NRC·CNRC

NRC Publications Archive
Archives des publications du CNRC

Marine evacuation systems: slides and chutes

Nolan, W.

For the publisher's version, please access the DOI link below./ Pour consulter la version de l'éditeur, utilisez le lien DOI ci-dessous.

Publisher's version / Version de l'éditeur:
https://doi.org/10.4224/8895215
Student Report (National Research Council of Canada. Institute for Ocean Technology); no. SR-2006-14, 2006

NRC Publications Archive Record / Notice des Archives des publications du CNRC :
https://nrc-publications.canada.ca/eng/view/object/?id=c06b81d0-df32-4583-a3a2-ba6500ac774a
https://publications-cnrc.canada.ca/fra/voir/objet/?id=c06b81d0-df32-4583-a3a2-ba6500ac774a

Access and use of this website and the material on it are subject to the Terms and Conditions set forth at
https://nrc-publications.canada.ca/eng/copyright
READ THESE TERMS AND CONDITIONS CAREFULLY BEFORE USING THIS WEBSITE.

L'accès à ce site Web et l'utilisation de son contenu sont assujettis aux conditions présentées dans le site
https://publications-cnrc.canada.ca/fra/droits
LISEZ CES CONDITIONS ATTENTIVEMENT AVANT D'UTILISER CE SITE WEB.

Questions? Contact the NRC Publications Archive team at
PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca. If you wish to email the authors directly, please see the first page of the publication for their contact information.

Vous avez des questions? Nous pouvons vous aider. Pour communiquer directement avec un auteur, consultez la première page de la revue dans laquelle son article a été publié afin de trouver ses coordonnées. Si vous n'arrivez pas à les repérer, communiquez avec nous à PublicationsArchive-ArchivesPublications@nrc-cnrc.gc.ca.

National Research Council Canada | Conseil national de recherches Canada

Canada

DOCUMENTATION PAGE

REPORT NUMBER	NRC REPORT NUMBER	DATE	
SR-2006-14		April, 2006	
REPORT SECURITY CLASSIFICATION Unclassified		**DISTRIBUTION** Unlimited	
TITLE **Marine Evacuation Systems: Slides and Chutes**			
AUTHOR(S) Wayne Nolan			
CORPORATE AUTHOR(S)/PERFORMING AGENCY(S) Institute for Ocean Technology, National Research Council, St. John's, NL			
PUBLICATION			
SPONSORING AGENCY(S) Institute for Ocean Technology, National Research Council, St. John's, NL			
IMD PROJECT NUMBER PJ_2066		**NRC FILE NUMBER**	
KEY WORDS Evacuation Slides, Chutes	**PAGES** 35, App.A-I	**FIGS.** 10	**TABLES**

SUMMARY

The following report presents an overview of the design and testing of Marine Evacuation Systems, particularly Marine Evacuation Chutes and Marine Evacuations Slides. Governing the design and performance of these systems are the regulatory requirements set forth by national and international organizations, and these have been outlined within the proceeding chapters. A severe lack of regulatory regime and available modeling programs has lead to a need for detailed testing of this equipment. The scope of this report is to present the information available today pertaining to; the design of each system, the regulatory regime and the past and future testing that has or should be conducted.

ADDRESS

National Research Council
Institute for Ocean Technology
Arctic Avenue, P. O. Box 12093
St. John's, NL A1B 3T5
Tel.: (709) 772-5185, Fax: (709) 772-2462

National Research Council Canada
Conseil national de recherches Canada

Institute for Ocean Technology
Institut des technologies océaniques

Marine Evacuation Systems: Slides and Chutes

SR-2006-14

Wayne Nolan

April 2006

Summary

The following report presents an overview of the design and testing of Marine Evacuation Systems, particularly Marine Evacuation Chutes and Marine Evacuations Slides. Governing the design and performance of these systems are the regulatory requirements set forth by national and international organizations, and these have been outlined within the proceeding chapters. A severe lack of regulatory regime and available modelling programs has lead to a need for detailed testing of this equipment. The scope of this report is to present the information available today pertaining to; the design of each system, the regulatory regime and the past and future testing that has or should be conducted.

Table of Contents

Terminology

Bowsing line: connection line between boarding platform or inflatable liferaft. Used to control position of liferaft or platform with respect to vessel

Boarding platform: inflatable platform. Connected to bottom of chute or slide, used to transferring evacuees to liferafts

Inflatable liferaft: a survival craft

Marine evacuation system (MES): an evacuation system consisting of a chute or slide, may include a boarding platform, and inflatable life rafts

Fender: inflatable apparatus, located on the inner side of the chute. Protects chute and evacuees from hull appendages

Slideway: inner lining of chute

1.0 Introduction

1.1 Background

Emergency evacuation systems for the marine and offshore industry have evolved over the past couple decades. These systems aid in the evacuation of passengers and crew from marine or offshore installations when emergency situations arise. The systems available today range from lifeboats and helicopters to slides and chutes, each with the goal to provide a safe and efficient means of evacuation.

Lifeboats are designed with a rigid hull and are equipped with a propulsion system. Their launch systems range from the conventional davit falls, to those with a free-fall system. They are available, but not required to be, partially or totally enclosed and may be self-righting. They're designed to be strong enough to be towed and to be safely launched into the water when fully loaded with passengers and equipment. Lifeboats enable crew and passengers to transfer from the vessel directly into the means of evacuation/survival, and enable the occupants to sail away from the immediate danger without the need for external assistance.

Helicopters are also available for emergency evacuation and transport of crew or passengers from vessels. Used often for medical evacuation, they provide a means of evacuation in a quick and safe manner. They can also be used in precautionary or full scale evacuations, providing a means that does not require any recovery or rescue apparatus. Helicopter operation has no dependence on the vessels power source and can be landed on vessels/floating installations with up to medium list and/or trim conditions.

More recently chutes and slides have entered the evacuation systems scene. Both are based on gravity deployment, with the systems having the capability to be deployed by one person. Each incorporates the use of liferafts for escape from the troubled vessel. They are operable in trimmed positions of up to 10 degrees and a list position up to 20 degrees, and any combination of these conditions. Chutes provide evacuation from large vertical heights and may exit directly into the liferaft or onto an open platform. Slides are restricted to shorter heights, up to fifteen metres*. They also exit either onto a platform or directly into a liferaft and are designed to self-inflate within a matter of minutes. The associated liferafts are also self-inflating, and provide shelter from harsh environmental conditions.

1.2 Purpose

In order to implement polices and regulations governing the design, construction and performance of evacuation systems and to develop accurate computer modelling software, model and full scale testing of the systems must be completed. Data and information are required on the system behaviour as a result of various parameter changes involving the environment and design and configuration of the system.

After conducting a literature review of existing information pertaining to chutes and slides, it was determined that limited technical material exists on these systems. At this time there are a small number of companies manufacturing and selling these systems around the world, and the regulations governing their design and performance are vague at best. No comprehensive computer models are available and the results of any previous physical model or full scale testing are limited or not available in the public domain.

Model and full scale test programs will provide the necessary data to develop and validate accurate math modelling programs. The current regulatory regime can also

* Height given for present systems available (Viking Life-Saving Equipment)

be assessed based on the increased knowledge of the Marine Evacuation Systems (MES) behaviour in changing environment conditions and variations to the system design and configuration. This assessment can address the vagueness of regulations to date; resulting in changes to the regulatory regime to adequately develop detailed polices governing the design and performance of these systems. The availability of math modelling programs and the implementation of a more rigorous and detailed regulatory regime will increase the safety, efficiency and effectiveness of chutes and slides in evacuation use.

1.3 Scope

This report provides information relating to Marine Evacuation Systems and the regulatory regime and math modelling software that exists pertaining to their construction and performance expectations and requirements. An outline of the regulatory regime governing marine evacuation systems is presented, followed by a description of several systems that are currently manufactured worldwide. Incidents involving chutes and slides for evacuation of a vessel or installation are covered, as well as the details of simulation and computer modelling software that is currently being developed. Full scale and model scale testing will be performed on these systems in the near future, and parameters that would be of concern during these tests are also detailed in further chapters.

2.0 Marine Evacuation Systems

2.1 International Life-Saving Appliance Code

At this time few policies and regulations have been set forth to the marine and offshore industry governing the design, construction and performance of Marine Evacuation Systems. The International Maritime Organization has composed the International Life-Saving Appliance Code and in this code there are some basic regulations that apply to MES.

The guidelines from the LSA Code deal with the construction as well as the performance of the chutes or slides. Construction of the Marine Evacuation System including the chute or slide and associated platform must provide a level of strength that meets satisfactorily with the approval of the Administration of the IMO. Marine Evacuation Systems must also be designed and built to allow for the evacuation of evacuees that are of various ages and sizes as well as persons of varying degrees of physical capability. The construction of the system, whether it be a slide or a chute, must also compensate for the wearing of approved lifejackets by the evacuees. In summary the design of these systems must take into consideration the different physical and environmental conditions while providing a safe descent for the evacuees.

After evacuating the vessel/installation, if the slide or chute provides direct access to a liferaft without the means of a boarding platform, the system must include a quick release mechanism so as to detach the liferaft from the MES. If there is a boarding platform, used to transfer the passengers and crew to liferafts, then the platform is required to provide sufficient buoyancy and stability. This level of buoyancy must be provided when the platform is loaded to working capacity. The platform should be subdivided so that if one compartment were to become damage and no longer efficient then the platform would remain operational. The platform should be designed to be stable, fitted with a stabilizing system, so as to provide a safe means of transfer and a working area for operators. This platform must be constructed to provide sufficient strength to secure liferafts that are associated with the chute or slide.

The performance of the MES must also meet the requirements of the Life-Saving Code. Timed trials and heavy weather sea trials determine the performance level of the system. Performance requirements are also associated with the deployment and evacuation capacity of the system. The system must be capable of being deployed by one person, be it a crewmember or passenger. A timed harbour trial must be completed to evaluate the capacity of the system. The system must be capable of evacuating the number of evacuees for which it is designed for within 30 minutes from the time that the abandon ship signal is given. This implies that for a system designed with the capability to evacuate 500 people, all 500 people must be transferred from the vessel to the liferafts in 30 minutes. There is no reference made to sea state for this regulation and it is unclear how the capacity of a system is determined. The system must be deployable even under unfavourable conditions of list and trim, and must remain effective, to a practical extent under icing conditions. Heavy weather sea trials must show that the system is capable of evacuating passengers in a satisfactory means in a sea state that is associated with Beaufort six wind forces, including average wave heights of 6.4 to 9.6 meters, with a wind velocity of 22 to 27 knots. Beaufort 6 wind force conditions are described as; large waves begin to foam, the white foam crests are more extensive everywhere, strong breeze.

Testing of the container and the materials of which the chute or slide are composed of must also be completed after construction has occurred. Weather and water tight tests, as well as dry deployments must be carried out to verify the effectiveness of system. Static loads should be applied to sections of the equipment to illustrate its resistance to deformation and other damage.

In the case of the slide system there are requirements as to what angle the slide creates with the horizontal (i.e. the still waterline). This angle is required to be between 30 and 35 degrees when the vessel is at even keel and at its lightship displacement. But in the case of flooding, this angle may increase to a maximum of 55 degrees.

From this brief outline of the polices and regulations found in the LSA Code governing chutes and slides and in the Revised Recommendations on Testing Life-Saving Appliances, it is evident further determination of safe and reliable design and performance regulations are required.

Inflatable liferafts, because of their past use for evacuation using davit falls, have been regulated more in their design requirements and performance levels. The International Life-Saving Appliance Code includes a chapter on survival craft, consisting of a section on both inflatable and rigid liferafts. The Code entails requirements for the construction and stability of the liferafts, as well as the containers in which they are stored. Inflatable liferafts are associated with Marine Evacuation Systems and must conform to the applicable sections of the LSA Code, governing Marine Evacuation Systems and survival craft.

Construction regulations of the inflatable liferaft govern the buoyancy and inflatable compartments of the craft. The liferafts main buoyancy chamber must be divided into two separate compartments, which must be arranged so that should one become damaged or fails to inflate the remaining compartment(s) will be able to support the support the maximum number of occupants for which it is rate for. The persons in the liferaft must be in a normal seated position and there must be positive freeboard surrounding the entire periphery of the liferaft. Inflation of the liferaft must be capable of being activated by one person and should be completed within one minute, in the case of an ambient temperature between eighteen and twenty degrees Celsius and a period of three minutes in the case of an ambient temperature of minus thirty degrees Celsius.

The inflatable compartments of the liferaft should be constructed to withstand a pressure of at least three times the working pressure of the craft. A relief valve or limited gas supply should be used though, to prevent the pressure from exceeding twice the working pressure. The construction of the liferaft must also enable it to be dropped when empty, from a height of 18 metres to the water. If the drop height is to be higher than eighteen metres, then a drop test must be performed to test the liferaft. The liferaft is required to be equipped with a canopy that is automatically set in place when the raft is inflated. The canopy should allow for ventilation while also providing insulation from the cold, heat and seawater. Construction of the liferaft must ensure, that when the liferaft is fully inflated and floating upright with the canopy in position, that it is stable in sea. If in the inverted position the liferaft must be stable enough to be righted in a seaway, and to be righted by one person when in calm water. The liferaft is required to be stable enough to allow it to be towed in calm water up to speeds of three knots when loaded with its full complement. This standard should also address what maximum speed a liferaft can be towed at in severe weather conditions. Given the fact that most evacuations are not likely to occur in calm water, the liferaft should also be stable enough for towing in deteriorating and severe conditions, up to a designated speed. With or without the canopy erected the liferaft must also be capable of standing up to repeated jumps on to it from a height of 4.5 metres.

Access into the liferaft from the water must be capable with a semi-rigid boarding ramp or a boarding ladder. The ramp must be arranged to prevent significant damage to the craft, resulting from damage to the ramp. Inside the raft there should be a means that will assist people in pulling themselves into the liferaft from a boarding ladder. Injured and disabled persons could find entry into the liferaft in this manner quite difficult. The LSA code should state that the boarding ramp is to be designed in such a way, that these people can also gain access into the liferaft from the water.

Incorporating the use of inflatable liferafts into MES places additional conditions on the capability of the survival crafts. The stowage location of the liferaft container must be situated close to the system container, but must allow for the liferaft to be dropped clear of the deployed system and boarding platform. There must be retrieval lines connecting the liferaft and platform that are either pre-connected or easily connected at the time. Liferaft containers should be releasable one at a time from the stowage rack and be equipped with an arrangement to enable the craft to be moored alongside of the platform.

Additional regulations relating to the container for the liferaft, equipment for the liferaft as well as release and launching mechanisms are also covered within the LSA Code as well as in the Revised Recommendations on Testing Life-Saving Appliances.

2.2 Transport Canada

Transport Canada acts as a regulatory board that imposes the regulations developed by the International Maritime Organization. In doing so, Transport Canada regulates the life-saving equipment used onboard the vessels and platforms, and have therefore set forth standards applying to the design, construction, and performance of inflatable liferafts and marine evacuation systems. Transport Canada approved liferafts also meet the Canada Shipping Act regulations and Safety of Life at Sea (SOLAS) standards. Although similar in requirements, some standards for Transport Canada do differ from the IMO International Life-Saving Appliance Code.

Reliability of the liferaft and its equipment is imperative, and should not deteriorate with the exposures occurring from stowage and saltwater contact. The liferaft and all associated equipment should function properly if stored in the container or valise for a period of up to fifteen months if stored on a weather deck with minimal protection and should be able to withstand 30 days afloat, independent of the sea conditions. The liferaft is expected to withstand repeated jumps on to it, up to the capacity of the liferaft up to a height of 4 instead of 4.5 metres (as in the LSA Code). The seams of the marine evacuation system and its components must be evaluated as well. This evaluation involves inspection and testing of the seams of the chute or slide, boarding platform and liferaft(s). The chute or slide is to be fully deployed when inspection occurs.

The buoyancy compartments of the liferaft shall not have a volume that is greater then sixty percent of the total volume of the liferaft. The main chamber that forms the boundary of the liferaft should be inflated by the same inflation system by which the raft is inflated. The stability of the liferaft is to be such that one person can right the raft whether in calm water or a seaway if inverted, unless self-righting. The inflation system used to inflate the liferaft shall be activated by the pull of a line, or an equally simple procedure. The gas cylinder and valve head shall be stowed securely on the outside of the raft.

Requirements for the canopy are similar in that it should provide insulation from the cold, heat and weather but allow ventilation, as well it should erect automatically with inflation of the craft. The maximum mass of the liferaft, the container, and equipment associated with it is 185 kg for both sets of regulations for a liferaft that is not to be launched by an appliance or stowed in a position that provides easy transfer. While the minimum carrying capacity is six persons for both regulatory boards, Transport Canada also imposes a maximum number of occupants in the liferaft at fifty persons.

Retro-reflective sections are required on the outside of the inflatable liferaft. These sections are to be located on the sides, roof and on the under side of the craft. The following figure (figure 1) outlines the placement of these reflective sections.

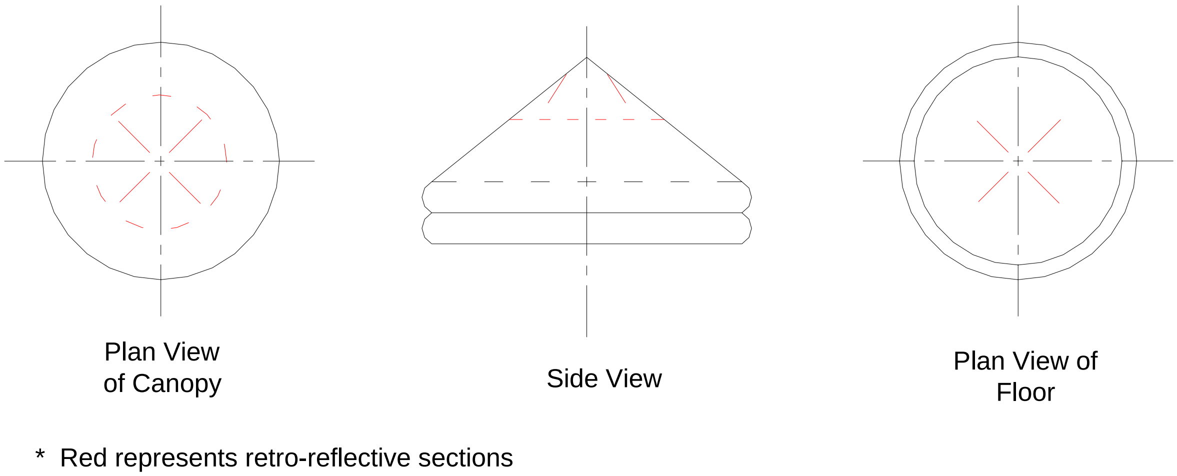


Figure 1:Placement of Retro-reflective Sections (dark black lines represent retro-reflective sections)

The container in which the liferaft is stored is to be as watertight as practical except for drain holes in the bottom. The liferaft should be packed within the container or valise so as to ensure it will open upright upon inflation.

In accordance to following these regulations the liferafts must be exposed to a number of tests, these being a drop, jump, weight, tow, and stability test to name a few. Each test would assess the performance of the liferaft, and determine if the liferaft met the given regulations that would apply.

Regulations for the inflatable platform that may be used in the marine evacuation systems have to comply with the same rules as the inflatable liferaft with the exception of requiring a canopy, and must be operable either side up, with buoyancy compartments mounted on either side of a single floor. The capacity of the platform is not to exceed seventy-five persons. If the platform is to contain drains they must drain the platform when it is fully loaded and must prevent back flow of water into the platform. Boarding ladders and ramps are to be attached to the platform; the number of each is dependent on the capacity of the liferaft and whether the ladder and/or ramps are functional with either side of the platform up. Retro-reflective tape is to be attached to each buoyancy compartment, on the upper and outer most surfaces.

On new passenger ships, the means of embarkation into a survival craft such as a liferaft is to be a chute or slide that is part of a marine evacuation system, if the embarkation deck is four metres or greater above the waterline. This distance to the waterline is to be measured while the vessel is in lightship condition. There is to be a chute or slide system on both sides of the ship. In the case of ships that are required to carry liferafts (Part I or II of the Canada Shipping Act) a marine evacuation system may be substituted for these liferafts and launching device if the liferafts associated with the MES provide at least the capacity of the removed liferafts. An example of this substitution would be the replacement of davit launched rigid liferafts, having a total capacity of 150 people, with a marine evacuation chute and inflatable liferafts having a capacity of 150 people. The MES being substituted in this situation is to meet the requirements of the International Life-Saving Appliance Code. The installation of the marine evacuation system on a new passenger ship must provide a clear area to allow a continuous and unobstructed flow of passengers.

A list of the referenced Transport Canada standards and regulations that have been outlined in the above section is located in appendix A.

2.3 Marine Evacuation Chutes/Slides

The Marine Evacuation System has been designed to allow for a safe, efficient means of evacuation while increasing ease of deployment and operability in changing vessel and installation conditions. A number of companies around the world now manufacture and sell MES for use on offshore and marine installations and vessels. These companies are located in Canada, Australia, Denmark and Northern Ireland. On the following pages the product(s) produced by these companies will be described and detailed.

DBC Marine Systems is a Canadian company with their headquarters in British Columbia. DBC manufactures both marine evacuation chutes and slides. The 'Slide' system is designed for freeboard heights of 3 to 3.65 metres, and incorporates the use of an open platform for evacuation. With the release of a safety pin the slide will deploy and inflate. The slide is made of a butyl fabric (a material made of nylon cloth and butyl rubber) and inflated by carbon dioxide stored in cylinders. All components including the slide and platform are located within a housing that is made of aluminium, which is powder coated to provide additional corrosion prevention. Additional platforms or liferafts can be launched from a separate launch point on the vessel and bowsed into place alongside the vessel. An area of 380 mm deep and 1380 or 1665 mm wide (dependent on capacity of platform) is required to accommodate this housing. Additional information and drawings of the housing and slide arrangement have been placed in appendix B of this report. Figure 2 shows a profile view of the slide and platform after deployment and inflation.

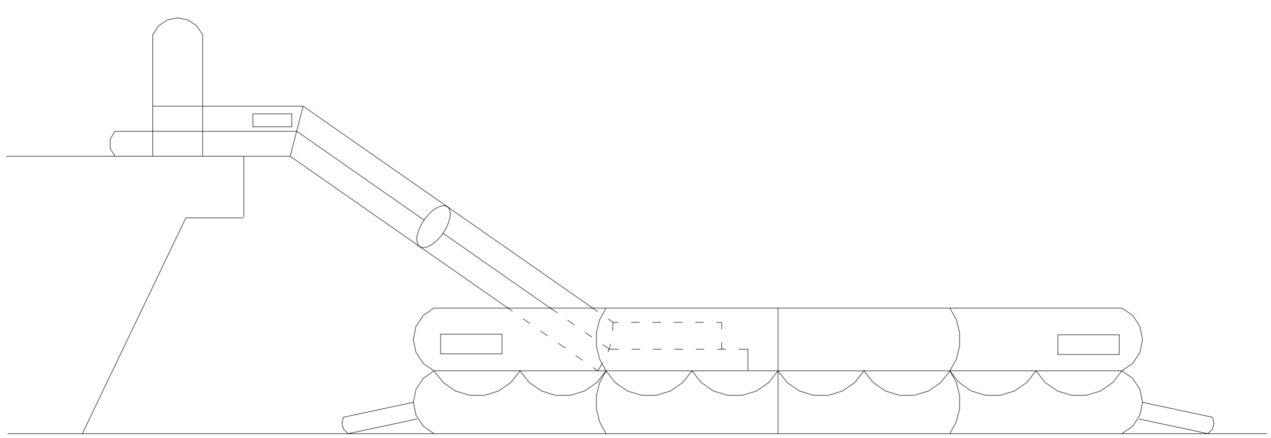


Figure 2: Deployed Slide and Platform (DBC Marine Systems)

The Marine Evacuation Chute, manufactured by DBC, is also stored in a compact housing with an inflatable platform. The housing may be located either at the embarkation deck or on the deck above. For the chute installed above the embarkation deck, the "O" type, an area of 1.6 square metres (1.5m wide by 1.3m deep) is needed for the housing. The release arm, when activated causes the chute pack to deploy. For the "I" type chute, which is mounted on the evacuation deck, an area of 2.4 square metres (1.5m wide by 1.65m deep) is required. The chutes of both the "I" and "O" type systems are composed of an inner slideway, constructed of a translucent fabric, which is contained inside a protective nylon covering. The inner slideway is sewn with a zigzag pattern at an angle of eighteen degrees to control the descent speed of the evacuee (see figure 3).

A fender is also available, to protect passengers and crew as well as the chute from interference with rub rails or protruding hull appendages. The fender is self-inflatable and is composed of a butyl fabric as well. The chute system is functional in positive and negative list conditions of 20 degrees and trim conditions of 10 degrees and all combinations of list and trim up to these values. Chutes are available in three models, with varying lengths up to 24.9 metres. More detailed information

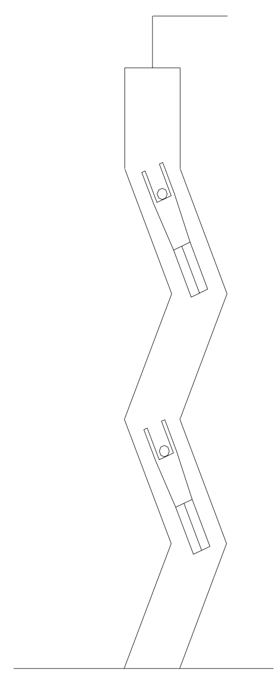


Figure 3: View Inside Chute, Zigzag Exaggerated (DBC Marine Systems)

regarding the design of both types of chutes is located in appendix C of this report. Figure 4 shows both chute systems in a deployed position.

