Ship Design I

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Summary

1. Process of a New Shipbuilding
2. What is Ship Design?
3. Ship Design Methodology
4. Entities Involved in the Process
5. Technical and Legal Documents Associated
   - Shipbuilding Contract
   - Ship Specification

Annex A. Systems for the Classification of Ship Components
Annex B. Beaufort Wind Scale
Annex C. Douglas Sea Scale

Decision Process

Shipowner Process:

- Analysis of the marine transportation market
- Identification of a business opportunity
- Study of the fleet of ship(s) required
- Characterization of the ship (Concept Design)
- Analysis of the possible alternatives:
  - Relocation of a ship from the existing Owner fleet
  - Freight of a ship
  - Acquisition of an existing ship (2nd hand)
  - Building a new ship
- Selection of the Consultant/Designer
- Development of the Preliminary Design

New Building Process

Steps of the commercial process of the Shipowner:

- Selection of the Yards
- Request for a declaration of interest from the Yards
- Send enquiries with request for quotation
- Analysis of the proposals from the yards
- Preparation of Contract *pro forma*
- Negotiation
- Discussion of the type of financing
- Signature of the Shipbuilding Contract
- Follow-up of the Construction
- Reception of the Ship

Engineering System Design Process

An engineering system design process can be seen as a sequence of the following stages:

- **Analysis**
  A process of partitioning or decomposing any system into its sub-systems and component parts to determine their separate and collective nature, proportion, functions, relationships, etc.
- **Synthesis**
  A process of integrating a collection of sub-systems so as to create a system with emergent properties.
- **Evaluation**
  A process of assessing the degree to which a solution satisfies the goals that were originally stated.

What is Ship Design?

- Process by which, from a marine or inland waterways transportation problem, characterized by transporting a given flow of a given cargo type from point A to point B, in a given time period
  - It is dimensioned a ship, specifying all of its systems
  - It is developed the information necessary to build and assemble it
- The application of the knowledge about Ship Design is not limited only to the actual development of the design of ships, it is equally necessary in other situations such as:
  - when the design is sub-contracted to others, or
  - when a 2nd hand ship is bought

Ship Design Methodology

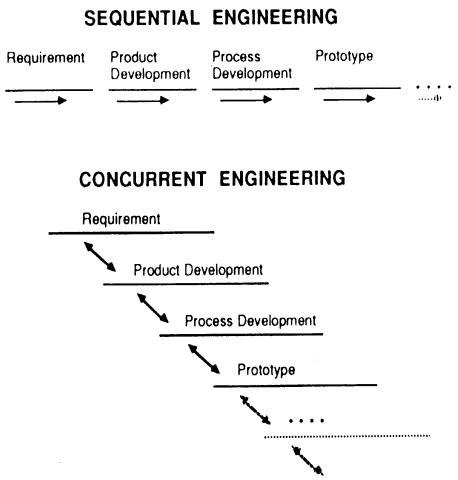
Types of Projects

- **Routine Projects**
  - Projects which are not substantially different from the previous ones in the same class
- **Creative Projects**
  - Projects with substantial differences in the solutions taken, resulting from the introduction of new options
- **Innovative Projects**
  - Projects with substantial differences in the solutions taken, resulting from the introduction of options and values of variables outside of the interval normally used.

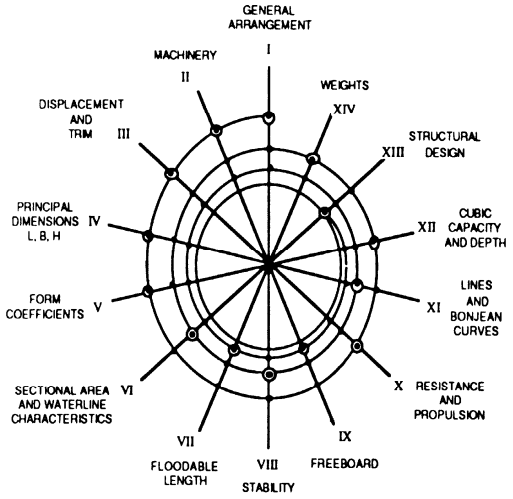
Design Methodologies

- **Sequential Engineering**
  - Limitations
    - Sequential and iterative process
    - Hard working and costly
- **Concurrent Engineering**
  - Definition
    - It is the systematic approach to the integrated and simultaneous design of products and of the processes related to them.
  - Objective
    - It is intended that the designer takes into consideration, since the beginning, all the elements of the lifecycle of the product, since its conception until its availability, including the quality, the cost, the planning and the user requirements.
    - The main objective is the minimization of costs along the lifecycle of the product while maximizing its quality and performance.
  - Characteristics
    - The flow of information is bi-directional
    - Attempt to increase the knowledge of the product at the preliminary stage.

