. If, for example, the forecasted call-size is 5,000 containers, fifty hours need to be set aside in the quay planning system and allocated to the particular quay positions. At this stage, the vessel's name is not known; and the entire planning is made on forecasted numbers only.



Example of a quay/crane planning

Feeder vessels and barges are entered into the quay planning system shortly before arrival at the terminal. These vessels occupy less quay space and require less time allocated to them in the quay planning system and the planning surrounding them can be much more flexible than that for the large ocean carriers.

Window confirmation

Approximately one month before the vessel's expected date of arrival, the shipping line will inform the terminal whether the vessel is still within window. At this moment, the vessel will have started the ocean voyage to Europe and the terminal can be provided with the exact call-size. Based on this updated information, the terminal can adjust the quay and crane planning further. At this stage, the shipping line will also provide the ship's name. The terminal will ensure that all vessel details needed for the stowage planning are available to them. If this is the first time the vessel calls at the terminal, the shipping line will have to provide the details needed for the terminal to prepare its planning programmes.

In the weeks that follow, the shipping line sends regular updates to the terminal about the vessel's expected arrival time. If it is possible that the vessel will fail to meet its window, the terminal's resource planner will check to see if the plan can be altered.

Cargo opening time

Approximately one week before the vessel's expected date of arrival, the terminal will grant trucks access to deliver the export containers. The container gate system contains information on which section of the stacking area has been assigned to the vessel's berth and any incoming trucks will be directed to the correct area of the container yard to deliver the containers.

Cargo closing time, data control and 24-hour fine tuning

Export containers are allowed to enter the terminal, up until 24 hours before the vessel arrives. This is referred to as the 'cargo closing time' or 'cut-off time'. After that time, export containers can be accepted with the permission of the terminal planner who prepares the preliminary stowage plan. Immediately after the cargo closing time, the data control centre of the terminal will verify that all the booked containers have arrived at the terminal. They will also check that the information contained in the transport company's documentation matches the information in the loading lists received from the shipping line's local agent. Items such as size of the container, weight, IMO status etc., will be checked. If any discrepancy is found between the two documents, the data centre will contact the shipping line's local agent to obtain more accurate information. If any uncertainty remains, the general principle is that the terminal will take the information from the documentation of the transport company which delivered the container to the terminal. Experience has shown that this is usually the most accurate information.

The terminal's data control centre has approximately 18 hours to complete these checks. The final loading information must be sent to the vessel's terminal planner at least six hours before the arrival of the vessel.

The day before the vessel's arrival, the resource planner will book the labour gangs needed to operate the quay cranes. The foreman of the lashing gang will obtain information on how many containers need to be unlashed and lashed and will arrange the labour force accordingly. The harbour pilot and mooring gangs will be informed about the exact berthing position of the incoming vessel. The terminal is now ready to receive the vessel. The shipping line and/or its local agent will be informed of the final arrangements made.

Load/discharge planning – crane sequencing

The terminal's planning department assigns a vessel planner, usually referred to as the 'terminal planner', to the vessel, who will be in charge of preparing the preliminary stowage plan and the division of work across the gantry cranes and other related equipment. The terminal planner will remain the central point of contact for all planning activities during the vessel's entire stay at the terminal.

Based on the number of containers to be loaded or unloaded as well as the planned stowage positions of these containers on board the vessel, the terminal planner will divide the work across the respective quay cranes and related haulage equipment, the so-called 'crane sequencing' or 'crane split'.

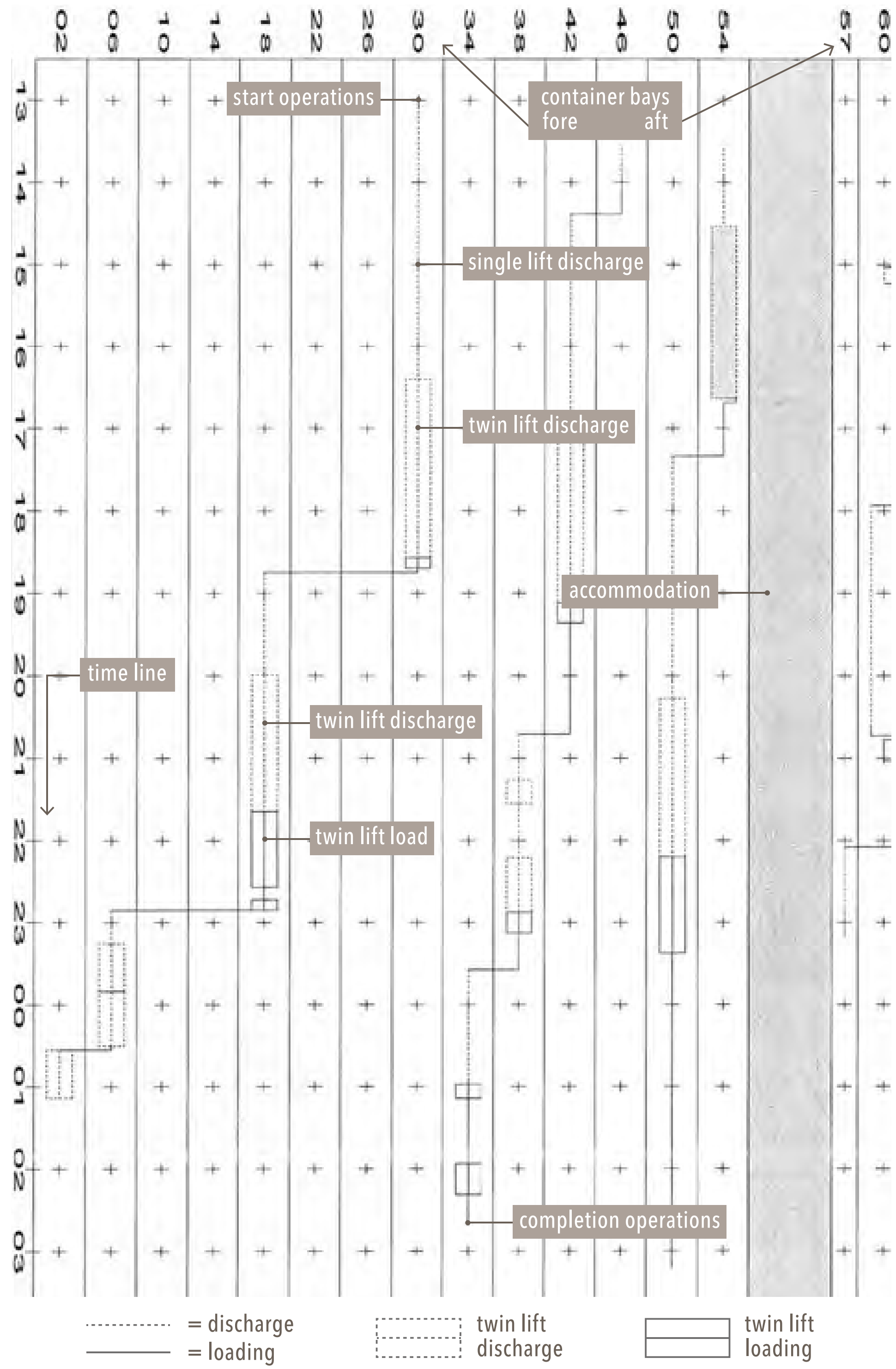
The crane sequence diagram shows the crane positions relative to the vessel and the length of time each crane works at a certain location on board the vessel.
The diagram is designed in such a way that, in an ideal world, all cranes complete their operations at exactly the same time. The crane diagram, in combination with the preliminary stowage plan, is translated into work orders for the ASCs and AGVs. These work orders are entered into the terminal's operating system (TOS) several hours before the vessel's arrival. This time is needed by the TOS to optimise and start the stacking sequence in the yard.

Once plans and schedules are ready for execution, the terminal's operations department will take over and will start monitoring and supervising their execution. This is done from the terminal building. The operator oversees the situation on board and on the quay using remotely operated cameras. There is direct radio contact between each crane and each crane works on a separate radio frequency to avoid interference between the cranes.

Preparation of the stowage plan

Container stowage planning can be described as the act of allocating positions to containers on board the vessel. For a number of reasons, accurate and correct stowage planning is vital, not only for the

Crane split diagram for container vessel to discharge and load containers (see right page)



efficiency of the operations at the terminal but particularly for the safety of the ship and crew.

The process of preparing the ship's stowage plan differs between liner operators. Some liner operators will have the final say over the stowage plan; others leave it entirely up to the terminal planner to prepare a plan.

At larger terminals the stowage plan is produced by computers based on general principles of good practice. These principles are part of the software used for the stowage planning. Stowage planning by the terminal has the major advantage that maximum optimisation can be achieved; i.e. a minimum of reshuffles in the yard and maximisation of the crane production. These factors have a positive effect on costs and the length of the vessel's stay in port.

In its simplest form, stowage planning is a two-step process. The first step is performed by the shipping line who prepares a very rough plan, the so-called 'pre-stow plan'. The central planner at the shipping line is responsible for this task. There is no reference to specific container numbers in the pre-stow plan, except for containers containing hazardous cargo and containers requiring a particular stowage position. The positions, or slots, for refrigerated containers are also indicated. The positions of the remaining containers are grouped by loading and discharge port without further reference to numbers, weight, etc.

The second step of stowage planning is executed by the terminal planner who assigns specific positions to each and every container to be loaded on board the vessel. This will result in a plan showing the exact position of every container on board and containing all the relevant details of each container.

In practice, however, stowage planning contains several more stages. It starts at the initial booking by the shipper and ends with the submission of the final approved plan to the Master of the vessel. The above outline and simple description of planning only applies when there is one shipping line and all cargo carried on board the vessel is booked by that particular shipping line. In reality, most container vessels operate in a pool or alliance with other shipowners.

The terminal's operations department

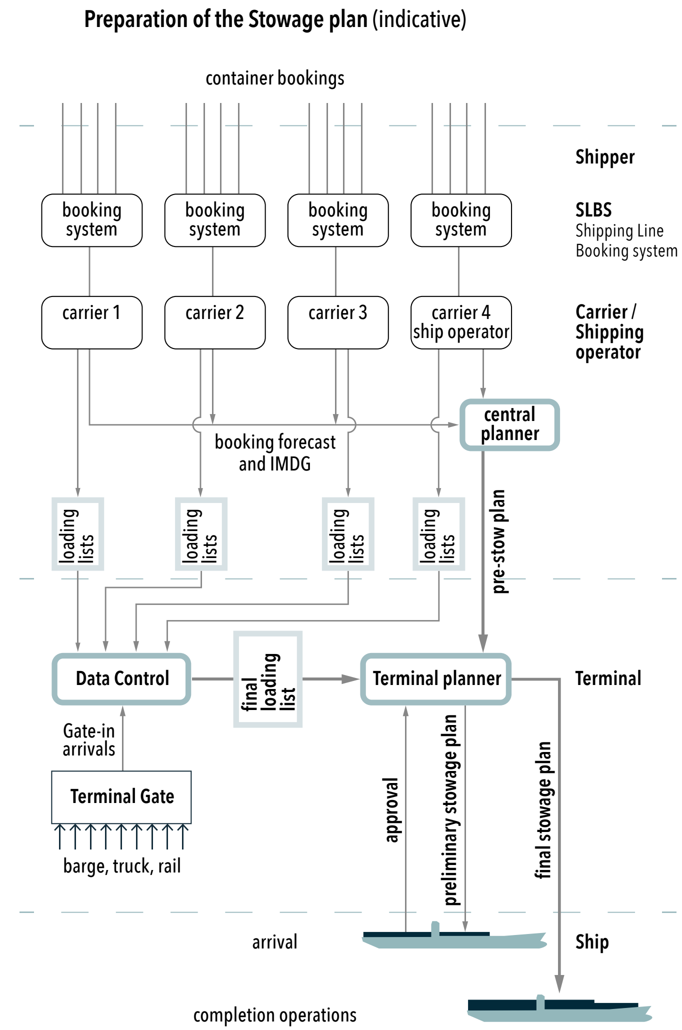


Chart showing the various stages in the stowage planning process for a vessel operating in a pool with four members

The principle of a shipping alliance is that different liner ship operators, who either own or charter the vessels, put a number of ships in a pool and that each operator is entitled to use a certain number of the container slots on every vessel. This way, each ship operator can offer their clients, for example, a weekly service and, at the same time, enjoy the benefits of scale when operating a large vessel instead of a smaller one. The liner operator who delivers the vessel in the pool provides the central planner; the others are referred to as 'partner lines' or 'slot charterers', and do not have a say in the stowage planning.

An additional complexity is the fact that, while the group of operators form a pool, they do not want to disclose sensitive commercial information to other members of the pool. As a result, the exchange of information between the pool members is kept to a minimum. Nevertheless, the terminal needs to obtain detailed information to organise their processes and to prepare a proper stowage plan. As a result, the flow of information follows different routes as described in the chart on page 146.

In the above example, the vessel in question operates in a pool with three other partners. An allocation of the container slots has been made in the pool agreement and each member is entitled to assign 25 per cent of the container slots to bookings under their own bill of lading. Pool member 4 is also the operator or owner of the vessel and therefore delivers the central planner to coordinate the port calls and stowage planning with the terminal.

The shipping line booking system (SLBS)

Every shipping line providing a container service has a booking system. The purpose of this system is to book cargo shipments and find the best route for each shipment to its final destination. The system requires input of data supplied by the shipper as well as information provided by the shipping line's agency.

Once completed, the following information is contained in the booking form:

» Port-of-load and discharge
» Pier-of-load and discharge
» Ready-date (date when the containers will be available for shipment)
» Ocean vessel name or call sign
» Ocean vessel voyage number
» Unique reference on booking level
» Unique reference for each container on container level
» Container ISO code or type size
» Container empty or full
» Container weight (only for full containers)
» Commodity (only for full containers)
» IMDG class (in case of hazardous cargo)
» Temperature settings (in case of refrigerated containers)
» Special stowage codes (e.g Out Of Gauge).

By using the booking system, the container line will know how many empty containers to release from its depot. By aggregating all the booking information, the shipping line will know how many containers are going to be shipped at each loading port.

A few days before the vessel's expected arrival date, the shipping line has to submit the booking forecast to the vessel's operator for the central planner to prepare the pre-stow plan. At this time, however, the complete booking information such as exact weight and quantity may not yet be available. The information received from the slot charterer may therefore not be entirely accurate until the terminal receives the final information from the trucking, rail or barge company delivering the container to the terminal.

The pre-stow plan

The central planner or planning centre has received the booking forecasts from all slot-charterers, including the booking information from their own agency, and will use the information to prepare the pre-stow plan. The purpose of the pre-stow plan is to ensure that all containers can be carried on board in a safe manner and that the cargo is loaded with a view to avoiding costly re-stows in future ports of call. The pre-stow plan will also provide some rough guidance to the terminal planner when the more detailed preliminary stow plan is prepared at a later stage.

The central planner will therefore work with known data – the containers already on board, as well as projected data which is the booking forecasts. The preparation of the stowage plan at the central planner's office will also require input on ship's stability, hull stress, draught, forward visibility, etc.

No specific container data has been entered in the plan yet. The only exception applies to containers with hazardous cargo. The stowage positions of these containers are fixed by the central planner and cannot be changed by the terminal planner, without the central planner's consent.

The central planner will subsequently transmit the completed pre-stow plan to the terminal to guide the planner at the terminal's office in the further planning of the stowage. This transmission will take place some 1-2 days prior to the vessel's arrival.

Loading lists

Prior to the terminal's cargo closing time, the local ship's agent of each slot charterer provides the terminal operator with a list of containers to be loaded and discharged, a so-called 'COPRAR message'.

In addition to the name of the ocean going vessel and the loading/discharge port, this message also lists the unique container identification numbers, weight and other references such as IMDG class or the required setting temperature.

The local agent also sends a message (COPARN) to the terminal, specifying the containers which will be delivered or picked up from the terminal and the mode of inland transportation used. This information will be checked against the information supplied by the various transport companies when they deliver their containers at the gate. The final checked loading lists will subsequently be transmitted to the terminal planner. In the meantime, the terminal will not take receipt of any further containers to be loaded.

Preliminary stowage plan

The preliminary stowage plan is compiled shortly before the vessel's arrival. Some six hours prior to the vessel's arrival is not uncommon. By this time, the terminal planner has received the inbound stowage plan from the previous port of call and the loading list of the containers to be loaded. The previously received pre-stow plan from the shipping line is also entered into the terminal planning system and serves as a rough work sheet for the planner.

The objective of the terminal planner is to prepare the most efficient preliminary stowage plan, taking into account the pre-stow plan, the limitations of the vessel, the general principles of stowage, the allocated resources (labour, cranes) and the way the containers are stacked in the yard and, at the same time, comply with the requirements by the central planner. During this part of the stowage planning, these general stowage principles are:

» minimise the number of reshuffles in the container yard
» no heavy over light stowage
» the maximum permissible stacking weight. This is the maximum weight the vessel's hatch covers are designed to carry and cannot be exceeded
» the positions of IMO and reefer containers are fixed.

The plan can be compiled manually, but is today mostly done by a computer programme. The following information will be contained in the stowage plan for each container position:

» container number
» carrier indication
» ISO size/type code (e.g. 2210,…)
» empty/full indication
» weight (gross weight)
» stowage position (Bay/Row/Tier)
» load port
» discharge port
» required transport temperature
» dangerous goods class (IMDG Code).

Approval of the preliminary plan by the vessel's staff

The preliminary plan, in BAPLIE format, will be sent back to the central planner and to the vessel for approval, prior to start of the operations.

The vessel is equipped with a loading computer capable of calculating the ship's trim, stability, shear force, bending and torsion moment. The computer will also check that the maximum permissible forces are not exceeded in the vessel's planned departure condition. The vessel's programme is also equipped with software to check that the requirements of the vessel's Cargo Securing Manual are met and that the prescribed limits are not exceeded in the vessel's planned departure condition. The computer programme can quickly upload the BAPLIE file in the system and will flag locations where forces may be exceeded. At this stage, the vessel's staff may have to instruct the terminal to change the stowage plan if this is the case. Once the plan is approved, the status of the stowage plan is final. Any changes to the plan after approval has been received, and which may result in different stowage forces will have to be agreed by the ship's staff and/or central planner in advance.

During loading and discharge operations, terminal staff will make a record of the containers which are loaded and discharged. This information will uploaded in the terminal operation system and a final version of the plan will subsequently be sent to the vessel and the central planner and will also be forwarded to the vessel's next port of call.

The cost of calling at a container terminal

Ships entering a port to load and unload cargo have to pay a range of costs which can broadly be split into the following categories:

» Port related costs (e.g. harbour costs)
» Navigation and mooring costs
» Stevedoring costs

Below is an example of the costs incurred by a 15,000 TEU container vessel calling at a terminal in north-west Europe to load 5,000 TEU and to discharge another 5,000 TEU.

The below list is an indication only and costs can vary considerably between different ports and terminals.

Port related costs		
Harbour costs	€ 65,000	
Compulsory waste fee	€ 875	
Navigation and mooring costs		
Pilotage (inward and outward)	€ 9,500	
Towage (inward and outward)	€ 4,800	(2 tugs)
Mooring gangs (2 x)	€ 8,800	
Stevedoring costs	€ 600,000	

Stevedoring costs include terminal handling charges and costs which are deemed part of the freight charges. Terminal handling charges are effectively charges which are incurred by the shipping line and which will be recovered from the shippers at the loading port and from the receivers at the discharge port. The basic principle is that all costs related to the handling of the container before it passes the ship's rail are terminal handling costs and that the costs incurred after the containers have passed the ship's rail are for the account of the shipping line and deemed incorporated in the freight charges. For example, the cost of lashing the containers and the vessel's planning are for the account of the shipping line. The costs related to the movement of the container at the yard and inspection of the container, are included in the terminal handling charges. Terminal handling charges also include a number of days with free storage after which a 'demurrage fee' is charged.

Chapter 5

Shipboard container operations

The basic function of a merchant cargo vessel is to transport goods from one place to another, and to deliver the cargo in the same condition as when it was loaded. While containerisation has changed every aspect of the transport of goods, this basic function has not changed. However, the method and equipment used to accomplish this are very different due to containerisation.

Throughout the evolution of containerisation, one common denominator has driven change; the need to make shipping more efficient and to reduce the overall cost of transport.

Prior to containerisation, the ocean voyage was an enterprise in itself. The Master of the vessel, being in full control of all cargo handling on board, knew exactly what cargo was on board, where it was loaded, and how it would be discharged. Once the ship had left port, the Master had to rely on his navigational skills, knowledge of the sea and weather to steer the ship safely to its destination. In addition to being specialists in ship handling and navigation, the ship's officers also had to possess detailed knowledge of the nature of the commodity carried and how to handle it in port and care for it during the voyage.

The role of the crew in the handling of cargo has developed towards a situation whereby virtually all co-ordination of loading, discharge and stowage is the responsibility of the central planner and the terminal. The ocean voyage is no longer a self-contained journey but is just a link, albeit an important one, in the entire supply chain. Except for containers with hazardous substances and refrigerated containers, the crew on a modern containership has little or no knowledge of the cargo contained in the boxes on board. Their role is mainly focussed on taking the vessel safely from one port to another and to maintain the vessel's tight sailing schedule.

At the same time, the crew's responsibility in terms of the volume and value of the cargo being carried has evolved tremendously. Today, the Master of a very large container vessel can be responsible for assets in excess of USD 1 billion; reason enough to take a closer look at the vessel itself, the container operations on board and the risks involved.

We will look at the following aspects of container transport in this chapter:

- The construction and layout of a modern container vessel
- Owners and operators
- Registration and classification
- Strength loads acting on containerships
- Navigation and ship handling
- Stowage
- Determination of forces
- Lashing and securing
- Major containership incidents.

5.1
The construction and layout of a modern container vessel

Containers can be carried on two types of ships:

» **Ships designed exclusively for the carriage of containers. These ships belong to the category 'containerships' and may again be divided into ships with hatch covers or hatchless ships, and ships with on-deck container handling equipment, e.g. cranes, or gearless ships. The majority of containerships are gearless, dedicated containerships with hatch covers.**

» **Ships that carry containers as well as other types of cargo. The combined carriage may be in only some cargo holds and can be different from voyage to voyage. These ships are classified as 'suitable for the carriage of containers'. This vessel category includes Ro-Ro vessels (rolling stock and containers), conbulkers (bulk cargo and containers), multi-purpose vessels (general cargo and containers) and specialised refrigerated vessels.**

For both the above categories of ships the rules of the applicable Classification Society must be adhered to in order to ensure that the ship and its fittings meet design and test criteria to carry containers safely.

Below is a schematic overview explaining the basic layout of a containership.

1 Foc's'le
2 Bow thruster
3 20' bay
4 40' bay
5 Main deck
6 Hatch cover
7 Wheelhouse
8 Accommodation
9 Engine room
10 Rudder / propeller
11 Poop (winch) deck

Hapag Lloyd containership

Hull

The typical hull structure of a modern containership has large deck openings, a sharp bow with a significant flare and an almost rectangular shape further towards aft narrowing towards the aft transom.

The deck openings stretch across the entire breadth of the cargo holds. This construction is used to minimise obstruction of the hatchway during loading and discharge of containers under deck. To promote safety and to ensure that the necessary strength is achieved, ships are constructed with a double, U-formed, hull structure with heavy transverse constructions at intermediate distances between every 40 foot container. The double hull itself is divided into various watertight compartments used as water ballast or fuel oil storage tanks.

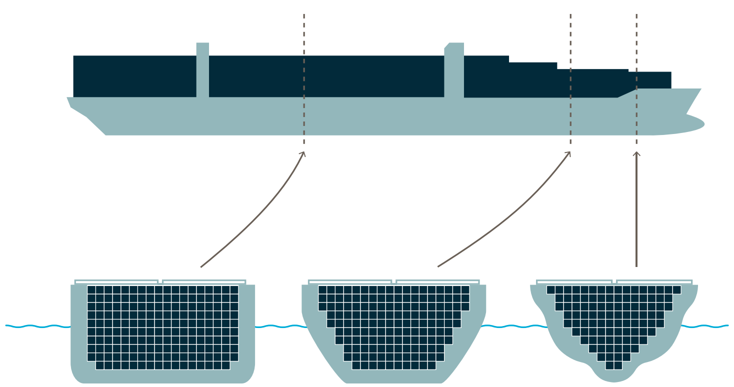
There is an internal passageway for access to the holds just below the main deck at either side of the ship running from fore to aft along the entire length of the ship.

Hull form of a modern container vessel

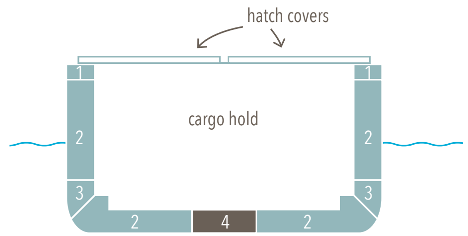
Cargo holds

Below deck, the vessel is divided into cargo holds separated by watertight transverse bulkheads. The holds are numbered from fore to aft; 1, 2, 3...

A typical design configuration has watertight bulkheads at every two 40 foot container bays with an open transverse frame construction in between. This layout divides the ship into a number of watertight compartments. The open frame construction also serves as a vertical passageway giving access to the containers, albeit from one side only.



Containership, cross sections



1 under deck passageway – access to holds
2 waterballast or fuel storage tank
3 void space or tank space
4 duct keel

Each cargo hold is connected to the ship's bilge (drainage) system to discharge rain and condensation water. The bilge system is also designed to cope with a certain amount of outboard leakage water, e.g. after a collision. Classification societies require increased pumping capacity for open-hatch containerships.

The ship, including the cargo holds, is fitted with various types of fire / smoke detection and fire-fighting equipments. These include fixed systems for extinguhising with water (possibly also automatic systems such as sprinklers) and smothering systems such as CO_2.

Ventilation of cargo holds can be done either naturally (air draft only) or mechanically (electric fans). Cargo holds certified to carry dangerous cargo under deck must have mechanical ventilation fans. Cargo holds designed to carry refrigerated containers can be equipped with additional ventilation fans. All the ventilation openings can be closed, for example, during a fire in the hold.

Deck / hatch covers

The cargo holds are covered by steel hatch covers. These are either hydraulically-operated folding hatch covers or steel lift-away pontoons, the latter being standard on cellular containerships. During cargo operations the hatch pontoons are lifted by shore cranes and stacked on top of each other on board the vessel or ashore. The undersides of the hatch pontoons are strengthened to carry the weight of the container stacks. Welded container foundations can be found at the four corners of each stack, e.g. for 20 foot and 40 foot stowage, where the weight of the container stack is transferred.

Container stanchions approximately 2.5 m high are fitted in line with the deck edge at the extremities of the deck. In this way, the deck stow covers the entire width of the vessel.

Containerships can also be built without hatch covers. These hatchless, or open-top, containerships have cell guides extending above the hatch openings. This design is particularly popular in the feeder and short sea shipping trade but has been abandoned in the ocean trade.

Mooring winches are located on the forward (foc's'le) and aft (poop) decks. The aft winch deck is usually over-stowed by containers resting on one tier high support bridges.

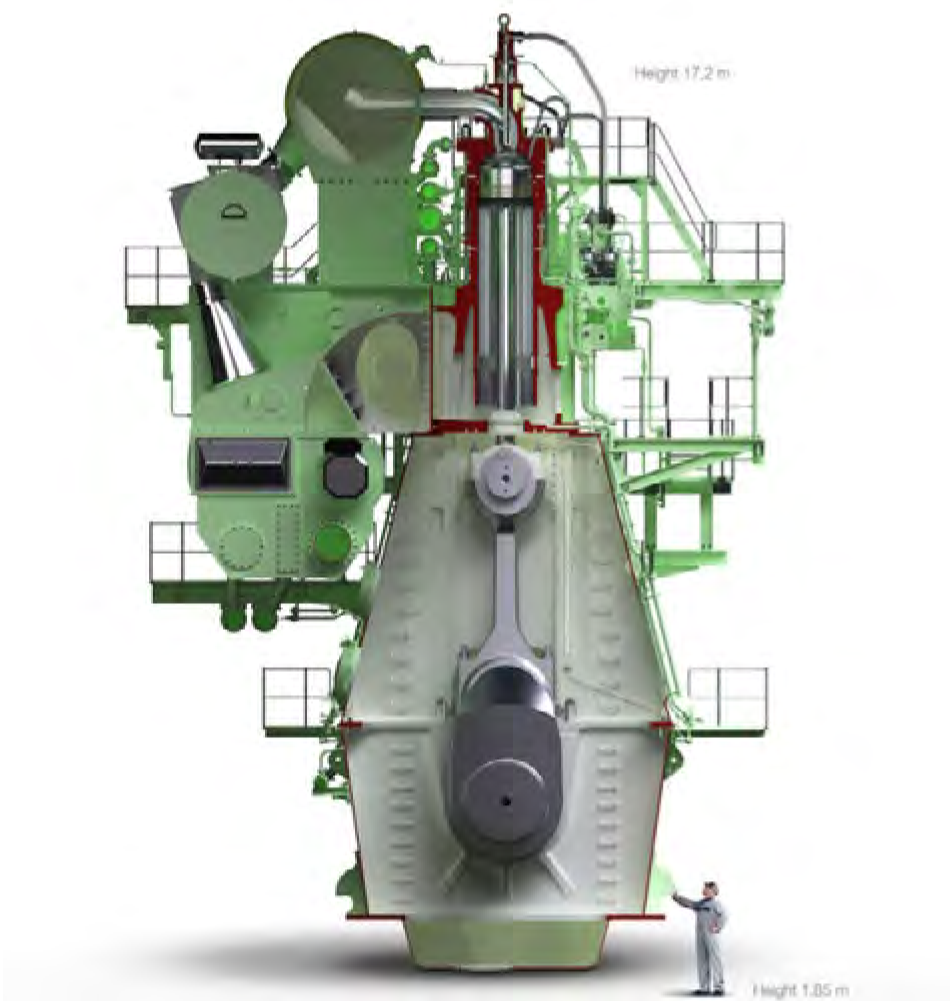
Engine room

The engine room contains the main engine and ancillary equipment such as pumps, generators, electrical switchboards etc.

The main engine drives the propeller via a shaft running through an enclosed space from the engine room towards the vessel's stern.

The propulsion engines on large containerships are two-stroke turbocharged low speed engines. These engines burn thick, heavy fuel oil which requires pre-heating, cleaning and filtering prior to being injected into the engine's cylinders.

The most powerful engine currently in service is the RT-flex96C from the Finnish manufacturer Wärtsilä. Its largest 14-cylinder version is 13.5 m high, 26.59 m



Source: MAN-B&W

long, weighs over 2,300 tonnes, and produces 80,080 kilowatts (107,390 horse power). This type of engine was, for instance, installed in 2006 on the Maersk E-class (EMMA, ELLY etc.) of vessels.

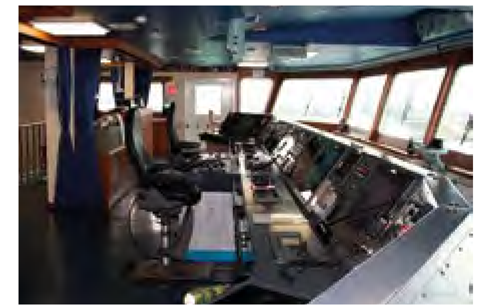
Another major engine manufacturer, MAN B&W, installed its 12S90ME-C Mark 9.2 engine on board the latest 19,000 TEU containership series purchased by China Shipping Container Lines (CSCL). This type of engine is 17.2 m high and has been de-rated to 56,800 kW to allow for a more efficient performance at lower speeds.

For the largest vessels in service, the above engines drive one single propeller measuring ten metres in diameter and weighing over 110 tonnes. Maersk's Triple E-class vessels are equipped with a custom designed 'twin-skeg' propulsion system with two 43,000 horse power engines each. Each engine drives a four-bladed propeller developing a service speed of 19 knots and a maximum speed of 23 knots.

In more recent years, the principle of slow steaming has been introduced in container shipping, driven by increasing fuel costs. Where, for example, the EMMA MAERSK would consume 150 tonnes of fuel per day for a service speed of 24 knots, this has been reduced to less than 100 tonnes a day for the triple E-class vessels, sailing at an average speed of 16 knots.

Accommodation

The accommodation houses the living quarters for the crew and the wheelhouse on top. The minimum number of crew (ratings and officers) on board is regulated by international conventions. This varies from 10 crew members on smaller container vessels, to a crew of 25 on larger vessels.



Bridge of a modern large container vessel

The crew consists of ratings and officers working either for the deck or engine department. A few shipping lines continue to use an integrated crew system, whereby the officers have dual qualifications and alternate between working in the engine room or navigating the vessel with working on deck. This system of integrated crew was introduced in 1980, but has been abandoned by most shipping lines.

Over the years, the location of the crew accommodation on board the vessels and its height above deck have undergone several changes. The demand for higher container stacking heights on deck made it necessary to increase the height of the accommodation superstructure. For example, the first generation of Panamax-sized container vessels built in the 1970's had three to four tiers of containers on deck. The latest generation of Panamax-sized container vessels have eight tiers of containers on deck.

Due to the development of containerships, the crew accommodation and engine room have moved forward. One of these developments was the size and the weight of the main engine on very large containerships requiring the engine to be positioned in that section of the vessel with more voluminous hull forms. At one point, e.g. the mid-island type Maersk E-class of vessels, the propeller shaft had to span a significant distance, up to 100 m, from the engine room towards the propeller. The moving of the engine room forward has introduced the need for a watertight door in the aft engine room bulkhead, which has to be kept closed at sea. Locating the crew accommodation further forward was also beneficial in view of the forward visibility requirements on ships as this would increase the number of containers that could be stowed on deck, aft of the accommodation.

The latest containership designs have separated the accommodation structure and the engine room. The accommodation together with the wheelhouse can be found approximately one-third from the ship's bow. The engine room and funnel are now located at two thirds from the bow. This concept is known as the 'two island design' and has further increased the vessels' on-deck stowage capacity. At the same time, the new design created space

Accommodation almost aft

Accommodation amidships

Two island configuration with accommodation at 1/3 from bow

under deck to construct heavy transverse frameworks to stiffen the vessel and make it less vulnerable to torsion stresses.

Bow and stern thrusters

Almost every vessel has a bow thruster, which is a transversal propulsion device built into the bow of the vessel. A similar type of thruster may also be built into the

stern of the vessel. The purpose of bow and stern thrusters is to improve the vessel's manoeuvrability in port. Large ships may have multiple bow and stern thrusters.

Gross tonnage and containership design: a topic of considerable discussion

For many years, there has been considerable discussion in the industry as to whether the definition of gross tonnage compromises the safe design of ships.

What is gross tonnage and what is the issue about?

Gross tonnage is a unit-less index related to a ship's overall internal volume. It was defined by the International Convention on Tonnage Measurement of Ships in 1969, adopted by the IMO in the same year and came into force in 1982. The purpose of the new definition was to arrive at a universal tonnage measurement system as the basis for determining ship manning regulations, safety rules, port dues etc.

Gross tonnage is calculated on the basis of the 'moulded volume of all enclosed spaces of the ship'. In practical terms, this is the volume enclosed by the ship's hull and main deck together with the volume of the accommodation. Gross tonnage is calculated by applying a multiplier to this volume.

It was argued that, in order to keep gross tonnage as low as possible, the ship designer was tempted to sacrifice a safe height of freeboard and to compensate for the loss of cargo space under deck by increasing the volume of containers stowed on deck.

A reduction in the vessel's freeboard reduces the angle of down-flooding, i.e. the angle at which the deck edge comes in the water, and may cause the vessel's stability to be compromised at low angles of heel, e.g. 12-15 degrees.

5.2

Owners and operators

Container carriers can be divided into

- Non-operating shipowners (NOO)
- Container shipping lines
- Non vessel owning common carriers (NVOCC).

Non-operating shipowners

Non-operating shipowners provide the market with ships which are chartered out to liner operators on a long term basis (e.g. five or ten years). This arrangement implies that the NOO takes responsibility for the vessel, its machinery, equipment, crew, navigation, stability etc. They are not carriers under a bill of lading and therefore have no direct responsibility under a carriage contract towards the shipper. A typical NOO does not own or lease containers.

The investment for the building of new ships may either be funded through corporate capital, external investors on the stock exchange (in case the company is publically listed) or funding by private investors and banks. Until 2008, the latter model was very successful and generated large sums of investment capital to build new containerships. The global economic crisis caused drop in demand for container space reducing the charter incomes. Meanwhile more (already ordered) containerships were being delivered from the shipyards in the Far East, causing an overcapacity in the market and a further drop of charter revenues. These developments have not gone unnoticed by many shipowners and several had to change their funding strategies.

Examples of major non-operating shipowners are: Seaspan Corporation (Singapore / Vancouver), Claus-Peter Offen (Hamburg), Blue Star Holding (Hamburg), Peter Dohle (Hamburg) and Costamare (Piraeus).

Container shipping lines

Container shipping lines offer scheduled services for container transport for which they own and / or charter containerships. They are seen as the parties who operate the vessel in a commercial manner, as opposed to managing the vessel on a technical basis in a role as shipowner, only.

There are many container shipping lines, the largest ones being Maersk Line (Copenhagen), Mediterranean Shipping Company (Geneva), CMA CGM (Marseille), Hapag-Lloyd (Hamburg) and Evergreen (Taiwan). Container shipping lines are either privately owned companies (e.g. MSC and CMA CGM), shareholder based (e.g. Hapag Lloyd) or a publically listed company (e.g. AP Moller / Maersk Line).

All container shipping lines have a strong maritime heritage and seafaring background by their initial founders. The history of some shipping lines go back over hundred years when operating as a steamship company whilst others have been founded just around the 1970's when container shipping was introduced into Europe. Quite remarkably, all of the container shipping lines who played a pioneering role in container shipping in North America (e.g. Sealand, Sea-Train etc.) no longer exist in their current capacity but have been merged with other companies. In that respect, there has been a real shift in emphasis on ownership of container shipping lines from the United States to Europe and, later, the Far East.

A further distinction can be made between container shipping companies being part of a large consortium with activities in other areas of business (e.g. AP Moller / Maersk, Evergreen) and shipping companies who have concentrated on shipping alone, either exclusively container shipping or also for instance in luxury cruises.

In general, it can be said that all of the ten largest container shipping companies operate globally whilst others are concentrated in certain geographic areas or particular trade lanes. Only a few container shipping lines are seen as specialised carriers of certain types of cargo such as the transport of refrigerated containers.

Collaboration arrangements between shipping lines

Container shipping lines may collaborate with one another in many different ways. The most common way is to share available container capacity on a certain liner trade by means of vessel sharing agreements, slot charter agreements, pool arrangements, etc. The reasons for collaboration are obvious: with a relatively limited number of ships, more frequent services covering a wider network can be offered, the ship's utilisation rates improve and slot costs can be reduced. Furthermore, the liner operators joining the agreement have a stronger bargaining position in negotiating arrangements with terminals.

Collaboration between shipping companies exist since the middle of the 19th century when the first regular liner services were being established. These first arrangements were called 'conferences', a system dominating the liner (and thus later the container) industry till 1994.

Apart from obtaining operational synergies, the conference system was very much focussed on fixing tariffs. For many decades, the general consensus (and acceptance) was that if liner operators were to compete among themselves on price, this would create rate wars and a destructive competition undermining the stability of the trade. Eventually, by 1990 the system of conferences was abandoned in the container industry because of anti-trust law concerns.

After 1995, other forms of collaboration amongst container liner operators developed in the form of consortia, global alliances and slot charter agreements.

In a consortium or an alliance, the objective is to rationalise capacity by offering joint liner services organised by two or more shipping lines, either globally or one particular trading route only. While all members share space amongst one another and use the same terminals, they continue to operate independently in respect of pricing, conditions, issuance of bills of lading etcetera.

Main alliances (2015)

2M

The 2M alliance was established in 2015 and is a 10-year vessel sharing agreement (VSA) between Maersk Line and Mediterranean Shipping Company (MSC).

Ocean Three (O3)

In September 2014, CMA CGM, China Shipping Container Lines and United Arab Shiping Co. formed the O3 alliance, a combination of a vessel sharing, slot exchange and slot charter agreement.

CKYHE

This alliance was formed in 2014 and comprises Cosco, K-Line, Yang Ming Line, Hanjin Shipping and Evergreen.

G6

The G6 was set up in 2014 for a period of two years and comprises APL (American President Lines), HMM (Hyundai Merchant Marine Co Ltd.), MOL (Mitsui OSK Lines), Hapag-Lloyd AG, NYK (Nippon Yusen Kaisha) and OOCL (Orient Overseas Container Line Ltd.)

NVOCC

The third category of container carriers is the Non Vessel Operating Common Carriers (NVOCC) also referred to as 'ship-less shipping lines'. NVOCC was first defined in the US Shipping Act of 1984, according to which NVOCC means 'a common carrier that does not operate the vessels by which the ocean transportation is provided, and is a shipper in its relationship with an ocean common carrier'.

Today, NVOCCs operate in every continent and do not necessarily operate under the above strict interpretation of the law.
In most instances, an NVOCC is considered an 'international intermodal service provider who uses the services of common carriers'. An NVOCC therefore acts almost like a common carrier, with the exception that an NVOCC does not actually operate the vessel it uses to move the container. An NVOCC act as a virtual carrier towards the shipper (for which it issues a bill of lading) and acts as shipper towards the shipping line. (for which it receives a bill of lading from the shipping line).

There are literally hundreds of NVOCCs, and analysis shows most of them operate in certain trade lanes / continents only.

NVOCC vs freight forwarder

The role of an NVOCC and freight forwarder are often mixed up with one another. This is understandable as in several instances they both operate under the same identity and offer the same kind of services. Both ship freight over long distances and both work with common carriers as well as with companies requiring transportation of their goods to complete an order. However, there are some distinct differences:

» NVOCCs can (and mostly do) own or lease the containers they operate. Freight forwarders do not.
» in certain countries, such as the United States, NVOCC operators must publish their tariffs. This requirement does not apply to freight forwarders.
» NVOCCs issue bills of lading and as a result take on the liabilities of the carrier.
» freight forwarding companies may act as either an agent or partner for an NVOCC; the vice versa is not true.

The differences between the three categories of container carriers is summarized in the below overview.

	NOO (non operating owner)	Shipping line (acting as charterer)	NVOCC (Non Vessel Operating Common Carriers)
owning ship	yes	no	no
providing crew	yes	no	no
providing bunkers	no	yes	no
maintaining fixed sailing schedules	no	yes	possible
enters agreement with terminal	no	yes	no
issue bills of lading	no	yes	yes
owns containers	no	yes	possible
lease containers	no	yes	possible

5.3

Registration and classification

Merchant ships must be registered in a country, known as their 'flag state'. The flag state has the authority and responsibility to enforce regulations applicable to vessels registered under its flag, including those relating to inspection, certification and the issue of safety and pollution prevention documents.

Flag state certification and inspections can be undertaken by the flag state's own authority, such as the Maritime and Coastguard Agency (MCA) for vessels registered in the United Kingdom, and the Coastguard (USCG) for vessels registered in the US.

Most merchant ships, however, are registered in a country where the owners of the vessels are not domiciled. Some of these flag states are known as 'flags of convenience', with lower standards for vessel, equipment, and crew than some other maritime countries. Panama is currently the world's largest flag state, with a quarter of the world's ocean-going tonnage registered there.

Most of the flag states have outsourced the certification and inspection of ships to classification societies.

Apart from the inspections and certification for or on behalf of the flag state, a ship must also be certified by the classification society itself in accordance with its Rules. The requirement to be certified by a classification society is not a formal requirement made by the flag state, but is necessary to obtain insurance for both the cargo and the vessel, which again is a prerequisite to trade.

A classification society is a non-governmental organisation that establishes and maintains technical standards for the construction and operation of ships and offshore structures. The society will also verify that the construction of a ship or offshore structure complies with the applicable standards and regulatory requirements. In this respect, regular surveys are carried out of ships in service and during dry-docking.

Apart from the ship's overall construction, the classification society will look at hatch covers, lashing bridges, cell guides and fixed fittings on containerships, to ensure that these have sufficient strength. Loose fittings such as twistlocks, turnbuckles and lashing bars are excluded from this certification process, but the shipowner may assess the adequacy of these fittings through a separate class notation, e.g. 'lashing'.

