Risk-Based Ship System Approval Process

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GL: Worldwide service on site

Over 3,200 employees, of which 1,900 are engineers, are working for you in over 176 offices in more than 76 countries.
Over 100 years of GL
– over 100 years of service

• Monitoring of ship newbuildings
  Outstanding know-how in design, construction and approval of technically demanding vessels

• Supervision of the GL classified fleet
  Regularly monitoring of the operating condition of vessels and assistance in ensuring the smooth and reliable sailing of ships

• Research and development
  Ship newbuilding is becoming increasingly challenging, GL is the leader with regard to hydromechanics, acoustics, oscillation behaviour and stability

• Engineering services
GL classification: The foundation for safe operations

Classification is important for:

- Shipowners and charterers
- Shipyards and sub-contractors
- Banks
- Maritime insurance companies
- National maritime safety authorities which issue so-called ‘trading certificates’ as a prerequisite for the operation of a ship
Germanischer Lloyd – Ship Classification since 1867
Germanischer Lloyd

Maritime Services

Industrial Services

Industrial Services
Advanced engineering and strategic research
Development engineering and strategic research

Collision investigations using modern calculation methods
- Optimisation of the construction
- Resistance to penetration and distortion
Development engineering and strategic research

Sound gauge prediction using NoiseFEM

- Prediction of structure-borne noise propagation
- Use of existing FE models
- Identification of main structure-borne noise path
- Prediction of noise level in work and accommodation areas

Noise level
Development engineering and strategic research

- Ship – sea interaction
Development engineering and strategic research

The 13,440 TEU container ship – design study

Length: 382.0 m
Breadth: 54.2 m
Draught: 13.5 m
Speed: 25.5 knots

Engine power: two 45,000 kW engines
Risk-Based Design in Shipping Industries

- Ships are designed in accordance with prescriptive Rules of Classification societies
- These Rules are based on SOLAS and MARPOL regulations
- Usually, these Rules are empirical based
Risk-Based Design in Shipping Industries

- Like in other industries risk-based methods are increasingly regarded as an alternative

- Examples:
  - High Speed Crafts
  - Demonstration of equivalence
  - IMO Rule making process
  - GBS
Demonstration of Equivalence

- Design challenging prescriptive Rules
- Compliance with the intention of existing Rules is demonstrated
- Process defined in MSC/Circ 1002
- Presently, only for selected chapters of SOLAS
FSA – Formal Safety Assessment

1. Definition of Goals, Systems, Operations
2. Hazard Identification
   - Scenario Definition
   - Cause and Frequency Analysis
   - Consequence Analysis
   - Risk Summation
3. Risk Controlled?
   - Yes
      - Options to mitigate Consequences
   - No
      - Options to decrease Frequencies
4. Cost/benefit Assessment
5. Reporting

[IACS]
Goal-Based New Ship Construction Standards (GBS)

Regulatory Framework

**today**
- IMO
  - IMO mission statement
- IMO/Flag States
  - Class
- Industry
  - Individual ship

**tomorrow**
- IMO
  - IMO mission statement
- Goal-based Regulation
  - Goals, objectives, Functional requirements
- IMO/Flag States
  - Class rules
- Industry
  - Individual ship

Design Process and Approval Process
Risk-Based Design

- Risk-based design challenges Rules of administration and classification
- Administrative Rules are focused on safety and environment
- Risk-based design is supported by risk analysis and risk evaluation
- Evaluation is performed by using defined acceptable risk for specific system
- Risk-based design requires acceptance criteria defined either explicitly by the administration or by existing Rules (equivalency)
Risk-Based Design

- If a new design does not influence the consequences of an accident the acceptable risk can be replaced by target failure probabilities for systems.

- Target failure probabilities are linked to overall risk via ship functions.
Motivation

- Risk-based design requires additional analysis and thus increases the engineering effort for design

- Although this: the number of risk-based designs appears to be increasing
  - SOLAS II-2/17: alternative design and arrangements for fire safety
  - In the future (2010): SOLAS II-1 (C, D, E) and SOLAS III

- Reasons:
  - Economic motivation (lower costs for fabrication, operation, maintenance)

Benefit: higher flexibility to develop solutions because prescriptive regulation are replaced by target values in terms of safety and environmental protection
Risk-Based Regulatory Framework

- Requirements:
  The risk-based evaluation of designs must be traceable, transparent and objective

- Guidelines, laws, rules provide the regulations to comply with the requirements

  - Regulatory Framework
  - Risk-based approval process for ship system design is part of framework
Risk-Based System Approval Process