Sequential and Concurrent Engineering



Sequential Engineering in Ship Design

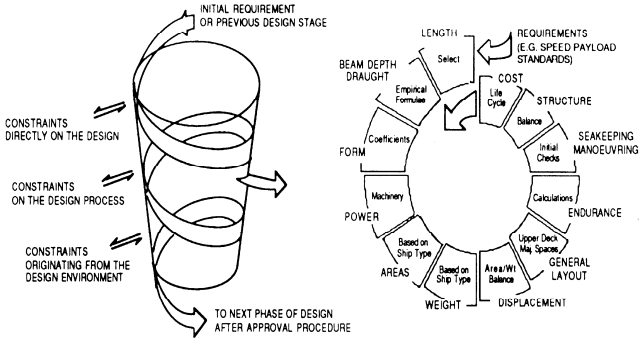


Design Spiral

- Evans (1959) introduced the concept of design spiral, which represents the sequential and iterative aspects of the process

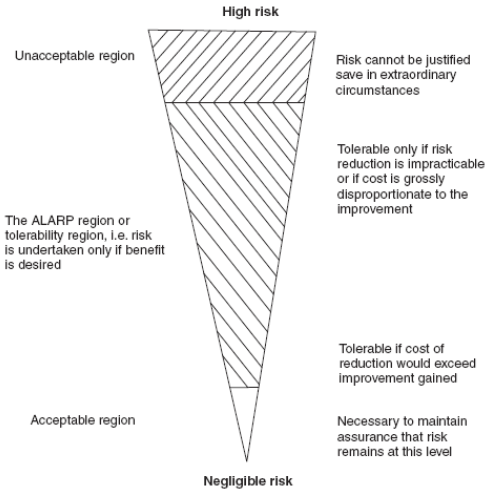
Sequential Engineering in Ship Design

- Buxton (1972), introduced the economical aspects
- Andrews (1981), added the notion of a 3ª dimension, the time.



ALARP Principle

- Design just to comply to the regulations is no longer an acceptable procedure
- **A**s **L**ow **A**s is **R**easonably **P**racticable (ALARP) – it is a principle to reach for a decision for the acceptability of a system



Specific Aspectos of Ship Design

- **Automobile, Aeronautic Industries, …**
  - Large series
  - Longer time to develop the design
  - Small variations in the design
- **Shipbuilding Industry**
  - Recreational boats
    - Series of the same design
  - Merchant Ships
    - Small series or single ships built
    - Shorter time to develop the design
    - Designs with big differences between them

Stages do Ship Design (1)

1. **Concept design**
   - Definition of the ship type, deadweight, type of propulsion, service speed.

2. **Preliminary design**
   - Determination of the main hull dimensions and of some form coefficients
   - Determination of the elements necessary and sufficient to allow the estimation of the ship building and exploitation costs

Stages do Ship Design (2)

3. **Contract Design**
   - Determination of the elements that define the general characteristics of the ship and its main equipment and that will annexed to the Shipbuilding Contract established between the Owner and the Builder.

4. **Detail Design**
   - Detail of the design at all levels in order to supply all the information necessary to its manufacture and assembly.

Information Produced (1)

1. Concept Design

- Definition of the ship type, deadweight, type of propulsion, service speed.

2. Preliminary Design

- Sketch of the General Arrangement, defining the compartment configuration
- Preliminary Body Plan, sufficient to allow the evaluation of the stability and of the cargo capacities
- Prevision of the propulsive power
- Estimative of the lightship weight
- Estimative do ship cost

Information Produced (2)

3. Contract Design

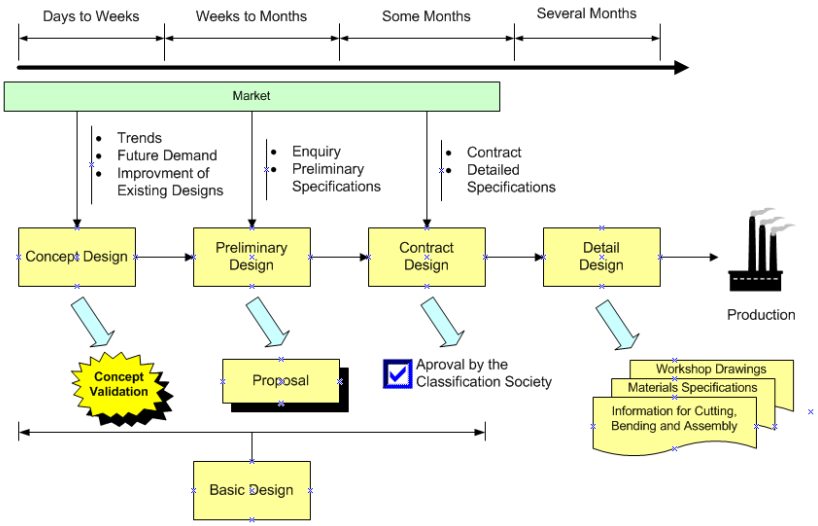
- Ship Specification
- General Arrangement
- Body Plan, with enough detail to allow the manufacture of scaled models for testing in hydrodynamic towing tanks
- Classification drawings of the structures (midship section, typical bulkheads, shell expansion, bow and stern structures)
- Stability and longitudinal resistance computations
- Diagrams of the main piping systems (cargo, ballast, bilge, firefighting, etc.)

