FERRY DESIGN AND SAFETY

BY

JOHN MANSELL
NEW ZEALAND MARITIME SAFETY AUTHORITY
WELLINGTON

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By J.N.K. Mansell

Introduction

The roll-on/roll-off ship[1] is one of the most successful types operating today. Its flexibility, ability to integrate with other transport systems and speed of operation have made it extremely popular on many shipping routes.

The roll-on/roll-off ship is defined in the International Convention for the Safety of Life at Sea (SOLAS), 1974 as being "a passenger ship with ro-ro cargo spaces or special category spaces..."

One of the ro-ro ship's most important roles is as a passenger/car ferry, particularly on short-sea routes. But despite commercial success, the ro-ro concept has always had its critics. There have been disturbing accidents involving different types of ro-ro ship, the worst being the sudden and catastrophic capsizing of the passenger/car ferry ***Herald of Free Enterprise*** in March 1987 and the even more tragic loss of the ***Estonia*** in September 1994.

This paper looks at the background of ro-ros, the problems involved and the way in which the International Maritime Organisation (IMO) has endeavoured to tackle them.

The development of ro-ros

The modern roll-on/roll-off ship can trace its origins back more than one hundred years to the early days of the steam train. Ships were specially designed to take trains across rivers which were too wide for bridges: the ships were equipped with rails, and the trains simply rolled straight on to the ship, which sailed across the river to another rail berth where the train would roll off again. An example is the Firth of Forth ferry in Scotland which began operations in 1851.

It was not until the Second World War, however, that the idea of applying the ro-ro principle of road transport became practicable - and was used in constructing the tank landing craft used at D-Day and in other battles. The principle was applied to merchant ships in the late 1940s and early 1950s. It proved to be extremely popular, especially on short-sea ferry routes, encouraged by technical developments on land as well as sea, notably the increase in road transport.

For the shipper, the ro-ro ship offered a number of advantages over traditional ships, notably speed. As the name of the system implies, cars and lorries can drive straight on to a ro-ro ship at one port and off at the port on the other side of the sea within a few minutes of the ship docking.

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[1] For the purposes or this paper, the term ro-ro is used for all ro-ro type ships, including passenger car ferries except where a particular type of ro-ro vessel is intended.

Ro-ro ships also integrate well with other transport development, such as containers, and the use of Customs-sealed units (first introduced in the late 1950s) has enabled frontiers to be crossed with the minimum of delay, thereby further increasing speed and efficiency for the shipper.

Ro-ros have also proved extremely popular with holiday makers and private car owners and have significantly contributed to the growth of tourism. Until the early 1950s someone wishing to take his car from one country to another by sea had to get it loaded into the ship's hold by crane, a time-consuming and expensive process. The development of the ro-ro car ferry changed all that and many ports boomed as a result.

In the United Kingdom, Dover's first pair of drive-on berths was opened in 1953. Until then the port had handled only 10,000 crane-loaded cars each year and forecasts that the berths would enable the port to handle ten times that many must have seemed decidedly optimistic. But the 100,000 figure was exceeded in the first year and by 1985 Dover was handling over 2.5 million vehicles and units through nine ro-ro berths. By 1994 the total had risen to more than 4.5 million.

By 1994 around 4,600 ro-ro ships were in operation around the world: They are particularly popular in Europe, and trading patterns reflect this. Whereas pure container ships are to be found in large numbers operating between Europe and North America, Europe and Japan and Japan and North America, ro-ros operate primarily between Europe and North America and Europe and the Middle East, although there is an important trade between North America and the Caribbean.

Today the world ro-ro fleet can be subdivided into a number of different types. They include ships designed to carry freight vehicles only; to carry a combination of containers and freight vehicles and to transport cars without passengers. There are various other types and freight-only ro-ro ships form about two thirds of the world ro-ro fleet at present.

However, the best known ro-ro ships are ferries designed to transport commercial vehicles and private cars, together with large numbers of passengers, usually on short voyages.

The problem areas

Although ro-ros have proved commercially very successful, some concern has been expressed about ro-ro ships from the safety point of view virtually ever since the first ro-ro ships were introduced. The whole design concept is different from that of traditional ships because of the introduction of a number of elements which make ro-ro ships unique.

The lack of internal bulkheads

On conventional ships, the hull is divided into a number of separate holds by means of transverse bulkheads, many of which may be watertight. In the event of the hull being holed, the bulkheads will limit or delay the inrush of water, resulting in the ship sinking slowly enough for the evacuation of those on board or even preventing the ship from sinking at all.

With ro-ro ships the installation of unpierced transverse bulkheads is a major obstacle, at least on the upper 'through' decks: the whole idea of the ro-ro ship depends upon being able to drive cargo on to the ship at one end and off again at the other. The installation of fixed transverse bulkheads would prevent this. Although ro-ros are all fitted with the watertight collision subdivision, and engine-room bulkheads below the freeboard deck prescribed by SOLAS, the huge vehicle decks make it possible for water to enter very rapidly and fire can also spread very quickly for the same reason.