I. Preparation
II. System Pre-Approval
III. System Design
IV. System Construction
V. System Installation
VI. System Operation
1. Pre-Design and Requirements Definition

- **Parties: Supplier**
- Pre-design by supplier
- This pre-design is used to:
  - Describe the system (function, arrangement, spaces, major components)
  - Define the system boundaries
  - Define a list of applicable rules and regulations
  - Specify a list of rules and regulations that are likely to be challenged
  - Define system requirements:
    - Safety
    - Environment
    - Operation (boundary condition such as thermal and mechanical loads)

- **Terminology**
1. Example: New LSA
1. Example: New LSA

- **System boundaries:**
  - Lifeboat, launching system
  - Evacuation process, maintenance, training

- **Applicable rules and regulations: LSA Code**

- **Specify a list of rules and regulations that are likely to be challenged**
  - Maximum capacity (300) > 150 persons
  - Regulation 13: interference between lifeboats
  - Regulation 21: storing on each side
  - …

- **Define system requirements:**
  - Safety: safe evacuation of crew and passengers
  - Operational: 6 knots speed fully loaded

- **Terminology: FSA glossary**
2. Preview

- **Parties:** Supplier, Approval Authority

- Documents of step 1 are submitted to Approval Authority (and/or recognised organisation)

- Preview of pre-design by AA

- Objective: decide whether implementation needs risk-based approach (risk evaluation)

- **Presently:** flag state is prescribed by ship owner. For a generic ship a flag state is not defined. Thus, supplier requires a possibility to contact a flag state!
2. Example: New LSA

- New design challenges different SOLAS/LSA regulations
  - capacity > 150 (LSA Code Ch. IV-4.4.2.1)
  - Reg. 13: interference between lifeboats
  - (Reg. 13: protected from fire & explosion)
  - Reg. 21: storing on each side
3. Define Requirements for Analysis

- **Parties:**  Supplier, AA
- **Requirements for the analysis (agreed with AA)**
  - Definition of risk acceptance criteria
  - Definition of the risk evaluation criteria
  - Definition of risk modelling approach
  - Identification of the relation between new design and ship functions
  - (required expertise)
- **Accuracy of the analysis in system pre-approval depends also on requirements of the supplier (required level of confidence for the results of this phase)**
3. Example: New LSA

- Requirements for analysis:
  - Qualitative and quantitative analysis for lifeboat, launching system in a generic vessel and processes (evacuation, training, maintenance).
  - Because of lifeboats storage position: consideration of evacuation routes from mustering to embarkation.
  - Atmosphere in the lifeboats during “waiting for rescue”
  - No consideration of life-rafts
  - Risk evaluation criteria: individual and societal risk
  - Risk acceptance criteria: derived from Rules conform design
  - Risk modelling: ET and FT
  - Ship function: Emergency control
  - Expertise: structural (lifeboat, vessel), machinery, operation/training, human behaviour
4. Analysis

- **Parties:**  Supplier, and additional Experts required.
  Approval Authority

- **Analysis consists of:**
  - Hazard identification
  - Risk analysis
  - Risk control option

- Usually, a step-by-step process with intermediate review/agreement by AA
4. Example: New LSA

- Hazard identification for a generic passenger ship and the new LSA design (FMEA)

- Example: main risk contributors:
  - blocked launching ramps
  - Human problems (evacuation route downstairs)

- Risk analysis and evaluation:
  - Develop risk model
  - Simulation to quantify basic events and nodes
  - Expert judgement
5. **System Requirements**

- **Parties:** Supplier, AA

- **Objectives:** specification of requirements for the risk analysis of the specific design as well as construction and installation

- **Safety:** define the functions the system must provide to meet safety requirements

- **Operation requirements:** operational boundary conditions, environment, maintenance etc.

- **Performance requirements:** measurable quantities for trial designs
5. **Example: New LSA**

- **Specification for RA:**
  - influence of (specific) parent vessel

- **Operation requirements:**
  - operational radius
  - velocity of X up to a wave height of Y

- **Safety requirements:**
  - safe shelter for specified number of passengers up to X days
6. Issue of Statement by Approval Authority

• **Parties:** Approval Authority

• **Approval Authority:**
  - Reviews / assesses the results of previous steps
  - Statement of by AA concerning the acceptability of the results and specifying the requirements for the design phase
  - Statement valid for a generic design
  - No guarantee that design will get final approval!