Information Produced (3)

4. Detail design

- Total fairing of the body plan, defining all the structural frames, decks, seams and butts of the shell plates
- Production drawings of the structures detailed to the block level
- Material Specifications
- Information for cutting, bending and assembly of plates and stiffeners (drawings, cutting tapes or files, moulds, pin-jigs, etc.)
- Isometric drawings of the piping systems (for manufacture)
- Arrangement of the piping systems (for assembly)

Stages do Ship Design – Time Scale



Entities Involved in the Ship Design and Shipbuilding Process

Entities Involved in the Process

- Ship Owner (*Armador*)
- Ship Designer (*Projectista*)
- Ship Builder (*Construtor*)
- Classification Society (*Sociedade Classificadora*)
- National Authorities (*Autoridades Nacionais*)

Ship Owner

- The entity that starts and finishes the process
- Eventually develops the concept design of the ship
- Contracts the basic design
- Contracts the shipbuilding
- Detains the property of the ship after it is built, although it is not necessarily the entity that operates it

Designer

- Entity which is responsible by the development of the basic design of the ship and which prepares the Ship Specification and the other technical documents
- It can be an independent design office or a department of a shipbuilding yard
- It can sub-contract the development of some parts of the design work to other designers

Ship Builder

- Yard which is responsible towards the Owner by the shipbuilding complying to all the clauses of the Contract and in accordance with the Ship Specification
- Responsible by the development of the Detail Design for manufacture and assembly of the ship taking into consideration the facilities and equipment/capacities available at the yard
- Can sub-contract other entities for the development of some parts of the Detail Design
- Can sub-contract other yards to build some parts/blocks of the ship

Classification Society

- Organization that establishes and applies technical standards for the design, manufacture and maintenance of installations in the marine field, such as ships and offshore platforms.
- Those standards are developed by the CS and published under the form of Rules.
- A ship built in compliance to the Rules of a CS can obtain from it a Class Certificate
- To issue the Certificate, the CS approves a set of design elements and carries out a set of inspections during the construction, to check the compatibility with the approved design
- It can also issue certificates of compliance with international standards of the IMO if they have such a mandate from the National Authorities

Historical Note – The Registry of Ships

- The first registry of ships (Lloyd's Register) was published in 1764
- It consisted in a list of ships with the following information:
  - Ship's name
  - Captain's name
  - Port of Registry
  - Port of destiny
  - Net tonnage
  - Number e dimension of the guns
  - Draught
  - Building place
  - Name of the Owner
  - Hull condition, using a scale A/E/I/O/U
  - Condition of the masts and sails, using the scale G/M/B (God, Middling, Bad)

Classification Societies (1)

- The first rules for the classification of wooden ships were published by Lloyd's Register in 1835 and aimed at the periodical survey of the ship in terms of maintenance
- The rules were more oriented for the selection of the timber and the type of connections than to the scantlings of the structure
- Rules based on a numeral obtained from the tonnage value

Classification Societies (2)

- In 1832 it was classified the first steel ship
- The first Rules for steel ships were published by Lloyd's Register in 1855.
- These Rules defined the scantlings of the structure as a function of the tonnage.
- In 1870 LR published new classification rules for steel ships, based on numeral values obtained from the ship dimensions
- In those rules were introduced new symbols of classification consisting in the notation 100A1, 90A1 or 80A1 followed by the Maltese cross

Classification Societies (3)

- The British Corporation Register of Shipping created a new process of classification of ships completely independent from the tradition inherited from the wooden ships
- It has become necessary to submit for approval drawings of the structural details
- From 1916 start to be used simple formulas for the determination of the scantlings of frames, beams, girders and stiffeners

National Authorities

- State Authority that has the responsibility of conceding the Building License and of verifying the compatibility with the international conventions from IMO and with the relevant national standards, issuing the respective Certificates.
- Can delegate in other recognized institutions (namely the Classification Societies) the competence to issue the certificates of conformity with the IMO conventions
- In Portugal, the institution that has this role is the Instituto Portuário e de Transportes Marítimos (IPTM)

Some Legal and Technical Documents Associated to Ship Design

Documents Associated to Ship Design

- Shipbuilding Contract
- Ship Specification (*Especificação ou Memória Descritiva do Navio*)

Types of Shipbuilding Contracts

- **Building a supplied Design**
  - The Owner supplies the Basic Design and requests the Building
- **Design and Building**
  - The enquiry is made in more generic terms, based on a measure of the cargo capacity (deadweight, cargo volume, lane length, TEU, number of passengers, etc.) and/or performance requirements
  - The Yard is responsible by the Design and Building

Shipbuilding Contract

Shipbuilding Contract - What is it?

- It is a legal document
- It is prepared by the technical staff of the contracting parties and the final version should be reviewed by lawyers
- It consists on a set of terms (clauses) and some enclosures
- The terms identify the contracting parties and define the conditions of the business transaction
- The enclosures
  - Price and payment conditions
  - Compensation
  - Milestones
  - Specification
  - Drawings

Shipbuilding Contract

- In most new buildings, conversions and repairs, it is the Builder that issues the first draft of the Contract
- The Contract is generally based on a *pro forma* document
- The most common *pro forma* Shipbuilding Contracts are:
  - SAJ, Shipowners Association of Japan (1974)
  - Norwegian Associations of Shipowners and Shipbuilders (2000)
  - MARAD Standard Form (1980), Maritime Subsidy Board (MSB) of the United States Department of Commerce
  - BIMCO NEWBUILDCON, Baltic and International Maritime Council (2007)
  - ✓ AWES (1972), Association of West European Shipbuilders, currently designated CESA – Committee of European Shipyards' Associations (2004)