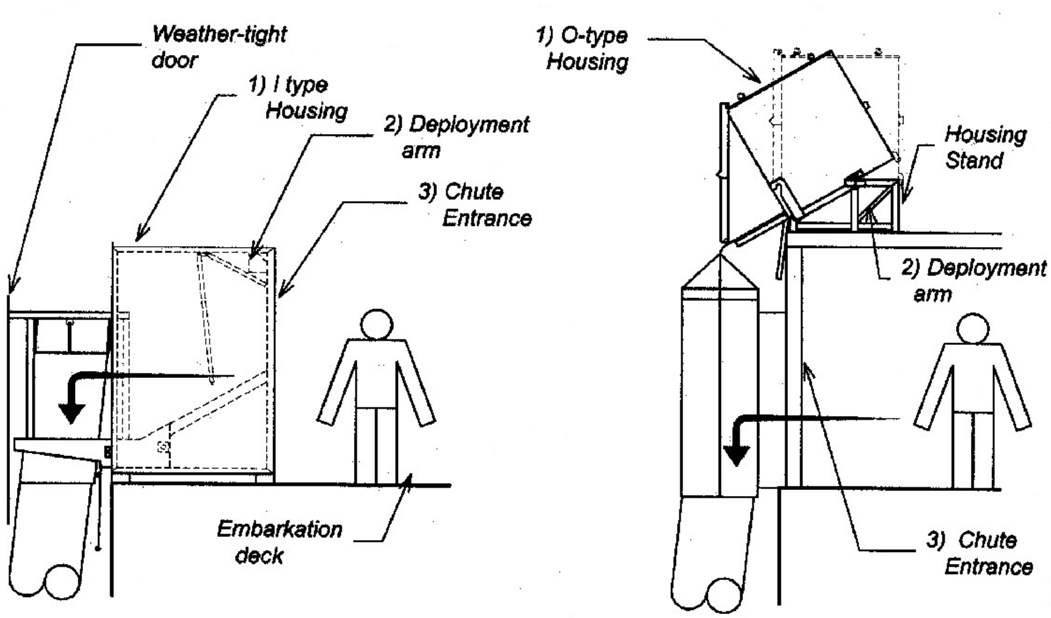


Figure 4: "I" and "O" type Marine Evacuation Chute (DBC Marine Systems)

Viking Life-Saving Equipment is located in Denmark, and also manufactures both 'Chute' and 'Slide' evacuation systems. The Viking systems do not require any external power supply and make use of a platform for transferring evacuated passengers and crew to liferafts.

The Viking Evacuation Slide is a dual-track slide consisting of eight separate compartments. Within these compartments are twelve main longitudinal tubes, which are each individually inflated. Inflation is by means of nitrogen and air aspirators. The bottom end of the slide is connected to the self-draining platform. The slide and platform are fabricated of nylon webbing covered with natural rubber. The slide and platform system is contained within a steel or aluminium stowage box and requires a deck area of 1.0 m deep and 2.3 m to 2.4 m in length, dependent on the stowage box material. There is a thirty-degree angle between the slide and ship's side and this is maintained with a bowsing line. This angle can be adjusted between zero and thirty degrees to compensate for sea and ship movements. There was no reference made as to how this angle was measured or who was responsible for the adjustment of the bowsing line. The slide itself is at an angle of thirty to thirty-five degrees with the waterline when the ship is upright, in calm water conditions. The system is available with slides in lengths from 12 to 25.5 metres. A single lane mini slide is also manufactured, for installation heights of 1.5 to 3 metres.

The Viking Evacuation Chute is designed for use in marine and offshore evacuation. For marine vessels, the chute can be used at stowage heights of 5 to 20 metres above the waterline. The marine chute consists of a Kevlar-nylon net for the lining, with a water and fire resistant nylon protective covering. The design of this system eliminates the need for a boarding platform when launching from passenger and marine vessels. Elimination of the boarding platform allows passengers to be evacuated directly from the vessel to the inflated liferaft, providing a dry-shod evacuation as stated by the manufacturer. The stowage box size varies from 2.73 m x 2.93 m x 3.0 m to 2.75 m x 2.93 m x 3.5 m [*].

The offshore chute is ideal for fixed and floating platforms with installation heights reaching up to 35 metres. The chute is divided into cells each with a speed-retarding slide. Each slide runs at an opposing angle to the previous one so as to create a zigzag pattern. A stabilizing weight is attached to the bottom of the boarding platform, and is situated five to ten metres below the water surface. This weight aids in reducing side motions in the chute and keeps the chute stable in rough wind and sea conditions. Several tension lines connect the stabilizing weight to the bottom of the chute through an

[*] Measurements given as depth by length by height.

opening in the platform. This allows the platform to rise and fall with the waves while avoiding submersion of the platform due to the stabilizing weight. When the system is released the stabilizing weight is deployed as part of the chute system. The platform is again self-inflating as in the slide system. The platform is composed of natural rubber while the chute is made of Kevlar stainless steel rings. Stowage for the offshore evacuation system is in a carbon steel box, that can be either in-deck mounted or cantilevered out from the platform.

Further details on the Viking Slide system can be found in appendix D, while additional information on both chute systems has been placed in appendix E. Figures 5 and 6 show a rough outline of the chute and slide systems manufactured by Viking.

Figure 5: Viking Marine Evacuation Slide System

Figure 6: Viking Marine Evacuation Chute System

RFD Marine is located in Northern Ireland. RFD Marine have also based the design of their marine evacuation system on the elimination of a boarding platform therefore passengers and crew can be transferred directly into the liferaft. With the use of a telescopically designed chute, which compensates for sea and ship motions, evacuees can make use of the chute in all weather conditions as stated by the manufacturer. The system is functional at a variety of installation heights, ranging from 8.0 to 23.5 metres. The self-contained stowage unit can be mounted on an open deck or in between decks and contains the chute and liferafts all in one. The manufacturer states that the system is operational within 90 seconds of being deployed by a single release mechanism. The system includes two side-by-side chutes, each equipped with a liferaft. Additional information outlining the RFD system can be found in appendix F.

Liferaft Systems Australia located in Tasmania manufacture a slide system. They have designed their evacuation system to eliminate the use of a boarding platform. The slide is available in a single or dual lane path and can be installed up to a height of

12.5 metres. Netting runs the length of the slide path to reduce descent speeds and a contour at the bottom of the slide reduces the evacuees' speed immediately before entering liferaft. The system is stowed on a marine grade aluminium stowage cradle. Permission was denied to publish any additional information pertaining to this system within this report.

Key features of all the systems discussed above have been highlighted in an Excel worksheet, and placed in appendix G, for quick reference and comparison.

2.4 Liferafts

All the MES detailed in the previous section incorporate the use of inflatable liferafts as the survival craft after evacuation of the distressed vessel. While inflatable liferafts can also be used as a means of evacuation and survival, such as in the case of davit-launched liferafts, in these systems the liferaft functions only as a survival craft after evacuation. The liferafts are self-inflating, with their source of inflation from a variety of gases.

DBC Marine Systems offers a reversible inflatable liferaft of varying capacities for use with their Marine Evacuation Systems. The liferafts offered have met Canadian and American Coast Guard SOLAS requirements for the 50-person capacity raft and have met Canadian approval for the 150-person raft. The primary liferaft used is the fifty-person raft. The buoyancy compartments are composed of a butyl fabric; two layers of nylon based cloth with butyl rubber between them and the canopy is made of a polyurethane coated nylon. Inflation of the liferaft is achieved with a mixture of carbon dioxide and nitrogen gas. A vertical pillar automatically elevates the double-sided canopy to the appropriate position, upon inflation of the raft.

Viking liferafts, when used in association with their MES are remote released from a cradle. The liferaft container is secured to the platform of the evacuation system and inflation of the liferaft is activated by the hard pull of a quick release line. The standard liferaft comes in varying capacities from four to fifty persons. If a liferaft of this type is needed with a one hundred-person capacity, 2 fifty person liferafts stored in one container are available. Self-righting liferafts are also available for use with the chute and slide systems; these are available in twenty-five, fifty-one, one hundred and one, and one hundred and fifty person capacities. Liferafts primarily used with the chute and slide systems have carrying capacities from fifty to one hundred and one. Viking liferafts basic material make-up is a strong webbing covered with natural rubber. The containers which house the survival crafts are made of a rigid fibreglass to withstand wear. An emergency pack is contained in every liferaft for survival while at sea.

RFD employs the use of a stand alone liferaft with their MES. This liferaft is composed of 6 buoyancy compartments, which provide additional survivability in the case of damage (see figure 7). The rafts are fully reversible with a carrying capacity of one hundred and six and one hundred and nine.

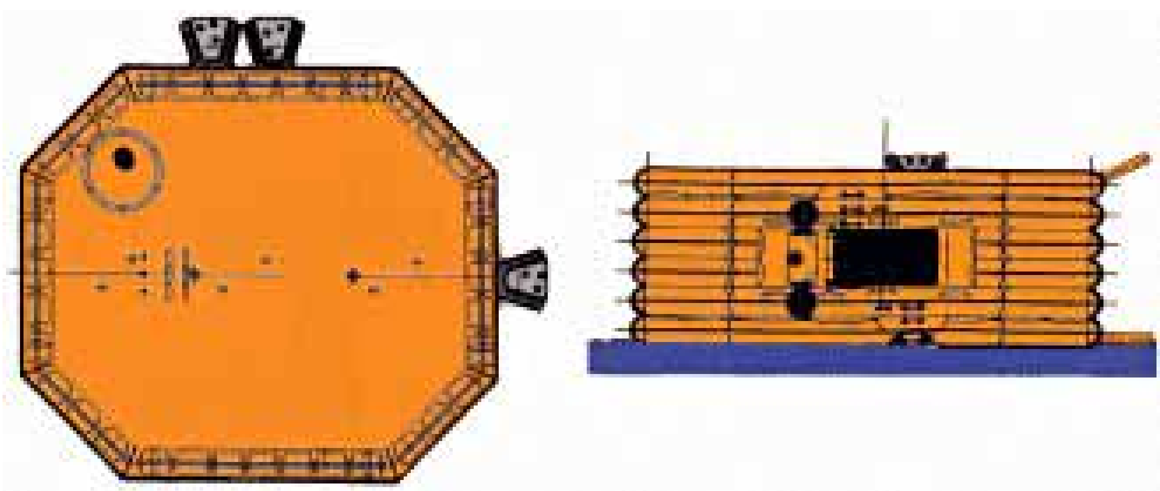


Figure 7: Stand Alone Liferaft: overhead and profile view (RFD)

2.5 Simulation and Use

To date, there have been few reports of MES use in an emergency evacuation. Marine Evacuation Systems are most widely used by the public when exhibiting the systems ability to fulfill the time requirement to evacuate within thirty minutes. These timed evacuation trials are performed within the shelter of a harbour in calm water. Timed harbour trials are preformed by a number of individuals designated to be representatives of the users of the chute or slide in an emergency situation. While the group of chosen individuals may represent the people that would make use of the system in an emergency, the sea and ship conditions do not. The shelter of a harbour may not simulate typical sea conditions on even a calm day, dependent on the degree of sheltering it provides. Listing or trimming by the vessel is not simulated; making transit through the vessel easier, and visibility is at a maximum without the simulation of smoke from a possible onboard fire. In the case of heavy weather sea trials, the environmental conditions experienced mimic a possible emergency situation. <u>But because ballast is used to create the effect of people in the liferafts during the drifting phases of the trials, and only twenty evacuees must execute an evacuation with the use of a MES, adequate testing of the safety level of the systems under heavy weather cannot be performed. From extensive research it was found that no heavy weather tests were reported to have been completed with the maximum designated capacity of evacuees for the system being tested and with humans as ballast in the liferaft instead of ballast water or weights.</u>

Instances in which a MES had been used in an emergency evacuation were even more difficult to locate. While the manufacturers of the Marine Evacuation Systems reported and detailed the testing of the chute and slides systems in timed harbour trial and heavy weather trials, very few reports have been made of their use in an emergency situation. While this has a positive side, in that emergencies should be avoided, realistic situations involving the use of MES would help to improve and increase the knowledge surrounding their efficiency and effectiveness in an evacuation situation. The only incident of the use of a MES in an emergency situation that was found involved the m/s Prinsesse Rahgnild. An engine room fire lead to the evacuation of the vessel with the use of a chute, though no report or evaluation of the evacuation procedures could be found.

Simulation of the behaviour of a Marine Evacuation System has not been developed to an adequate level either. Computer modelling of chutes and slides in varying environmental conditions would eliminate the need to put human life in danger if simulation was accomplished to the desired level accuracy. MaritimeEXODUS, a software program that has been developed by British Maritime Technology and the University of Greenwich is aimed towards simulating emergency evacuations with the use of chutes, slides and other MES. The software includes features that can allocate passengers to an evacuation system, and account for the performance of the chute or slide. The software can also model a passengers movement during evacuation.

BMT Fleet Technology Limited has designed an apparatus to simulate the conditions onboard a vessel to determine the movement of humans in evacuations. This system is referred to as the Ship Evacuation Behaviour Assessment facility (SHEBA) (see figure 8). List and trim of a vessel can be simulated to an angle of twenty degrees, and smoke conditions can also be simulated in the facility. From the use of this facility, human behaviour can be recorded, assessed, and then simulated by computer modelling and will enhance the accuracy of the MaritimeEXODUS program and similar software.

Figure 8: Ship Evacuation Behaviour Assessment Facility (SHEBA)   (BMT Fleet Technology)

With the blending of data from facilities such as SHEBA and from model and full scale testing of Marine Evacuation Systems, accurate computer modelling can evolve. Full scale and model scale testing will provide the data on MES performance, while human behaviour can be assessed through the use of facilities such as SHEBA. Extensive testing on both human aspects and system behaviour in the evacuation process will enable society to develop this simulation software, thereby eliminating the need to place human lives in danger. Reports of weather tests that have been completed and recorded as well as an outline of the MaritimeEXODUS software and the SHEBA facilities have been placed in appendix H.

3.0 Project Overview

3.1 Past Testing

Model tests preformed in Sweden have examined the behaviour of a slide system, composed of a dual track slide, boarding platform and liferafts. Parameters such as the ship condition, severity of the environment, slide parameters and the loading of the liferafts and the platform were examined on both the leeward and windward sides of the ship. The parameters were varied to assess the risk of deformation of the slide occurring, the resultant inclination angle of the slide and the condition of the platform and liferafts.

The prototype for the slide system in the testing conducted by the Department of Vehicle Engineering in Stockholm, Sweden was a dual-track slide with a fixed boarding platform and liferafts. Slide parameters that were adjusted were the slide length and the angle between the slide and the ship. The inclination angle of the slide with respect to the still waterline remained the same at 30 degrees, as required by IMO regulations. Pressure was also evaluated in the testing; the slide was inflated to normal pressure as well as 50 % over normal pressure. The loading of the boarding platform and the liferafts was adjusted for several cases, having no passengers in either for one case. In other cases the boarding platform was filled to 25 and 50 percent of it's capacity while the loading of the liferaft(s) was at zero, half or full capacity. The ship was adjusted for heel in both directions, towards incoming waves and away from, and the slide was launched on both the leeward and windward side. Wave height and period were also varied to simulate various environmental conditions.

The estimation of risk that was associated with evacuation using this model slide system was evaluated based on deformation of the slide, the steepness of the slide with respect to the water line, the condition of the boarding platform, whether it was lifted off the water surface or pushed under the water and the roll angle of the platform and the liferafts. Risk levels of low, moderate and high were categorized based on numerical values for the steepness of the slide, the deformation, etc. A low risk corresponded with a risk of injury of 0.5%, moderate with a 5% risk and high as a 50% chance of injury.

Results that arose from this testing are conclusive in showing that the length of the slide, the loading of the platform and liferafts, as well as the launching side has an effect of the performance of the system. Conclusions that were formed from the evaluation of the results are:

- Increased wave height increase the risk associated with evacuation
- Stiffness of the slide can effect whether or not the platform is pushed under the water
- A free connection between the slide and platform, where the slide was able to move 0.5 m in the longitudinal direction had a positive effect on deformation and the intensity (refer to figure 9)
- Systems that evacuate passengers directly to a liferaft are advantageous in reducing exposure to weather conditions. Covered or closed slide systems would also reduce this exposure.
- Slide length was very important in testing while the ship was in a heeled position. The shorter slide experienced unfavourable inclination angles in this condition, negative angles while on the low side, increased positive angles, up to 70 degrees while on the high side

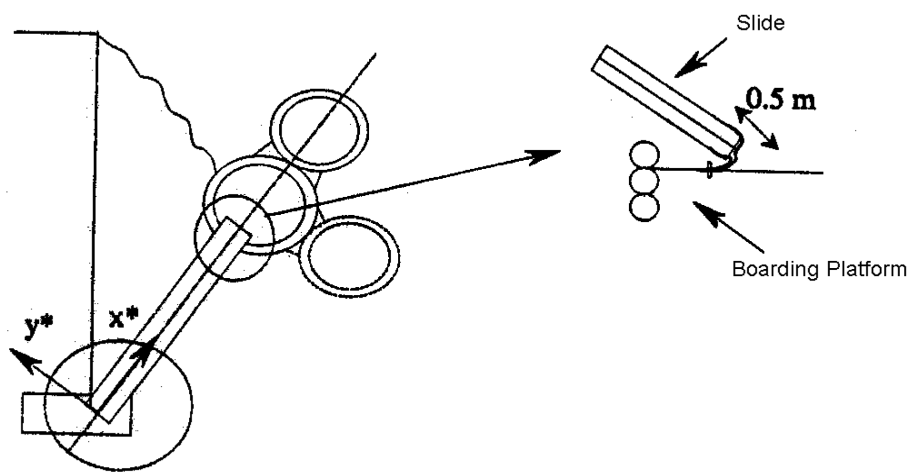


Figure 9: Longitudinal Axis of Slide

While these results covered many areas of the slide performance, further testing would be ideal to determine the limitations of the slide system.

Observational inspection of both systems, by this Swedish group, has provided insight into the benefits and detriments of Marine Evacuation Systems. Advantages and disadvantages of the chute and slide systems were observed regarding space requirements, launching device, exposure to wind and waves and risk of injuries. Advantages cited were the space efficiency of the systems, the need for only one launching device for many liferafts, limited demand for skilled seaman or crew, and the low risk for serious injury during training and calm and warm environment use because only one person uses the system at a time. The difficulty for children, elderly and disabled people to use the system was viewed as a disadvantage. Exposure to wind, waves and cold weather is great and it would be difficult to avoid being exposed to large amounts of seawater. This aspect of exposure may be decreased even eliminated with the use of a system that does not require a boarding platform. Additional disadvantages of the chute system that were cited are:

- The close vicinity of the platform and liferaft to the ship. This closeness would increase the risk of the liferaft or platform being caught on any appendages of the vessel.
- When the period of the waves being tested was at a minimum, larger reflections off the shipside were experienced which doubles the relative motion between the platform and ship.

These disadvantages of the chute system would be more of a concern when evacuating a ship, because of the configuration of an offshore installation, wave reflection would not occur to the same degree, and interaction with appendages would be minimal.

Testing of chutes by a representative group of DBC Marine Systems, has centred on the safety of chutes in regards to the effects on the human body due to the vertical descent. Safety tests completed by a group consisting of a bio-medical specialist, an orthopaedic surgeon and a material engineer have measured stresses on the body during descent and allowed the group to determine the types and degrees of injuries that may occur. Tests subjects ranged in height, weight and girth, as well as age. The types of clothing that the subjects wore were also varied.

The testing measured ergonomic stresses on the body, and it was found that the spinal acceleration loads were well below the limit of axial loads on the spine. Injuries that were experienced were limited to minor surface burns on the hands or elbows. These burns resulted as a result of trying to slow the drop. These attempts to slow the descent speed through the chute seemed to be the only factor that affected the drop speed. The drop speed appeared to be independent of the body’s height, weight or girth, as well as the experience or fear of the subject. Times for the drops were measured at taking between two and four seconds from the time the subject entered he chute until reaching terminal velocity at the base of the chute. Descent speeds have been measured to be between 4 and 6 metres per second. (DBC Marine Systems)

Past testing has looked into the performance and behaviour of marine evacuation systems, though not to the level of detail that has allowed the industry to gain full knowledge of the systems.

3.2 Future Testing

The influence of the environment, the ship conditions and key parameters of the evacuation system in question are to be determined. A full understanding of the performance of Marine Evacuation Systems can only be accomplished if all circumstances of use are considered and tested.

Wind and wave conditions corresponding to a number of Beaufort sea states should be considered. Testing that was completed by a Swedish group, as mentioned in the pervious section, only focused on wave height and period. In real life conditions, wind is also a factor of the environment that should be considered. Waves also intercept a vessel or structure at collinear, angled and irregular approaches, which should also be included in testing. Ship or installation conditions should be altered to determine their effect on the behaviour and effectiveness of the given system. It was shown in previous testing that launching side and heel condition has an effect on the deformation and inclination angle of slides. Leeward and windward placement may have profound effects on the performance of chutes as well. Protection from the wind may help reduce swaying of the chute when on the leeward side. Heel and trim conditions can alter the drop height of the chutes, which should also be considered in testing.

Testing can also determine the effects of slide inflation, and frictional effects of the chute material, along with the descent speeds for each system. It was determined in previous testing that a sufficient stiffness in the slide could cause the platform to be submerged. A maximum and minimum value for the pressure in the slide system should be determined so as to provide adequate stiffness in the slide while avoiding submersion of the platform, or buckling under the weight of evacuees. The LSA Code has imposed values for the inclination angle of the slide and a maximum value for this angle has been determined. The effects of changing this vertical angle as well as the horizontal angle between the installation or ship and the slide should also be assessed through testing. While appropriate values for the horizontal angle have been determined, the changes in the performance of the system as a result of changing this angle are unknown. Different slide lengths will experience changing inclination angles in similar sea states as was apparent in the testing described above and so a minimum slide length may be necessary to avoid poor slide performance. The pressure and the inclination angle of the slide may have effects on the descent speed of the passengers and crew as well. A safe descent speed is essential in preventing injury to evacuees. Changes in the material of the slide can affect the frictional forces on passengers altering their descent speed. Materials approved for use in slide systems should be tested for their frictional interaction with clothing and resulting descent speed. Deformation of the slide, submersion of the platform or liferafts and descent speed are all very important factors to assess in determining the safety and effectiveness of an evacuation system. All should be considered in testing the slide system.

The chute system should be assessed in similar terms, such as the descent speed and the length of the chute. Changes in the wave height as well as heeling and trimming of the vessel or installation will alter chute length. Combined together these variations in length could be as much as 6 metres (Rutgersson, Tsychkova). Heeling or trimming of the vessel could also cause interference between the chute or platform and liferafts and the structure or structure appendages, leading to injury or ineffectiveness of the system. Therefore the effects of heeling and trimming on the chute length and the consequences should be evaluated. The length of the chute will affect the final velocity that the evacuee will achieve (except in the offshore chute designed by Viking) and high descent speeds may have negative effects on evacuees, such as injury or increased fear levels. The frictional effects of the chute material will also alter descent speed; therefore any materials that may be suitable for manufacturing the chute should be tested. Caution should be taken to be sure that no person could become stuck in the chute due to a high level of friction, which may lead to injury or death. It is important to also avoid extremely low levels of friction that may cause high descent speeds leading to possible impact injuries upon reaching the platform or liferaft. The inner lining of some chute systems have been designed in a telescopic nature that provides a controlled descent (see figure 10). A zigzag pattern has also been designed to reduce descent speed (see figure 3 from previous section). Changes in the angle of this pattern could alter the drop speed, which could also be considered during testing procedures.

