Index on Applicable Risk Analysis for Marine and Offshore

December 2017

Guidance Note
NI 635 DT R00 E

Marine & Offshore
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MARINE & OFFSHORE - GENERAL CONDITIONS

1. INDEPENDENCY OF THE SOCIETY AND APPLICABLE TERMS

1.1. The Society shall remain at all times an independent contractor and neither the Society nor any of its officers, employees, servants, agents or subcontractors shall be or act as an employee, servant or agent of any other party hereto in the performance of the Services.

1.2. The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not, in any circumstances, involve monitoring or exhaustive verification.

1.3. The Society acts as a services provider. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty. The Society is not and may not be considered as an underwriter, broker in Unit's sale or chartering, expert in Unit's valuation, consulting engineer, controller, naval architect, manufacturer, shipbuilder, repair or conversion yard, charterer or shipowner; none of them above listed being relieved of any of their expressed or implied obligations as a result of the interventions of the Society.

1.4. The Services are carried out by the Society according to the applicable Rules and to the Bureau Veritas' Code of Ethics. The Society only is qualified to apply and interpret its Rules.

1.5. The Client acknowledges the latest versions of the Conditions and of the applicable Rules applying to the Services' performance.

1.6. Unless an express written agreement is made between the Parties on the applicable Rules, the applicable Rules shall be the rules applicable at the time of the Services' performance and con tract's execution.

1.7. The Services' performance is solely based on the Conditions. No other terms shall apply whether express or implied.

2. DEFINITIONS

2.1. "**Certificate(s)**" means class certificates, attestations and reports following the Society's intervention. The Certificates are an appraisement given by the Society to the Client, at a certain date, following surveys by its surveyors on the level of compliance of the Unit to the Society's Rules or to the documents of reference for the Services provided. They cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

2.2. "**Certification**" means the activity of certification in application of national and international regulations or standards, in particular by delegation from different governments that can result in the issuance of a certificate.

2.3. "**Classification**" means the classification of a Unit that can result or not in the issuance of a class certificate with reference to the Rules.

2.4. "**Client**" means the Party and/or its representative requesting the Services.

2.5. "**Conditions**" means the terms and conditions set out in the present document.

2.6. "**Industry Practice**" means International Maritime and/or Offshore industry practices.

2.7. "**Intellectual Property**" means all patents, rights to inventions, utility models, copyright and related rights, trade marks, logos, service marks, trade dress, business and domain names, rights in trade dress or get-up, rights in goodwill or to sue for passing off, unfair competition rights, rights in designs, rights in computer software, database rights, topography rights, moral rights, rights in confidential information (including know-how and trade secrets), methods and proto cols for Services, and any other intellectual property rights, in each case whether capable of registration, registered or unregistered and including all applications for and renewals, reversions or extensions of such rights, and all similar or equivalent rights or forms of protection in any part of the world.

2.8. "**Parties**" means the Society and Client together.

2.9. "**Party**" means the Society or the Client.

2.10. "**Register**" means the register published annually by the Society.

2.11. "**Rules**" means the Society's classification rules, guidance notes and other documents. The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical minimum requirements but are not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

2.12. "**Services**" means the services set out in clauses 2.2 and 2.3 but also other services related to Classification and Certification such as, but not limited to: ship and company safety management certification, ship and port security certification, training activities, all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

2.13. "**Society**" means the classification society '**Bureau Veritas Marine & Offshore SAS**', a company organized and existing under the laws of France, registered in Nanterre under the number 821 131 844, or any other legal entity of Bureau Veritas Group as may be specified in the relevant contract, and whose main activities are Classification and Certification of ships or offshore units.

2.14. "**Unit**" means any ship or vessel or offshore unit or structure of any type or part of it or system whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

3. SCOPE AND PERFORMANCE

3.1. The Society shall perform the Services according to the applicable national and international standards and Industry Practice and always on the assumption that the Client is aware of such standards and Industry Practice.

3.2. Subject to the Services performance and always by reference to the Rules, the Society shall:

- review the construction arrangements of the Unit as shown on the documents provided by the Client;
- conduct the Unit surveys at the place of the Unit construction;
- class the Unit and enters the Unit's class in the Society's Register;
- survey the Unit periodically in service to note that the requirements for the maintenance of class are met. The Client shall inform the Society without delay of any circumstances which may cause any changes on the conducted surveys or Services.

The Society will not:

- declare the acceptance or commissioning of a Unit, nor its construction in conformity with its design, such activities remaining under the exclusive responsibility of the Unit's owner or builder;
- engage in any work relating to the design, construction, production or repair checks, neither in the operation of the Unit or the Unit's trade, neither in any advisory services, and cannot be held liable on those accounts.

4. RESERVATION CLAUSE

4.1. The Client shall always: (i) maintain the Unit in good condition after surveys; (ii) present the Unit after surveys; (iii) present the Unit for surveys; and (iv) inform the Society in due course of any circumstances that may affect the given appraisement of the Unit or cause to modify the scope of the Services.

4.2. Certificates referring to the Society's Rules are only valid if issued by the Society.

4.3. The Society has entire control over the Certificates issued and may at any time withdraw a Certificate at its entire discretion including, but not limited to, in the following situations: where the Client fails to comply in due time with instructions of the Society or where the Client fails to pay in accordance with clause 6.2 hereunder.

5. ACCESS AND SAFETY

5.1. The Client shall give to the Society all access and information necessary for the efficient performance of the requested Services. The Client shall be the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out. Any information, drawings, etc. required for the performance of the Services must be made available in due time.

5.2. The Client shall notify the Society of any relevant safety issue and shall take all necessary safety-related measures to ensure a safe work environment for the Society or any of its officers, employees, servants, agents or subcontractors and shall comply with all applicable safety regulations.

6. PAYMENT OF INVOICES

6.1. The provision of the Services by the Society, whether complete or not, involve, for the part carried out, the payment of fees thirty (30) days upon issuance of the invoice.

6.2. Without prejudice to any other rights hereunder, in case of Client's payment default, the Society shall be entitled to charge, in addition to the amount not properly paid, interests equal to twelve (12) months LIBOR plus two (2) per cent as of due date calculated on the number of days such payment is delinquent. The Society shall also have the right to withhold certificates and other documents and/or to suspend or revoke the validity of certificates.

6.3. In case of dispute on the invoice amount, the undisputed portion of the invoice shall be paid and an explanation on the dispute shall accompany payment so that action can be taken to solve the dispute.

7. 7. LIABILITY

7.1. The Society bears no liability for consequential loss. For the purpose of this clause consequential loss shall include, without limitation:

- Indirect or consequential loss;
- Any loss and/or deferral of production, loss of product, loss of use, loss of bargain, loss of revenue, loss of profit or anticipated profit, loss of business and business interruption, in each case whether direct or indirect.

The Client shall save, indemnify, defend and hold harmless the Society from the Client's own consequential loss regardless of cause.

7.2. In any case, the Society's maximum liability towards the Client is limited to one hundred and fifty per-cents (150%) of the price paid by the Client to the Society for the performance of the Services. This limit applies regardless of fault by the Society, including breach of contract, breach of warranty, tort, strict liability, breach of statute.

7.3. All claims shall be presented to the Society in writing within three (3) months of the Services' performance or (if later) the date when the events which are relied on were first discovered by the Client. Any claim not so presented as defined above shall be deemed waived and absolutely time barred.

8. INDEMNITY CLAUSE

8.1. The Client agrees to release, indemnify and hold harmless the Society from and against any and all claims, demands, lawsuits or actions for damages, including legal fees, for harm or loss to persons and/or property tangible, intangible or otherwise which may be brought against the Society, incidental to, arising out of or in connection with the performance of the Services except for those claims caused solely and completely by the negligence of the Society, its officers, employees, servants, agents or subcontractors.