AWES Shipbuilding Contract

AWES Shipbuilding Contract (1)

1. Subject of Contract
   - Description and main characteristics of the ship
   - Yard number
   - Registry and Classification of the ship
   - Decision of the Classification Society
   - Sub-contracting by the yard
2. Inspection and Approvals
3. Modifications
   - Due to the Owner
   - Due to the Builder
   - Due to Regulating Offices or to the Classification Society

AWES Shipbuilding Contract (2)

4. Sea Trials
5. Guarantee for Speed, Cargo Carrying Capacity and Fuel Consumption
   - Penalties, Limit of Acceptance, Rewards
6. Delivery of the Vessel
   - Place and Date
   - Documentation
   - Penalties and Rewards
   - Force Majeure
7. Price
8. Property
   - Generic drawings, Specifications and detail drawings
   - Ship

AWES Shipbuilding Contract (3)

9. Insurance
10. Default by Purchaser
    - Penalties due to
        - Missing payments
        - Missing the delivery of the ship
        - Delays in the deliverance of the Owner's Supplies
11. Default by the Contractor
    - Devolution of installments paid and penalties
12. Guarantee after Deliverance
13. Contract Expenses
14. Patents

AWES Shipbuilding Contract (4)

15. Interpretation, Reference to Expert and Arbitration
16. Condition for the Contract to Become Effective
17. Legal Domicile
18. Assignment
19. Limitation of Liability
20. Mail Addresses

BIMCO NEWBUILDCON

BIMCO NEWBUILDCON
Key Features (1)

- Form readily adaptable to all types of vessels in all jurisdictions, including features which will be needed for projects in China.
- More comprehensive provisions detailing obligations during production, particularly subcontracting, approvals and inspection, tests and trials, modifications, and buyers suppliers.
- Buyer's relationship with Class is more clearly defined.
- Mechanisms included to avoid delays in delivery in the event of minor defects.
- Wordings for refund and performance guarantees, vetted by banking lawyers, which are suitable for use in projects in China.

BIMCO NEWBUILDCON Key Features (2)

- Harmonized refund provisions in the event of termination.
- Clearer legal provisions dealing with permissible delays, builders' guarantees, responsibilities and exclusions from liabilities, insurance and termination.
- Responsibility clauses expressed mutually where possible, producing a more balanced contract.
- Comprehensible force majeure clause with an easy-to-check list of force majeure events.
- Checklist of documentation required on delivery.
- New IMO Hazardous Materials Inventory and Protective Coatings clauses.

BIMCO NEWBUILDCON Key Features (3)

- Modernized dispute resolution provisions clause incorporating reference to the latest dispute resolution methods including Class and expert determination, mediation and arbitration.
- Clear provisions relating to provision of refund and performance guarantees.

Shipbuilding Contract – Typical Clauses

- ***Force Majeure***
  - Means any event or occurrence beyond the reasonable control and without guilt or negligence from the Seller that he didn't manage to avoid or bypass
  - Can include for instance, natural disasters, floods, storms, aggravated weather conditions and other Acts of God, fires, explosions, riots, wars, sabotage, labor problems of the Seller (including strikes, but excluding lockouts), energy blackouts, and acts of the government.
- **Default by Contractor** (*Incomprimento pelo Contractado*)
  - Defines the procedure in the case of non compliance with critical requirements (speed, cargo capacity,…)
  - Establish penalties and limits of acceptance of the ship

Trends for New Clauses

- Steel prices
- Currency risk

Typical Installments Plan

- Independently from the type of financing, the payment of the ship to the Builder is generally composed by installments in function of the progress of the construction, in accordance to the stated in the Contract
- A typical installment plan can be as follows:
  - 10% at *Contract Signature*
  - 10% at *Materials Arrival*
  - 10 % at *Keel Laying*
  - 20% at *Launching*
  - 50% at *Delivery*

Refund Guarantees

- What are they?
  - Guarantee of repayment of pre-delivery installments for buyer
  - Not a guarantee of yard's performance
- Who are the refund guarantors?
  - Banks-Export-import banks
  - Insurance companies
  - Importance of credit rating
- Why are they important?
  - Security
  - Financiers will require these

Ship Specification

Ship Specification (1)

- Technical description of the Ship and of all its systems
- Annexed to the Shipbuilding Contract
- Must be signed in every page by the representatives of both the Yard and of the Owner

Ship Specification (2)

- Ship
  - Main dimensions
  - Service speed
  - Classification Society and class notation
  - Cargo, ballast and fuel capacities
  - Autonomy
  - Rules and Conventions considered
- Hull
  - Type of hull construction and materials
  - Surface treatment, painting, cathode protection
- Machinery and Equipment

Ship Specification (3)

- For each System
  - Specification of the components (pumps, compressors,..), quantities and nominal characteristic (flow rate, pressure,..)
  - Driving type, required power
  - Piping, nominal diameters, materials
  - Extension of supply
- Owner Supplies

Examples of Typical Specifications (1)

Deadweight Capacity

- The vessel's deadweight is to be about 145,000 metric tonnes at design draught of 16.00 m in salt water (density 1025 kg/m3).
- The specified deadweight to include fuel and lubricating oils, provisions, consumable stores, fresh water, crew and effects plus spare parts and equipment in excess of what is required by Classification Society, as well as items supplied by the Buyer and Owner's extras.