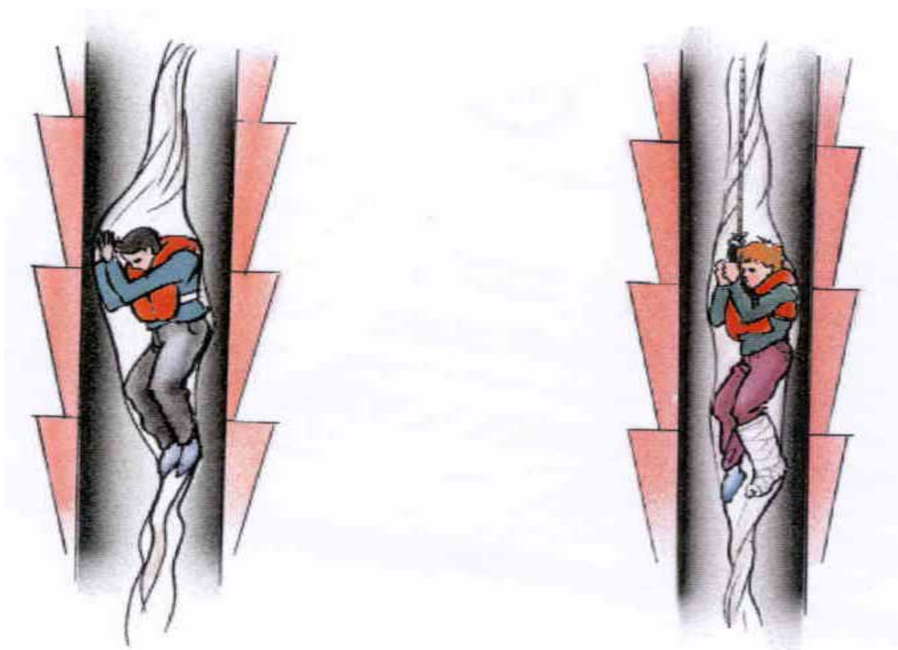


Figure 10. Telescopic Chute Design (Viking Life-Saving Equipment)

Roll of the platform would also be an issue in the evacuation of passengers and crew from a troubled structure. Large roll of the platform may make transfer of evacuees to the liferafts extremely difficult, even impossible. Stabilization of the platform should be tested; aiming for the highest level of stability and elimination of the platform could be considered for severe conditions. The elimination of a boarding platform has been considered by several of the companies mentioned in this report, which decreases the exposure to the environmental conditions, as well as eliminating the transfer stage to liferafts.

Future testing of chute and slide systems would involve a large number of parameters dealing with the environment, the vessel or installation being evacuated and the system itself. A possible test matrix has been developed and placed in appendix I for reference. While the behaviour of the chute, slide, boarding platform and liferafts would be extremely important to evaluate, human performance is also a key aspect of the effectiveness of these systems.

4.0 Conclusions

Emergency evacuation from a ship or offshore structure is a dangerous procedure, especially in deteriorating weather conditions. A safe and effective means of evacuation is necessary to avoid injury and death to those being evacuated. Chute and slide systems are presently being upgraded to provide this. A small number of companies around the world have been manufacturing and patenting their design over the past number of years. These designs are based on the most basic regulations that exist today. These regulations should be assessed and amended to ensure that the proper design and configuration for each system is achieved, to provide the highest level of safety and efficiency. The expected performance of each system should be known and understood to avoid injury in emergency situations. Proper modelling techniques and programs will reduce the need to use human test subjects in evaluation of the equipment. More rigorous regulations and adequate math modelling can be developed with the data, information and knowledge that will result from model and full scale testing of marine evacuation chutes and slides and the associated components of these systems.

Current designs and regulations make the use of chutes and slide difficult and questionable for the elderly and physically disabled. No attention has been given to the transfer of disabled people from the bottom of the chute or slide to the liferafts. Are these people to be carried or dragged? Or if injury was to occur during transfer from the vessel or installation to the bottom of the chute or slide, what procedure is there in caring for these people. Elderly people do not have the same agility and flexibility as those of a younger age, and may be injured during the evacuation process, or may not be able to manoeuvre themselves through a chute or down a deformed slide. Considering that slides and chute are installed on passenger vessels, these concerns need to be addressed.

The design of the slide system also presents a limitation in their use on fixed and floating platforms having large installation heights. Regulations 6.2.2.1.5.1 and 6.2.2.1.5.2 state that the slide is to create an angle of 30 to 35 degrees with the waterline when the vessel is at its light ship displacement and in calm water, while this angle may increase to a maximum of 55 degrees in the final stage of flooding. To achieve this 30 degree angle, a platform with a 30 metre installation height would require a slide that is 60 metres in length. This is quite a lengthy slide and the risk of deformation may increase for a slide of this length. In this situation the chute system appears to be advantageous over the slides system for evacuation from platforms and vessels with large installation heights. Other standards stating that one person must be capable of righting a liferaft are inappropriate. One person cannot right a 50-person liferaft on his or her own, given any sea condition. This standard should be revised to take into consideration the capacity of the liferaft, as well as the present sea conditions. Other areas of concern regarding the design and performance of MES are the determination of a systems capacity, time limitations for evacuation in heavy weather, and the operation of bowsing lines for the slide system. Additional attention should also be allotted to the task of assessing the procedures of towing the life rafts away from the troubled vessel or installation. Evacuation is not complete until passengers and crew have been relocated to a safe area.

If using chutes and slides for evacuation of a vessel or installation, a good understanding of their design performance must first be accomplished. Detailed standards are necessary to be sure that all systems provide a high level of safety, while maintaining effectiveness in all emergency situations.

5.0 References

Canada Shipping Act. 2003. www.tc.gc.ca/acts-regulations/GENERAL/C/CSA/menu.htm *Transport Canada.*

DBC Marine Systems. www.dbcmarine.com

Escape Slide System Technical Package. 1996. *DBC Marine Systems.*

IMO. 1997. International Life-Saving Appliance Code (LSA Code) Resolution MSC.48 (66), Chapter IV: Survival craft. *International Maritime Organization.*

IMO. 1997. International Life-Saving Appliance Code (LSA Code) Resolution MSC.48 (66), Chapter VI: Launching and embarkation appliances. *International Maritime Organization.*

IMO. 1998. Testing of LSA. Marine Evacuation Unit Resolution MSC.81 (70) Revised Recommendations on the Testing of Life-Saving Appliances Part 1-Prototype Test for Life-Saving Appliances, Chapter 12: Marine Evacuation Systems. *International Maritime Organization.*

Liferaft Systems Australia www.liferaftsystems.com.au

Marine Evacuation Chute Technical Package. 1996. *DBC Marine Systems.*

RFD. www.rfd.co.uk

Rutgersson, O., Tsychkova, E., Experimental Investigation of “Slide” and “Fall” Evacuation Systems. *Department of Vehicle Engineering. Sweden, BriteEuram project 97-4229 “MEPdesign” WP2d.*

Simões Ré, A., Veitch, B., Newbury, S. 1999. Workshop on Escape, Evacuation and Rescue in the Offshore Industry, Section 2.5. *Institute for Marine Dynamics.*

Transport Publications/ Marine Safety. 2003. www.tc.gc.ca/MarineSafety/TP/menu.htm *Transport Canada*

Viking Life-Saving Equipment. www.viking-life.com

Welcome to the SHEBA facility – Ship Evacuation Behaviour Assessment, Link: The Facility. www.shebafacility.com/

Welcome to the SHEBA facility – Ship Evacuation Behaviour Assessment, Link: The Software. www.shebafacility.com/

Appendix A

Transport Canada Standards

Referenced Transport Canada Standards and Regulations

Marine Safety Publications

Standards for Liferafts and Inflatable rescue Platforms

www.tc.gc.ca/marinesafety/Tp/TP7321/TP7321E.htm

Regulations for Marine Evacuation Systems

Life Saving Equipment Regulations

www.tc.gc.ca/acts-regulations/GENERAL/C/CSA/regulations/030/csa032/csa_32-a.html

Appendix B

DBC Emergency Evacuation Slide

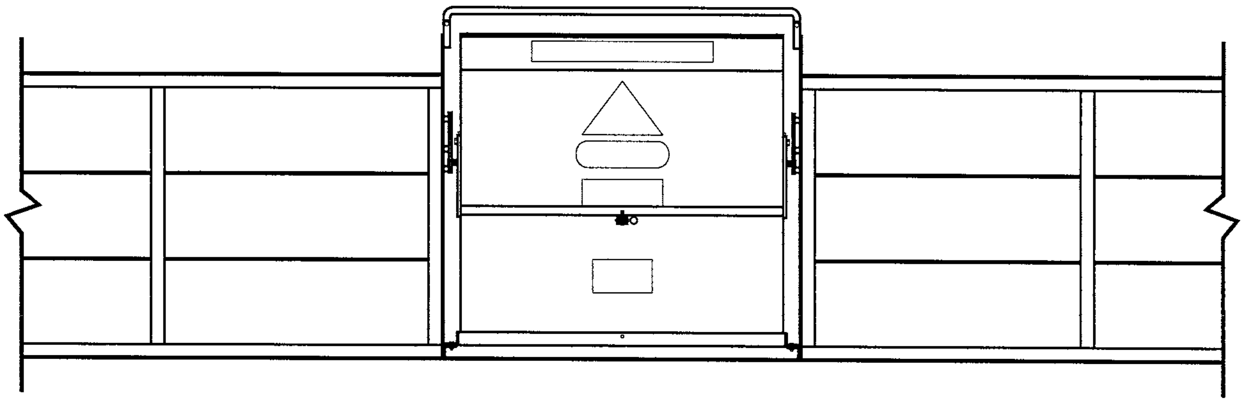
DBC Marine Safety Systems

Escape Slide System
Technical Package

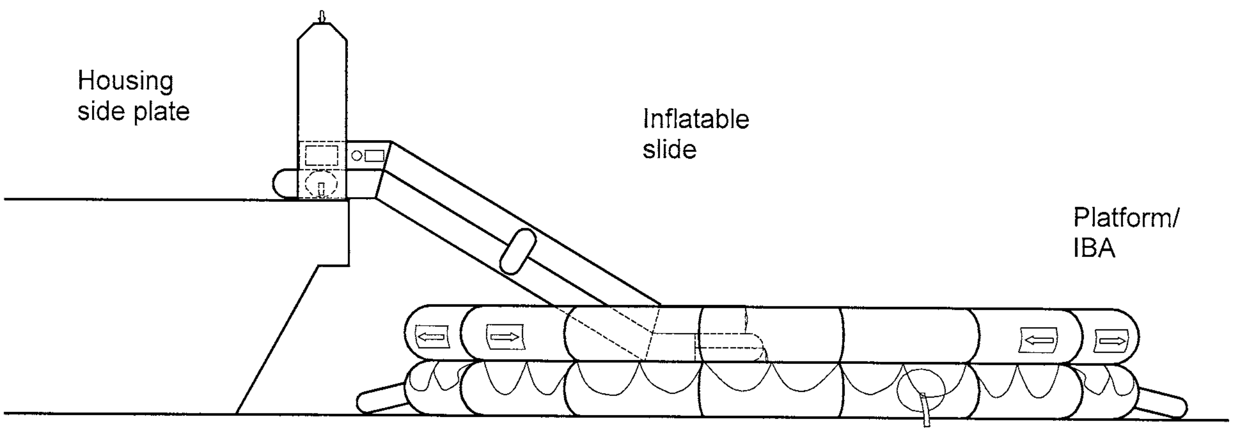
TABLE OF CONTENTS - ESS TECHNICAL PACKAGE

DBC Marine Safety Systems

INTRODUCTION

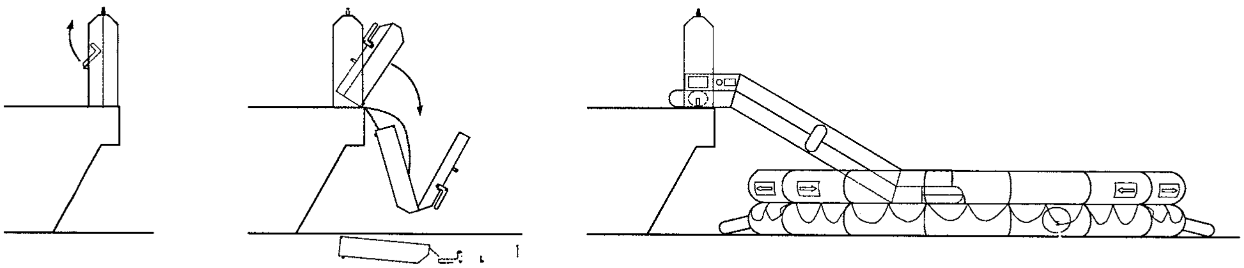


The DBC Marine Safety's Evacuation Slide System (ESS) is an efficient, easy to use, flexible and cost-effective marine evacuation system for low freeboard vessels. As a gravity launched system DBC Marine Safety's ESS System evacuates passengers and crew with the utmost safety in the shortest possible time.

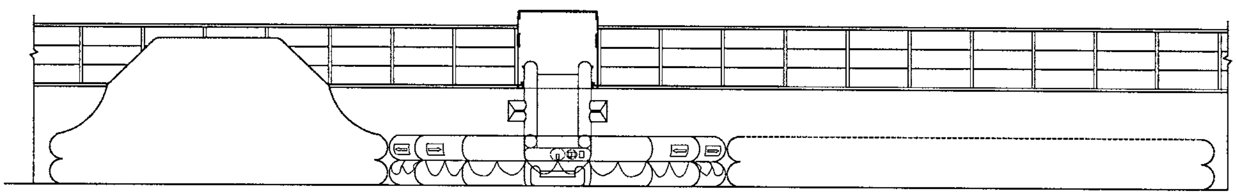


HOW IT WORKS:

An inflatable platform (IBA) and slide are stored in a compact housing on the embarkation deck (inside or outside the vessel). During an emergency, a crew-member releases the ESS with an upward pull on the handle while gently pushing the housing outboard. As the ESS falls to the water both the platform and slide automatically inflate and the system is ready for passenger evacuation.



The single platform stored with the slide can be used either on its own or as the staging point for transfer of passengers to additional liferafts or platforms which have been launched from the vessel and bowsed to the staging platform and then inflated by the ESS crew.



Once the single platform, or bowsed liferafts/platforms have been loaded, they are then towed away from the vessel with the rescue boat. At this point, another liferaft or platform can be launched, bowsed in place and loaded, if required.

BENEFITS OF THE DBC MARINE SAFETY'S ESS SYSTEM:

- **Ease of use.** The ESS system is less complicated to operate than other evacuation systems and can be deployed by only one crewmember.
- **Safety.** All components of the system are contained in one housing, fully adjustable to accommodate wind, weather, and sea conditions during an evacuation.
- **Flexibility.** DBC Marine Safety's ESS Systems are lightweight, compact and easily installed in a variety of configurations without any major alterations. The system can fit on new or existing ships, be transferred from vessel to vessel and integrate with existing liferafts or platforms.
- **Cost.** The initial investment, as well as installation and maintenance, are significantly lower than other types of marine evacuation systems.

- **Service.** Because the ESS system is less complex than other systems, turnaround time for servicing is the same as for conventional liferafts or platforms, typically 24 hours.

- **Trust.** DBC Marine Safety's ESS System is a total system approved by Canadian and United States Coast Guard administrations and manufactured to ISO 9001 standards. DBC Marine Safety Systems ensures that all components are of the highest quality and reliability.

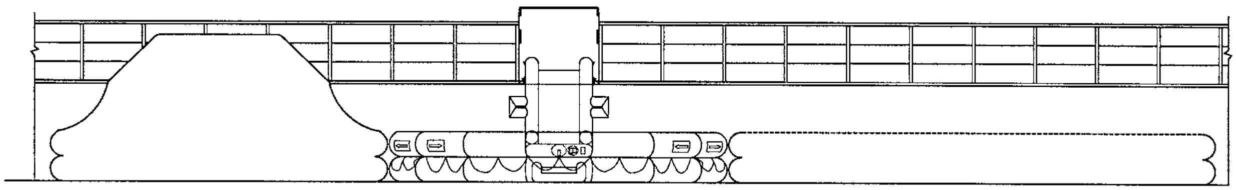
ESS COMPONENT DESCRIPTIONS

1) **Housing.** The housing is designed to be installed on the embarkation deck of low freeboard vessels and is ideal for those vessels with a limited embarkation deck area. The housing is fabricated from aluminium which is then powder coated for additional corrosion resistance. The footprint area is 380mm x 1380mm for the model ESS 25 with 50/75 person platform and 380mm x 1665mm for the model ESS 25 with 100/150 person platform. The housing rests in it's own stand, once the release arm is activated, the housing pivots outboard to deploy the integrated slide and platform, which then inflate automatically.

2) **Slide.** At the heart of the ESS is the slide. The slide is constructed of butyl fabric and is automatically CO_2 inflated when the ESS system is deployed. The slide meets all Coast Guard requirements including hot and cold tests.

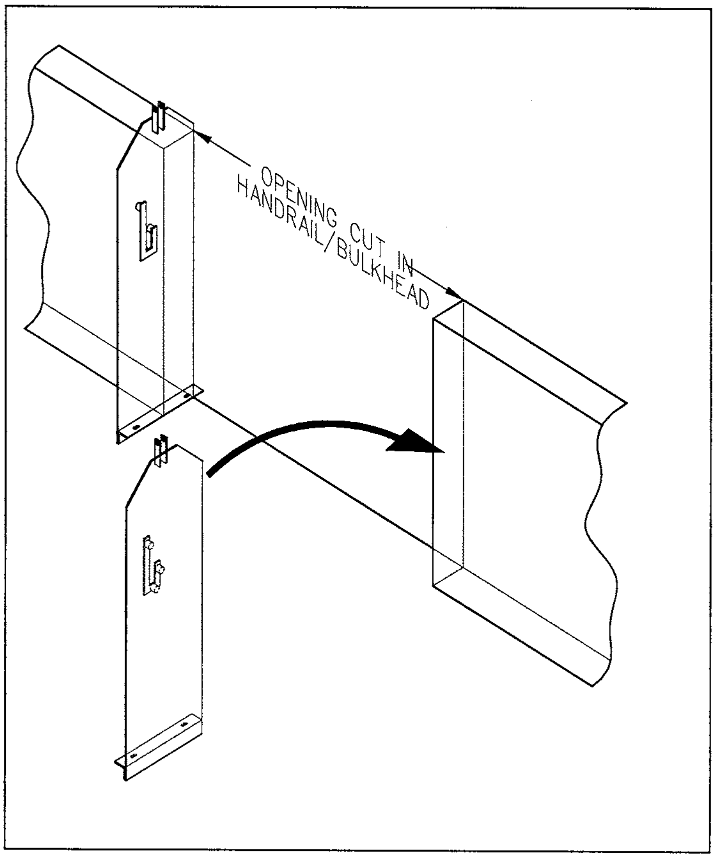
3) **Platform.** DBC Marine Safety's ESS platform is constructed of butyl fabric and is automatically CO_2 inflated when the ESS system is deployed. The platform meets all Coast Guard requirements including hot, cold, and self-draining tests.

4) **Additional Liferafts or Platforms.** Once passengers descend the ESS they can either remain in the platform or be transferred to a liferaft or platform that has been bowsed to the ESS platform, depending on the passenger capacity of the vessel. DBC Marine Safety's 50 person liferaft, as well as their other liferaft sizes, meet both Canadian and United States Coast Guard SOLAS requirements. For those vessels operating on inland or coastal routes DBC Marine Safety Systems offers Canadian approved platforms up to 150 person capacity and United States approved IBA's up to 100 person.



INSTALLATION

The DBC Marine Safety's ESS System is simple to install and requires no major structural modifications to the vessel. All necessary modifications can be done without dry docking the vessel. DBC Marine Safety Systems' technical staff are available for consultation with the vessel's owner, it's crew, the shipyard and marine architects.



Step A) Determine location of ESS, at the edge of the embarkation deck with a suitable clear area around it for passenger control.

An area 1380mm wide by 380mm deep is required for the Model ESS 25 with 50/75 person platform.
An area 1665mm wide by 380mm deep is required for the Model ESS 25 with 100/150 person platform.

Step B) Remove the deck railing and position the two housing side plates. If necessary, this section of the deck railing can be reinforced prior to welding the side plates.

Step C) Position the ESS housing into the side plates and remove transport bolts.

The ESS is ready for service.

CREW REQUIREMENTS

The DBC Marine Safety's ESS System is designed for simplicity and a minimum of crew requirements. Every ship's requirements are unique but the ESS system can be easily operated by a single crewmember.

TRAINING

DBC Marine Safety Systems offers extensive crew training at the time of ESS installation or at any time required by the customer. Since every vessel has different crewing configurations and requirements DBC Marine Safety Systems is available to work with the ship's personnel to design the evacuation plan. Training will consist of actual deployments of the system so the crew can be familiarized with the system operation and system components. ESS Operation placards, videotapes and manuals will be supplied.

MAINTENANCE

As per Coast Guard regulations, each ESS system on the vessel must be inspected and serviced annually. Turn-around times can be as fast as 24 hours depending on installation and vessel location.

Other than annual servicing, no additional maintenance to the ESS system is required.

ESS SPECIFICATIONS

DBC Marine Safety Systems offers 2 ESS systems, dependent on the size of platform required. Contact DBC Marine Safety Systems for assistance in determining which ESS system will be best suited for your vessel.

	Embarkation Height	Operational Weight	Platform Capacity Canada	USA	Approval Certification
ESS Model 25 50/75 Platform	10-12 feet max. 2.5(meters)	475 lb. (216 kg)	75	50	USCG 160.010/88/0 CCG TC 216-035-003
ESS Model 25 100/150 Platform	10-12 feet max. 2.5(meters)	700 lb. (318 kg)	150	100	USCG 160.010/115/0 CCG TC 216-035-009

ESS Specifications cont'd....

	Footprint Dimensions	Height	Weight	Construction	Installation Location
ESS 25 50/75 Platform	15 x 53.5" (380 x 1380mm)	52" (1320mm)	475 lb. (216 kg)	Aluminium Housing Steel Side Plates	Embarkation Deck
ESS 25 100/150Platform	15 x 65.5" (380 x 1665mm)	58" (1470mm)	700 lb. (318 kg)	Aluminium Housing Steel Side Plates	Embarkation Deck

Note that weights and dimensions given here are for information only and subject to change.

CERTIFICATION

The DBC Marine Safety's ESS has been approved by both the United States and Canadian Coast Guard to their latest standards, as applicable.

REFERENCES

The following drawings are available on request;

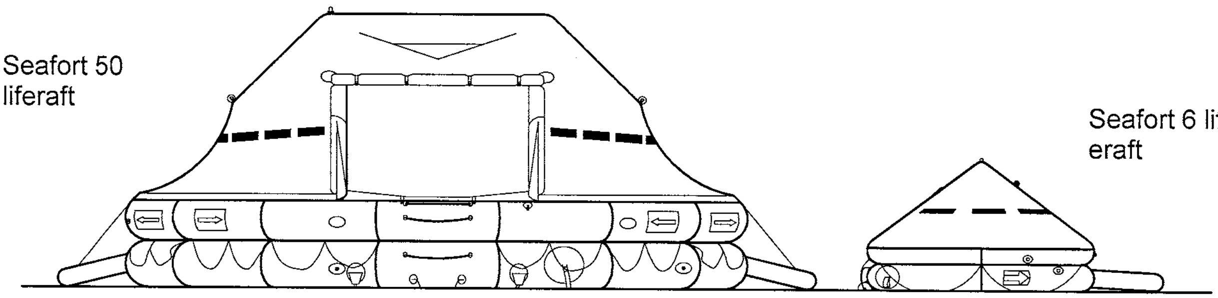
SLIDBOX1.DWG - ESS Housing (for 50/75 person platform) General Arrangement
SLIDBXE1.DWG - ESS Housing (for 100/150 person platform) General Arrangement
SLIDEDEP.DWG - ESS Stowage and Deployment (for 50/75 person platform)
SLIDDEPE.DWG - ESS Stowage and Deployment (for 100/150 person platform)

Please note that the information in the above drawings is for reference only and subject to change.

Other DBC Marine Safety Systems Products

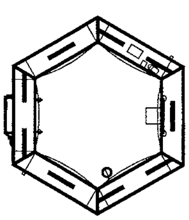
Liferafts. DBC Marine Safety Systems offers the Seafort line of Canadian and United States Coast Guard approved SOLAS liferafts ranging in size from 6 person to 50 person capacity, as well as the Swiftsure II limited service liferafts in the same size ranges.

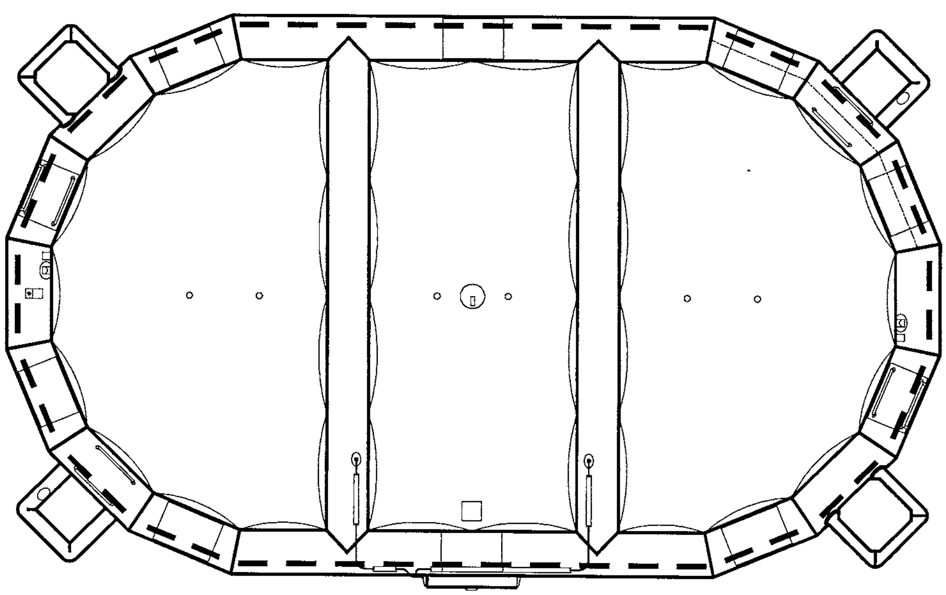
Seafort 50 liferaft



Seafort 6 liferaft

Inflatable Rescue Platforms (IBA's). Canadian Coast Guard approved inflatable platforms are available in size ranges from 10 person to 150 person with the United States approved IBA's available in 4 person to 100 person sizes.