Cargo access doors

The cargo access doors at the stern and bow of the ship represent a potential weak spot, as do the side doors with which some ro-ro ships are equipped. Over the years such doors can become damaged or twisted, especially when the door also serves as a ramp.

Stability

The movement of cargo on the vehicle deck can affect the intact stability of the ship, causing it to list. The sudden inrush of water following damage to the hull or failure of watertight doors can be even more serious (and rapid). The fact that ro-ro ships generally have a very large superstructure compared with other types means that they can be more affected by wind and bad weather.

Low freeboards

Cargo access doors fitted on cargo-only ro-ros are often very close to the waterline. This means that a defective trim or a sudden list, caused, for example, by the movement of cargo, can bring the access threshold below the waterline, resulting in a sudden inrush of water (if the door is open) which will in turn result in the list increasing and a possible capsizing of the ship.

Cargo stowage and securing

A list can cause cargo to break loose if it is not correctly stowed and secured. The problem is made worse because the crew of the ship cannot normally see how the cargo is stowed inside or on the trailer in which it is transported. A heavy load which breaks loose can cause other units to follow suit. The result can be an increased list the spillage of dangerous substances and, in extreme cases, damage to the hull and ship's structure.

A survey of ro-ro damage in the Channel and Mediterranean, carried out by the French marine insurance market and quoted in Lloyd's List in January 1984, stated that at least half could be attributed to inadequate or defective securing of vehicles or other cargo.

Another survey carried out by the United Kingdom Department of Trade and Industry in 1979 of 26 ro-ro ships, including some passenger car ferries, showed that 12 had suffered accidents resulting from the shifting of cargo following the failure of security arrangements. Of these, nine were said to be minor in nature, but three were serious and resulted in extensive damage to vehicles and cargo. The survey was carried out because the Department had become concerned by the frequency of such incidents in the previous two years.

Life-saving appliances

The high sides of many modern ro-ros, including passenger ships, pose problems regarding life-saving appliances: the higher a lifeboat, for example, is stowed the more difficult it can be to launch, especially if the ship is listing badly.

The crew

The factors referred to above indicate that ro-ros are highly sophisticated ships which require very careful handling. This makes them exceptionally vulnerable to human error.

How safe are ro-ros?

Because of the publicity surrounding accidents involving passenger ro-ro ships such as the ***Herald of Free Enterprise***, ***Scandinavian Star*** and ***Estonia*** it is sometimes assumed that this type of ship is much more dangerous than others. This is not borne out by statistics. The World Casualty Statistics for 1994 published by Lloyd's Register of Shipping show that passenger/ro-ro cargo loss rate per thousand ships was 2.3 - the same as the average figure for all ships.

However, when one considers loss of life at sea the picture changes. Between 1989 and 1994, the Lloyd's Register figures show that 4,583 lives were lost in accidents at sea. Of these 1,544 were lost in accidents involving passenger/ro-ro cargo ships - exactly one third, even though ro-ro ships make up only a small fraction of world merchant marine tonnage. This would seem to indicate that although passenger ro-ro ships are involved in an average number of accidents the consequences of those accidents are usually far worse.

An important study concerning the safety of ro-ro ships (including cargo ships) was submitted to IMO in 1983 by Norway. The study was compiled by the classification society det Norske Veritas (dNV) and covered the years 1965-1982. Of 341 casualties during the period, 217 were defined as serious and 36 resulted in the total loss of the ship.

The study showed that the most common causes of serious casualties were collisions (24%); machinery damage (17%); grounding (17%); shift of cargo and operational (16%); fire and explosion (14%). The figures changed significantly when total losses were studied. Here the most common cause was shift of cargo and operational faults (43%); collision (25%) and fire and explosion (18%).

The dNV study showed that total losses as a result of a collision were much higher for ro-ros than for other ships (with only a 9% occurrence). Both collisions and uncontrolled shifts of cargo more frequently led to serious consequences with ro-ros.

The paper noted that more than 70% of all ro-ro total losses due to collision resulted in loss of lives while 60% of ships reported to have capsized or sunk following a collision did so in less than ten minutes. Nearly all of the total losses involved ships of less than 110 metres in length.

A further important point made by the dNV study was that the ro-ro ships most frequently exposed to serious casualties and total losses were the pure ro-ro and freight-only types.

Pure ro-ros had a high percentage share of all casualties and especially of total losses. Passenger ferries, on the other hand, had a fairly high percentage share of all categories but the serious casualty/total loss frequency was relatively low.

The study also showed that the total loss rate for ro-ros was significantly lower than the average for the world fleet (under 0.25% over the 13-year period compared with about 0.55% for the world fleet).

A quick look at some of the best-known accidents involving ro-ro ships also indicates some of the major problem areas. Several of them involved water getting on to the vehicle deck through the cargo doors, either as a result of a mistake or an accident.