Examples of Typical Specifications (2)

Speed

- The trial speed on summer draught (abt. 17.10 m) in deep, calm sea with clean hull will be about 15.0 knots with main engine developing 20,300 BHP, which corresponds to its selected maximum continuous rating (MCR). Correction for wind and waves to be done only if weather conditions in excess of Beaufort 2 (two).
- The service speed is estimated to be abt. 14.0 knots at 160,000 TDW and under conditions as above, including a sea margin of 15%.
- Verified speed trial test report to be provided, including a curve showing speed/power on the draught under trial conditions as well as a curve giving the service speed under conditions given above.

Examples of Typical Specifications (3)

Buyer's Deliveries (Owner Supplies)

- The following items to be furnished by the Owner:
  - Equipment, materials and hand tools for bosun's store, paint room, engine room, engine workshop, pumpman shop, electrical workshop except those listed elsewhere in specification.
  - All bedding (blankets, covers, pillows, sheets, except matresses), towels and table cloths.
  - All cook's and steward's utensils (silverware, dishes, glasses, pots, pans, cutleries, crockery,..)
  - ……..

Examples of Typical Specifications (4)

Buyer's Deliveries (Cont.)

- Buyer's supplies are to be delivered to Builder's yard, free of cost, in perfect condition, properly packed and individually identified. Buyer is to cover all expenses of insurance until the arrival of the shipyard.
- The Builder will be responsible for storing and handling, after the delivery to the shipyard.
- A detailed list of Buyer's furnished equipment and materials is to be presented to Builder at the early stage and a schedule will be prepared for deliveries.

Examples of Typical Specifications (5)

Drawings for Buyer´s Approval

- Drawings from the Builder or its subcontractors which require Buyer´s approval prior to commencement of work, shall if otherwise not explicitly agreed, be submitted to Buyer in four (4) copies with a covering letter.
- Buyer to have a reasonable time, not exceeding fourteen (14) calendar days, to study received drawings, whereafter one (1) copy (approved) should be returned to the Builder with Buyer's approval and/or possible comments and with a covering letter.
- When the Buyer find it is impossible to return the approved drawings within the above specified time, the Buyer shall notify the Builder without delay. In case delay is in excess of 7 calendar days and no notice is given by the Buyer, drawings to be considered approved.

Examples of Typical Specifications (6)

Official Sea Trials

- The trials to be conducted at the draught equal to 17.10 m, corresponding to the condition executed at the model tank tests.
- The official speed trials are to take place in deep water and with approved measuring means, which shall be agreed with Buyer.
- The sea weather conditions at this time should be fair or up to Beaufort 3 (three) and at corresponding wave conditions.
- Heavy fuel of viscosity as close to 700cSt. at 50°C as available, but not less tan 350 cSt. at 50 °C shall be chosen as fuel oil in accordance with the approved testing schedule and all endurance tests will be carried out with such oil.
- All horsepowers during the sea trials shall be measured by a torsion meter. MIP diagrams shall be taken.

Ship Specification – General Notes

- In the description of the systems, generally there are no references made to commercial brands
- The identification of the brands decreases the negotiating capacity for the purchasing of the equipments
- However, there are some components (main machinery, auxiliary machinery, cargo pumps,..) which eventually the Owner requires to be from a determined maker (or model) and therefore must be identified in the Specification (generally the main machinery)
- In case of occasional contradictions between the Specification and the drawings, the drawings must prevail

Other Legal Documents

Hull Insurance Contract

- Covers errors in design, material or workmanship and similar "latent defects"
- Initiated with the so-called **Inchmaree Clause**, introduced as a part of the first edition of the English hull insurance clauses, from The Institute Time Clauses-Hull (ITCH), 1888
- The insurance covered loss or damage to hull and machinery through bursting of boiler, breakage of shafts or through any latent defect in the machinery or hull
- The English clause have been revised twice recently, on 2002 and 2003
- The Comity Maritime International (CMI) harmonizes marine insurance clauses

Concept of Latent Defect

- A defect in the construction of a ship or machinery that is not readily discernible to a competent person carrying out a normal inspection.
- Discovery of a latent defect does not give rise to a claim on the ordinary hull policy, but damage caused thereby is usually covered.