9. TERMINATION

9.1. The Parties shall have the right to terminate the Services (and the relevant contract) for convenience after giving the other Party thirty (30) days' written notice, and without prejudice to clause 6 above.

9.2. In such a case, the class granted to the concerned Unit and the previously issued certificates shall remain valid until the date of effect of the termination notice issued, subject to compliance with clause 4.1 and 6 above.

10. FORCE MAJEURE

10.1. Neither Party shall be responsible for any failure to fulfil any term or provision of the Conditions if and to the extent that fulfilment has been delayed or temporarily prevented by a force majeure occurrence without the fault or negligence of the Party affected and which, by the exercise of reasonable diligence, the said Party is unable to provide against.

10.2. For the purpose of this clause, force majeure shall mean any circumstance not being within a Party's reasonable control including, but not limited to: acts of God, natural disasters, epidemics or pandemics, wars, terrorist attacks, riots, sabotages, impositions of sanctions, embargoes, nuclear, chemical or biological contaminations, laws or action taken by a government or public authority, quotas or prohibition, expropriations, destructions of the worksite, explosions, fires, accidents, any labour or trade disputes, strikes or lockouts

11. CONFIDENTIALITY

11.1. The documents and data provided to or prepared by the Society in performing the Services, and the information made available to the Society, are treated as confidential except where the information:

- is already known by the receiving Party from another source and is properly and lawfully in the possession of the receiving Party prior to the date that it is disclosed;
- is already in possession of the public or has entered the public domain, otherwise than through a breach of this obligation;
- is acquired independently from a third party that has the right to disseminate such information;
- is required to be disclosed under applicable law or by a governmental order, decree, regulation or rule or by a stock exchange authority (provided that the receiving Party shall make all reasonable efforts to give prompt written notice to the disclosing Party prior to such disclosure.

11.2. The Society and the Client shall use the confidential information exclusively within the framework of their activity underlying these Conditions.

11.3. Confidential information shall only be provided to third parties with the prior written consent of the other Party. However, such prior consent shall not be required when the Society provides the confidential information to a subsidiary.

11.4. The Society shall have the right to disclose the confidential information if required to do so under regulations of the International Association of Classifications Societies (IACS) or any statutory obligations.

12. INTELLECTUAL PROPERTY

12.1. Each Party exclusively owns all rights to its Intellectual Property created before or after the commencement date of the Conditions and whether or not associated with any contract between the Parties.

12.2. The Intellectual Property developed for the performance of the Services including, but not limited to drawings, calculations, and reports shall remain exclusive property of the Society.

13. ASSIGNMENT

13.1. The contract resulting from to these Conditions cannot be assigned or transferred by any means by a Party to a third party without the prior written consent of the other Party.

13.2. The Society shall however have the right to assign or transfer by any means the said contract to a subsidiary of the Bureau Veritas Group.

14. SEVERABILITY

14.1. Invalidity of one or more provisions does not affect the remaining provisions.

14.2. Definitions herein take precedence over other definitions which may appear in other documents issued by the Society.

14.3. In case of doubt as to the interpretation of the Conditions, the English text shall prevail.

15. GOVERNING LAW AND DISPUTE RESOLUTION

15.1. The Conditions shall be construed and governed by the laws of England and Wales.

15.2. The Society and the Client shall make every effort to settle any dispute amicably and in good faith by way of negotiation within thirty (30) days from the date of receipt by either one of the Parties of a written notice of such a dispute.

15.3. Failing that, the dispute shall finally be settled by arbitration under the LCIA rules, which rules are deemed to be incorporated by reference into this clause. The number of arbitrators shall be three (3). The place of arbitration shall be London (UK).

16. PROFESSIONNAL ETHICS

16.1. Each Party shall conduct all activities in compliance with all laws, statutes, rules, and regulations applicable to such Party including but not limited to: child labour, forced labour, collective bargaining, discrimination, abuse, working hours and minimum wages, anti-bribery, anti-corruption. Each of the Parties warrants that neither it, nor its affiliates, has made or will make, with respect to the matters provided for hereunder, any offer, payment, gift or authorization of the payment of any money directly or indirectly, to or for the use or benefit of any official or employee of the government, political party, official, or candidate.

16.2. In addition, the Client shall act consistently with the Society's Code of Ethics of Bureau Veritas. http://www.bureauveritas.com/home/about-us/ethics+and+compliance/

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SECTION 1 GENERAL

1 General

1.1 Purpose

1.1.1 The present Note is an index of the risk analysis to help Owners & designers identify in advance the studies and risk analysis which are required or recommended in the Marine & Offshore main Rules & Regulations (BV Rules and Notes, IMO regulations, Industry best practice).

1.2 Application

1.2.1 This Guidance Note is intended to cover wide range of floating units, as detailed hereafter:

- sea-going merchant ships
- renewable energy units:

  Current & Tidal Turbines, Floating Offshore Wind Turbine…
- offshore units and installations
- naval ships
- inland navigation vessels.

This Guidance Note only references the documents for which risk analysis are required or recommended. These reference documents remain the reference and the detailed requirements about risk analysis are those indicated in the text themselves.

1.3 Notice

1.3.1 This document summarizes in tables the various types of risk analysis and their required status. The tables are divided for easy reference by the source of referenced documents:

- BV Rules, as detailed in Sec 2
- IMO regulations, as detailed in Sec 3:
  - SOLAS convention
  - IGC code
  - IGF code
  - HSC code 2000
  - Polar code
- Industry good practices, as detailed in Sec 4:
  - Ship to ship transfer guide
  - Tanker Management and Self-Assessment (TMSA2)
- Inland navigation vessel, as detailed in Sec 5.

The required statuses are the followings:

- Recommended:

  the risk analysis are optional but highly recommended
- Mandatory
- Mandatory if:

  the risk analysis is mandatory under specific condition (specified in the description)
- If requirement adapted:

  the risk analysis is required in case of deviation from the original requirement
- BV satisfaction:

  the risk analysis may be required at the Society satisfaction
- Administration satisfaction:

  the risk analysis may be required at the Administration satisfaction
- For type approval:

  the risk analysis is required under the scope of product type approval
- Guidance:

  the risk analysis is not required, only guidance is given.

1.3.2 Description of tables

Risk analysis are listed in tables where rows correspond to risk analysis inputs and the columns correspond to categories of information:

- First column indicates the subject considered for the application of the risk analysis.

  The subject can be the classification notations, ship type, domain,...
- Second column indicates the type of risk analysis which are recommended, as defined in Article [2].
- Thrid column indicates the requirement levels of the risk analysis, as defined in [1.3.1].
- Fourth column gives details on risk analysis.
- Last column gives the references to the considered document where the risk analysis is mentioned.

Tables only refers to the documents for which risk analysis are required or recommended. Requirements about risk analysis are those indicated in the referenced documents themselves.

2 Definitions

2.1 Hazard

2.1.1 Hazard means any source of potential damage or casualty, or any situation with potential to cause it.

2.2 Risk

2.2.1 Risk is a concept quantifying a hazard, consisting in a combination of probability or frequency and consequence of the related hazard.

2.3 Risk analysis

2.3.1 Risk analysis is a structured method involving:

- identification of hazards related to the unit, installation or equipment
- estimation of hazard probabilities or frequencies
- estimation of hazard consequences.

2.4 Risk assessment

2.4.1 Risk assessment is a systematic analysis of risks including risk analysis, review of risk acceptability by comparison with agreed criteria and identification of risk reduction measures, when relevant.