The first ro-ro ship to be lost at sea was the ***Princess Victoria,*** a rail ferry which sank on a voyage to Belfast in 1953 when heavy seas stove in the stern door: 133 lives were lost. At least 264 people died in 1966 when the Greek ferry ***Heraklion*** sank in heavy seas on a voyage to Piraeus. Although not a ro-ro, the ship did have a large car deck without subdivisional bulkheads. This deck flooded when the loading hatch was smashed by a vehicle which had broken loose. The cargo ro-ro ***Hero*** was lost in 1977, partly as a result of water entering through a leaking stern door. In September 1994 the passenger ro-ro ***Estonia*** was lost with more than 900 lives when the bow door was torn off by heavy seas. The car deck flooded and the ship capsized within a few minutes.

These accidents happened in heavy seas, but other ro-ros have been lost through water entering doors in port or sheltered waters. They include the ***Straitsman,*** which sank when the stern door was opened as the ship approached land, with the crew unaware that the door sill was below the waterline: and the ***Seaspeedora,*** which capsized in 1977 when a movement of cargo caused the ship to list sufficiently for water to enter through an open bunkering door. In the case of the ***Herald of Free Enterprise,*** water entered through the bow door which had been left open.

Ro-ro ships which have sunk rapidly as a result of a collision have included the ***Jolly Azzurro*** (1978), ***Collo*** (1980), ***Tollan*** (1980), ***Sloman Ranger*** (1980), ***Ems*** (1981), ***European Gateway*** (1983) and ***Mont Louis*** (1984).

Among ships which have been lost following a shift of cargo are the ***Espresso Sardegna*** (1973), ***Zenobia*** (1980) and ***Mekhanik Tarasov*** (1982, in very bad weather).

IMO's activities in the area of ro-ro safety

Since coming into being in 1959, IMO has adopted numerous international conventions and other instruments which are designed to improve maritime safety in general. Some of these are particularly relevant to ro-ros.

The International Regulations for Preventing Collisions at Sea, 1972, for example, contain a series of measures to improve the safety of shipping in confined waters, such as straits and narrow channels. These include the introduction of traffic separation schemes and other Routeing measures. Ro-ros, such as passenger ferries, frequently operate in such waters which are not only confined but are frequently congested as well.

These measures have been very successful in reducing collisions, especially head-on collisions. Studies made of collisions in the English Channel, for example, show that the collision rate has been cut dramatically since the 1960s and there can be little doubt that these measures have saved many ro-ro ships operating on the short-sea crossing between the United Kingdom and the Continent from accidents.

Other important conventions which are relevant to safety include the International Convention for the Safety of Life at Sea, 1960 and 1974, the International Convention on Load Lines, 1966, and the International Convention for Safe Containers, 1972.

However, since the early 1970s, when ro-ros were appearing in increasing numbers, IMO has developed various measures with the special features of ro-ro ships in mind. These deal with, *inter alia*:

- Subdivision
- Damage Stability
- Fire Safety
- Cargo Safety

The *Herald of Free Enterprise* disaster

In March 1987 the roll-on/roll-off passenger ferry ***Herald of Free Enterprise*** capsized and sank shortly after leaving Zeebrugge in Belgium. The accident occurred because the bow door was left open when the ship left port allowing water to enter and flood the car deck. The accident resulted in the deaths of 193 passengers and crew members.

It was not the first time that a ro-ro ship had capsized but the circumstances of the disaster - not least the dramatic photographs that appeared in the press and on television - made a strong impression on public opinion.

Shortly after the accident the United Kingdom went to IMO with a request that a series of emergency measures by considered for adoption. Most of these consisted of proposed amendments to the International Convention for the Safety of Life at Sea (SOLAS), 1974, the most important treaty dealing with the safety of the world's ships. It has so far been ratified by 128 countries and applies to 98% of world merchant tonnage.

The proposals, many of which were based on the findings of the inquiry into the disaster, were presented to IMO in separate packages, the first of which was adopted in April 1988 and included, *inter alia*

- Integrity of the hull and superstructure,
- Damage prevention and control,
- Remote indicators of all doors which, if left open, could lead to major flooding of a special category space or a ro-ro cargo space, and
- Patrol of cargo decks

The amendments entered into force only 18 months after adoption - an indication of the great importance which IMO attaches to ro-ro safety.

SOLAS 90

In October 1988 the Maritime Safety Committee (MSC) of IMO met again in a special session requested and paid for by the United Kingdom to consider a second package of amendments arising from the ***Herald of Free Enterprise*** tragedy. The amendments adopted entered into force on 29 April 1990. They became known as the "SOLAS 90" standard.

One of the most important amendments is designed to improve the stability of passenger ships in the damaged condition. Work on the amendment had actually begun some years before following an accident involving another ro-ro ship. This was the ***European Gateway,*** which capsized following a collision with another ship in 1982. Like the ***Herald of Free Enterprise*** five years later, the ***European Gateway*** ended up lying on her side in relatively shallow water and only five lives were lost. The adoption of the amendments was brought forward because of its relevance to ro-ro safety.