Inchmaree Clause

- Standard clause in Marine Insurance contracts
- Covers risk of events not directly linked to perils at sea such as, but not necessarily limited to, loading accidents
- It protects property damaged or destroyed as the result of the negligent acts of the crew.
- The name is derived from a steamer in which a pump was damaged by its crew's negligence.
- A British Court, in 1884, held that such an accident was not a *peril of the sea* and so not covered by the standard wording of insurance contracts of the time
- Since then, maritime insurance contracts specifically address that by including a comprehensive clause on such risks that, while not directly linked to perils of the sea, nonetheless relate directly to shipping

UK Marine Insurance Act (MIA)

- UK Marine Insurance Act (MIA), 1906
- Reviewed in 1909, 1963, 1994, 2002, 2003

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- ✓ Veenstra, Albert W. and Ludema, Marcel W.(2006), "The Relationship Between Design and Economic Performance of Ships", Maritime Policy & Management, Vol.33, No.2, pp.159-171. (CD-ROM#51)

Organizations (1)

- Baltic and International Maritime Council (www.bimco.org)
- British Marine Equipment Association
- Comite Maritime International (www.comitemaritime.org)
- Community of European Shipyards Associations – CESA (www.cesa-shipbuilding.org)
- Hill Dickinson Marine Lawyers (www.hilldickinson.com)
- MARAD – US Maritime Administration (www.marad.dot.gov)
- Society of Maritime Industries (www.maritimeindustries.org)

Organizations (2)

- UK Shipbuilders and Shiprepairers Association (www.ssa.org.uk)
- Nordic Association of Marine Insurers (www.cefor.no)
- Norwegian Marine Insurance Plan (www.norwegianplan.no)
- Norwegian Maritime Law Association
- Norwegian ShipOwners Association

National Links

- www.imarpor.pt (Instituto Portuário dos Transportes Marítimos)
- www.ancruzeiros.pt (Lista de Legislação Náutica de Recreio)
- www.fpvela.pt (Federação Portuguesa de Vela)
- www.hidrografico.pt (Instituto Hidrográfico)
- www.isn.org.pt (Instituto de Socorros a Náufragos)

Annex A. Systems for the Classification of Ship Systems and Components

Systems for the Classification of Ships

- Were developed to provide to the yards and to the companies involved in the management and operation of ships tools to support the following activities:
  - Ship Specifications
  - Estimative of ship building (or repair) costs
  - Estimative or determination of the Lightship Weight
  - Procurement of materials, equipments and services

Some Existing Classification Systems

- **MARAD** - MARitime ADministration, used by the U.S.A. administration
- **SWBS** - Ship Work Breakdown Structure, used by the USA Navy and adopted by the Portuguese Navy (ICAM).
- **SFI** – developed by the Ship Research Institute, from Norway

- The SWBS and the SFI are organized in a number of main groups, wich are divided in groups, sub-groups e so on.
- The MARAD system is less defined and complete in its structure
- In each of these systems, a *classification number* is assigned to each item or group of items of the ship, according to a tree structure.

MARAD

- It is a system based in three digits.
- Letters are used to define the three main groups:
  - A. Steel hull
  - B. Outfit
  - C. Propelling machinery

Ship Work Breakdown Structure (1)

- System based in three characters

SWBS	Title
100	**Structure**
164	Ballistic Plating
165	Sonar Domes
191	Ballast, Fixed or Fluid and Buoyancy Units

Ship Work Breakdown Structure (2)

SWBS	Title
200	**Propulsion**
202	Machinery Plant Central Control Systems
233	Propulsion Internal Combustion Engines
241	Propulsion Reduction Gears
242	Propulsion Clutches and Couplings
243	Propulsion Shafting
244	Propulsion Shaft Bearings
245	Propellers
259	Uptakes

Ship Work Breakdown Structure (3)

SWBS	Title
300	**Electrical**
311	Ship Service Power Generation
400	**Command and Control**
403	Personal Safety
420	Navigation System
421	Non Electrical/ Non Electronic Navigation Aids
433	Announcing System
437	Indicating Order and Metering System
440	Exterior Communications
450	Surveillance Systems (Surface)
460	Surveillance Systems (Underwater)
470	Countermeasures
480	Fire Control Systems
491	Electronic Test, Checkout and Monitoring Systems
493	Non-combat Data Processing Systems

Ship Work Breakdown Structure (4)

SWBS	Title
500	**Auxiliary Systems**
512	Ventilation System
514	Air Conditioning
520	Sea Water Systems
529	Drainage and Ballasting System
533	Potable Water
541	Ship Fuel and Fuel Compensating System
542	Aviation and General Purpose Fuel Systems
553	O2N2 System
555	Fire Extinguishing System
561	Steering and Diving Control Systems
573	Cargo Handling Systems
581	Anchor Handling and Stowage Systems
582	Mooring and Towing System
588	Aircraft Handling, Service and Stowing
589	Miscellaneous Mechanical Handling Systems

Ship Work Breakdown Structure (5)

SWBS	Title
600	**Outfit and Furnishings**
625	Airports, Fixed Portlights and Windows
640	Living Spaces
644	Sanitary Spaces and Fixtures
651	Commissary Spaces
652	Medical Spaces
671	Lockers and Specially Stowage
673	Cargo Stowage

Ship Work Breakdown Structure (6)

SWBS	Title
700	**Weapons**
710	Guns and Ammunition Systems
720	Missiles and Rocket Systems
750	Torpedo Systems
770	Cargo Munitions Handling and Stowage
780	Aircraft Related Weapon Systems

ICAMN

- Índice de Classificação por Assuntos do Material Naval
- System adopted by the Portuguese Navy, based on the SWBS from the US Navy
- Oriented essentially to naval ships (combatant and auxiliary)
- PGSUM 001 (B), "Índice de Classificação por Assuntos do Material Naval", Superintendência dos Serviços de Material, 2004.

