

SHIP CONSTRUCTION AND RISK ASSESSMENT?

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1. INTRODUCTION

The heading of this speech is "Shipconstruction and ... Risk assessment?"

Yes, we should apply risk assessment to shipconstruction, but before we do so, we should study IMO / flag state and classification legislation and rules and regulations, which are one of the basic requirements for the naval architect to design and engineer a ship construction.

In this capitalistic world, it is however economics and competition which rule the waves. In general a shipowner can not afford to build a ship to a specification, which exceeds the requirements of legislation, and rules and regulations. He is therefore forced to build ships, which are fit for purpose, but as close as possible to the requirements of legislation, and rules and regulations. If he does so, he cannot be assured that he has built a safe and reliable ship.

It is therefore necessary that we first look into the history of shipconstructions and the applicable legislation, and rules and regulations.

We will learn that if we strictly apply and take advantage of the legislation, and rules and regulations in an economic sense we might end up with an unsafe ship.

Most partners in the shipping industry realise this and we are now looking into the legislation, and rules and regulations with a sense of safety and reliability to build robust ships which can sail the seas safely and environmentally friendly. We should however never forget that the seas are as substandard an environment as we could wish to find, which is the main reason why there is no room to be complacent about quality and safety.

If we wish to do so we have to change our culture from a method based culture of compliance i.e. in compliance with the present legislation, and rules and regulations which are in fact a minimum standard or the highest practicable to ... a goal based culture of improvement which requires the settings of safety and performance standards and criteria, rather than the prescribing of procedures or particulars of design.

The above would require a formal safety assessment (FSA) and the failure mode and effects analysis (FMEA).

However the reactive and prescriptive legislation, and rules and regulations, in certain areas supplemented by goal oriented regulations such as for complex structures and novel design, will continue to play an important role. But having said that, it is equally probable, that there may be a growing pressure on the industry to take a more risk based approach to safety.

Let us now look into:

- Historical bird's-eye view
- Legislation, and rules and regulations
- Naval architect, ship design and construction

2. HISTORICAL BIRD'S-EYE VIEW

For many centuries ship designers and builders enjoyed the pleasure of freedom from formal rules and regulations.

They designed and built ships using their craftsmanship while endeavouring to comply with the requests of their clients.

In the 17th century books on naval architecture were published.

This was also the century of Lloyd's Coffee house, the Register of Shipping and the Register's Society.

Ship- and cargo owners and underwriters developed rules for the seaworthiness of ships.

All parties cooperated on the basis of trust and responsibility.

In the 18th and 19th century the basis for cooperation of parties remained to be trust and responsibility.

In this period classification societies were established from a need by Owners, Underwriters, Shippers and Financers, who required an independent opinion on the fitness of a ship to trade and the risk involved.

The classification societies, each for themselves, developed rules for the construction and building of hulls and machinery.

Also maritime flag states developed legislation which however differed substantially from each other.

Particular developments were:

- Loadlines, freeboard and Plimsoll marks
- Various legislation by maritime flag state
- Merchant Shipping acts
- Requirements for the qualification of ship's officers.

In the 20th century developments continued. This period however must be split into the period upto 1945/50 and the period after 1945/50.

It should however be noted that rules and regulations from classification societies and flag states legislation remained far from uniform.

In the period upto 1945/50 shipowners were concerned and proud about their traditional shipping companies. Their objective was the transport of goods by sea and they still cooperated on the basis of trust and responsibility.

The sinking of the "Titanic" in 1912 however resulted in Solas 1914, which are reactive and prescriptive regulations. Rules and regulations continued to be reactive i.e. in reaction of incidents, accidents, etc., such as Torrey Canyon (1967), Amoco Cadiz (1978), etc. until to date.

The period from 1945/50 till to date was initially characterised by the shortage of shipping capacity required for the rebuilding, constructions, development and economical growth after world war 2.

The shipbuilding capacity was adapted to the demand, but the scale tipped and until the mid 1970's an overcapacity was built.

The growth was driven by cheap loans and government subsidies. The overcapacity caused a crisis with ups and downs until the end of the 20th century.

In the same period independent shipowners appeared in the shipping arena some of which did not have the maritime background and their objectives were mainly economically with financial profit in mind i.e. asset play/fast money.