A separate flag state requirement is the approval of the ship's Cargo Securing Manual (CSM), which is described further in the chapter on lashing and securing.

Apart from providing classification and certification services, the larger classification societies also conduct research at their own facilities and provide additional services such as innovation, technology support and consultancy.

There are more than fifty companies worldwide classifying themselves as ship classification societies, but most have no recognition by major flag states and insurance providers. Of the internationally recognised classification societies there are twelve, all members of the International Association of Classification Societies (IACS). IACS was established to serve as a forum for the exchange of knowledge and technical development and to harmonise class rules and survey procedures across the societies. Classification societies can become members of IACS by demonstrating a consistently high standard of operation.

List of IACS Classification Societies

name	abbreviation	date	head office	EMSA member
American Bureau of Shipping	ABS	1862	Houston	Yes
Bureau Veritas	BV	1828	Paris	Yes
China Classification Society	CCS	1956	Beijing	Yes
Croatian Register of Shipping	CRS	1949	Split	Yes
DNV/GL*	DNV/GL	1864/1867	Oslo	Yes
Indian Register of Shipping	IRS	1975	Mumbai	No
Korean Register of Shipping	KR	1960	Busan	Yes
Lloyd's Register	LR	1760	London	Yes
Nippon Kaiji Kyokai (ClassNK)	NK	1899	Tokyo	Yes
Polish Register of Shipping	PRS	1936	Gdánsk	Yes
Registro Italiano Navale	RINA	1861	Genoa	Yes
Russian Maritime Register of Shipping	RS	1913	St. Petersburg	Yes

* DNV/GL is the merger (in 2013) of Oslo-based Det Norske Veritas (DNV) and Hamburg-based Germanischer Lloyd

The European Union has recognised eleven classification societies as belonging to the European Maritime Safety Agency (EMSA). Maritime authorities in EU Member States can only authorise a classification society recognised by the European Union to undertake surveys on their behalf.

European Maritime Safety Agency; Lisboa, Portugal (EMSA)

5.4

Strength loads acting on containerships

The types of stresses on a ship's hull structure are:

- longitudinal strength loads – bending moments, shearing forces and torsional moments
- transverse strength loads
- local strength loads – vibrations, slamming, stacking loads etc.

The loads acting on a ship are either internal loads, e.g. caused by cargo, ballast, fuel etc., or external loads caused by sea, wind and ice, and can occur in a still water (harbour) condition or in a dynamic (seagoing) condition.

Longitudinal stresses and certain local stresses are of particular interest for containerships. The longitudinal loads are bending moments, shear forces and torsional stresses.

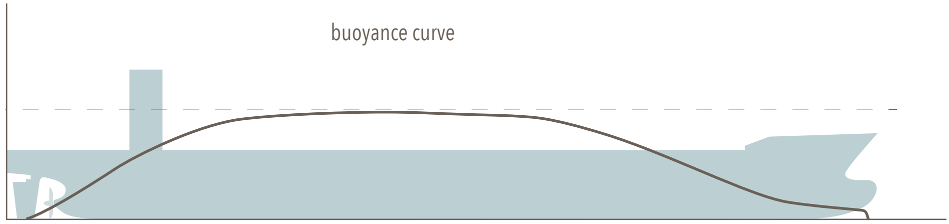
Bending moments

The hull of a ship has many of the same properties as a single steel beam. Therefore, when describing the nature of the vessel's hull, a simple beam theory can be applied. This is usually referred to as 'the hull girder theory', i.e. thinking of the vessel's hull as a floating hollow steel beam.

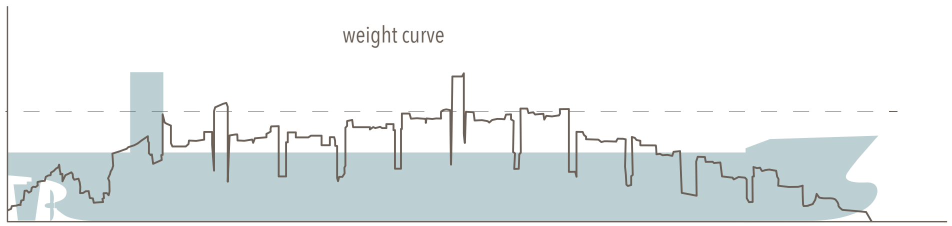
When a vessel floats in still water, there are two forces acting on the hull: buoyancy acting upwards, and weight acting downwards. The resultant force is zero (Archimedes' principle).

The buoyancy force will be more at the midships area as the submerged volume in this region is larger. The buoyancy force gradually decreases at the less voluminous shaped aft and forward ends.

The weight distribution varies along the length of the ship. In addition to the distribution of the weight of the ship itself,



Typical buoyancy curve for a container vessel



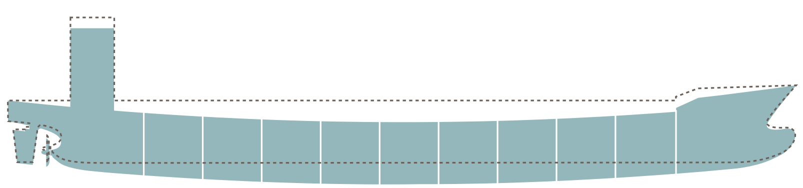
Typical weight curve for a container vessel

it also depends on the location of the ship's equipment such as the main engine and machinery, and propulsion system, and in particular, the location of the cargo, ballast and fuel. This weight variation along the vessel's length is displayed in the weight curve.

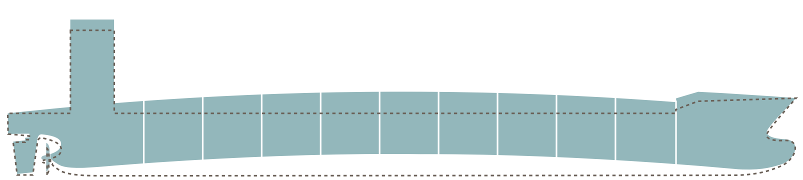
In any condition, the total area under the weight curve will equal the total area under the buoyancy curve. The unevenness in the weight distribution acting downwards and the buoyancy force distribution acting upwards results in a still water bending moment. This causes the hull girder to bend. If the hull is bending upwards, this is called 'hogging' as opposed to 'sagging' if the hull is bending downwards.

In addition to weight and buoyancy forces, wave forces also act on the hull girder at sea; the wave bending moment.

For example, when the length of the waves are equal to the ship's length and the wave crests are at the bow and stern; the ship will tend to bend downwards in the midships area in way of the wave trough (sagging). On the other hand, when the wave crest is right at the middle of the ship's length, the ship will tend to bend upwards (hogging). The sum of the still water bending moment and the wave bending moment is the 'total bending moment'.



sagging



hogging

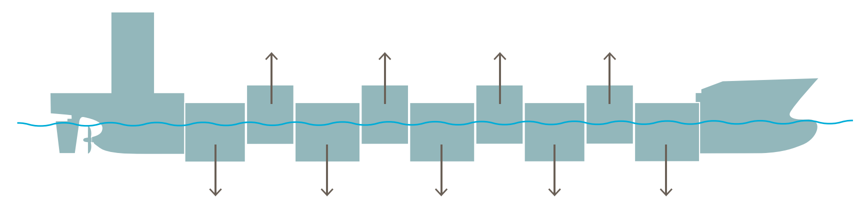
Shear forces

When a ship floats in still water, the ship's own weight and that of the variables on board, such as cargo, ballast, fuel etc., are supported by the overall buoyancy force acting on the exterior of the ship's hull. There will be local differences in the vertical forces of buoyancy and ship's weight along the length of the ship. These unbalanced net vertical forces acting along the length of the ship will cause the hull girder to shear. All ships classed with an IACS classification society are assigned permissible still water shear forces (SWSF).

Torsional stresses

Torsional stresses twist the ship's hull along the longitudinal centreline. Torsional stresses occur particularly when the ship's hull is subject to oblique waves. At a given point in time, the sea may be attempting to roll the forward end to starboard while the after end is trying to roll to port. The ship is designed to withstand these wave-induced torsion stresses.

Most ships, being fully loaded with cargo do not induce torsional stresses.
In containerships, however, it is possible

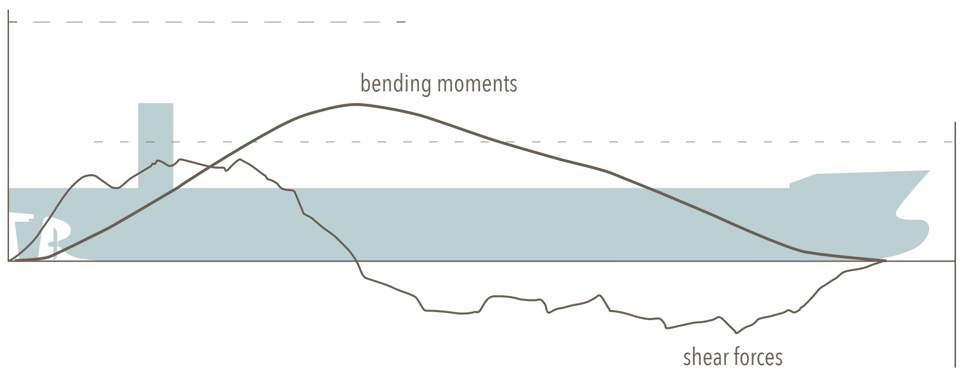


Shear forces

At sea, the continuously changing wave pressures on the hull produce shear forces on the vessel's hull as well; referred to as the 'wave induced shear forces'. The still water and wave induced shear forces are taken into account during the design phase of the vessel as well as in the day to day operation of the vessel when loading/unloading and ballasting/de-ballasting the vessel.

that excess weight to one side at one bay is balanced by an excess to the other side at another bay, thus setting up a torsional stress.

New containership designs using the two-island configuration has improved the vessel's strength against torsional stresses as heavy transverse constructions are built at 1/3 and 2/3 of the ship's length.



Shear forces and bending moments

Loadicator
Classification societies require that the vessel is equipped with a loading instrument (called 'loadicator') capable of calculating the shear forces and bending moments, usually a computer program. The computer program also calculates transverse stability, draught, trim and lashing forces. Torsional stresses may also be calculated.

With regard to bending moments and shear forces, the loading computer produces overviews showing the load curve, shear forces and bending moments at regular intervals along the ship's length. These values are entered into a graph and appended to the calculation results.

Regulations
Information on the highest permissible stresses at designated frames of the vessel is provided in the vessel's loading manual. These values are also included in the loading computer programs. The calculated stresses are usually expressed in terms of percentage with 100 per cent being the ceiling limit.

The International Association of Classification Societies (IACS) has issued a set of Unified Requirements for the structural requirements and loads applied to a ship's hull. UR (Unified Requirement) S11, which has been common to all IACS members since 1992, is particularly relevant to ships over 90 m in length and in unrestricted service.

UR S11 requires the bending strength to be calculated for the midships region, covering 40 per cent of the ships length. Any bending strength requirements outside this area are at the discretion of the individual classification society.

5.5
Navigation and ship handling

Training and education on navigation, meteorology and ship handling in heavy weather is an important part of the education provided by nautical academies. Mariners with a nautical degree are specialists on these subjects due to their training. They are well aware of the dangers posed by heavy weather and extreme sea states to the ship, crew and cargo. Excessive ship motions are often the result of extreme weather or an excessive sea state, but this may not necessarily be the case.

The following topics related to navigation and ship handling of containerships will be discussed in this chapter:

- Waves and swell
- Significant wave height
- Excessive ship motions
- Notorious areas.

Prior to departure, the Master approves the voyage plan for the voyage to the next port. This plan will take into account the latest reported weather conditions, recommendations by the routing company if provided, navigational hazards and the required arrival time in the next port. Weather forecasts are updated continuously and routing advices may recommend that the vessel deviate from its original voyage plan.

Many research studies have been conducted by universities, classification societies and ship design organisations on the subject of ocean waves and ship motion. The topic is very complex and the approaches are usually highly mathematical in nature. Below is a simplified explanation:

Waves and swell
Ocean waves can be divided into 'seas' or 'wind waves' and 'swell'. Seas are waves which are generated fairly quickly, often within an hour or so, in the immediate area where the wind is blowing, and they usually subside shortly after the wind has died down. The wave height is dependent on:

» wind speed
» fetch, which is the horizontal distance over which winds blow from a single, constant direction
» the length of time the wind blows consistently over the fetch
» water depth.

Generally speaking, the stronger the wind and the longer it persists in the same direction without changing speed, the larger the waves. The fetch required for waves to develop their maximum potential in the open sea is 60 km for a wind of 5 m/s and 1000 km for a wind of 20 m/s.

Once waves have been formed, they can continue to travel for thousands of kilometres even through areas with no wind. These waves, which are no longer the result of local winds, are called 'swell'.

Seas are shorter in length, steeper, more irregular and more confused than swell.

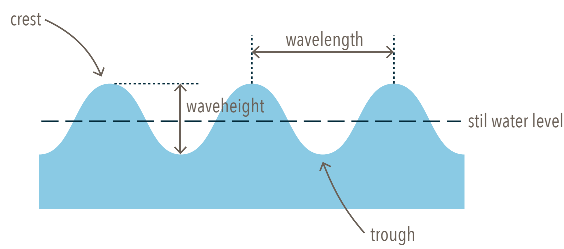
The term 'sea state' is used to describe the overall condition of the water surface which takes into account the combined effects of wind waves, swells, and surface currents.

In a constant sea state, waves can occur with a whole range of individual heights which can vary from minute to minute or indeed wave to wave but changes in sea state generally take a number of hours. The sea state can either be assessed by an experienced observer, such as a trained mariner, or through instruments such as weather buoys, wave radar or remote sensing satellites. There is a large number of variables which together create the sea state.

These cannot be quickly and easily summarised, so simpler scales are used to provide an approximate but concise description of conditions for reporting in a ship's log or similar record, e.g. the (1-10) Douglas Sea Scale.

The wave conditions can be characterised by four main elements:

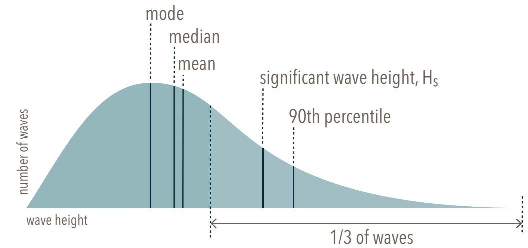
» height, which is the distance measured from the trough to the crest of the wave
» length, which is the distance between successive crests (or troughs)
» period, which is the time that elapses between the passing of successive crests (or troughs)
» steepness, which is the slope determined by the ratio between wave height and wave length.



Significant wave height

Marine weather forecasts usually provide information on wind velocity (speed and direction) and wave height. The usual term to define wave height is 'significant wave height', abbreviated as H_S. This is the average of the highest one-third (33 per cent) of waves, measured from trough to crest, that occur during a given period.

Significant wave height is therefore an average of the largest waves and this does mean that individual waves may be higher. Significant wave height is actually a statistical term and indicative of a certain range of wave heights. This is best explained on the basis of a graph showing the wave numbers on the vertical axis and wave height on the horizontal axis.



As can be seen in the above graph, there are a relatively high number of small waves (left side of graph) and a low number of very large waves (right side of graph). This implies that you will not encounter a significant wave very frequently. However, statistically, it is possible to encounter a wave that is much higher than the significant wave.

For example, given that H_S is 10 m, statistically this implies that:

H	(mean)	=	(0.64) H_S	=	6.4 m
H	(most probable)	=			6 m
H1/10	(10% highest waves)	=	(1.27) H_S	=	12.7 m or higher
H1/100	(1% highest waves)	=	(1.67) H_S	=	16.7 m or higher
H 1/1000	(0.1% highest waves)	=	(1.86 H_S)	=	18.6 m or higher

The Canadian National Marine Weather Guide provides information on the likelihood of meeting a particular wave height within a given time frame:

highest wave likely over a 10-minute period	1.6 x H_S
highest likely wave over a 3-hour period	2.0 x H_S
highest likely wave over a 12-hour period	2.25 x H_S
highest likely wave over a 24-hour period	2.35 x H_S

The energy generated by a wave is proportional to the square of its height. For example, a 30 m high wave will hit the vessel with a force equivalent to four times that of a 15 m wave.

Excessive ship motions

Following extensive research on this subject, it has been recognised that containerships are sensitive to certain ship motions and hydrodynamic effects, such as:

» excessive rolling, i.e. beyond the design criteria
» slamming (bow and stern)
» hydro elastic effects (springing and whipping).

Excessive rolling

When a vessel is moving in following or quartering seas, dangerous situations can occur causing heavy rolling. Problems arising from the heavy rolling of ships, particularly containerships sailing in following or quartering seas, have been known for some time. The issues surrounding this were addressed in the IMO MSC Circular 1228, dated 11 January 2007.

The effect of stern or quartering seas on any vessel may give rise to any of the following:

Surf-riding and broaching-to

When a ship is located on a steep forefront of a high wave in following and quartering seas, the ship can be accelerated to ride on the wave; this is known as 'surf-riding'. When a ship is surf-ridden, the so-called 'broaching-to' phenomenon may occur, which puts the ship in danger of capsizing as the result of a sudden change of ship's heading and unexpectedly large heeling.

Reduction of intact stability when riding a wave crest amidships

When a ship rides a wave crest, the intact stability will decrease substantially. This stability reduction may become critical with wave lengths within the range of 0.6 L to 2.3 L, where L is the ship's length in metres. This situation is particularly dangerous in following and quartering seas, as the duration of riding the wave crest becomes longer.

Synchronous rolling motion

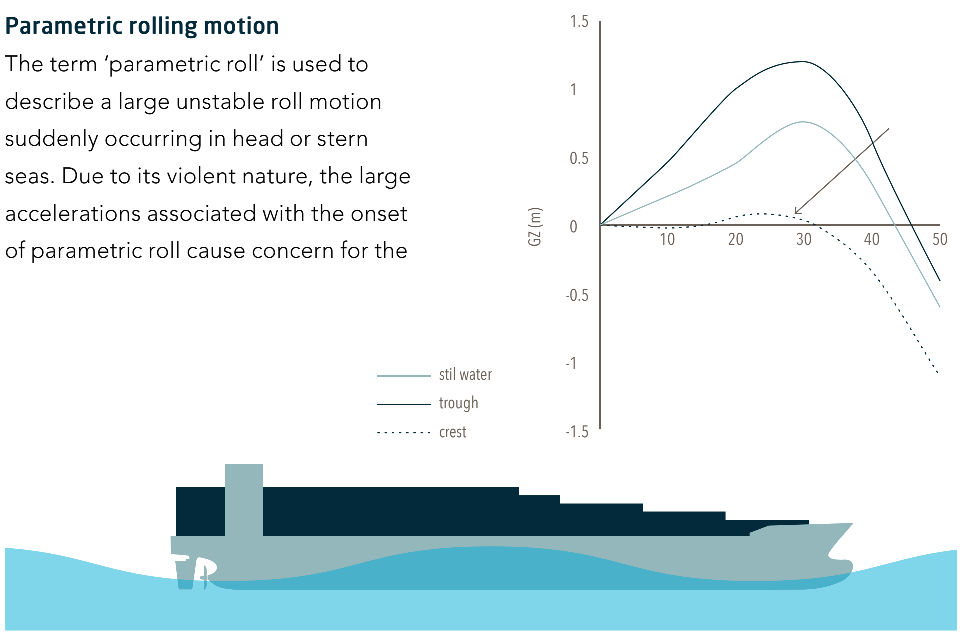
Large rolling motions may occur when the natural rolling period of a ship coincides with the wave encounter period. When navigating in following and quartering seas, this may happen when the transverse stability of the ship is marginal and therefore, the natural roll period is longer.

Parametric rolling motion

The term 'parametric roll' is used to describe a large unstable roll motion suddenly occurring in head or stern seas. Due to its violent nature, the large accelerations associated with the onset of parametric roll cause concern for the safety of containerships. Parametric roll is a threshold phenomenon as a combination of environmental, operational and design parameters needs to come together before it is encountered. These are:

» the ship travels with a small heading angle to the predominant wave direction (head or stern seas)
» the wavelength is comparable to the ship length and wave height is large
» the ship's roll damping characteristic is low
» if unfavourable tuning occurs between the wave encounter period and natural, or twice natural, roll period of the vessel, parametric roll motion can occur

Although the phenomenon has been known for a long time, investigations into the APL CHINA incident in 1998 revealed that



Parametric rolling: wave crest amidships, temporary loss of stability (see GZ curve)

(post) Panamax containerships, with large bow flares, are particularly prone to head-sea parametric rolling.

Parametric rolling can best be described as a situation where there is loss of stability, followed by a complete recovery of stability, half a wave frequency later, see illustration.

Official guidance has been provided by the IMO in IMO MSC Circular 1228, dated 11 January 2007 to the Master for avoiding dangerous situations in adverse weather and sea condition, including parametric rolling. The Circular includes an operational guidance, assisting the Master with ship handling procedures to avoid dangerous situations such as this occurring. Various data such as wave height, wave period, wave length, wave speed, roll angle and encounter period must be obtained from on board measurements tools and input into the various diagrams provided.

Other situations which can occur include:

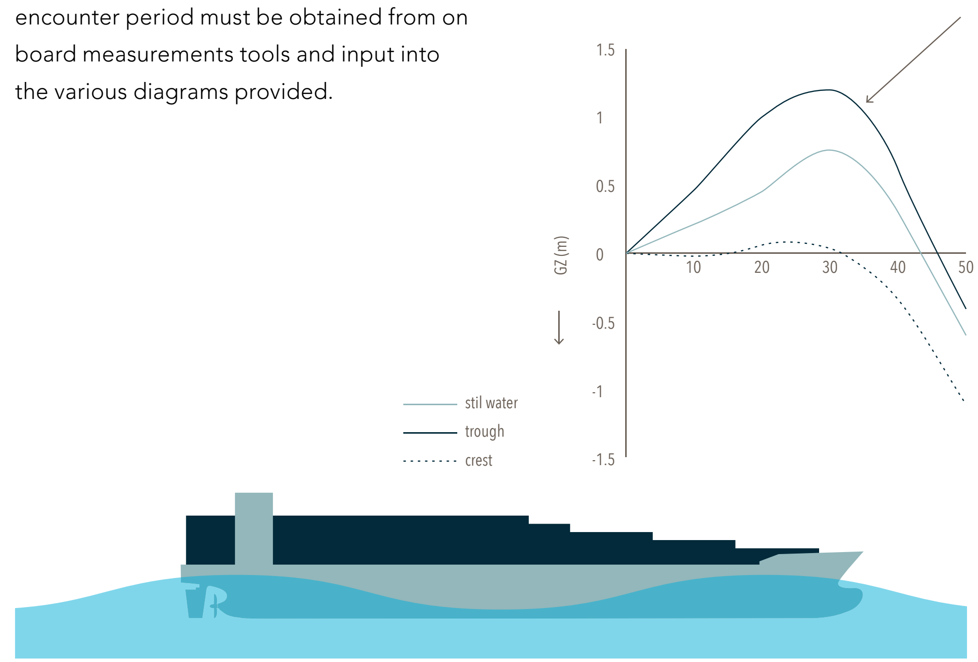
Slamming

Slamming occurs when a ship's hull impacts heavily with the water surface.

The accelerations caused by slamming may create high compression forces on the container stacks. Modern containership designs are sensitive to wave impacts due to the large bow flares and wide and flat overhanging sterns. Slamming can have an impact in both the bow and stern areas. There are two types of bow slamming:

Bottom slamming

The ship's bottom emerges from the water and suffers a severe impact on re-entry, often also referred to as 'pounding'.



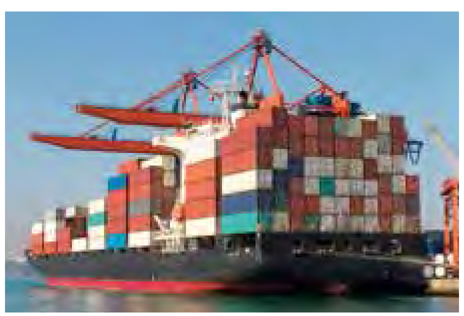
Parametric rolling: wave crest forward and aft. Recovery of stability (see GZ curve)

Bow flare slamming

This occurs when the upper flared part of the bow is forced deeper into the wave. The buoyancy of the bow section increases proportionally over time and thereby progressively dampens the downward movement of the bow.

Stern slamming

This is when the underside of the vessel's stern impacts with the water surface. For reasons of propulsion efficiency and the desire to have more cargo space in the aft area of the vessel, the exposed plating around the aft waterline has over time become a more or less flat surface. The development of the so-called 'overhanging sterns' does not solely apply to recent designs of containerships, but can also be found on passenger vessels and sailing yachts.



Overhanging stern

Under certain, even moderate, conditions wave impacts against the flat bottom may create huge impact forces. These impacts may occur in following waves even in mild sea states when sailing at low speed. If the transom is out of the water the overtaking waves may slam into the stern plating.

Even where this effect is not severe it can be clearly felt in the ship structure and in particular in the accommodation and wheelhouse.

When sailing in head sea conditions and / or at reduced speed, the transom may also come free of the surface due to large pitching motions. Re-entry may lead to high stern slamming loads.

Hydro-elastic forces / springing / whipping

Ship motion tests in water basins use rigid body models to determine loads and accelerations. However, ships do flex along the hull, particularly when navigating through high head seas.

The term 'springing' is used to describe strong hull girder vibration due to oscillating wave loads. The term (slamming induced) 'whipping' is used to describe an increasing vibration along the ship's hull after an excitation at the ship's bow, usually a slamming event.

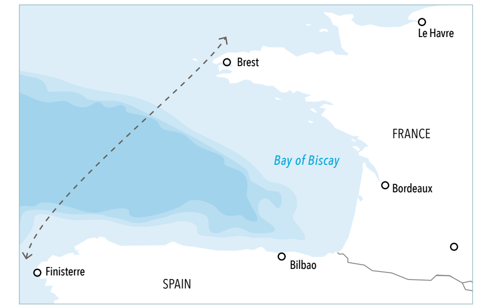
Full scale and model tests, with flexible models, have indicated that the additional wave load because of whipping is typically between 10 and 50 per cent. Classification societies are currently (2015) carrying out further testing in this regard.

In summary, containerships and their lashing and stowage arrangements are designed for a certain operational envelope and it may be possible that weather, sea state and ship motions become so severe that this envelope is exceeded. Mariners,

therefore, recognise the importance of staying clear of the most severe weather systems such as tropical cyclones and deep Atlantic or Pacific depressions. The most economic and effective approach in this respect is to rely on crew capabilities to overcome bad weather. To assist in the decision process there are various on-board tools as well as shore based weather routing systems. Some major containership companies even operate an in-house fleet and weather monitoring system to guide their ships' masters to make the best navigational decisions.

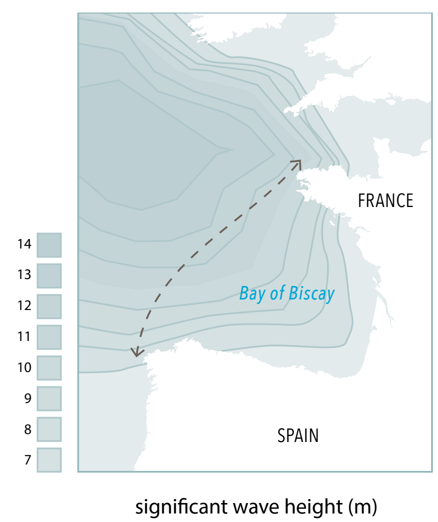
Notorious areas

There are many notorious areas around the world known for their extreme weather. Most of these areas, such as Cape Horn and the Southern Pacific, are not major trade lanes for containerships. When looking at the major trade lanes of containerships the following areas have a relatively high record of container (loss) incidents:

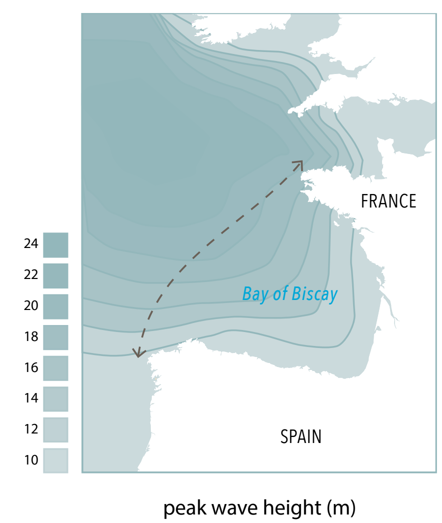


The Bay of Biscay

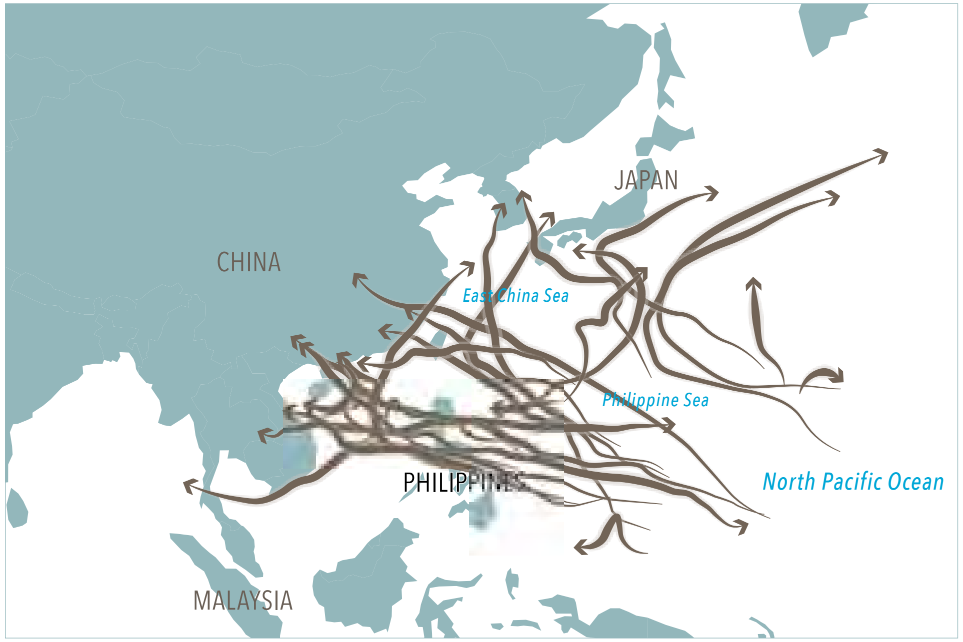
The Bay of Biscay is home to large storms and many ships have been lost there over the centuries. The Bay stretches from Brest in France to Finisterre in Galicia, Spain. As can be seen from the bathymetric chart, the continental shelf forms a trench for Atlantic swells and weather systems entering the Bay from west – northwesterly direction.



Wave height analyses Bay of Biscay, north west 9 Bft. Storm. Significant wave height up to 14-15 m



Peak wave height (1% highest waves): over 20 m source : BMT Argoss



Typical typhoon tracks, western Pacific, over a year period

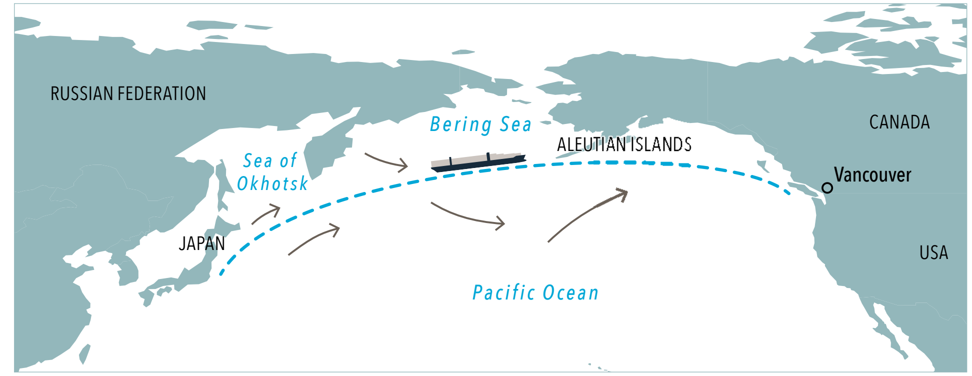
Some 50,000 ships transit the Bay annually. They may find westerly waves of impressive heights crossing their course from abeam with no availability of shelter.

The wave analyses (based on satelitte measurements) after a north-west storm 9 Beaufort is indicative of the possible magnitude of wave heights in the Bay of Biscay.

The Hong Kong – Japan coastline

This area is probably one of the busiest shipping lanes in the world and at the same time, notorious for the presence of tropical cyclones. These cyclones, known as 'typhoons' in Asia, have their origin in the warm tropical waters of the Pacific Ocean. Once developed into a cyclone, the devastating weather system intensifies during its westerly course towards mainland China where it either will make landfall or turn northwards to develop into a Pacific depression. The northwest Pacific sees tropical cyclones year round, with the smallest number in February and March and a peak in early September.

Ships crossing the China Sea often have to make the decision whether it is safe to pass ahead of the track of the typhoon, to divert or to delay the voyage. Especially ships sailing on a northerly course and anticipating maintaining a certain speed might find themselves in difficulty as the anti-cyclical direction of the winds will force them to slow down, reducing the distance between the ship and the centre of the typhoon.



North Pacific, great circle navigation. High following seas for ships sailing in easterly direction

North Pacific, great circle

Containerships are sensitive to stern and quartering seas as when wave riding and parametric rolling can occur. Most containerships trading between Asia and the West coast of North America take a great circle route reaching high altitudes with weather depression systems prevailing most of the time. As a result, ships trading on this route in the easterly direction (Asia to North West America) operate in high following seas most of the time. The classification society DNV/GL estimates this would apply to 70-80 per cent of the ships using this route. Many container losses have occurred in this area in recent decades and, almost without exception, the experience of the ships was that the rolling behaviour of the vessels suddenly changed from regular moderate motions to very violent motions with large amplitudes in short periods of roll.

5.6

Stowage

Containers are stacked in such a way that the ISO corner posts of every container in the stack rest on top of the corner post of the container below. The basic principle used in container stowage is to stow the containers lengthwise with the doors facing aft. On some ships, e.g. certain type of Ro-Ro vessels, the containers are stowed athwart ships.

The bay-row-tier numbering system

The location of a container on board a vessel is called a 'slot'. These slots are three-dimensional and each position is allocated three coordinates. Each coordinate consists of two digits. The official standard to indicate the containers' positions on board containerships is ISO 9711-1:1990, the six-digit 'bay-row-tier numbering' system.

Bay

The bay position indicates the position of the container along the length of the vessel. Bays are numbered from bow to stern, with odd numbers, 01, 03, 05 etc., for 20 foot containers, and even numbers, 02, 04, 06 etc., for 40 and 45 foot containers. Two 20 foot containers can be stowed in a 40 foot bay position. An even numbered bay position, e.g. 04, occupies two 20 foot positions – in this case bay numbers 03 and 05.

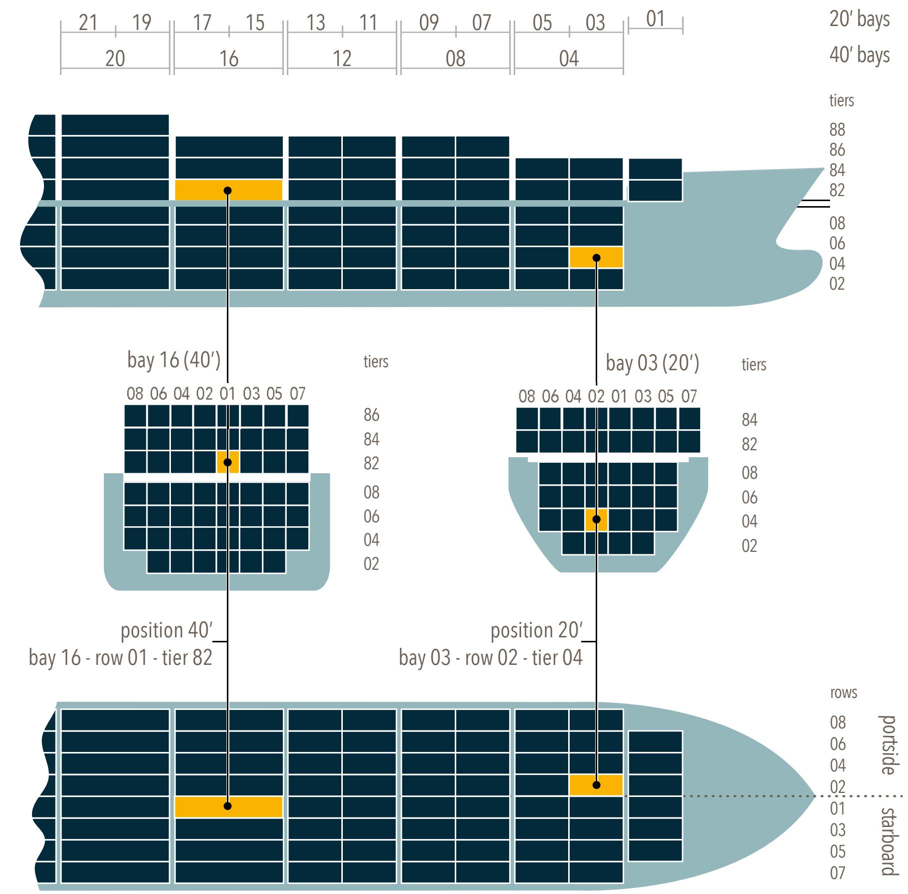
Row

The row position indicates where the container is placed across the width of the ship. The numbering starts at the centre line and increases outwards with odd numbers, 01, 03, 05 etc., on the starboard side, and even numbers, 02, 04, 06 etc., on the portside. A container with the row position 00 is stowed on the centre line. A container row is also known as a 'stack'.

Tier

The tier position indicates the level where the container is stowed. The tier coordinate is an even number for standard high containers and uneven for half-height containers. The number increases the higher up the container is located. The tier-coordinates also indicate if a container is stowed in the cargo hold or on deck. The numbering of containers stowed in the cargo hold start with 02.

The tier numbering on deck, usually starts with 80 if the container is stowed on the main deck, and 82 if the container is stowed on the hatch covers. Containers are stowed on the main deck when there are no underdeck stowage positions in that location, for example on the deck above the engine room.



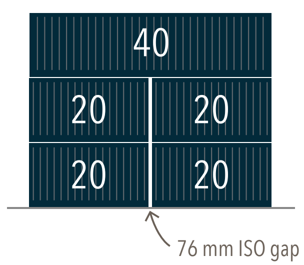
Point load – line load

The most common way of stowing containers is in a pointload where the container is resting on the four bottom corner castings. In a pointload, the forces in the container stack are transferred through the corner posts and finally to the foundation on the deck, hatch cover or tank top.

Another way of stowing containers is in a lineload, which avoids the high point loads on the bottom corner castings of containers stowed in the classic way. The lineload system also allows for a lighter construction of the supporting structure, for example the hatch covers. To stow containers in a line mode, a recess deep enough to prevent the corner castings from touching the supporting structure, is made in way of the four bottom foundations. The weight of the containers is not supported by the founding tiers, but by the containers' longitudinal bottom girders. The lineload stowage system is mostly used on general cargo ships where the hatch covers have been modified to carry containers.

Russian stow

The basic principle of container stowage is that containers can only be stacked with the ISO corner castings resting on top of one another. From this principle follows that two 20 foot containers cannot be stowed on top of one 40 foot container, but that one 40 foot container can be stowed on top of two 20 foot containers. This type of stowage is called 'Russian stowage'.



A key component of the design of dedicated containerships is the use of cell guides which are fixed to the vertical steel structure of the vessel with an angled profile to guide the containers into their stowage positions in the cargo hold and to secure the containers during the voyage. In a common cell guide configuration the cell guide profiles are distanced for 40 foot containers. Depending on the size of the ship, the containers may be stacked as many as nine to ten tiers below deck.

Some containerships, particularly those operating in the short sea shipping sector in Europe, have convertible cell guides to fit a variety of different sized containers. These frames are usually placed in position by a crane. Some general cargo and multi-purpose ships capable of carrying containers have removable cell guides or do not have cell guides at all.

Containers may also be stowed in cargo holds without cell guides where they are stowed on top of each other and restrained by means of a transversal lashing system. See chapter on Lashing and securing.

Stowage limitations

The hatch pontoons are constructed to carry a maximum weight for each stack. Exceeding the applicable maximum stack weight could cause damage to the hatch covers. The ship's maximum stack weight values can be found in the ship's manuals and values are provided for both 20 foot and 40 foot stowage.

The maximum permitted stacking weight not only depends on the strength of the tanktop, hatch covers and the container itself, but also on the lashing system used. Stowage in cell guides afford for the highest stacking heights; whilst containers lashed by lashing bars have lower maximum permissible stacking weights.

5.7

Determination of forces

The following topics are covered in this chapter:

- **Mass, weight, force and acceleration**
- **Forces acting on container stows**
- **Stability**
- **Design criteria for containerships**
- **Limitations.**

Some knowledge of forces and stability is necessary to understand the way forces are determined on board ships and how these are applied to lashing and securing.

Mass, weight, force and acceleration

The following basic terms and definitions are used when considering forces:

Mass

Mass is the basic measure of the quantity of matter in a body, and is expressed in terms of the kilogram (kg) and the tonne (t), also known as the 'metric tonne' or 'metric ton' (mt).

Weight

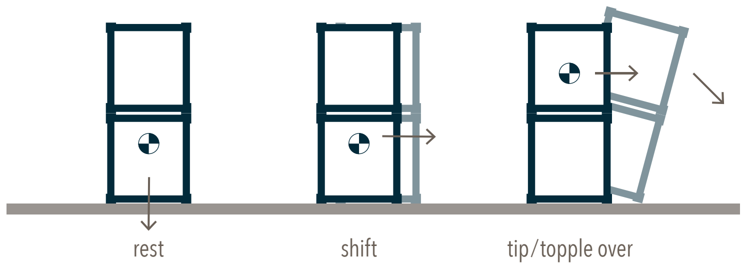
Weight is the force exerted on a body by the earth's gravitational force. The direction of the weight is towards the centre of the earth and it is measured in terms of Newton (N) or, in thousands, kiloNewton (kN).

Velocity

The velocity of a body is the rate of its displacement with respect to time in a particular direction (m/s).

Acceleration

The acceleration of a body is the rate of change of velocity in relation to time. The unit of acceleration (a) is metre per second squared (m/s^2). If a body is moving at a constant speed, the acceleration is zero. The acceleration will be at its highest at the point where the moving body is changing speed.



The point of application and the direction of a force will determine whether an object will stay at rest, shift, or to topple over

Centre of gravity

The centre of gravity of a body is the point where its mass may be assumed to act vertically downwards, with a force equal to its weight.

Force

A force may be described as any push or pull exerted on a body and has three elements:

» magnitude
» direction
» point of application.

Isaac Newton's second law states that force is the multiplication of mass by acceleration F = m x a

The earth's gravitational acceleration (g) is approximately 9.81 m/s². Therefore, a body with a mass of 1 kg has a force due to gravity of 9.81 Newton. In practice, this is rounded up to 10 Newton. Most of the forces involved in cargo securing are expressed in kiloNewton (kN). These forces in kN must be divided by 9.81, although 10 is commonly used, to derive the weight in tonnes. This is useful when selecting lashing equipment which is certified in tonnes.

Static force

The static force is the force exerted by an object due to its own weight while at rest.

Dynamic force

The dynamic force is the force exerted by an object resulting from its movement. The most important dynamic forces experienced on board a ship are those generated by the ship's motions.

Forces acting on container stows

The safe transport of containers by sea requires that the forces acting on the container stows are resisted by the lashing gear and the containers themselves.

Containers, like any other construction, are designed and built to withstand a maximum force. When the forces exerted on the containers exceed this limit, the construction can suffer a structural failure. In terms of container stacks, this means that the stack can collapse or disintegrate. In this chapter we look at the forces in a container stow and their origin.

The forces acting on container stows on board seagoing vessels are a combination of:

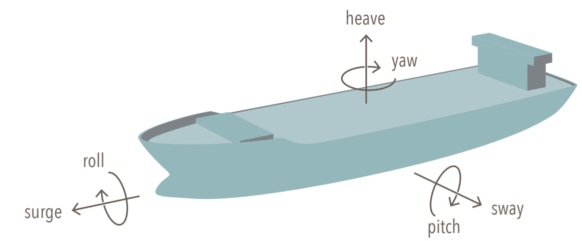
» static load
» dynamic load
» wind load
» forces exerted by pre-stressing of the lashing gear.