ICAMN – Áreas Funcionais

0 – Estudos e Requisitos da Marinha e Contractação
1 – Casco
2 – Instalação Propulsora
3 – Instalação Eléctrica
4 – Comando e Vigilância
5 – Sistemas Auxiliares
6 – Aprestamento
7 – Armamento
8 – Projecto, Construção e Alterações
9 – Montagem (Integração) e Serviços de Apoio à Construção e à Manutenção
Apêndice A - Carga

SFI Group System (1)

- The SFI is a system for the classification of the ship equipment and components, that was developed and published by the Norge Skips Forsknings Institutt (NSFI) from Noruway, and which is now property of XANTIC (www.xantic.net).
- This system is based on a three digit classification, and it comprises 10 main groups. Each of these is subdivided in 10 groups and each of these in 10 sub-groups.

Therefore, the item number will have the format:

M G S

where:

M – digit of the main group
G - digit of the group
S - digit of the sub-group

SFI Group System (2)

- Lately an extension was developed, *SFI Detail Code*, which increases the number of digits to 6, to allow the identification of items at a more detailed level.
- At the highest level, from the 10 main groups, only 8 are currently utilized for Ships:
  0. (reserved)
  1. Ship General
  2. Hull
  3. Equipment for Cargo
  4. Ship Equipment
  5. Equipment for Crew and Passengers
  6. Machinery Main Components
  7. Systems for Machinery Main Components
  8. Ship Common Systems
  9. (reserved)

SFI Group System (3)

- There is also a SFI Group System for Rigs with the following Main Groups:
  1. Rig General
  2. Hull and Structure
  3. Drilling Equipment and Systems
  4. Platform Equipment
  5. Equipment for Crew
  6. Machinery Main Components
  7. Systems for Machinery Main Components
  8. Platform Common Systems

1. Ship General

10. Specification, Estimating, Model Testing, Drawings, Ordering
11. Insurances, Fees, General Expenses, Representation
12. General Work and Models
13. Provisional Rigging During Construction
14. Work in Connection with Ways, Launching and Docking
15. Inspection, Measurements, Tests and Trials
16. Guarantee and Mending Work
17. (reserved)
18. (reserved)
19. General Consumption Articles

2. Hull

20. Hull Materials, General Hull Work
21. Afterbody
22. Engine Area
23. Cargo Area
24. Forebody
25. Deck Houses, Superstructures
26. Hull Outfitting
27. Material Protection, External
28. Material Protection, Internal
29. Miscellaneous Hull Work

3. Equipment for Cargo

30. Hatches and Ports
31. Equipment for Cargo in Holds and on Deck
32. Special Cargo Handling Equipment
33. Deck Cranes with Rigging, etc. for Cargo
34. Masts, Posts with Derrick Booms, rigging and Winches, for Cargo
35. Loading and Discharging Systems for Cargo
36. Freezing, Refrigerating and Heating Systems for Cargo
37. Gas/Ventilation Systems for Cargo Holds/Tanks
38. Auxiliary Systems for Cargo
39. (reserved)

4. Ship Equipment

40. Maneuvering Machinery and Equipment
41. Navigation and Searching Equipment
42. Communication Equipment
43. Anchoring, Mooring and Towing Equipment
44. Repair, Maintenance and Cleaning Equipment, Outfitting in Stores and Workshops, Name Plates, Special Foundations
45. Lifting and Transport Equipment for Machinery Components
46. Hunting, Fishing and Processing Equipment
47. Armament, Weapons and Weapon Countermeasures
48. Special Equipment
49. (reserved)

5. Equipment for Crew and Passengers

50. Lifesaving, Protection and Medical Equipment
51. Insulation Panels, Partition Bulkheads, Doors, Side Scuttles, Windows and Skylights
52. Internal Deck Covering, Ladders, Steps, Railing, etc.
53. External Deck Covering, Ladders, Steps, etc., Fore and Aft Gangway and Deck Equipment
54. Furniture, Inventory and Entertainment Equipment
55. Galley and Pantry Equipment, Arrangements for Provisions, Ironing and Drying Equipment, Laundry.
56. Lifting and Transport Equipment for Crew, Passengers and Provisions. Shore Gangway Equipment and Helicopter Platform
57. Ventilation, Air-Conditioning and Heating Systems
58. Sanitary Systems with Discharges, Drainage Systems for Accommodation
59. Other, for Passenger Ships

6. Machinery Main Components

60. Diesel Engines for Propulsion
61. Steam Machinery for Propulsion
62. Other Types of Propulsion Machinery
63. Transmissions and Foils
64. Boilers, Steam and Gas Generators
65. Motor Aggregates for Main Electrical Power Production
66. Other Aggregates and Generators for Main and Emergency Electrical Power Production
67. Nuclear Reactor Plants
68. (reserved)
69. (reserved)

7. Systems for Machinery Main Components

70. Fuel Oil Systems
71. Lube Oil Systems
72. Cooling Systems
73. Compressed Air Systems
74. Exhaust Systems and Air Intakes
75. Steam, Condensate and Feed Water Systems
76. Distilled and Make-up Water Systems
77. (reserved)
78. (reserved)
79. Automation Systems for Machinery