Appendix C

DBC Marine Evacuation Chute

DBC Marine Safety Systems

Marine Evacuation Chute
Technical Package

TABLE OF CONTENTS

DBC Marine Safety Systems

INTRODUCTION

The DBC Marine Safety's Evacuation Chute (MEC) System is an efficient, easy to use, flexible and cost-effective marine evacuation system. As a gravity launched system DBC Marine Safety's MEC System evacuates passengers and crew with the utmost safety in the shortest possible time.

HOW IT WORKS:

A fabric descent chute and inflatable platform (IBA) are stored in a compact housing either on the evacuation deck (inside or outside the vessel) or unobtrusively on the deck above. During an emergency, a crew-member releases the MEC with a pull of a handle. As the chute pack falls to the water the platform automatically inflates and is ready for the two person platform crew to descend.

The first crewman can then launch the liferafts which are bowsed to the platform by the MEC crew and then inflated. Passengers can then enter the chute and safely descend to the platform where they are transferred to the liferafts (or platforms) without entering the water. See figure 1.

Once each liferaft is loaded it can then be towed away from the vessel with the rescue boat. Another liferaft can be launched and bowsed in place and loaded, if required.

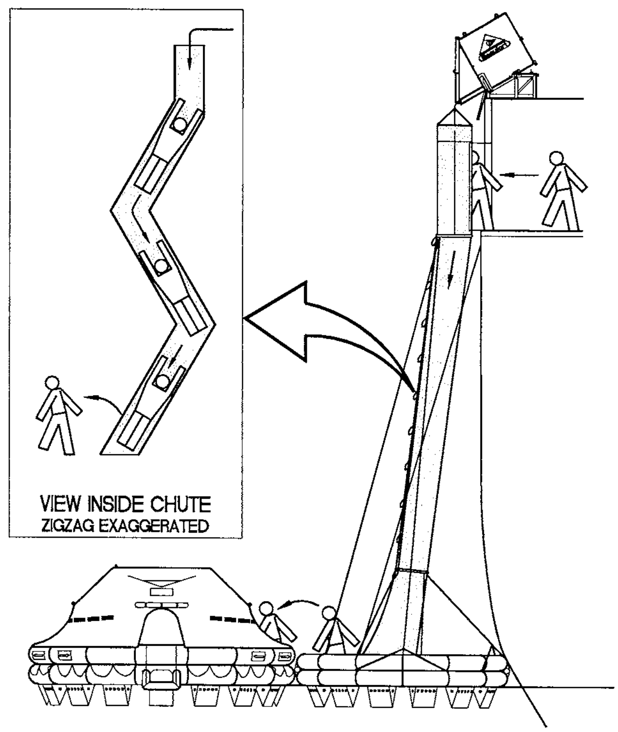


Figure 1. MEC with inflated platform and liferaft.

MEC housing installed above Evacuation deck.

BENEFITS OF THE DBC Marine Safety's MEC SYSTEM:

- **Ease of use.** The system is less complicated to operate than other evacuation systems and requires fewer crew.
- **Safety.** All components of the system are fully adjustable to accommodate wind, weather, and sea conditions during an evacuation. The zigzag design of the chute slideway ensures a controlled, safe descent of passengers to the platform.
- **Flexibility.** DBC Marine Safety's MEC Systems are lightweight, compact and easily installed in a variety of configurations without any major alterations. The system can fit on new or existing ships, and be transferred from vessel to vessel.
- **Cost.** The initial investment, as well as installation and maintenance, are significantly lower than other types of marine evacuation systems.
- **Service.** Because the MEC system is less complex than other systems turnaround times for servicing can be as low as 24 hours.
- **Trust.** DBC Marine Safety's MEC System is a complete end-to-end system approved to SOLAS and manufactured to ISO 9001 standards. DBC Marine Safety Systems ensures that all components of the highest quality and reliability.

MEC COMPONENT DESCRIPTIONS

1) **Housing.** There are two styles of MEC housings, the "O" type is designed to be installed on an exterior deck or stand above the evacuation station. This is ideal for those vessels with a limited embarkation deck area. The housing is fabricated of galvanized steel with stainless steel cladding, footprint area is 18 square feet or 1.6 square meters. The housing rests on it's own stand, once the release arm is activated it can pivot forward which causes the internal sliding tray to deploy the chute pack away from the vessel's side.

   The "I" type housing is mounted on the embarkation deck either outside or inside the vessel with a weather-tight door flange. Fabrication is the same as the "O" type MEC, though if mounted inside the vessel alternate cladding can be requested. The housing is a self contained box with a simple roll up door for entry, once the arm is released the pack can slide down and out from the vessel to deploy the system. Footprint area is 25 square feet or 2.4 square meters. See figure 2 for housing designs.

MEC Component descriptions cont.'...

If the "I" type housing is installed inside the vessel a flange is welded into the ship's side which will provide a weather-tight seal with the housing door. Both the "O" and "I" type MEC housings are self contained using only mechanical actions to deploy the chute, though a remote release can be rigged.

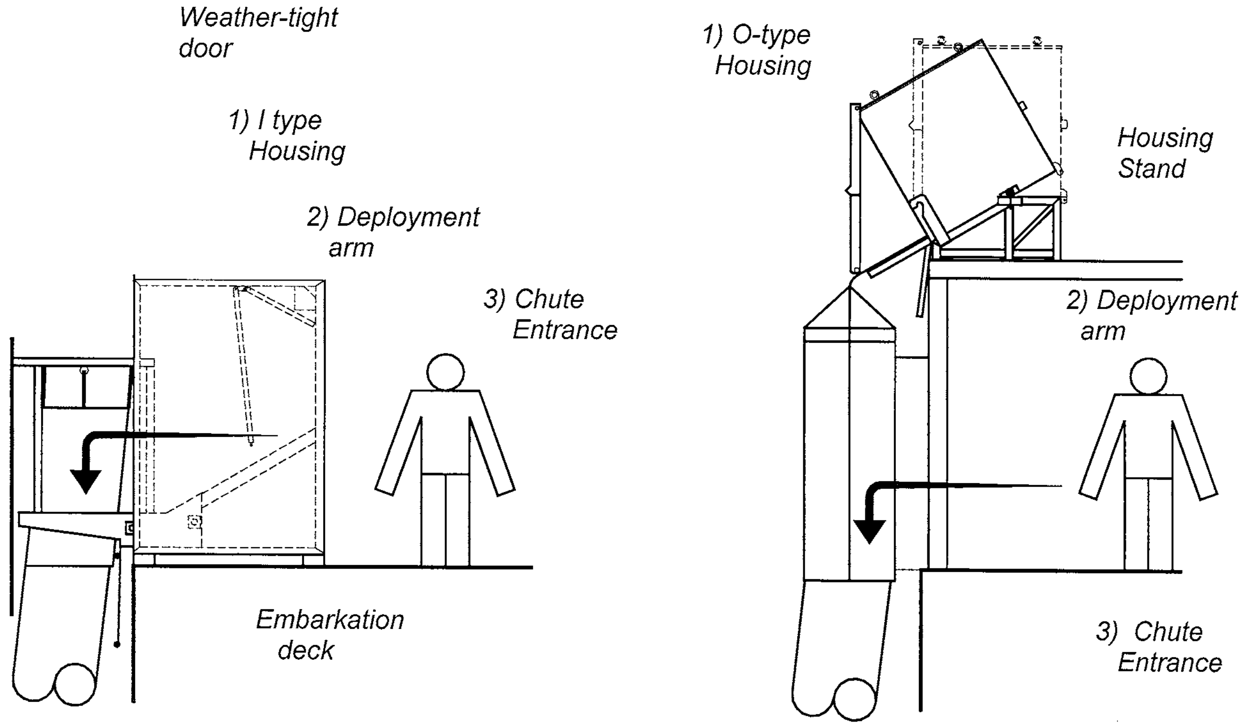


Figure 2. "I" & "O" type MEC housings, shown deployed.

2) **Deployment Arm.** On the "O" type housing a steel arm clamps the housing and stand together, by pulling downward on the arm the system is free to pivot and release. Pulling downward on the "I" type's arm releases the spigot pins holding the moving section to the frame allowing it to slide forward and deploy the chute system. Both deployment arms require little effort to activate and are equipped with safety pins to prevent tampering.

3) **Chute Entrance.** The entrance to the MEC is heavy duty vinyl curtain which is tied of to each side of the plinth or handrail, effectively funneling the passengers into the chute without being distracted by views of the sea. A floor pad between the chute and the evacuation deck completes the entrance. On the "I" type housing the entrance is pre-connected and is pulled into place when the system deploys.

MEC Component descriptions cont.'...

4) **Protective Cover.** The fabric MEC chute slideway is protected from the elements and abrasion by the ship's hull by a heavy duty nylon cover which extends from the entrance to just above the platform. The cover is fully adjustable for 20 degree positive and negative list conditions.

5) **Slideway.** At the heart of the MEC is the slideway. The slideway is constructed of a translucent fabric sewn with a zigzag seam designed to control a person descent. The slideway is fully adjustable for 20 degree positive and negative list conditions.

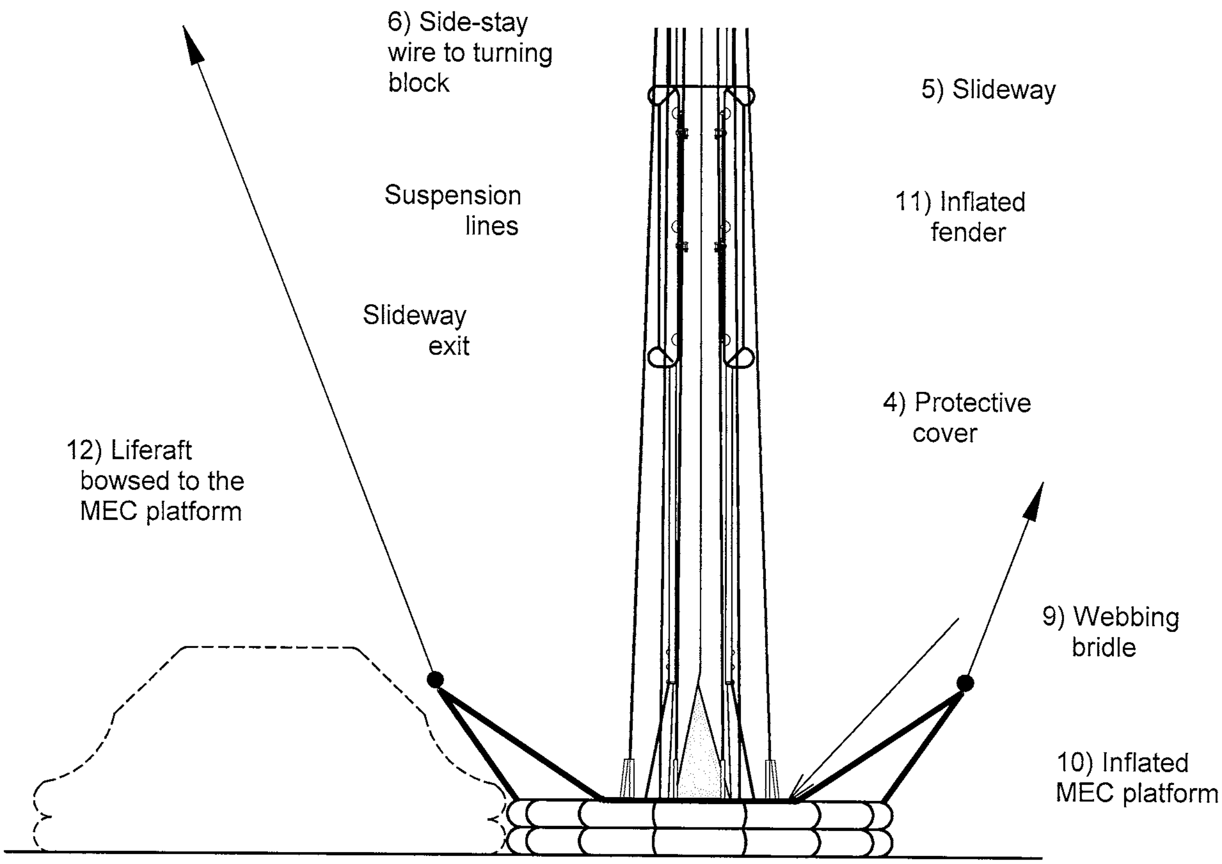


Figure 3 - View of MEC at water level.

6) **Wire Rope.** The wire ropes are used to adjust the side-stay lines (lines that keep the platform in place relative to the chute) is 5/8" galvanized steel, cut to length and engineered for maximum loads with a generous safety margin. See figure 4 for mooring system components.

MEC Component descriptions cont.'...

7) **Winch and Stand.** To adjust the side stay lines a hand winch is installed on a galvanized steel stand to one side of the entrance. Like the MEC system itself the winch is simple to use and reliable. Both the winch and stand are engineered for maximum loads with a generous safety margin.

8) **Blocks.** To route the side stay lines through corners the MEC system uses specially engineered galvanized steel blocks. These blocks are designed to be as unobtrusive as possible while still meeting all loading conditions with generous safety margins.

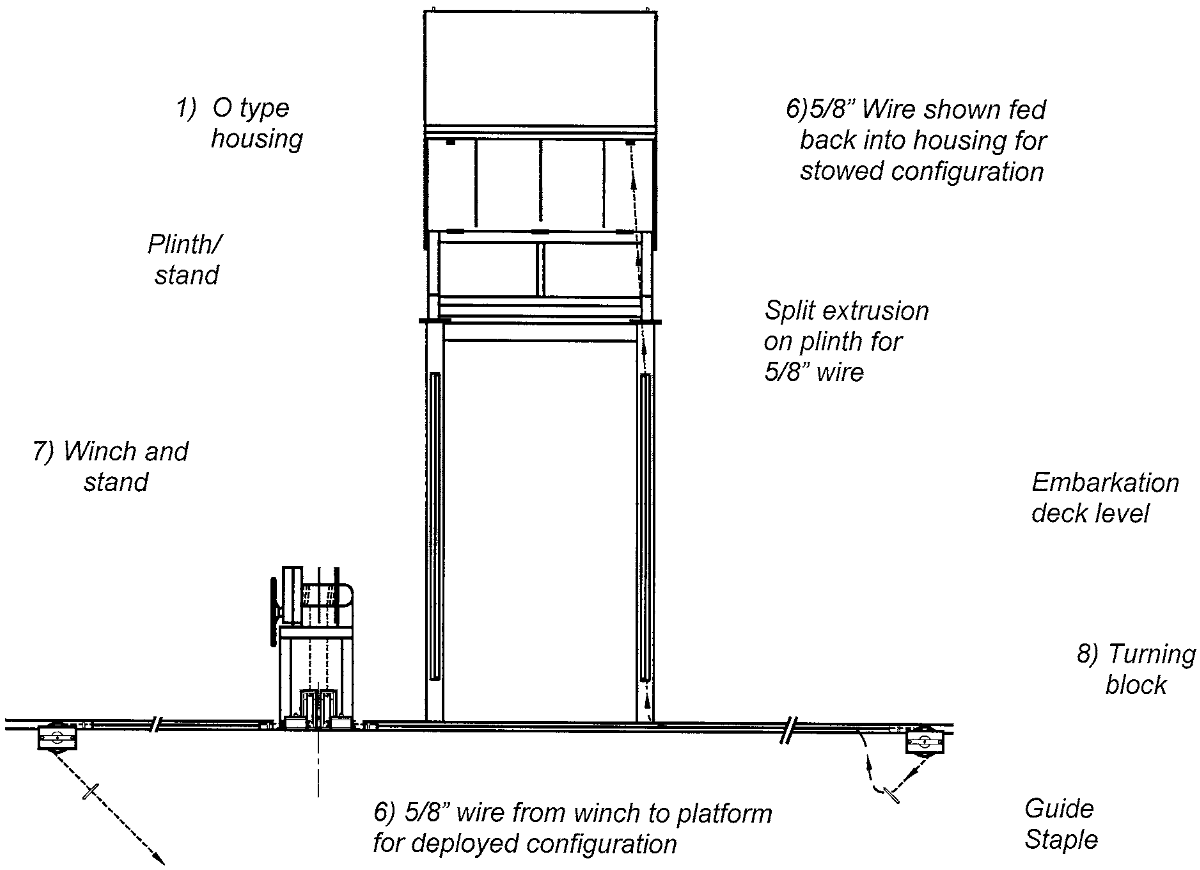


Figure 4. - MEC O type looking inboard (handrail not shown).

9) **Webbing Bridle.** The connection between the side-stay lines and the MEC platform is a four inch wide engineered webbing shackled to the platform, effectively eliminating any excess tensions on the platform.

MEC Component descriptions cont.'...

10)**Platform.** DBC Marine Safety's MEC platform is constructed of butyl fabric and is CO_2 inflated. The platform meets all SOLAS requirements including hot, cold, and self-draining tests.

11)**Fender.** For those vessels with a rub rail or protruding hull DBC Marine Safety Systems offers an inflatable butyl fabric fender to safeguard the passengers and the system during an evacuation. The fender is a self inflating unit and is adjustable for all list conditions.

12)**Liferafts or Platforms.** Once passengers descend the MEC chute they are then transferred to a liferaft that has been bowsed to the platform. DBC Marine Safety's 50 person liferaft, as well as their other liferaft sizes, meet both Canadian and United States Coast Guard SOLAS requirements. For those vessels operating on inland or coastal routes DBC Marine Safety Systems offers Canadian approved platforms up to 150 person capacity and United States approved IBA's up to 100 person.

INSTALLATION

The DBC Marine Safety's MEC System is simple to install and requires no structural modifications to the vessel, plus all modifications can be done without dry docking the vessel.
DBC Marine Safety Systems' technical staff are available for consultation with the vessel's owner, it's crew, the shipyard and marine architects.

Step A) Determine location of MEC, a area 1.5 meters wide by 1.3m deep (for the "I" type 1.5 meters wide by 1.65m deep) is required at the edge of the evacuation deck with a suitable clear area around it for passenger control.

Step B) For the "O" type housing a plinth or stand is constructed to elevate the MEC housing approximately 8 feet above the evacuation deck. If the housing is being installed on the above deck suitable reinforcing and bolting pads are installed.

The "I" type, if installed on an exterior deck, requires four steel 3" high riser pads welded to the embarkation deck. For interior mounted "I" type housings riser pads are welded to the deck and a hole is cut in the side of the vessel into which a flange is welded.

Step C) The winch stand, blocks, and guide staples are welded to the ship's deck and hull. The winch can then be installed on it's stand and the 5/8" wires strung.

Installation cont.'...

Step D) A split tubing or extrusion is installed on the outboard side of the fishplate to house the 5/8" cable. The tubing can be screwed, riveted or bolted on.

Step E) The "O" type MEC housing and it's pivot stand is lifted to the top of the plinth and bolted down. The empty housing unit weighs less than 1500 lbs (680 kg) though a crane with suitable reach is required.

The "I" type housing is lifted onto it's riser pads (or through the flange if interior mounted) and bolted down. The empty housing weighs 2500 lbs (1135 kg) and will also require a suitable crane.

Step F) Liferaft racks and release systems are installed as per their requirements.

Step G) Load tests are performed on the housing installation and the bowsing system (blocks, winch and stand) as per regulatory requirements. Used wires are discarded.

Step H)) The MEC platform and chute, packed in it's own valise, are lifted into the MEC housing and new cables are run from the winch, through the blocks, and back up to the housing for attachment to the platform.

The MEC is ready for service.

CREW REQUIREMENTS

The DBC Marine Safety's MEC System is designed for simplicity and a minimum of crew requirements. Every ship's requirements are unique but here are some guidelines;

Evacuation Leader. One crewman to deploy system and operate winch, will also regulate evacuation and monitor platform and surrounding area for hazards.

Passenger Controller. One crewman to feed passengers into MEC and use remote control to launch liferafts.

Platform Crewman 1. One crewman to make initial decent to platform and adjust chute for list conditions. After chute is adjusted this crewman will assist passengers from bottom of MEC and may enlist help from passengers.

Crew Requirements cont.'...

Platform Crewman 2. One crewman to follow first and bowse the 50 person liferafts to the platform, the inflate liferafts. This crewman can also assist passengers transferring from platform to liferafts.

Rescue Boat Crewmen 1 and 2. Two crewmen to operate the rescue boat which will be used to tow the loaded liferafts to safety.

TRAINING

DBC Marine Safety Systems offers extensive crew training at the time of MEC installation or at any time required by the customer. Since every vessel has different crewing configurations and requirements DBC Marine Safety Systems is available to work with the ship's personnel to design the evacuation plan. Training will consist of live deployments of the system so the crew can be familiarized with the system operation and system components. MEC Operation placards, videotapes and manuals will be supplied.

MAINTENANCE

As per Coast Guard regulations, one MEC system on the vessel must be deployed once a year and then serviced and repacked. The remaining MEC units on the vessel will also require inspection and re-packing but do not need to be deployed. Turn-around times can be as fast as 24 hours depending on installation and vessel location.

The housings, blocks and winch require only visual inspection with periodic greasing of those moving parts exposed to the elements.

CHUTE MODEL SPECIFICATIONS

DBC Marine Safety Systems offers 3 chute models, each varying in length to fit vessels of different dimensions or requirements. For SOLAS vessels the MEC must be able to function in positive and negative 20 degree list and positive and negative 10 degree trim, plus all combinations of these.

Chute Model Specifications cont.'...

All of DBC Marine Safety's MEC systems function in the above conditions though vessel size and MEC location will dictate the size of the chute need-ed. Contact DBC Marine Safety Systems for assistance in determining which chute model will be best for your vessel.

	Length	Slideway Diameter	Operational Weight Packed with Platform
FSD-70S	**40' - 0" (12.4 meters)**	**22" (560mm)**	**400 lb. (182 kg)**
FSD-100S	**58' - 0" (17.9 meters)**	**22" (560mm)**	**425 lb. (193 kg)**
FSD-145S	**81'-0" (24.9 meters)**	**22" (560mm)**	**450 lb. (205 kg)**

Trim Conditions

List Conditions

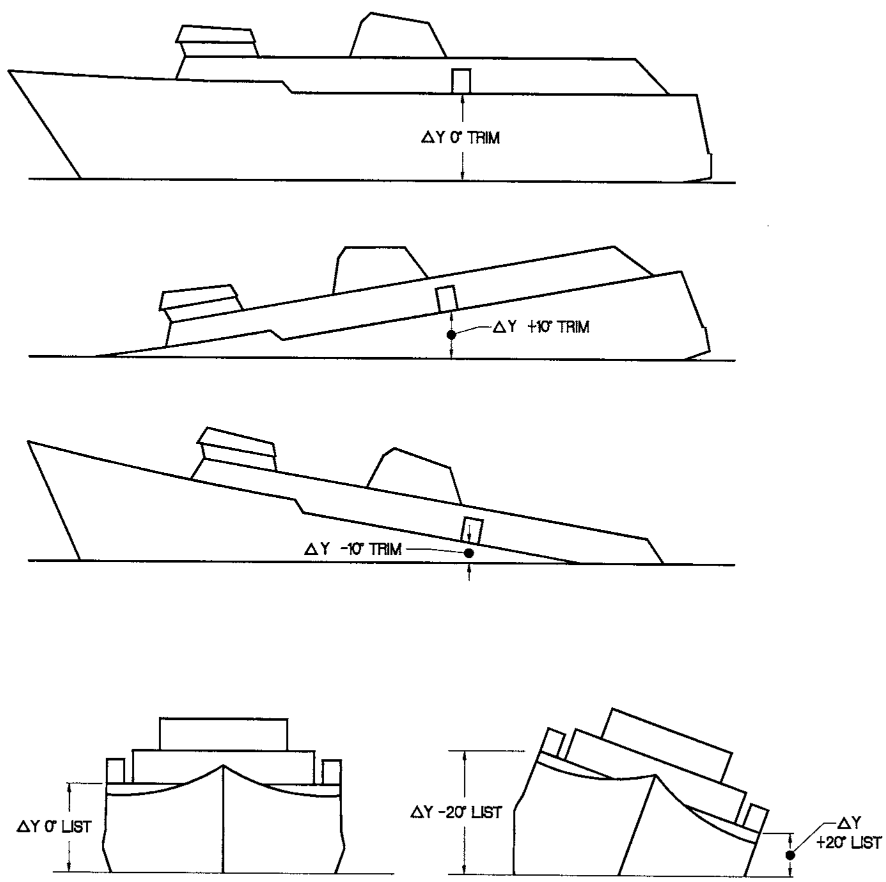


Figure 5 - Trim and list conditions.