The amendment applies to ships built after 29 April 1990. The amendment considerably expands the existing regulation and takes into account such factors as the crowding of passengers on to one side of the ship, the launching of survival craft on one side of the ship and wind pressure. The amendment stipulates that the maximum angle of heel after flooding but before equalisation shall not exceed 15 degrees.

A research programme set up by the United Kingdom Department of Transport analysed the new standard and the Steering Committee carrying out the study reported that SOLAS 90 "should provide an adequate standard of protection against capsize up to sea state 3, i.e. in moderate seas having a significant wave height[2] up to 1.5m. This is an important finding and one which appears to validate SOLAS 90 as a standard that should enable ro-ro ferries and any other conventional design of passenger ship to survive the effects of prescribed damage in such seas."

A further amendment was proposed by the United Kingdom. It is concerned with intact rather than damage stability. It requires masters to be supplied with data necessary to maintain sufficient intact stability and the amendment expands the section by requiring that the information must show the influence of various trims taking into account operational limits.

Ships must also have scales of draught marked clearly at the bow and stern. Where these are not easily readable the ship must also be fitted with a reliable draught indicating system. After loading and before departure the master must determine the ship's trim and stability.

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[2] Wave height is the vertical distance between the crest and trough of the wave. The UK Steering Committee report says that as a wave heights in a given sea state are subject to considerable variation it is the recognised practice to refer to their apparent height as being the significant wave height. This is defined as the average of the third highest observed wave height over a given period.

Another amendment requires that cargo loading doors shall be locked before the ship proceeds on any voyage and remain closed until the ship is at its next berth.

Further amendments to SOLAS were progressively adopted over succeeding years until May 1997 covering important requirements to enhance ro-ro ferry safety such as:

- Remotely controlled watertight doors.
- Changes to the method of calculating the sub-division and stability of all ro-ro ships greater than 100 metres, build after 1992.
- Cargo stowage and security.
- The International Safety Management (ISM) Code being made mandatory for all passenger ships from 1 July 1998.

The April 1992 SOLAS Amendments

Although the entry into force of the October 1988 amendments to SOLAS meant that all ro-ro passenger ferries built since April 1990 had been built to improved damage stability standards, some Governments were still concerned at the safety levels of existing ships.

The United Kingdom proposed that the SOLAS 90 standard be made mandatory on existing ships under a phase-in programme that would have lasted from 1994 to 2004, with the ships that were furthest from the standard being converted first. The British Government pointed out that the study initiated following the ***Herald*** disaster had shown that for existing ships "capsize may still be a possibility if damage of the prescribed extent is received in the most vulnerable regions of the ship whilst operating in a moderate sea.

Although there was general agreement that an improvement to the standard for existing ships was needed, the majority of IMO Member States felt that the SOLAS 90 standard was too high. Traditionally major changes to ship design had only be made applicable to new ships because of the costs involved in applying them to existing tonnage. The industry pointed out that United Kingdom estimates showed that it would cost on average £650,000 a ship to bring the British passenger ro-ro fleet up to the SOLAS 90 standard and several Governments also raised the question of cost (they would reach a "prohibitive magnitude" according to one paper submitted to IMO).

When the proposed amendments were discussed in April 1992, therefore, the majority of Governments (with the exception of the United Kingdom and Ireland) opted for a slightly modified version of the SOLAS 90 standard and agreed that it would be phased in over 11 years beginning on 1 October 1994.

The application of the modified SOLAS 90 standard to existing ships means modifying a large part of the world's ro-ro fleet. In some cases the changes could be extensive and the high cost involved has already led to some of them being scrapped and replaced with new tonnage.

The United Kingdom announced after the meeting that it would be considering national action to ensure the safety of ferries operating between its ports and the Continent of

Europe and in 1993 an agreement was concluded which meant that existing ferries operating on most of these routes would have to meet the full SOLAS 1990 standard.

Scandinavian Star

Important amendments were also made to SOLAS which were influenced by an accident that occurred in 1988 when the passenger ferry ***Scandinavian Star*** caught fire during a voyage from Norway to Denmark. As a result 165 people lost their lives and although the fact that the ship was a ro-ro did not contribute to the disaster it again resulted in increased public concern about this type of ship. IMO was called upon to take action and developed a number of amendments to SOLAS which were also adopted in April 1992 and also apply to existing ships.

It is, perhaps, worth stressing that the April 1992 amendments are particularly important because they apply to existing ships. In the past, major changes to SOLAS have been restricted to new ships by the so called "grandfather clauses". On this occasion the IMO decided that the new stability and fire safety standards were so important that they should be applied to existing ships as well.

The *Estonia* disaster of September 1994

Following the adoption of the May 1994 amendments to SOLAS, the shipping community was looking forward to a period of consolidation during which the changes of the previous few years could be absorbed. It appeared to many that the doubts concerning ro-ro ships had been solved and that no more major changes were needed. Then, on 28 September 1994 the passenger ro-ro ship ***Estonia*** suddenly capsized in a severe storm in the north Baltic Sea and sank with the loss of more than 900 lives.