The rules and regulations followed with the establishment of IMCO in 1948, which changed into IMO in 1959 and IACS was created in 1968 and recognised by IMO in 1969.

It was the intention to develop unambiguous rules and regulations, applicable for all flag states.

The rules and regulations expanded in reaction to various incidents, such as Solas with amendments, MARPOL with amendments, USCG-OPA 90, IMO codes (ISM, ISPS, STCW), etc.

The overcapacity and crises also brought about the following:

1. Flags of convenience.
2. IMO/Flag state regulation and legislation, but under political pressure were the highest practicable or maximum attainable.
3. Classification society's rules which were the minimum, but were applied as the maximum.
4. Flat states delegated their activities to classification societies.
5. Competition between classification societies
6. Insufficient requirements for ship's crews, such as minimum safe manning and competency.

These factors initiated, as from about 1975, the substandard ships and shipping, which we still have today.

The reaction to substandard shipping, and particularly in response to the OECD report of 1995, was fierce with the partners in the shipping industry developing inspections on board ships independently from existing authorities, flag states and classification societies.

Additional rules and regulations were developed to the point of overkill.

The shipping industry was being plagued by the continuing growth of rules, regulations and inspections, which became unmanageable for shore- and ship's personnel.

In fact the 'law of nature' applies:

"Each regulating activity will result in an additional increase of disorder and chaos"

The 21st century and the future

And that is where we are today, but how do we restore trust in shipping.

3. LEGISLATION, AND RULES AND REGULATION

The historical bird's-eye view has given a general outline of developments in the shipping industry.

The following gives an abridged outline of the regulatory bodies and legislation and rules and regulations.

3.1 REGULATORY BODIES

The international and national legislation, rules and regulations are adopted, implemented and enforced by:

- IMO and flag states
- Classification societies

3.1.1 IMO and flag states

IMO is the International Maritime Organisation formed as a specialised UN-agency, who sets standards in IMO conventions, codes and other instruments, which are developed following proposals made by member Flag states, that are both users and providers of international shipping services, and are generally adopted on a consensual basis.

Flag states have the responsibility to implement and enforce these standards on ships flying their flag to ensure the safety of life at sea and in ports and a clean marine environment.

The major aims of IMO are as follows:

- To provide an effective machinery for technical, legal and scientific cooperation among Flag states in the field of the protection of the marine environment from pollution from ships and related activities.
- To adopt the highest practicable standards in matters concerning maritime safety and the prevention and control of marine pollution from ships and related activities.
- To encourage the widest possible acceptance and effective implementation of these standards at the global level.

The IMO regulations are the international agreed minimum standards.

They are not the highest possible or conceivable standards, but the highest practicable.

Flag states however can ask, from ships under their flag, higher standards than those laid down in IMO's convention, but they can not go lower.

The IMO conventions mainly consist of:

- SOLAS, safety of life at sea
- MARPOL, prevention and control of marine pollution
- ISM code, international safety management
- ISPS code, international ship and port security code
- STCW, standards of training, certification and watchkeeping, the HUMAN factor
- Tonnage Measurement
- Load Lines
- Collision Regulations
- Various Codes
- Etc.

The IMO should have the authority to control and police, but has not.

The necessity of achieving wider enforcement of IMO conventions was considered such an important issue that, some years ago, it was decided to set up a specific subcommittee for this purpose which was called Flag State Implementation (FSI).

The new body has developed important instruments and guidelines to facilitate Flag states in fulfilling their obligations under the applicable conventions but the core of the problem still remains unresolved, i.e. how to **strengthen the IMO role in the enforcement process**. For the time being, there continues to be widespread resistance to granting the IMO any enforcement authority of this kind.

A number of Port states have adopted Port State Control (PSC), but their authority is limited and their inspections are generally superficial, with insufficient depth and detail.

It is the Flag state shipping inspectorates who in fact are the only parties, who can act, but only on ships flying their Flag.

It is therefore disappointing and frustrating that a great many of Flag states have delegated their responsibility to classification societies.

3.1.2 Classification societies

The main function of a classification society is to lay down standards for the construction and subsequent maintenance of ships and to ensure that these standards are fully implemented. These standards are published in the form of Rules and Regulations and Procedures.