2.5 Acronyms

2.5.1

CSRA	:	Cryogenic Spill Risk Analysis
DORA	:	Dropped Object Risk Assessment
EERA	:	Escape, Evacuation and Rescue Analysis
ERA	:	Explosion Risk Analysis
ESSA	:	Emergency System Survivability Analysis
ETA	:	Event Tree Analysis
FMEA	:	Failure Modes and Effects Analysis
FMECA	:	Failure Modes, Effects and Criticality Analysis
FRA	:	Fire Risk Analysis
FSA	:	Formal Safety Assessments
FTA	:	Fault Tree Analysis
GDA	:	Gas Dispersion Analysis
HAZID	:	Hazard Identification
HAZOP	:	Hazard and Operability Study
LFD	:	Large Fire Door
LSA	:	Life Saving Appliance
MVZ	:	Main Vertical Zone
QRA	:	Quantitative Risk Assessment
RA	:	Risk Assessment
RAM	:	Reliability, Availability and Maintainability
RCM	:	Reliability Centered Maintenance
SCRA	:	Ship Collision Risk Analysis
SGDA	:	Smoke and Gas Dispersion Analysis
SIL	:	Safety Integrity Level allocation and verification.

3 Type of analysis

3.1 Hazard Assessment

3.1.1 HAZID - Hazard Identification

The HAZard IDentification (HAZID) is a structured method for identifying hazards, threats and consequences associated with a process, operation or area. It consists of a brainstorming workshop with designer and client personnel engineering disciplines about project management, commissioning and operations.

The major findings and hazard risk ratings help to deliver HSE compliance, and form part of the project Risk Register required by many licensing authorities and company in-house standards

3.1.2 HAZOP - Hazard and Operability Study

A HAZard and OPerability (HAZOP) study, also known as process hazard analysis (PHA), is a well-proven, structured, team-based method for process hazard identification commonly used during the process design phase or for proposed modifications. HAZOP makes detailed examination of the process and engineering intention of new or existing facilities to assess the potential hazards from operating outside of the intended design, or malfunction of individual items of equipment and their consequential effects on the facility as a whole. HAZOP is led by an experienced facilitator.

For an oil & gas project, a core team would typically include personnel from Process, Instrumentation, Machines, Project Engineering, and Operations, and it might require the involvement of process technologists, environmental specialists and corporate Health & Safety and Environment (HSE) staff for some parts of the work

3.1.3 FMEA - Failure Mode and Effects Analysis

A practical, realistic and documented assessment of the failure characteristics of the ship and its component systems should be undertaken with the aim of defining and studying the important failure conditions that may exist.

The FMEA is based on a single failure concept under which each considered system at various levels of a system's functional hierarchy is assumed to fail by one probable cause at a time. The effects of the postulated failure are analysed and classified according to their severity. Such effects may include secondary failures (or multiple failures) at other level(s). Any failure mode which may cause a catastrophic effect should be guarded against by system or equipment redundancy unless the probability of such failure is extremely improbable. For failure modes causing hazardous effects corrective measures may be accepted in lieu. A test program should be drawn up to confirm the conclusions of FMEA.

3.1.4 What-if

The What-if method uses loosely structured questioning to postulate potential upsets that may result in mishaps or system performance problems and ensure that appropriate safeguards against those problems are in place.

3.2 Risk analysis

3.2.1 FTA - Fault Tree Analysis

The Fault Tree Analysis, FTA, is a logic diagram showing the causal relationship between events which singly or in combination occur to cause the occurrence of a higher level event.

3.2.2 ETA - Event Tree Analysis

The event tree analysis (ETA) is an analysis to identify and evaluate the sequence of event in scenarios following the occurrence of an initiating event.

3.2.3 DORA - Dropped Object Risk Assessment

The dropped object study is an analysis to find out what happens to the facility and personnel safety if items are dropped. If the lost object results in an accident or event, structures must be sufficiently protected to absorb the impact energy. The analysis aims at answering the following typical questions:

- which types of lifts should be taken into account, (e.g. maintenance or operations)
- how many lifting points are there and what are the potential dropped object zones/crane arcs/laydown areas
- what types of lifts could result in damage to subsea equipment
- what types of dropped objects need to be assessed.

3.2.4 SCRA - Ship Collision Risk Analysis

For a fixed or permanently moored marine asset, such as a platform, the Ship Collision Analysis involves understanding the level of shipping traffic and the effects resulting from a collision.

The first step of the Risk analysis is a thorough study of the shipping traffic around the asset: the traffic data can be in the form of AIS data or data from Port Authorities.

The second step identifies and selects the likely collision scenarios.

Then an assessment of the probability of collision detailed by type of vessel is carried out based on world recognised casualty databases. The probabilities are then corrected to take into account local parameters (e.g. traffic, environment, pilot assistance).

The consequences of the collision (e.g. structural damage, damage to environment and possible loss of life) are then assessed through various methods using casualty database analysis, qualitative structural assessments, semi-empirical methods, simplified numerical calculations or finite element calculations.

The outcome of the analysis is an evaluation of the risk of collision against the risk acceptance criteria. For a moving asset, say a fleet of LNG/Oil carriers navigating through confined channels, the Ship Collision Analysis involves a study of the navigated channels, the expected traffic and a Risk Analysis of the main risks such as collision, allision, grounding, foundering, fire/explosion and mechanical failure. This study is often used to provide an insight into the risk to the onboard cargo (e.g. oil and LNG) with regards to local environment and people, in the scope of construction of new O&G infrastructures.

3.3 Consequence analysis

3.3.1 FRA - Fire Risk Analysis and ERA - Explosion Risk Analysis

The objectives of the Fire and Explosion Risk Analysis (FERA) are:

- to identify the fire and explosion scenarios resulting from process and non-process failure scenarios
- to evaluate the intensity of effects for these scenarios (i.e. Flame length, Pool size, Heat flux, Gas cloud extent, Overpressure contours)
- to identify the targets vulnerable to the fire and explosion scenarios and evaluate their response to such events
- to identify the escalation potential of each accidental event and the possible damages to the asset, and
- to identify the possible requirement for additional risk reduction measures to help prevent and/or mitigate the effects of the identified fire and explosion scenarios.

3.3.2 GDA - Gas Dispersion Analysis

Gas Dispersion Analysis (GDA) uses a Vent Dispersion Study. The objectives are:

- to model the dispersion of flammable/toxic vapour from the top of the vent mast using appropriate modeling tools, considering all relevant release scenarios
- to evaluate the thermal effects on personnel and structure in case of ignition of the released gas cloud, and
- to check the potential for hazardous exposure of personnel and evaluate impact on the facility.

3.3.3 SGDA - Smoke and Gas Dispersion Analysis

Smoke and gas releases (toxic or flammable) present major hazards to personnel, environment, assets and the business of the operator. To properly control these hazards, companies must anticipate the consequences of such events and develop appropriate and cost-effective measures in terms of plant lay-out, safety design and additional safeguard implementation.

The objectives of the Smoke and Gas Dispersion Analysis (SGDA) are:

- to identify the release scenarios resulting from process and non-process failure events
- to evaluate the intensity of effects for these scenarios (i.e. distance to LC1%, Gas cloud extent)
- to identify the targets vulnerable to the toxic exposure and evaluate their response to such events
- to identify the possible requirement for additional risk reduction measures to help prevent and/or mitigate the effects of the identified dispersion scenarios.

3.3.4 EERA - Escape, Evacuation and Rescue Analysis

The Escape, Evacuation and Rescue Analysis (EERA) encompass all escape, evacuation and rescue items provided on the unit, including the temporary refuges, the muster stations, the escape and evacuation routes, the different evacuation and rescue means (e.g. helicopter, life boats, life rafts) and survival equipment.