8. Ship Common Systems

80 Ballast and Bilge Systems, Gutter Pipes Outside Accommodation
81 Fire and Lifeboat Alarm Systems, Firefighting Systems, Wash Down Systems
82. Air and Sounding Systems from Tanks to Deck
83. Special Common Hydraulic Systems
84. Central Heat Transfer Systems with Chemical Liquids
85. (reserved)
86. (reserved)
87. (reserved)
88. Electrical Common Systems
89. Electrical Distribution Systems

Annex B. Classification of the Wind Force

Beaufort Wind Scale (1)

- Scale to estimate the wind speed created by the British admiral Sir Frances Beaufort (1805)
- Developed to help the seamen to estimate the wind speed by visual observation
- The wind speed associated to a given scale value can be obtained by the formula:

$$v = 0.837\, B_{scl}^{1.5} \quad [m/s]$$

- The scale was enlarged in 1944 by adding forces 13 to 17 for special weather conditions such as cyclones and tropical storms (used exclusively in Taiwan and China)
- The Beaufort scale is often used to define environmental conditions for ship speed measurements in sea trials

Beaufort Wind Scale (2)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
0	0	0	0	0-0.2	0 / 0 / 0	Calm	0	0	Flat.	Calm. Smoke rises vertically.
1	1-3	1-6	1-3	0.3-1.5	2 / 4 / 2	Light air	0.1	0.33	Ripples without crests.	Wind motion visible in smoke.

Beaufort Wind Scale (3)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
2	4-6	7-11	4-7	1.6-3.3	5 / 9 / 6	Light breeze	0.2	0.66	Small wavelets. Crests of glassy appearance, not breaking	Wind felt on exposed skin. Leaves rustle.
3	7-10	12-19	8-12	3.4-5.4	9 / 17 / 11	Gentle breeze	0.6	2	Large wavelets. Crests begin to break; scattered whitecaps	Leaves and smaller twigs in constant motion.

Beaufort Wind Scale (4)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
4	11-16	20-29	13-18	5.5-7.9	13 / 24 / 15	Moderate breeze	1	3.3	Small waves.	Dust and loose paper raised. Small branches begin to move.
5	17-21	30-39	19-24	8.0-10.7	19 / 35 / 22	Fresh breeze	2	6.6	Moderate (1.2 m) longer waves. Some foam and spray.	Smaller trees sway.

Beaufort Wind Scale (5)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
6	22-27	40-50	25-31	10.8-13.8	24 / 44 / 27	Strong breeze	3	9.9	Large waves with foam crests and some spray.	Large branches in motion. Whistling heard in overhead wires. Umbrella use becomes difficult.

Beaufort Wind Scale (6)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
7	28-33	51-62	32-38	13.9-17.1	30 / 56 / 35	Near gale	4	13.1	Sea heaps up and foam begins to streak.	Whole trees in motion. Effort needed to walk against the wind.
8	34-40	63-75	39-46	17.2-20.7	37 / 68 / 42	Gale	5.5	18	Moderately high waves with breaking crests forming spindrift. Streaks of foam.	Twigs broken from trees. Cars veer on road.

Beaufort Wind Scale (7)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
9	41-47	76-87	47-54	20.8-24.4	44 / 81 / 50	Strong gale	7	23	High waves (2.75 m) with dense foam. Wave crests start to roll over. Considerable spray.	Light structure damage.

Beaufort Wind Scale (8)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
10	48-55	88-102	55-63	24.5-28.4	52 / 96 / 60	Storm	9	29.5	Very high waves. The sea surface is white and there is considerable tumbling. Visibility is reduced.	Trees uprooted. Considerable structural damage.

Beaufort Wind Scale (9)

Beaufort number	Wind speed				Mean wind speed (kt / km/h / mph)	Description	Wave height		Sea conditions	Land conditions
	kt	km/h	mph	m/s			m	ft		
11	56-63	103-117	64-72	28.5-32.6	60 / 111 / 69	Violent storm	11.5	37.7	Exceptionally high waves.	Widespread structural damage.
12	>63	>117	>72	>32.7	N/A	Hurricane	14+	46+	Huge waves. Air filled with foam and spray. Sea completely white with driving spray. Visibility very greatly reduced.	Massive and widespread damage to structures.

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Annex C. Douglas Sea Scale

Douglas Sea Scale

- Created by the English Admiral H.P. Douglas in 1917, while he was head of the British Meteorological Navy Service
- Its purpose is to estimate the sea's roughness for navigation.
- Consists of two codes:
  - one for estimating the state of the sea (fresh waves attributable to local wind conditions)
  - the other for describing sea swell (large rolling waves attributable to previous or distant winds)

Douglas Sea Scale

The Douglas Sea Scale is expressed in one of 10 degrees:

- Degree 0—no measurable wave height, calm sea
- Degree 1—waves <10 cm., rippled sea
- Degree 2—waves 10–50 cm., smooth sea
- Degree 3—waves 0.5–1.25 m., slight sea
- Degree 4—waves 1.25–2.5 m., moderate sea
- Degree 5—waves 2.5–4 m., rough sea
- Degree 6—waves 4–6 m., very rough sea
- Degree 7—waves 6–9 m., high sea
- Degree 8—waves 9–14 m., very high sea
- Degree 9—waves >14 m., phenomenal sea