It should be appreciated that, in general, classification Rules and Regulations do not cover such matters as the ship's floatational stability, life saving appliances, pollution prevention arrangements, and structural fire protection, detection and extinction arrangements where these are covered by the IMO conventions and Flag state requirements and the amendments thereto, **nor do they protect personnel on board** from dangers connected with their own actions or movement around the ship.

This is because the handling of these aspects is the prerogative of the Flag states with which the ship is registered.

A great many of these Flag states, however, delegate such responsibilities to the Classification Societies who then undertake them in accordance with agreed procedures.

Classification Societies however have no authority to carry out surprise or unplanned inspections/ surveys. Class surveyors are but occasional visitors.

Class can only attend periodical surveys as defined in their Regulations and only at the request of the Owner/ Operator/ Manager, or at the request of the Owner/ Operator/ Manager in accordance with his responsibilities and Regulation requirements.

Periodical surveys are carried out on annual, intermediate (2 to 3 years) or special survey (5 years) cycles, thus a great number of inspections/ surveys are carried out in a five (5) year cycle, whilst a ship could be neglected in maintenance and deteriorate within six (6) months and affect her safety.

Furthermore unprotected steel could be affected by corrosion to such an extent that her remaining strength will be below the requirements of the Classification Society within five (5) years or less.

All partners in the shipping industry have their specific interest in shipping, but all wish to maintain or increase the safety of ships sailing at sea and carrying their goods.

Their interests however are conflicting and in many cases have resulted in substandard shipping.

The classification Society=s on their own have not and can not maintain the safety of ships under all circumstances due mainly to the following:

- Class dependence on the shipowners or for newbuilding on shipyards
- Conflict of interest as class is often carrying out statutory surveys and issuing certificates on behalf of Flag states.
- Classification rules and Regulations and procedures are the absolute minimum standards.
- Class has no or at least very limited authority to implement and enforce regulations.
- Class in fact does not have direct responsibility.

3.1.3 **Final remarks**

The classifications society=s are willingly or unwillingly the ΔAchilles Heel of Safety Assurance@, but aren't all the partners in the shipping industry responsible.

IMO and Flag states are however the only partners, entitled to issue legally binding national and international regulations which have to be implemented, enforced, supervised and controlled, but we still have a long way to go, and are influenced by political factors and conflicting interests.

3.2 **LEGISLATION AND RULES AND REGULATIONS**

The international rules and regulations by IMO, Flag states and classification societies provide a kind of level playing field.

The question is how can we achieve safety by:

- The prescriptive or regulatory approach, the method-based culture of compliance or
- The goal setting and risk reduction approach, i.e. the goal-based culture of compliance

The present regulations are prescriptive and regulatory.

There is however a tendency towards the minimalistic approach, but the interpretation of the regulations is maximum requirements.

There is a focus on compliance rather than an actually achieving safety.

The present flag / IMO and classification rules and regulations can be described in the following groups:

- Technical regulations
- Safety regulations
- Economical regulations
- Operational regulations
- Security regulations

3.2.1 **Technical regulations**

How to build a ship!

- Classification Rules & Regulations (minimum)
- IMO Codes (highest practicable)

These regulations mainly include the rules and regulations of the classification societies, for how to design and build a ship to keep her afloat and operate her satisfactorily under normal operating conditions.

3.2.2 **Safety regulations**

IMO / Flag state

- Statutory regulations : SOLAS
Marpol
Loadline
Collision regulations
Various codes

Mainly in reaction of incidents, therefore subjective and a compromise

Includes most of the statutory regulations issued by IMO and Flag state such as subdivision, stability, structural fire protection etc.

These requirements were introduced following major disasters and as a consequence these requirements are in essence rather subjective.
They are the result of compromises between different opinions on how to avoid such disasters or to restrict its effects.
They are not based on simple and unambiguous engineering rules.
Consequently these requirements have a great effect on the work of the designer.
They determine to a greater or lesser extent, depending on the ship type, the geometry and the subdivision of the ship.

3.2.3 **Economical regulations**

- Tonnage Measurement Rules

THE WEAKEST LINK

Sometimes referred to as the drive to unsafe ships.