Outputs from a Fire and Explosion Risk Analyses (FERA), Smoke and Gas Dispersion Analysis (SGDA) and recommended practices along with understanding of personnel distribution are commonly used to develop escape, evacuation and rescue scenarios in order to:

- evaluate the adequacy of the escape, evacuation and rescue means under identified emergency scenarios (i,e, effects of thermal radiation, blast and smoke/toxic gas)
- assess the adequacy of the evacuation philosophy in terms of primary, secondary and tertiary means of evacuation and circumstances in which different evacuation routes take precedence
- assess the integrity and endurance time of temporary refuges, and
- assess the escape from the individual areas of the installation (i.e. process area decks, accommodation, hull and utility rooms).

3.3.5 ESSA - Emergency System Survivability Analysis

An Emergency Systems Survivability Analysis (ESSA) is carried out to assess the ability of emergency systems to withstand accident conditions such as fire, smoke, blast and hazardous gas releases. It is vital to ensure that these systems perform their function during Major Accident Events.

3.4 Reliability and integrity

3.4.1 FMECA - Failure Mode, Effects and Criticality Analysis

A Failure Mode, Effects and Criticality Analysis (FMECA) study considers each mode of failure for every component of a system, and determines local effects and end effects on system operation, on personnel safety and environment protection. Failure modes are classified in relation to likelihood of the failure occurring and severity of failure effects. Likelihood in combination with severity will generate a criticality rating for each failure mode, which is based upon a predetermined risk matrix.

Starting from the basic failure characteristics of elements and functional structure of the system, FMECA systematically documents the ways equipment can fail, the possible causes, the effects these failures can produce on system performance and ranks each potential failure according to the combination of its severity, its probability of occurrence and the possibility that it can be detected.

These three parameters are qualitatively evaluated referring to defined levels. Five levels for probability, consequences and non-detection are defined. The combination of these three figures (probability, consequences, and non-detection) provides the criticality score associated to the considered failure mode.

The FMECA is carried out on a series of worksheets, where the results are listed in a tabular format, equipment item (or function) by equipment item (or function), following a systematic bottom up approach starting from the lowest level of component failure and rising through the next level of system hierarchy up to the overall system level.

3.4.2 SIL - Safety Integrity Level allocation and verification

Assessing the safety, availability and reliability of Safety Instrumented Systems (SIS).

3.4.3 RAM - Reliability, Availability and Maintainability

Reliability, Availability and Maintainability study (RAM) is a simulation of the configuration, operation, failure, repair and maintenance of equipment. It includes the physical components, equipment configuration and maintenance philosophy in a system. It generates sufficient data needed in order to make decisions for possible systems changes that may increase system efficiency, and therefore increase project profits.

RAM modeling can simulate the configuration, operation, failure, repair and maintenance of equipment. The inputs to RAM modeling will include the physical components, equipment configuration and maintenance philosophy in a system and the outputs can determine average production of the system over the facility or vessel life. RAM studies will generate sufficient data on which to base decisions for possible systems changes that may increase system efficiency, and therefore increase project profits.

3.4.4 RCM - Reliability Centered Maintenance

Reliability Centered Maintenance study (RCM) is a logical, systematic decision making process for defining optimum maintenance tasks (part of Asset Integrity Management Systems, AIMS):

- to focus the preventive maintenance effort on equipment essential to health, safety, environment and/or operation
- to implement an optimized maintenance plan (what, when, how), oriented as far as possible on Condition-Based-Maintenance
- increase inherent reliability and availability of the unit/system in its operating context Validate the adequacy between the installation design, the operation and preventive maintenance
- demonstrate a commitment to improve the reliability, safety and environmental integrity in front of insurers, charterers, regulatory bodies…

3.5 Risk quantification/reduction

3.5.1 RA - Risk Assessment

Generally, the risk assessment study has the following objectives:

- evaluation of the design, taking into account the operational procedures
- determination of limiting conditions of operations (e.g. loading/offloading)
- assessment of safety and operability through risk assessment techniques (e.g. for transfer system).

Risk assessment methodology may be based on the provisions of EN 1474-3 or other recognized standards, such as EN ISO 17776 "Guidelines on tools and techniques for hazard identification and risk assessment".

3.5.2 QRA - Quantitative Risk Assessment

Quantified Risk Assessment (QRA) is a structured approach to identifying and understanding the risks associated with hazardous activities.

The assessment starts by taking inventory of potential hazards, their likelihood, and consequences, including:

- review of safety documents (firefighting and safety layout drawings, fire and gas detection studies, escape, evacuation and rescue analysis and design stage studies, etc.)
- process hazard analysis
- scenario development
- likelihood/frequency analysis
- consequence analysis (such as fire and explosion modeling)
- impact assessment
- risk assessment (comparison against defined criteria)
- recommendations for risk reduction measures
- reporting and documentation.

QRA provides valuable insights into the features of the industrial plant, highlighting those aspects where failures may result in harm to operators, members of the public, the environment and or the asset itself. QRA provides a basis for decision-making in the design and operation of the plant, and may also be required to legally show "fitness to operate".

SECTION 2 RISK ANALYSIS IN THE SOCIETY'S RULES

1 General

1.1 General

1.1.1 The risk analyses in BV Rules and Notes are regrouped for easy reference into the following categories:

- General:

  risk analysis for general case, non-associated to a specific classification notation, see Tab 1.

- Service and type notation:

  risk analysis in relation with a structural type notation, service notation or additional service features (according to NR467, Pt A, Ch 1, Sec 2, [4] and NR445, Pt A, Ch 1, Sec 2, [4] and NR445, Pt A, Ch 1, Sec 2, [7]), see Tab 2.

- Additional equipment or specific arrangement - Additional class notation:

  risk analysis in relation with an additional class notation, (according to NR467, Pt A, Ch 1, Sec 2, [6] and NR445, Pt A, Ch 1, Sec 2, [6]), see Tab 3.

- Naval Ships:

  risk analysis for naval ships, see Tab 4.

2 Service notations and additional service features

2.1 Risk analysis for the type or service - Service notation and additional service features

2.1.1 Risk analysis for service notation and additional service features are listed in Tab 2.

3 Additional equipment or specific arrangement - Additional class notation

3.1 Risk analysis for additional class notation

3.1.1 Risk analysis for additional class notation are listed in Tab 3.

4 Naval ships

4.1 Risk analysis for naval ships

4.1.1 Risk analysis for naval ships are listed in Tab 4.

Table 1 : Risk analysis for general application

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
Marine Renewable Energy (MRE)				
Current or Tidal Turbine	HAZID	Mandatory if	**Loads** If relevant, risk analysis is to be performed considering collision with vessels	NI 603, Ch 1, Sec 3
	HAZID, FMECA	BV satisfaction	**Loads** For accidental scenarios, a risk analysis may be required to: • determine applicable loads and the probabilities of occurrence of various events considered through accidental scenarios.	NI 603, Ch 1, Sec 3
		Mandatory	**Certificate** Risk assessment for prototype, type and project certificate is to: • identify hazardous situations (collision or climatic extremes). HAZID is recommended • identify components failures. FMECA is recommended.	NI 603, Ch 1, Sec 2
MRE technologies	HAZID, FMEA	Recommended	**Prototype certificate** Risk assessment for prototype certificate is to: • identify hazardous situations (collision or climatic extremes). HAZID is recommended • identify components failures. FMECA is recommended.	NI 631, Sec 3
			Type certificate Risk assessment for type certificate is to: • identify hazardous situations (collision or climatic extremes). HAZID is recommended • identify components failures. FMECA is recommended.	NI 631, Sec 4
			Project certificate Risk assessment for project certificate is to: • identify hazardous situations (collision or climatic extremes). HAZID is recommended • identify components failures. FMECA is recommended.	NI 631, Sec 5