The static load is caused by the vessel's heeling and trim angle, the weight of the container stack, and pretension of the lashing bars.

The dynamic load is caused by a ship moving in a seaway. Like any other type of floating structure, a ship has a freedom of movement, referred to as 'six degrees of freedom'. The resulting motions can be divided into linear and rotational motions.

Linear motions are:

» *heave* the vertical (up and down) motion
» *sway* the lateral (side to side) motion
» *surge* the longitudinal (fore to aft) motion.



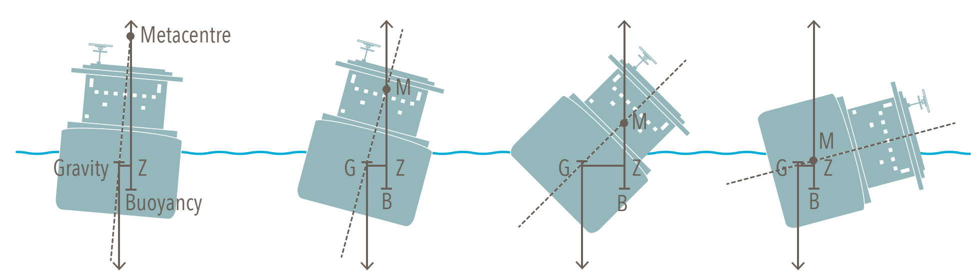
Vessel, 6 degrees of freedom

Rotational motions are:

» *pitch* the motion along the transverse axis, causing the bow and stern of the ship to move up and down
» *roll* the motion along the longitudinal axis, causing the port and starboard side to move up and down
» *yaw* the motion along the vertical axis, causing the bow and stern to move sideways.

Stability

An assessment is made during stability calculations of the vessel's overall centre of gravity (G), the centre of buoyancy (B), the metacentre (M) of the vessel and how these interact with each other. The interaction between these points works as follows: as soon as the vessel begins to heel, one side of the hull rises from the water and the



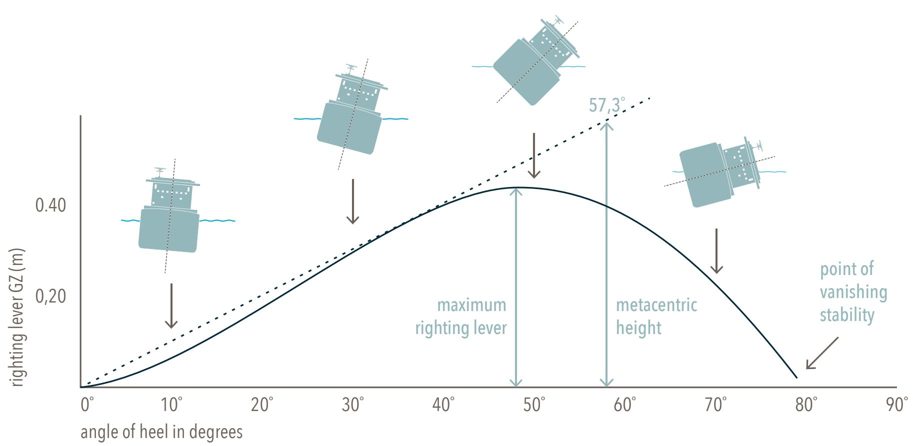
other side submerges. In a well-designed ship, this causes the centre of buoyancy to shift towards the side that is deeper in the water. A vertical line can be drawn from the new centre of buoyancy and where this intersects the centreline, the so-called 'metacentre' is located. As long as the 'metacentre' is located above the centre of gravity, the ship is stable in an upright condition. The distance between G and M is referred to as the 'metacentric height (GM)' and is a measure of the vessel's stability.

A larger metacentric height implies greater initial stability. The GM also determines the natural roll period of the vessel, with large metacentric heights being associated with shorter roll periods and high forces of acceleration.

If G moves upward, stability will reduce and become zero when in the same position as M. If G is located above M, the vessel has a negative stability and may capsize instantly. The up or downward movement of the centre of gravity (G) is relative to the weight and position of the cargo

Snow and ice adding unknown weight and dislocation of the centre of gravity (G) of the vessel

loaded / discharged. The same applies for ballast water, fuel etc. A decrease of the GM value may also occur in connection with slack tanks, i.e. tanks which are not full, also known as the 'free surface effect'. In certain situations, e.g. tanks with a large width, this free surface effect can have a detrimental effect on the stability of the entire ship. The position of G may also change significantly because of snow and ice on the containers. A ship may also be unstable in its upright position, but stability may become zero and subsequently positive at larger angles of heel. The vessel will then reach an equilibrium at a certain angle, known as the 'angle of loll'. This is not to be



confused with 'angle of list' which is caused by an unequal distribution of weight on either side of the vessel's centre line.

The metacentric height is an approximation of the vessel's stability at a small angle (0-15 degrees) of heel. Beyond that range, the vessel's stability is dominated by what is known as the 'righting arm' (or 'righting lever'), indicated as GZ. This is the horizontal distance between the lines of buoyancy and gravity. The lower the vessel's centre of gravity, the bigger the righting arm (GZ) will be. The righting arms for different angles of heel can be plotted onto a graph and a line can be drawn. This curve is known as the 'stability curve'. The stability curve's shape does need to meet the requirements normally referred to as the 'IMO Res. A.167 criteria', which were included in the IMO Code on Intact Stability for all types of Ships covered by IMO Instruments (IMO Res. A.749) in 1993.

The stability criteria apply to all types of vessels. Large containerships can suffer from significant fluctuations in stability when navigating through particularly high sea states. These fluctuations can cause severe rolling of the vessel and are further discussed in the chapter on Navigation and Ship Handling.

Design criteria

When designing ships and lashing systems, it is important to know how ship's motions respond to waves. Design criteria assist naval architects in designing ships fit for particular weather and sea conditions.

Central to any design methodology is estimating the prevailing sea state and selecting a design wave height. Therefore, during the initial design phase, information is collected on the wave spectrum a vessel is expected to meet during its service life (usually 20-25 years). These assumptions, together with several other service conditions, are important as they determine how strong the build of the ship's hull need to be to resist bending, torsion and shear forces. The strength of other structures on board the ship, such as hatch covers, lashing bridges, crane platforms etc., are also based on the assumption of the maximum wave height to be encountered by a ship during its lifetime.

The ship designer may determine these criteria on the basis of tests with models in a wave basin. This is quite an expensive method and, alternatively, computers can be used to simulate the conditions in the wave basin. A more common method is the use of so-called 'Response Amplitude Operators (RAO)' derived from model tests and which are in fact a set of statistics used to predict the behaviour of a ship at sea.

When setting up model tests or computer programs, wave heights statistics can be used which are available to purchase from various organisations.

In commercial shipping, the most common method of determining the strength of the hull is to apply the Rules of the classification societies. After all, the ship is designed

IACS recommendation 34 Standard Wave Data

IACS provides recommendations and guidelines related to adopted resolutions that are not necessarily matters of class but where IACS considers it beneficial to provide advice to the marine industry. IACS recommendation 34 applies to Standard Wave Data and applies to ships carrying goods at sea, specifically aiming at ships covered by Unified Requirement S11 and focussing on extreme wave loads.

(Note : UR S11 is the longitudinal strength standards and applies only to steel ships of length 90 m and greater in unrestricted service.)

Hs/Tz	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5	10.5	11.5	12.5	13.5	14.5	15.5	16.5	17.5	18.5	SUM
0.5	0.0	0.0	1.3	133.7	865.6	1186.0	634.2	186.3	36.9	5.6	0.7	0.1	0.0	0.0	0.0	0.0	0.0	0.0	3050
1.5	0.0	0.0	0.0	29.3	986.0	4976.0	7738.0	5569.7	2375.7	703.5	160.7	30.5	5.1	0.8	0.1	0.0	0.0	0.0	22575
2.5	0.0	0.0	0.0	2.2	197.5	2158.8	6230.0	7449.5	4860.4	2066.0	644.5	160.2	33.7	6.3	1.1	0.2	0.0	0.0	23810
3.5	0.0	0.0	0.0	0.2	34.9	695.5	3226.5	5675.0	5099.1	2838.0	1114.1	337.7	84.3	18.2	3.5	0.6	0.1	0.0	19128
4.5	0.0	0.0	0.0	0.0	6.0	196.1	1354.3	3288.5	3857.5	2685.5	1275.2	455.1	130.9	31.9	6.9	1.3	0.2	0.0	13289
5.5	0.0	0.0	0.0	0.0	1.0	51.0	498.4	1602.9	2372.7	2008.3	1126.0	463.6	150.9	41.0	9.7	2.1	0.4	0.1	8328
6.5	0.0	0.0	0.0	0.0	0.2	12.6	167.0	690.3	1257.9	1268.6	825.9	386.8	140.8	42.2	10.9	2.5	0.5	0.1	4806
7.5	0.0	0.0	0.0	0.0	0.0	3.0	52.1	270.1	594.4	703.2	524.9	276.7	111.7	36.7	10.2	2.5	0.6	0.1	2586
8.5	0.0	0.0	0.0	0.0	0.0	0.7	15.4	97.9	255.9	350.6	296.9	174.6	77.6	27.7	8.4	2.2	0.5	0.1	1309
9.5	0.0	0.0	0.0	0.0	0.0	0.2	4.3	33.2	101.9	159.9	152.2	99.2	48.3	18.7	6.1	1.7	0.4	0.1	626
10.5	0.0	0.0	0.0	0.0	0.0	0.0	1.2	10.7	37.9	67.5	71.7	51.5	27.3	11.4	4.0	1.2	0.3	0.1	285
11.5	0.0	0.0	0.0	0.0	0.0	0.0	0.3	3.3	13.3	26.6	31.4	24.7	14.2	6.4	2.4	0.7	0.2	0.1	124
12.5	0.0	0.0	0.0	0.0	0.0	0.0	0.1	1.0	4.4	9.9	12.8	11.0	6.8	3.3	1.3	0.4	0.1	0.0	51
13.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	1.4	3.5	5.0	4.6	3.1	1.6	0.7	0.2	0.1	0.0	21
14.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	1.2	1.8	1.8	1.3	0.7	0.3	0.1	0.0	0.0	8
15.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.6	0.7	0.5	0.3	0.1	0.1	0.0	0.0	3
16.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.2	0.2	0.1	0.1	0.0	0.0	0.0	1
SUM:	0	0	1	165	2091	9280	19922	24879	20870	12898	6245	2479	837	247	66	16	3	1	100000

Probability of sea-states in the North Atlantic described as occurrence per 100,000 observations.
Derived from BMT's Global Wave Statistics

Hs is significant wave height (in metres) and values are listed in the left column. Tz is Wave Period (in seconds).
Where the value of Hs and Tz intersect, one can find the probability (per 100,000 observations) of meeting such a wave.

in accordance with the Rules of the classification society.

When considering wave height, the common standard used by the classification societies, and thus shipbuilders, is Recommendation 34 of the International Association of Classification Societies (see *IACS Recommendation 34 Standard Wave Data*).

The assumption of wave height is used to establish the behaviour of the ship at sea and the accelerations to the cargo (containers) and lashings. The assumption on accelerations determine how high containers can be stowed and the maximum permissible weight distribution for a certain lashing arrangement. Therefore, the aspect of sea state (waves) and ship motions are particularly important for containerships. The most important motions considered by the classification societies when calculating the forces in a container stack are pitching, rolling, and heaving.

There is currently no agreement between classification societies on the formulas for calculating standard acceleration forces. As a consequence, different classification societies can arrive at different stowage and lashing requirements for the same ship. The extent of the forces is mainly coming from the roll angle (amplitude) and the rolling period (time / velocity). Roll angle and period are therefore the main design criteria for determining the stowage and lashing arrangements on board.

Roll motions / amplitude

Obviously, more and stronger lashings are required for a ship expected to roll 40 degrees than for a ship rolling 20 degrees. Therefore, classification societies assume a certain worst case scenario, based on technical research carried out by them for the vessel in question. This roll angle is the 'design roll angle'. Current practice in container shipping is that this design roll angle varies between 17 and 30 degrees, where the lowest angles apply to ultra-large container vessels. The design roll angle is usually listed in the Container Lashing Manual.

Roll motions / period

The rolling period is how long it takes for the vessel to make a full roll motion from port to starboard and back. There is one main criterion for the rolling period for any given type of vessel, and that is stability (GM), see below formula:

whereby:

T_{roll} natural roll period of the vessel in seconds

$$T_{roll} = \frac{0.7 \times B\ ship}{\sqrt{GM}}$$

B ship width of the ship
GM metacentric height
0.7 block coefficient (here assumed to be 0.7, but for containerships this is usually somewhere in the range of 0.65-0.75)

The transverse accelerations on board a ship with a long rolling period are relatively low. It is for this reason that the rolling period is kept deliberately long on passenger vessels, as too many passengers would otherwise become seasick. Ships with a short rolling period create high acceleration forces on the ship's structure and cargo, which in turn may cause damage.

Thus:

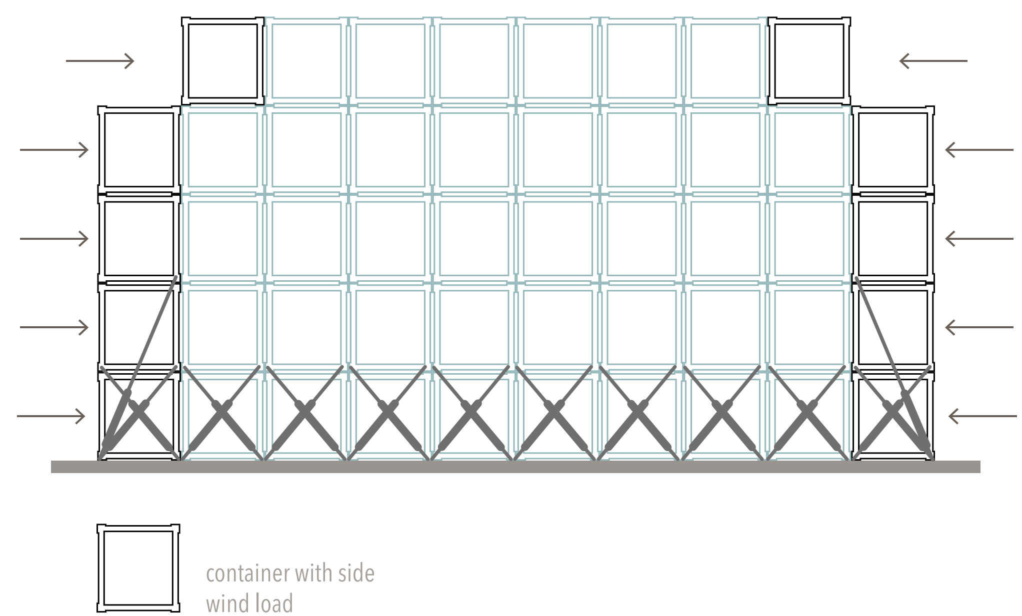
low stability » long rolling period
» low accelerations (a_y)
» low dynamic forces (F_y)

high stability » short rolling period
» high acceleration forces (a_y)
» high dynamic forces (F_y)

Wind load

Containers stowed on deck act as a wind shield and the stack would easily be blown over without lashings.

When calculating container lashings, a side wind force is assumed to act only on those containers exposed to side winds. These are the containers located in the outboard stacks and the containers in the inboard stacks extending above the block of containers (see illustration below).
A standard wind force of 40 m / s (more than 12 Bft) is used to calculate the wind load on the containers. The standard wind force results in the following forces on containers in tonnes (This is the outcome of the wind pressure formula: pressure (N / m^2) = ½ x air density x windspeed^2 x shape factor, with air density taken as 1,25 kg / m^3 and shape factor taken as 1).



Standard side wind load

20 foot standard high container	1.6 tonnes
40 foot high-cube container	3.5 tonnes
45 foot high-cube container	4.0 tonnes

Limitations

Strength criteria of containers

The stowage and lashing configurations should be arranged in such a manner that any forces will not cause the container stows to collapse. This means that the forces must stay within the structural limits of the containers and the safe working loads of the lashing material. If these forces are exceeded for one reason or another, the container stow is at risk of damage, collapse, and/or loss overboard.

The permissible forces on containers are laid down in the Convention for Safe Containers and the international standard ISO 1496. In addition, classification societies maintain their own criteria. The most important limitations are the following:

Racking force (a)

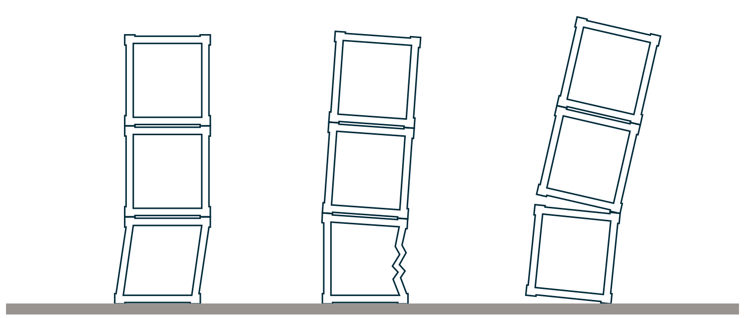
The racking force acts by changing the shape of a container end frame from a rectangle to a parallelogram, and ultimately to fold it flat. The racking force is governed by the construction of the container. According to the CSC Convention and ISO specification 1496, the maximum racking force a container is designed to withstand is 150 kN (15 t). Racking forces have no safety margins, and where there are racking forces greater than 150 kN, symptoms of racking failure may be seen.

Vertical compression forces (b)

Vertical compression forces act vertically on the compression side of a container through the corner posts. According to the ISO specification 1496, the maximum permissible design compression force at each corner post of a 40 foot, 30.5t. rated container is 848 kN (86.4 t)

Vertical tension forces (c)

Vertical tension forces act on the container through the corner posts. These forces cause a container to tip or pull out of its corner fittings, and/or from the bottom foundation on the hatch cover. The vertical restraint required to contain this force is provided by the twistlocks and the containers' corner castings. The maximum allowable safe working load by a pull-out force on a corner casting of a container as designed under ISO 1496, is 250 kN (25 t.).



a b c

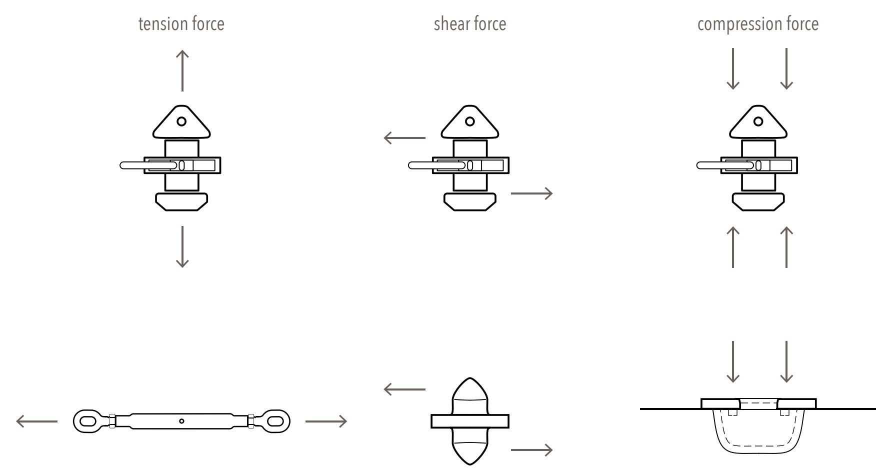
Strength of the lashing gear

Classification societies have imposed minimum strength criteria for the lashing gear used in container stows. The manufacturers of lashing equipment have to construct the material in such a way that it meets these requirements. The most important criterion is the 'breaking load' (BL), which is the minimum load a lashing item has to sustain before breaking. The 'maximum securing load' (MSL) is derived from the breaking load strength and is defined as the 'maximum permissible load allowed on a lashing device when in use'. The standard practice for evaluating container lashing equipment is that the BL and the MSL should differ by a factor 2, meaning that the maximum securing load is half the breaking load.

In test configurations, reference is also made to the term 'proof load'. No permanent plastic deformation is allowed to remain in the lashing device after the item has been subjected to the proof load. The proof load must be around 1.3 times the maximum securing load, although there is some variation between the classification societies on this.

There are three different types of forces affecting the lashing material:

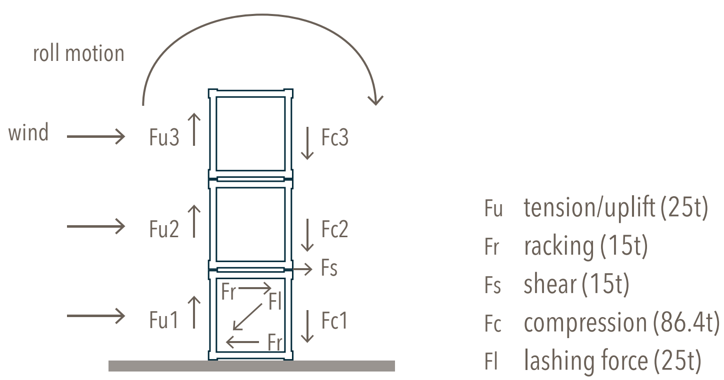
tension force	the pulling force on each end of a lashing device
shear force	the unaligned force from pushing one part of an item in one direction, and another part of the item in the opposite direction
compression force	the pushing force on a device, with the object of reducing the thickness or length of the item along that direction.



Forces on container lashing material

The particular classification society and relevant ISO standard specify the required minimum breaking loads for each lashing element.

To summarise, in a container stack secured with twistlocks and lashing bars, the following forces and limitations are present:



Maximum permissible forces in container and lashing gear

It may appear from the strength specifications of containers and lashing material, that the racking and compression forces of an ISO container are maximum forces with no safety margin. Strength limits of lashing gear are based on their MSL and do have a safety margin before breaking.

5.8
Lashing and securing

In this chapter, we will look at:

- **Methods of lashing and securing container stows**
- **Container lashing systems and equipment**
- **Container lashing routines**
- **Cargo Securing Manual**
- **Container lashing software.**

Methods of lashing and securing container stows

Containers on board seagoing vessels can be lashed and secured in three different ways.

For containers stowed under deck:

» in a block of stacks with side supports and (double) stacking cones
» in cell guides.

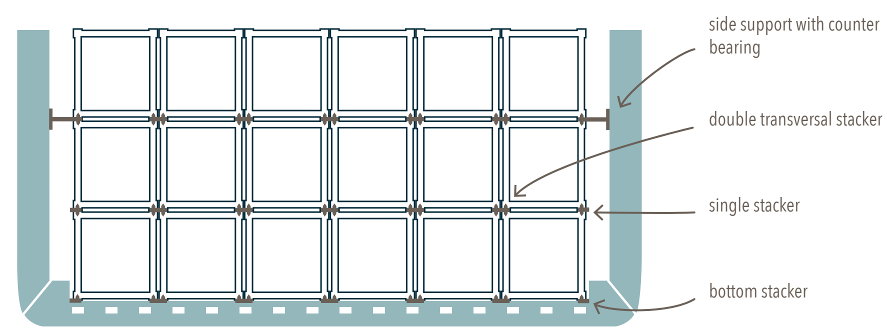
For containers stowed on deck:

» independent stacks with locking elements and lashing rods.

Under deck stowage in a block with side supports and (double) stacking cones

This method is mostly used on feeder vessels, general cargo vessels and multi-purpose vessels and is not common on dedicated ocean-going containerships.

The containers are stowed in a block and connected to the foundations in the tanktop of the hold by single stacking cones. A stacking cone provides a horizontal restraint against shifting but does not provide vertical restraint against lifting. The containers are transversally interconnected by double stacking cones between the container tiers. In this way, the container stacks form a tight block with



Block or transverse lashing of containers stowed under deck locking elements between each container at every tier. In order to avoid the entire block of containers shifting sideways, pressure or pressure/tension supports are fitted between the outboard container stacks and the longitudinal bulkhead of the hold. Special attachment points, recesses or reinforced areas are fitted in the longitudinal bulkhead for these pressure or tension/pressure supports.

This is known as 'transverse lashing', as opposed to 'vertical lashing', because the forces are transmitted to the sides. Relatively higher stacking loads can be achieved using this (transverse) method. The major disadvantage of this system is that all the containers in each tier must be of the same height and, therefore, a mixed stowage with different container heights needs careful planning. Careful planning is also necessary when containers with different discharge ports are stowed in one block. Furthermore, because of the use of double stacking cones, loading and discharging can only be done layer by layer, and not stack by stack.

Stowage in cell guides

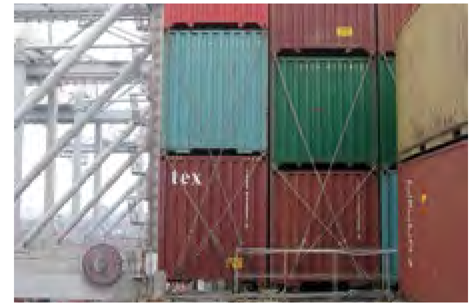
This is the most commonly used method of container stowage on board ocean going, dedicated container vessels, including short sea vessels.

The containers are stowed on top of one another in a cell with vertical guide rails at each corner. No connection fittings are needed between the containers, and

Stowage in cell guides

between the lowest container and the foundation in the bottom of the hold. This method of stowage and lashing can also be extended above the hatch opening on cell-guided hatch-less vessels. On some vessels, cell guides are also installed up to a certain level on deck. The major advantages of this system are that no lashing elements are required and that relatively high stack weights can be achieved. The forces are transmitted to the cell guides as well as to the bottom of the stack and stowing containers with different heights is not an issue.

The major disadvantage of this method is that the cell guides are suitable for one container length only. The most common cell guide length is 40 feet, plus an approximate 40 mm margin at each end. Additional lashings must be used if containers with a length of 30 or 20 feet are stowed in these cell guides. A common method is to stow two 20 foot containers in a 40 foot cell guide with stacking cones at the 20 foot open ends.



Lashing and securing of containers on deck

A two tier high lashing bridge

Another disadvantage is that cell guides are prone to damage thus requiring the crane driver to handle the containers carefully.

Independent stacks with locking elements and lashing rods

This method is the only method for loading containers on deck, except on ships with cell guides on deck, and may also be used for under deck stowage on board feeder and general cargo vessels.

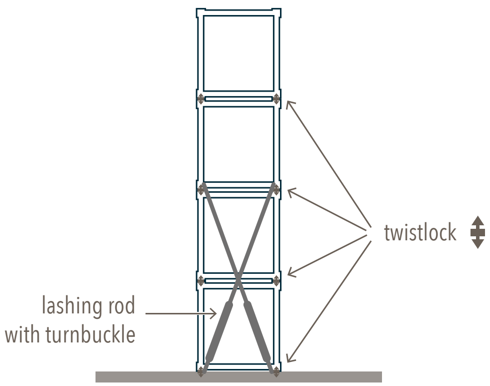
The containers are stowed in a stack and connected to one another and to the four foundations on the hatch covers using a locking device, e.g. twistlocks.

There are no transversal connections with adjacent stacks as every stack is lashed and secured individually. The container lashing calculations assume that there is no interaction between the adjacent container stacks.

This lashing system provides maximum flexibility in terms of the sequence used to load and discharge the containers, i.e. stack by stack or layer by layer, and containers with different heights can be loaded in one stack. It is even possible to stow containers with different lengths in one container stack, although this requires careful planning, taking into account the basic principles of proper stowage and/or lashing.

The major disadvantage of this system is that all the forces acting on the container stack are transmitted through the corner posts and locking devices to the container at the base of the stack and, subsequently, to the foundations on the hatch cover. Therefore, if using twistlocks alone, the forces exerted on the stack foundations will exceed the permissible limits quite easily when containers are stacked three or four high. For higher stowage configurations, lashing bars are required at both ends of the containers. The height of the stowage can be further extended using long lashings and lashing bridges.

Another complication when using this system is that the forces acting in the front and door end of the lashed containers must be evaluated separately, as the two ends of the container have a different deformation characteristic.



Lashing of independent stacks on deck

Container lashing equipment and systems

Container lashing equipment can be divided into fixed and loose fittings. Fixed fittings are welded to the ship's hatch covers and structures and form an integrated part of the vessel. Loose fittings are stored in separate bins and can be used where and when needed. The fixed and loose fittings together form the lashing system. Each fixed fitting has a loose counterpart within the system.

A container lashing system is part of the vessel's overall design. Shipowners, manufacturers and the yard work closely together during the vessel's design and construction phase to decide where containers fittings need to be placed and the system to be used. This is an important aspect of the overall design of the ship, as the lashing system chosen determines how high containers can be stacked and how heavy the containers in each tier of the stack can be.

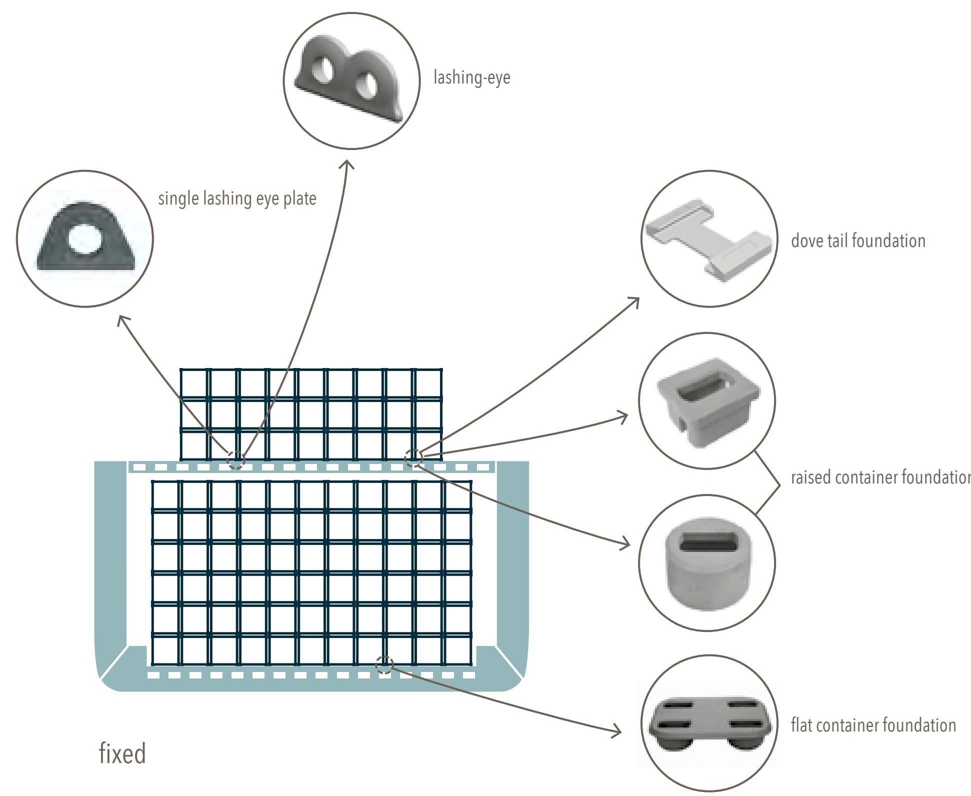
There is a large variety of lashing components and systems on the market today. For example, the catalogue of one of the leading manufacturers of container lashing equipment lists 160 types of fixed lashing equipment and 50 types of loose lashing equipment. Each manufacturer has its own range of products, which are often patented, and each year additional products enter the market. As a result, there are several hundred different types of fittings in service on board containerships today.

In addition to the distinction between fixed and loose fittings, the lashing elements can also be grouped in the following subcategories:

Deck of large container vessel with fixed and loose lashing gear

Fixed

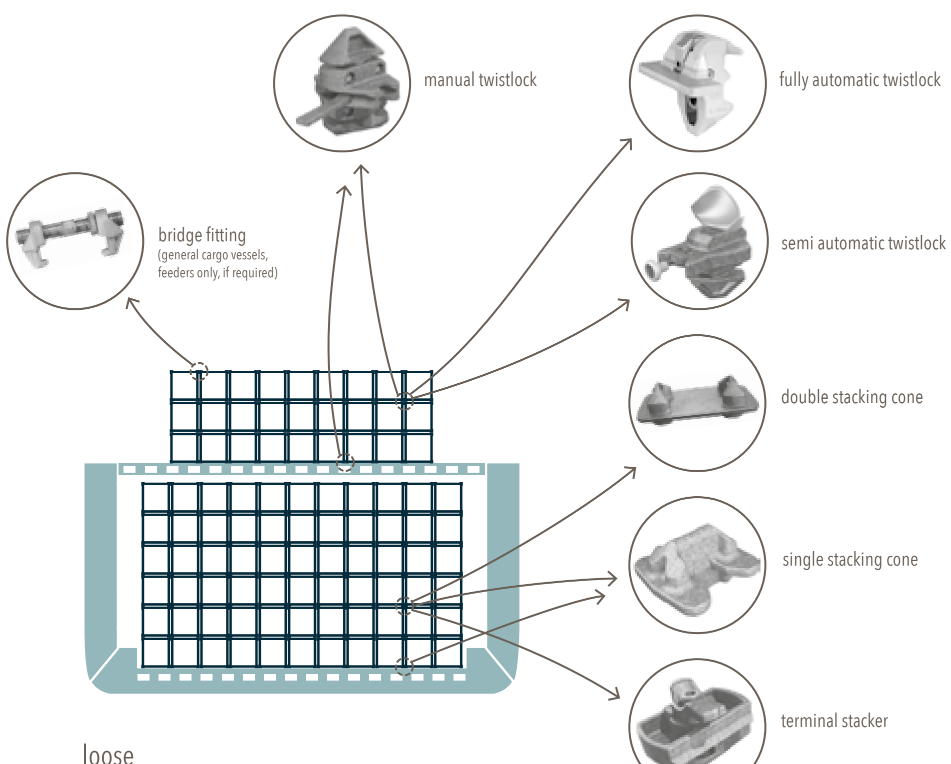
deck fittings	flush foundations, raised foundations, twistlock pockets, sliding foundations, lifting foundation sockets, base plates, dovetail foundations, etc.
lashing points	D-rings and lashing eyes.



Example fixed lashing equipment

Loose

bottom fittings	base stacking cones, base twistlocks, cone plates, etc.
stacking and locking fittings	twistlocks, midlocks, automatic locking cones, single stacking cones, terminal fittings, stackers, etc.
block stowage systems	bridge fittings, double stacking cones, pressure elements, tension pressure elements, etc.
lashings	turnbuckles, lashing chains and lashing rods, etc.



Example loose lashing equipment

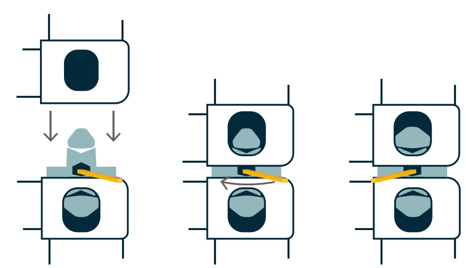
The most important piece of lashing equipment in most of today's systems is the twistlock. Over the years, the design has undergone many changes.

Twistlocks

Twistlocks are used to attach the containers in one stack to each other. The conventional twistlock consists of two cones connected to each other by a steel shaft, which is operated with a handle. In between the cones is a 30 mm thick plate (flange) with a collar attached to it at either side. The flange and collar sit between two containers stacked on top of each other. The upper cone sits in the bottom corner casting of the upper container and the lower cone sits in the top corner casting of the bottom container. When the handle is moved into the locked position, the two cones rotate approximately 60 degrees, locking the two containers to each other. This is done at all four corners of each container resulting in a tight connection between the two containers. A similar twistlock connection can be made between a foundation on the hatch cover and the base container of the stack. In the locked position, the vertical play of the locked cone in the container castings is no more than 12 mm. Twistlocks may close in the clockwise or anti-clockwise direction, depending on the requirement of the purchaser. There is no international standard, requiring one specific direction for closing / opening.

The principle of locking containers together using the twistlock mechanism was the invention of Keith Tantlinger, who released his patented twistlock design in June 1967. His design was the world standard for many decades (see *Keith Tantlinger, the inventor of the twistlock*).

In the late 1990's, the conventional twistlock design was criticised by the US Occupational Safety and Health Administration (OSHA) following several fatal incidents involving US longshoremen. This led to new regulations for ships calling at American ports which prohibited terminal operators from placing longshoremen on top of containers. The regulations entered into force on 26 July 1999.



Operating principle twistlock

The new regulations forced manufacturers of container lashing equipment to develop a twistlock compliant with the new OSHA regulations. This resulted in the semi-automatic twistlock (SAT), which is still widely used in the industry today. The novelty of this twistlock was the shape of the spring-loaded cones which were shaped in such a way that they would automatically engage when pushed into the ISO corner casting of the container. The advantage was that it could be attached to the container's bottom corner castings ashore, and would

Keith Tantlinger, the inventor of the twistlock

If Malcom McLean was the father of containerisation, then Keith Tantlinger was the father of the shipping container.

Keith Walton Tantlinger was a mechanical engineer and inventor. In the course of his professional career, Tantlinger was granted 79 United States patents, all related to transportation equipment. Many of his patents related to container transport, commercial highway freight trailers and transit buses.

Keith W. Tantlinger in 1958

In the 1950's Tantlinger started to work very closely with Malcolm Mclean to develop the idea of transporting goods in standardised units. Tantlinger's technical inventions were crucial to this development. His most important inventions for containers were the corner casting and in particular, the twistlock, a container locking device still in use today.

Tantlinger played a key role in the process of container standardisation, working extensively as a member of a committee of the American Standards Association (ASA) and later with ISO. Tantlinger's role in standarisation was not only technical but also commercial. Most importantly, it was Tantlinger who convinced McLean to release the patents for the container design, so that other ship operators could adopt the same designs. In 1965, ASA adopted Sea-Lands/Tantlinger's design as a global standard.

Tantlinger was born in Orange Co., California, on 22 March 1919. He was educated at the University of California, Berkeley, where he was awarded a bachelor's degree in mechanical engineering. During his professional career, Tantlinger worked as chief engineer and vice president of engineering at Brown Trailers; vice president of engineering and manufacturing at Fruehauf Corporation in Detroit; and senior vice president, ground transportation systems at Rohr Industries in Chula Vista, California.

In 2010 he was awarded the Gibbs Bros Medal by the National Academy of Sciences for 'his visionary and inventive design of the cellular containership and the supporting systems which transformed the world shipping fleet and facilitated the rapid expansion of global trade.'

Keith W. Tantlinger died at his home in Escondido, CA on 27 August 2011, at the age of 92.

Sources: NY Times 7 September 2011. *Keith Tantlinger, Builder of Cargo Container, Dies at 92*, by Margalit Foxsept
The Telegraph, 15 September 2011. *Keith Tantlinger Obituary*
The Orange County Obituary Registers

automatically lock itself during stacking of the container on board the vessel. Prior to discharge, the SATs have to be unlocked following which the container, together with the SATs in the four bottom corner castings, can be discharged ashore. The position of the upper and lower cone of the SAT can be changed by an operating wire (see below).

Depending on the design, SATs have one or two operating wires. The locking cones can be set in three different positions:

» upper cone locked, lower cone unlocked, – during discharge of the container
» upper cone unlocked, lower cone locked – when the SAT is used as a bottom twistlock and needs to stay on board during discharge
» upper and lower cone locked. This is the locked position, but is also the position when the container is loaded.

Shortly after the introduction of the semi-automatic twistlock, manufacturers started experimenting with more revolutionary types of twistlocks. These new locking devices would not require any manual manipulation prior to discharge and would lock and unlock automatically. Between 2000 and 2003, manufacturers experimented with several concepts. The preferred design, receiving class approval, had a specially shaped lower cone without any rotating elements. Consequently, the term 'twistlock' was no longer appropriate for this device, renamed a 'Fully Automatic Lock (FAL)'. In 2003, this new concept went into mass production and was delivered in

conventional twistlock

semi-automatic twistlock

fullly automatic twistlock

upper cone unlocked, lower cone locked

upper cone locked, lower cone unlocked

upper end lower cone locked

large quantities to the new containerships launched at the shipyards in Asia. In subsequent years, the FAL went through a range of modifications to optimise its functionality. Its use has been widely adopted by the industry. In addition to the fact that no labour was required to unlock the FAL prior to discharge and thereby making significant cost savings, the time containerships had to spend in port was reduced with several hours for each port call.

Twistlocks exist in many different versions, but their main purpose is to provide a minimal tension load. A 500 kN breaking load is uniform for all types. The basic functional requirements, as well as size tolerances to make the lock compatible with ISO corner castings, are laid down in ISO 1161.

Lashing rods and turnbuckles

A container stack lashed by twistlocks alone will be limited in height and weight and the on deck cargo capacity will be heavily underutilised.

For higher and heavier deck stows, lashing calculations will show that additional lashings are needed. The most commonly used method is to apply lashing rods with a tensioning device, usually a turnbuckle. The lashing rod is hooked to the corner casting of the container(s) in the lower part of the stack and subsequently, via a turnbuckle, anchored to a fixed lashing eye on the vessel. Each turnbuckle has one anchoring point on the vessel. The stowage capacity on deck can be further increased by constructing fixed lashing bridges between each 40 foot bay. These lashing bridges are one, two or three tiers high and move the anchoring points between the vessel and the lashing higher up.

Knob type lashing bar and turnbuckle combination

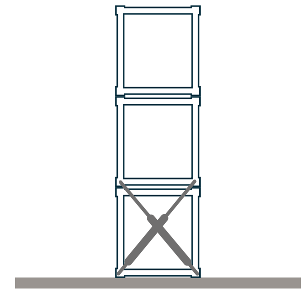
A lashing rod must be combined with a compatible turnbuckle. Although both are separate lashing elements, the lashing rod and turnbuckle are used in combinations prescribed by the manufacturer.

The most commonly used system is the knobbed lashing rod in combination with a turnbuckle with one spindle. The turnbuckle is tightened with a lever to a set tension. Manufacturers advise against overtightening the turnbuckle. Some slack can develop in the lashing during the voyage, requiring the crew to tighten it. Various additional devices are available on the market to prevent the lashings becoming slack during the voyage, e.g. 'slack reducer'.

The lashings can be applied to the container stack in different ways.
The following configurations apply for both ends of the container:

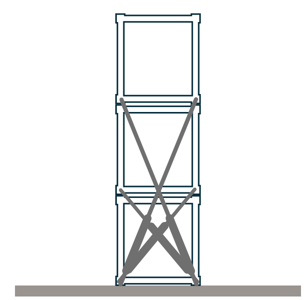
Single mode

One pair of lashings is applied diagonally to the bottom corner castings of the container in the second or third tier from the anchoring point.



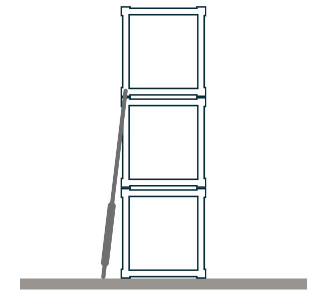
Dual mode

One pair of short lashings is applied to the bottom corner castings of the container in the second tier AND one pair of long lashings is applied to the bottom corner castings in the third tier from the anchoring point. Both pairs are applied diagonally.



Vertical mode (wind lashing)

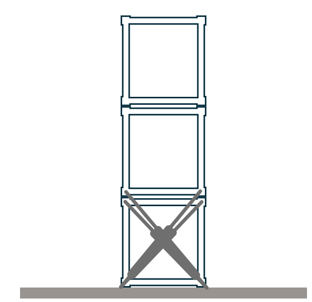
A single vertical lashing is applied to the bottom corner casting of the container in the second or third tier from the anchoring point. This is a so-called 'wind lashing' and is only applied to stacks exposed to wind.



Parallel internal lashing

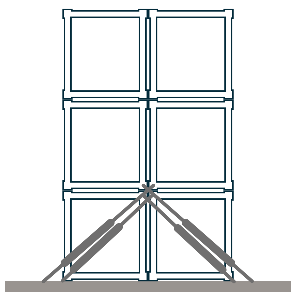
This is the most commonly used system on container vessels today, also called 'Paralash' or 'Flexilash'.

The parallel internal lashing comprises a double set of short lashings where one pair is applied diagonally to the top corner castings of the containers in the bottom tier, and another pair applied diagonally to the bottom corner castings in the second tier. The lashing rods are running almost parallel to each other.