The scale of the disaster was so great that immediately the whole question of ro-ro safety was reopened. Preliminary inquiries showed that the outer bow door of the ship had been ripped off during the storm allowing water to accumulate on the car deck to such an extent that the ship very quickly listed and then rolled over and sank. The accident occurred in the early morning when most passengers were asleep and the ship sank so suddenly that the majority of them had virtually no chance of escaping. And unlike the ***Herald of Free Enterprise*** and the ***European Gateway*** the ***Estonia*** was operating in deep water and did not end up lying on her side on a sandbank but sank to the bottom several hundred metres below.

The fact that the accident once again involved a bow door and water on the car deck led to renewed criticisms of ro-ros, the way they were operated and the basic ro-ro concept.

On 4 October, the Secretary-General of IMO, Mr William A. 0'Neil, proposed that a complete review of the safety of roll-on/roll-off ferries be carried out by a specially selected panel of experts.

He made it clear that the review should look not only at such key issues as bow and stern door safety and the possible need for sub-divisions on the vehicle deck but everything involved in ro-ro ferry operations.

In his proposals, which were submitted to the Maritime Safety Committee (MSC) of IMO for consideration at its meeting in December 1994, the Secretary-General listed a number of items which needed particular attention. They included:

- the strength and watertightness of openings to the vehicle spaces, in particular bow and stern doors
- increasing survivability standards by the fitting of bulkheads
- the evaluation of life-saving appliances and on-board evacuation arrangements, if necessary
- the need to prepare operational guidelines for use in adverse weather conditions, given the size and type of the ro-ro ships concerned and their area of operation
- the on-board communication issues, in particular when ships are manned by multinational crews carrying multinational passengers
- revising the reporting of incidents concerning safety matters of ro-ro ships to appropriate authorities and the action the authorities should take on receiving these reports.

The MSC met from 5-9 December 1994 and agreed to establish a panel of experts to carry out an intensive study into ro-ro design and operations.

The panel's reports and recommendations were considered by the Steering Committee in April and then by the full MSC at its 65th session in May. The report represented the most complete study into ro-ro ferry safety ever made and it is expected that its implications will be far reaching and take several years to implement fully.

Although it was recognised, that implementing the complete package of proposals would involve several years of work, the MSC recognised that some matters had to be dealt with as a matter of urgency. It was therefore agreed that a special conference would be held at IMO headquarters in November 1995 to consider a number of proposed amendments to SOLAS. These included amendments concerning:

Intact and damage stability of ro-ro passenger ships

One of the most important proposals in the report of the Panel of Experts concerns the effect of build-up of water on the enclosed ro-ro deck, which it describes as the "most dangerous problem for a ro-ro ship."

As we have seen, since April 1990 all new passenger ro-ro ships have had to be built according to SOLAS 90 while a slightly modified version was made applicable to existing ro-ro passenger ships. Tests carried out in the United Kingdom have shown that SOLAS 90 would give an "adequate standard" of protection following an accident, such as a collision, which occurs in wave heights of up to 1.5 metres.

The Panel concluded that these requirements should be improved to include the effect of water being accumulated on the ro-ro deck in order to enable the ship to survive in more

severe sea states. It felt that this could certainly not be excluded when realistic scenarios are considered and the Committee endorsed that view.

It agreed the Panel's proposals would have profound implications for the existing ro-ro fleet, necessitating substantial design and construction improvements which would, in turn, be costly and could make some existing ro-ros commercially non-viable. Understandably, there were considerable difference of opinion among delegates about the proposals and in particular about the recommendation that SOLAS 90 should be modified to take into account water on the vehicle deck.

Nevertheless, draft texts were prepared and circulated to Parties to the SOLAS Convention. This had to be done at least six months before the November Conference for legal reasons. Having decided this, the Committee turned its attention to other issues raised by the Panel of Experts' reports, such as:

- **One-compartment standard of subdivision**
- **Second line of defence** (inner bow door)
- **Drainage** (from ro-ro deck)
- **Operational matters** (ISM Code)
- **Working language for crew**
- **Operation limitations** (record to be maintained throughout ships life)
- **Lashing and securing of cargoes** (from 1 July 1996 Cargo Securing Manual required)
- **Access to ro-ro decks** (denied to passengers when ship underway)
- **Alarms on, and surveillance of, hull doors**
- **Constructional matters** (to eliminate flooding of ro-ro deck through ventilation trunks and air pipes)
- **Training and related matters** (for crew members with special duties in emergencies)
- **Communications** (public address systems and emergency communications and "black boxes")
- **Survey requirements** (unscheduled inspections)
- **Search and rescue** (number and identity of passers - helicopter landing area, search and rescue communications)
- **Fire safety**
- **Life-saving appliances** (life-rafts, fast rescue boats, rescue platforms, life jacket lights)
- **Evacuation arrangements**
- **Safety information to passengers**
- **Crisis management** (training for rapid decision making in emergencies)
- **Formal safety assessment** (to be adopted as basis for IMO's future work)

The IMO Assembly: 19th session, 1995

The IMO Assembly, which met in November 1995, adopted five resolutions concerning the safety of roll on-roll off passenger ships as follows:

- Safety culture in and around passenger ships
- Strength and securing and locking arrangements of shell doors on ro-ro passenger ships

- Surveys and inspections of ro-ro passenger ships
- Navigational guidance and information scheme for ro-ro ferry operations.
- Decision-support system for masters on passenger ships.