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
Offshore units				
Conversion of ship	FMEA	Mandatory	**Systems** FMEA is to be submitted covering machinery, electrical and safety systems.	NI 593, Sec 1
		Mandatory if	**Machinery spaces automation** Whenever machinery spaces previously designed for manned operations are intended to be modified in view of operations in an unmanned mode, the automation is to be compatible with the equipment and an FMEA is to be submitted for approval, on a case-by-case basis.	NI 593, Sec 4
	HAZID, HAZOP, FRA, ERA, EERA, ESSA, QRA	BV satisfaction	**Arrangement and systems** If deemed necessary by the Society, a risk analysis is to be performed to validate the arrangement and to determine the accidental loads that the equipment and the systems are capable to withstand.	NI 593, Sec 4
Offshore units and installations	Fault tree	For type approval	**Computer based system** Risk analysis considering the computer based system ensuring safety function and which are not backed-up by non-computer-based devices, is to: • demonstrate the availability and reliability of the computer based system.	NR 445, Pt C, Ch 3, Sec 3
	FMEA	For Type Approval	**Automation system** For type approval of systems category III, FMEA is to: • demonstrate the reliability of the automation system, including the computer based system. In accordance with IEC 60812.	NR 445, Pt C, Ch 3, Sec 1
			Dual fuel engine FMEA is to be submitted, examinating: • possible faults affecting the combustion process.	NR 445, Pt C, Ch 1, App
			Diesel engine electronic control FMEA is to be submitted and is to: • demonstrate that failure of an electronic control system will not result in the loss of essential services for the operation of the engine and that operation or the engine will not be lost or degraded beyond an acceptable performance criteria or the engine • help to select cases for integration test of electronically controlled diesel engine.	NR 445, Pt C, Ch 1, Sec 2
		Mandatory	**Exhaust gas treatment system** Risk analysis is to: • substantiate the availability of the machinery served by the exhaust gas treatment systems • demonstrate that in case of failure of such equipment, propulsion power and auxiliary power supplying essential functions are not affected (where necessary, a bypass is to be installed), and that in case of black out, automatic starting of engines, if provided, remains effective.	NR 445, Pt C, Ch 1, Sec 7

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
Offshore units and installations	FMECA	Recommended	**General** Risk Based Qualification of New technology Methodology Guidelines. Reference to IEC 60812.	NI 525, Sec 1
	FRA	Mandatory	**Plastic piping** For plastic pipe, the Fire Risk Analysis Study and Report complies with: • level of fire endurance of plastic pipes on hull deck of offshore units.	NR 445, Pt C, Ch 1, App 2
	HAZID	Mandatory	**Exhaust gas treatment system** When use of substances mentioned in IMDG code: • ventilation necessity (treatment products tanks) is considered with relevant risk analysis • common ventilation (compartment where treatment products are stored or used with other compartments) may be accepted based on risk analysis • specific risk analysis is to be submitted in case of substance covered by IEC 60092-502 or -506 are used • risk analysis is to be provided to evaluate the occurrence and level of danger for crew and passengers in case of interference of filling systems for treatment products with other ship activity • risk analysis is to be submitted for approval for treatment products tanks if located in category A machinery space • risk analysis is to be provided for compartment containing treatment products tanks.	NR 445, Pt C, Ch 1, Sec 7
		Mandatory if	**Accidental situation** Depending on the type and service of the unit, a risk analysis may be required to: • assess the risk of explosion, collision and dropped objects.	NR 445, Pt B, Ch 2, Sec 1
	HAZID, HAZOP, FRA, ERA, EERA, ESSA, QRA	BV satisfaction	**Arrangement of unit** Risk analysis is to be performed considering the layout of the unit or installation, in order to: • validate the arrangement • determine accidental loads equipment and systems are capable to withstand. Reference to Recommended Practice API RP 14J, EN ISO 13702, EN ISO 17776.	NR 445, Pt C, Ch 4, Sec 2
	ERA, SCRA, DORA	Mandatory if	**Local structural improvements** When risk of explosion, collision or dropped objects is considered as relevant, risk analysis is required to assess the corresponding risk.	NR 445, Pt B, Ch 3, Sec 9
offshore access systems (gangway)	FMEA	Mandatory	**Gangway** Compliance with the safety principles is to be demonstrated by a FMEA.	NI 629, Sec 1

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
Sea going ship				
LNG bunkering	HAZID, HAZOP	Mandatory	**Gas** Risk analysis determines the: • exclusion zone (restricted area around the LNG transfer system and bunkering connections).	NI 618
	HAZOP	Mandatory	**Gas** HAZOP is to identify: • cases of failures, malfunctions • external events (such as sudden change in the ambient conditions). HAZOP is to identify emergency situations for Management Plan: • LNG leakage and spill on the receiving ship, on the bunkering facility or on the LNG transfer system • gas detection • fire in the bunkering area (e.g. starting from the tank truck) • unexpected loosening of mooring lines • unexpected moving of the tank-truck • unexpected venting on the receiving ship or on the bunkering facility.	NI 618, Annex 2 NI 618, Annex 4
		Mandatory if	**Gas** Only if required by the Port Authorities, safety assessment and HAZOP study is to be performed before setting up a LNG bunkering project.	NI 618
LSA	HAZID	Recommended	**Alternative design and equivalent** HAZID should be used for: • hardware component of the system (mechanical failure, structural failure, etc.) • human vulnerability towards hazards faced during the process (impacts, accelerations, hypothermia, seasickness, etc.).	NI 560
Ships	FMEA	BV satisfaction	**Control system** FMEA is to be performed to: • demonstrate the reliability of the power plant control systems (blackout due to electric propulsion operation to be eliminated).	NR 467, Pt C, Ch 2, Sec 1
			Automation system Documentation to be submitted for information: • risk assessment report. Documentation to be submitted for approbation: • test programs and procedures for functional tests and failure tests including a supporting FMEA or equivalent, at the request of the Class Society. For Category II and III systems: • a FMEA may be requested by the Society in order to support containment of failure tests programs.	NR 467, Pt C, Ch 3, Sec 3

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
Ships	FMEA	For Type Approval	**Diesel engine** FMEA is to help to: • select cases for integration test for electronically controlled diesel engines. Documentation to be submitted for information: • FMEA (for engine control system).	NR 467, Pt C, Ch 1, Sec 2
		Mandatory	**Dual fuel engine** Risk analysis is to consider: • malfunction of the gas admission valve • leaking cylinder inlet/exhaust valves.	NR 467, Pt C, Ch 1, App 2
			Computer based system Document to be submitted for approval: • test programs and procedures for functional tests and failure tests including a supporting FMEA or equivalent (for system of Cat II and III).	NR 467, Pt C, Ch 3, Sec 3
		Mandatory if	**Steering gear** Documentation to be submitted where main steering gear comprises 2 or more identical power units: • steering capability: omission of steering gear.	NR 467, Pt C, Ch 1, Sec 11
			(Documentation to be submitted) where steering gear is so arranged that more than one system can be simultaneously operated: • steering capability: hydraulic locking.	NR 467, Pt C, Ch 1, Sec 11
	FMEA, HAZID	Mandatory	**Exhaust gas treatment system** Risk analysis is to be submitted for approval including: • failure of the exhaust gas treatment system • leakage of wash water, sludge or chemical • fire.	NR 467, Pt C, Ch 1, Sec 10
			Risk analysis is to substantiate the: • availability of the machinery served by the exhaust gas treatment system.	NR 467, Pt C, Ch 1, Sec 10
	FMEA, HAZID	Mandatory if	• **Exhaust gas treatment system** When use of substances mentioned in IMDG code: • ventilation necessity (treatment products tanks) is considered with relevant risk analysis • common ventilation (compartment where treatment products are stored or used with other compartments) may be accepted based on risk analysis • specific risk analysis is to be submitted in case of substance covered by IEC 60092-502 or -506 are used • risk analysis is to be provided to evaluate the occurrence and level of danger for crew and passengers in case of interference of filling systems for treatment products with other ship activity • risk analysis is to be submitted for approval for treatment products tanks if located in category A machinery space • risk analysis is to be provided for compartment containing treatment products tanks.	NR 467, Pt C, Ch 1, Sec 10