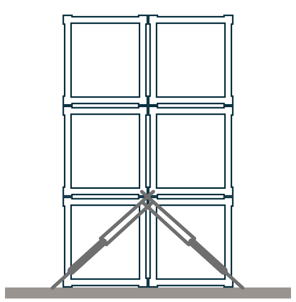
External parallel lashing

This system was introduced around 2005 with the purpose of further increasing the stacking heights and stacking weights of containers. Their application is similar to that of the internal parallel system, although the lashing hooks are applied to the lifting side of the container stack, as opposed to the compressed side as in the internal parallel system.



Equalash

The Equalash system is different as only one turnbuckle is needed for each pair of lashings and the head of the Equalash turnbuckle is equipped with a double hook system.



Lashing of containers on inland navigation barges

There are no international rules or standards for the lashing of containers on inland navigation barges as barges do not navigate in the open sea and are not exposed to significant motions.

Only a very limited number of inland barges have cell guides. Common practice in Europe is to secure containers by means of stacking cones. These cones are usually only applied to the most outboard containers at port and starboard, and only to those containers which extend above the hatch coaming. Although barges are not exposed to significant motions, sideward forces may act on the containers because of heavy side wind or when the barge is making a turn.

Container lashing routines

The stowage and lashing of containers are inextricably linked to each other. The stowage must be done in such a way that it makes the lashing plan possible and easy to execute.

Below is a list of examples where defective stowage may conflict with lashing requirements:

» the stowage in the same tier of containers with different heights using a transverse lashing system with double stacking cones and side elements
» similarly, if using a transverse lashing system as above, containers with different discharge ports are stowed in the same block
» the off-set stowage of 45 foot containers on top of 40 foot containers as they can only be lashed if they are stowed symmetrically on top of 40 foot containers
» the stowage of 30 foot containers in 40 foot cell guides, unless special arrangements are available
» the stowage of 40 foot containers in 45 foot bays on deck. Although this is possible, the reduced strength of the lashings should be considered
» the stowage of overwide containers in places where there is insufficient space in the adjacent container stack.

On the other hand, the stowage plan assumes a certain lashing arrangement. The maximum utilisation of the vessel's container capacity can only be achieved if the required lashing plan is executed.

The lashing (and unlashing) can either be done by the crew or by special lashing gangs. There is an ongoing discussion between the various interests in the industry as to who has the right to perform these operations.

Shore labour or ship's crew

There are no specific international regulations relating to port work and cargo handling, but the customary understanding is that cargo handling is done by dock workers. This may be supported by International Labour Organisation conventions such as ILO 152, (The American Occupational Safety and Health (Dock Work) Convention), and the ILO 137, (Dock Work Convention, 1973), however, the implementation of these conventions depend on ratification by nation states.

There are uniform collective agreements by the International Transport Workers' Federation (ITF), including the requirement that ships' crews shall not be involved in the handling of cargo.

On the other hand, a process of deregulation is in progress as a result of increased competition between ports and the emergence of private ports and terminals. This has led to situations where port authorities may decide, for example, whether to use non-union or casual labour.

Container lasher at work

Whether the lashing and unlashing is carried out by the ship's crew, stevedores, or special lashing gangs, lashing of containers is a strenuous and hazardous task which requires training and education. Lashing rods may be up to five metres long and weigh more than 20 kg. The lashings may have to be hooked up in a narrow space, several metres above the deck or above the outboard water, during the hours of darkness and on slippery decks, sometimes covered with ice and snow. Furthermore, a vessel calling at a port to load some 3,000 containers on deck may require 10,000 twistlocks and 2,000-3,000 lashings to be applied within a tight time frame. Lashing of containers by the ship's crew on board large container vessels is therefore often impractical. Common practice is to employ special lashing gangs to perform these operations on medium-sized and large containerships, and that the ship's crew only get involved in the operations on small feeders or general cargo ships.

Safety code: Annex 14

The hazardous working conditions on board containerships have led to extensive regulations covering the operational condition as well as the design of containerships. These new regulations are covered in Annex 14 of the IMO CSS Code.

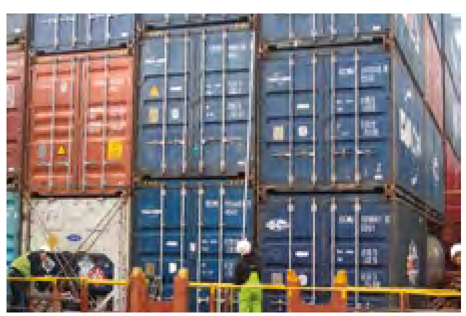
In addition, individual ports and terminals may have their own regulations and it is not unusual for inspectors to board the vessel prior to operations in order to determine whether the working conditions meet local requirements. There have been instances, e.g. in Australia, where stevedores refused to handle the ship because of unsafe working conditions. The vessel in question had to return to sea without any containers having being handled.

Discharge

Once the vessel has been cleared for the operations to commence, the containers to be discharged are unlashed first. These unlashing operations comprise the removal of the lashings and the unlocking of the semi-automatic twistlocks (SAT), unless fully automatic locks (FAL) are used.

The SATs can be unlocked from deck level by means of a light-weight aluminium pole (an actuator pole), although only containers up to the fourth tier can be unlocked this way. The twistlocks of the containers stowed higher up must be unlocked by the stevedores using a special lifting basket (see photograph). This is a time-consuming operation. The unlocking of a full deck of containers aboard a very large container vessel can easily take two to three hours.

Prior to discharge operations, the ship's steel bins with lashing material are lifted



Unlocking twistlocks prior to discharge
left: Using a so-called 'gondola' operated by the crane; right: From deck using an actuator pole

Ship-owned bins with twistlock on flatrack

Container discharged with (semi-)automatic twistlocks still attached to bottom corner castings

ashore and placed where the twistlocks are removed from the vessel. This can be on the quay or on a special platform on the crane. These bins are marked with the name of the vessel and the type of lashing material they contain. The stevedores only use the twistlocks in these bins. This procedure is followed to avoid any accidental mixing of lashing material occurring ashore, e.g. mixing with lashing material from another vessel. To remove the twistlocks from the container, the crane driver holds the container approximately 1.5 m above the quay or above the crane's lashing platform. At each end of the container, one person from the lashing gang takes out the twistlocks from the bottom corner castings and places the twistlocks in the bins.

Loading

When loading containers, the same operation is carried out but in reverse.

The procedure is different for containers which are stowed in the base tier on deck. These containers are not fitted with semi-automatic twistlocks ashore, but are placed on top of the bottom twistlocks fitted to the foundations on board. These bottom twistlocks are applied before the containers are loaded to prevent damage to the ship's container foundations.

Once the bottom containers have been loaded, the lashings can be applied. The stevedores' foreman will, meanwhile, have familiarised himself with the way the lashings need to be applied in order to meet the requirements of the ship's container securing manual.

Supervision and checks

During loading operations, the stevedores will have a deck man in attendance at each crane, or a combination of cranes, to check that the containers are stowed correctly and properly. The stevedores' deck man will not be engaged with checking the lashings, if the lashings are carried out by a special shore gang. This is usually the task of the foreman and the vessel's crew. In many ports, stevedores do not permit the vessel's crew to enter the area of the container operations for safety reasons and the crew will in such circumstances have to check the lashings after container operations are completed.

The crew's inspections will be limited to an inspection of the lashings and the bottom twistlocks. If the bottom twistlocks are of the manual type, the locking position can be checked on the basis of the position of the lever. This explains the importance of using manual twistlocks which all close in the same direction as manufacturers produce both right and left hand closing twistlocks for the bottom twistlocks.
For the container stowed above the base tier, the crew will rely on the automatic locking function of the (semi)automatic (twist)locks, but it is only possible to verify that every container is locked for those stowed in the lower tiers.

The crew will also check if the lashings have been applied in accordance with the Container Securing Manual and that they are moderately tight.

After the completion of all lashing operations, the stevedores may ask the Master to sign a voucher stating that the operations were carried out satisfactorily.

In summary, on modern large container vessels, the duties of the vessel's crew with regard to the lashing and unlashing operations are limited to an inspection of the correct application of lashing material only.

Stevedores' deck man in attendance on board during operations

Most of the work by the ship's crew will take place in the cargo office in the ship's accommodation, from where the ballast pumps and loading computers are operated. An excessive trim or list will complicate the cargo operations and can be rectified by (de)ballasting, managed from the cargo office. Dedicated container vessels are often equipped with an automatic anti-heeling system.

As the containers have been lashed for a calculated worst case scenario, adding lashings during the voyage is not standard practice. Firstly, all available lashing points on deck are most likely in use already and, secondly, lashing containers during heavy weather is very dangerous. The crew's tasks with regard to the container lashings during the voyage will involve a daily inspection and occasional additional tensioning, although no over-tensioning, where necessary.

The Cargo Securing Manual (CSM)

Legislation

According to the IMO Code of Safe Practice for Cargo Stowage and Securing (The CSS Code), all vessels carrying cargo units, defined as wheeled cargo, pallets, coils, packaged units, etc., must have a Cargo Securing Manual (CSM) on board. The manual is prepared in accordance with the IMO Code and the relevant Rules by the Classification Society. In June 2010, the IMO published MSC Circular 1 / Circ. 1353 which is the revised guidelines for preparing these manuals. The CSM summarises the lashing material required on board, the user manual for the lashing material, the general stowage principles for special cargoes etc. It also provides an explanation on how to calculate forces acting on lashing gear according to the methods described in Annex 13 of the IMO Code.

Preparation and approval

Cargo Securing Manuals are approved by the flag state authority, or by the classification society if they have been authorised by the flag state to carry out these inspections on their behalf.

The CSM must contain a separate section covering the stowage and lashing of containers if the vessel in question is approved and equipped to carry containers. This is the Container Lashing Manual, also known as the 'Container Securing Manual'. This section lists the permissible weight distribution of the containers in different bays and stacks for one or more GM values. The manual specifies the size of containers for which the manual was prepared and thereby, which size containers the vessel can carry. The calculations take into account the strength of the container, the strength and application of the fixed and loose lashing gear, the strength of the supporting structure etc. On bay-specific overviews, the manual clearly indicates which lashing element is required in which position. The CSM, including the Container Lashing Manual, is usually prepared by the suppliers of the lashing manual, employing naval architects for this purpose. After completion, the CSM is passed to the vessel's classification society for approval. The classification society verifies that the maximum permissible forces in the containers and lashings are not exceeded according to their own criteria. The Container Securing Manual must receive separate approval from the classification society.

User limitations

When relying on CSMs, the following observations should be noted:

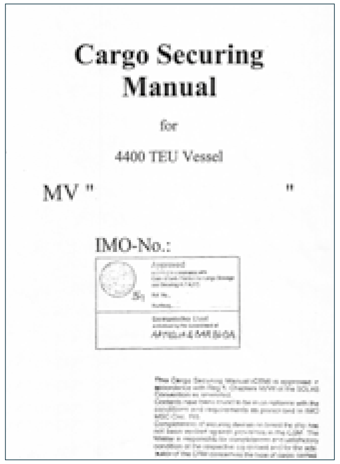
GM value

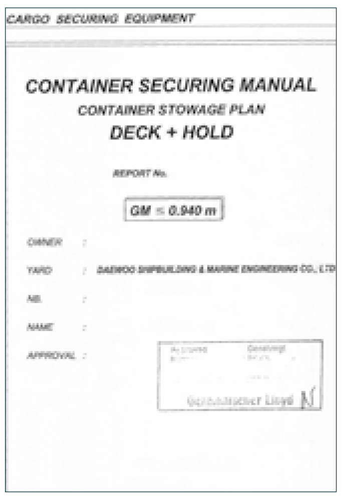
One of the main design criteria for the Manual is the vessel's stability (GM value).

Classification Societies set the lowest maximum GM value the manual must be designed for.

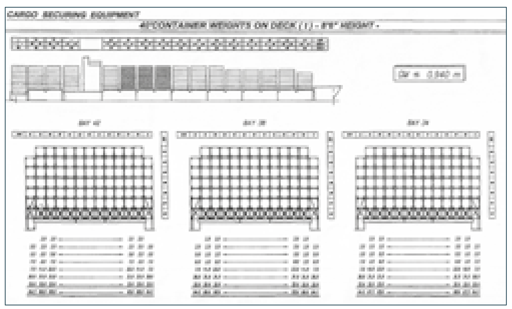
The front page of the CSM usually lists the design GM; see example on the next page.

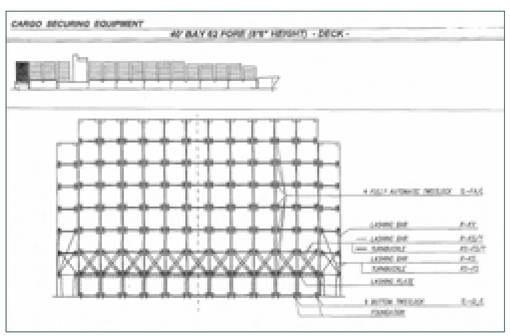
It is important that the user is aware of the fact that the CSM is invalid if the vessel operates at a GM value which is higher than the design GM. This does not mean that the vessel cannot operate at that larger GM value, but the implication is that the vessel must use alternative means to establish that the forces acting on the containers and lashings remain within the permissible values. This can, for example, be done using class approved software programmes.





Top: Cargo Securing Manual frontpage
Below: Container Securing Manual frontpage





Top: Page from CSM showing container stowage and. weight overview per bay
Below: Page from CSM showing lashing arrangement

The ship's crew has limited control over the vessel's GM value on every part of the voyage, as this largely depends on the weight distribution of the containers on board. Coastal voyages with only part of the deck space occupied are typically voyages with high GM values. The GM value will usually be less during ocean voyages, particularly on transits where the vessel is loaded up to its capacity, e.g. China-US and China-Europe.

It is important to understand the principle of the design GM value and this may be explained as follows: Classification Societies set a certain value of the GM value to ensure that the CSM is not designed for an unrealistically low GM. The design GM

differs between classification societies as the Rules for each classification society are different. For example, the classification society Lloyds Register calculates the design GM on the basis of the width of the vessel, whilst DNV/GL includes the freeboard distance and stacking height on deck. Classification societies also stipulate that the CSM is calculated based on two GM values, for example 2.5 per cent and 7.5 per cent of the vessel's width; see the Rules of Lloyd's Register.

Roll angle

Another important design principle for the Container Securing Manual is the 'design roll angle'. Classification societies incorporate in their Rules formulas for calculating the amplitude of the design roll angle. Alternatively, the classification society may take into consideration additional information provided by the shipowner, such as model tests or computer simulations. The current range for design roll angles for containerships varies between 17 and 30 degrees, whereby the lower range of roll angles applies to the very large ships.

The front page of the CSM usually lists the design roll angle, otherwise the classification society can provide it.

Container dimensions

The Container Securing Manual states the container sizes the CSM has been designed and approved for. Should different container sizes be carried, the classification society may require an extension of the CSM. This applies particularly to high-cube containers with a high centre of gravity requiring additional lashing components.

Container lashing software

Container lashing calculations are very complex and cannot be replaced by general rules of thumb or methods based on common sense. To complicate things further, the manner of calculation differs between the classification societies.
The vessel's staff must evaluate the safety of the stow in a relatively very short period of time. It would be impossible to make these assessments for ships carrying several thousand containers. Therefore, the use of computer programs with specialised container lashing software has become standard on board containerships. These programmes are approved by the relevant classification society and are capable of reading the BAPLIE files (Bayplan occupied and empty containers Edifact message) commonly used in the communication between the planners and the vessel.

As previously indicated, the CSM is valid only for certain GM values, which is problematic if the ship operates at a higher GM value. The following are typical examples which describe the problems and explain the need for lashing software:

Example 1

The CSM for a 6,500 TEU vessel shows a maximum design GM of 1.65 m. The CSM shows that the containers in a particular bay on deck can be stowed six tiers high only and that the weight in the top tier should not exceed 7 tonnes. During the voyage in question, however, the GM appears to be 3.30 m. If the Chief Officer ignored the effect of the actual GM being twice the design GM, the forces acting on the lashings at the base of the container stack would increase by approximately 75 per cent. If the ship were to encounter heavy weather and would roll at its design roll angle of, for example 22 degrees, the permissible forces would be exceeded and the stow would be at risk of collapse. Using lashing software and recalculating the forces for a GM of 3.30 m, the Chief Officer will establish by how much to reduce the tier weight and/or stack height to keep the forces within permissible limits.

Example 2

The same CSM shows that in a certain bay on deck the containers can be stacked six tiers high, and that the tier weight from the base to the top is: 30 t, 20 t, 20 t, 15 t, 10 t, 7 t. The maximum stack weight is then 102 tonnes. However, containers are never loaded exactly as prescribed by the CSM. If, for example, the container in the bottom tier weighs 21 tonnes instead of 30 tonnes, the first instinctive reaction may be that the forces will be less than the example given in the CSM, and the stowage would therefore be safe. However, the opposite is the case as less weight in the bottom tier will create higher forces as the centre of gravity of the stack moves upwards.

There are several container lashing programmes available on the market. Most of these programmes form part of the ship-specific loading computer. The advantage of these integrated systems is that the results from the stability calculations can be included in the lashing calculations, meaning that the crew always has an overview of the actual situation. Most programmes will give a warning indication if any securing components or individual containers are likely to be overloaded.

5.9
Major containership incidents

Over the last decades, containerships have been involved in several major incidents. A review shows that these incidents can be divided into the following categories according to the nature of the incident:

- **cargo related fires and explosions**
- **grounding**
- **capsizing, loss of stability**
- **structural failure**
- **container losses**

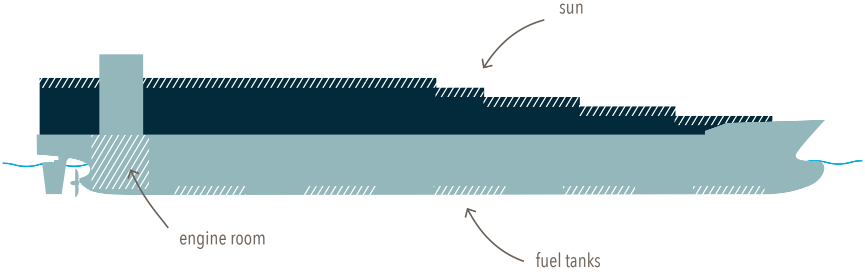
Major cargo related fires and explosions

A fire aboard a containership can be very intense and difficult to control and extinguish, especially if the fire starts in the cargo hold. The tight stowage means that the source of fire can be difficult to locate and difficult to access once the fire has spread to adjacent container stacks.

Several of these major incidents involved chemical cargoes liable to spontaneous combustion. This is a process of self-heating followed by a rapid acceleration to high temperatures which finally leads to ignition. The causes of spontaneous combustion, or ignition, can be the unstable nature of the cargo itself, production errors, a reaction with other substances or heating by an external source which starts / accelerates

Total devastation of vessel and containers from a cargo fire / explosion

the process of self-ignition. Heat sources on board a containership can be fuel tanks, the engine room bulkhead and strong sunlight on containers stowed on deck. Fire and explosion incidents are very severe and frequently lead to the total loss of the vessel and all its cargo. It may take weeks or even months to extinguish the fire and large



Containership heat sources

year	vessel(s)	incident / cargo
1996	HANSA CLIPPER	Cargo fire (barbeque coal)
1996	MARLENE S.	Cargo fire (barbeque coal)
1997	BELLATRIX	Cargo fire (barbeque coal)
1997	CONTSHIP FRANCE	Cargo fire / explosion (calcium hypochlorite)
1998	ACONCAGUA	Cargo fire / explosion (calcium hypochlorite)
1998	DG HARMONY	Cargo fire / explosion (calcium hypochlorite). Total loss
1998	CMA DJAKARTA	Cargo fire/explosion (calcium hypochlorite)
2002	HANJIN PENSYLVANIA	Cargo fire/explosion
2004	NYK ARGUS	Hot stow
2006	HYUNDAI FORTUNE	Cargo fire/explosion
2006	YM GREEN	Cargo fire/explosion
2010	CHARLOTTE MAERSK	Cargo fire
2012	MSC FLAMINIA	Cargo fire/explosion. Loss of life
2012	AMSTERDAM BRIDGE	Cargo fire
2013	MAERSK KAMPALA	Cargo fire
2013	CMA CGM LILAC	Cargo fire
2013	HANSA BRANDENBURG	Cargo fire
2013	EUGEN MAERSK	Cargo fire
2015	CAPE MORETON	Cargo fire
2015	KAMALA	Cargo fire
2015	HANJIN GREEN EARTH	Cargo fire
2015	ALULA	Cargo fire
2015	MOL CONTRIBUTION	Cargo fire
2015	MARENO	Cargo fire
2015	BARZAN	Cargo fire

quantities of cooling and extinguishing water are needed. Subsequently, the clean-up and removal of the waste and fire extinguishing water is a very time consuming and costly exercise.

Other incidents involving hazardous cargoes are mainly due to leakage and disruption caused by mis-declaration of the cargo. These irregularities can become apparent when the container has been loaded on board or is still at the terminal

and, depending on the hazardous nature of the cargo, can result in significant extra costs and delays.

Clearly, there are significant risks related to the carriage of hazardous substances which explains why the transport of these goods is heavily regulated. The overarching regulations are SOLAS (the International Convention for the Safety of Life at Sea) and MARPOL (the International Convention for the Prevention of pollution from ships), the regulations of which are contained in the International Maritime Dangerous Goods (IMDG) Code. Around seven to ten per cent of all containerised cargoes are hazardous substances in one form or another. The regulations contained in the IMDG Code therefore form part of virtually all containership operations.

Several hundred thousand substances classified as hazardous may be carried in containers. Each substance is classified according to its hazardous nature. The IMDG Code has nine hazardous cargo classes. If a substance has more than one dangerous characteristic, a subsidiary risk is added to the classification.

The vessel must be in possession of a valid Document of Compliance. The document is issued by the flag state and has an appendix which sets out, in compliance with the class requirements, the locations where dangerous goods can be stowed. It is also based on the particulars of the fire-fighting and fire / smoke detection systems, the rate of hold ventilation, the electrical equipment and bilge system.

There are rules regarding segregation which must be followed when stowing containers with dangerous cargo on board and these must to be taken into account already at the stowage planning process. Usually, the planning of the stowage of the container with hazardous cargo is done by the central planner of the shipping line and subsequently executed by the terminal. On smaller container vessels (e.g. feeders, general cargo vessels), the IMDG planning is done by the Master or the terminal.

Each dangerous cargo shipment must be accompanied by a Dangerous Goods Declaration / Container Packing Certificate supplied by the shipper. This is a signed certificate or declaration stating amongst others that the consignment, as offered for carriage, is properly packaged, marked, labelled as appropriate and in an appropriate condition for carriage.

Information related to the hazardous cargo must be immediately available at all times for use in an emergency. This information is contained in separate documents, safety data sheets or the Emergency Response Procedures for Ships Carrying Dangerous Goods (EMS Guide) combined with the transport document and the Medical First Aid Guide for use in accidents involving dangerous Goods (MFAG).

The IMDG Code requires the Master to prepare a list of dangerous cargo on board, listing the relevant information such as container number, line operator, port of loading / discharge, dangerous goods class, UN number, proper shipping name, weight, flash point, EMS, etc.

Major grounding incidents

The most common causes of grounding are engine failure, anchor failure or human (navigational) error. In that respect, the risk of grounding is no different for a containership than for any other type of vessel, except that the wind load could have a large impact on the navigation of the vessel because of the large number of containers on deck.

The consequences of a grounding incident can, however, be much more complex for containerships.

Ships hard aground and unable to be refloated using own power or tugs, need to be lightered. This is the removal of weight from the vessel in order to reduce the vessel's draught, respectively pressure on

year	vessel(s)	incident / cargo
2001	HEINRICH BEHRMANN	Grounded. Zeebrugge Belgium
2001	CMA CGM NORMANDIE	Grounded Singapore Strait
2002	ALVA STAR	Grounded Zakinthos, Greece
2002	CONTI SEATTLE	Grounded Miami, USA
2003	SEALAND EXPRESS	Grounded Table Bay. South Africa
2005	FOWAIRET	Grounded and fractured. Scheldt river, Netherlands
2005	APL PANAMA	Grounded Ensenada beach Mexico
2005	CP VALOUR	Grounded Azores. Oil pollution
2006	SAFMARINE AGULHAS	Grounded Port East London, South Africa
2006	ROKIA DELMAS	Grounding west coast, France
2008	ISLAND INTREPID	Grounded Miami
2009	WESTERHAVEN	Grounded Belize
2010	PACIFIC VOYAGER	Grounded Jamaica
2011	RENA	Grounding, Tauranga New Zealand
2011	CAFER DEDE	Grounding Syros, Greece
2012	CELIA	Grounded Valencia (storm)
2012	SUNRISE	Grounded Valencia (storm)
2012	BARELI	Grounded off Fuzhou, China
2014	YUSUF CEPNIOGLU	Grounding Mykonos
2015	MOL EXPRESS	Grounded Tateyama, Japan

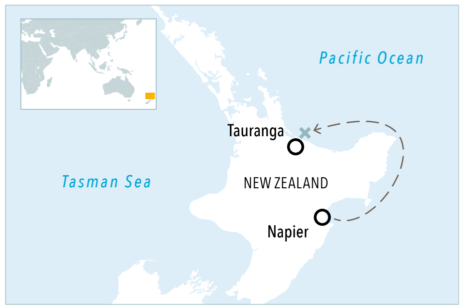
the seabed. Sometimes it can be enough to discharge the ballast water and fuel from the vessel, but if more weight needs to be removed, containers have to be discharged. Most modern containerships do not have on board cranes and, therefore, mobile or floating cranes must be used.

These cranes are not always readily available and it may take quite some time before they reach the stranded vessel (see *The grounding of the RENA*). In the meantime, the emergency situation can seriously deteriorate.

Salvors have voiced concerns regarding a possible casualty involving containerships as so far, salvage operations of grounded containerships have only involved medium-sized ships and that no cranes would be available to lighter the latest generation of ultra large container vessels.

The grounding of the RENA

On 5 October 2011, at 02:20 hrs , while sailing in clear weather from Napier to Tauranga, New Zealand and with a speed of 17 knots, the MV RENA ran aground on the Astrolabe Reef close to Tauranga port. The ship was carrying 1,368 containers, 1,700 tonnes of heavy fuel oil and 200 tonnes of marine diesel oil.



The bow section was wedged on the reef and its stern section was afloat with a significant list to port. Two of its cargo holds were flooded and there were several fractures in the hull. The day after the grounding, oil was seen spilling from the vessel. During a storm on 10 October 2011, the vessel changed from a port to a starboard list and containers were lost overboard. The entire crew was evacuated from the vessel and both oil and containers from the stricken vessel were washing ashore.

Salvors managed to remove some 1,300 tons of heavy fuel from the vessel and started the operation to remove the containers. This was a very complex task as the ship was listing nearly 20 degrees. On 8 January 2012, the fore and aft ship separated during a storm. The fore ship remained on the reef and the aft part sank on the slope of the reef. In early April 2012, the stern section of the vessel sank in 65 m of water. On 5 April 2012, the Lloyd's Open Form (LOF) contract between salvors and the owners of the vessel was terminated and the removal of the containers was continued under a Wreckhire contract. By June 2012, all containers had been discharged from the fore ship.

Grounding of container vessel. Westerschelde approach to Antwerp. Salvage in progress

Major capsizing incidents

year	vessel(s)	incident / cargo
2000	DONGEDIJK	Capsized in the approach to the Suez Canal
2007	EXCELSIOR	The river Rhine
2010	ANGELN	Ship capsized and sank after departure from St. Lucia
2011	DENEB	Ship capsized at berth in Algeciras

A ship capsizes because of loss of stability. Only rarely does the capsizing (or heavy listing) of a containership result in the loss of the vessel. This is mainly due to the fact that, as the vessel heels over, containers are lost overboard and the vessel regains stability and returns to an upright position.

It is generally smaller containerships and barges which are prone to large reductions in stability when loaded.

The following factors are important in the stability of containerships:

Loading sequence

Stability requirements may demand that the heavier containers are loaded in the cargo holds and the lighter container loaded on deck. This loading sequence will require careful planning as the heavy containers need to come alongside the vessel first before the lighter containers are loaded on deck.

Reduction in freeboard

Width and freeboard are the main dimension determining the stability of an empty vessel. The wider the ship and the higher the freeboard, the better the ship's stability will be. The freeboard is particularly important as it determines the angle at which the deck edge is under water.
As soon as the deck edge is under water, the stability will decrease.

Flag states permit vessels to be constructed with a relatively low freeboard in certain circumstances. These types of ships are particularly popular in the short sea and feeder trade.

Container centre of gravity

Errors in the stability calculation can occur if the container's centre of gravity has been estimated too low. Classification societies use 0.4 or 0.45 times the container height as the container's centre of gravity.

Container height

Containers are either 8'6" (standard height) or 9'6" high (high-cube). While the difference in height is only one foot, 30.5 cm, and a difference in the centre of gravity will therefore not be significant for the individual container, a large number of incorrect heights can have an adverse effect on the vessel's overall centre of gravity.

Container weights

The stability calculations on board are based on the weights listed in the bay plan. If these weights are, for whatever reason, incorrect, the consequences can be significant. There are no means available to the vessel's crew to visually check the weight of the container. The only option available is to check the vessel's draught readings and to compare these readings with the vessel's calculated draught produced by the loading computer. This difference is referred to as 'dead load'. However, the dead load value gives an overall indication only and does not indicate the location of the weight differences.

The issue of container weights has been highlighted in many investigation reports following incidents involving aspects of stability, hull strength or lashing failures. This has resulted in new regulations, which will come into force on 1 July 2016.
(see *Chapter 6 Container weights*).

Major hull failure incidents

year	vessel(s)	incident location
1997	MSC CARLA	Broken in the Azores
2007	MSC NAPOLI	Hull fracture in the English Channel
2013	MOL COMFORT	Broken and sunk in the Arabian Sea

The consequences of these structural failures are clearly very significant. With the total loss of the vessel and 4,382 containers, the MOL COMFORT became the largest casualty in container shipping (see *The loss of the MOL COMFORT).*

All three mentioned incidents occurred in the open sea during heavy weather. Another common feature of these incidents was that the ships broke around the mid-ships area. Research into these incidents has focussed on the hull strength and current regulations for containerships operating in seagoing condition as well as into the effect of improperly declared container weights.

Following the MOL COMFORT incident, IACS developed two new Unified Requirements, namely UR S11A (longitudinal strength standard for containerships) and URS 34 (functional requirements for direct analyses by finite element method of containerships, including a set of loading conditions).

The loss of the MOL COMFORT

The MV MOL COMFORT was a post-Panamax containership, built in 2008 at Mitsubishi Heavy Industries in Japan. On 17 June 2013, the vessel broke in two at her mid ships section while transiting the Arabian Sea, on her way from Singapore to Jeddah with 4,382 containers and some 3,000 tonnes of fuel on board. The 26 crew abandoned the vessel and were rescued by other ships nearby diverted to the site of the incident.

Following the structural failure, both sections of the vessel remained afloat with the majority of the cargo intact. Salvors were contracted to tow the sections to safety. However, on 25 June the stern section sank to a depth of 4,000 m before any salvage operation could commence.

The tow of the bow section broke free in adverse weather on 2 July and on 6 July a fire broke out in the bow section, destroying most of the 2,400 containers on board. The following night, the damaged bow section sank to a depth of 3,000 m.

The sinking of the MOL COMFORT is said to have cost insurers between USD 300-400 million in claims, excluding the cost for the loss of the vessel and machinery. After the incident, sister ships of the MOL COMFORT were withdrawn from service and their hull structures upgraded to increase the longitudinal strength.

In 2014, IACS launched an expert group on structural safety of containerships. The team carried out a review of the MOL COMFORT incident, which also took into account a number of past incidents.

Container collapse and loss of containers

Major container loss incidents (total ship losses excluded)

year	vessel	quantity lost/damaged
1998	APL CHINA	406 lost/1,000 damaged
2000	OOCL AMERICA	350 lost/217 damaged
2014	SVENBORG MAERSK	517 lost/250 damaged

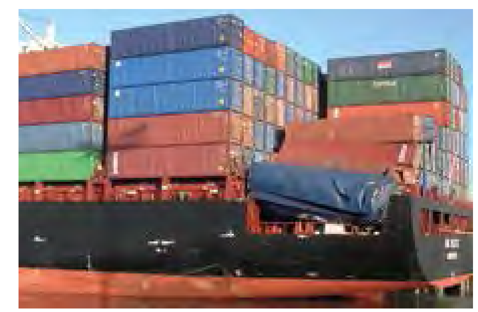
According to the World Shipping Council, 546 containers on average are lost at sea each year, excluding catastrophic events. When including catastrophic events, such as the RENA and the MOL COMFORT, the average is a total of 1,679 containers.

A major container insurer published statistics indicating that every year 10,000 containers are involved in container collapses and that some 2,000 containers are lost overboard during these incidents.

Whatever the actual number is, the number of containers lost at sea vary between incidents: from a single container to several hundred on one occasion. Not every collapse of stow results in a loss of containers overboard. For example, a collapse of containers under deck does not result in a loss overboard. Collapse of on-deck stowed container stows may result in only part of the containers being lost overboard.

When excluding lost containers from a total loss or ship incident, the largest container losses have been recorded from three major incidents, see above.

Various reports and scientific research papers have been published on these incidents. These listed heavy weather, high sea state and excessive rolling of the vessels at the time of the incidents as important contributory factors.



Ship in port after having lost containers at sea

In 2009, a joint industry project led by a Dutch research institute looked at the causes of container losses from several other incidents. They also did a survey amongst masters of containerships. Apart from the already mentioned heavy weather and excessive rolling of the vessel, the investigations by the project team identified issues such as lashing and stowage failure, the declared weight of the container, and high vertical accelerations from slamming as additional potential factors.

Chapter 6
The container

The following topics are covered in this chapter:

- Definition
- Container owners
- Regulations governing the transport of freight containers
- Certification and testing of new containers
- ISO Standards
- Requirements on the design and construction of containers
- Types of containers
- Labelling and marking of containers
- In-service inspections of containers
- Maintenance and repair
- Container security.

20 foot and 40 foot containers

6.1

Definitions

Many different terms are used when referring to containers used to carry freight. In its most generic form, a container may be defined as 'An object for holding or transporting something' (Oxford dictionary), or more specific as a 'large cargo-carrying standard-sized container that can be loaded from one mode of transport to another' (Collins English dictionary) or a 'standardized re-sealable transportation box for unitized freight handling with standardized equipment' (Business dictionary).

Over the years, various organisations involved in standardisation and regulation in the transport industry have developed more refined definitions.

The Convention for Safe Containers 1972 (CSC) and ISO Standard 668 both provide the regulatory definition of a container as follows: 'Container means an article of transport equipment:

a of a permanent character and accordingly strong enough to be suitable for repeated use
b specially designed to facilitate the transport of goods, by one or more modes of transport, without intermediate reloading
c designed to be secured and/or readily handled, having corner fittings for these purposes
d of a size such that the area enclosed by the four outer bottom corners is either
i at least 14 sq.m. (150 sq.ft.) or
ii at least 7 sq.m. (75 sq.ft.) if it is fitted with top corner fittings.

The term container includes neither vehicles nor packaging; however, containers when carried on chassis are included.'

The requirements contained in the Convention apply to the great majority of freight containers used globally, except those designed for carriage by air.

Also used is the term 'Cargo Transport Unit' (CTU), being 'A freight container, swap body, vehicle, railway wagon or any other similar unit in particular when used in intermodal transport' (CTU Code: the 2014 IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units). This definition is similar to that of an Intermodal Transport Unit (ILU).

ISO container

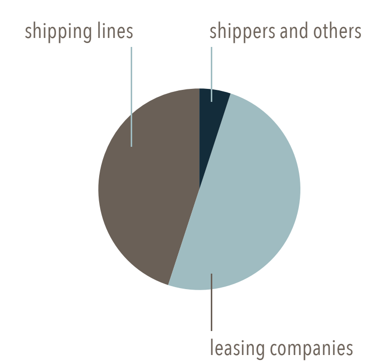
This term is used in many shipping contracts, classification requirements, software, on-board manuals etc.
'An ISO freight container refers to a freight container (in the context of the CSC Convention) complying with all relevant ISO standards in existence at the time of manufacture' (def. ISO 668).

6.2

Container owners

Containers are owned either by shipping companies or container leasing companies. Traditionally, shipping lines owned the largest number of containers worldwide, but since 2014 this position has been taken by the container leasing companies who currently own some 50 per cent of the total word fleet of containers. (Source: World Cargo News). In addition, a very small percentage of containers is owned by shippers.

Millions of new containers enter the market every year. China accounts for more than 90 per cent of the global production of containers. In 2015, some 60 per cent of the newly manufactured containers were acquired by leasing companies. No shipping line in the world would be able to meet the demand for containers by using their own fleet of containers only and all use the services of container leasing companies.



Container owners (2015)

In the 1970's, when containerisation became global, leasing companies emerged in order to offer shipping lines flexibility in the management of their containerised assets. This appeared to fulfil a demand in the market and additional leasing companies entered the business in the following decades. In the 1990's a period of consolidation took place which resulted in the current position where nearly 50 per cent of the globally leased container fleet is owned by the four largest leasing companies, each owning a fleet of more than 1 million TEU.

The major advantages of leasing containers are flexibility, local availability and, depending on the contract used, the possibility of leaving the empty container at its destination. Furthermore, the lessee, i.e. the party which leases the containers from the leasing company, is not responsible for the maintenance and repair of the container, its certification etc. This is done by the lessor, i.e. the leasing company.

From an operational point of view, leasing containers is more expensive than owning containers. The largest container leasing companies are Textainer, Triton Container Int. Ltd., TAL International and Florens. Each own and manage a fleet of several million containers, through a global agency network of offices and container depots.

6.3

Regulations governing the transport of freight containers

All types of containers have to comply with international regulations governing road, rail and sea transportation. This chapter provides an overview of the most important regulations and codes governing the transport of freight containers.

The International Convention for Safe Containers (CSC) 1972

Due to the rapid increase in the use of freight containers and the development of specialised containerships, the International Maritime Organization (IMO) instigated a study of the safety of containerisation in sea transport in 1967. The container itself emerged as the most important aspect to be considered. IMO, in co-operation with the Economic Commission for Europe (UNECE), developed a convention which was adopted by the United Nations and the IMO in 1972. This convention is known as the 'International Convention for Safe Containers' (CSC).

The aim of the Convention is to ensure a high level of safety for personnel during handling and transport of containers and also to facilitate international trade by providing uniform international safety regulations. The CSC made the approval of new containers mandatory and was a welcome means of regulating the construction and safety of containers. The Convention contains procedures for the approval of new containers to be enforced by the State Party, or organisations authorised by such State Parties. The evidence of such approval, a Safety Approval Plate, is recognised by all once granted by a State Party. The system would allow the cross border movement of containers with a minimum of safety and custom formalities. Interestingly, the CSC was not introduced for the safety of the cargo carried in the containers, but for the safety of the people working around them.

Cover CSC

Several amendments to the CSC have been implemented since 1972. Most of these were agreed following recommendations by the IMO or following reports by various Maritime Administrations into container casualties. The most important amendments were:

- Clear provisions for containers operated under the Approved Continuous Examination Programme (ACEP) including detailed requirements for a review of these programmes every ten years.
- Containers where the stacking and racking values are less than 192,000 kg. or 150 kN respectively, e.g. certain types of 30 foot bulk containers, swap bodies etc., must be conspicuously marked to clearly differentiate them from standard ISO containers. The implication of this new requirement was that all non-ISO containers must to be re-marked before 1 July 2015.
- Testing and marking requirements for containers operated with one door off.
- The introduction in 2005 of so-called 'Serious Structural Deficiencies', listing the most sensitive components of a container with their maximum permissible damage permitted. This list was expanded and became more detailed following the 2014 amendments. The purpose of this list was to assist the designated persons (authorised officers) in deciding whether the movement of a container should be stopped or restricted.

Note

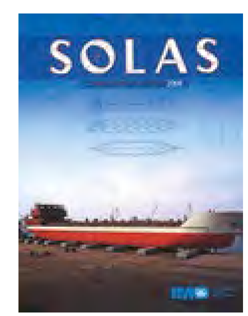
The CSC permits governments to approve containers that do not meet the structural criteria of the International Organization for Standardization (ISO - see below). Most stowage systems on board ships and container constructions, however, must conform with ISO and, as a result, the use of containers that do not conform with ISO standards is not recommended unless specific provisions are in place.

Other IMO regulations

In addition to the Convention for Safe Containers, there are numerous other international rules and regulations which apply to ships carrying containers, the most relevant of which are imposed by the International Maritime Organization (IMO), such as:

The Safety of Life at Sea Convention (SOLAS)

The SOLAS Convention, including its many amendments, govern all areas of safety at sea for all types of ships, including purpose-built containerships and ships that only occasionally carry containers.

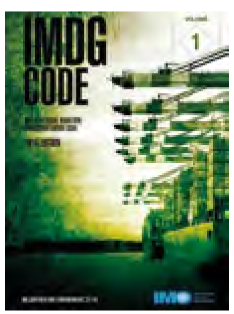


Cover SOLAS

Cover CSS Code

The Code of Safe Practice for Cargo Stowage and Securing (CSS Code)

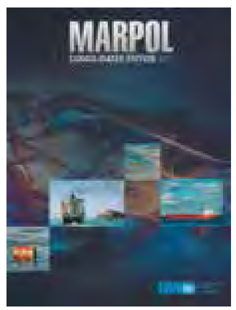
The CSS Code is referenced in Chapter VI of the SOLAS Convention. The Code establishes general principles for safe stowage and securing and is intended to provide an international standard for the level of forces likely to be encountered during sea transport. An important mandatory requirement in this Code is the Cargo Securing Manual (CSM) which must be found on board all ships needing to secure cargo.



Cover IMDG Code

The International Maritime Dangerous Goods (IMDG) Code

This instrument forming part of the SOLAS Convention governs the transport by sea of packaged dangerous goods. Apart from carriage requirements, the IMDG Code also concerns itself with terminology, classification, documentation, packaging, labelling, marking, stowage and segregation, emergency response etc. The impact of the Code therefore extends beyond the usual ship and shore side operations involving packaged dangerous cargo. The Code is under permanent review and amendments are published at regular intervals, usually every two years.



Cover MARPOL

Regulations for the Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form

The jettisoning of harmful substances carried in packaged form, including from containers, is prohibited under Annex III of the IMO Convention for the Prevention of Pollution from Ships (MARPOL), unless the action was necessary for the purpose of securing the safety of the ship and crew. These regulations set out packaging and stowage requirement for marine pollutants to minimise any accidental pollution. These regulations are also linked to the definitions in the IMDG Code.

Protocol on Preparedness, Response and Co-operation to Pollution Incidents by Hazardous and Noxious Substances (OPRC-HNS Protocol)

This protocol entered into force in 2007 and aims to provide a global framework for international co-operation in the combating of major incidents or threats of marine pollution from ships carrying hazardous and noxious substances (HNS), including those carried in containers. One of the important requirements of this Protocol is that ships subject to the regime have to carry a Shipboard Marine Pollution Emergency Plan on board.

In addition to the above, the following more general IMO regulations are important:

- » The IMO International Safety Management (ISM) Code
- » The IMO International Ship and Port Facility Security (ISPS) Code
- » The IMO Convention on Standards for Training and Watch keeping for Seafarers (STCW)
- » The IMO Convention for the Prevention of Pollution from Ships (MARPOL)
- » The IMO Convention on Facilitation of International Maritime Traffic (FAL Convention) including binding regulations concerning stowaways

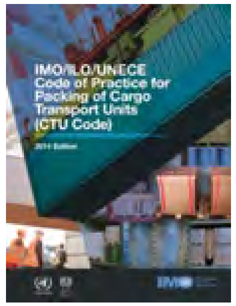
Other requirements

Containers may also have to comply with other requirements including those for railway and road transport or for particular uses, such as:

- » The US Occupational Safety and Health Administration (OSHA) with specific requirements for containerships calling at US ports
- » The International Labour Organization (ILO)
- » The WCO Customs Convention
- » The International Union of Railways (UIC)
- » The Association of American Railroads (AAR)
- » The US Federal Railroad Association (FRA)
- » The European Regulations concerning the carriage of Dangerous Goods by Rail (RID)
- » The European Agreement concerning the carriage of Goods by Road (ADR)
- » The US Department of Transport Regulations CFR 49 for the transportation of Intermodal and Portable tanks
- » The United Nations Customs Convention on the International Transport of Goods under cover of TIR carnets 1975
- » For foodstuffs and thermal and reefer containers: The United Nations Agreements on the International Carriage of Perishable Foodstuffs and on the Special Equipment to be used for such Carriage (ATP Convention)
- » Cargo liability conventions (Hague-Visby Rules, Hamburg Rules, Rotterdam Rules, UNCITRAL), etc.