IMO and Flag state regulations, which have no relation with technical or safety matters, but the effect may have economical consequences for the Owner.
The ΔTonnage Regulations@ in this respect plays a role as port and others dues are based on the gross tonnage.
The formula for gross tonnage is a function of ship=s length, breadth, depth and volume of superstructure.
The depth parameter is favoured by designer=s to minimize gross tonnage.
A reduction in depth would reduce the freeboard, which in turn reduces the ship=s reserve buoyancy, thus adversely affecting the ship=s safety.

3.2.4 **Operational regulations**

These include the IMO and Flag state regulations s.a. ISM code and manning regulations (STCW).
It is here where the HUMAN FACTOR should be directed and in this respect we quote William O=Neil, previous IMO secretary general:

*It is easy, in an age where technology is changing at a staggering rate, to be impressed by the wonders that are unfolding every day that we tend to assume that science and technology can solve everything.
They can certainly do a great deal, but we should never forget that safety concerns, and is primarily about, PEOPLE.*

The human factor is a critical factor of all aspects of ship or system design and operation.
Human error may be the immediate cause of an accident.
The root cause can often be traced back to human influences on design and construction.

3.2.5 **Security regulations**

The International Ship and Port Security code (ISPS code).

This code was adopted as a consequence of terrorism and piracy.
This code applies to the chain of ship, port, harbour, terminal and related companies.
The future will learn us whether this code is effective.

4. NAVAL ARCHITECT, SHIP DESIGN AND CONSTRUCTION

A ship is designed and built in compliance with the requirements of the shipowner and legislation and rules and regulation, but notwithstanding, the end product might be "substandard".

Naval architecture in it's application is not an exact science, but as from the 1960's it has developed substantially, particularly due to application of computer technology.

We should however never forget that the input sets the standard for the output.

Herebelow an outline is given for the development in the design and building of ships as from the 1960's.

4.1 THE 1960=s

In the 1960=s the design was still heavily reliant on empirical formulae s.a.

- Determination of hull and wavemaking resistance.
- Hydrostatic characteristics of a given hull form.
- Longitudinal bending or shear stresses on a hull structure.
- Propulsive power calculation.
- Damaged state residual stability.
- Etc.

Result: Ship=s built in the 1960=s upto 1980 were rugged and strong designs and simple to built.

4.2 IN THE 1980=s

In the 1980=s naval architecture was moving towards a more exact science with modern computing techniques.

Mathematical modelling of sea state, finite element analysis etc., but we still required judgement and experience of the individual designer.

Progressively alloy steels were applied.

New designs were optimised with minimum scantlings.

Result:

- New designs were barely meeting strength requirements.
- Building of ships required high skill and modern techniques.
- Building errors could be catastrophic.

Note: Statistics indicate that ships of this period had a lower lifespan and a higher risk span

4.3 THE 1990=s

In the 1990=s and today we are rethinking our designs, rules and regulations and standards on the basis of life span, fatigue life and corrosion margins.

Result:

- Quality ships.
- Reliable, safe and efficient.

4.4 THE 2000'S

Notwithstanding the development in the 1990's we have to remain alert.

The concept of phasing out of single hull tankers and the requirements in the pipeline for bulkcarriers, etc. have moved the shipdesigner and naval architect towards:

- Optimised designs and light scantling i.e. double hull is not double strong
- Increased application of high tensile steel and furthermore
- The currently accepted practices of management and maintenance may result in
 - increased stress areas and increased structural problems
 - increased corrosion particularly due to varying corrosion control margins
 - double hulls, complicated and optimised design built to certain standards are practically "non-maintainable"

4.5 TODAY AND THE FUTURE

The rules and regulations are at present of a prescriptive nature facilitating the application in certain designs.

They give an exact description of the means to achieve the goal s.a. sufficient strong structure and reliable machinery and equipment.

The advantages of prescriptive rules are that they:

- Are widely known and used
- Do not require advanced structural knowledge
- Enable designs to be generated rapidly
- Are respected as being generally reliable, at least for conventional ship types, sizes and materials
- Include much structural expertise into readily-used formulae or tables
- Are backed by extensive feed-back of data on service experience, and by the practical judgement of rule developers

However, the following disadvantages are sometimes mentioned, some of which are more important or real than others.