Risk analysis for general application				
Application	Type	Required status	Descriptions	References
☝ Ships	RA	Mandatory	**Computer based system** Document to be submitted for information: • risk assessment report to determine the risk to the system throughout the lifecycle by identifying and evaluating the hazards associated with each function of the system. May be based on IEC/ISO31010 “Risk management - Risk assessment techniques”. Where the risks associated with a computer based system are well understood, it is permissible for the risk assessment to be omitted, however in such cases the supplier or the system integrator shall provide a justification for the commission.	NR 467, Pt C, Ch 3, Sec 3
offshore access systems (gangway)	FMEA	Mandatory	**Gangway** Compliance with the safety principles is to be demonstrated by a FMEA.	NI 629, Sec 1
Fuel cell system	HAZOP, FMEA, FTA	Mandatory	**General** Risk analysis is to be submitted for approval including: • fuel gas piping system • fuel gas containment/ventilation systems • gas detection systems • control, monitoring and safety systems • fuel cell power system • other ship systems • gas leakage • black-out • human factor. Risk analysis is to consider consequences of: • a failure affecting the concerned systems • a gas leakage.	NI 547, Ch 1
		Mandatory if	**Arrangement and systems** For new or altered concept or configuration, risk analysis should be conducted in order to: • address risks arising from the use of the fuel cell installation affecting the structural strength and the integrity of the ship (installation, operation and maintenance). Relevant standards: IEC 61882 HAZOP studies; IEC 60812 Procedures for FMEA; IEC 61025 Fault tree analysis: • identify spaces in which explosive mixtures may be encountered, their volumes, their probability of explosion and the associated consequences.	NI 547, Ch 2

Table 2 : Risk analysis for the type or service - Service notation and additional service features

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
Offshore units				
column stabilized unit	HAZID	BV satisfaction	**Loads** For accidental situations a risk analysis may be required to: • determine applicable loads and the probabilities of occurrence of various events considered through accidental scenarios.	NR 571, Sec3
diving support - integrated, diving support - portable, diving support - capable	FMEA	Mandatory	**Diving systems** FMEA of the diving system is to be conducted at an early stage of the new built projects or when a portable diving system is to be installed on-board. (Reference to IMCA D039 - FMEA guide for diving systems). Documentation to be submitted for information: • FMEA of the diving system.	NR 609, Sec1
diving system	FMEA	If requirement adapted	**Diving sub systems** Self Propelled Hyperbaric Lifeboat (SPHL): If diver capacity is less than 100% on each side of the diving unit, it has to be justified in the risk analysis.	NR 610, Ch 2, Sec 5
		Mandatory	**Diving systems** A FMEA is to be conducted at an early stage of the project. (Reference to IMCA D039 - FMEA guide for diving systems). Document to be submitted for information: • FMEA or FMECA report.	NR 610, Ch 1, Sec 3
			Breathing gas: The quantities of breathing gas and pure oxygen to carry on-board is to be assessed for each diving campaign and justified by a risk analysis.	NR 610, Ch 3, Sec 3
Drilling	HAZID, HAZOP, FMECA	BV satisfaction	**Layout** If deemed necessary by the Society, risk analysis it to be performed in order to: • Validate various layouts • Determine critical conditions. (Based on standards API RP 14J, EN ISO 17776).	NR 569, Sec 8
FSRU	SCA	If requirement adapted	**Bulkhead** When the risk of collision is mitigated and duly justified (collision analysis,…), the Society may accept an exemption from having a: • collision bulkhead • aft peak bulkhead.	NR 645, Sec 3

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
liquefied gas storage, gas production, gas liquefaction	FRA	If requirement adapted	**Fire** Risk analysis or fire load analysis showing lower class of bulkheads may be accepted.	NR 542, Sec 13
	HAZID, HAZOP	Mandatory	**Topside** Risk analysis is to be performed in order to: • validate the topside layout • determine the critical conditions (topside arrangement and systems). Based on recognized standards: • API RP 14J • EN ISO 17776. Documentation to be submitted for information: • detailed report for risk analysis • detailed follow-up report of actions and mitigation measures taken in response to risk analysis findings. (Other risk analysis are recommended: SIL, QRA, FRA, ERA, SCRA, CSRA, Collision impact FE analysis, Blast FE analysis, DORA...).	NR 542, Sec 13
	ERA, SCRA, DORA	Recommended	**Structure, equipment** Calculation procedures are to be submitted for information: • dropped object analysis procedure • collision analysis procedure • explosion analysis procedure.	NR 542, Sec 1
	HAZID, GDA	If requirement adapted	**Cargo area** Risk analysis is to be submitted for information considering in the cargo area: • arrangements • access • ventilation and venting spaces.	NR 542, Sec 11
offshore TLP	FRA, ERA, DORA, SCRA	BV satisfaction	**Loads** Risk analysis is to assess: • risk of explosion, fire, collision and dropped objects.	NR 578, Sec 4

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
oil storage, production	HAZID, HAZOP	Mandatory	**Use of gas fuel** Use of process gas and crude oil as fuel Risk analysis is to be submitted covering: • operation of the engines on crude oil • possible presence of crude oil vapours in the machinery spaces.	NR 445, Pt D, Ch 1, Sec 13
	HAZOP	Mandatory	**Cargo system** HAZOP of the Cargo tanks vents recovery system (COTVR) are to be submitted.	NR 445, Pt D, Ch 1, Sec 10
	HAZOP, ERA	Mandatory	**Piping** HAZOP of the Hydrocarbon blanket gas system is to be submitted.	NR 445, Pt D, Ch 1, Sec 12
	ERA, SCRA, DORA	Recommended	**Loads** Risk analysis is to assess: risk of explosion, collision and dropped objects.	NR 445, Pt D, Ch 1, Sec 9
POSA MU	FMEA	Mandatory	**Thruster Assisted Mooring** FMEA is to determine the worst thruster system failure: • failure of any mooring line • failure of any single thruster • stop of thruster occurring in the event of the most serious failure in the power system.	NR 493, Sec 5
Sea going ship				
air-cushion vehicle	FMEA, RAM	Mandatory	**Power plant** Documentation to be submitted: • results of failure and breakdown consequence analysis • reliability analyses of appliances.	NR 203
Compressed natural gas carrier	QRA	Mandatory	**General** A Quantified Risk Assessment is to be submitted for information.	NR 517
			Innovative components A risk analysis is to be conducted on innovative components of each design • containment system • process during cargo operations. (IMO IGC code).	NR 517
	QFSA	Mandatory	**General** A Quantified Formal Safety Assessment is to be submitted to document that safety level is equivalent or better than comparable ships covered by IGC Code. (Complying with IMO Guidelines MSC/Circ. 1023).	NR 517
	QCGRA	Mandatory	**Cargo tanks** A Quantified Collision and Grounding Risk Assessment is to verify that damage assumptions are valid.	NR 517