The IMO / ILO / UNECE Code of Practice for Packing of Cargo Transport Units (CTU Code)

The CTU Code is an important code of practice for the carriage of cargo in containers. The Code provides advice on the safe packing of cargo transport units (CTUs) to those responsible for the packing and securing of the cargo and to those whose task it is to train people to pack such units. The aim of the Code is to provide details of correct packing and securing of CTUs and it gives practical advice to ensure the safe packing of cargo onto or into CTU's. The CTU Code contains information and advice for all parties in the supply chain up to and including those involved in unpacking the CTU. The CTU Code is not intended to conflict with, or to replace or supersede, any existing national or international regulations which may refer to the packing and securing of cargo in CTUs, in particular existing regulations which apply to one mode of transport only, e.g. for transport of cargo in railway wagons by rail only.



Cover CTU Code

There are several other Guidelines or Codes of Practice applying to containerised transport, such as for example the The International Maritime Fumigation Organisation (IMFO) Code of Practice, providing guidance to fumigators and ships' masters in respect of the use of pesticides and fumigants.

6.4 Certification and testing of containers

According to the Convention for Safe Containers (CSC), the government of a contracting party under whose authority containers are approved (the administration) shall have procedures in place for the testing, inspection and approval of containers. The Convention, however, may entrust these tasks to organisations authorised by that government.

Most contracting governments have authorised classification societies to approve the design, inspection and testing of new containers. Classification societies certify containers just as they do vessels and they were already engaged in the container certification at the time the CSC entered into force.

However, organisations which are not classification societies can also be authorised to carry out such work. The criteria according to which containers should be tested, inspected, approved and maintained are found in Annex 1 of the CSC.

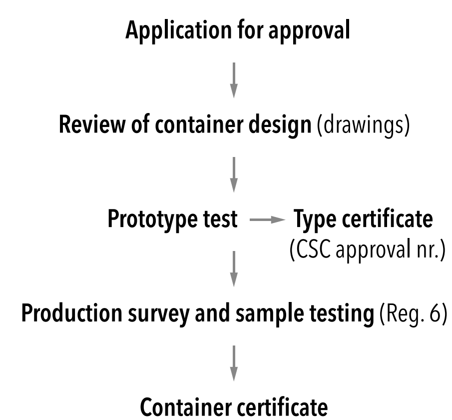
Approval and certification of new containers

The approval process by the authorised organisation normally includes:

Approval of the manufacturing process

A surveyor from the classification society will carry out an audit of the container production plant. This is to verify that the manufacturer has the capability, processes and procedures in place to continuously produce the proposed container at a consistent high level of quality. This audit is usually carried out during the production of the test containers submitted for type approval.

CSC Approval of new containers



The classification society will issue a certificate on the successful completion of the audit.

Design type approval and prototype testing

This consists of a review of documents and detailed technical drawings followed by a type approval inspection and test.
The (proto)type approval test includes:

» A visual inspection of each component of the container looking for the presence of any defects.
» A visual inspection to verify that the container is dimensioned according to the relevant ISO specification and has been manufactured within the tolerances given.
» A mass measurement to determine the tare mass (empty weight) of the container.
» Strength tests. This is the most extensive part of the type approval process. A range of clearly defined tests is necessary to determine the strength of the container sides, floor and roof, the stacking capability and lifting arrangements, the racking strengths etc. On completion of these tests, the container shall show neither any permanent deformation beyond the applicable criteria, nor any fracture or other abnormality rendering the container unsuitable for its intended use.
» A weather tightness test. On completion of the test, the interior of the container must remain dry.

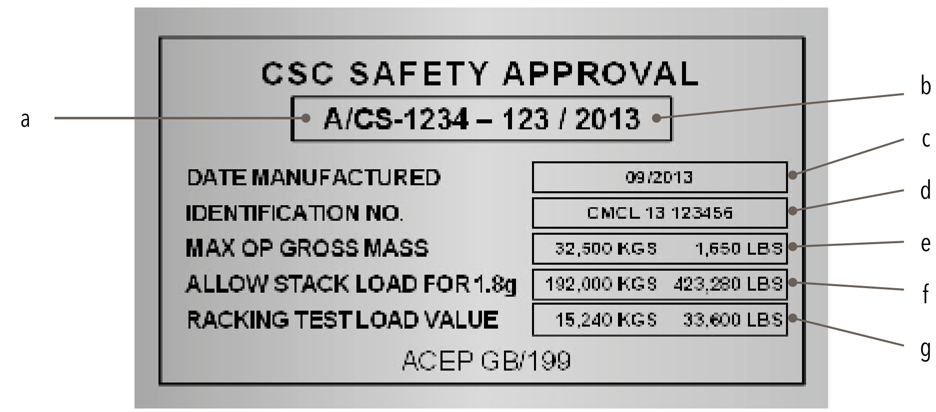
On completion and satisfactory compliance with the test criteria the classification society will issue a prototype test certificate, listing, amongst others, the type series of the container covered by the test.

Survey of the unit once in production

To ensure that all containers of a given type are manufactured in accordance with the approved design, the Administration examines or tests as many units as it considers necessary, at any stage during production of the type concerned. (CSC Reg. 6, Annex 1). This inspection comprises the same tests as the proto type tests and only a number of randomly selected containers will be tested. The racking and panel tests are normally excluded during the inspection of the unit in production. Upon satisfactory completion of the inspection, the classification society will issue a container production certificate. This certificate states the type approval certificate number and the manufacturer's serial number.

CSC approval plate

Regulation 1 of Annex 1 of the CSC deals with the safety approval plate. Each container constructed in accordance with the approved design type and which has passed the production unit inspection carries the CSC Convention safety approval plate as shown furtheron under this heading. The CSC safety approval plate must be made of permanent, non-corrosive, fireproof material, measuring not less than 200 mm x 100 mm. It contains information



CSC approval plate

about the country of approval (a), approval reference (b), date of manufacture (c), manufacturer's identification number (d), maximum gross weight (e), allowable stacking weight (f) for 1.8g (9.81 m/s^2) and transverse racking load value (g). Optionally, the plate may also list the end and side wall strength if this deviates from the CSC criteria which are, respectively 0.4 and 0.6 times the maximum permissible payload of the container. The plate has space for adding the month and year of the first examination of the new container and subsequent examination dates. The plate can also state the strength of the container with one door off. The CSC plate can be found on the exterior of the container doors. Classification societies usually place a sticker with their logo on the container door, confirming that they carried out the initial certification of the container itself and the factory producing it. This sticker is, however, only for marketing and does not evidence the approval or maintenance of the container. The all-important proof of compliance with the CSC is the approval plate.

Buyer's inspections (optional)

The buyers of the containers will want to know that the containers have been constructed exactly as agreed with the manufacturer. These inspections may include items of a less critical nature as to the overall construction, such as, but not limited to, painting, floor fitting, general appearance etc. These inspections may be carried out concurrently with the examinations undertaken by class during production, but the buyer may also choose to have an inspector present during the entire production process. The classification organisation may also be asked to perform the buyer's inspections. In order to avoid a conflict of interest, the buyer may, however, prefer to contract an external party to undertake this inspection.

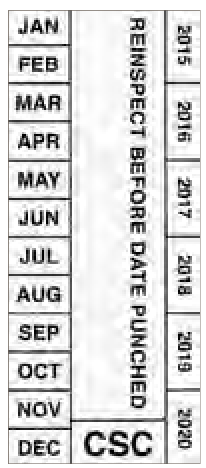
Maintenance requirements and in-service examinations

Regulation 2 of Annex 1 of CSC deals with maintenance and the requirements for examination of the container after manufacturing. The overarching principle is that *every container shall be maintained in a safe condition in accordance with the provisions of Annex 1* (Art. IV.4 of the CSC), i.e. with a stacking capability of 192,000 kg and a racking strength of 150 kN.

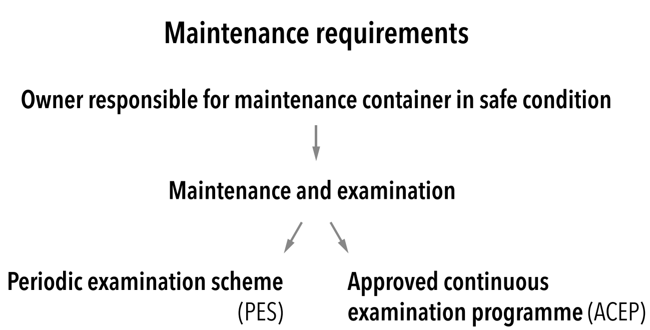
While the CSC requires new containers to be approved by a competent authority authorised by the relevant government, subsequent maintenance examinations of an approved container in safe condition is the responsibility of the container owner. For this purpose, the container owner may choose between two inspection regimes: The Periodic Examination Scheme (PES) or the Approved Continuous Examination Scheme (ACEP). The PES and the ACEP systems differ from one another only in the frequency with which the examinations are necessary and the marking of the inspection dates on the containers. The underlying criteria used during the inspections are not different.

The Periodic Examination Scheme (PES)

This is a system of regular inspections arranged by the container owner every 30 months and starting no later than five years after the date of manufacture. Following each inspection, the month / year of the next inspection is stamped on the safety approval plate. The CSC also permits the use of stickers to show the next due date of examination. Therefore, for containers certified under the PES it is possible to see from the container itself whether it is within dates.



Inspection sticker to indicate due date for next examination



The Approved Continuous Examination Program (ACEP)

Under this system, the letters ACEP are displayed on the CSC plate or on a sticker next to the CSC plate. Furthermore, the plate also lists the approval number and the reference of the administration which approved the container. Containers under ACEP are subject to examinations arranged by the owner concurrently with major repairs, refurbishments or on / off-hire interchanges. These containers are inspected practically every time they are used, but under no circumstance can inspections take place more than 30 months apart. The date of the next examination cannot be seen from the container itself, but should be documented by the owner of the container.

Regulation 2 of Annex 1 of the CSC, lists the specific requirements an ACEP programme must comply with. In summary, these are:

» The standard for maintaining the container in a safe condition must not be inferior to the Periodic Examination Scheme.
» The ACEP programme must be reviewed every 10 years. This audit should cover, amongst others, the method, scope and criteria, the frequency of the examinations, the qualifications of the personnel carrying out the examinations, record keeping etc.

Most containers operate under the ACEP system.

6.5

ISO standards

Container Standards can apply at different levels and include:

- **International standards, prefixed by ISO or EN, and sometimes by both**
- **National standards, e.g. the British Standard BSI, the German Standard DIN, the American Standard ASA etc.**
- **Industrial / sector related standards**

Standards have been defined as an 'agreed, repeatable way of doing something' (BSI). They are normally published documents containing technical information to guide or define practice in a consistent way, and are used by designers and manufacturers of products as well as service providers.

The use of standards is voluntary and they do not impose a legal responsibility. However, in some cases legislation may incorporate a specific standard thereby effectively giving it the force of law. Alternatively, their use may be declared by a manufacturer, contract or classification society, effectively binding the contracting parties to the requirements of the standard. There are many types of freight containers in use today, but the purpose of each of them is essentially the same, namely quick and efficient handling and stowage, and the interchangeability between different modes of transport on a global scale. This is only possible if the system and containers comply with a certain set of standards. The most common standards in container shipping are set by the International Organization for Standardization (ISO). In 1968, the ISO published its first standard on freight containers. Since then, some 45 standards involving freight containers have been published (see insert for an overview of the most important ISO standards for freight containers).

Although compliance with ISO standards is voluntary and does not have a formal legal status, statutory documents such as the Cargo Securing Manual refer to ISO freight containers only. This also applies charterparties and carriage contracts and, as such, ISO standards are binding and almost universally complied with in overseas transport of containers.

An ISO container is a container that fully complies with all non-optional provisions of the ISO standards that were in force at the time of its construction. Accordingly, a non-ISO container is one that does not meet ISO standards. Examples are containers with a lower payload, a lesser stacking capability or racking strength.

The International Organization for Standarization (ISO)

ISO (The International Organization for Standardization) is an independent, non-governmental organisation and the world's largest developer of voluntary international standards. The organisation was founded in 1947, and has since then published more than 19,500 international standards covering almost every aspect of technology and business. Its headquarters are in Geneva, Switzerland, and as of 2013 works in 164 countries. The use of ISO standards assist in the manufacturing of products and creation of services that are safe, reliable and of good quality, while minimising errors and waste.

The organisation today known as the ISO began in 1926 as the International Federation of the National Standardizing Associations (ISA). It was suspended in 1942 during World War II, but after the war the ISA was approached by the recently formed United Nations Standards Coordinating Committee (UNSCC) with a proposal to form a new global standards body. In October 1946, ISA and UNSCC delegates from 25 countries met in London and agreed to join forces to create the new International Organization for Standardization and the new organisation officially began operations in February 1947.

The Technical Management Board is responsible for over 250 technical committees, who develop the ISO standards. ISO has three membership categories:

» Member bodies are national bodies considered the most representative standards body in each country. These are the only ISO members with voting rights.
» Correspondent members are countries that do not have their own standards organisations. These members are informed about ISO's work, but do not participate in the standards promulgation.
» Subscriber members are countries with small economies. They pay a reduced membership fee, but can follow the development of standards.

ISO members appoint national delegations to the standards committees. In all, there are some 50,000 experts contributing annually to the work of the ISO. The ISO is funded by its member bodies. The subscription amounts are proportional to the gross national product and trade figures of each country. Furthermore, the ISO generates income through the sale of standards.

The founding committe in 1947

Probably ISO's best known and most frequently used standard is ISO Standard 31 from 1960 on quantities and units, e.g. metre for distance and second for time, better known as 'the SI system'. This standard has since that time been replaced by ISO 80,000.

Overview of the most important ISO Standards for Freight Containers	
ISO 668	Classification, dimensions and ratings
ISO 830	Vocabulary
ISO 1161	Corner fittings - Specification
ISO 1496-1	Specification and testing Part 1: General cargo containers for general purposes
ISO 1496-2	Specification and testing Part 2: Thermal containers
ISO 1496-3	Specification and testing Part 3: Tank containers for liquids, gases and pressurized dry bulk
ISO 1496-4	Specification and testing Part 4: Non-pressurized containers for dry bulk
ISO 1496-5	Specification and testing Part 5: Platform and platform-based containers
ISO 3874	Handling and securing
ISO 3874:1997/Amd 1	Twistlocks, latch locks, stacking fittings and lashing rod systems for securing of containers
ISO 3874:1997/Amd 2	Vertical tandem lifting
ISO 3874:1997/Amd 3	Double stack rail car operations
ISO 3874:1997/Amd 4	45 ft containers
ISO 6346	Coding, identification and marking
ISO 9669	Interface connections for tank containers
ISO 9711	Information related to containers on board vessels - Bay plan system
ISO 9897	Container equipment data exchange (CEDEX) - General communication codes
ISO 10368	Freight thermal containers - Remote condition monitoring
ISO 10374	Freight containers - Automatic identification
ISO/TS 10891	Freight containers - Radio frequency identification (RFID) - Licence plate tag
ISO 14829	Straddle carriers for freight container handling - Calculation of stability
ISO/TR 15069	Handling and securing - Rationale for ISO 3874
ISO/TR 15070	Rationale for structural test criteria
ISO 17712	Mechanical seals
ISO 18185	Electronic seals
ISO 18186	RFID cargo shipment tag system

Note

ISO standards refer to series one freight containers. This would suggest there are other series of containers as well, but this is not the case. The concept of series was initially developed to cover different sizes of containers but this was never developed and there is no intention to do so in the future.

6.6

Requirements on the design and construction of containers

The design and construction of containers must meet certain criteria to comply with international rules and conventions. The most important regulation is the International Convention for Safe Container (CSC). The main purpose of this convention is the safety of the personnel working round them. Standards have been developed for the purpose of standardisation, that is to make the freight containers interchangeable between different modes of transport which can be applied on a universal basis. Thus:
CSC = Safety
ISO = Standardisation

The CSC and ISO together determine the dimensions, mass and volume of containers, the required structural strength of the container body and corner castings, the strength and arrangement of additional features such as forklift pockets, gooseneck tunnels, anchoring points in the container, etc. The most important design and strength criteria are discussed below

Dimensions

The dimensions of ISO freight containers are set out in ISO Standards 668:2013 and ISO 1496. ISO 668:2013 summarises the external and some internal dimensions of a freight container. The dimensions of each type of container are defined in the appropriate part of ISO 1496, which is the authoritative document for internal container dimensions.

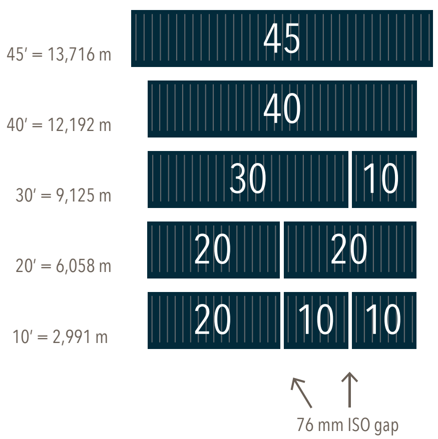
Length

ISO 668:2013 specifies the following six container lengths:

container length denotation (foot)	nominal length (m)	actual length (m)
10 feet	3,038	2,911 mm
20 feet	6,096	6,058 mm
30 feet	9,144	9,125 mm
40 feet	12,192	12,192 mm
45 feet	13,716	13,716 mm

The nominal length of a container is the length by which a container may be identified. With the exception of the 40 and 45 foot container, this is, however, not the actual length of the container, see last column above.

The original ISO standard was developed as a modular system, using the 40 foot length as a starting point. All the containers with a shorter length were dimensioned in such a way that they allowed a 76 mm gap inbetween the containers in every configuration in the modular system. Therefore, except for the 40 foot container, all containers in the modular system are shorter in length than suggested by their indication in feet; this is done to make the modular system work in practice. The 45 foot container is not part of the modular system as it was introduced to the market after the modular system became the standard.



Modular system incl. 76 mm ISO gap

The 10 foot container is mostly used in the offshore sector, but is not a transport unit seen on board modern commercial container vessels.

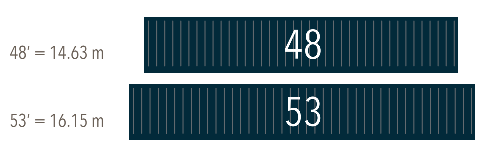
The 20, 40 and 45 foot containers are the only ISO containers which are usually loaded on ocean going container vessels, provided this is approved in the vessel's Container Securing Manual. The 45 foot container can only be carried on deck, unless special cell guides are fitted under deck. By far the majority of the containers used in intercontinental transport are 40 foot containers.

The 30 foot container is particularly popular in the European short sea trade as the most suitable container to carry bulk cargoes. Generally, the 30 foot container, however, is not carried on ocean going container vessels, unless special provisions are made.

The 45 foot container may conflict with road traffic regulations in some areas, e.g. the European Union, and is therefore not permitted everywhere. In September 2014, the first steps were taken in Europe to increase the use of the 45 foot containers by allowing these containers to be carried by road in the Benelux countries. Similar initiatives took place in other countries as well. As a result, it is expected that the 45 ISO container will become increasingly popular in the international container trade.

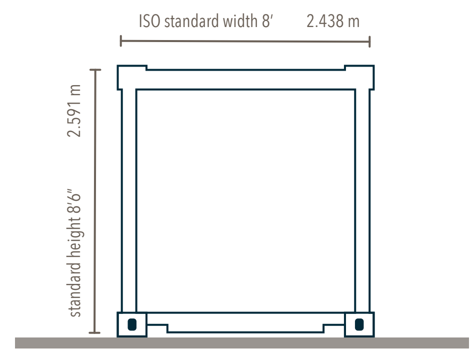
48 foot and 53 foot containers

In 1986, the 48 foot (14.63 m.) container was introduced by American President Lines, mainly for domestic use in the United States. Three years later the 53 foot (16.15 m) container was introduced as well but this container was not strong enough to be carried on ships. In 2007 APL introduced the first 53 foot containers capable of ocean transport. These were employed in the trans-Pacific trade to Asia. This service using 53 foot containers was terminated in 2013. The 48 and 53 foot long containers continue to be used in North America in transport by sea, road and rail.



Tolerance

Not every container can be manufactured to the exact standardised length. ISO therefore provides an allowance of minus (-) 10 mm for 40 foot containers and minus (-) 6 mm for 20 foot containers. Lengths in excess of the standardised values are not permitted under ISO.



Width

Standard ISO containers are 8 foot (2.438 m) wide.
However, this width has proven to be rather inefficient when stowing standard pallets. The standard pallet sizes used by the industry are:

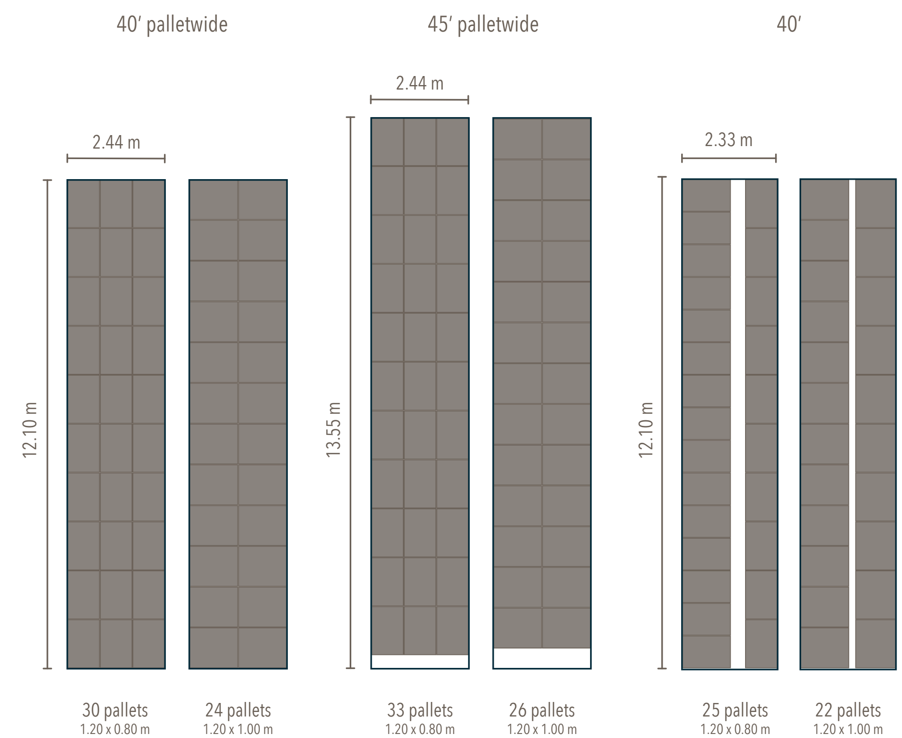
» The ISO (or sea pallet) measuring 1.00 x 1.20 m, and
» The EUR pallet measuring 0.80 x 1.20 m and used by most supermarkets.

An external width of an ISO container of 2.438 m gives an internal width of approximately 2.33 m, not enough to stow two ISO pallets (2 x 1.20 m) or three EUR pallets (3 x 0.80 m) next to one another. Therefore, to achieve a better use of the available space in the container, the so-called 'pallet-wide' container with an external width of 2.50 m was developed. These containers have about 4 inches (10.2 cm) more internal floor width than standard containers. The 45 foot (13.72 m) pallet-wide high-cube shortsea container has gained wider acceptance, particularly in Europe, as these containers can replace the 13.6 m (44.6 feet) swap bodies common in truck transport in Europe. The EU has started a standardisation of pallet-wide containers in the European Intermodal Loading Unit (EILU) initiative.

Pallet-wide containers are not ISO compliant and are therefore usually not carried on board ocean going vessels in the intercontinental trade. Warnings are displayed on the outside of a container to indicate it is over-wide. In addition to the 2.50 m wide container, 2.55 m wide containers are also being used especially in the short sea sector in Europe. Similar pallet-wide containers are used in Australia, the so-called 'RACE containers' – Railways of Australia Container Express, for domestic transport only.

Tolerance

Under ISO standard 668, there is a tolerance in the width of minus (-) 5 mm.



Stowage patterns for standard and pallet-wide containers

Height

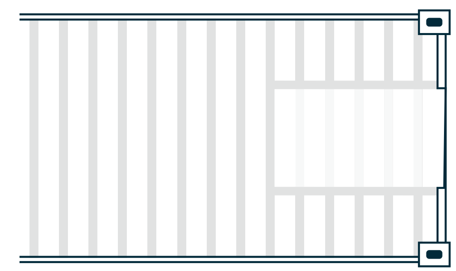
ISO 668:2013 recognises four different container heights:

9′6″ foot (2.896 m)
8′6″ foot (2.591 m)
8′ (2.438 m)
Less than 8′ (< 2.438 m)

The standard container height was 8 feet (2.438 m.) during the early days of containerisation. This was mainly done to avoid conflict with the limits on United States highways and railway passages. However, these 8 foot high containers are no longer in use. Currently, the standard height is 8′6″ (2.59 m), although the 1 foot taller high-cube container 9′6″ – 2.90 m has become very popular in recent years. Market reports have indicated that by 2015, the majority of the containers being carried by sea are 40 foot long high-cube containers. As the extended height of 2.90 m conflicts with height limitations in several countries, the use of a special lowered gooseneck chassis is needed for road carriage. The container is fitted with a gooseneck tunnel to fit onto the chassis.

Tolerance

The tolerance in height according to ISO 668 is minus (-) 5 mm.



Gooseneck tunnel (view of underside of container)

Weight

Given that there is a variety of types and sizes of containers in use, the weight restrictions related to their carriage varies quite significantly. With this in mind and rather than taking each container type in turn, it is perhaps more fitting to outline the factors involved and the most common weight ranges. The tare weight of a container (indicated by the letter T) is the weight of the empty container without cargo. This weight will depend on the construction material used, additional fittings and will typically range between 2 and 2.5 m.t. for a 20 foot container and 3.5 and 4 m.t. for a 40 foot container. The gross weight of the container is the weight of the empty container (T) plus the weight of the cargo known as ‘Payload’ (P). This gross weight is also referred to in Standards as Rating and is indicated by the letter R. This value includes a safety margin to account for the vertical accelerations during a sea voyage.

The CSC requires that the values for both the gross weight and the tare weight are clearly marked on the CSC plate and the container itself.

ISO standard 668 lists the gross weights for 20 and 40 foot containers as 24 and 30.480 m.t. respectively. These are significantly lower than the maximum permissible gross weights of up to 30.5-34 m.t. for 20 foot and 34 m.t. for 40 foot containers for which today’s containers are designed. However, ISO also recognises that containers are available with ratings in excess of these values, but warns that these containers may not be fully intermodal worldwide.

Thus:

R = rating
(maximum permissible gross weight)
T = tare
(weight of the empty container)
P = payload
(max. permissible weight of the cargo)
P = R - T

Furthermore, the stated maximum permissible payloads are based on the cargo being evenly distributed across the container floor so that the loads can be safely transferred to all four corners. If the weight of the cargo cannot be evenly distributed, the limitations of the container floor and the corresponding load spreading should be considered.

A way of calculating the permissible load per meter length is to divide the payload by the number of cross members supporting the floor of the container. So for example a 30 tonne rated 20 foot container with 16 cross members may carry approximately 1.8 m.t. per cross member. An often used rule of thumb is to keep a maximum of 4.5

m.t. per metre for a 20 foot container and 3.0 m.t. per metre for a 40 foot container.

The issue of container weights has been the subject of considerable discussion.

This discussion focussed in particular on the differences between the weight as declared by the shipper of the container and the weight as actually loaded into containers (*see insert*).

Container weights and new IMO requirements on weighing

The issue

Weight declarations are usually made at two different stages of the container carriage. The first is when the shipper makes a booking with the shipping line. This can be several days, or weeks, prior to the arrival of the container at the terminal. This weight declaration is often an estimated weight.

The second declaration is when the road carrier picks up the container at the warehouse for transport to the terminal. At this point, the road waybill is issued stating the container weight as declared by the warehouse. This weight is declared by the road carrier to the terminal upon delivery.

The data control centre at a modern container terminal will usually check the weight declared by the shipping line against the weight declared by the road carrier. If a discrepancy is found, the terminal will check with the shipping line as to the correct container weight to be used and to be entered into the system.

It is important that this weight is as accurate as possible as it is used in the preparation of the ship's stowage plan. On every containership, the maximum container weight of each container tier is strictly limited and should not be exceeded. In general, the higher the container is stowed on the deck of a vessel, the lower the maximum permissible container weight will be. Therefore, if the weights declared are not accurate, i.e. the container is in reality heavier than the stated weight, it can end up being stowed higher in the stow on deck than its actual weight would allow. This can lead to a failure of the lashings and the containers becoming overloaded. Secondly, a discrepancy between the total declared weight of all the containers on board and the actual container weight on board, referred to as 'dead load', may impact the strength calculations for the vessel as a whole, e.g. bending moments, torsional strength and shear forces.

New legislation for container weighing was initiated following investigations by the UK Marine Accident Investigation Branch (MAIB) into the MSC NAPOLI incident in 2007. The MAIB concluded that misdeclared container weights were a major factor in the structural failure of the vessel. The second initiative came from a Netherlands-led joint government-industry research project into the lashing of containers at sea, known as the 'Lashing at Sea project'.

Legislation as at 1 July 2016

IMO has amended the Safety of Life at Sea Convention (SOLAS) and added a requirement in chapter VI, part A, regulation 2 which states that the gross mass of packed containers must be verified prior to stowage aboard a ship. Under this new requirement the shipper is responsible for the verification of the gross mass and for ensuring that the mass is communicated in shipping documents sufficiently in advance to be in the preparation of the ship's stowage plan. In order to achieve a common approach in the implementation and enforcement of the new SOLAS requirement, the IMO has issued MSC circular no. 1 / Circ. 1475 dated 9 June 2014 entitled Guidelines regarding the verified gross mass of a container carrying cargo.

Below is a short summary of the new requirements:

» Before a container can be loaded on board a ship, its weight must be determined by weighing. This responsibility lies with the shipper.
» This requirement applies to all containers governed by the International Convention for Safe containers (CSC). There are no exceptions to this requirement.
» There are two methods for weighing that can be used:
  - to weigh the container after it has been packed
  - weighing the cargo loaded in the container and add that weight to the tare weight of the container itself as indicated on the CSC plate / door end of the container.
» The only exception is that 'individual, original sealed packages that have an accurate mass of the packages and cargo items clearly and permanently marked on their surfaces do not need to be weighed again when they are packed into the container.'
» The carrier may rely upon the shipper's weight statement and does not need to verify the actual weight.
» The weight declaration must be signed by a representative of the shipper, whose name must be stated in the document.
» Estimated cargo weights are not permitted.
» When a terminal receives a packed container for export without a shipper's weight statement, the container can be weighed at the port. That weight must then be used for the vessel's stowage plan.
» Vessel stowage plans should only use verified weights for packed containers loaded on board.

Strength and structural requirements

The requirements for structural safety and tests to be carried out on containers for approval under the Convention for Safe Containers are described in Annex II of the Convention. This section describes in general terms how the tests are to be carried out, the elements to be included, e.g. wall pressure, roof and floor load etc., the minimum strength criteria, etc. More detailed test specifications are provided in ISO Standard 1496 (Specification and Testing), the most recent issue is the sixth edition of 1 July 2013. The Standard consists of five parts, covering the following types of containers:

Part 1 General cargo containers for general purposes, i.e. dry box containers
Part 2 Thermal containers, i.e. reefer containers
Part 3 Tank container for liquids, gases and pressurised dry bulk
Part 4 Non-pressurised containers for dry bulk
Part 5 Platform and platform based containers, i.e. flat racks etc.

Apart from the strength requirements, ISO 1496 contains very specific requirements for forklift pockets, gooseneck tunnels etc. The design of container corner fittings is specified in a separate ISO Standard (ISO 1161).

An important principle to consider is that neither the CSC nor ISO accept that the strength of the container will degrade below its design values during its life cycle and that the starting point for all the criteria is the design strength of the container. In this regard, the CSC states in the introduction to Annex II:
'In setting the requirements for this Annex, it is implicit that in all phases of the operation of containers the forces as a result of motion, location, stacking and weight of the loaded container and external forces will not exceed the strength of the container. In particular, the following assumptions have been made:

» The container will be so restrained that it is not subjected to forces in excess of those for which is has been designed;
» The container will have its cargo stowed in accordance with the recommended practices of the trade so the cargo does not impose upon the forces in excess of those for which it has been designed.'

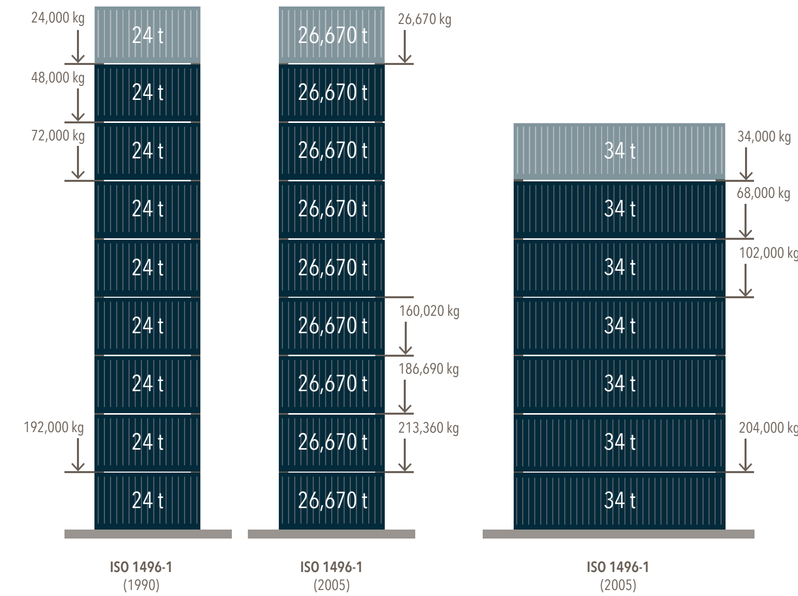
The above implies that the strength requirements do not include a safety margin and that the strength of, for example, a 20-year old container is expected to be the same as that of a new container. In day to day container operations this is logical, as, as long as the containers bear a valid CSC plate and have complied with the in-service examinations, new containers can be stowed mixed with old containers. However, at no stage during the life cycle of the container, will it be subjected to the same level of tests as during the initial approval stage.

Below is a summary of the most important test and strength criteria for ISO freight containers. However, the classification societies also maintain their own criteria which are specified in their Rules. These Rules use the ISO Standard and CSC criteria as the minimum requirement.

Stacking

The container structure must have sufficient strength to allow containers to be stacked when transported by the vessels.

The vertical accelerations imposed by the vessel's motions (pitch and heave) must be taken into account when considering stacking capacity. Under the provisions of the CSC, a maximum vertical acceleration



Stacking

of 0.8 x g is assumed, with g being the gravitational acceleration (9.81 m/s^2). When the dynamic force of 0.8 g is added to the static force of 1.0 g, the resulting total force may be taken as 1.8 g. Furthermore, it is assumed that containers are stacked nine tiers high in cell guides with all containers rated to 24,000 kg. This means that the bottom container must be capable of supporting a superimposed mass of 8 x 24,000 kg. = 192,000 kg. The corner posts of the containers are known to have been tested to 86,400 kg (848 kN) under test conditions. The vertical force at the base of the stack at each corner is then 954 kN.

All containers tested in accordance with ISO Standard 1496-1 of 1990 will be capable of supporting the above mentioned loads.

Under the 2005 edition of the ISO standard 1496-1, the superimposed mass to be supported by a fully loaded container was increased from 192,000 kg to 213,360 kg. For the stacking of 45 foot containers, special stacking limitations apply for particular stacking configurations.

Notes

» It is assumed that the containers are stacked in cell guides and that the clearance in the longitudinal direction is 38 mm and 25 mm in the transverse direction. This implies that the above stacking configuration includes the containers to be stacked off-set in accordance with these clearances.
» The assumed rated weight of 24,000 kg is the maximum gross weight of a 20 foot container according to ISO 668.

Today, ISO containers are manufactured with a considerable higher permissible weight and a gross mass of 34,000 kg for standard containers is no longer exceptional. However, when stacking such containers fully loaded up to their rated weight, the maximum stacking height must be reduced accordingly so that the maximum weight of 192,000 kg (ISO 1496-1 of 1990) or 213,360 kg (ISO 1496-1 of 2013) respectively, is not exceeded.

- The same restriction applies to vessels stacking containers up to 10-11 tiers high. The weight of each container will have to be reduced to remain within the stacking weight limit.
- There is no system known to separate containers with the higher stacking capacity of the 2013 ISO Standard from containers with a lower stacking capacity from the 1990 Standard. Therefore in considering maximum permissible stacking weights the lowest value of 192,000 kg may preferably have to be used to avoid overloading.
- Large numbers of non-ISO containers are used in the marine industry, mainly short-sea, with a considerable lower stacking capacity. Examples of such containers are the European extra-wide 30 foot bulk containers, capable of being stacked a maximum of four tiers high. According to the latest amendments to the CSC Code, these containers must be marked differently (see 6.8 *The labelling and marking of containers*).

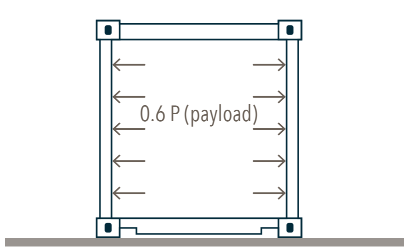
Panel loads

Front and rear end

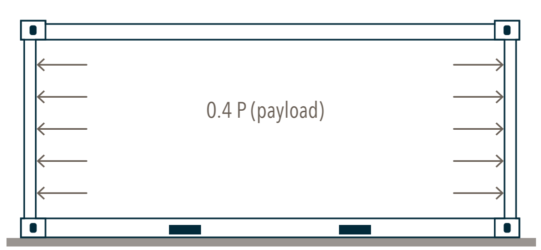
The most dominant forces in the longitudinal (fore – aft) direction, are those experienced during rail transport and when the emergency brake is applied when the container is transported by road. The design test load assumes a uniformly distributed mass equal to 0.4 times the rated payload (P) of the container to be applied on the front or rear end of the container.

Side panel

The determining factor for the required strength of the container's side panels is the transverse acceleration resulting from

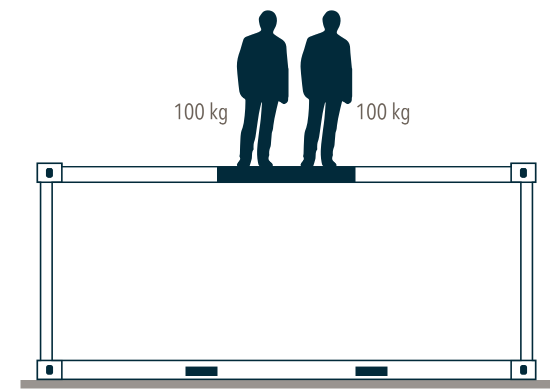


forces on side panels



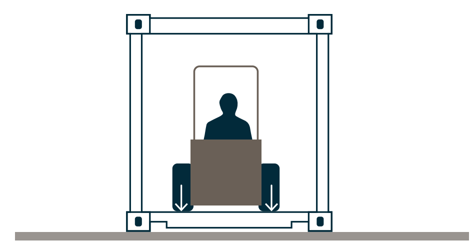
forces on front and rear end

the vessel's roll motion. The design test load assumes a uniformly distributed mass equal to 0.6 times the rated payload of the container to be applied to the side panel.



Roof

The container's roof structure must be strong enough to support two workers, with a weight of 100 kg each. Under ISO 1496, the test requires a load of 300 kg to be uniformly distributed over an area of 600 x 30 mm located at the weakest point of the container roof.

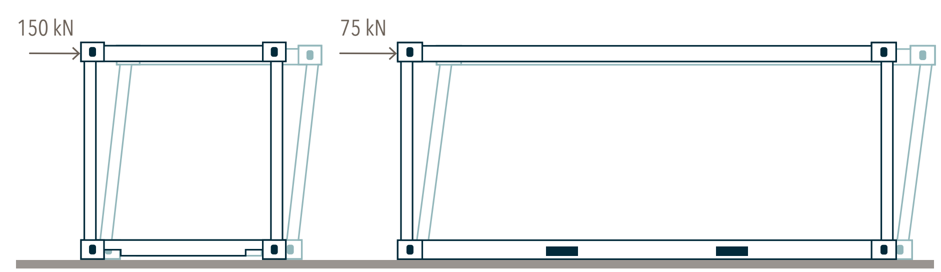


Floor

The base structure of the container must be capable of withstanding the forces imposed during cargo operations involving powered industrial trucks. The minimum required strength (ISO 1496-1, 2005) is calculated from the vertical pressure from a tired vehicle with an axle weight of 7,260 kg (or 3,630 kg per wheel), a wheel width of 180 mm, a contact area per wheel of 142 cm^2 and the wheels centred 760 mm apart.

Racking

The container must be rigid enough to withstand the racking affecting the bottom container in a stack of containers carried on deck under conditions affording limited external racking restraint. The front and rear panel should be capable of withstanding a racking force of 150 kN during test load conditions. The minimum required racking force in longitudinal direction is 75 kN.

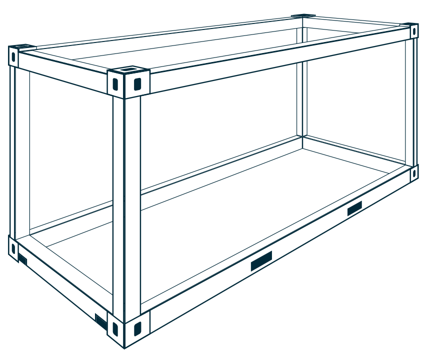


Racking

6.7

Container types and their main features

The basic design of a shipping container consists of a rectangular steel frame with steel corner fittings (castings) at all eight corners welded to the corner posts, top and bottom side and front rails and rear door sill and header.



The function of the corner posts is mainly to transfer the vertical forces occurring during storage and transport. The corner castings are essential for lifting, lashing and stacking the containers and have to be able to absorb a great deal of forces. The design of corner castings is therefore carefully detailed in a separate ISO Standard (ISO 1161). The corner castings at the bottom of the container are shaped differently to the corner castings at the top of the container. Every type of container (with the exception of flatrack containers and some types of tank containers), will consist of this basic framework and serves as the basis for many different applications, mainly depending on the type of cargo to be carried. The ISO recognises five main categories of containers:

- General purpose containers
- Thermal containers or reefer containers
- Tank containers for liquids, gases and pressurized dry bulk
- Non-pressurized containers for dry bulk cargoes
- Platform and platform-based containers (flat racks).

These will be described in further detail below.

General purpose containers

As the name suggests, this container is suitable for the carriage of all types of general cargo and, with appropriate temporary provisions, also for the carriage of bulk cargoes, both solid and liquid, e.g. flexi tanks.

By definition it is 'a freight container, totally enclosed and weatherproof, with a rigid roof, rigid side walls, and floor, having at least one of its end walls equipped with doors and intended to be suitable for the transport of cargo of the greatest possible variety' (ISO 830).

General purpose containers may be made of aluminum or steel. Cost advantages, however, have led to the predominant use of steel. The steel used for manufacturing containers is COR-TEN, a registered trademark of US Steel Corporation and the abbreviation stands for CORrosion resistant and TENsile strength. This is a weathering steel that is more resistant to long term corrosion, rendering it more suitable for salty conditions.

General purpose containers can be divided into three categories:

» Closed freight containers
» Ventilated containers, including fantainers
» Open top containers, including hard-top containers.

Closed freight containers

Side panels, a front panel, roof and floor are attached to the basic framework. The container space can be accessed through two hinged doors at the rear end. Some containers have doors at either end or doors in the side panel, but these are generally rare.

20 foot general purpose (dry cargo) container

The roof, front panel and side panels are corrugated steel profiles to give strength and rigidity. The roof in way of the four corners, adjacent to the corner castings are usually constructed with steel reinforcement plates to provide additional protection from incorrect application of the container handling equipment.