HOUSING MODEL SPECIFICATIONS

	Footprint Dimensions	Height	Weight with Chute Pack*	Construction	Installation Location
Type O Housing	45 1/2 x 56 5/8" (1155x1400mm)	74" (1900mm)	1950 lb. (885 kg)	Galv. steel with stainless cladding	Above the embarkation deck
Type I Housing - External	63 x 59" (1600x1500mm)	90" (2286mm)	2800 lb. (1275 kg)	Galv. steel with stainless cladding	On the embarkation deck
Type I Housing - Internal	63 x 59" (1600x1500mm)	90" (2286mm)	2800 lb. (1275 kg)	Galv. steel with stainless cladding	On embarkation deck inside
Flange for Internal housing	4 x 68 3/4" (100x1772mm)	100 3/4" (2560 mm)	400 lb. ** (182 kg) **	Galvanized steel	Bulkhead of vessel
Mooring System	varies	varies	560 lb. (255 kg)	Galvanized steel	Exterior of vessel

* - Chute pack weight based on largest chute size.

** - 51 square feet is cut out of the vessel's bulkhead for the flange installation. The removal of this will cancel any extra weight the flange adds.

Note that weights and dimensions given here are for information only and subject to change.

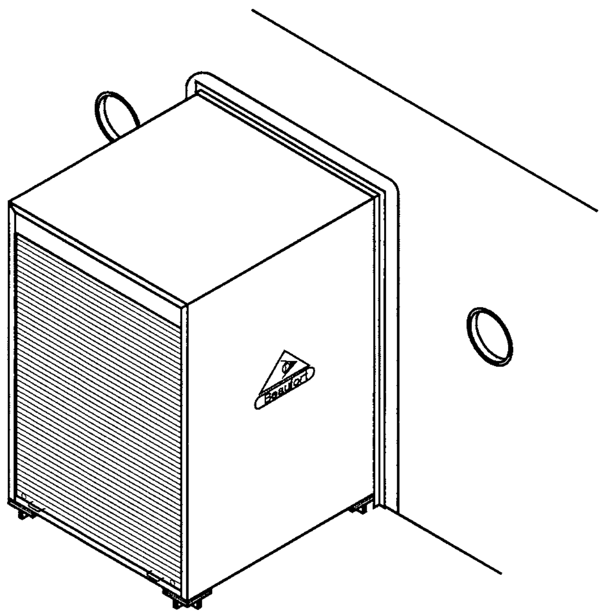


Figure 6 - Type I Internal Housing

(view from inside vessel)

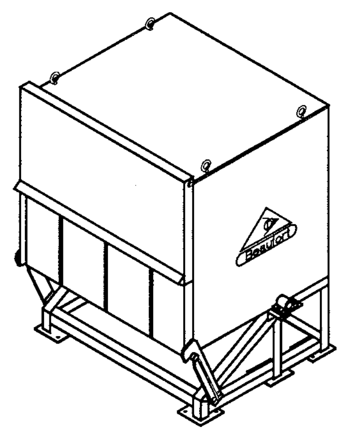


Figure 5 - Type O housing

(view looking inboard)

CERTIFICATES AND TESTS COMPLETED

The DBC Marine Safety's MEC has been certified by both the United States and Canadian Coast Guard to SOLAS standards which include;

1) A timed **harbor trial** under controlled conditions to evacuate passengers of various ages and abilities in 30 minutes. In February of 1995, the DBC Marine Safety's MEC successfully evacuated 400 persons, ranging in ages from 13 to 60, in 30 minutes with no injuries.

2) A **heavy weather sea trial** in force 6 sea conditions to demonstrate deployment and usage of the MEC. Off the coast of Prince of Wales Island, Alaska, the MEC was successfully deployed and tested in both leeward and windward configurations in force 6 and greater sea states. October 1995.

3) A 5 minute fire **hose testing** of the housing weather seals.

4) Deployment of the housing in various **list and trim configurations**.

5) **Load testing** of structural and suspension components.

6) Performance testing of the chute when **wet** and dry.

7) **Durability** of chute components. Long term test are still being conducted to confirm the life-span of the MEC.

REFERENCES AND RELATED MATERIAL

The following drawings are attached;

MECEXTGA - MEC Type I Exterior Installation General Arrangement
MECINTGA - MEC Type I Interior Installation General Arrangement
MECABVGA - MEC Type O Above Deck General Arrangement
MECEXTDT - MEC Type I Exterior Installation Details and Locations
MECINTDT - MEC Type I Interior Installation Details and Locations
MECABVDT - MEC Type O Above Deck Installation Details and Locations

Please note that the information in the above drawings is for reference only and subject to change. Video tapes of the MEC are available on request.

Other DBC Marine Safety Systems Products

Liferafts. DBC Marine Safety Systems offers the Seafort line of Canadian and United States Coast Guard approved SOLAS liferafts ranging in size from 6 person to 50 person capacity, as well as the Swiftsure II limited service liferafts in the same size ranges.

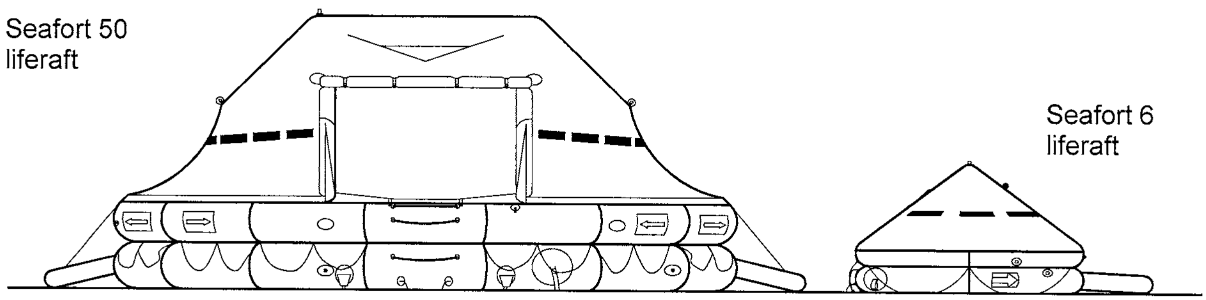
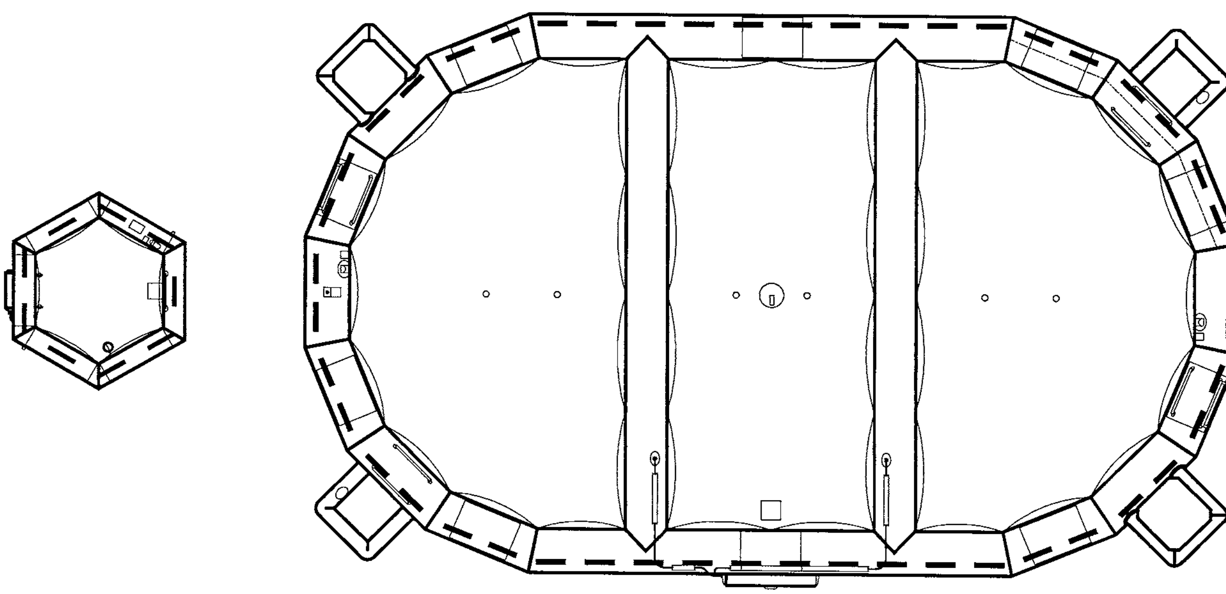


Figure 7 - 6 and 50 Person liferafts.

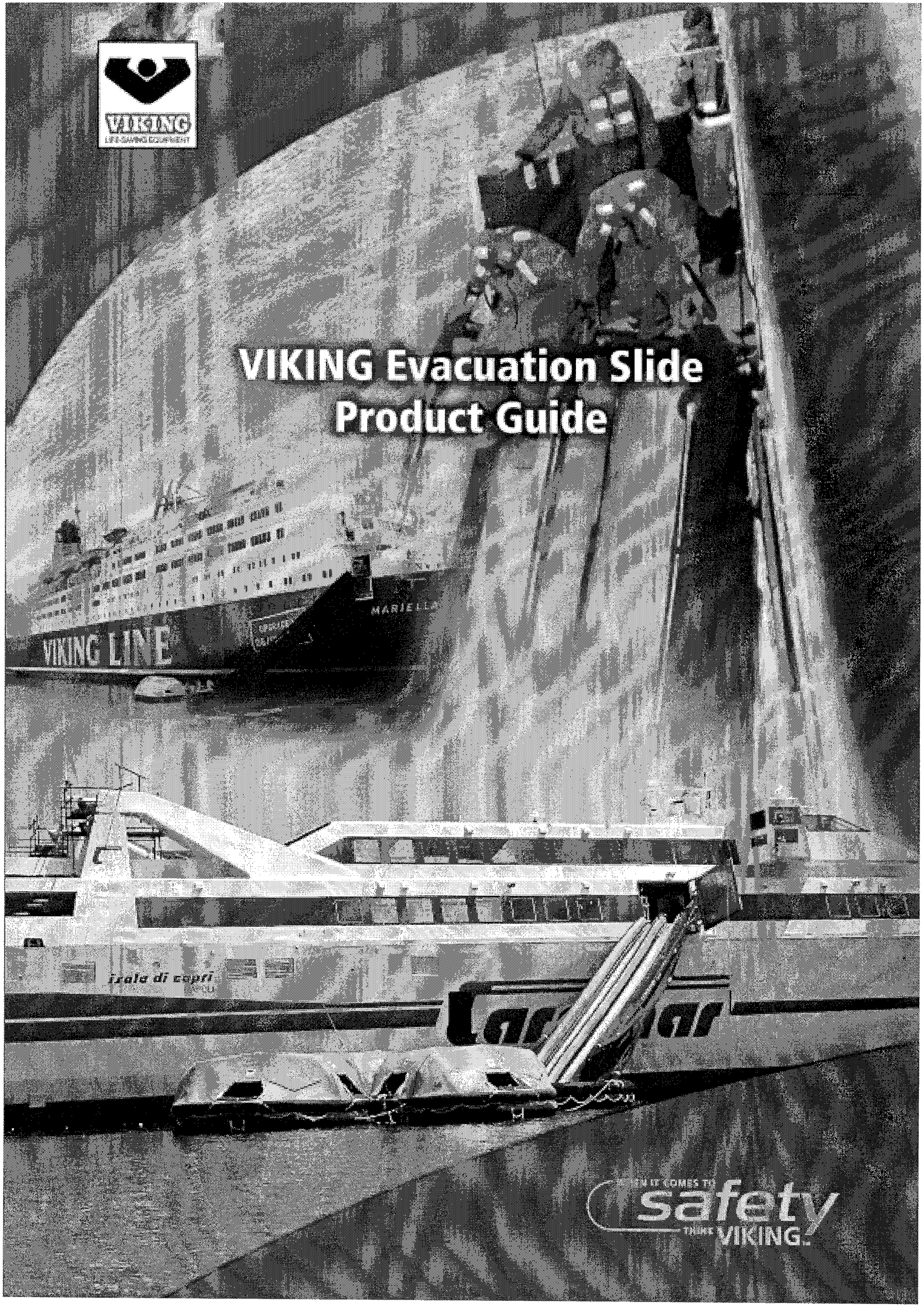
Inflatable Rescue Platforms (IBA's). Canadian Coast Guard approved inflatable platforms are available in size ranges from 10 person to 150 person with the United States approved IBA's available in 4 person to 100 person sizes.



Appendix D

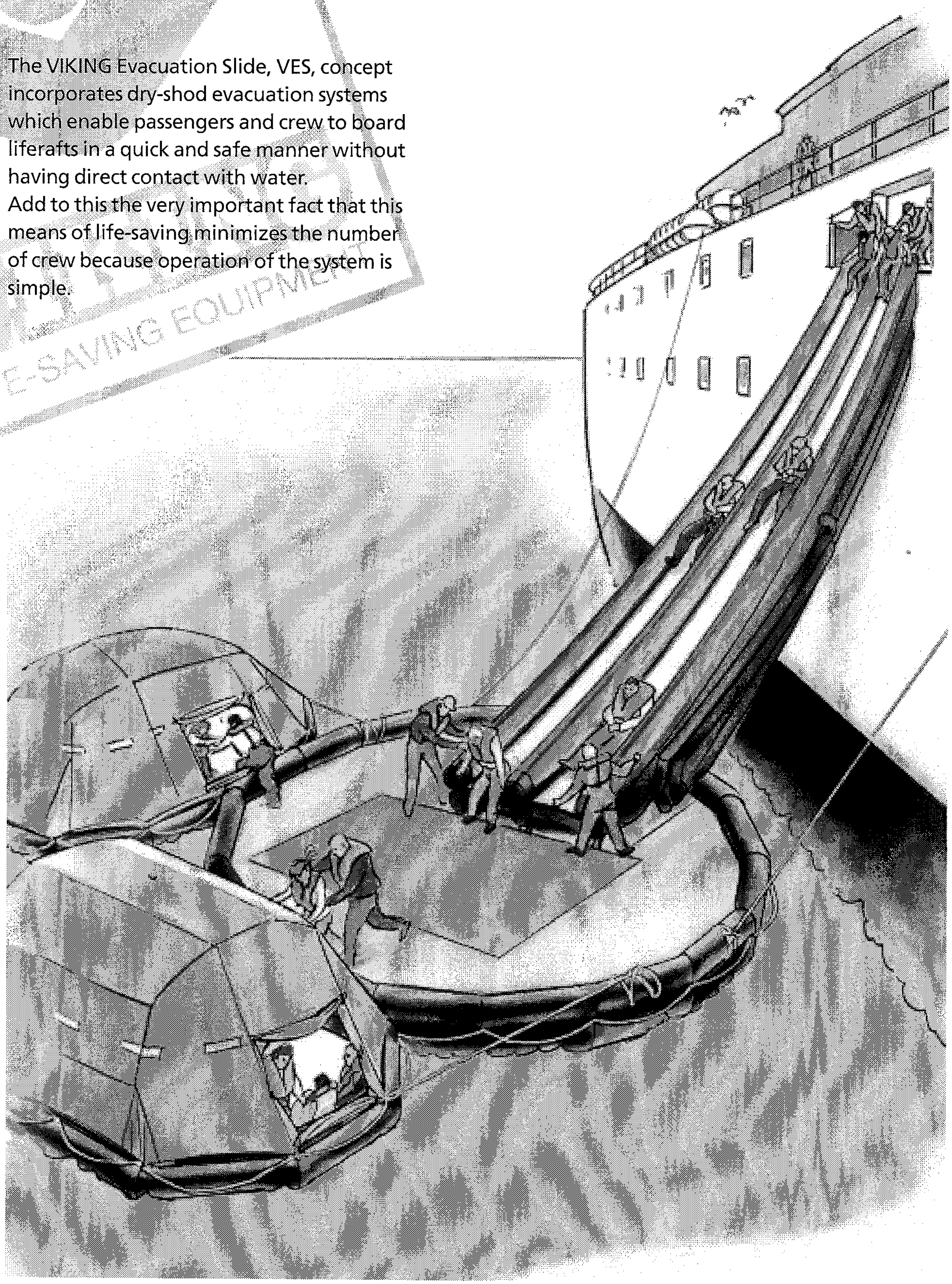
Viking Evacuation Slide

VIKING Evacuation Slide Product Guide

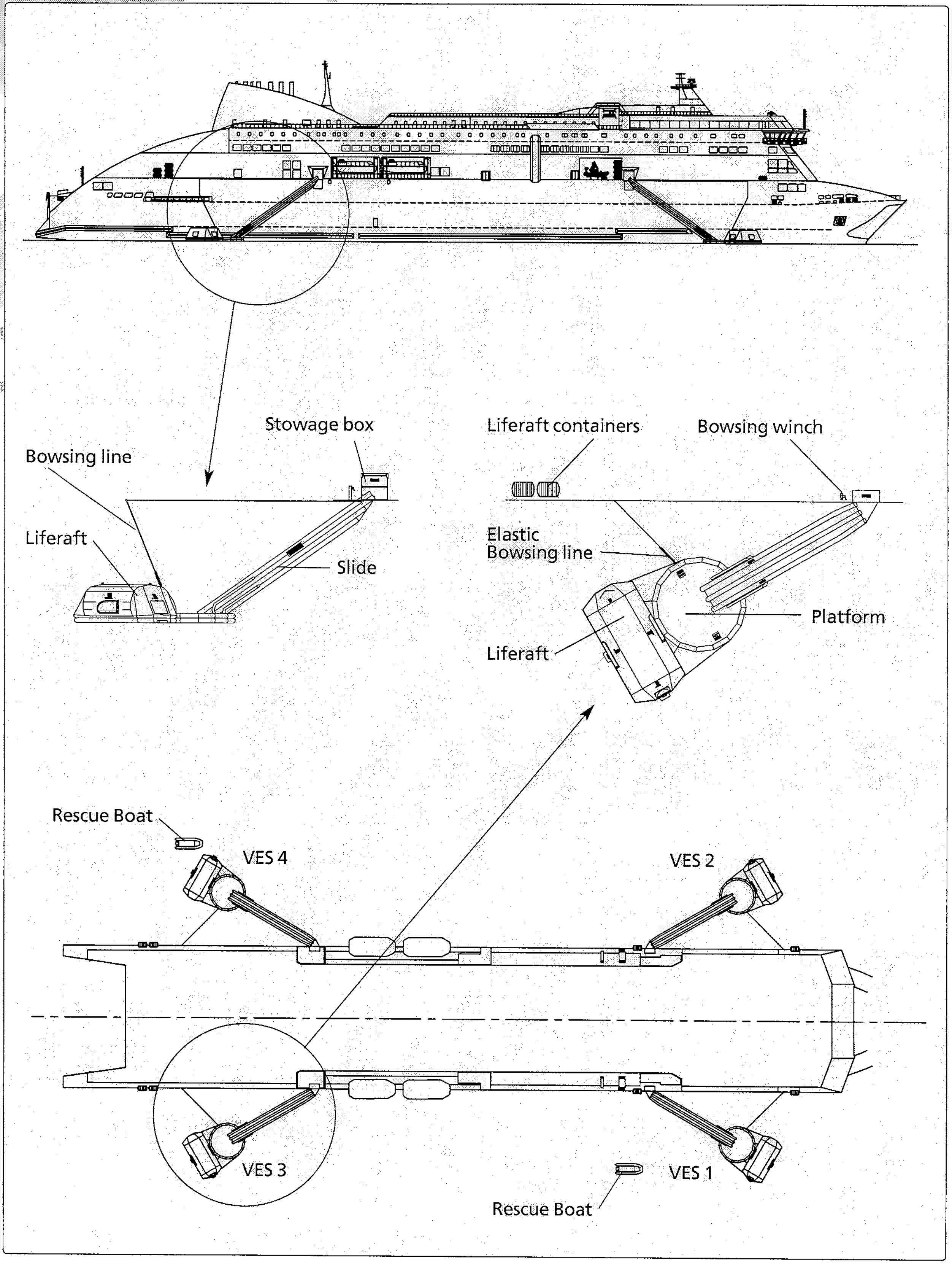


© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

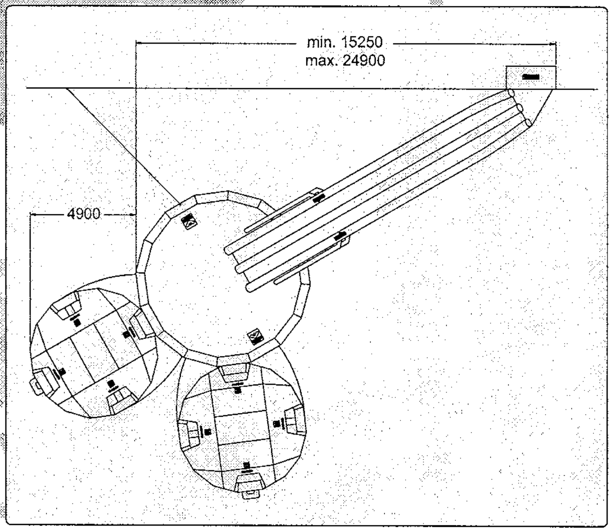
The VIKING Evacuation Slide, VES, concept incorporates dry-shod evacuation systems which enable passengers and crew to board liferafts in a quick and safe manner without having direct contact with water.
Add to this the very important fact that this means of life-saving minimizes the number of crew because operation of the system is simple.



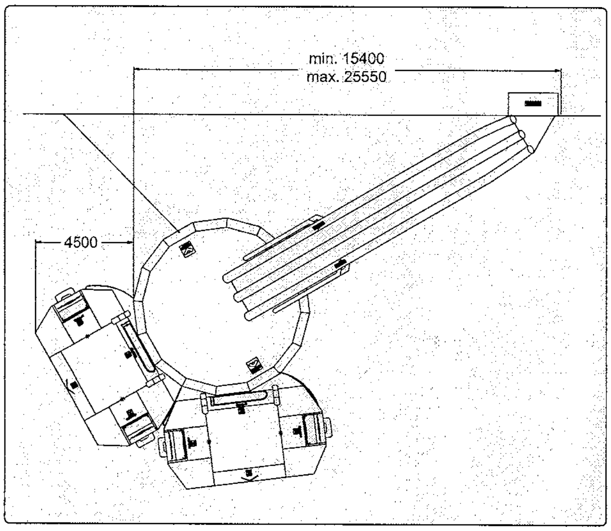
© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.



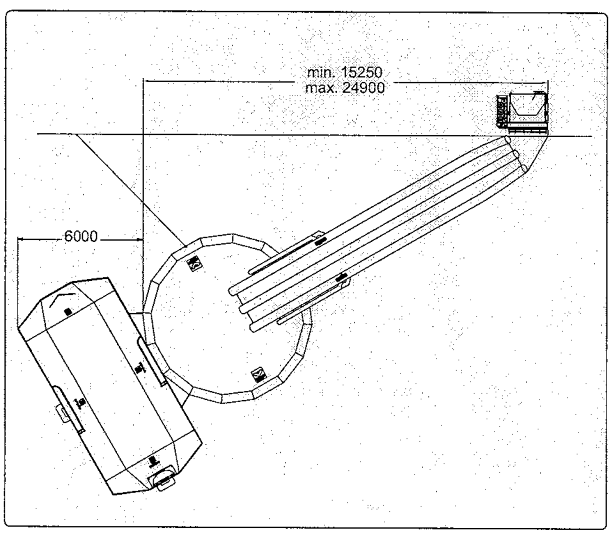
© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.



Dual-track slide shown with 2 x 50 person liferafts.
Steel Box - Free-On-Deck.
Slide length: 12 - 25.5 m.
Evacuation capacity: 500 people within 30 minutes.



Dual-track slide shown with 2 x 50 person self-righting liferafts.
Steel Box - Built-In.
Slide length: 12 - 25.5 m.
Evacuation capacity: 500 people within 30 minutes.

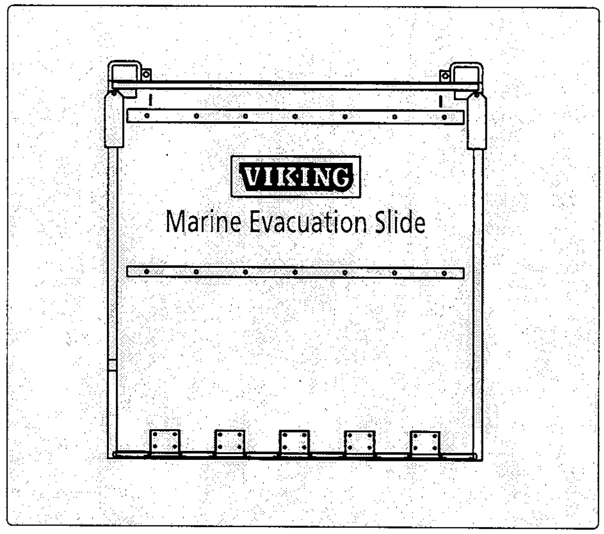


Dual-track slide shown with 1x100 person self-righting liferaft.
Aluminium Box - Built-In.
Slide length: 12 - 18 m.
Evacuation capacity: 500 people within 30 minutes.