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
diving support - integrated, diving support - portable, diving support - capable	FMEA	Mandatory	**Diving systems** FMEA of the diving system is to be conducted at an early stage of the new built projects or when a portable diving system is to be installed on-board. (Reference to IMCA D039 - FMEA guide for diving systems). Documentation to be submitted for information: • FMEA of the diving system.	NR 467, Pt E, Ch 7
diving system	FMEA	If requirement adapted	**Diving sub systems** Self Propelled Hyperbaric Lifeboat (SPHL): If diver capacity is less than 100% on each side of the diving unit, it has to be justified in the risk analysis.	NR 610, Ch 2, Sec 5
		Mandatory	**Diving systems** A FMEA is to be conducted at an early stage of the project. (Reference to IMCA D039 - FMEA guide for diving systems). Document to be submitted for information: • FMEA or FMECA report. Breathing gas: The quantities of breathing gas and pure oxygen to carry on-board is to be assessed for each diving campaign and justified by a risk analysis.	NR 610, Ch 3, Sec 3 NR 610, Ch 3, Sec 3
FSRU	SCA	If required adapted	**Bulkhead** When the risk of collision is mitigated and duly justified (collision analysis,…), the Society may accept an exemption from having a: • collision bulkhead • aft peak bulkhead.	NR 645, sec 3
gasfuel, dualfuel	FMECA	Mandatory	**Arrangement and systems** FMECA is to be carried out for the very high pressure equipment: • electrical generation and distribution systems.	NR 529, Part A

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
gasfuel, dualfuel	HAZID	Mandatory	**Arrangement and systems** Risk analysis is to be submitted for approval, covering: • loss of function • component damage • fire, explosion • electric shock. Any risks arising from the use of gas as fuel: structural strength and integrity of the ship: installation, operation, maintenance, disposal.	NR 529, Part A
			Risk analysis is to cover gas and liquid fuel leakage.	NR 529, Part A
			HAZID is to be carried out for each gas-fuelled ship, covering: • tank connection space (TCS) • enclosed and semi-enclosed fuel preparation rooms • enclosed and semi-enclosed bunkering stations • spaces containing very high pressure gas or liquid fuel piping • ESD-protected machinery spaces • GVU spaces (except GVU enclosures) • zones where vent lines and safety valve discharge lines are led • containment systems and adjacent structure.	NR 529, Part A
		Recommended	**Arrangement and systems** Risk analysis is to determine: • additional relevant accident scenarios. Risk analysis is to cover: • specific risks arising from the use of portable tanks.	NR 529, Part A-1 NR 529, Part A-1
	HAZOP	Mandatory	**Arrangement and systems** HAZOP analysis is to be carried out for the very high pressure gas fuel installation.	NR 529, Part A
	SGDA	BV satisfaction	**Arrangement and systems** Gas dispersion analysis may be required to better assess the risk associated with gas venting or pressure relief.	NR 529, Part A
	QRA	Recommended	**Arrangement and systems** Tank connection space: • risk analysis may be carried out to justify the relevance of the leakage scenarios to be considered • equivalence of alternative ventilation installations shall be demonstrated by a risk assessment.	NR 529, Part A-1
	ERA	Mandatory	**ESD-protected machinery spaces** An explosion analysis is required for ESD-protected machinery spaces.	NR 529, Part A

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
HSC	FMEA	Mandatory	**Control system** FMEA is to include: • directional control system.	NR 396, Ch 5
			Electrical system FMEA is to include: • electrical system, taking into account the effects of electrical failure on the systems being supplied.	NR 396, Ch 12
			Gas turbine FMEA is to include: • automatic safety devices to guard against hazardous conditions arising in the event of malfunction in the turbine installation.	NR 396, Ch 9
			Machinery systems FMEA is to include: • machinery system and their associated controls.	NR 396, Ch 9
			Operational and safety performance In relation to operational and safety performance, FMEA or similar analysis is to: • determine failures leading to major or more severe effects.	NR 396, annex 9
			Stabilization system FMEA is to include: • stabilization system.	NR 396, ch 16
		Mandatory if	**Control system** FMEA is to be submitted for approval where manual intervention for averting of a danger is not possible, covering: • programmable electronic systems.	NR 396, ch 11
Icebreaker	FMEA	Mandatory	**Propulsor in ice and polar waters** FMEA is to be submitted for approval covering: • propulsion and steering functions of the propulsor.	NR 584, Sec 1
Liquefied gas carrier	FRA	Mandatory	**Fire** The risk of fire propagation from turret compartments to adjacent spaces shall be evaluated by a risk analysis.	NR 467, Pt D, Ch 09, Sec 03
	HAZID	Mandatory	**Accidental situation** Additional relevant accident scenarios shall be determined based on a risk analysis.	NR 467, Pt D, Ch 09, Sec 04
	ERA	Mandatory	**Turret compartment** Risk analysis is to: • substantiate characteristics of explosion or uncontrolled high pressure gas release for turret compartments with due consideration of the capabilities of the pressure relieving devices.	NR 467, Pt D, Ch 09, Sec 03

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
LNG bunkering ship	HAZID, HAZOP	Mandatory	**LNG transfer** Documentation to be submitted for information: • risk analysis - LNG transfer system • follow up report • risk analysis of the bunkering operations. The design and the installation of the LNG transfer system are to be substantiated by a risk analysis.	NR 620, Sec 1
Passenger ship Ro-ro passenger ship	HAZID, FMEA	Mandatory	**Gas fuelled ship** For propulsion and electrical production plants using gas as fuel, risk analysis is to consider: • vessel itself • interface with the bunkering facilities (trucks, barge or shore storage plant).	NI 388, 1, D-
see SOLAS Ch02-2, Part F, Reg 17		If requirement adapted	**Fire** Risk analysis may allow: • new alternative designs.	NI 388, 3, A, Chap II-2
POLAR CAT-A POLAR CAT-B POLAR CAT-C	HAZID	Recommended	**Polar water navigation** Operational assessment: • identify relevant hazards • develop a model to analyse risks: - accident scenarios - probability consequences • assess risk and determine acceptability....	NR 527, Sec 4
semi-submersible cargo ship	FMEA	Mandatory	**Ballast system** Documentation to be submitted for information: • ballast system FMEA. FMEA is to be performed regarding the ballast system, including its control and monitoring systems. FMEA is to address the ballast functions with reference to the different modes of operation, and regarding float-on/float-off or load-on / load-off operations.	NR 467, Pt E, Ch 09, Sec 01

Risk analysis for the type or service - Service notation and additional service features				
Application	Type	Required status	Descriptions	References
SRtP	FRA, FMEA	Mandatory	**Safe return to port** For each system required to remain operational during the safe return to port / orderly evacuation, overall assessment study to be submitted (supplemented by detailed assessment study if necessary). Detailed assessment study may be required such as: • fire analysis • FMEA • detailed analysis of possibility of flooding of a particular compartment with its consequences on the system components. Overall assessment mandatory. Detailed assessment may be required to BV satisfaction. (Reference to IMO MSC.1/Circ.1369).	NR 598, Sec 1
Wind farms service ships	FMEA	Mandatory	**Light ship** A Failure Mode and Effects Analysis (FMEA) is to be carried out for light ship.	NI 589, Sec 6

Table 3 : Risk analysis for additional equipment or specific arrangement - Additional class notation