The doors are made of steel or ply metal (steel faced) panels, opening 180 degrees and with sealing rubbers to provide weather tightness. Locking mechanisms with sealing devices are fitted to secure the container doors.

The side panels of the closed container may be fitted with labyrinth protected openings for venting (pressure compensation), although these openings are not supposed to measurably support air exchange with ambient atmosphere. This is different from the special purpose ventilated containers providing natural ventilation inside the container (see *Ventilated containers*).

The floor is usually made of 25-30 mm hard or soft laminated plywood and supported by steel cross members. Today, bamboo is being used more and more in the construction instead of plywood. The floors in general purpose containers have been treated against pests and infestations by insects. Various national requirements apply to such preventive treatment. Closed freight containers may be equipped with additional features such as:

Forklift pockets

These allow empty containers to be handled with forklift trucks. Packed containers must not be picked up in this way unless specifically permitted to do so as there is a risk that the container and truck will topple over. Forklift pockets are installed mainly in 20 foot containers and are arranged parallel to the centre line of the container in the bottom side rails. According to ISO 1496-1 (2013), 30 foot, 40 foot and 45 foot containers shall not be provided with forklift pockets. The reason for this provision is that such larger containers are more difficult to balance. However, there are 30 foot and 40 foot containers with forklift pockets.

Gooseneck tunnel

Many 40 foot containers have a recess in the floor at the front end which helps to centre the containers on the gooseneck chassis. These recesses allow the containers to lie lower and therefore to be of a taller construction. Gooseneck tunnels are often needed on high cube containers in particular.

Grappler pockets

Containers are generally handled by top spreaders using the corner fittings or corner castings. However, some containers have grappler pockets for handling by grapplers applied to the bottom fittings.

Cargo securing systems

These are permanent fittings to which lashings such as ropes, straps, wires or chains may be attached. They are not intended to be used for any other purpose than securing the cargo in the container. The fittings are either hinged or sliding eyes, rings or bars. Depending on their position in the container, these fittings are either classed as 'anchoring points' or 'lashing points'.

Anchoring points

These are located in the base structure of the container. Typically:

» 40 and 45 foot containers have 16 anchoring points,
» 30 foot containers have 12 anchoring points,
» 20 foot containers have 10 anchoring points,

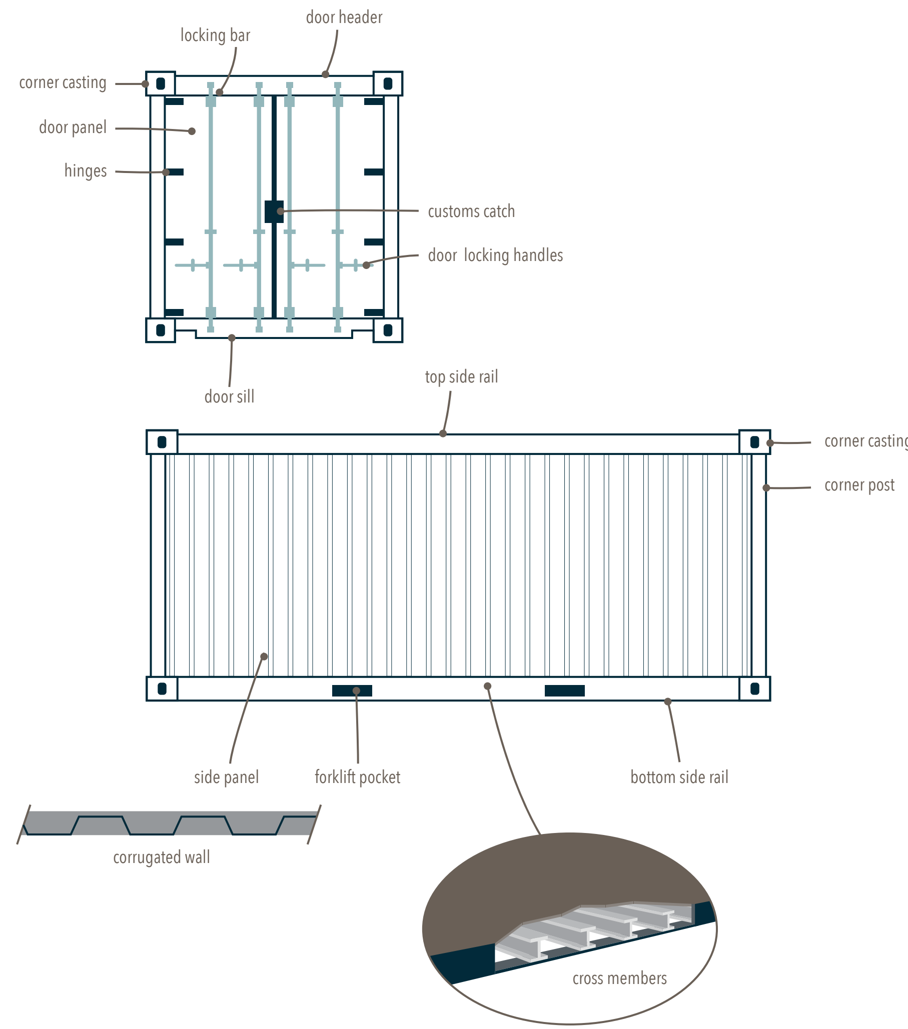
equally spaced between the left and right hand side of the container.

According to ISO Standard 1496-1, each anchor point shall be designed and installed to provide a minimum rated load of 1,000 kg applied in any direction.

Lashing points

These are the securing devices located in any part of the container other than the base structure.

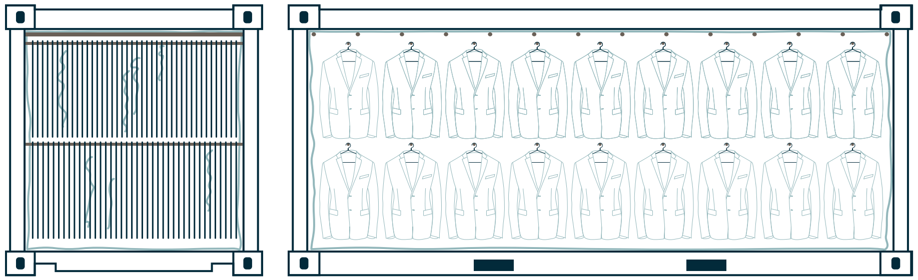
According to ISO Standard 1496-1, each lashing point shall be designed and installed to provide a minimum rated load of 500 kg applied in any direction.



Particular modifications of closed freight containers

Depending on its intended use, the closed freight container can be modified in many different ways, for example:

» Containers for garments on hangers (GOH) fitted with an internal string or bar system or a combination of both, for the transportation of garments in the same way as one sees in retail shops, also called 'hangtainers'.
» Open side, or curtain-sided containers for side loading. The strength of the end walls is similar to that of a closed freight container but the curtain side of the container provides limited strength and no restraint capability. These containers are therefore not covered by the ISO standards.
» Containers with double load floors for the carriage of cars.



Hangtainer

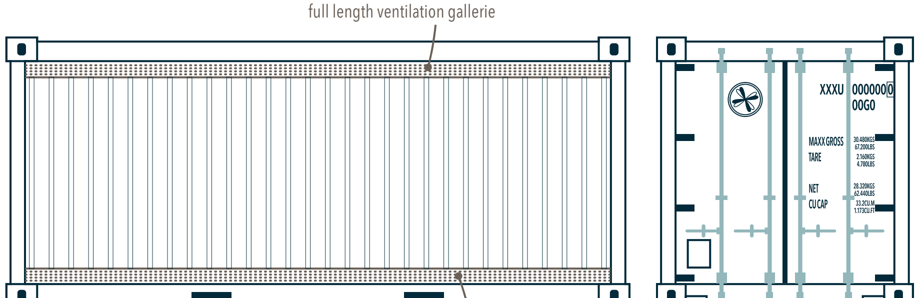
» Containers with large flexi-tanks for the carriage of (non-hazardous) liquids in bulk.

Ventilated containers

The construction of these containers is more or less the same as that of the general purpose container except for the inclusion of full length ventilation galleries located along the top and bottom side rails. These openings allow for a limited exchange of air and humidity between the interior of the container and the ambient atmosphere outside. The air exchange is based on the principle of pressure differences and convection: the warm air inside the loaded container rises and exits at the top through the ventilation openings. Cooler air then enters the container at the bottom through the floor ventilation strips. The ventilation arrangement is such that there is no ingress of water. These containers are mainly used for the transport of organic cargoes with a high moisture content such as cocoa and coffee beans, hence their name 'coffee containers'.

Fantainers

The fantainer is a ventilated container, albeit not classified as such under the ISO type code. These are essentially general purpose containers fitted with a hatch in one of the doors allowing for the fixing of an electric extraction fan with an



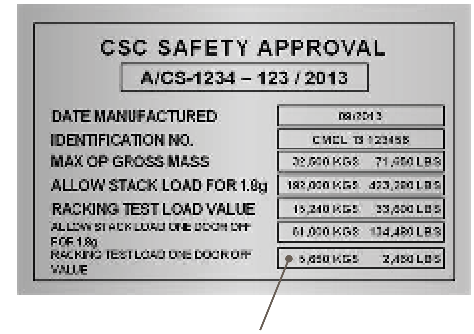
Left: ventilated container; right: fantainer

external power source. Ambient air is drawn into the floor of the container through an especially designed perforated lower front sill. he cargo is stowed on pallets to create a false floor forming an air duct under the cargo. The hot and moist air is removed through the extraction fan. The aim is to remove any heat developed by the cargo and align the temperature of the air within the container with that on the outside to prevent condensation.

Fantainers are mainly used for the transport of onions over long distances, e.g. Australia / New Zealand to Europe or to Asia. A common variation of the fantainer is the so-called 'one door-off' variant. In this configuration using a closed freight container, one container door is removed and replaced with a plywood bulkhead where the extraction fan is mounted. The container door is reinstalled after discharge of the cargo at the place of destination. As freight containers carried with one door off or one door open will have reduced allowable stacking mass and racking strength, the practice is discouraged as it is dangerous and only legal if it is marked accordingly on the CSC plate.

Ventilation gallery under the top side rail

The reduction in strength of the container must be taken into account when stowage and stacking the container on board a vessel.



40 foot open top container

Open-top container

This is a general purpose container without a rigid roof commonly used for the carriage of heavy and awkward cargoes requiring top-loading. It is also used for cargoes with a height in excess of that which can be stowed in a general purpose container. The door header can be removed or swivelled out as well to allow loading either directly through the roof aperture or through the door using overhead lifting equipment. Roof protection, if required, is provided by a tarpaulin-type cover made of canvas or reinforced plastic material supported by (re)movable roof bows. The purpose of the roof bows of an open-top container is not solely to support the tarpaulin, but also to contribute to the container's stability.

Hard-top container

This container can be classed as an open-top container, but has typically two distinguishing structural features:

» It is equipped with a removable steel roof. In some types, the roof has points to accommodate the use of forklift trucks, allowing the roof to be lifted by forklift truck. The roof weighs approximately 450 kg.
» The door header can also be swivelled out.

These two structural features greatly simplify the process of packing and unpacking the container. In particular, it is very easy to pack and unpack the container from above or through the doors by crane or crab when the roof is open and the door header is swivelled out. In the case of transport of an over height cargo, the container roof may be left open and fastened directly to an inner side wall of the container. The roof only needs approximately 13 cm (5 1/8 inches) of space for this to be done.

Thermal containers

Thermal containers are designed to carry perishable cargo in a temperature controlled environment. More commonly, these containers are called 'reefer' or 'refrigerated containers' although their proper name is 'temperature controlled container'. The transport of cargoes requiring accurate temperature control during the voyage is a large and steadily growing business and not just limited to fruit, vegetables and meat. Approximately 70 per cent of world seaborne trade in perishable cargoes is carried in reefer containers and their share of this market segment is continuously growing at the expense of carriage by specialised reefer vessels. Most containerships are designed to carry large numbers of reefer units. This design necessitates the availability of power connections on deck or in the hold and auxiliary equipment to provide a power supply. The latest generations of very large containerships may have a reefer container capacity of up to 15 per cent of the total container intake capacity. Some specialised reefer container carriers have even greater capacity and some specialised carriers operate ships capable of exclusively carrying reefer containers. These ships have the capacity of carrying as much as 2,200 reefer TEUs on one trip.

This book only deals with the different types of reefer containers used in sea transport. For further information on the transport requirements for individual commodities requiring temperature or atmospheric control, please refer to specific information provided by shippers and carriers.

Generally, there are two main types of reefer containers:

» The porthole container, and
» The integral reefer container.

The porthole container

The porthole container was particularly popular during the early days of refrigerated container transport in the 1960's and 70's and has remained in use until very recently. The container, also known as a 'ConAir container', is insulated to a similar extent as the integral reefer container, but does not incorporate refrigeration equipment or fans. One end of the container is fitted with two porthole apertures connected to a system of air ducts in the vessel's hold through which cold air is supplied from a central battery of air coolers. A clip-on unit supplying air has to be connected to the porthole apertures when the container is stored ashore or transported by land. This, together with the significant investment needed in the on-board reefer and air ducting system, lead to the phasing out of this container type.

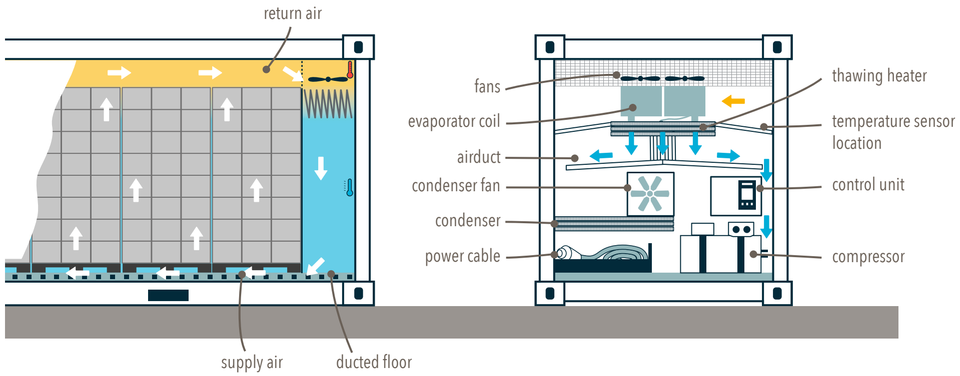
The integral reefer container

Integral refrigerated containers have, as the name suggests, a refrigeration unit that is an integral part of the container body. Electric power is supplied via a cable plugged into the ship's or terminal's power supply system. If electric power supply is not possible or available, the units must be supported by a diesel-operated generator set (a so-called 'genset').

Integral containers are typically designed to maintain the temperature of perishable goods at levels from -30°C to +30°C, in ambient air temperatures from -10°C to + 38°C or more. An important feature of this container is that normal reefer units are designed to maintain cargo temperatures only. This means that the cargo must be cooled to the required carriage temperature prior to the container being stuffed. This is particularly important for palletised commodities with a compact manner of stacking and packing.

40 foot high cube reefer container

The container body is insulated by a thick layer of fibreglass matting or synthetic foam with aluminium or stainless steel cladding. The container floor is made from aluminium T-sections providing a longitudinal double floor for the passage of cold air into the container stow. The principle of cooling is, therefore, based on the so-called 'vertical air supply'. Air circulation fans in the reefer unit introduce cooling air into the cargo space through a supply in the bottom of the container via the T-barred floor. Subsequently, the cooling air is forced upwards through the cargo and returned to the refrigeration unit via the void space below the container ceiling. When passing through the refrigeration unit, the air is cooled again to the required supply temperature and, if needed, mixed with fresh air to avoid the build-up of respiration



Air flow, parts and terminology

gases, for example during the carriage of fruits and vegetables.

The majority of the reefer containers used today are 40 foot long high-cube containers and are carried on deck, up to the third tier. Stacking reefer containers higher up is often impossible because of the length of the power cable and inaccessibility, including the danger of crew falling when inspecting, respectively, repairing the reefer unit during the voyage. Some carriers employ specialised reefer engineers for this purpose, particularly where large numbers of reefers are carried on board. Some reefers are equipped with a water cooling system that can be used to remove the heat generated if the reefer unit is stored below deck on a vessel without adequate ventilation.

As water cooling systems are expensive, vessels rely more on forced air ventilation to remove heat from cargo holds. The success of under-deck carriage of reefer containers depends heavily on the amount of air ventilation and ability of the ventilation air to reach all corners of the cargo hold. Results may not always be satisfactory, particularly when the vessel is passing through an area with a tropical climate with high ambient and seawater temperatures. The presence of heated bunker tanks and hot engine room bulkheads impose additional requirements on the air ventilation system to remove the heat from the cargo hold.

Controlled atmosphere (CA) containers

In a normal reefer unit, the cooling air is ambient air composed of approximately 21 per cent oxygen, 78 per cent nitrogen and 1 per cent other gases, amongst which 0.3 per cent CO_2 or nitrogen. In such an atmosphere, fruits and vegetables ripen and respire at normal rates.

Manufacturers of refrigeration equipment and carriers of reefer containers, together with shippers and receivers developed new techniques to control the atmosphere in the container and, thereby delay the ripening process and to increase the post-harvest life of the produce.

Frederick McKinley (Fred) Jones, the inventor of the refrigerated transport unit

The reefer transport technology applied to preserving perishable goods in transport containers was invented by Fred Jones, who in 1938 received patent for his invention.

Fred Jones was born on 17 May 1893 in Covington Kentucky as the son of a black mother and a white railroad employee of Irish ancestry. Already at an early age, Fred exhibited great interest in mechanical workings and cars. At the age of twelve he ran away from home and began working in a garage, doing the cleaning and sweeping.

Most of his time, however, he devoted to watching the mechanics as they worked on the cars. His observations, along with a passion for learning through reading developed within Fred a deep knowledge of motor vehicles. Within three years, he became the foreman of the garage. Later, he began designing and constructing race cars. In his thirties, Jones started working with Joe Numero, at that time head of Ultraphone Sound Systems. At some point in time Numero was asked to develop a device which would allow large trucks to transport perishable goods. Jones was set to work and developed a cooling process that could refrigerate the interior of a tractor trailer. In 1939 Fred Jones and Joe Numero acquired a patent for this invention and Numero sold his business and together they founded a company named after their first vehicle air-conditioning system, called 'Thermo King'.

For the next 20 years, Jones and Numero introduced improvements to existing devices and created new inventions when necessary. In 1942, Jones developed the first portable refrigeration units for troops stationed overseas during World War II. He also introduced the first refrigerated boxcars in the 1940s, which made fresh produce more widely available and affordable to the public.

Frederick McKinley Jones died in February 1961. During his life, Jones was awarded 61 patents of which 40 were for refrigeration equipment. He was inducted into the Minnesota Inventors Hall of Fame in 1977. Joseph Numero passed away in 1991 at the age of 94.

The same year (1991), both were awarded The US National Medal of Technology by President George Bush because of their contribution to revolutionising the transport of perishable goods. Jones was the first African American to receive the award and became known as one of the most important black inventors ever. Today, Thermo King continues to be one of the largest manufacturers of refrigeration units for containers.

Sources: Thermo King; African-American Inventors, Capstone Press, 1998; The New York Times

The basic principle of a controlled atmosphere is mainly to remove the oxygen from the air and to replace it with a different type of gas – mostly CO_2. Different systems exist, from integral units built into the reefer container, via units adjusting the level of ventilation to systems whereby the ambient air in the container is flushed out by a gas of a different composition than air.

The development of a controlled atmosphere started around 1990, once the nitrogen separator became commercially available at reasonable costs. This separator not only eliminated the need to carry a large supply of liquid nitrogen but also made it possible for CA storage to be used in sea-going transport. Reefer containers using a nitrogen separator, use nitrogen to reduce the oxygen level in the container to a certain fixed point. A computer monitors and controls the atmosphere in the container and may adjust the levels of the different gases by varying the volume and purity of the nitrogen applied. This system has the advantage that is has few moving parts, it controls the atmosphere accurately and the dimensions are small meaning it can be integrated in the cooling unit of an integral container without occupying extra cargo space.

There are also systems taking advantage of the fact that the respiration of fruit converts oxygen into carbon dioxide (CO_2). In gas tight cells, the CO_2 content produced by the breathing fruit is allowed to increase. The oxygen content is reduced similarly, so an increase of say 4 per cent in the CO_2 content will reduce the O_2 content to approximately 17 per cent. The combined percentage of O_2 and CO_2 will always remain at 21 per cent using this system. The required air condition can subsequently be maintained by simply admitting fresh air into the container's interior. This system has the advantage that it does not require an expensive nitrogen separator. The disadvantage is, however, that good control is difficult to maintain when the respiration rate of the fruit is low.

AFAM and AFAM+ system

A cost effective way to alter the atmosphere in a refrigerated container is the Automated Fresh Air Management system, which uses a motorised fresh air exchange system and CO_2 and O_2 sensors to control the respiration gases naturally produced by the fruit in transit. The system maintains the optimum CO_2 levels throughout the voyage. AFAM uses a small motor to control the fresh air exchange; AFAM+ adds a gas to the unit to vary the air exchange based on O_2 and CO_2 levels.

Other reefer containers

These include:

» Special integral containers for the carriage of flower bulbs and products requiring humidity control;
» Integral containers with additional cooling capacity such as Magnum for -35° C freezing and Superfreezers for quick cooling down cycles to -60° C., e.g. for the transport of raw fish for the sushi industry as well as certain pharmaceuticals.

Tank containers

The tank container comprises two basic elements, the tank shell and the framework. The frame must be compatible with standard container dimensions (CSC/ISO) to render it suitable for intermodal transport.

The specifications of the shell and the fittings determine the class of the tank and thereby the type of products it can carry. The frame is designed to support the tank when fully loaded. Most ISO tank containers are 20 foot long. Capacities generally range from 15,000 to 27,000 litres. There are several different designs for the frame and tank construction:

» Frame tank; this is a full frame with side rails connection between the end frames and is the most common tank container
» Beam tank has only end frames; this tank has a lower tare weight and therefore higher payload capacity
» Collar tank
» Ten tank
» The swap tank.

A filling port/manhole is located on the top of the tank and a dip rod with calibration scale is provided. Other fittings include a pressure/relief valve to protect the tank against over pressure or a pressure valve to protect against excess external pressure, airline connections for pressuring the tank during discharge/testing or vapour recovery and a discharge pipe valve and cap at the bottom rear end. Loading and discharge may be done using a top outlet valve connected to vertical siphon pipe.

20 foot tank container - frame type

20 foot tank container - frame type (top view)

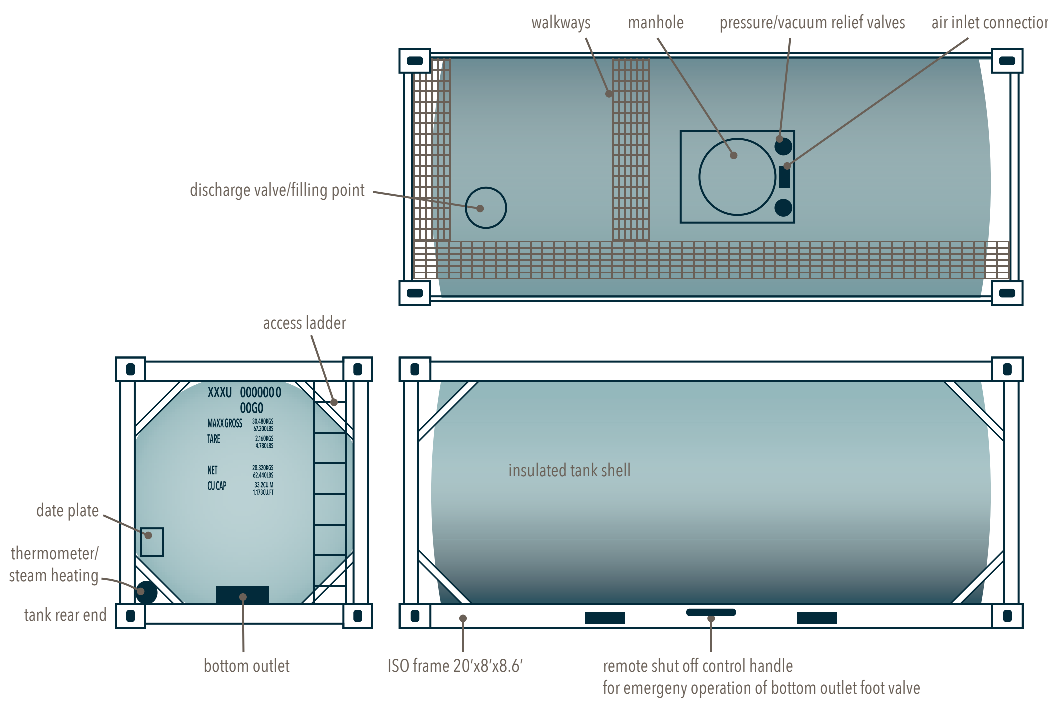
20 foot tank container - beam type

20 foot tank container - swap tank

Steam or electric heating systems can be fitted to the tank container and are usually capable of maintaining air temperatures up to 110°C. Reefer tanks are also available. Insulation is usually in the form of expanded polyurethane. Tanks capable of carrying dangerous cargoes conform to IMO requirements and are classed according to how hazardous the cargo is and whether it is a liquid or gas. Food grade tanks are commonly referred to as type '0 tanks' and are suitable for the transport of food stuffs intended for human consumption, although some alcohols / spirits may fall within the IMO dangerous good requirements. These tanks and their fittings are usually constructed of stainless steel with highly polished smooth interiors to prevent the accumulation of contaminants.
There are hundreds of tank container operators worldwide and they can differ considerably in the service they offer. The bigger operators typically offer a wide range of services, while smaller operators may only offer services in one region or with one type of tank.

Tank containers can be grouped according to their test requirements and intended use:

» IMO type 0 food grade tank container
» IMO type 1 hazardous cargo
» IMO type 2 semi / non-hazardous cargo
» IMO type 5 gases and other explosives



Tank container

Different test requirements apply to each type of tank container. These are set out in ISO Standard 1496-3. Tank containers must be at least 80 per cent full to prevent dangerous surging of the liquid during transit. There is also a general rule that the tanks should not be filled more than 95 per cent to allow for thermal expansion of the liquid.

Typical for tank containers particularly in the short sea trade in Europe is the variation in the dimensions of the containers available, not always meeting the ISO standard. Examples are the 30 foot bulk container with a capacity of 40,000 litres, the wide body tank, and the swap tank where the exterior of the tank protrudes beyond the forward and aft tank frame. There are also 40 foot tank containers with a capacity of 56,000 litres, mainly for the transport of dry bulk. Many of these tanks are owned by shippers, logistic service providers or production facilities.

Bulk containers

These containers are officially known as 'non-pressurized dry bulk containers'. They are general purpose containers specially designed to carry bulk cargoes such as dry powders and granular cargoes and are capable of withstanding the loads resulting from filling, transport motions and discharging . There are bulk containers for tipping discharge which have filling and discharge openings and a door.

Another type of bulk container is the hopper type for horizontal discharge. These

30 foot bulk container

containers are usually not fitted with the hinged doors of closed freight containers. They are commonly fitted with mild steel floors to enable easy cleaning. ISO type bulk containers are usually 20 foot long. The 30 foot bulk container is particularly popular in the European short sea sector. This container has a container-wide discharge hatch at the rear end, with or without hinged container doors above.

Platform containers

These containers, commonly known as 'flat racks' or 'flats', are designed to facilitate the carriage of cargo with dimensions in excess of the space available in general purpose or open top containers. They consist of a flat bed with either fixed or collapsible end walls, i.e. flat racks, or just flats without end walls (platforms). There are no side walls or a roof. Despite this, the tare weights of platform containers are generally greater than for general purpose containers because of their heavy construction.

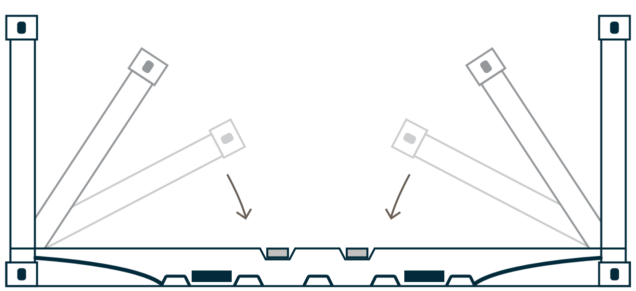
The bottom structure consists of at least two strong longitudinal H-beam girders, connected by transverse stiffeners and lined with solid wooden boards. Strong

40 foot flatrack with collapsible end walls

lashing points are welded to the outer sides of the longitudinal bottom side rails. Flat racks may be provided with stanchions when carrying certain types of cargo. The maximum payload can be used only if the load is distributed evenly over the floor structure. If the weight of the cargo is applied to only a small proportion of the floor, it must be distributed evenly and the manufacturer of the flat racks may have to be consulted on safety issues. Platform containers are the only ISO type containers which cannot be stacked when loaded with cargo. Therefore, on board ships, they are usually loaded in the top tier on deck or in the hold.

Platforms consist solely of a floor structure with an extremely high loading capacity; they have no side or end walls. This high loading capacity makes it possible to carry heavy weights in small areas. The platform consists of a steel frame and a wooden floor structure and are used mainly for oversized and very heavy cargo.

A combination of two or more platforms can be used to form a temporary platform to load very large items which cannot be placed in containers. This way, cargo to be transported on board a cellular container vessel on a 'port to port' basis is carried as it would have been on board a conventional break bulk vessel.



40 foot flatrack with collapsible end walls

6.8
The labelling and marking of containers

The international standard dealing with the coding, identification and marking of containers is ISO Standard 6346. The first edition of the Standard was published in 1984 and an amended edition was published in 1995. The 1995 amendment not only included a new regulatory regime on the mandatory status for marking, but also completely revised the marking and identification codes. In 2012 the Standard was amended again to accommodate and distinguish non-ISO containers.

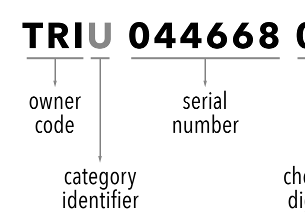
The ISO Standard 6346 and its changes can be summarised as follows:
The ISO 6346 Standard of 1984 did not contain a mandatory requirement to mark the containers. It only provided a standard to be used if marking the containers. Therefore, it is possible that ISO containers built before 1984 will not carry size and type codes.

This changed with the 1995 edition of ISO Standard 6346, published on 12 January 1995. It stated that every ISO container shall be marked with the appropriate size and type codes described in the Standard.

The mandatory requirements were limited to the marking of the owner's code, the equipment category, serial number, check digit, size and type codes. There was no way to distinguish non-ISO containers from ISO containers through the type codes used.

As already mentioned, this changed with the 2012 amendment and the introduction of type codes for non-ISO.

The above changes resulted in two sets of size codes and three sets of type codes being in use today. The first set of codes will be found on containers built between 1984 and 1995. The second set of type codes is found on containers built after 1995, whilst the third set of type codes applies to containers which are approved under the requirement of the Convention of Safe Containers (CSC) but do not meet the requirements of ISO standard 1496-1.



ISO Standard 6346

Below is a summary of the mandatory requirements of the latest ISO 6346 Standard.

Identification system

This consists of the following four elements:

The owners code – three letters

Every container owner has a unique number registered with the Bureau International des Conteneurs, based in Paris.

The equipment category – one letter

» This is the letter U for all freight containers.

The serial number – six numerals

This number consists of six numerals, eg. 123456, or 001234.

The check digit – one numeral

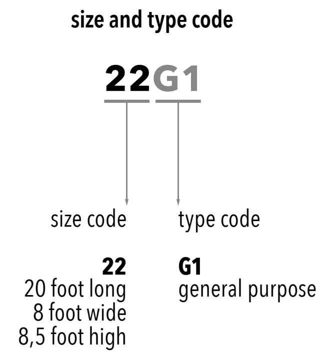
The check digit is the result of a mathematic formula, derived from the owner's code, the equipment code and the container number, and is ten digits long. The calculation of the check digit is to verify that the entire serial number of the container, e.g. when entered into a computer, has been entered correctly.

Size and type codes

This is a four digit code, e.g. 22G1.

Size code

The first two digits indicate the container size. The first digit represents the length of the container whilst the second digit represents the width and height of the container.



Size and type code

Example (2012 edition):

code 22 20 foot long, 8 foot wide and 8.5 foot high

code L5 45 foot long, 8 foot wide and 9.5 foot high

code 2N 20 foot long, more than 2,500 mm wide and 9.5 foot high

Type code

This is also a two digit code. The first digit represents the container type whilst the second character indicates the main characteristics of this container type. The latest ISO 6346 Standard provides the coding of 67 different types of containers.

Example (1995/amd.3:2012 edition):

code G1 a general purpose container with full stacking and racking capability, without ventilation but with passive vents at the upper part of the cargo space

code GB same as G1 but this container has been designed and tested with reduced stacking and/or racking capability

code RO a mechanically refrigerated container with full stacking and racking capability

code RA same as R0 but with reduced stacking and/or racking capability.

ISO 6346:1995/Amd.3:2012 requires that containers with reduced stacking or reduced racking strength shall have the size type code marks on the front (blind end) and on the roof at either end.

Weight markings (mandatory)

According to ISO 1496, other mandatory markings are those that indicate the maximum gross mass and the tare (empty) mass of the container. It is not mandatory to show the permissible payload of the container, but this is usually done in practice.

The maximum gross mass of the container must always be in accordance with the value

Weight markings

stated on the CSC plate. If there are any variations, the mass mentioned on the CSC plate will prevail.

Another mandatory marking applies to containers with heights in access of 2.60 m, e.g. high-cube containers. These must be marked as follows:

» On both sides, the height in metres and feet, to one decimal/inch, rounded off to the highest decimal/inch. This mark should be displayed at both ends of the container

» An area of yellow and black stripes on the top members of each end container frame and side wall, e.g. to warn crane drivers that the container is a high-cube container.

Other markings

All other permanent markings on containers are optional under the ISO 6346 Standard. A container can display many markings, labels or placards required by various regulatory bodies or imposed by international regulations to display warnings or information about the cargo in the container. An obvious example is the hazardous cargo labels as required by the IMDG Code. The ISO Standard 6346 only requires that these other markings are displayed in such a way that they do not interfere with the marks required under the Standard.

6.9

In-service inspections of containers

In service-inspections of containers can be divided into statutory inspections and routine operational inspections.

Statutory inspections (CSC)

Statutory inspections must be carried out for the container to comply with the IMO Convention of Safe Containers. This Convention requires that a party operating containers internationally by sea, has in place a system of examination, maintenance and record keeping, to ensure that the container fleet is maintained and operated safely. This system must be approved by a competent government authority.

As described above, this system can be either an Approved Continuous Examination Programme (ACEP) or a Periodic Examination Scheme (PES).

Evidence of the container being in compliance with the CSC, and thereby approved for use under either of these inspection regimes, is the CSC plate being stamped with the Next Examination Date (NED) for a container operating under a PES regime, or with an ACEP approval decal.

The CSC inspection is a visual inspection only to be carried out by a competent person. With the exception of tank containers, tests are not required. During this inspection, all load bearing parts and structural components should be examined and checked for corrosion, mechanical damage, wear and tear etc. The condition of the welding and riveting should be checked visually as well.

The container owner must keep a record of the findings of the examination and to retain these records until the completion of the next inspection. The CSC delegated the control of the movement of unsafe containers to governments. Such unsafe containers may be allowed to proceed to the place of unloading, but cannot be loaded again until a further examination, repairs and updating have taken place.

Until 2005, the CSC did not specify when a container was to be classified as 'unsafe'. In 2005, an amendment to the CSC (IMO Circular CSC/Circ. 134 of 27 May 2005) identified the critical safety components of a container and the maximum permissible deformation to these components. This list was referred to as the 'Serious Structural Deficiencies'.

In a new amendment, which entered into force in July 2015, the subject of out of service determinations was further specified in a new Annex III to the CSC. These new guidelines set out when containers were to be taken out of service immediately or when the movement of the container was to be restricted. For example, the new regulations stated that a container with a corner casting that was deformed or worn beyond certain defined criteria (in mm), had to be taken out of service immediately. This was an important step in promoting safe container handling as such measures were not mentioned in the previous editions of the CSC.

Routine operational inspections

In addition to these standard periodical inspections, containers are inspected for various other reasons, each inspection serving a particular purpose:

Cargo worthiness inspections

These inspections verify that the container is not only fit and safe for international transport but that it is also suitable to load the intended cargo. The purpose of the inspection is to minimise the risk of damage to the cargo during the voyage.

Taking a standard dry box container as an example, for the container to be cargo worthy it must:

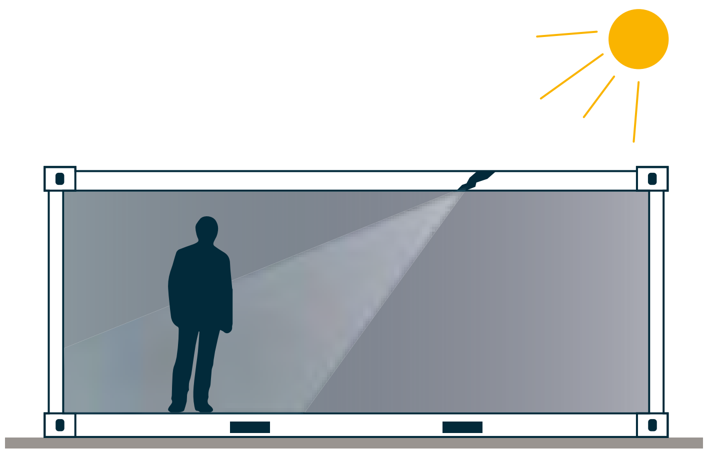
- » have a valid CSC plate
- » be weathertight
- » have properly closing doors
- » be free from adhesive labels, e.g. IMDG placards from previous cargo
- » be free from cargo residues
- » be free from infestation by animals, insects or any other living organisms
- » be neutral in odour
- » be free from nails in the floor or other protrusions which could damage the cargo, etc.

These are the responsibility of the container operator/carrier who makes the container available to the shipper of the goods, however, the container operator will mostly rely on the container depot contracted to store and inspect the containers for these tasks. The reality is, however, that containers may move directly from the consignee to the next packing station without passing through a depot or intermediate inspection.

This carrier's responsibility for maintaining the containers does not discharge the packing station/shipper from their obligation to inspect the containers prior to stuffing. The inspection is fairly easily undertaken and is based on common sense. For example the weather tightness can be checked using a day-light check, preferably with the container doors closed. Some container operators have warnings posted inside the container, informing the shipper to ensure that the container is fit for use before loading.

Responsibility inspections/Equipment Interchange Report (EIR)

During a normal journey, the container crosses many lines of responsibility.
The general principle of responsibility is that any damage to a container requiring repair or cleaning will have to be paid by the party in whose custody the container was at the time of the incident. It is therefore in the



Daylight test

interest of all parties involved that there is system in place for accurate documentation of container damage at the points of any hand-over. These are the points where, for instance, the road truck delivers a container at a depot or where a container is discharged from a vessel or barge.

Equipment Interchange Reports (EIR) are usually issued at the various hand-over points. A container interchange report is a document that provides a detailed description of the external condition of the container at the time of transfer of responsibility from one party to another. By preparing an interchange report for each transfer, it can easily be established when any damage to a container occurred, and identify the party who had the container in his possession during that period and can be held responsible. This document can be either in an electronic format or in paper form and contains diagrams to be used for marking where the defects have been found on the container. During delivery or redelivery of a container, an EIR can serve as a valid contract between the shipping line, or appointed sub-contractor, and the road carrier.

An EIR is not necessarily issued every time. For example, large container terminals use cameras with Optical Character Recognition (OCR) at the entry gates. The cameras automatically identify and record the arriving container using its unique 7-digit reference number, seal status, direction of the door, and any container damage. If the system detects any irregularities with the container, it can automatically prevent the container from entering the terminal.

There is one party in the transport chain which does not inspect every container entering their area of responsibility. That is the vessel itself. In the past when loading rates were low, it was still customary for the on board crew to inspect every container being loaded. The speed of loading, together with the large number of containers passing the ship's railing moved by multiple cranes working simultaneously have made inspections by the crew practically impossible. The vessel's crew relies on the stevedores' deck men to find and report any damage to the container during the loading or discharge operations. This is not always the case and the damage to the container may only be found when the container is landed ashore at the next port. At that time, a dispute may arise between the vessel, the loading and discharge terminal as to the exact time when the damage occurred.

On / off-hire inspections

Container leasing companies keep large amounts of containers in stock for leasing to container operators. These stocks piles are situated at strategic points all over the world to make containers easily and readily available to container operators. When a leasing company (lessor) delivers a container to a client (lessee), the latter will want to assess the condition of the container. The opposite is the case when the client redelivers the container to the leasing company.

Surveyors are usually engaged at the hand over points to carry out condition assessments for and on behalf of their client. This can be a survey conducted by two different surveyors appointed by either party, or may be one independent surveyor acting jointly for both the lessor and lessee.

The contract between the leasing company and the client sets out the criteria for these inspections and when damage will require repair or not. See Inspection and repair criteria.

Container repair terminology

Several specific terms are used when dealing with container repairs although some degree of variation in these definitions may exist depending on the standard being used:

Straightening	To mechanically or hydraulically restore a damaged component as close as possible to its original shape without the removal of any portion of the component, although in certain cases adjacent components may have to be unfastened from the component being straightened.
Welding	To fuse two separated pieces of metal together using heat and a third piece of metal.
Inserting	To restore a damaged component to its original size, shape and strength by cutting out a portion of the component that is less than the full-profile section and welding or fastening replacement material of the original size, shape and strength in place. The replacement part itself is called an insert.
Patching	The same as inserting, except that the replacement material is slightly larger than the material being removed, and its edges overlap the parent material. The replacement part itself is called a patch. Note: Except for on panels, patching is mostly not allowed.
Sectioning	To restore a damaged component to its original size, shape and strength by cutting out a portion of the component that extends through its full profile and welding or fastening replacement material of the original size, shape and strength in place. The replacement part itself is called a section.
Replacement	To remove an entire damaged component and weld or attach a complete new component of the original size and strength. In some cases, a different shape may be permitted.
Wear & tear	An unavoidable change or deterioration of the container brought about by routine operational use.

6.10

Maintenance and repair

All containers must be maintained in a safe condition and must be repaired to comply with mandatory regulatory requirements valid at the location in which they were placed at the time, including but not limited to CSC requirements.

Only a few container owners have preventive maintenance programmes in place for their container fleet. Such preventive maintenance, if undertaken, is usually limited to the treatment of rust spots, fixing paint damage etc. A more common way of maintenance is to carry out repairs in accordance with in-service repair standards. The reporting mechanisms will ensure that the container owner is informed about any damage to the container which will require repair.

Repair facilities

Container terminals do not usually allow container repairs to be carried out at their premises. This means that the container has to be taken out of service temporarily and brought to a repair facility. These repair facilities are usually located at, or in the close vicinity of the empty container depots. The most inconvenient situation for a carrier is repairs required to a container loaded with cargo, particularly if the damage is such that the container can no longer be transported safely. In such an event, the cargo may first have to be re-stuffed into a replacement container before the damaged container can be transported to a repair facility. To demonstrate a certain minimum standard, repair facilities may decide to apply for accreditation by a classification society. Most repair shops in large container ports are in possession of such an accreditation. During the accreditation process, the repair facility must demonstrate knowledge of the supply of materials, quality and the manufacturers' specifications. Furthermore, an inspection system must also be in place providing satisfactory quality control of all the repairs performed. To ensure that the right level of quality control is maintained, the classification society will conduct regular audits, e.g. annually or every two years.

Repair workshop

Repair standards and procedures

Container repairs are needed when:

- any damage to the container which affects the safe handling, structural integrity or cargo worthiness of the container, or
- the repair is identified as being necessary by industry in-service repair standards, or because of specific instructions/requirements by the container owner or manufacturer.

All necessary repairs must be undertaken in accordance with the applicable repair standards. There are different standards in use in the industry. The standard to be used will be stated in the contract with the container owner. The standards differ from one another quite significantly with regard to the tolerances and list of permitted damages. There are also separate repair standards for refrigerated and tank containers.