- They are difficult to apply to novel designs or unusual circumstances, or to incorporate new technology
- They are not sufficiently explicit in defining load actions, limit states, design criteria or safety standards
- They do not provide a good basis for future development as technology becomes more complex or diversifies
- Some conventions and regulations may lead to unsafe ships particularly the economical regulations

It is further felt by some that the primary function of rules and regulations should be the setting of standards and criteria to which designs should conform to ensure safety and reliability, rather than the prescribing of procedures or particulars of design.

Also a review of modern practice in other major fields of structural engineering, such as offshore structures and land civil structures, shows changes towards standard-setting codes which are less prescriptive and more explicit in ensuring safety by requiring a proper relationship between expected operating conditions and the possible failure modes of structures.

Although both prescriptive and performance standards are already embedded in the Rules and Regulations and Procedures of classification societies, it is anticipated that in the future the performance standards will play a more significant role in the design process.

The concept of Formal Safety Assessment (FSA) therefore becomes more widespread in the maritime industry.

This could result in a more scientific approach to ship safety, also with an emphasis on performance or goals rather than prescriptive requirements using risk assessment or the so called safety case regime.

A Formal Safety Assessment (FSA) could comprise the following steps:

- Identification of hazards
- Assessment of risks associated with those hazards
- Consideration of alternative ways of managing risks
- Cost benefit assessment of alternative risk management options
- Decisions on which options to select

This method could be adopted as the basis for deriving future classification and convention requirements.

This would provide the advantages of a risk based approach while avoiding the disadvantages associated with a safety case regime for individual ships.

If successful, such an approach would bring a number of advantages. It would:

- Enable a consistent and comprehensive regulatory framework to be developed, which addresses all aspects of maritime safety in an integrated way
- Facilitate cost effective regulation, whereby safety investment is targeted where it will achieve the greatest benefit
- Be proactive (rather than reactive) in its approach, enabling hazards that have not yet given rise to accidents to be properly considered
- Give confidence that the system of regulation and control is risk based, i.e. that regulatory requirements are in proportion to the severity of the risks being controlled and
- Provide a rational basis for assessing and controlling new risks posed by ever changing marine technology

Studies have shown that the Formal Safety Assessment method could be practicable and beneficial to the shipping industry.

However, the introduction will be a slow process.

It is not expected that it will become an important tool for the design of individual ships.

But it may become an attractive method for general requirements, as mentioned above, for special ships, for novel designs, for a large series of ships of the same type or for special facets of the ship design process.

The failure mode and effects analysis (FMEA) in this case would address e.g.

- Separation of machinery compartments
- Demonstration that a single failure in the propulsion and related auxiliary systems will not cause loss of all propulsion or steering capability
- Fire in a machinery space or control room
- Flooding of any watertight compartment which could affect propulsion or steering capability

In conclusion, it is not expected that performance standards and safety case methods will in the foreseeable future be required universally for ships.

The prescriptive rules, in certain areas supplemented by goal oriented regulations such as for complex structures and novel designs, will continue to play an important role.

But having said that, it is equally probable that there may be a growing pressure on the industry to take a more risk based approach to safety.

5. CONCLUSION

The international regulations and ship design have an essential relationship. This relationship stems from the designer's primary objective to design a ship for specific service conditions with optimum life cycle costs, while complying with international regulations.

The designer will endeavour to strike the right balance between the various criteria placed by the owner, shipyard, classification society and national administration.

If the relationship between regulations and ship design is to be successful, then it should make sense:

- Economic sense
the drive behind every commercial shipping activity
- Technological sense
the ability to drive the activity
- Social sense
the acceptance of consequences and responsibilities

As the economics of design change under pressures of international regulations, the ship design profession has to be prepared to meet changing needs.

On the other hand, those people responsible for the rules and regulations should understand and appreciate the position of the other players in the field; without of course losing sight of their ultimate responsibility towards the issue of safety and reliability.

Practice shows that these conditions may be fulfilled and when this is the case the relationship between ship design and rules and regulations is not only unavoidable and essential but also healthy.

But, in spite of all endeavours of designers and rulemakers the following words from Rudyard Kipling remain true:

ΔThis new ship here is fitted according to the reported increase of knowledge among mankind.

Namely, she is cumbered end to end, with bells and trumpets and clock and wires, it has been told to me, can call voices out of the air of the waters to con the ship while her crew sleep.

But sleep Thou lightly.

It has not yet been told to me that the Sea has ceased to be the Sea@.