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

DD-MES System Type 3.3 - Free-On-Deck

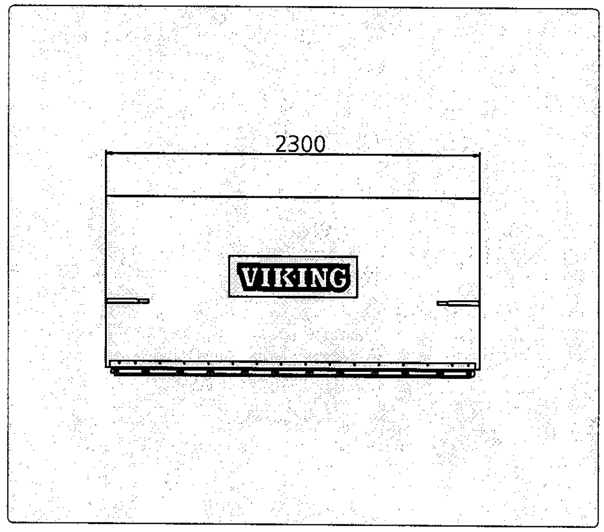
This system is for free-on-deck installation or alternatively built into the ship's side in an open recess. Providing direct access from the accommodation area it allows easy and quick embarkation by a large number of passengers.
No additional covering of the system is needed.

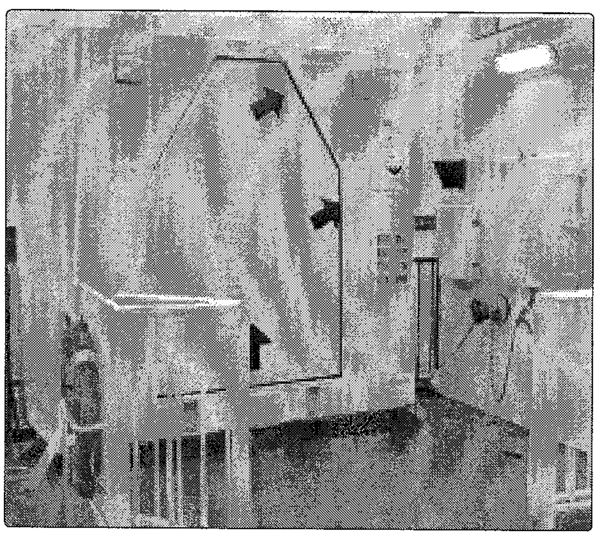


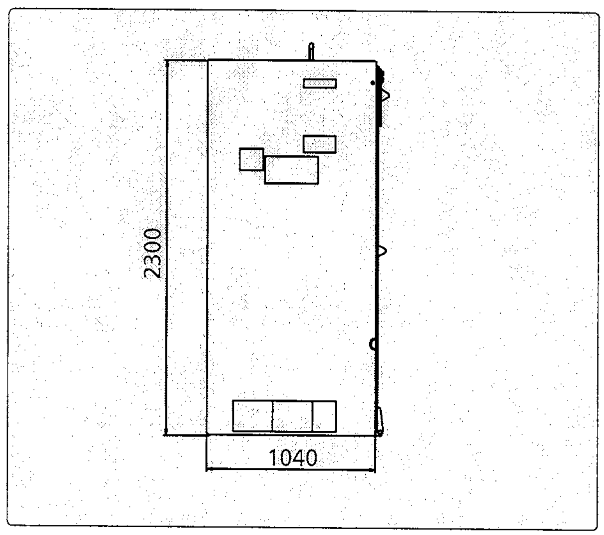
Dimensions

Length:	2300 mm	
Height:	2300 mm	
Depth:	1040 mm	
Weight:	3250 kg	12 m slide
	3500 kg	25.5 m slide

VIKING LIFE-SAVING EQUIPMENT







© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

DD-MES System Type 3.3 - Built-In (standard)

This system is for built-in installation. Providing direct access from the accommodation area it allows easy and quick embarkation by a large number of passengers.
The coaming of the system forms a watertight connection to the ship's side.

Dimensions

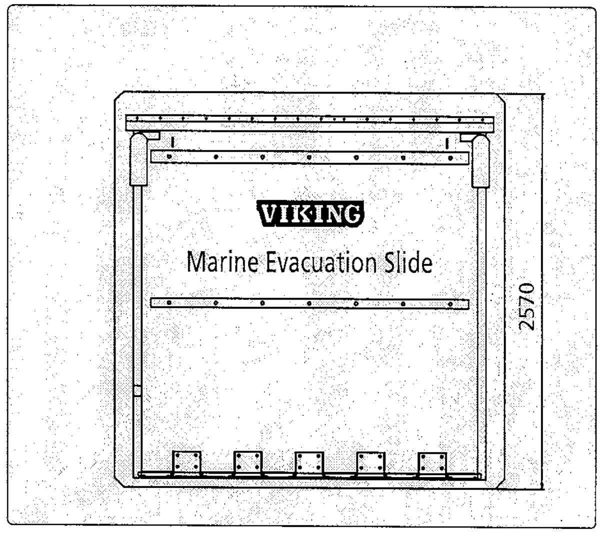
Box:

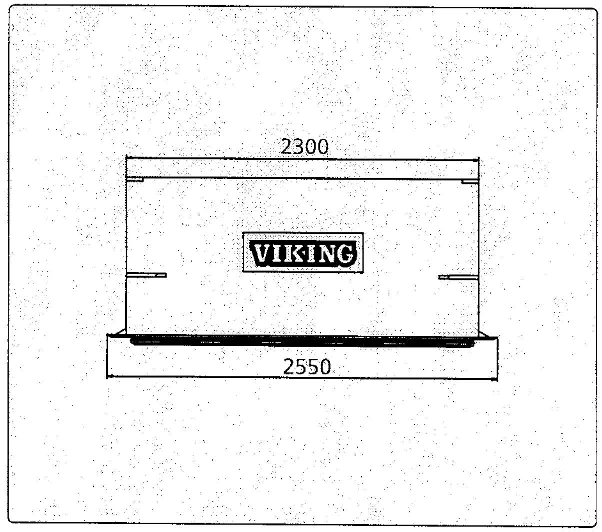
Length:	2300 mm	
Height:	2300 mm	
Depth:	1040 mm	
Weight:	3350 kg	12 m slide
	3600 kg	25.5 m slide

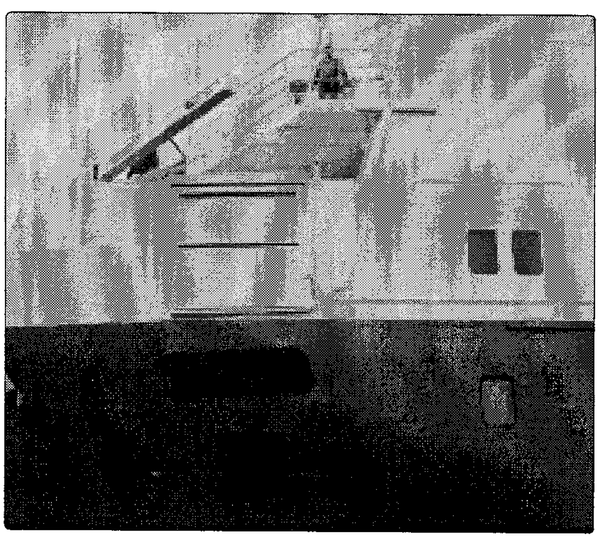
Coaming:

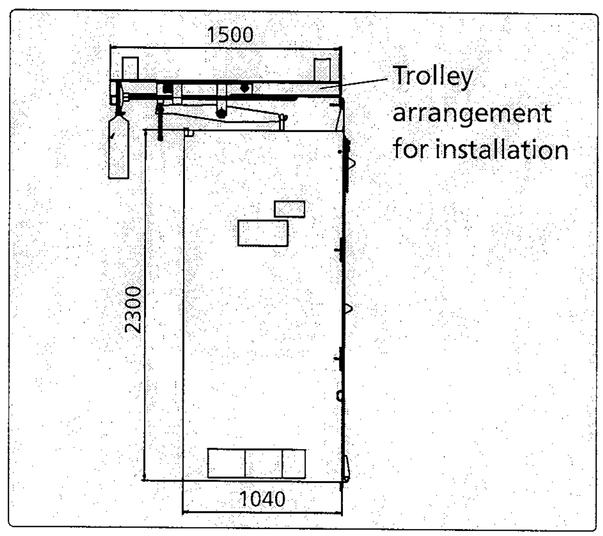
Length:	2550 mm
Height:	2570 mm

VIKING LIFE-SAVING EQUIPMENT





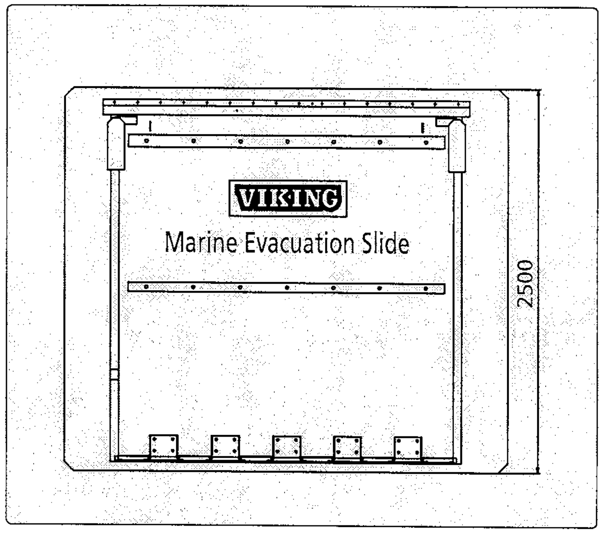




© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

DD-MES System Type 3.3 - Built-In (low installation)

This system is for built-in installation. Providing direct access from the accommodation area it allows easy and quick embarkation by a large number of passengers.
The coaming of the system forms a watertight connection to the ship's side.



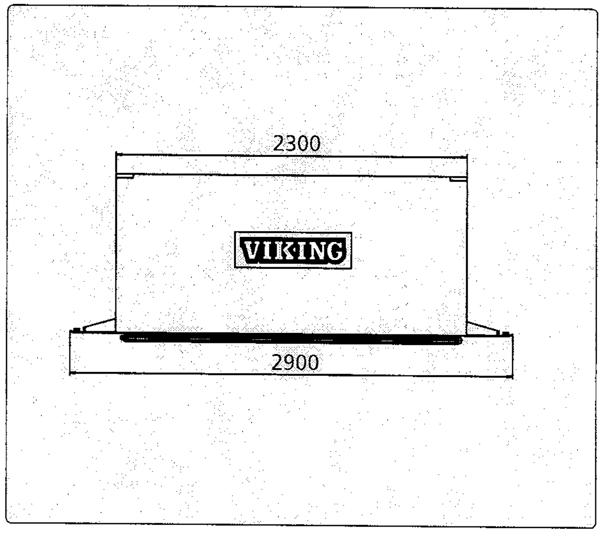
Dimensions

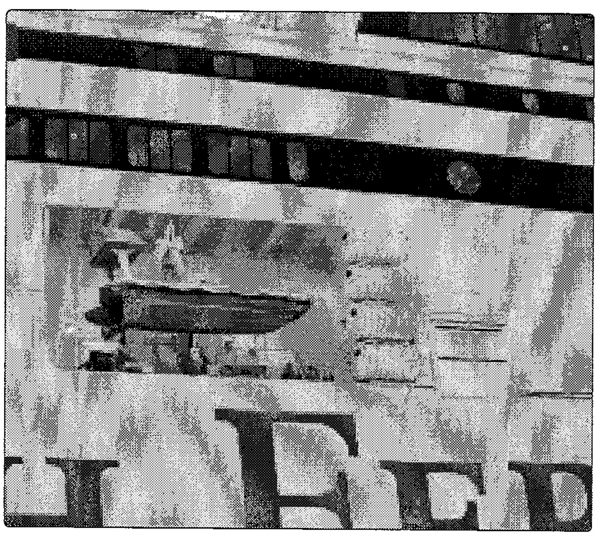
Box:

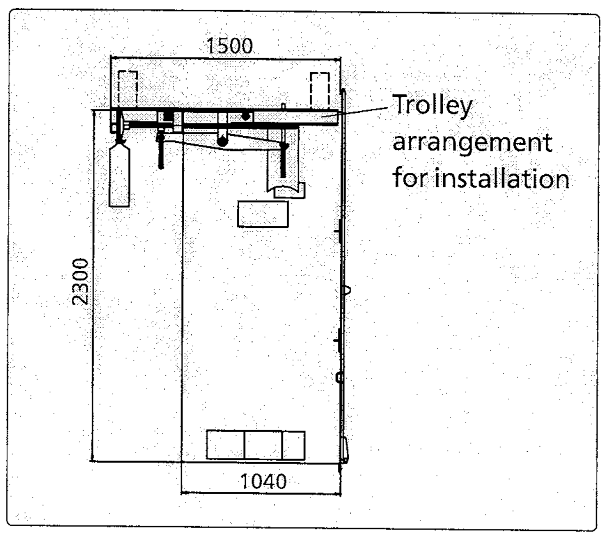
Length:	2300 mm	
Height:	2300 mm	
Depth:	1040 mm	
Weight:	3350 kg	12 m slide
	3600 kg	25.5 m slide

Coaming:

Length:	2900 mm
Height:	2500 mm





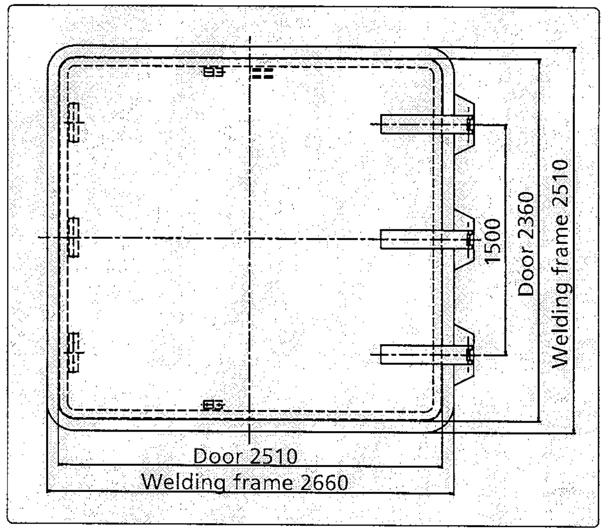


© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

VIKING LIFE-SAVING EQUIPMENT

DD-MES Alu System Type 3.3 - Built-In

This system is for built-in installation especially on HSC vessels or other vessels with high focus on weight.
Providing direct access from the accommodation area it allows easy and quick embarkation by a large number of passengers.
The door in front of the system forms a water-tight connection to the ship's side.



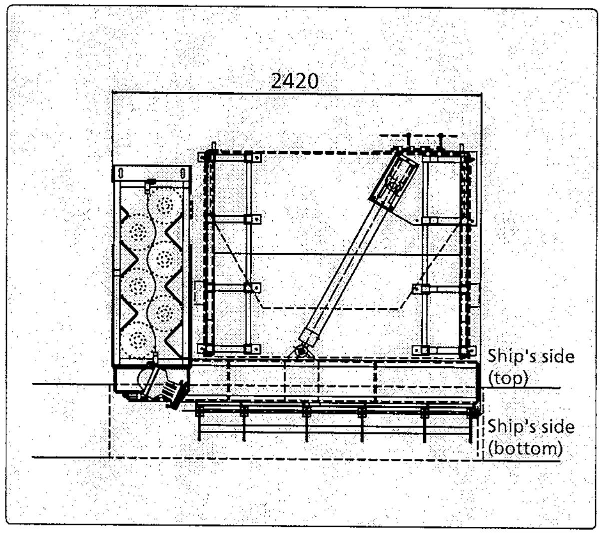
Dimensions

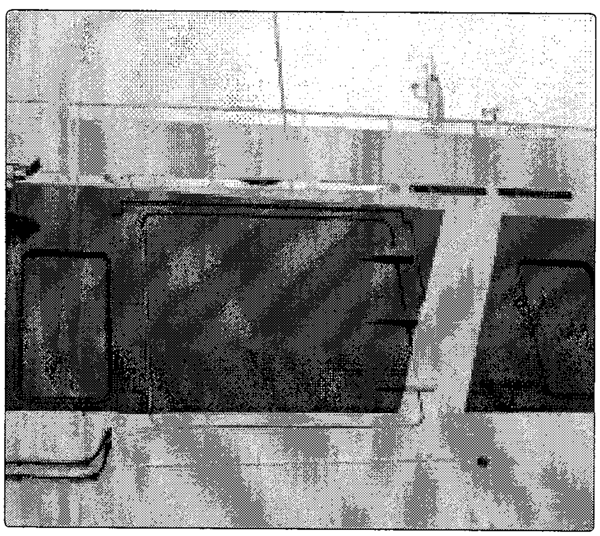
System:

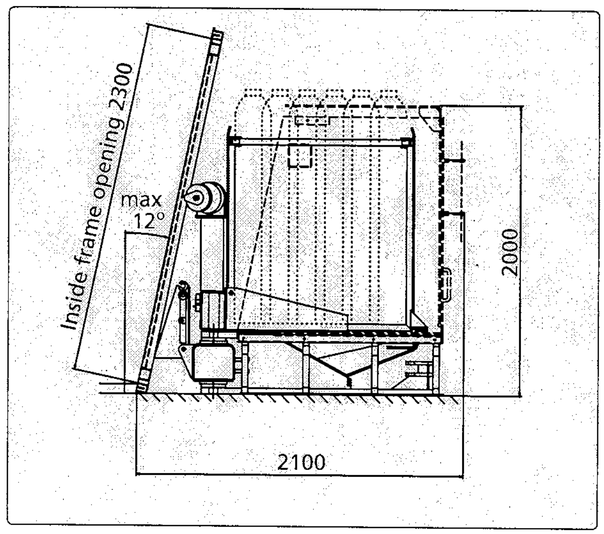
Length:	2420 mm	
Height:	2000 mm	
Depth:	2100 mm	
Weight:	1950 kg	12 m slide
	2100 kg	18 m slide

Door:

Length:	2510 mm
Height:	2360 mm



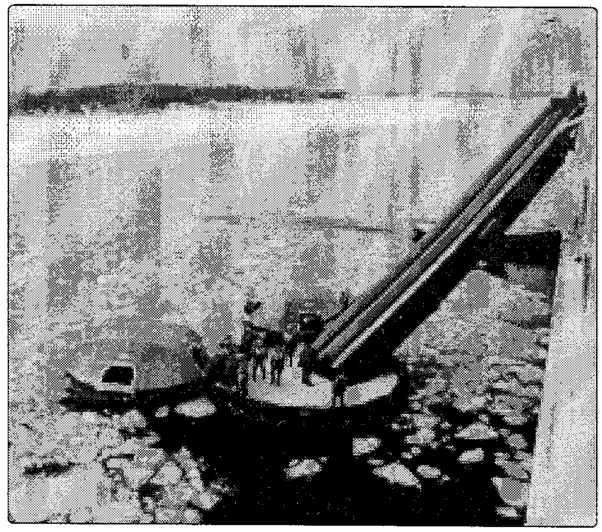


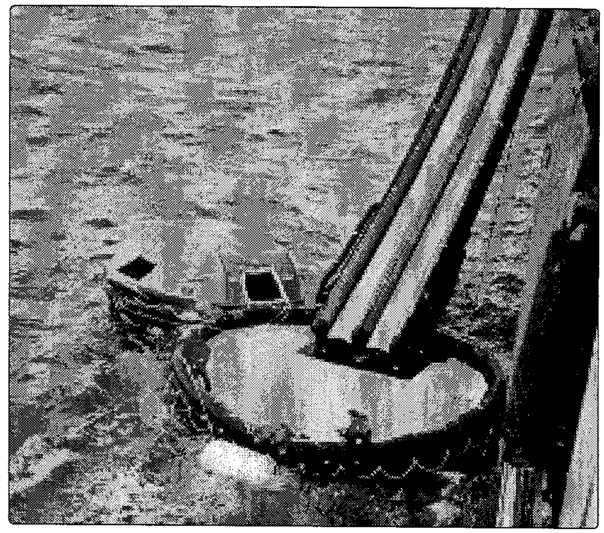


© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

The VES System

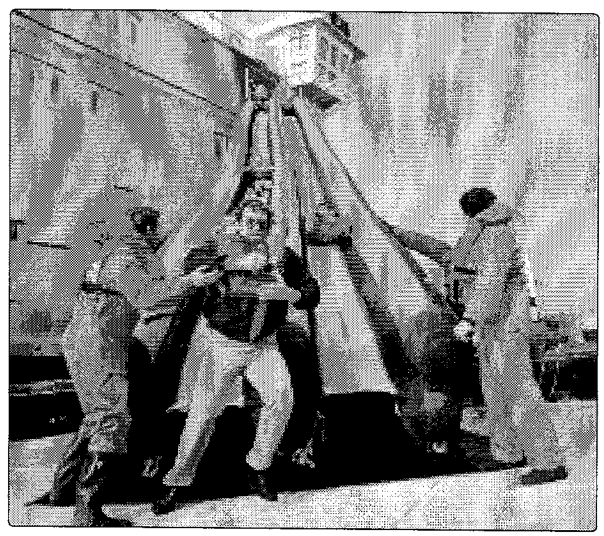
The VIKING slide-based evacuation system provides fully enclosed, dry-shod evacuation from the ship safefully into liferafts. This very compact system is developed, engineered and manufactured to the international quality assurance standard ISO 9001.
Designed to comply with the latest international legislation, this system has been approved to the strictest requirements calling for compliance with the most recent international regulations in the marine industry.
Exhaustive trials onshore and at sea under extreme conditions have ensured the efficiency and capability of the slide.





The slide

The dual-track slide consists of 12 main longitudinal tubes within 8 separate main compartments, each individually inflated. This means that any damage and subsequent loss of air in a main compartment still enable a safe function of the slide. The slide is connected to a 100 person self-draining platform. This platform can be cut free from the slide and function as a supplementary rescue raft in addition to the number of liferafts required for the particular vessel.
The 30° angle between slide and ship ensures that the system can compensate and absorb extreme ship and sea movements.



Material

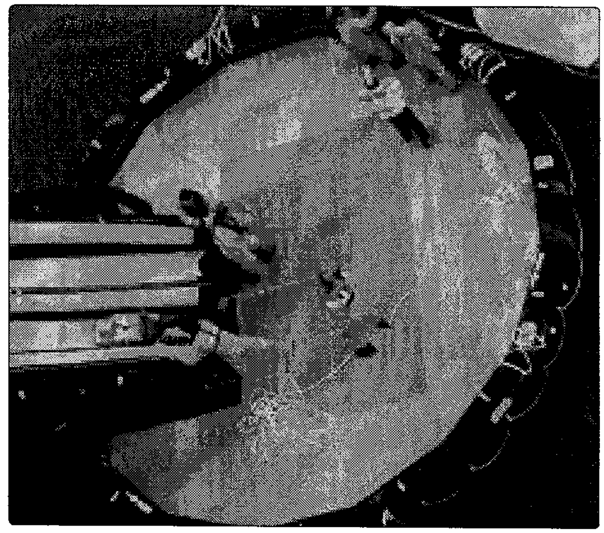
The system structure is made of steel or seawater resistant aluminium.
The slide with platform is fabricated of nylon webbing covered with natural rubber as similar for the liferafts.
The liferaft containers are made of GRP (Glassfibre Reinforced Polyester).

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

LIFE-SAVING EQUIPMENT

Activation

The VIKING Evacuation Slide is activated by nitrogen (N_2) pressure, released by one handle.
The front door will open and pull out the slide and platform and immediately start inflation by means of nitrogen (50% over-capacity included) and air aspirators.
The slide system itself does not require any external power supply.



Capacity

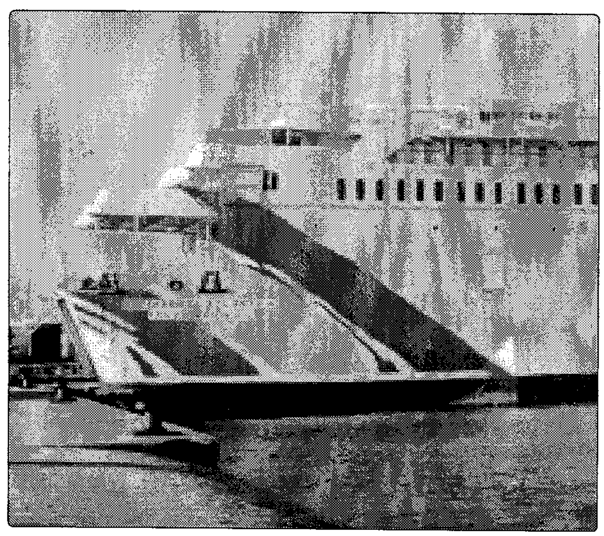
The VES System has an evacuating capacity almost second to none as it evacuates 500 people in 30 minutes.
For ships built according to the high speed craft code, the slide system evacuates 350 people or more within 17 min. 40 sec.
A wide range of different liferafts can be used in combination with the slide system:

- 25, 50 person canopied liferafts (cruise and HSC vessels)
- 25, 51, 101 person self-righting liferafts (ro-ro vessels)
- 25, 50, 100 person open reversible liferafts (ships on domestic routes)

Available with all these sizes of liferafts, the system ensures a very high degree of flexibility, which is of vital importance to the ship operators. So, the life-saving appliances will fit the number of persons to be evacuated for each individual ship.