• Decision if new design deviations from conventional design is marginal

  ➔ no further analysis for detailed design required?
  ➔ conventional approval process can be followed?
7. Specific System Design

- **Parties:** Supplier
- Design the specific system conforming with requirements (step 5) on basis of the statement of the AA
7. Example: New LSA

- Supplier develops lifeboat according to purchaser requirements (e.g. tender-boat)
- Supplier adjusts launching system to the real parent vessel
8. Review

- **Parties:** Supplier, Yard, Owner, AA

- Review of specific design to determine the range of specific risk analysis (difference between specific and generic system design)

- If no specific risk analysis needed, the approval process is continued with step 10 “Specific Requirements”

- Needed for each detailed design

  **Example: New LSA**

  Differences require a review of HazId.

  Quantitative risk analysis required with special attention to evacuation process and launching of lifeboats
9. Specific Analysis

- **Parties:** Supplier, Yard, Owner, AA

- **Objective:** Demonstration that specific design is in conformance with the requirements of step 5 “System requirements”

- Similar to step 4 “Analysis” in the Pre-Approval phase of the process
  - Check if new hazards exist -> modification of risk model
  - Qualitative/quantitative risk assessment considering data of specific design
  - Evaluation of specific design with agreed risk acceptance criteria
  - If necessary, identify/evaluate RCOs
9. Example: New LSA

- A new FMEA for the specific design is performed

  → No new hazards

- Revision of the risk model using the data of the specific design

- Evaluation

- **RCO**: special fire extinguishing system for evacuation routes

- **RCO**: launching ramps alongside
10. Specific System Requirements

- **Parties:** Supplier, Yard, Owner, AA

- Requirements for system and each component on basis of quantitative risk analysis in step 4 or 9 ("Analysis" or "Specific Functional Analysis")

Example: New LSA

- Safety: embarkation time
- Operation/Maintenance/Inspection: testing of electrical equipment and record of failures
- Data acquisition: determination of corrosion rate (launching system)
11. Document Approval

- **Parties:** Approval Authority

- **After completion of previous steps documents exist for**
  - Pre-design and Requirements
  - Requirements of analysis
  - HazId of generic and real system
  - Quantitative risk analysis of generic and real system
  - System and specific requirements
  - Drawings, etc
  - Specifications for operation and maintenance

- Additionally, documentation of verification by AA received

- AA approves the specific risk-based system design

Example: New LSA approval by AA received
12. Manufacture

- **Parties:** Supplier
- Components and eventually sub-systems are assembled
- Quality control as specified in specific requirements must be considered

**Example:** New LSA
Construction and assembly of new lifeboat.
Construction of the launching system for the specific ship.
13 Approval Test (FAT)

- **Parties:** Supplier, AA

- Testing of the Manufacturer’s work similar to factory acceptance test (FAT)

- Based on system requirements (step 5 “system requirements” and step 10 “specific requirements”)

Example: New LSA
New lifeboat exists: Embarkation tests (verify specified embarkation time)
Further steps

14 Installation of System
- Parties: Supplier and Yard

15 Trials (SAT)
- Parties: Supplier, Yard, AA
- Validation of the system, similar to sea acceptance test (SAT)

16 Final System Approval
- Parties: AA
- The acceptance of the system by AA is attested by a certificate if applicable

17 Operation and Maintenance
- Parties: Purchaser/Operator, AA

Example: New LSA
Installation of the launching system and the lifeboats.

Sea trials of the lifeboat in combination with parent vessel and launching system.
Summary

- Risk based design for ships and ship systems offers a higher flexibility to develop optimal solutions tailored for a specific task.
- Risk-based design is fundamentally different to traditional design and requires an approval process taking into account the special issues of risk-based design.
- Such an approval process for risk-based ship system design was developed in SAFEDOR.
- The approval is focused on safety and environmental requirements.
- The approval process contains two risk analysis phases:
  - risk analysis concerning the pre-design (for a generic system)
  - risk analysis concerning the specific design.
Summary

- To provide a sound basis for the statement by AA a quantitative risk analysis is part of the first risk analysis.
- Often, the risk based analysis and the approval started in a later project phase. Higher costs for necessary modifications.
- To increase the benefit of the phase system pre-approval suppliers should have the possibility to perform the system pre-approval without a specific ship (before order).
- This implies that all flag states mutually accept the statement by AA.
- RBA process definition provides an increased reliance for suppliers “by the assignment of responsibilities the supplier has the assurance to receive a statement from the approval authority after defined process steps”
Vielen Dank für Ihre Aufmerksamkeit!