The November 1995 SOLAS Conference

The conference had on its agenda a number of important - and controversial - proposed changes to SOLAS. The most important concerned requirements for the watertight integrity and stability of ro-ro passenger ships.

A major success was the unanimous adoption of amendments which would have the effect of applying the full SOLAS 90 damage stability standard to existing passenger ro-ro ferries. A new regulation will mean that existing ro-ro passenger ships would have to fully comply with SOLAS 90 in accordance with an agreed phase-in programme, designed to assess the survivability characteristics of existing ro-ro passenger ships. Ships will have to comply fully between 1 October 1998 and 1 October 2005.

A new regulation was also adopted which contains special requirements for ro-ro passenger ships carrying 400 passengers or more. This is intended to require new ships to be built, and existing ships built to a one-compartment standard of subdivision to be phased out, to ensure that they can survive with two compartments flooded following damage.

The most controversial issue before the conference concerned the Panel of Experts' proposal that the SOLAS 90 standard could be met with up to 50cm of water on the vehicle deck. It also proposed that this standard should not only be applied to new ships but should be applied to existing ferries over a number of years. It was recognised that this could result in extensive modifications having to be made to some existing ships and that the costs would be so high that some of the ships might have to be scrapped.

An indication of the costs involved was given in a report by the United Kingdom into the costs of making changes to the British fleet, based on a study of 12 ferries. This showed that six already complied with the SOLAS 90 standard.

The capital cost of complying with SOLAS 90 for those which still required to be improved, varied between £0.645 million and £1.50 million per ship. The capital cost of complying with SOLAS 90 plus the further requirements proposed by the Panel of Experts (50cm of water-on-deck) varied between £0.546 million and £2.30 million. The paper said that it was not possible to give any precise indication of the costs needed to modify any other ferry. However, using the average cost likely to be incurred to modify the ro-ro ferries investigated, the following estimates were prepared:

- The average cost for the UK ships operating on international voyages to comply with SOLAS 90 alone, is approximately £1.024 million per ship (for those which need to comply). For the 23 ships which do not comply with SOLAS 90, this would give a total of £23.55 million for the UK fleet.

- The costs identified to comply with the Panel of Experts' recommendations, for all ships, were estimated to average £0.793 million per ship and £28.55 million for the UK fleet.

- The total cost to the UK fleet of complying with both SOLAS 90 and the Panel requirements is therefore estimated to be £52.10 million.

The ship modifications may also result in a loss of revenue due to reduced capacity and longer turnaround times. In ships which are relatively small, the space for long commercial vehicles may be particularly restricted. Including these losses and making an allowance for the annualised capital costs of modification, the total cost for a UK international ferry to move from SOLAS 90 to the higher standard of SOLAS 90 + 50cm of water on deck is estimated to be in the order of 5% of gross annual revenue for the ship concerned.

During the course of the conference it became clear that a number of countries felt that meeting this standard would be very difficult and costly for some ships and many would have to be scrapped. Several Governments said that sea and weather conditions in their regions meant that the proposed standard was not necessary.

Proposals that a new requirement dealing with water on the vehicle deck be included in the SOLAS Convention were given up and instead the conference adopted a resolution which permits regional agreements to be concluded on specific stability requirements for ro-ro passenger ships. The draft resolution was submitted by Denmark, France, Italy, Norway, Spain, Sweden and the United Kingdom.

The resolution acknowledges the desire of certain SOLAS Contracting Governments that, having regard to the prevailing sea conditions and other local conditions, specific stability requirements should apply to all ro-ro passenger ships undertaking regular scheduled voyages between designated ports of those Contracting Governments.

It then agrees that two or more Contracting Governments may conclude agreements modifying the requirements in respect of every ro-ro passenger ship carrying passengers on regular scheduled voyages between designated ports in their territory, provided that these ships comply with safety requirements which are adequate, in the opinion of these Governments, for the voyages to be undertaken.

It also agrees that, if these safety requirements include specific stability requirements, they should not exceed those specified in the Annex to the resolution. These requirements include provisions that are designed to ensure that the SOLAS 90 stability standard can be achieved even with up to 50cm of water on the vehicle deck.