Stowage / installation

The self-contained and very compact stowage box allows installation anywhere on the ship: on an open deck, between decks (open recess) or built into the ship's side.
Due to the 30° slide angle, the stowage box may alternatively be placed in an extreme forward or after position on the ship, the slide either facing after or forward.



© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

This gives the slide system a unique advantage for fitting into a huge range of different ship designs.

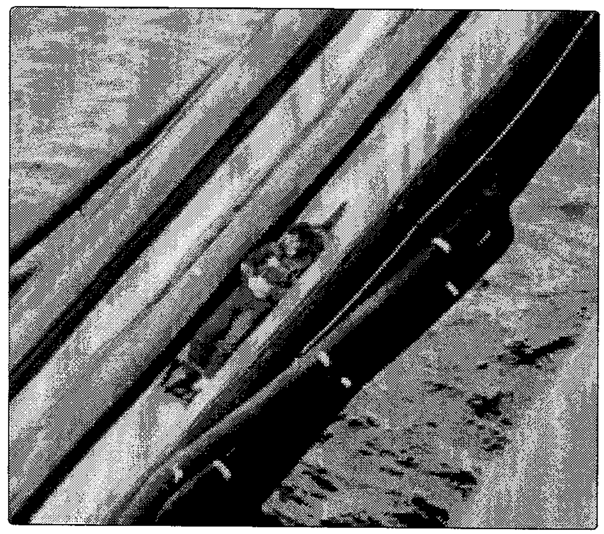
Stowage height

Steel box: 6 - 15 m.
Aluminium system 6 - 10.7 m.
Calculated from lightest seagoing condition to installation deck.

VIKING LIFE-SAVING EQUIPMENT

Means of Rescue

The VIKING Evacuation Slide can also be used as a Means Of Rescue system.
People in the water can be moved on to the platform either directly from the water or via a rescue boat. From the platform a person can, if capable of walking, walk up the slide using the slide grap lines.
Alternatively, positioned in a special stretcher* people can be hoisted/towed up the slide.



* Not included in the basic system.

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

VIKING
LIFE SAVING EQUIPMENT

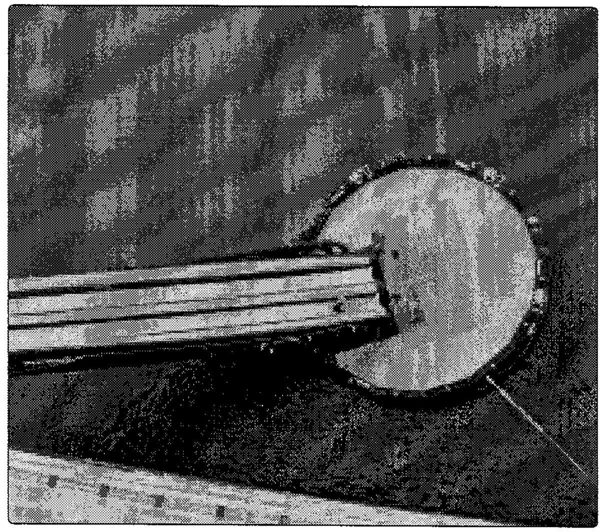
Deployment/Launching

1. The VES System ready for deployment. One-handle pull activates and deploys the full system.

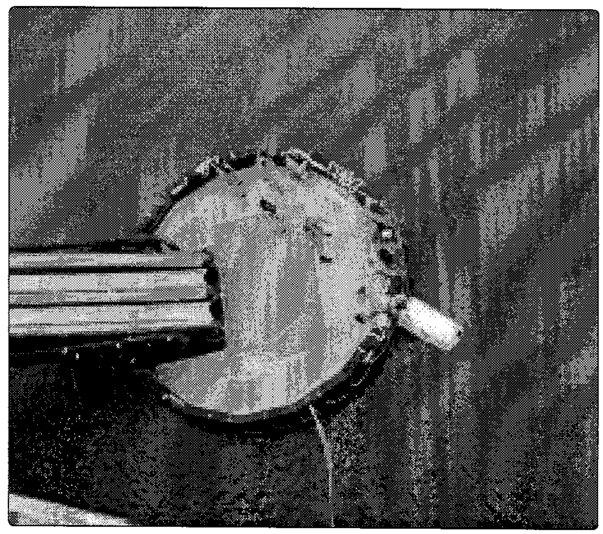
2. Front door opening and pulling the slide with platform out of the stowage box.
The box landing simultaneously goes into position.

3. The slide and platform drop on to the water and start inflation immediately.

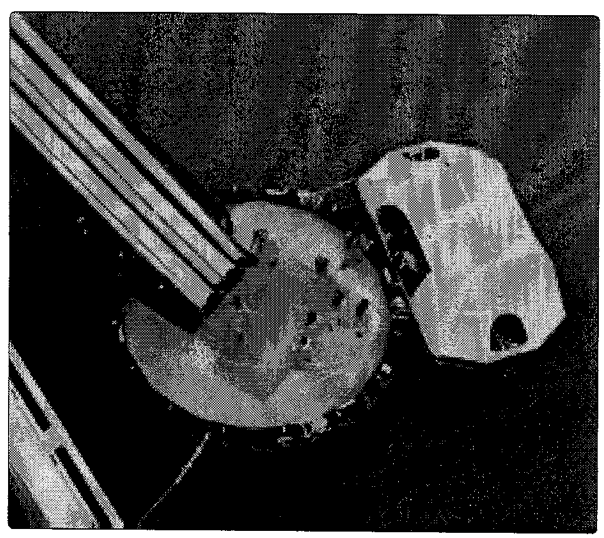
© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.



4. Slide and platform fully inflated within 3 minutes of having the release handle pulled.



5. The liferaft containers are released from the nearby racks with the pneumatic Hammar release system. The liferafts can only be released in the right order. When waterborne, the liferaft containers are pulled to the slide platform.

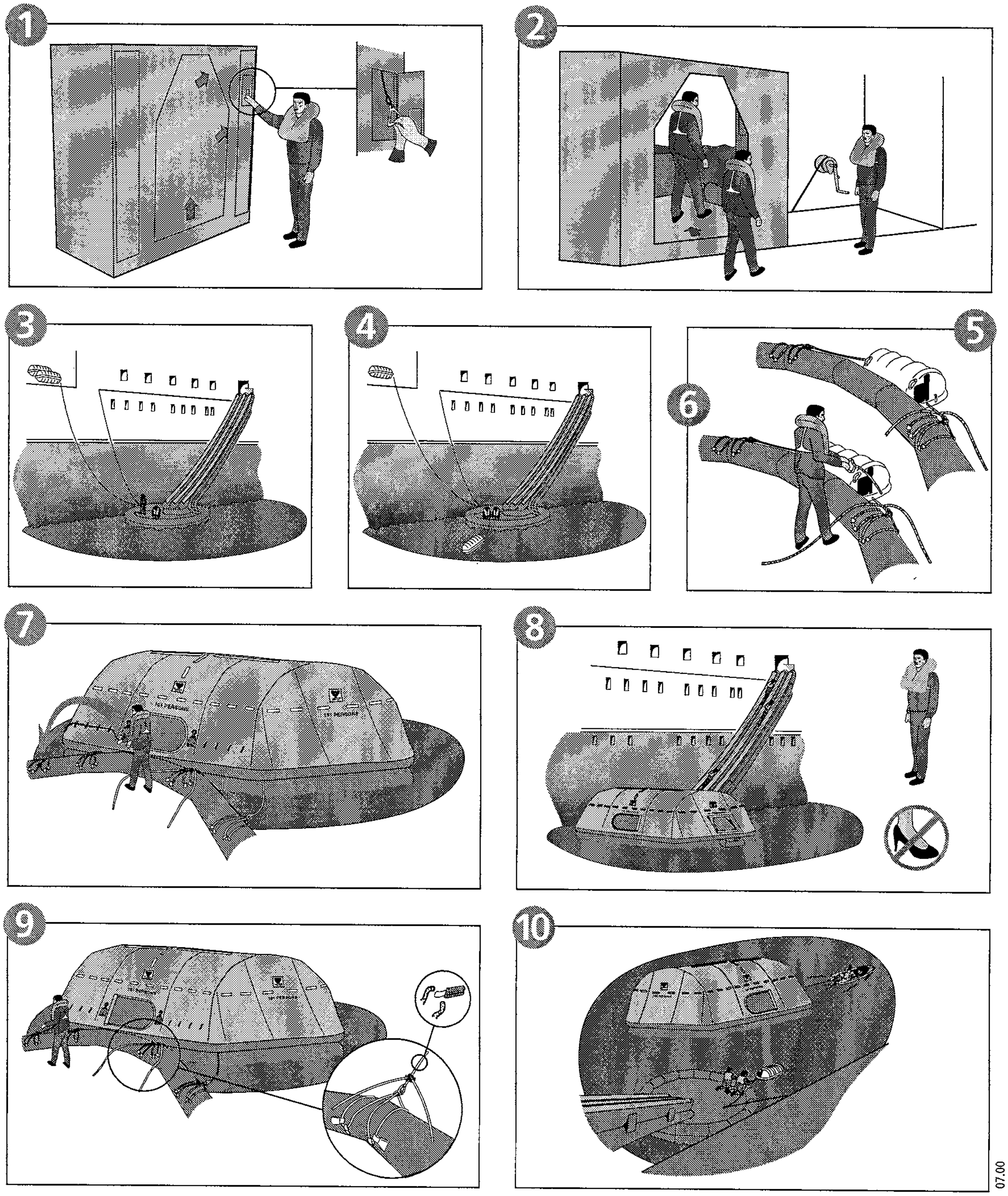


6. The liferaft container is connected to the platform and inflated when the quick release line is pulled.

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

VIKING
LIFE-SAVING EQUIPMENT

LAUNCHING AND OPERATING INSTRUCTIONS FOR EVACUATION SYSTEM
UDSÆTNINGS- OG BETJENINGSINSTRUKTION FOR EVAKUERINGSSYSTEM



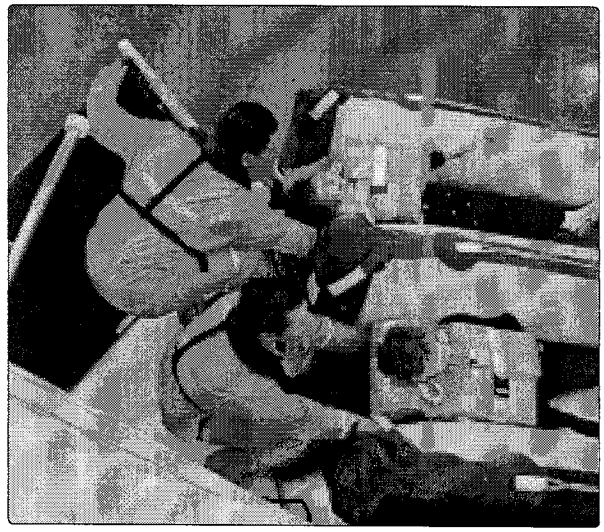
Head Office: VIKING LIFE-SAVING EQUIPMENT A/S · P. O. Box 3060 · 6710 Esbjerg V · Denmark
Tel +45 76 11 81 00 · Fax +45 76 11 81 01 · Tlx 54114 vikng dk · www.viking-life.com · e-mail: viking@viking-life.com

024-0492 en/da (udg. 2)

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

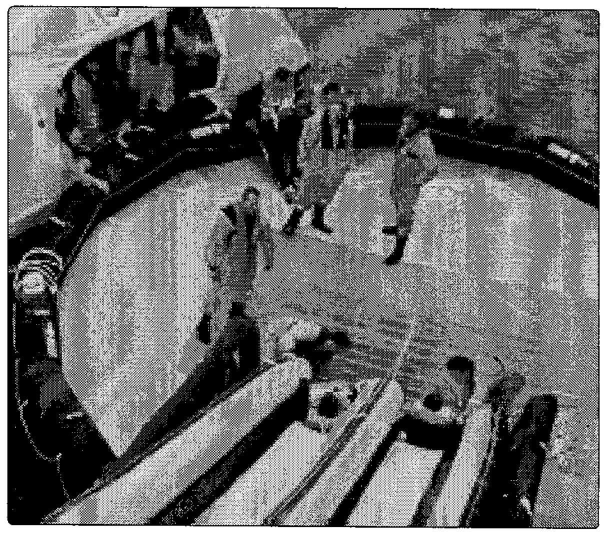
Training

An important aspect of cost savings is the simplicity of its operation and the fact of it being a single-stowage unit. This means that less crew-hand are required to supervise the evacuation at each muster station. The cost of crew training is therefore also substantially reduced.



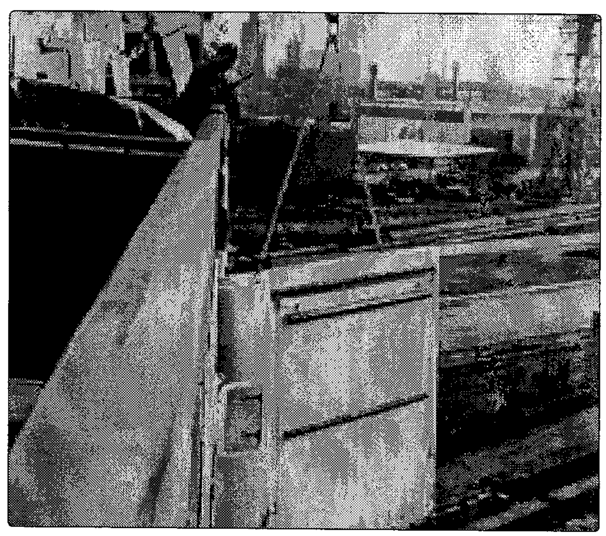
Servicing

The system provides substantial cost benefits to the shipowner. Its easy installation and the compact nature of stowage saves the shipowner time and money when commissioning or reinstalling the equipment after servicing. Simplified installation makes the system removable and re-installable in a short period of time. The existence of fewer components to be inflated means reduced annual servicing costs.



Annual servicing

The stowage box is mobile and may be unbolted and easily lifted off the vessel by crane for servicing.
The liferaft containers are also easily disconnected from the racks.



© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

EC Type-Examination Certificate
VIKING Evacuation Slide
For 500 persons within 30 minutes


DET NORSKE VERITAS

EC TYPE-EXAMINATION CERTIFICATE

Marine evacuation systems

DD-MES SIZE 12-14-15-16-18-20-22.5-25.5 METERS

Viking Life-Saving Equipment A/S

Esbjerg V, Denmark

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

EC Type-Examination Certificate
101 person liferaft

DET NORSKE VERITAS

EC TYPE-EXAMINATION CERTIFICATE

This is to certify that the product

Automatically self-righting liferafts

with the type designation(s)

100 DKS

Manufactured by

Viking Life-Saving Equipment A/S

Esbjerg V, Denmark

Place and date

for DET NORSKE VERITAS

Notified Body No.:

Page 1 of 3

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.

EC Type-Examination Certificate
51 person liferaft

DET NORSKE VERITAS

EC TYPE-EXAMINATION CERTIFICATE

CERTIFICATE No. MED-B-101

This is to certify that the product

AUTOMATICALLY SELF-RIGHTING LIFERAFT

with the type designation(s)

50 DKS

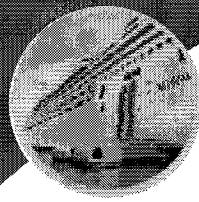
Manufactured by

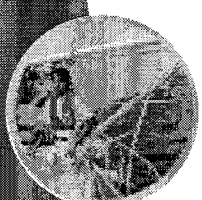
VIKING LIFE-SAVING EQUIPMENT A/S

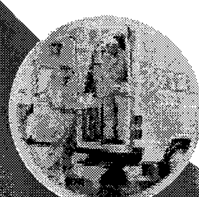
ESBJERG, DENMARK

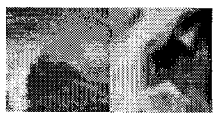
This Certificate is valid until 12 February 2004

© VIKING proprietary business information - Release to others without the express written permission of VIKING prohibited.









WATER AND FIRE
are forces strong enough
to end human life.
We make every effort
to avoid this.

C A N A D A :
VIKING Life-Saving Equipment Canada Ltd
Tel: +1 6044211110 · Fax: +1 6044211945
e-mail: viking-can@viking-life.com

F I N L A N D
VIKING Life-Saving Equipment Oy
Tel: +358-(0)2-489 500 · Fax: +358-(0)2-489 5011
e-mail: viking-fi@viking-life.com

F R A N C E :
VIKING Life-Saving Equipment France S.a.r.l.
Tel: +33 (0) 160 87 09 00 · Fax: +33 (0) 160 87 09 01
e-mail: viking-f@viking-life.com

G E R M A N Y :
VIKING Life-Saving Equipment GmbH
Tel: +49-(0)40 670 10 25 · Fax: +49-(0)40 670 10 67
e-mail: viking-d@viking-life.com

H O N G K O N G :
VIKING Life-Saving Equipment Hong Kong Ltd.
Tel: +852 24297878/24252410 · Fax: +852 24236228
e-mail: viking-hk@viking-life.com

I C E L A N D :
VIKING Life-Saving Equipment Iceland ehf.
Tel: +354 544-2270 · Fax +354 544-2271
e-mail: viking-is@viking-life.com

M I D D L E E A S T :
VIKING Life-Saving Equipment (Middle East)
Tel: +971-2-555 9944 · Fax: +971-2-555 9095
e-mail: viking-uae@viking-life.com

T H E N E T H E R L A N D S :
VIKING Life-Saving Equipment B.V.
Tel: +31-78-610 28 33 · Fax: +31-78-610 33 61
e-mail: viking-nl@viking-life.com

N O R W A Y :
VIKING Life-Saving Equipment Norge AS
Tel: +47-23-19 40 60 · Fax +47-22-64 62 61
e-mail: viking-n@viking-life.com

VIKING Life-Saving Equipment Bergen AS
Tel: +47-56-32 61 00 · Fax: +47-56-32 61 10
e-mail: viking-n-bergen@viking-life.com

S I N G A P O R E :
VIKING Life-Saving Equipment Pte Ltd.
Tel: +65-62825122 · Fax: +65-62822056
e-mail: viking-sg@viking-life.com

S P A I N :
VIKING Life-Saving Equipment Iberica S.A.
Tel: +34-91-5624833 · Fax: +34-91-5613805
e-mail: viking-e@viking-life.com

S W E D E N :
VIKING Life-Saving Equipment Sweden AB
Tel: + 46 (0)8 7700170 · Fax: +46 (0)8 7700183
e-mail: viking-se@viking-life.com

U N I T E D K I N G D O M :
VIKING Life-Saving Equipment Ltd.
Tel: +44 (0) 1603 767677 · Fax: +44 (0) 1603 766700
e-mail: viking-uk@viking-life.com

U N I T E D S T A T E S :
VIKING LIFE-SAVING EQUIPMENT (America) Inc.
Tel +1 (305) 374 5115 · Fax +1 (305) 374 1535
e-mail: viking-usa@viking-life.com

D E N M A R K (H e a d O f f i c e) :
VIKING Life-Saving Equipment A/S
Tel: +45 76 11 81 00 · Fax: +45 76 11 81 01
e-mail: viking@viking-life.com

www.viking-life.com

slide product guide 06.02

Appendix E

Viking Evacuation Chute

Offshore Evacuation System
Model: SES Basic

The SES Basic is an evacuation system designed for fixed and floating platforms and rigs with installation heights of 8-35 meters above sea level.

A SES Basic Offshore Evacuation System consists of the following components:

The Stowage box is the structural interface to the platform deck. It also protects the Evacuation Chute against all types of weather. The Stowage Box consists of a load bearing welded frame, which is bolted to a foundation in the deck structure. The foundation, which is integrated as part of the deck structure, can either be in-deck mounted or cantilevered out from the edge of the platform deck. The frame is made of carbon steel and painted according to offshore specifications. The walls are made of GRP sheets.

The Evacuation Chute provides a simple, safe and reliable method of transferring evacuees from deck levels down to sea level. Structurally, the chute is an elongated arm of the platform, mechanically connected to the platform through the four stressmembers.
The chute is subdivided along its length into cells, complete with speed retarding slides. Each slide runs at an opposing angle to the one above, creating a zigzag lattice through the entire length of the chute. It is possible to slide down the chute on stretchers or wearing life jackets, survival suits, breathing apparatus etc. Evacuees can enter and exit the chute at any level through openings located behind each retarding slide. Evacuees can also climb up inside/outside the chute.

The length of the chute is calculated to allow side motion due to wind and sea current.

The Release System. Drop release of the system is carried out by means of a special knife or pneumatic cutter. After the strap is cut the stabilising weight is released out of the bottom of the stowage box. Then the stabilising weight, the Boarding Platform and the chute is falling freely down to sea level.

The Boarding Platform is situated at the bottom of the chute. The Boarding Platform is automatically inflated, and acts as sea reference point where escaping evacuees can await to be rescued or to be dry transferred to throwover-board Liferafts or to a fast rescue craft. By cutting the chute guidance ropes, the Boarding Platform can drift away and be used as an ordinary raft.

The Stabilising Weight, is connected at the bottom end of the chute vertical stabilising ropes. The weight, which is made of carbon steel and painted according to offshore specifications, is situated 5-10 meters below the water surface, when the chute is deployed. It keeps the chute stable and reduces side motion in the

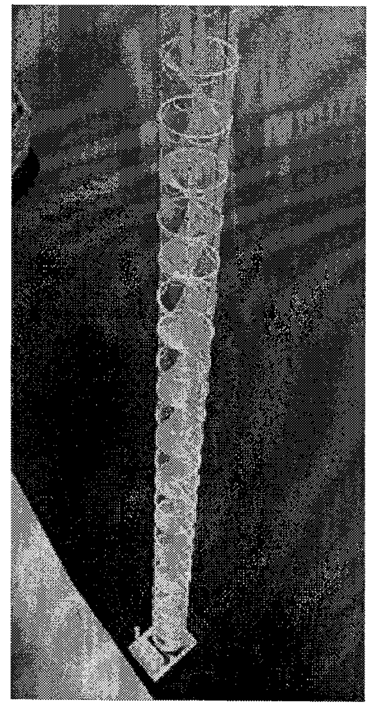
chute due to wind and sea current.
Throw-over-board Liferafts can be used in connection with the SES Basic.

The unit can easily be installed on existing platforms by bolting it over a cut out in the deck.

The unit must be serviced annually.

Components	Material	Dimensions(L x W x H)	Weight
Stowage Box	Aluminium or Carbon Steel and Fiberglass	2090 x 1400 x 1670 mm	200 kg
Evacuation Chute	Kevlar Stainless Steel Rings	1500 x 1000 x 26 mm per cell(folded)	7 kg/metre
Boarding Platform	Natural Rubber	25 persons	85 kg
Stabilising Weight	Carbon Steel	1300 x 1500 x 100 mm	300 kg
Total SES Basic			Approx. 720 kg

Offshore Evacuation System
Model: SES-2A



The SES-2A is a chute based evacuation system designed for fixed and floating platforms and rigs with installation heights from 10 to 60 meters above sea level. The maximum capacity of one SES-2A is 140 persons. The system is launched by winch in a controlled manner. At any time before the equipment hits the sea, the system can be retrieved completely and without recertification. This also allows for regular operational training.

The SES-2A consists of the following components:

The Container is the structural interface to the plat-form deck. It also protects the Evacuation chute against all types of weather, and environmental aspects as earthquakes and explosions. The container consists of a load bearing welded frame, which is bolted to a foundation on the deck structure. The foundation is normally in a cantilevered position, but it can also be placed further in on the deck. The frame is made of carbon steel and painted according to offshore specifications. The walls are made of corrugated steel plates.

The Evacuation Chute is made of materials that are fire resistant up to 400°C, and provides a simple, safe and reliable method of transferring evacuees from deck levels down to sea level. The chute is subdivided along its length into cells, complete with speed retarding slide. Each slide runs at an opposing angle to the one above, creating a zigzag lattice through the entire length of the chute. It is possible to slide down the chute on stretchers or wearing life jackets, survival suits, breathing apparatus etc. Evacuees can enter and exit the chute at any level through openings located behind each retarding slide. Evacuees can also climb up inside/outside the chute.
The length of the chute is calculated to allow side motion due to wind and sea current.

The Winch, together with the winch motor, offers a controlled deployment and recovery.

The Boarding Platform is situated at the bottom of the chute. The Boarding Platform is automatically inflated, and acts as sea reference point where escaping personnel can await to be rescued or to be dry transferred to the life rafts or to a fast rescue craft.

The Life Raft(s) provide a means of travel away from the platform area. During storage these Life Rafts are stored in a cradle mounted on the stabilising weight. One to four Life Rafts can be installed, and the size can vary from 12 persons rafts to 35 persons rafts, according to required capacity of the system.

The Stabilising Weight is connected at the bottom end of the three winch-wires. The weight, which is made of carbon steel and painted according to offshore specifications, is lowered approx. 10 meters below the water surface, when the chute is deployed. It keeps the chute stable, and reduces side motion in the chute due to wind and sea current.
The SES-2A format has been tested in full scale on Stat-pipe 16/11-S for 17 hours with wind speeds up to 63 knots and peak to peak wave heights of up to 11 meters. The conclusion from Statoil was that the system was fully operational during the whole test.