UCIRC (Unified Container Inspection and Repair Criteria)

This is the main standard used by most container shipping lines. The last edition of the Standard dates from 2004. For refrigerated containers a separate standard may be used: the Unified Reefer Inspection and Repair Criteria (URIRC).

IICL – Institute of International Container Lessors

This organisation includes some of the largest container and chassis leasing companies worldwide. The IICL sets repair standards for its members by which all repairs are to be carried out. The IICL has the strictest repair criteria for used containers.

Since 1971, the IICL has produced over twenty publications covering container inspection, repair, cleaning and refurbishment, chassis inspection and maintenance, as well as other topics. The latest edition for container repairs is the IICL-5 standard which was introduced in 2007. The publication is over 100 pages long, describing in great detail how repairs are to be carried out for each individual item of a freight container.

CIC (Common Inspection Criteria)

In 2005, a group of leasing companies began a study to determine if the inspection standards used for the interchange of containers between leasing companies and shipping lines could be revised to bring them more in line with the standards used by shipping linesin the in-service operation of their container fleets.

The revised inspection criteria used under the CIC standard are based on UCIRC, the shipping industry's in-service inspection standard, and the Institute of International Container Lessors' IICL-5 interchange standard. This alignment between container operators and leasing companies has simplified operations by improving the efficiency of repair depots and reducing the number of unnecessary repairs, whilst lessening the confusion among surveyors and estimators.

Company specific requirements

Several of the major shipping lines maintain their own inspection and repair requirements. These may well differ from the more universally applied standards referred to above.

The usual procedure when containers need repairs is that the repair company prepares a cost estimate to be approved by the container owner prior to commencement of the repairs. Container owners may also have their own in-house inspectors or engage the services of independent surveyors to monitor and check the repairs.

Technical Reference for Freight container equipment interchange receipt – TR39:2015

On 29 January 2015, the Manufacturing Standards Committee (MSC) under the purview of the Singapore Standards Council (SSC), SPRING Singapore and Singapore Manufacturing Federation Standards Development Organisation (SMF -SDO) launched the Technical Reference TR 39: 2015 for freight container equipment interchange receipt.

This TR serves as a reference and guide on the conduct of visual survey and inspection, accurate reporting and updating of the condition of the freight container at each point of handing and taking over. It establishes the baseline on common definitions and terminologies, visual qualitative and quantitative survey and dissemination of the information on the conditions of the freight container to minimise disputes and delays at each point of the interchange.

This TR is expected to be referred to by the shipping lines, container owners, container lessors, terminal operators, logistics service providers, container depot operators, consignees and shippers. TR39:2015, Technical Reference for freight container equipment interchange receipt covers the following:

- The scope of the TR
- Definitions of all the terms for the purpose of the TR
- Reporting criteria for the condition of freight containers
- Guidelines on the conduct of visual survey and inspection on freight containers
- Relay and acceptance of the condition of freight containers
- Standardised container equipment interchange receipts forms – for both General and Tank containers
- The various types of reportable container conditions
- A feedback form.

6.11

Container security

Since their first appearance in the 1950's the shipping container has revolutionised the international transport of goods to the extent that most of the world's non-bulk cargo is now carried in freight containers. One of the reasons for its success is the strength of the container box, shielding the cargo from the environment and protecting the goods.

However, this closed construction can also be a disadvantage from a security point of view. In the absence of scanners that scan the entire box, it is practically impossible to establish exactly the contents of the container. The only option would be to open the doors and to carry out a manual inspection, in practice, a time consuming and virtually impossible task to conduct on large numbers of containers.

The security of the container has been a major problem ever since its introduction. The main issues involve the theft of goods, illegal immigration, smuggling of illegal goods, weapons and drug trafficking. In addition to these criminal matters, a new security threat was revealed after the September 11 attacks in the United States. Many countries realised that they had relatively little control over the possible misuse of the maritime container by international terrorists.

In particular the threat of a Chemical, Biological, Radiological or Nuclear (CBRN) weapon being delivered in an anonymous shipping container has become the primary terrorism threat to containerised transport. This has become the principal driver of international transport security policy since 2001. Understandably, after 2001 the United States' government in particular implemented a set of new regulations.

Generally speaking, the measures put into place following the September 11 attacks fall into the following five categories:

» Measures seeking to scan or otherwise physically confirm the contents of the container
» Measures seeking to ensure the physical integrity of the container
» Measures aimed at ensuring the security of the container environment as it moves and is handled in the container transport chain
» Measures seeking to track and trace the container in the supply chain
» Measures centred on the provision and use of information relating to the shipments.

This chapter provides an overview of the most relevant security regulations and how these impact the international container trade.

The Container Security Initiative (CSI)

This program is led by the United States Customs and Border Protection (CBP) within the Department of Homeland Security (DHS) focussing on screening containers whilst still located at foreign ports. The CSI programme is part of the CPB's layered cargo security strategy.

CSI deploys expert teams to address the threat to US border security and global trade posed by the potential terrorist use of a maritime container. These teams target and examine high-risk cargo before it is laden on board a vessel bound for the United States. The practical implication of this rule is that, at least 24 hours prior to loading, the shipping lines have to send the manifest data for all cargo destined for the US to the CBP. The CBP transmits the data to the US National Targeting Centre Cargo (NTCC) for screening to identify high-risk cargoes. When suspicious cargo is identified, US CSI officials exchange information and work closely together with the customs of the host country. This cooperation is usually confirmed in a declaration of intent between the custom administrations of the host country and the United States of America and is based on legislation and mutual administrative assistance. It enables customs in the host country to make a better selection of containers that have to be screened or scanned before leaving the port bound for the United States. Non-suspicious cargo is cleared for entry into the United States and can be loaded. For this purpose, foreign ports may apply for approval to become a CSI port. One of the conditions that must be fulfilled in order to achieve this status is to have approved scanning equipment. The World Customs Organization (WCO), the European Union (EU), and the G8 support CSI expansion and have adopted resolutions implementing CSI security measures introduced at ports throughout the world. At the time of publication, over 80 per cent of all maritime cargo imported into the United States is subject to pre-screening.

Container scanner

The Customs Trade Partnership against Terrorism (C-TPAT)

This is a voluntary compliance program for companies to improve the security of their corporate supply chains. It is led by US Customs and Border Protection (CBP) and focusses on improving the security of private companies' supply chains with respect to terrorism. The program was launched in November 2001 with seven initial participants, all large US companies. The program has more than 10,000 members today.

Companies who achieve C-TPAT certification must have a documented process for determining and alleviating risk throughout their international supply chain. This allows companies to be considered low risk, resulting in expedited processing of their cargo, including fewer customs examinations.

The SAFE Framework

The World Customs Organization (WCO) adopted the Framework of Standards to Secure and Facilitate Global Trade in 2005. This framework consists of supply chain security standards for customs administrations. The SAFE Framework consists of four core elements. Firstly, it harmonises the advance electronic cargo information requirements on inbound, outbound and transit shipments. Secondly, countries joining the SAFE Framework commit to employing a consistent risk management approach to address security threats. Thirdly, the framework requires that, at the reasonable request of the receiving nation, based upon a comparable risk targeting methodology, the sending nation's Customs administration will perform an outbound inspection of high risk cargo and/or transport conveyances, preferably using non-intrusive detection equipment such as large-scale X-ray machines and radiation detectors. And lastly, the SAFE Framework suggests the benefits provided by Customs to businesses that meet minimal supply chain security standards and best practices. Amongst others, the SAFE Framework recommends that customs implement a container integrity programme involving the use of high security seals meeting ISO Standard 17712.

The Global Container Control Programme (CCP)

This is a joint United Nations Office on Drugs and Crime (UNODC)/World Customs Organization (WCO) initiative. The objective of this initiative is to establish effective container controls at selected ports across the globe with the aim of preventing the trafficking of drugs, chemicals and other contraband and to facilitate trade by strengthening cooperation between the customs, trade and enforcement communities.

The IMO International Ship and Port Facility Security (ISPS) Code

This Code came into force on 1 July 2004. Under the Code, vessels and port facilities must conduct vulnerability assessments and develop security plans that may include passenger, vehicle and baggage screening procedures, security patrols, establish restricted areas, personnel identification procedures, access control measures, and/or installation of surveillance equipment. Another requirement of the ISPS Code was the installation of an Automatic Identification System (AIS) on board ships. The AIS requires vessels to have a permanently marked and visible identity number and a record must be maintained on board of its flag, port of registry and address of the registered owner. Ships fitted with AIS must maintain the AIS in operation at all times except where international agreements, rules and standards provide for the protection of navigational information.

Container security measures

The shipping container, in its basic form, is a simple reinforced steel box with one point of entry – a double sided door on one end - that is closed using a locking bar system. Once the container is stuffed and leaves the shipper's premises, the container is vulnerable to interception and tampering with its content.

The most common method used to steal the contents is to break the seal on the container door and to replace or repair it afterwards. There are ways a seal can appear to be intact when it has in fact been tampered with.

A not uncommon method for stealing containers is simply to hijack the truck carrying it. Road truckers trying to protect their shipments often opt to travel in convoys, employing armed guards and storing the containers at protected parking spaces. Another method used to steal goods in containers is through fraud. Forged documents are used to obtain the release of the containers from ports or container yards.

It is worth noting that the techniques used for gaining access to containers can also be used for placing items into a container. In order to prevent this from happening, the Customs Convention on Containers (1972) and the TIR Convention (1975) set out technical specifications on secure containers and sealing. This may also involve the sealing of an empty container.

ISO Security Standards

In 2004 ISO published the Publicly Available Specification (PAS) for mechanical door seals. This standard was replaced by ISO Standard 17712 in 2007. ISO Standard 17712 describes three types of mechanical seals:

» High security seals
» Security seals
» Indicative seals.

Security door seal

The Standard sets out best practices for seal manufacturers. The objective of these recommendations is to ensure that seals are only delivered to bona fide users and that a record is kept of the seals delivered and the numbering of seals.

In 2006, ISO published a fifth amendment to ISO 1496-1 applicable to new built containers. The objective of this amendment was to address the vulnerability of the traditional door handle seal location and to impose additional requirements for door seals.

ISO 18185 deals with the specific requirements for electronic door seals.

chapter 7
Container Insurance

(by Geir Kjebekk, Gard)

Container and Equipment Insurance

Gard's container and equipment cover (CEI) has been developed to meet the insurance needs of owners, operators or lessees of containers, which are typically liner vessel operators or non-vessel operating common carriers (NVOCCs).

Scope of cover

The CEI cover is a property cover and responds to the damage to and loss, including theft, of containers, flat racks, MAFIs and similar equipment used for carrying goods. The cover also responds to the container owner's duty to contribute to salvage and/or general average. The CEI cover is not limited to loss or damage occurring during sea transport as it also responds to loss of or damage to containers stored at a shore-side terminal or during inland transport by truck. Being property insurance, the CEI complements liability covers such as P&I and the Comprehensive Carriers Cover (CCC). However, whilst marine liability insurance is normally closely linked to the insured ship, the CEI cover is different in that respect as it is intrinsically linked to the cargo-carrying equipment. For example, an overriding condition for the P&I cover to apply is that the liability has arisen in direct connection with the operation of the entered ship – see Rule 2.4 of the Gard Rules for Ships.

Types of property covered

The CEI cover is tailored to cover cargo-carrying equipment, which is in practice primarily containers. However, the cover also includes other cargo-carrying equipment such as MAFIs, roll trailers, bolsters, bogies etc., whether on or off a ship at the time of the insured event.

Amounts recoverable

Owned containers and equipment

Loss: The replacement value of the container or other equipment, but not exceeding the insured value at the time of the loss.

Damage: The reasonable repair costs of the container or other equipment, but not exceeding the replacement value or insured value, whichever is less, at the time of damage.

Leased containers and equipment

Loss: The amount payable to the owner under the terms of the lease agreement, or the replacement value of the container or other equipment, whichever is less, but not exceeding the insured value at the time of the loss.

Damage: The reasonable repair costs, or the amount payable under the terms of the lease agreement, or the replacement value of the container or other equipment, whichever is less, but not exceeding the insured value at the time of damage.

Conditions

The assured is covered for the loss, damage, costs or expenses that have arisen out of the activities and/or operations customarily carried on by, or at the risk and responsibility, of the assured in his capacity as an owner, lessee, or operator of the containers and/or other equipment. Otherwise, Conditions and Exclusions apply as set out in Gard's Additional Covers Standard Terms and Conditions, Section 17.F.

Special exclusions

Loss, damage, costs or expenses arising from or attributable to:

- Wear and tear, corrosion, rottenness, inadequate maintenance and similar
- Errors in design/manufacture or faulty material
- Mechanical/electrical breakdown or malfunction
- Mysterious disappearance or inventory loss
- Inherent vice, quality or defect
- Insolvency or financial default
- Unfitness of conveyance for safe carriage
- Embargo, requisition or compulsory order of any authority.

Limit and deductible

The following limits and standard deductibles apply:

- For any and all claims arising from any event off the ship: limit of USD 50 million per event
- For any and all claims arising from any event on board the ship: limit of USD 30 million per event
- For any and all claims arising out of any one event, including any legal and other costs and expenses a deductible of USD 25,000.

The limit of cover may be tailored to meet the needs of the insured, but subject to a maximum limit of USD 50 million for all claims arising out of one and the same event. The amount of compensation will be based on insured values as declared by the assured. If the market value of the lost or damaged property is higher than the insured values the CEI cover will be limited to the insured values.

USD 50 million is the maximum limit at the time of publication. This may be subject to change over time. Please contact the Gard's Underwriting Department for updated information.

Comprehensive Carrier's Liability Cover

Gard's Comprehensive Carrier's Liability Cover (CCC) is a named risk insurance, which covers a number of liabilities arising from events on or off the ship, and which fall outside standard P&I cover. The CCC cover is only available to Members with ships entered in Gard for P&I.

Scope of cover

The CCC cover provides cover for liabilities in respect of cargo, lost or damaged property, personal injury and pollution that arise in connection with, or result from:

- Transshipment of cargo in breach of contract of carriage
- Land carriage of cargo in breach of contract of carriage
- Prolonged landside storage of cargo
- Geographic deviations from the contractual voyage in breach of contract of carriage
- Carriage of cargo on deck in breach of contract of carriage
- Cargo loading at a port other than that named in the bill of lading/contract of carriage
- Delivery of cargo at a port other than that named in the bill of lading/contract of carriage
- Lightering of cargo in breach of the contract of carriage
- Cargo carried on vessels other than those stated in the bill of lading/contract of carriage
- Delivery of cargo without production (at the time of delivery) of negotiable bills of lading or other documents
- The issue of 'ad valorem' bills of lading
- Vessel dry-docking with cargo onboard
- Contracting on terms more onerous to the carrier than those of the Hague or Hague-Visby Rules.

Furthermore, the CCC cover provides cover for liabilities in respect of cargo, property, personal injury and pollution arising under various approved contracts with:

- Shippers and receivers of cargo
- Terminal operators and owners
- Ship agents
- Clean-up contractors
- Shipowners/charterers in connection with blending operations
- Shipyards
- Port authorities
- Sub-contractors, including rail and trucking companies
- Tug owners.

Exclusions

Liabilities, losses, costs and expenses arising from performance guarantees provided by the assured.

Liabilities arising from warranties given by the assured of the assured's or any other party's strict compliance with applicable laws and regulations.

Liabilities, losses, costs and expenses resulting from delay, including but not limited to, the vessel's delayed arrival.

Operational costs and expenses including but not limited to taxes, fees or charges.

Liabilities, losses, costs and expenses arising out of the assured's products or reliance upon a warranty or representation made in respect thereof.

Providing the widest range of risk solutions

In a world of increasing complexity, Gard's objective is to help our Members and clients manage the totality of their exposures – both to existing and developing risks.

As a multi-line insurer – with the strongest rating in the marine market – Gard is uniquely positioned to understand how risks fit together, and identify the best choice of products, ensuring seamless coverage and service. Innovation has always been a cornerstone of Gard's business model and, over the years, we have refined and extended our standard products and introduced a range of additional products, responding to special needs and requirements from different parts of the marine industry.

Further information can be found on our webpage (www.gard.no) under Products, or from the Association's underwriting department.

Glossary of Terms

Acceptance of goods
The process of receiving a consignment for on-carriage from a consignor, usually against the issue of a receipt. As from the time and at the place stated the carrier's responsibility for the consignment begins.

Accompanied transport
Transport of road vehicles by another mode of transport, e.g. train or ferry etc., accompanied by their respective drivers.

Ad valorem
Meaning 'in proportion to the value'; a phrase used to describe freight or customs duties levied on goods, property, etc., calculated as a percentage of their value.

ADR
The European agreement covering the international carriage of dangerous goods by road. The letters stand for Accord européen relatif au transport international des merchandises Dangereuses par Route.

Advance freight
Freight paid in advance of the actual carriage.

Advanced interline
An interline carrier that picks up cargo from the shipper and delivers it to another carrier for shipment to the consignee.

Anti-rack device
Hardware normally attached to doors to provide additional strength and stiffness to the container door and end frame assembly. The device enables containers to withstand greater twisting transverse (racking) forces.

Apparel
- A vessel's outfit, such as rigging, anchor and life boats.
- A term used to describe a single piece of clothing, a garment, in the distribution/transport of clothing.

ACEP Approved continuous examination programme
Agreement between the owners of the equipment and the responsible government body to allow the continuous examination of the equipment, i.e. containers.

Arrival notice
A notice sent by a carrier to a nominated party advising the arrival of a given shipment (ANF in US).

Automated Ctr/B/L tracking and tracing
These allow the customer to check the latest status of his cargo and/or documents at any time.

Automated guided vehicle system
Unmanned vehicles fitted with automatic guidance equipment which follow a prescribed path, stopping at each station for automatic or manual loading or unloading of containers at a terminal.

Automatic container landing systems
Fitted to modern gantry cranes to achieve precise motion control of the container during landing on the terminal vehicle.

Automatic track control
Fitted to modern gantry cranes which allows the spreader to follow set paths along the trolley to automatically position the spreader above the container stacks. The driver takes control during the last few metres before the spreader is lowered on to the container or into the cell guides.

Average adjusters
A person who calculates and apportions the cost of damage to or loss of a ship or the cargo it carries for insurance purposes between the parties with an interest in the maritime venture. They also prepare the claims being submitted to hull and machinery insurers.

Average
In marine insurance: loss or damage to or in respect of goods or equipment.

Axle loading
The total downward pressure exerted through any given axle, which may be transmitted through two or four wheels.

Ballast
Materials solely carried to improve the trim and the stability of the vessel. Water is usually carried in tanks specially designed for this purpose.

BAPLIE
The electronic data interchange (EDI) message contains information on vessels' bay plans to be used for the exchange of information between agents, ships planners, terminals and vessels about the stowage of containers on board including their cell positions and place of loading/ discharge.

Bar coding
Electronic tracking of goods using bar code and bar code readers.

Barge
Flat bottomed inland cargo vessel with or without own propulsion, used on canals and rivers for the purpose of transporting goods.

Bay plan
A stowage plan showing the locations of all the containers on the vessel.

Bay
A vertical division on a vessel used as a part of the indication of container's stowage location. The bay number indicates the stowage position along the vessel's length. Bay numbers run from forward to aft.

Bending moment
The result of vertical forces acting on a ship due to local differences between weight and buoyancy. The total of these forces should be zero, as otherwise a change in draft of the vessel will occur. At sea the bending moment will change due to wave impact which will periodically change the buoyancy distribution.

Berth
A location in a port where a vessel can be moored, often indicated by a code or name.

Berthing window
Period of time that a vessel is allowed to berth, usually agreed between the terminal operator and the shipping line to grant a vessel some degree of guaranteed berthing time.

Bimodal trailer
- A road semi-trailer with retractable running gear to allow mounting on a pair of rail boogies.
- A trailer capable of carrying different types of standardised units and loads, e.g. a chassis suitable for the carriage of one FEU or two TEUs.

Block train
A number of railway wagons loaded with containers, departing from a location and running straight to a place of destination, without marshalling, transhipping or any coupling or decoupling of wagons.

Bogie
A removable, self-contained assembly of axles, wheels, springs, suspension and brake components built specifically to be used as rear wheels under a chassis. Assemblies which are not removableare known as undercarriages or running gear.

Bonded
The storage of goods in the custody of customs, i.e. under customs' seal, until the import duties are paid or until the goods are exported.
- Bonded warehouse – a place where the goods can be placed under bond.
- Bonded goods – goods for which customs duties have not yet been paid, i.e. goods in transit or warehoused pending customs clearance.

Booking reference number
The number assigned to a booking by the carrier or his agent.

Bordereau
Document used in road transport, listing the cargo carried by a road vehicle, often referring to appended copies of the road consignment note.

Bottom lift
Handling of containers with equipment attached to the four bottom corner fittings (corner castings).

Bottom slamming
Also referred to as 'pounding': the ship's bottom suffering a severe impact upon re-entering after it has emerged from the water.

Bow flare slamming
When the upper flared part of the ship's bow is forced deeper into the wave, the buoyancy of the bow section increases proportionally over time, thereby progressively dampening the downward movement of the bow.

Bridge fitting
A fixture with integrated turnscrew to keep top sides of adjacent containers together. Part of the lashing equipment.

Bulk container
A container designed for the carriage of free-flowing dry cargoes, which are loaded through hatchways in the roof of the container and discharged through hatchways at one end of the container.

Bunker
Tank spaces on board a vessel to store fuel.

Bushing
A synthetic or non-ferrous lining located between the hinge and hinge pin on a container to reduce electrolytic corrosion and provide ease of rotation. A synthetic lining does not need lubrication.

Cabotage
Pricing packages designed to encourage repositioning of containers into areas with a container deficit. Also refers to foreign vessels operating in domestic trade.

Cabover
Style of truck that has a vertical front or 'flat face', with the cab of the truck sitting above, or forward of, the front axle, offering greater manoeuvrability and a better overview for the driver. This contrasts with a conventional truck, where the engine is mounted in front of the driver. Also known as a 'flat-nose' truck.

Cam retainer
Female component which retains the cam locking device, sometimes called a 'keeper'.

Cam
The part of the door securing device (locking bar) that engages the female retainer (see cam retainer above) which, by a lever action, together forms the cam lock.

Camber
Slightly arched container floors used to strengthen the construction.

Cargo closing time
Containers for export are not allowed to enter the terminal after this time. The terminal's data control centre will verify that all the booked containers have arrived at the terminal.

Cargo opening time
Usually approximately one week before the vessel's expected date of arrival. The terminal grants trucks access to deliver the containers for export, and the container gate system assigns a section of the stacking area to the vessel's berth.

Cargo restriction code
A code indicating that the use of the container is restricted to a particular type of cargo.

Cargo tracer
A document sent by the agent to all the relevant parties, stating that cargo is either missing or overhauled.

Cargo
- Goods transported or to be transported, and all goods carried on a ship covered by a bill of lading.
- Any goods, wares, merchandise, and articles of any kind whatsoever carried on a ship, other than mail, ship's stores, ship's spare parts, ship's equipment, stowage material, crew's effects, containers and passengers' accompanied baggage (IMO).

Carriage
The process of transporting (conveying) cargo from one point to another.

Carrier haulage
The inland transport service performed by the sea carrier under the terms and conditions of the tariff and the relevant transport document.

Carrier
The party undertaking transport of the goods from one point to another.

CAD Cash against documents
Terms of payment; the buyer of the goods pays for the goods against transfer of the documents, entitling him to obtain delivery of the goods from the carrier.

Cattle container
A partly open container equipped with rails, boxes, and cribs for the transport of livestock.

Cell guides
The guidance system enabling containers to be lowered into and lifted from the hold of the vessel. The holds have vertical guides into which the containers are lowered to form secure stacks restrained at all four corners.

Cell
Stowage location on board a container vessel for one container.

Cellular vessel
A vessel fitted with cell guides and specially designed and equipped for the carriage of containers.

Central planner
A planner or planning centre, usually located at the ship's operators' offices, preparing a pre-stow plan with the input from booking forecasts, slot-charterers and booking information from their own agency.

Centre of gravity
Point at which the weight of a body may be considered as concentrated so that if supported at this point the body would remain in equilibrium in any position.

Certificate of origin
A certificate, showing the country of original production of goods. Frequently used by customs to assess duties under preferential tariff programmes or when regulating imports from specific sources.

CWE Cleared without examination
Cleared by Customs without inspection.

COU Clip on unit
A portable refrigeration unit designed to clip on to insulated containers which normally rely on a central refrigeration system for their cold air supply.

Closed ventilated container
A closed container, similar to a general purpose container, but specially designed for the carriage of cargo requiring natural or mechanical (forced) ventilation.

Cofferdam
An empty space between two bulkheads or two decks on board a vessel separating oil tanks from each other and/or the engine room or other compartments.

Collapsible container
A container with walls that are hinged, at the front and back ends in collapsible flat racks, or removable so that its volume may be reduced for transporting in an empty condition.

Combined transport operator
A forwarder providing combined transport and operating as carrier (see MTO).

Commercial invoice
A document showing the commercial value of the transaction between the buyer and seller.

Commodity box rate
A rate classified by type of commodity and quoted per container.

Commodity code
Code used in the harmonised system for the classification of the most commonly produced and traded goods.

Commodity
Indication of the type of goods. Commodities are coded according to the harmonised system.

Cones
Devices for facilitating the positioning and lashing of containers. The cones are inserted into the bottom castings of the container. A cone does only provide sideward restraint, no vertical restraint. Synonym: locating pins.

Conference
Also referred to as a liner conference. A group consisting of two or more vessel-operating carriers, providing regular services for the carriage of cargo on a particular trade route and which has an agreement or arrangement to operate under uniform and common freight rates and any other agreed conditions. e.g. FEFC = Far Eastern Freight Conference.

Consignee
The party stated in the transport document to whom the goods, cargo or containers are to be delivered.

Consignment
A separate identifiable number of goods to be or being transported from one consignor to one consignee using one or more than one modes of transport and specified in one single transport document. Synonym in the USA: Shipment.

Consignor
Also referred to as 'shipper'. The person by whom, in whose name or on whose behalf a contract of carriage of goods has been concluded with a carrier or any party by whom, in whose name or on whose behalf the goods are actually delivered to the carrier in relation to the contract of carriage.

Consolidate
To group and stuff several shipments together in one container.

Consortium
A form of co-operation between two or more carriers to operate in a particular trade.

Container bolster
A container floor without sides or end walls which does not have the ISO corner fittings and is generally used for Ro/Ro operations.

Container chassis
A vehicle specially built for the purpose of transporting a container so that when the container and chassis are assembled, the complete unit serves as a road trailer.

Container depot
Storage area for empty containers.

CFS Container freight station
A facility at which (export) LCL cargo is received for loading (stuffing) into containers or at which (import) LCL cargo is unloaded (stripped) from containers and delivered.

Container head
Refers to the end opposite to the doors. Also known as the container front or bulkhead.

Container lift truck
Container terminal equipment used to lift containers. Rubber-tyred vehicle powered by a diesel or hybrid diesel-electric engine, using a telescopic lifting frame in front of the vehicle to lift fully loaded containers. Containers are lifted vertically using the side apertures of the top corner castings.

Container load plan
A list of items loaded in a specific container and, where appropriate, their sequence of loading.

Container load
A consignment which fully occupies the internal capacity of one container or reaches the maximum payload for that particular unit.

Container manifest
The document specifying the contents of freight containers or other transport units, prepared by the party responsible for their loading into the container or unit.

Container moves
The number of actions performed by one container crane during a given period.

Container number
Identification number of a container, consisting of a prefix, serial number and check digit.

Container part load
A consignment which neither occupies the full capacity of a container nor equals the maximum payload and will, therefore, allow the addition of other part loads.

Container platform
A container floor without sides or walls, which can be loaded by a spreader and is used for Lo-Lo operations.

Container pool
Stock of containers used by several container carriers and/or leasing companies.

Container Safety Convention
International convention for safe containers 1972.

Container service charges
Charges to be paid by cargo interests according to the agreed tariff.

Container yard
Location at container terminal where containers are stored temporarily and which links the waterside and landside operations. Also known as a 'storage area'.

Container
An item of equipment as defined by the Convention of Safe Containers and International Organisation for Standardization (ISO) to be used for transport purposes.

Controlled atmosphere
Can be used in addition to temperature control to prolong the storage life of fruit.

Convention International concernant le transport des Marchandises par chemin de fer (CIM)
International agreement between 19 European railway companies setting out the conditions for international railway transport of goods and the liabilities of the carrier.

Convention relative au contrat de transport international de Marchandise par Route (CMR)
The Convention for the international carriage of goods by road, setting out the conditions of carriage and the liabilities of the carrier.

Converter dolly
An auxiliary undercarriage assembly consisting of a chassis, fifth wheel and towbar used to convert a semi-trailer or a container chassis into a full trailer.

Corner fitting
A corner fitting is a fixture consisting of standard apertures and faces which provide a common interface for handling and securing containers.

Corner post
Vertical structural posts at either side of container's end frame joining a top and a bottom corner fitting and thereby forming a 'corner structure'.

Corrugated container
A container with corrugated walls and ends for added strength.

CSC plate
Refers to the plate affixed to the door of a container recording the container's serial number, technical data (MGW, tare, payload etc.), as well as information on its manufacture, owner and the date of last CSC inspection.

Curbside
The side of the container/chassis nearest to the curb when the container/chassis is on the road driving on the right-hand side; i.e. the right hand side when travelling in the USA. and the European continent. Opposite to 'roadside'.

Customs seal protection cover
Rain cover fastened over door handle retainer to which the customs seal is affixed.

Customs seal retainer
Retainer to which customs seal is affixed, usually positioned by the door handle on inner bar of closure door.

Customs
The department within the Civil Service that deals with the levying of duties and taxes on imported goods from foreign countries and the control of the export and import of goods, e.g. quotas, prohibited goods etc.

Dangerous Goods Declaration
Document issued by a consignor in accordance with applicable conventions or regulations, describing hazardous goods or material for transport purposes, and stating that the latter have been packed and labelled in accordance with the provisions of the relevant conventions or regulations.

Dangerous goods
Goods which must be considered dangerous if the transport of such goods might cause harm, risk, peril, or other danger to people, the environment, equipment or any other property whatsoever.

Data plate
A plate affixed to a container giving details of gross and tare weights and the external dimensions of the container.

Deadfreight
Slots paid for but not used.

Deadload
The difference between the actual and calculated ship's draft.

DWT Deadweight
The total weight of cargo, cargo equipment, bunkers, provisions, water, stores and spuare parts which a vessel can lift when loaded to her maximum draught as applicable under the circumstances. The deadweight is expressed in tonnes.

Decal
Pressure sensitive label printed with the appropriate numbering, letters or symbols for identification purposes.

Demurrage
Fees charged when containers are left inside the terminal for longer than the agreed free days, and applies to all containers that remain at the terminal.

Depot
The place designated by the carrier where empty containers are kept in stock and received from or delivered to the container operators or merchants.

Design gross weight
The weight rating on which the structural design of the container is based, and is to be equal to or greater than the maximum gross weight.

Design load factor
Takes into account, insofar as practicable, the static and dynamic loads and other applicable considerations.

Design load
The minimum statically applied load which the container is designed to withstand.

Detention
Fees charged when containers are held outside the terminal longer than the agreed free time. All units will continue to incur a daily charge while in the custody of the consignee until returned to the shipping line.

Devanning
Sometimes used for the process of unpacking a container.

Direct interchange
Transfer of leased (container) equipment from one lessee to another.

Disbursement
Sums paid by a ship's agent at a port and recovered from the carrier.

Dispatch bays
The point from which containers are physically loaded or unloaded.

Displacement
The weight of the water displaced by the vessel. The displacement of the vessel on her light draft represents the weight of the vessel ready for use including stores etc.
Dispositioning
All activities relating to the inland movement of empty and/or full containers.
Distribution
Activities which ensure the availability of goods in customers' desired quality, quantity, place and time.
Dock leveller
A device used to span the difference in level between the loading bank and the container floor. It also bridges the gap between the bank and the container.
Dolly
A set of wheels placed under the front of a container to provide support when the unit is disconnected.
Door-to-door transport
The transport of cargo from the premises of the consignor to the premises of the consignee. Known as house-to-house in Europe or point-to-point in the US.
Double stack train
Railway wagons, usually a block train, on which containers can be stacked two-high.
Draft
Also referred to as 'draught'. The draft of a vessel is the vertical distance between the waterline and the underside of the keel of the vessel. During the construction of a vessel the marks showing the draft are welded on each side of the vessel near the stem, the stern and amidships.
Drayage
Road transportation between a railway terminal and the stuffing/stripping place.
Dricon
A chemical used in the treatment of timber against wood-boring insects.
Drop off charge
Charge made by the container owner and/or terminal operators for delivery of a leased, or pool container into depot stock.
Dry port
An inland terminal which is directly linked to a maritime port.)
Dual trolley system
A dual trolley gantry crane with a manned main trolley which moves the container from the vessel on to a platform and an automatic trolley which moves the container from the platform to the quay (or in reverse).
Dunnage
Stowage material, mainly timber or boards, used to prevent damage to cargo during carriage or to spread the load.
Duty free zone
An area where goods or cargo can be stored without paying import customs duties, awaiting further transportation or manufacturing.
EDI link
Connection between customer and carrier, allowing electronic data interchange (EDI).
EDI Electronic Data Interchange
The electronic transfer of structured data, by agreed standards from applications on the computer of one party to the applications on the computer of another party.
End load
The end load is the combined static and dynamic load imposed by the cargo on the container walls or doors, or both, which are perpendicular to the longitudinal axis of the container.
EDR Equipment Damage Report
Written statement covering damage to the equipment, based on a physical inspection.
EIR Equipment Interchange Receipt
Physical inspection and transfer receipt.
ETA Estimated Time of Arrival
The expected date and time of arrival in a given port.

ETD Estimated Time of Departure
The expected date and time of departure from a given port.
Fairway
A navigable channel for vessels, often the regular or prescribed track a vessel will follow to avoid hazards.
Feeder ship
A container vessel used in coastal trade serving ports where deep-sea containerships do not call.
Feeder
A vessel normally used for local or coastal transport, for the carriage of cargo and/or containers, to and from ports not scheduled to be called by the larger oceangoing vessel, directly connecting these ports to the oceangoing vessel.
Fetch
The horizontal distance over which wind blows from one constant direction.
Fifth wheel
A device used to connect a truck tractor to a chassis in order to permit articulation between the units. It usually consists of a trunnion plate and latching mechanism mounted on the truck tractor.
Fish plate
A plate which is welded or bolted across the joint of two connecting members in order to provide structural continuity at the joint.
Flash point
The lowest temperature at which a product or substance produces enough vapour to form a flammable mixture with air.
Flat bed trailer
A wheeled trailer or a semi-trailer with a flat cargo carrying surface or deck but without any superstructure.
Flat rack container
A container with two end walls and open sides. Synonym: flat.
Flat
A container with two end walls and open sides. Synonym: flat rack container.
Flat-nose truck
Body style of truck that has a vertical front or 'flat face', with the cab of the truck sitting above (or forward of) the front axle, offering greater manoeuvrability and a better overview for the driver. This contrasts with a conventional truck, where the engine is mounted in front of the driver. Also called a cabover.
Floor load
The combined static and dynamic load imposed on the floor by the cargo and by the wheels of the handling equipment.
Floor loading
The static and dynamic loads imposed on the floor by the payload and the wheels of the handling equipment.
Footprint
The area of the tyre which comes into contact with the surface on which it is operating under a given load, measured in square inches. For the purposes of container floor design, the footprint of a pneumatic and cushion tyre is estimated at 22 square inches.
Fork lift truck
Container terminal equipment used to lift containers. Rubber-tyred vehicle powered by a diesel or hybrid diesel-electric engine, used to lift fully loaded containers. Containers are lifted by inserting the prongs into the forklift pockets in the container's base frame.
Fork pockets
Openings or recesses in a side of a container for insertion of the forks of a fork lift truck.
FEU Forty foot equivalent unit
Unit of measurement equivalent to one forty foot container.

Forwarder
The party arranging the carriage of goods including connected services and/or associated formalities on behalf of a shipper or consignee.

Forwarding instruction
Document issued to a freight forwarder, giving instructions to the forwarder for the forwarding of the goods described therein.

Franchise
The amount which will have to be borne by the assured in a claim for damage.

Free In and Out
Transport condition denoting that the freight rate excludes the costs of loading and discharging and, if appropriate, stowage and lashing.

Freeboard of a vessel
Vertical distance from the main deck to the surface of the water measured at the middle of the vessel's length.

Freight collect
Freight and charges to be paid by the consignee.

Freight prepaid
Acknowledgement of payment of freight by shipper.

Freight
The amount of money due for the carriage of goods and payable either in advance or upon delivery.

Front pin locking device
A container securing device that, when locked, prevents the container from disengaging from the chassis.

FCL Full container load
A container stuffed or stripped under risk and for account of the shipper and/or the consignee.

Full tilt container
A container with full sides and roof, occasionally also the ends, covered by tarpaulin, drop sides notwithstanding.

Fumigation
Exposing the insides of a container to toxic gas, in line with regulations, to prevent certain parasites and bacteria from entering a country.

Gantry crane
A crane or hoisting machine mounted on a frame or structure spanning an intervening space, which often travels on rails. Designed for loading/discharging containers onto/from containerships.

Garments on hangers
Garments prepacked onto hangers and hung from rails during transit, reducing any handling of the garments.

Gen-set
Motor generator set as power source for, e.g. thermal containers.

Gooseneck
The upper level of the front of the chassis and the structure which connect the chassis to the lower level. The gooseneck rails normally fit into the tunnel recess of containers constructed for this purpose.

GRT Gross Tonnage
The measure of the overall size of a vessel determined in accordance with the provisions of the International convention on tonnage measurement of ships 1969, and usually expressed in registered tons.

GVWR Gross Vehicle Weight Rating
The structural capacity of a chassis supported at the kingpin and axles with the load uniformly distributed along its length. In some countries other than the United States this includes the weight of the tractor.

Gross weight
The weight of a chassis and a container together with the weight of its entire contents.

Groupage
The collection of several small consignments and the formation of one large shipment from these smaller consignments.

Hard-top container
A closed container with a roof that opens or lifts off.

HS Harmonised System
A numeric multipurpose system, developed through customs co-operation.

Hatch cover
Means of closing the hatchway of a vessel.

Haulage
The inland carriage of cargo or containers by truck between named locations/points.

Header bar
A beam or bar, usually above the end doors of an open-top container, which may be swung to one side or removed to improve access.

Heave
Linear motion: vertical, or up and down movement of a vessel.

Hinterland
The inland area served by a port.

Hogged
The loaded condition of a vessel in such a way that the centre of the vessel is slightly raised - arching upwards at the centre.

Hold
The space below the deck of a vessel, used to carry cargo.

Home port
The vessel's the port of registration.

Horn
A structural part on the front of a chassis that serves as a gathering device for guiding a container into its proper place on the chassis for securing. In transit, the horn provides a mechanical stop to prevent forward movement of the container with respect to the chassis. The horn frequently serves as a mounting place for the connection box. Also known as 'container guide' or stop.

House Bill
A bill of lading issued by a groupage/consolidating agent to his customers for goods consolidated into one container, for which the carrier issues a bill of lading to the agent.

House-to-house transport
Term used in Europe. The transport of cargo from the premises of the consignor to the premises of the consignee. Also termed door-to-door, or point-to-point (US).

House-to-pier
A container packed inland but unpacked at the pier of the destination port.

Hub
Major ports where containers are transferred between oceangoing containerships and feeders.

Hull girder theory
Theory which thinks of a vessel's hull as a floating single steel beam. Applies to strength load calculations.

Hull
Outer shell of a vessel, made of steel plates or other suitable material to keep water on the outside of the vessel.

Husbanding
Taking care of a vessel's non cargo related operations as instructed by the master or owner of the vessel.

Idle time
The amount of ineffective time whereby the available resources are not used, e.g. a container in a yard.

Importer
The party responsible for the import of goods. For customs purposes, it is the party who makes, or on whose behalf an agent makes, an important declaration. This party may be the party who is entitled to possession of the goods or to whom the goods are consigned.

In transit
The status of goods or persons between the outward customs clearance and inward customs clearance.

Incoterms
Provides internationally accepted definitions and rules of interpretation for most common commercial terms. First published by the International Chamber of Commerce in 1936, and have been regularly updated since that time.

Indemnification
Compensation for loss, damage and/or expenses incurred.

Infrastructure
System of roads, waterways, airfields, ports and/or telecommunication networks.

ICD Inland clearance depot
A common-user inland facility with public authority status, equipped with fixed installations and offering services for the handling and temporary storage of goods, including containers, carried under customs transit by any applicable mode of inland surface transport, and placed under customs control to clear goods for home use, warehousing, temporary admission, re-export, temporary storage for onward transit, and outright export.

Inland Container Depot
A common-user facility with public authority status equipped with fixed installations and offering services for the handling and temporary storage of import/export laden and empty containers carried under customs transit by any applicable mode of transport and placed under customs control. All the activities related to clearance of goods for home use, warehousing, temporary admissions, re-expert, temporary storage for onward transit and outright transport, and transhipment take place from such facilities.

Inland freight terminal
Any facility, other than a port or an airport, operated on a common-user basis, at which cargo in international trade is received or dispatched.

Inland port
Located inland, generally far from seaport terminals; and supplies the region with an intermodal terminal offering value-added services or a merging point for different modes of traffic involved in distributing merchandise that comes from ports.

Inland Waterways Bill of Lading
Document made out to a named person, to order or to bearer, signed by the carrier and handed to the sender after receipt of goods to be carried by inland waterways craft.

Insulated container
A container with insulated walls, roof, floor, and doors which reduce the effect of external temperature on the cargo without the use of cooling and/or heating devices.

Interface
The point at which two systems meet, i.e. road transport and terminal – terminal and ship.

Intermodal freight centre
A combination of financially independent freight and supplementary service companies located within an area where a change of transport units between traffic modes can take place.

Intermodal transport
The movement of goods (containers) in one loading unit or vehicle using several modes of transport without need for handling of the goods themselves when changing transport mode.

IACS International Association of Classification Societies
An organisation where the major classification societies are members, and whose principal aim is the improvement of safety at sea standards.

ICS International Chamber of Shipping
A voluntary organisation consisting of national shipowners' associations with the objective of promoting the interests of its members, primarily within the technical and legal areas of shipping operations.

ILO International Labour Organisation
A United Nations agency, dealing with employment rights and working conditions both at sea and in ports.

IMDG Code International Maritime Dangerous Goods Code
Classification of dangerous goods as defined by the International Maritime Organisation (IMO) and in compliance with international legal requirements.

IMO International Maritime Organization
A United Nations agency concerned with safety at sea. Its work includes codes, conventions and rules relating to the tonnage measurement of vessels, load lines, pollution and the carriage of dangerous goods. Previously the Inter-governmental Maritime Consultative Organization (IMCO).

ISO International Organisation for Standardization
A world-wide federation of national standards institutes (ISO member bodies).

Itinerary
The route undertaken by a transport carrier, indicated by the names of the ports of call or other locations, often including estimated arrival and departure dates.

Joinable container
A container whose dimensions and specifications are fixed to permit the loading of the containers onto a container flat enabling the complete unit to be handled as one ISO container.

Jones Act
Merchant Marine Act of 1920. US federal rule that supports the promotion and maintenance of the American merchant marine. Regulates, amongst others, matters of maritime commerce in US waters and between US ports.

Keel
Longitudinal girder at the lowest point of a vessel from which the framework is built.

King pin
The coupling pin, welded or bolted in the centre of the front underside of a semi-trailer chassis, which joins it to the fifth wheel of the towing tractor or dolly converter.

Land bridge
Overland transit between two ocean passages during a container's journey from starting point to destination.

Landing gear
Devices, generally adjustable in height, used to support the front end of a chassis in an approximately level position when disconnected from the towing vehicle. Also known as supports.

Landing legs
Vertically adjustable supporting legs on landing gear to which sandshoes or wheels are attached.

Landside area
Location at a container terminal where containers are delivered or leave the terminal by road, rail or barge.

Latticed-sided
An open or closed container with at least one side consisting of elements with openings between them.

LCL Less than Container Load
An LCL container is a container in which multiple consignments or parts of consignments are shipped, and where the carrier is responsible for packing and/or unpacking the container.

Lessee
The party to whom the possession of property has been transferred for a period of time in return for rental payments.