Governments proposing an agreement will have to notify the Secretary-General of IMO of their intention to negotiate an agreement and shall make appropriate arrangements for other interested Contracting Governments to be involved in the negotiations. An agreement shall not enter into force until 12 months after its conclusion has been notified to the Secretary-General. The Governments which had initially proposed the SOLAS 90 + 50 cm standard duly concluded an agreement (the Stockholm Agreement) which entered into force on 1

April 1997. Existing ferries operating between ports in the signatory countries will have to be upgraded between then and 1 October 2002.

A table summarising the extensive amendments made to the SOLAS Convention at the 1995 SOLAS Conference is attached.

The adoption of the amendments represents only the most urgently needed amendments to the SOLAS Convention in a programme of change that is expected to take several years to complete. The Panel of Experts made many other proposals for improving ferry safety. Some of them dealing with training were adopted by the July 1995 conference to amend the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), 1978. Others were prepared by the Maritime Safety Committee and adopted by the IMO Assembly while others were delegated to subcommittees for further consideration.

The future

During the last few years a great deal of work has been done by IMO to improve the safety of ro-ro ships and the proposals made by the Panel of Experts will keep the MSC and its sub-committees occupied for some time to come. But experience has shown that safety cannot be assured just by adopting regulations.

Many of the accidents to ro-ros that have occurred have been because regulations were not properly implemented or through human error. This is true of other ship types as well, of course, but ro-ro ships are perhaps more complex than most ships and any errors made can lead to catastrophic consequences, because of the large number of people on board.

A new Sub-Committee has been created to improve the way measures are implemented by flag States. The creation of regional port State control systems has been encouraged. The ISM Code will help to raise management standards while the amendments to the STCW Convention will do the same for the training and certification of seafarers. Further work is being carried out on such issues as fatigue and other causes of accidents.

Many of the measures adopted by IMO in the past have been designed to minimise the consequences of accidents. The emphasis now is on trying to prevent accidents happening at all.

References

- "Focus on I.M.O." January 1997. IMO and ro-ro Safety.
- Paper to Spring 1997 meeting of The Royal Institution of Naval Architects by Tom Allan, Director (Marine Standards Division) United Kingdom Marine Safety Agency.

1995 SOLAS CONFERENCE AMENDMENTS - DATES OF IMPLEMENTATION

SUBJECT	NEW PASSENGER SHIPS (built on or after 1 July 1997)		EXISTING PASSENGER SHIPS (built before 1 July 1997)	
	Ro-Ro's	non Ro-Ro's	Ro-Ro's	non Ro-Ro's
Compliance with SOLAS '90 damage stability standard **SOLAS II-1/8-1**	Applies	Applies	1st periodical survey after 1 October 1998 up to 1 October 2005 depending on A/Amax value	N/A
Application of side damage anywhere in the ship length for ships carrying more than 400 persons **SOLAS II-1/8-2**	Applies	N/A	1st periodical survey after 1 October 1998 up to 1 July 2016 depending on A/Amax, number of persons on board or age of vessel	N/A
Extension to collision bulkhead restricted to limits for main bulkhead **SOLAS II-1/10**	Applies	Applies	N/A	N/A
Revised limits on position of extension to collision bulkhead for existing ships **SOLAS II-1/10**	N/A	N/A	1 July 1997	1st periodical survey after 1 July 1997
Requirement to log certain watertight doors closed during navigation, for ships built before 1 February 1992 **SOLAS II-1/15**	N/A	N/A	1 July 1997 for affected vessels	1 July 1997 for affected vessels
Strengthening of decks and trunks to withstand water pressure during heel **SOLAS II-1/19**	Applies	Applies	1st periodical survey after 1 July 1997	1st periodical survey after 1 July 1997
Additional requirements to protect watertight integrity above margin line **SOLAS II-1/20**	Applies	Applies	N/A	N/A
Increased requirements for watertight integrity to accesses leading to spaces below the bulkhead (ro-ro) deck **SOLAS II-1/20-2**	Applies	N/A	1st periodical survey after 1 July 1997	N/A
Passengers to be denied access to ro-ro decks without authorization **SOLAS II-1/20-3**	Applies	N/A	Applies 1 July 1997	N/A