The unit must be serviced annually.

Components	Material	Dimensions/size (Lx W x H)	Weight/Capacity
Container	Carbon steel	4200 x 2200/4400 x 2900 mm	Approx 3000 kg
Evacuation Chute	Kevlar Stainless Steel Rings	1500 x 1200 x 26 mm per cell(folded)	7 kg/metre
Winch		ZR 420	SWL 2,2 tons
Boarding platform	Natural rubber	25 persons	85 kg
Stabilising weight	Carbon steel	4030 x 1600 x 460 mm	Approx. 1000 kg
Inflatable Life rafts B-pack(number and size according to total required capacity of the system)	Natural rubber	12 pers 16 pers 20 pers 25 pers 35 pers	100 kg each incl container 124 kg each incl container 140 kg each incl container 165 kg each incl container 264 kg each incl container
Total SES-2A incl. 4 rafts			Approx. 7000 kg

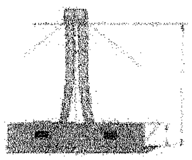
Certificate of Type Approval for Ship's Equipment, Norwegian Maritime Directorate Download PDF

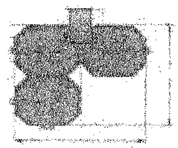
Appendix F

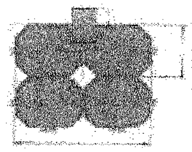
RFD Evacuation System

Marin-Ark
Technical Information

System Configurations
- RFD provide a range of system configurations to suit all types and sizes of passenger vessels from conventional Ro-Ro ferries, cruise ships and high speed ferries.







Installed Heights
- A pack 8 - 17m
- B pack 8 - 23.5m

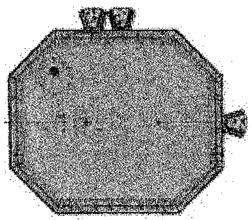
Model 212
- 2 chutes and 2 liferafts
- Weight -
  A pack 3660kg
  B pack 3620kg
- Capacity - 212 persons

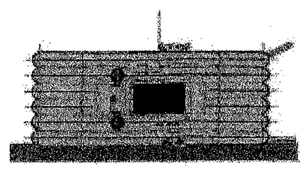
Model 321
- 2 chutes and 3 liferafts
- Weight -
  A pack 4860kg
  B pack 4500kg
- Capacity - 321 persons

Model 430
- 2 chutes and 4 liferafts
- Weight -
  A pack 5860kg
  B pack 5380kg
- Capacity - 430 persons

Stand Alone Liferaft
- Weight - A pack 1000kg. B pack 880kg
- Capacity - 106/109 persons
- Container dimensions:
  A pack 2.6m length x 1m diameter
  B pack 2.3m length x 1m diameter

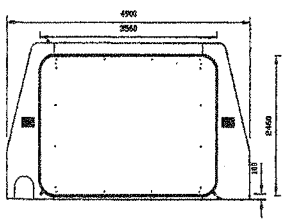
- Single and double launching racks available
- Single point bowsing option - to bowse liferaft flush to the ship's side following deployment
- Required towing force at 2 knots is 214 kN

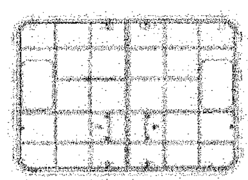




Installation Options
Open Deck Installation
- Comes with GRP weather proof deck housing
- Weight - 840kg
- Dimensions - 4900mm length x 2500mm depth x 2750mm height

Between Deck Installation
- Comes with option of ship's door and door frame
- Weight - 300kg
- Dimensions - Aperture 3650mm length x 2550mm height c/w corner radii

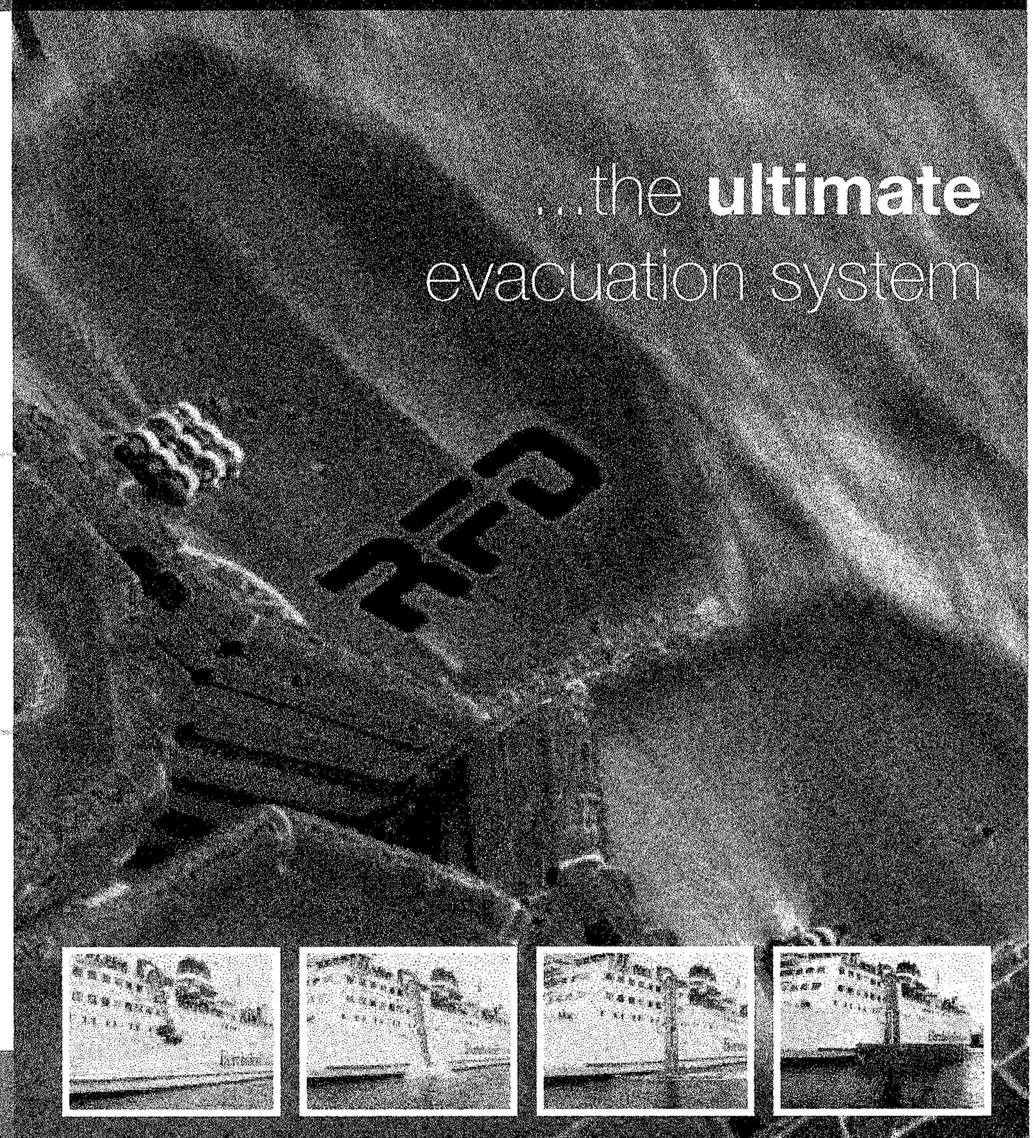




RFD Marin-Ark is the first evacuation system in the world to comply with the latest International Maritime Organisation (IMO)/SOLAS Chapter III regulations.

RFD Limited The Survival Specialists Kingsway, Dunmurry, Belfast BT17 9AF Northern Ireland
tel: +44 (0)28 9030 1531 fax: +44 (0)28 9062 1765 email: info@rfd.co.uk web: www.rfd.co.uk

Marin-Ark
Evacuation System



RFD Commercial Marine & Leisure Division The Survival Specialists www.rfd.co.uk

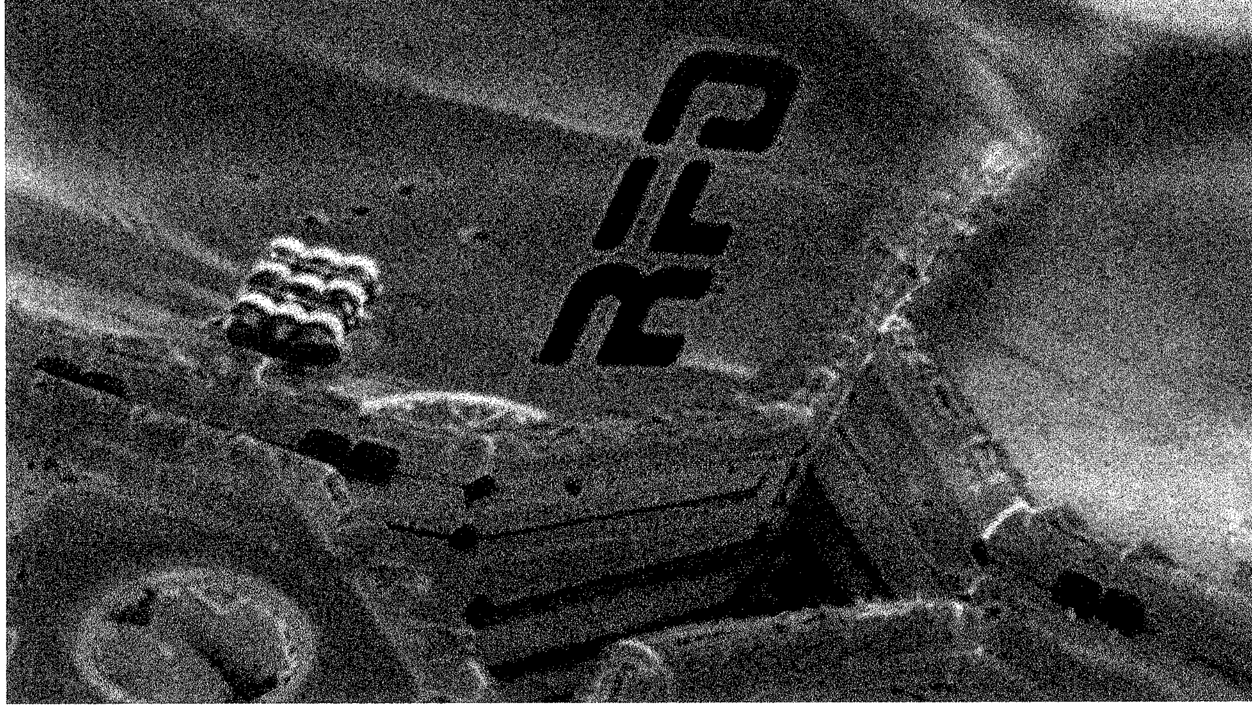
survitecgroup
Part of the SURVITEC group of companies

Marin-Ark
Evacuation System

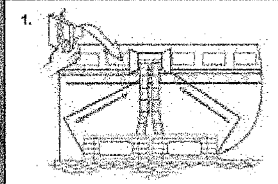
The RFD Marin-Ark marine evacuation system provides the most advanced way of evacuating passengers and crew from all types of passenger vessels in an emergency.

Evacuees transfer quickly and safely from the ship directly into the liferaft without exposure to the weather. The innovative RFD Marin-Ark was the first evacuation system in the world to fully comply with the latest International Maritime Organisation (IMO)/SOLAS Chapter III regulations governing safety on board passenger vessels.

RFD has over four decades of industry-leading experience dealing with marine evacuation systems and our ultimate survival system, the RFD Marin-Ark, has been installed on a substantial number of vessels including cruise ships, conventional passenger ferries and high-speed craft.

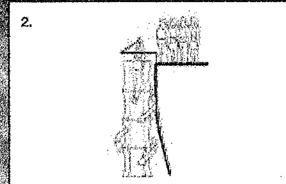


1.



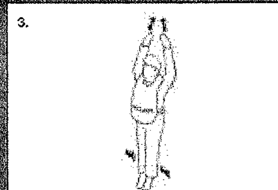
RFD Marin-Ark is deployed by a single release mechanism and is fully operational within 90 seconds of deployment

2.



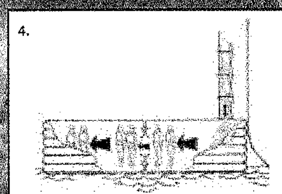
Fully enclosed chute ensures that evacuees transfer quickly and safely from the ship to the liferaft without exposure to the weather

3.



Instruction on the correct position for descent will be given by personnel at the top of the chute

4.



On descent, evacuees can then be moved away from the bottom of the chute completing an entirely dry-shod evacuation

Impressive Marin-Ark Features

- Up to four totally reversible 100+ person capacity liferafts and two fully enclosed telescopic descent chutes, all housed within one complete stowage unit

Liferafts

- Fully reversible liferafts which always deploy the right way up
- Unique design ensures high stability in heavy weather
- Six separate buoyancies provide additional survivability in the event of damage

Chutes

- Enclosed chute protects evacuees from the environment, providing a completely dry-shod evacuation
- Unique telescopic design compensates for ship and sea motion and ensures the chute is continuously useable in all weather conditions
- Internal slide path design ensures a rapid and very safe descent for evacuees

Stowage

- The self-contained stowage unit enables the system to be installed on an open deck or between decks
- Stowage design ensures that chutes never come into contact with ship's side, even in the most severe conditions
- Automatically ejects and releases the liferafts to float free in the event of the sudden and catastrophic sinking of the ship

Key Benefits

- Ease of operation as the RFD Marin-Ark is deployed by a single release mechanism
- Speed of operation as the evacuation system is fully operational within 90 seconds of deployment
- Totally enclosed evacuation as evacuees transfer directly from the ship into the liferaft without exposure to the harsh marine environment
- Many installations successfully completed on new and existing vessels of all types and sizes, throughout the world
- Cost effective and efficient servicing, conducted by experienced and approved service engineers

Appendix G

Marine Evacuation Systems

(Key Features)

RFD Marine

Evacuation System

<table>
<tr><th></th><th>Chute Material</th><th>Platform Material</th><th>Housing Material</th><th>Chute Length (m)</th><th>Installation Height (m)</th><th>Footprint Dimensions (l x d x h) (mm) *</th><th>System Weight (kg)</th></tr>
<tr><td>Model 212 (2 side-by-side chutes with 2 liferafts)</td><td rowspan="3">Information not available</td><td rowspan="3">Information not available</td><td rowspan="3">Information not available</td><td rowspan="3">Information not available</td><td>A pack: 8 -17, B pack: 8 - 23.5</td><td>4900 x 2500 x 2750</td><td>A pack: 3860, B pack: 3620</td></tr>
<tr><td>Model 321 (2 side-by-side chutes with 3 liferafts)</td><td>A pack: 8 -17, B pack: 8 - 23.5</td><td>4900 x 2500 x 2750</td><td>A pack: 4860, B pack: 4500</td></tr>
<tr><td>Model 430 (2 side-by-side chutes with 4 liferafts)</td><td>A pack: 8 -17, B pack: 8 - 23.5</td><td>4900 x 2500 x 2750</td><td>A pack: 5860, B pack: 5380</td></tr>
</table>

* Dimensions given are for open deck installation

Appendix H

MaritimeEXODUS / SHEBA

maritimeEXODUS

maritimeEXODUS

"*The evacuation simulation tool for the shipping industry*"

*maritime*EXODUS is an advanced software program specifically designed for the analysis of movement and/or evacuation of people on a ship or offshore structure. The software goes far beyond the traditional examination of layout and safety systems, to incorporate human performance factors such as individual and group behaviour, interaction and response to the environment.

Applications

- Enables the analysis of complex people-people, people-structure and people-environment interactions on ships and offshore oilrigs.
- Can be used to analyze ship layout, exit arrangements, muster stations, lifeboat and evacuation system sizes and locations.
- Can be used to model unlimited numbers of people on all types of vessels, from small ferries and tourist boats with closely packed seating, to large multi-deck cruise ships carrying thousands of passengers and crew; from aircraft carriers, to offshore drill platforms.

Enhanced Realism

The realism of the model is enhanced by a number of advanced behavioural features such as allowing individuals or groups to perform tasks. For example, crew can be assigned to specific locations, or occupants can be directed to the location of lifejackets before evacuation.

Circulation in Non-emergency Situations

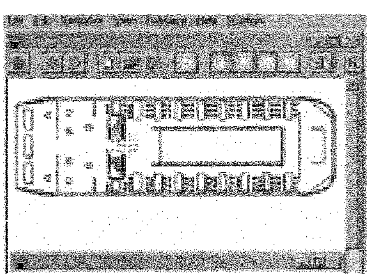
The introduction of the 'Itinerary List' function allows *maritime*EXODUS to be used beyond emergency situations to model normal circulation patterns of people on ships, predicting how passengers and crew will interact in non-emergency conditions such as disembarkation, emergency drills, or even the clearing of a theatre or dining room. The model's features permit occupants to be designated as crew or passengers, with varying levels of familiarity with the layout.

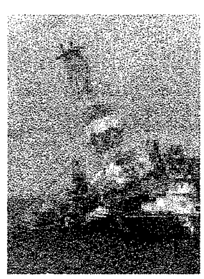
Fully-Integrated Abandonment Model

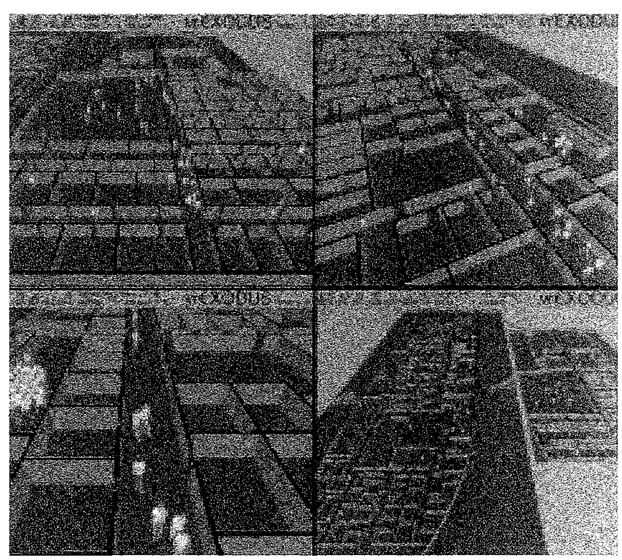
*maritime*EXODUS models passenger exit via life-saving apparatus (LSA) such as lifeboats and evacuation chutes and slides. Passengers can be allocated to an LSA, and the performance of the LSA and its operational status, accounted for. This feature includes LSA entry delay times, as well as an allowance for the LSA's performance in poor weather.

Real-Time Operations

*maritime*EXODUS has the potential to be used on-board to simulate the consequences of re-routing passengers if an area of the ship – or an LSA – becomes inaccessible.







"Designed by international modelling experts, and based on over ten years of development and experience in the building and aviation industries, *maritime*EXODUS incorporates sophisticated passenger behaviour (such as group behaviour, life-jacket collection, crew interaction, static list behaviour, etc.), an abandonment model, and a fire toxicity model."

maritimeEXODUS

Fire and Smoke Hazards

The program can interface with fire and smoke-spread models, and will calculate the effect of smoke and toxic gases on occupants; when a person succumbs to smoke and falls, the obstruction is accounted for in the passage of subsequent persons.

*maritime*EXODUS has Virtual Reality 3D view to assist in the visualization of traffic patterns and human interaction. The program output includes a full set of statistics which, in addition to overall evacuation time, can provide individual waiting and evacuation times, the path taken by any person, and numerous other useful parameters.

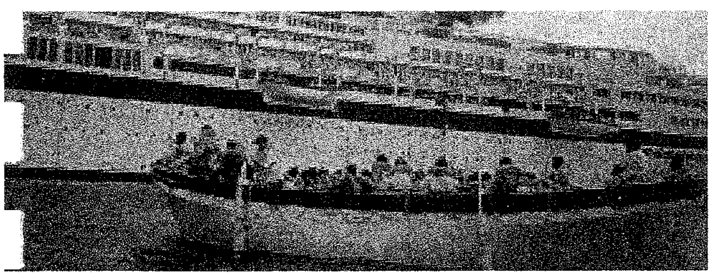
Specifications

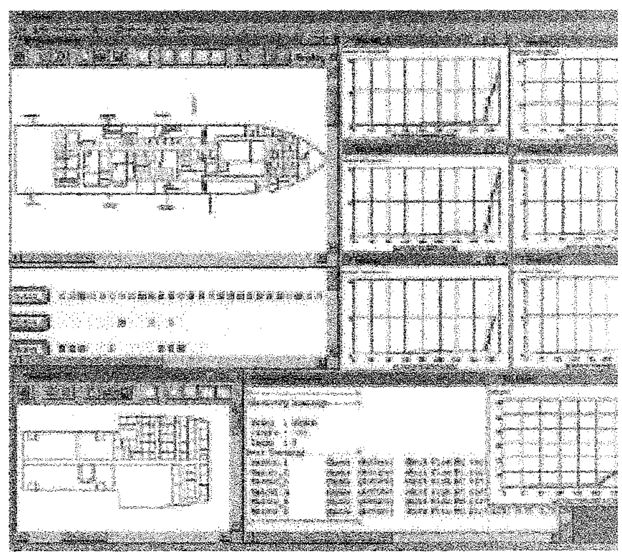
*maritime*EXODUS is written in C++ and utilizes rule-based software technology to control the behaviour of the occupants. The vessel geometry can be read into *maritime*EXODUS using a CAD 'dxf' format file. The software runs on a PC with a minimum Pentium II 300 MHz and 128 MB RAM, under WINDOWS 95/98/2000/NT.

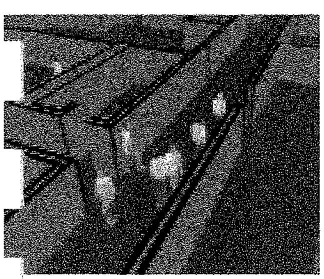
The model has been developed by the leading international behaviour and modelling experts of the Fire Safety Engineering Group at the University of Greenwich in collaboration with Fleet Technology Limited. The program has evolved from over ten years of research and experience, and forms part of the EXODUS suite of programs used by over 60 clients in the building and aviation industries in 20 countries. It is supported by a team of full time staff and on-going research at the University of Greenwich.

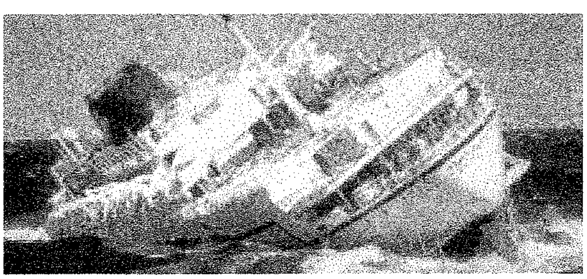
Fire Safety Engineering Group
School of Computing and Mathematical Sciences
University of Greenwich
30 Park Row, Greenwich SE10 9LS, London UK

FSEG Home Page: http://fseg.gre.ac.uk









*maritime*EXODUS is available exclusively from:

North America
Fleet Technology Limited
+(613) 592 2830
evacuation@fleetech.com
www.fleetech.com/ses/

UK and Europe
BMT Seatech
+(0) 2380635122
enquiry@bmtseatech.co.uk

Asia
BMTAsia Pacific Pte Ltd
+(65) 777 8745
bmtasia@singnet.com.sg

Appendix I

Test Matrix

Test Matrix

Parameters:

Ship	Waves	Wind	Platform	Liferafts	Slide	Chute
heel	height	speed	loading	loading	angle with	length
trim	period	direction*	pressure*	pressure*	pressure	material*
leeward	direction		stabilization weight*	stabilization weight*	length	angle of zigzag*
windward					material*	

* Additional parameters to be considered for testing, (not listed in test plan below)

Baseline Conditions: (conducted with normal pressure in slide, platform, liferafts, a 30 degree angle between the slide and ship/installation, 18 angle of zigzag in chute)

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Heel:

Heel 10 degrees to port

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Heel 10 degrees to starboard

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Heel 20 degrees to port

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Heel 20 degrees to starboard

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Trim:

Trim 5 degrees to Stern

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Trim 10 degrees to Bow

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Trim 5 degrees to Bow

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Trim 10 degrees to Bow

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Wave Steepness:

1/10 Steepness of Waves

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

1/15 Steepness of Waves

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Wave Direction:

Irregular Wave Direction

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Collinear Wave Direction

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Pressure in Slide:

Below Normal Pressure in Slide

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Normal Pressure in Slide

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Above Normal Pressure in Slide

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Slide Angle with Ship/Installation:

15 Angle of Slide wrt Ship/Installation

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

60 Angle of Slide wrt Ship/Installation

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

45 Angle of Slide wrt Ship/Installation

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

90 Angle of Slide wrt Ship/Installation

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Slide Length:

Short Slide

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Normal Slide Length

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Long Slide

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Chute Length:

Short Chute

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Normal Chute Length

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Long Chute

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Platform Loading:

Zero Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Half Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Full Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Effects of Liferaft Loading:

Zero Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Half Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		

Full Capacity

	Leeward	Windward
Beaufort 4		
Beaufort 5		
Beaufort 6		
Beaufort 7		
Beaufort 8		