Liner conference
Also referred to as a 'conference'. A group of two or more vessel-operating carriers, which provides regular services for the carriage of cargo along a particular trade route and which has an agreement or arrangement to operate under uniform and common freight rates and any other agreed conditions (e.g. FEFC = Far Eastern Freight Conference).

LIFO Liner In Free Out
Transport condition denoting that the freight rate is exclusive of the sea carriage and the cost of loading, the latter in accordance with the custom of the port. It also excludes the cost of discharging.

Liner terms
Condition of carriage stating that costs for loading and unloading are borne by the carrier subject to the custom of the port concerned.

Loading list
List of containers to be loaded and discharged, containing information such as unique container identification numbers, weight, and other references such as IMO class and if necessary, the required setting temperature. The list is provided by the local ship's agent of each slot charterer to the terminal operator.

Loadmaster
A load calculator designed for a specific vessel and approved by its classification society for calculation of the vessel's stability.

Locating pins
Devices for facilitating the positioning and lashing of containers. The cones are inserted into the bottom castings of the container. Synonym: cones.

Logistic centre/freight village
Group of independent companies and bodies involved with freight transport (for example freight forwarders, shippers, transport operators, customs) and accompanying services (for example storage, maintenance and repair), including at least a terminal.

Logistics
The planning, execution and control of the movement and placement of people and/or goods, and the support required to perform those tasks.

Mafi trailer
German brand name of a roll trailer used for RoRo purposes.

Malaccamax
Term used by naval architects when referring to the largest ship capable of passing through the 25 metre deep Strait of Malacca.

Maximum gross weight
R or rating is the maximum permissible combined mass of the container and its cargo for which the container ihas beens tested and is expressed in kilogrammes and pounds.

Merchant haulage
Inland transport of cargo in containers arranged by the merchant.

MTO/Carrier Multimodal Transport Operator/Carrier
The party on whose behalf the transport document or any document evidencing a contract of multimodal carriage of goods is issued and who is responsible for the carriage of goods pursuant to the contract of carriage.

Multimodal transport
The carriage of goods (containers) by at least two different modes of transport.

Net tonnage
The measure of the useful capacity of a vessel determined in accordance with the provisions of the International Convention on Tonnage Measurement of Vessels 1969.

Net weight
The weight of goods, excluding all packaging.

NVOCC Non Vessel Operating Common Carrier
A party who undertakes to carry goods and issues in his own name a bill of lading for such carriage, without using own means of transport.

Notice of Readiness
Written document or telex issued by the master of a vessel to the charterers advising them the when a vessel is ready to load or discharge.

Notify Address
Address of the party other than the consignee to be advised of the arrival of the goods.

On-carriage
The carriage of goods (containers) by any mode of transport after discharge from the ocean going vessel (the main means of transport) at the port (place) of discharge to the place of delivery.

Open-sided container
Container with wire-mesh frames at the sides covered by a tarpaulin which can be rolled up to give unrestricted access to the sides of the container for loading or discharging.

Open-top container
A freight container similar in all respects to a general purpose container except that it has no rigid roof, but may have a flexible and movable or removable cover (called a tilt).

OOG cargo Out-of-gauge cargo
Cargo of a size exceeding the standard dimensions of a 20 or 40 foot container, e.g. overlength, overwidth, overheight, or a combination thereof.

Packing list
Document specifying the contents of each individual package.

Pallet
A platform on which goods can be stacked in order to facilitate movement by a fork lift or sling.

Panamax size
The maximum measurements and dimensions of a vessel able to go through the Panama Canal.

Parametric rolling motion
Large unstable rolling motion suddenly occurring in head or stern seas.

Payload (container)
The maximum weight of cargo that can be loaded in a container (payload = MGW – tare)

Payload
P or payload is the difference between R and T and is expressed in kilogrammes and pounds.

Payment against documents
Instructions given by a seller to his bank to the effect that the buyer may collect the document necessary to obtain delivery of the goods only upon payment of the invoice, i.e. a documentary collection.

Pendulum motion control
Equipment found in modern gantry cranes which eliminates the effects of wind and container imbalance.

Piggyback
The carriage of road vehicles and trailers on railway wagons.

Pilferage
Theft of goods from a ship's hold, container, cargo shed or warehouse.

Pitch
Rotational motion: movement along the transverse axis, causing the bow and stern of the ship to move up and down.

Place of acceptance
The location where a consignment (shipment) is received by the carrier from the shipper, i.e. the place where the carrier's liability for the goods commences. Also referred to as the 'place of receipt'.

Place of delivery
The location where a consignment (shipment) is delivered to the consignee, i.e. the place where the carrier's liability for the goods ends.

Place of receipt
The location where a consignment (shipment) is received by the carrier from the shipper, i.e. the place where the carrier's liability for the goods commences. Also referred to as the 'place of acceptance'.

Plymetal
Panel construction consisting of a plywood core and galvanised steel or aluminium facing.

Point-to-point transport (US)
The transport of cargo from the premises of the consignor to the premises of the consignee. Known as house-to-house in Europe, or door-to-door.

Poop
Aft part of a vessel where the steering engine is located.

Portainer (crane)
A port (vessel) container gantry crane.

Pounding
Also referred to as 'bottom slamming': the ship's bottom suffering a severe impact upon re-entering after it emerging from the water.

Precarriage
The carriage of goods (containers) by any mode of transport from the place of receipt to the port (place) of loading onto the oceangoing vessel.

Precarrier
The carrier used to move the goods prior to the main transport.

Precision vehicle positioning
Equipment on modern gantry cranes used to align the vehicles on the quay in an optimal position for loading or unloading.

Prefix
Container alpha prefix which forms part of the containers' identification number. The 4 letters that proceed the 6-digit serial number and check digit on a container.

Preliminary stowage plan
Stowage plan produced by the terminal planner based on the pre-stowage plan, the inbound stowage plan from the previous port of call, and the loading list with the containers to be loaded. Purpose of the preliminary stowage plan is to assign container numbers to positions on board the vessel by adhering to general principles of stowage. The preliminary stowage plan is compiled shortly before the vessel's arrival.

Pre-shipment inspection
Goods are surveyed by an independent surveyor (the inspection company) before shipment for the purpose of determining the quantity and/or quality of the goods and for phytosanitary, sanitary and veterinary controls.

Pre-stowage plan
Prepared by the terminal's planning centre on the basis of booking information received to ensure that all containers can be carried on board in a safe manner and that the cargo is loaded in such a way as to avoid re-stows in future ports of call.

Pre-trip inspection
Technical inspection of reefer containers prior to positioning for stuffing.

Process of quay planning
Booking an intended quay position and allocating cranes to a vessel, taking into account the vessel's technical requirements and the restrictions at the berthing place, such as air draught, water draught, outreach of the crane, etc.

Protection and indemnity (P&I) association
An association of shipowners providing insurance protection against liabilities incurred by carriers on a mutual basis.

Prototype
A representative unit of a series of identical containers built under conditions which duplicate, insofar as is practicable, the conditions under which all of the containers in the series are to be manufactured.

Racking force
One of three strength criteria for containers: force that changes the shape of a container from a rectangle to a parallelogram, ultimately folding it flat.

Rails
Main horizontal frame components attached to the corner fittings and corner posts at top and bottom of a container.

Rating
A crew member who is not an officer.

Reach stacker
Also called a 'top picker'. Container terminal equipment used to stack containers. Rubber-tyred vehicle powered by a diesel engine or a hybrid diesel-electric engine, and used to lift fully loaded containers. A telescopic arm with a spreader device attached to the top lifts the container by the top corner castings. Can stack containers five tiers high.

Reconditioning
All activities connected with restoring and/or adjusting the packaging of a product in such a manner that it can be presented to the customer in the required form.

Reefer cargo
Cargo requiring temperature control during the carriage.

Reefer container
A thermal container with refrigerating appliances (mechanical compressor unit, absorption unit, etc.) to control the temperature of cargo.

Reference mass
The mass which is to be multiplied by the design load factor to obtain the design load.

Regroupage
The process of splitting up shipments into various consignments (degroupage) and combining these small consignments into other shipments (groupage).

Road carrier
The party undertaking the transport by road of goods from one point to another as set out in the contract (also known as a haulier).

Roadside
The side of the container/chassis furthest away from the curb when driving on the road on the right-hand side. Opposite to 'curbside'.

Roll trailer
Special trailer for terminal haulage and stowage on board Roll-on Roll-off vessels. Also known as a Mafi trailer.

Roll
Rotational motion: movement along the longitudinal axis of the ship, causing the port and starboard sides to move up and down.

RORO Roll-on Roll-off
Loading and discharging a vessel whereby the cargo is driven on and off the vessel by means of a ramp.

Roof bows
Transverse components attached to the container's top side rails, supporting the roof.

Roof load
The combined static and dynamic load imposed on the roof of a container.

Roof reinforcement plate
An additional plate attached to the container roof, adjacent to the top corner fittings, providing additional roof protection from handling equipment.

Rotation
The sequence in which a vessel calls at the ports on her itinerary.

Row
A vertical division of a vessel from starboard to port side, used as a part of the indication of a stowage place for containers. The numbers run from midships to both sides.

Russian stow
Stowage where a 40 foot container is placed on top of two 20 foot containers. The basic principle behind this type of stowage is that containers can only be stacked with the ISO corner castings resting on top of one another.

SWL Safe working load
The maximum load any lifting appliance can handle.

STC Said to contain
Term used in a bill of lading to indicate that the carrier is unaware of the nature or quantity of the contents of, e.g. a container, carton, crate, container or bundle and is relying on the description furnished by the shipper.

Seal
A device used on containers, locker, trucks or lorries to prove to the relevant parties that they have remained closed during transport.
Semitrailer
A vehicle without motor power and with one or more axles designed to be drawn by a truck tractor and constructed in such a way that a portion of its weight and that of its load rest upon, e.g. the fifth wheel of the towing vehicle.
Service bill
A contract of carriage issued by one carrier to another carrier for documentary and internal control purposes only.
Setting/air delivery temperature
Content of the bill of lading stating the air supply temperature to the container.
Shear forces
Vertical forces acting along the length of a ship which are locally not balanced with the overall buoyancy force acting on the exterior of the ship's hull, and which will cause the hull girder to shear.
Ship operator
A ship operator is either the shipowner or the (legal) person responsible for the management of the vessel and its crew.
Shipowner
The (legal) person officially registered as such in the vessel's certificate of registry.
Shipment (USA)
Also referred to as 'consignment'. An identifiable number of pieces of goods (available to be) transported from one consignor to one consignee via one or more modes of transport and listed in one single transport document.
Shipper
Also referred to as 'consignor'. The merchant (person) by whom, in whose name or on whose behalf a contract of the carriage of goods has been concluded with a carrier or any party by whom, in whose name or on whose behalf the goods are actually delivered to the carrier in relation to the contract of carriage.
Shipping line booking system
System used to book cargo shipments finding the best route for each shipment to its final destination. Input supplied by shipper and shipping line's agency.
Shipping marks
Marks shown on individual packages in order to identify them and to enable the cargo to be checked against transport documents.
Side load
The combined static and dynamic load imposed by the cargo on the container's walls or doors, or both, which is perpendicular to the transverse axis of the container.
Side loader
A lift truck with the lifting equipment for handling containers operating to one side.
Significant wave height
Statistical term, indicative of a certain range of wave heights which is an average of the largest waves, meaning that individual waves may be higher.
Single trolley system
System whereby a single trolley crane transports the container in one move from its stowage position on board to the quay or on to a terminal vehicle.
Skeletal trailer
Road trailer consisting of a frame and wheels, specially designed to carry containers.
Slamming
A ship's hull impacting heavily with the water surface.
Slot charterer
A charter where the shipowner agrees to place a certain number of container slots (TEU and/or FEU) at the charterer's disposal.

Slot
The amount of space on board a vessel required by one container, mainly used for administrative purposes.
Snake loading
Loading a product into a container in the sequence that the goods will be unloaded and stored at its destination.
Specified dimensions
The length, width, and height of a container which are the maximum permissible external dimensions.
Spreader
- Device used for lifting containers and unitised cargo.
- Beam or frame that holds the slings vertical when hoisting a load, to prevent damage to the cargo.

Springing
Strong hull girder vibration due to oscillating wave loads.
Stack car
Railroad car designed to carry containers used in intermodal freight transport. Also known as a 'well car' or 'double-stack car'.
Stack
An identifiable number of containers stowed in an orderly way in one specified place at an (ocean) terminal, container freight station, container yard or depot.
Stacking cone
A fitting piece between two containers located at each corner, to provide sideways restraint only.
Staggers Rail Act
Deregulation law covering rail transport in the US (1980), providing rail operators with the possibility of establishing their own rates and contracts with shippers. The Act was named after its sponsor, Harley O. Staggers.
Stem
The foremost part of a vessel.
Stern slamming
The underside of the vessel's stern impacting with the water surface.
Stern
The aftermost part of a vessel.
Stevedore
A party running a business involved in the loading, stowing and discharging of vessels.
Still water bending moment
Result of an unevenness in the weight distribution acting downwards and the buoyancy force distribution acting upwards, causing the hull girder to bend.
Storage area
Location at a container terminal where containers are stored temporarily and which links waterside and landside operations. Also called 'container yard'.
Storage on chassis
Terminal storage system where containers are placed on a chassis consisting of a simple steel frame resting on supporting legs, with guides to allow easy and correct positioning of the container. Particularly popular in the US.
Stowage factor
Ratio of a cargo's cubic measurement to its weight, expressed in cubic feet to the tonne or cubic metres to the tonne, used to determine the total quantity of cargo which can be loaded in a certain space.
Stowage
The placing and securing of cargo or containers on board a vessel, or of cargo in a container.
Straddle carrier
Container terminal equipment used to stack containers. Straddle carriers pick and carry containers while straddling their load and connecting to the top lifting points of the container using a container spreader. Can stack containers up to four tiers high.

Straddle crane
A crane, usually running on rails and spanning an open area such as rail tracks, roadways or container yards.

Stripping
A term sometimes used for unpacking a container.

Stuffing
A term sometimes used for packing a container.

Surf riding
Acceleration of a ship located on the steep forefront of a high wave in following and quartering seas.

Surge
Linear motion: longitudinal (fore to aft) movement.

Swap body
Separate unit without wheels used to carry cargo by road, sometimes equipped with legs and used to carry intermodal cargo within Europe.

Sway
Linear motion: lateral (side to side) movement.

Synchronous rolling motion
Large rolling motions of a ship, occurring when its natural rolling period coincides with the wave encounter period in following and quartering seas.

Tandem lift
The lifting of two (or three) containers side by side.

Tank container
A tank, usually surrounded by a framework with the overall dimensions of a container for the transport of liquids or gasses in bulk.

Tare mass of container:
Mass of an empty container including all its fittings and appliances associated with that particular type of container in its normal operating condition. Also referred to as 'tare weight of container'.

Tare weight of container
Mass of an empty container including all its fittings and appliances associated with that particular type of container in its normal operating condition. Also referred to as 'tare mass of container'.

Tare weight
The weight of a chassis without the container.

Tare
T or tare is the mass of the empty container, including its normal complement of fittings, equipment and devices, and is expressed in kilogrammes and pounds.

Terminal planner
Vessel planner at the terminal's planning department responsible for preparing the preliminary stowage plan and the division of work between the gantry cranes and other related equipment. Central point of contact for all planning activities during the vessel's stay at the terminal.

Terminal
A location at either end of a transportation line which includes servicing and handling facilities.

Tier
A horizontal division of a vessel from hold bottom to top. The numbers run from hold bottom to deck and from deck upwards and are used as a part of the indication of a stowage place for containers.

TCT Timber component treated
The treatment of all exposed wood components in containers to protect them from insect infestation is a requirement of the Commonwealth of Australia. Permanent protection is usually accomplished by treatment with approved preservatives. A list of approved preservatives and the minimum retention requirement can be found in Quarantine Aspects and Procedures' issued by the Commonwealth of Australia, Department of Health.

Top picker
Also called a 'reach stacker'. Container terminal equipment used to stack containers. Rubber-tyred vehicle powered by a diesel engine or a hybrid diesel-electric engine, used to lift fully loaded containers. A telescopic arm with a spreader device attached to the top lifts the container by the top corner castings. Can stack containers five tiers high.

Torsional stresses
Forces twisting the ship's hull along the longitudinal centre line.

Track & trace
The pro-active tracking of the product along the supply chain, and the flow of paper information relating to the other.

TOFC Trailer on flat car
Carriage of piggyback highway trailers on specially equipped railway wagons.

Trailer
A vehicle without engine power, designed for the carriage of cargo and to be towed by a motor vehicle.

Tramp vessel
A vessel not operating on a regular schedule.

Trans Siberian Landbridge
Overland route from Europe to the Asia via the Trans Siberian Railway (TSR).

Transhipment
A shipment under one bill of lading, whereby sea (ocean) transport is divided into two or more parts. The port where the sea (ocean) transport is divided is the transhipment port.

Transit cargo
Cargo located between outward customs clearance and inward customs clearance.

TIR Transport International by Road
A set of rules developed following a customs convention to facilitate the international European transport by road with minimal interventions under cover of TIR carnets.

Truck tractor
A motor vehicle used for pulling a chassis or semitrailer which carries part of the chassis weight and load.

Tugmaster
Brand name of tractor units used in ports to pull trailers. They are equipped with a fifth wheel or a gooseneck type of coupling.

TEU Twenty foot Equivalent Unit
Unit of measurement equivalent to one 20-foot container.

Twin lift
The lifting of two 20-foot containers at the same time in a 40-foot spreader.

Twistlock
A securing device consisting of a rotatable head and fixed collar that is inserted into the bottom aperture of a bottom corner fitting to prevent the disengagement of the container from the chassis when the rotatable head is in the locked position.

Undercarriage
Consists of the complete subframe suspension, with one or more axles which may be interconnected, together with wheels, tires and brakes.

UN/ECE United Nations Economic Commission for Europe
The UN/ECE is one of a number of Economic and Social Commissions established by the General Assembly of the United Nations. Despite its name it embraces both Europe and North America. The aim is to advance the economic development of Europe and associated countries through trade facilitation and common agreements.

Vanning
An American term sometimes used for packing a container.

Vendee
Buyer.

Vendor
Seller.

Ventilated container
A container with openings in the side or end walls to allow for the ingress of outside air when the doors are shut.

Vertical compression forces
One of the three strength criteria for containers: force acting vertically on the compression side of a container through the corner posts.

Vertical tandem lift
The lifting of two containers locked one above the other in one operation.

Vertical tension forces
One of the three strength criteria of containers: force acting on the container through the corner posts, causing a container to tip or pull out of its corner fittings and/or from the bottom foundation on the hatch covers.

Waterside area
Location at container terminal with quay wall, apron and cranes where ships and barges are discharged and loaded.

Wave height
Distance measured from the trough to the crest of a wave.

Wave length
Distance between successive wave crests or troughs.

Wave period
The time that elapses between the passing of successive wave crests or troughs.

Wave steepness
The slope determined by the ratio between wave height and wave length.

Waybill
Non-negotiable document evidencing the contract for the transport of cargo.

Well car
Railroad car designed to carry containers used in intermodal freight transport. Also known as a 'stack car' or 'double-stack car'.

WWT Wind and water tight – repair criteria
Criteria under which containers would literally be 'wind and water tight'. This commonly used criteria makes no reference to the quality of the understructure of the container and should therefore not be considered as safe for the transport of cargo unless it was explicitly confirmed that the containers meet the CSC.

Yard crane
Container terminal equipment used to stack containers, consisting of a steel portal frame, a trolley and a spreader. The crane drives on either rubber tyres (TG – rubber tyred gantry) or moves on a rail system (RMG – rail mounted gantry).

Yard
Fenced off, outdoor storage and repair area.

Yaw
Rotational motion: movement along the vessel's vertical axis, causing the bow and stern to move sideways.

Abbreviations

ABS American Bureau of Shipping
ACEP Approved Continuous Examination Programme
ACP Panama Canal Authority
ADR Accord européen relatif au transport international des merchandises Dangereuses par Route. (The European agreement concerning the international carriage of dangerous goods by road.)
AF Advance freight
AGV Automated guided vehicle
AGVS Automated guided vehicle system
AHR Antwerp-Hamburg range (of ports)
ALV Automated lifting vehicle
AND Agreement on the transport of dangerous substances by inland waterway
ANSI American National Standards
ARMG Automated rail mounted gantry crane (also referred to as ASC)
ARTG Automated rubber-tired gantry crane
ARTUBAR Articulated tug barge
ASA American Standards Association
ASC Automatic stacking crane (also referred to as ARMG)
B/L Bill of lading
BIC Bureau International des Containers. Paris based organisation that maintains the official registry of alpha container prefixes used to identify containers.
BSC British Shippers' Council
BSI British Standards Institution
BV Bureau Veritas
CA Controlled atmosphere
CAD Cash against documents
CAF Currency adjustment factor
CCS China Classification Society
CCTV Closed-circuit television
CDIC Container damage inspection criteria
CDNI Convention on the treatment of waste produced during inland navigation
CEN Comité Européen de Normalisation
CFO Container flow operation
CFS Container freight station
CIC Container inspection criteria
CIF Cost, insurance and freight
CIM Convention International concernant le transport des Marchandises par chemin de fer
CINS Cargo Incident Notification System (see www.cinsnet.com)
CLNI Convention on the limitation of liability in inland navigation on the Rhine and elsewhere
CLP Container load plan
CMNI Convention on the contract for the carriage of goods by inland waterway
CMR Convention relative au contrat de transport international de Marchandise par Route
COARRI Container arrival message
COC Carrier owned container. A container owned or leased by a shipping line – new or used – to transport goods by providing both the container and the transportation service. COC is the opposite of an SOC
CODECO Container departure confirmation
COFC Container on flat car
COG Centre of gravity
COPARN Container pre-arrival notice
COPRAR Container pre-arrival message
COREOR Container Release Order
CORTEN or COR-TEN is a registered trade mark of the United States Steel Corporation. Commonly referred to as CORTEN, this type of steel is carbon enriched to make it stronger (than mild steel) and more resistant to corrosion
COTIF Convention Concerning International Carriage by Rail (CIM/CIV)
COU Clip on unit
CRS Croatian Register of Shipping
CSC Container Safety Convention. The 1972 Convention for Safe Containers to maintain a high level of safety of human life in the transport and handling of containers by providing generally acceptable test procedures and related strength requirements and to facilitate the international transport of containers by providing uniform international safety regulations
CSM Cargo securing manual (IMO/SOLAS)
CSS Safe practice code for cargo stowage and securing (IMO)
CTO Combined transport operator
CW Cargo-worthy certificate. Certificate issued by a surveyor pursuant to an inspection confirming a container is suitable for transportation under TIT/UIC/CSC
CWE Cleared without examination (at Customs)
CY Container yard

DNV GL Classification society, result of merger between Det Norske Veritas and Germanischer Lloyd, 2013
DPP Damage protection plan. Damage protection offered by containers lessors who are not technically allowed to offer insurance which is a regulated market
DWT Deadweight
ECE Economic Commission for Europe (UN)
ECH Empty container handler (front loaders capable of up to 9-high stacking ashore)
EDI Electronic data interchange
EDIFACT Electronic data interchange for administration, commerce and transport
EDP Electronic data processing
EDR Equipment damage report
EIR Equipment interchange receipt. Document established at the time a container arrives in or leaves from a depot that will serve to document the transfer of responsibility. While not systematic, most EIRs will record the verification of a container's condition at the time of transfer
EMS Guide Emergency response procedures for ships carrying dangerous goods
EMS Emergency medical service
EMS European modular system
EMSA European Maritime Safety Agency
ESN European shortsea network
ESPO European Sea Ports Organisation
ETA Estimated time of arrival
ETD Estimated time of departure
FAL Fully automatic lock
FCC Fully cellular containership
FCL Full container load
FCR Forwarder's certificate of receipt
FEFC Far Eastern Freight Conference
FEU Forty-foot equivalent unit (2 TEU = 1 FEU)
FILO Free in liner out
FIO Free in and out
FOB Free on board
FOT Free on truck. Generally accepted acronym (not an INCOTERM) that implies that containers are delivered on to the truck and implies that the seller is responsible for the cost of loading the container on to the truck.
FWC Fully-loaded weight and capacity
GA General average
GIWW Gulf intracoastal waterway
GL Germanischer Lloyd (Classification society)
GMDSS Global Maritime Distress and Safety Service (Signal)
GRT Gross tonnage
GVWR Gross vehicle weight rating
HS Harmonised system
IACS International Association of Classification Societies
ICC International Chamber of Commerce
ICCO International Council of Containership Operators
ICD Inland clearance depot
ICHCA International Cargo Handling Coordination Association
ICS International Chamber of Shipping
IICL Institute of International Container Lessors. Washington DC based organisation which groups the largest container and chassis leasing companies in the world
ILO International Labour Organization
IMDG Code International Maritime Dangerous Goods Code
IMGS International Medical Guide for Ships
IMO International Maritime Organization (UN)
INSA International Shipowners' Association
IRS Indian Register of Shipping
ISM The International Safety Management code (IMO)
ISO International Organization for Standardization. International organisation based in Geneva that works towards harmonising worldwide technical standards including those governing the construction of shipping containers
ITF International Transport Workers' Federation
KR Korean Register of Shipping
L/C Letter of credit
LCL Less than container load
LCV Long combination vehicle, or road train. There are several different arrangements:
B-double (20 + 40 or 20 + 20)
B-triple (20 + 20 + 40)
Double road train / 'pocket train' (40 + 40)
AB-triple (40 + 20 + 40)
BAB Quad (20 + 40 + 20 + 40)
ABB Quad (40 + 20 + 20 + 40)
Triple road train (40 + 40 + 40)
2AB Quad (40 + 20 + 20 + 40)
Powertrain (40 + 40 + 40 + 20 + 40 + 40 + 40)
LIFO Liner in free out
LOC Letter of compliance
LR Lloyd's Register
MFAG Medical First Aid Guide for use in accidents involving dangerous goods
MH Merchant haulage
MOS Motorways of the sea
MSC Maritime Safety Committee
MTO Multimodal transport operator
MTS Multi trailer system
MTU Multi trailer unit
NHTSA US National Highway Traffic Safety Administration
NK Nippon Kaiji Kyokai (ClassNK)
NMB National Maritime Board
NVO(C)C Non vessel operating (common) carrier
OH Over height
OHB Overhead bridge crane
OOG Out of gauge
OOGC Out of gauge cargo
OSHA US Occupational Safety and Health Administration
P&I Association Protection and indemnity association
P&I Protection and indemnity
PHA Port health authority
PLOD Place of delivery
PLOR Place of receipt
POD Port of discharge; place of delivery
POL Port of loading
PRS Polish Register of Shipping
PSI Pre-shipment inspection
PTI Pre-trip inspection
RAO Response amplitude operators
RHA Road Haulage Association
RID International Regulations concerning the International Carriage of Dangerous Goods by Rail
RINA Registro Italiano Navale
RMG Rail mounted gantry crane
RORO Roll-on roll-off
RS Russian Maritime Register of Shipping
RTG Rubber-tired gantry crane
SAT Semi-automatic twistlock
SC Straddle carrier
SCA Suez Canal Authority
SDR Special Drawing Rights
ShC Shuttle carrier
SLBS Shipping line booking system
SOC Shipper owned container. A container owned or leased by the shipper – new or used – to transport goods. SOC is by opposition to COC.
SOLAS International Convention on the Safety of Life At Sea
STC Said to contain
STS Ship-to-shore, for instance STS crane (a type of quay crane)
SWL Safe working load
SWSF Still water shear forces
TCT Timber component treatment. quarantine regulations established by the Australian health ministry (AQIS = Australian Quarantine and Inspection Service Department of Agriculture, Fisheries and Forestry). Includes detailed requirements for the treatment of container's wooden floors to avoid the proliferation of pests. Required for the containers to be able to transit through Australia
TEN-T Trans-European transport networks
TEU Twenty foot equivalent unit. Usually refers to a standard (although could be special) container of 20 feet in length. Commonly used to express vessel capacity or throughout at container factories and ports
TIF International transit by rail
TIR Transports Internationaux Routiers (International Road Transport). An international harmonised system of customs control that facilitates trade and transport whilst effectively protecting the revenue of each country through which goods are carried. In order for containers to be able to transport goods under custom seal they need to meet TIR requirements
TOFC Trailer on flat car
TOS Terminal operation system
TTU Terminal tractor with trailer unit
UCC Ultimate container carrier
UCIRC Unified container inspection and repair criteria. An International Chamber of Shipping guide available to be used for in-service and on/off hire inspections
UIC Union International de Chemins de fer (International Union of Railways). Containers need to meet UIC requirements in order to be able to transport goods on the rail.
UN/ECE United Nations Economic Commission for Europe
UNCITRAL United Nations Commission on International Trade Law
UNCTAD United Nations Conference on Trade and Development
UNECE United Nations Economic Commission for Europe
UR Unified requirement
WWT Wind and water tight repair criteria

Bibliography

Books

Agney, J., Huntley, J., – *Container Stowage, A Practical Approach,* White & Farrell (London) Ltd., 1972.

Antapassis, A., Athanassiou, L., Rosaeg, E., – *Competition and Regulation in Shipping and Shipping Related Industries,* Martinus Nijhoff Publishers, 2009.

Bose, J.W. , Brinkmann, B., – *Handbook of Terminal Planning,* Springer Media, 2011.

Branch, A.E., – *Elements of Shipping,* Eight Edition, Routledge, 2007.

Brodie, P.R., – *Illustrated Dictionary of Cargo Handling,* Lloyds of London Press Ltd, 1991.

Broeze, F., – *The Globalization of the Oceans: Containerisation from the 1950's to the Present,* International Maritime Economic History Association, 2002.

Brolsma, J.U., – *Havens, Kranen, Dokken en Veren. De Gemeentelijke Handelsinrichtingen en het Havenbedrijf der Gemeente Rotterdam 1882 – 2006,* Uitgeverij Matrijs, 2007.

Carpenter, R., – *Container Ships,* Model & Allied Publishers, 1971.

Chung-Yee Lee, Qiang Meng, – *Handbook of Ocean Container Transport Logistics. Making Global Supply Chains Effective,* Springer International Publishing, 2015.

Cudahy, B.J., – *Box Boats. How Container Ships Changed the World,* Fordham University Press, 2006.

De Boer, D., – *Piggyback and Containers,* Golden West, 1992.

De Haan, H., – *The Transport of Refrigerated Containers,* BMT, 2007.

Dear, I.C.B., Kemp, P., – *The Oxford Companion to Ships and The Sea,* Oxford University Press, 2006.

Dong-Wook Song, Panayides, P.M., – *Maritime Logistics. A complete Guide to Effective Shipping and Port Management,* Kogan Page Limited, 2012.

Donovan, A., Bonney, J., – *The Box that Changed the World. Fifty Years of Container Shipping – An Illustrated History,* Commonwealth Business Media, 2006.

Duijnen, M., Pastoor, H., Verploegh, G., – *Maritieme Meteorologie en Oceanografie,* DeBoer Maritieme Handboeken, 1971.

George, R., – *Ninety Percent of Everything: Inside Shipping, the Invisible Industry that Puts Clothes on Your Back, Gas in Your Car, and Food on Your Plate,* Metropolitan Books, Henry Holt and Company, LLC, 2013.

Gibney, R., – *Container Lines: The Strategy Game,* Lloyds of London Press, 1984.

Groen, P., – *De Wateren van de Wereldzee,* Unieboek b.v., 1974.

Hartog, A., – *Bremerhaven. Tor zur Welt. 80 Jahre Columbuskaje Bremerhaven,* Edition Temmen, 2008.

Hecht, H., Pawlik, T., – *Maritime Container Shipping,* Hanseatic Lloyd Reederei GmbH. & Co. KG, Bremen, 2007.

Jephson, C., Morgen, H., – *Creating Global Opportunities Maersk Line in Containerisation 1973-2013,* Cambridge University Press, 2014.

Jones, G., Zeitlin, J., – *The Oxford Handbook of Business History,* Oxford University Press, 2007.

Kemme, N., – *Design and Operation of Automated Container Storage Systems,* Springer-Verlag, 2013.

Kunadt, T., – *Hamburger Reeder und Ihre Schiffe,* Koehlers Verlagsgeselschaft GmbH, 2010.

Levinson, M., – *The Box - How the Shipping Container Made the World Smaller and the World Economy Bigger,* Princeton University Press, 2006.

McKenzie, D.R., North, M.C., Smith, D.S., – *Intermodal Transportation - the Whole Story,* Simmons-Boardman Books, 1989.

Oisterwijk, B., – *Op een koers. Royal Nedlloyd,* Deltadruk, 1988.

Oisterwijk, B., Regt, de W., – *Terug op koers.* Thieme Grafi Media Groep, 2004.

Pearson, R., Fossey, J., – *World Deep-Sea Container Shipping: A Geographical, economic and Statistical Analysis,* Marine Transport Centre, University of Liverpool, 1983.

Petzold, E., Grobecker, K., – *Reederei Blue Star. Renaissance einer Flotte,* Convent Verlag, 2004.

Pinder, D., Slack, B., – *Shipping and Ports in the Twenty-first Century: Globalisation, Technological Change, and the Environment,* Routeledge, 2004.

Prager, H.G., – *Zu Schiff durch Europa,* Koehlers Verlagsgesellschaft, 1973.

Rath, E., – *Container Systems. Materials Handling and Packaging Series,* John Wiley & Sons Inc., 1973.

Ritter, L., Barrett, J.M., Wilson, R., – *Securing Global Transportation Networks.* The McGraw-Hill Companies, 2007.

Rodrigue, J.P., Comtois C., Slack B., – *The Geography of Transport Systems,* Third Edition, Routledge, 2013.

Steenken, D., Voss, S., Stahlbock, R., – *Container Terminal Operation and Operations Research – a Classification and Literature Review,* Springer Verlag, 2004.

Strauch W., – *Container Handbook (Volume I & II),* Gesamtverband der Deutschen Versicherungswirtschaft e.V. (GDV), 2002.

Whittaker, J., – *Containerization,* Hemisphere Publishing, 1975.

Wijnolst, N. & Wergeland, Tor, – *Shipping Innovation,* IOS Press, 2009.

Zuidhoek, A., – *De mooiste schepen van de Nedlloyd,* Uitgeverij Aprilis, 1990.

Publications, papers and theses

Andersson, L., – *Container Lashing,* Swedish National Testing and Research Institute Mechanics, 1997.

Avriel, M., Penn, M., – *Exact and Approximate Solutions of the Container Ship Stowage Problem,* Computers and Industrial Engineering 25, 1993.

Basedow, J. et al., – *The Hamburg Lectures on Maritime Affairs,* Springer- Verlag, 2009.

Belamaric, G., – *Theoretic Approach of Ship's Motion and Lashing Forces,* 2014.

Bureau International des Containers et du Transport Intermodal. **BIC Code Register 2014.**

Cederqvist, H., – *Container Terminal Yard Automation,* Port Equipment Manufacturers Association, 2012.

Chan, C., – *IACS Develops New Rules after MOL Comfort Casualty.* IHS Maritime, 2015.

De Haas, J., – *Container Transport to Africa,* Thesis, University of Antwerp, 1990.

De Haas, J., – *Tying down the cargo. Container Lashing and Securing,* The Naval Architect, 2010.

De Haas, J. – *A Benchmarking Study of Classification Rules for Lashing and Securing of Containers,* Lloyds Register of Shipping, 2012.

De Haas, J., Brown, D., – *Effect of Eccentric Container Loads on Base Twistlocks and Container Foundations,* The Naval Architect, 2010.

De Haas, J., Burnay, S., – *Going Large,* The Naval Architect, 2010.

Ducruet, C., Notteboom, T., – *Developing Liner Service Network in Container Shipping. A Complete Guide to Effective Shipping and Port Management,* Kogan Page, 2012.

Fricke, W. Koster, D., – *Strength Aspects of Large Container Ships,* Transactions STG. Vol. 86, 1992.

Fruin, J., – *Moving Containers on the Mississippi River,* University of Minnesota, 2004.

Gabrysch, J., – *Containerverluste auf See – Eine statistische Analyse der Jahre 1990 bis 2005,* Thesis Hochschule Bremen, Fachbereich Nautik und Internationale Wirtschaft, 2006.

Gard, – *Containers,* A selection of articles previously published by Gard AS, 2004.

Germanischer Lloyd, – *Small Container and Feeder Vessels,* 2007.

Ham, J.C. van, – *The Feasibility of Mega Container Vessels,* European Transport, Delft University of Technology, 2005.

– *Handbook Customs Convention on Containers,* 1972, World Customs Organisation, 2004.

ICHCA Int. Ltd., – *An Illustrated Guide to Container Marking Codes,* Second edition, 2014.

ICHCA Int. Ltd., – *Provision for the Safe Lashing of Deck Containers,* 2011.

Johansen, R.S., – *Container Terminal Planning: Improving System Productivity to Service Larger Container Vessels,* JWD Group in Port Technology, 2013.

Kallas, S. et all, – *New Markings of Intermodal Loading Units in Europe,* International Union of Combined Road-Rail Transport Companies, 2011.

Kang J-G, Kim Y-D, – *Stowage Planning in Maritime Container Transportation,* Journal of the Operational Research Society 53, 2002.

Magelssen, W., Dohlie, K., Rongland, E., – *Cost Effective Design and Safety of Container Ships,* Det Norske Veritas AS, 1998.
Mahoney, J.H., – *Intermodal Freight Transportation, ENO Foundation for Transportation, 1985.*
Mathai, A., – *Shear Strength Assessment of Ship Hulls,* International Journal of Engineering and Innovative Technology, 2013.
Munchener Re Group, – *Containers Transport. Technology. Insurance, 2000.*
Murdoch, E., Tozer, D., – *A Master's Guide to Container Securing,* The Standard P&I Club and Lloyds Register Group, 2012.
Nash, B.J., – *The Voyage to Containerization. How a North Carolina Trucker Freed the World,* Federal Reserve Bank of Richmond, 2012.
Notteboom, T., Konings, R., – *Network Dynamics in Container Transport by Barge,* Belgeo, 2004.
Organisation for Economic Co-operation and Development (OECD), – *Container Transport Security across Modes,* European Conference of Ministers of Transport, 2005.
Pacino, D., – *Fast Generation of Container Vessel Stowage Plans, using Mixed Integer Programming for Master Planning and Constraint Based Local Search for Slot Planning,* Thesis for University of Copenhagen, 2012.
Rathje, H., – *New thinking on container losses,* The Naval Architect, Feature on Design and Construction of Containerships, 2008.
Rizvi, Z.H., – *The Containership – how big: What are the Prospects for Malacca-Max?* Port Technology International, 2007.
Rodrigue, J-P., Notteboom, T., – *The Geography of Containerization: Half a Century of Revolution, Adaption and Diffusion,* Hofstra University, 2008.
– *Safe Transport of Containers by Sea. Guidelines on Best Practices,* International Chamber of Shipping and World Shipping Council, Marisec Publications, 2008.
Seidelman, C., – *40 Years of Road-Rail Combined Transport in Europe. From Piggyback System to the Intermodal Transport System,* International Union of Combined Road-Rail Transport Companies, 2010.
Shi, B., Liu, D., Wiernicki, C., Tang-Jensen, P., – *Technology Advances in Design and Operation of Large Container Carriers,* Paper presented on behalf of American Bureau of Shipping during RINA Conference, 2006.
Shipowners P&I Club, – *Basic Stability for Small Vessels,* 2007.
– *ShortSea NL, Factsheet Short Sea.* Voorlichtingsbureau Short Sea, 2014.
Storhaug, G., Drummen, I., – *Fatigue damage due to springing/whipping of large container vessels,* Paper presented during Boxship 2007, Hamburg.
Svitzer, – *Overview of Salvage cases,* 2015.
Tanaka, N., – *Container Shipping and Container Ports of the World in Recent Times,* NKK Line, 1994.
Tang-Jensen, P., Shi, B., – *It's not Just a Matter of Size. Applied Technology will Differentiate Operational Efficiency of Ultra Large Container Ships,* American Bureau of Shipping, 2007.
– *The new CTU Code,* United Nations Economic Commission for Europe, 2014.
– *The Ultra Large Container ship (ULCS): Original Conceptualist Lloyd's Register Predicts the Future,* The Baltic, 2001.
Ting, E., – *Introduction to Transportation and Navigation,* National Taiwan Ocean University, Department of Transportation and Navigation Science, 2012.
Tozer, D., – *Design Challenges of Large Container Ships,* Paper presented during 2006 ICHCA Conference, Singapore, 2006.
Wijnolst , N., Scholtens, M., Waals, F., – *Malacca- Max – The Ultimate Container Carrier,* Delft University Press, 1999.

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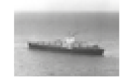
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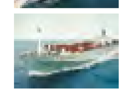
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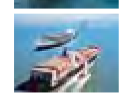
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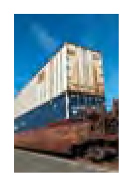
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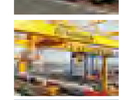
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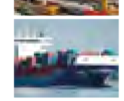
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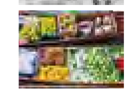
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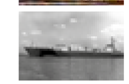
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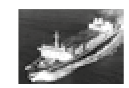
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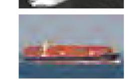
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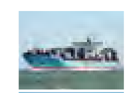
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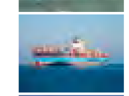
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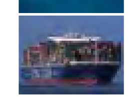
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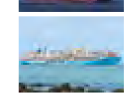
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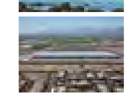
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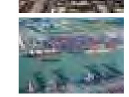
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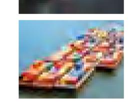
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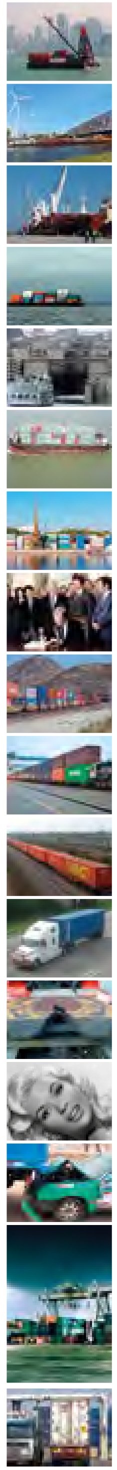

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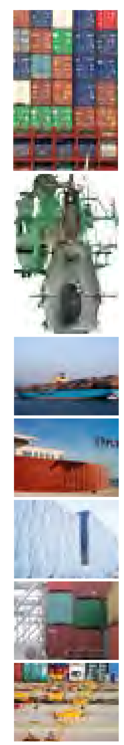

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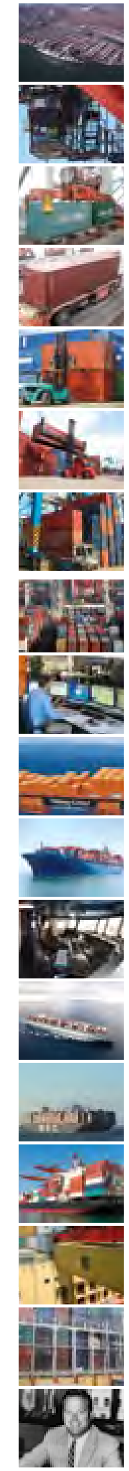

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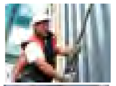
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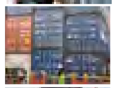
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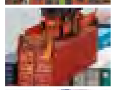
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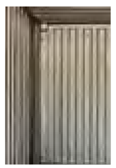
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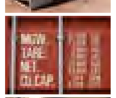
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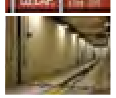
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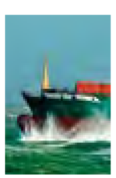
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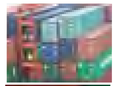
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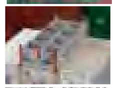
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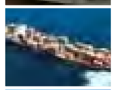
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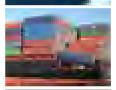
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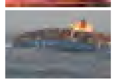
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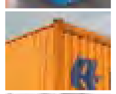
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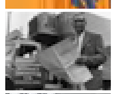
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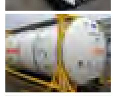
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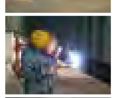
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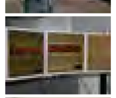
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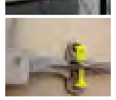
Lars Heineken

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