SUBJECT	NEW PASSENGER SHIPS (built on or after 1 July 1997)		EXISTING PASSENGER SHIPS (built before 1 July 1997)	
	Ro-Ro's	non Ro-Ro's	Ro-Ro's	non Ro-Ro's
Closure of bulkheads fitted on ro-ro decks to confine accumulated seawater **SOLAS II-1/20-4**	Applies	N/A	Applies 1 July 1997	N/A
Increased requirements for indication of shell/loading doors status to bridge, monitoring of ro-ro spaces and provision of operating procedures for such doors **SOLAS II-1/23-2**	Applies	N/A	Applies 1 July 1997	N/A
Increased requirements for cabling of emergency alarms and public address systems **SOLAS II-1/45**	Applies 1 July 1998	N/A	Applies 1 July 1998 Applicable to retro-fit/conversions	N/A
Enhanced means of escape **SOLAS II-2/28-1.1**	Applies first periodical survey after 1 July 1997	N/A	Applies first periodical survey after 1 July 1997	N/A
Enhanced means of escape **SOLAS II-2/28-1.2**	Applies	N/A	N/A	N/A
Evacuation analysis **SOLAS II-2/28-1.3**	Applies to ships built after 1 July 1999	N/A	N/A	N/A
Opening of special category space scuppers **SOLAS II-2/37**	Applies	N/A	Applies	N/A
Fitting of public address systems **SOLAS III/6**	Applies	Applies	Applies (Certain parts only apply following the first periodical survey after 1 July 1997)	Applies (Certain parts only apply following the first periodical survey after 1 July 1997)
Liferafts to be served by marine evacuation systems or launching appliances, for vessels built prior to 1 July 1986 **SOLAS III/26.2.1**	N/A	N/A	Applies first periodical survey after 1 July 2000	N/A
Every liferaft provided with a float-free stowage arrangement **SOLAS III/26.2.2**	N/A	N/A	Applies first periodical survey after 1 July 2000	N/A
Every liferaft to be fitted with an enhanced standard of boarding ramp **SOLAS III/26.2.3**	Applies 1 July 1998	N/A	Applies first period survey after 1 July 2000	N/A

SUBJECT	NEW PASSENGER SHIPS (built on or after 1 July 1997)		EXISTING PASSENGER SHIPS (built before 1 July 1997)	
	Ro-Ro's	non Ro-Ro's	Ro-Ro's	non Ro-Ro's
Every liferaft to be either automatically self righting or of the canopied reversible type or alternatively, in addition to the vessels normal complement of liferafts, at least an additional 50% of the enhanced type are to be fitted. This arrangement is only applicable to vessels with post 1986 liferafts fitted **SOLAS III/26.2.4**	Applies 1 July 1998 N/A	N/A N/A	Applies first periodical survey after 1 July 2000 Applies first periodical survey after 1 July 2000	N/A N/A
One fast rescue boat and enhanced launching/recovery device; with at least two crews for each fast rescue boat **SOLAS III/26.3**	Applies 1 July 1998	N/A	Applies first periodical survey after 1 July 2000	N/A
One means of rescue device with suitable launching device **SOLAS III/26.4**	Applies 1 July 1998	N/A	Applies first periodical survey after 1 July 2000	N/A
Sufficient lifejackets stowed in vicinity of assembly stations and lifejackets fitted with lights **SOLAS III/26.5**	Applies 1 July 1998	N/A	Applies 1 July 1998	N/A
Information on passengers; Persons to be counted prior to departure **SOLAS III/27.1**	Applies 1 July 1998	Applies 1 July 1998	Applies 1 July 1998	Applies 1 July 1998
Information on passengers; Names and details of gender to be provided **SOLAS III/27.3**	Applies 1 January 1999	Applies 1 January 1999	Applies 1 January 1999	Applies 1 January 1999
Helicopter pick-up area to be provided **SOLAS III/28.1**	Applies 1 July 1997	N/A	Applies first periodical survey after 1 July 1997	N/A
Helicopter "landing" area to be provided on ships of 130m length and above **SOLAS III/28.2**	Applies 1 July 1999	Applies 1 July 1999	N/A	N/A
Decision support system for emergency management **SOLAS III/29**	Applies 1 July 1998	Applies 1 July 1998	Applies first periodical survey after 1 July 1999	Applies first periodical survey after 1 July 1999
Distress panel to be installed at conning position **SOLAS IV/6.4 - 6.5 - 6.6**	Applies 1 July 1997	Applies 1 July 1997	Applies first periodical survey after 1 July 1997	Applies first periodical survey after 1 July 1997
A two-way on scene radiocommunication for SAR purposes **SOLAS IV/7.5**	Applies 1 July 1997	Applies 1 July 1997	Applies first periodical survey after 1 July 1997	Applies first periodical survey after 1 July 1997

SUBJECT	NEW PASSENGER SHIPS (built on or after 1 July 1997)		EXISTING PASSENGER SHIPS (built before 1 July 1997)	
	Ro-Ro's	non Ro-Ro's	Ro-Ro's	non Ro-Ro's
One radio person to be assigned to perform radiocommunications duties during distress incidents **SOLAS IV/16.2**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997
Distress messages - Masters obligations and procedures **SOLAS V/10**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997
Masters discretion for safe navigation **SOLAS V/10.1**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997
Effective working language to be established on board **SOLAS V/13(c)**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997
Search and rescue plan onboard for co-operation with SAR organisations in event of an emergency **SOLAS V/15(c)**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997
List of all operational limitations of the vessel to be kept on board and updated where necessary **SOLAS V/23.1 - 23.2**	Applies first periodical survey after 1 July 1997	Applies first periodical survey after 1 July 1997	Applies first periodical survey after 1 July 1997	Applies first periodical survey after 1 July 1997
Stowage and securing of cargo units **SOLAS VI/5.6**	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997	Applies 1 July 1997