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
Offshore units				
DRILL	HAZID, HAZOP, FMECA	Mandatory	**Equipment** Risk analysis of the design and layout of the equipment is to result on: • unnecessary hazards are to be avoided whenever practicable though safe design • hazard mitigation measures are to be defined whenever such hazards cannot be avoided through other means.	NR 570, Sec 2
HIPS	FMEA, SIL analysis	Mandatory	**HIPS system** For the HIPS system and for each sub-system, a failure modes and effects analysis (FMEA) is to be documented. (Refer to IEC 61508 Part II §.7.4.7.4). • diagnostic tests coverage is to be reported in the failure mode effect analysis (FMEA) • the safe failure fraction (SFF) is to be calculated for individual component only. The results of the FMEA are to be used to calculate the SFF.	NI 524, Sec 3
	HAZOP, SIL allocation (LOPA)	Mandatory	**Procedure** In preliminary studies, hazard and risk analysis (HAZOP, QRA, preliminary risk analysis) is to determine: • hazards and hazardous events of the process and associated equipment • sequence of events leading to the hazardous event • process risks associated with the hazardous event • risk reduction that has to be brought by the HIPS system.	NI 524, Sec 2
	Fault tree with PFD calculation	Mandatory	**HIPS system** A fault tree method may be used to: • calculate the Probability of Failure on Demand over the lifetime period of the HIPS system • demonstrate that no single event leads to the unwanted event "loss of safety function" • show the impact of common cause failures.	NI 524, Sec 3
Liquefied gas offloading	HAZID, HAZOP, SCE, (FMECA)	Mandatory	**LNG transfer** For transfer systems, the followings are to be submitted for information: • detailed follow-up report of actions and mitigation measures taken in response to risk analysis findings • risk assessment report: - operational procedures - limiting conditions for loading/offloading operations - safety and operability of the transfer system. Risk assessment approach based on the requirements of EN 1474-3. EN ISO 17776 “Guidelines on tools and techniques for hazard identification and risk assessment“ may be accepted. SCE identification and SCE assessment forms development, (FMECA if the system or a part of it should tolerate more than one failure (e.g. HPU of ERCs)).	NR 542, Sec 14

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
oil offloading (transfer arms)	HAZID, HAZOP, FMECA	Mandatory	**Transfer system** • A risk assessment study is to be carried out, as a part of overall assessment of the transfer system based on the provisions of EN 1474-3, [4.6] EN ISO 17776 "Guidelines on tools and techniques for hazard identification and risk assessment may be accepted. • check that the performance standards are achieved for each safety critical element.	NR 588, Sec 2
PROC	HAZID, FERA, EERA, QRA	Recommended	**Topside system** Reference to recommended practice API RP 14J, EN ISO 17776 and NORSOK Z-013	NR 459, Sec 2
	HAZOP	Mandatory	**Systems** HAZOP report is to be submitted for review or information.	NR 459, Sec 2
RBA	HAZID	Mandatory	**Floating offshore units** Identification of major accident events requires a HAZID analysis.	NI 567, Sec 2
	RA	Mandatory	**Classification process** For RBA notation, classification process is carried out through a risk analysis approach. Requirements in NR568 Classification of Offshore Units - Risk Based Approach	NR 445, Pt A, Ch 1, Sec 2
	Safety Case (HAZID, HAZOP, Bow-Tie, Hazard register, ALARP demonstration, QRA, SCE identification and development of performance standards), EERA.	Mandatory	**Risk analysis approach** Classification based on a risk analysis approach, which may be accepted by the Society can credit for Risk Based Verification (similar approaches). Offshore units classed through a risk analysis approach fulfill also a significant part of the procedure for UK compliance. As additional work, the following items are to be considered: • a formal safety case is required • evacuation, escape rescue and recovery are to be specially considered. The verification scheme is developed for SCE according to their failure mode, their risk ranking of hazards and roles in risk reduction (Sec 2, [2.5.3]).	NI 567, Sec 1

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
RBA	Safety Case (HAZID, HAZOP, Bow-Tie, Hazard register, ALARP demonstration, QRA, SCE identification and development of performance standards), EERA	Mandatory	**Risk analysis approach** Procedures and methodologies for the classification of floating offshore units based on a risk analysis approach, formalized through the additional class notation RBA. • appropriate in the following cases: - new technology or based on novel design, for which the existing record of in-service information is insufficient to provide prescriptive Rules. - units for which the Society also provides independent verification services based on the principles of NI 567 Risk Based Verification of Floating Offshore Units. • alternatives or modifications of the requirements of the Offshore Rules accepted only for the part of the unit covered by the classification based on risk analysis approach • possible classification based on a risk analysis approach of existing units: - update of the verification scheme - significant changes of design or operation of the unit - significant feedback of the inspection activities.	NR 568, Sec 1
REGAS	HAZID, HAZOP	Mandatory	**Regasification installation** In addition to typical HAZID and HAZOP study for liquefied natural gas storage unit, relevant hazard and risks scenarios with respect to regasification operation are to be identified (which might not be addressed by recognized code and Rule).	NR 645, Sec 10
	RA	Mandatory	**Regasification installation** Documentation to be submitted for information: Risks assessment and analysis study reports	NR 645, Sec 10
	FRA, ERA, DORA, SCA	Mandatory if	**Regasification installation** According to the results of the HAZID and HAZOP study, specific risks analyses are to be carried out, if they are relevant.	NR 645, Sec 10
STAR-MACH	RCM	Mandatory	**General** Risk analysis is to be performed: • for propulsion and steering installations (if any) and marine auxiliary systems (machinery, electrical) in order to support and validate the maintenance plan in the operating context.	NR 445, Pt A, Ch 1, Sec 2
STAR-MACH SIS	RCM	Mandatory	**General** Risk analysis is to be performed: • for propulsion and steering installations (if any) and marine auxiliary systems (machinery, electrical) in order to support and validate the maintenance plan in the operating context.	NR 445, Pt A, Ch 1, Sec 2
STAR-CARGO	RCM	Mandatory	**Cargo handling installation** RCM study is to be performed in order to support and validate the maintenance plan in the operating context, covering: • cargo handling installation and its associated marine systems.	NR 445, Pt A, Ch 1, Sec 2

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
STAR-REGAS	RCM	Mandatory	**Regasification installation** RCM study is to be perform covering: • regasification installation and its associated systems. RCM study documentations are to be submitted for review.	NR 445, Pt A, Ch 1, Sec 2
Sea going ships				
AUT-IMS	FMEA	Mandatory	**Control and monitoring** FMEA is to demonstrate: • the availability of control and monitoring functions in case of failure of the integrated computer based system. In accordance with IEC 60812.	NR 467, Pt F, Ch 3, Sec 4
AVM	FMEA	Guidance	**Additional notation** procedures for FMEA	NR 467, Pt F, Ch 2, App 1
AVM-APS	FMEA	Mandatory	**Propulsion** Risk analysis is to be submitted for approval, demonstrating the availability of operating conditions in case of system failure. Risk analysis is to consider: • alternative propulsion system (required sea trials tests) • auxiliary systems serving the propulsion system • electrical power plant.	NR 467, Pt F, Ch 2, Sec 1
AVM-DPS	FMEA	Mandatory	**Propulsion** Risk analysis is to be submitted for approval, demonstrating the availability of operating conditions in case of system failure. Risk analysis is to consider: • propulsion systems and steering system and electrical power plant (required sea trials tests) • auxiliary systems serving the propulsion system.	NR 467, Pt F, Ch 2, Sec 2
AVM-FIRE	FMEA	Mandatory	**Propulsion and steering system** Risk analysis is to be submitted for approval, demonstrating the availability of machinery and control stations of propulsion and steering system in case of fire in one main diesel generator room.	NR 467, Pt F, Ch 2, Sec 4

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
AVM-IPS	FMEA	Mandatory	**Propulsion, steering and power generation** Risk analysis is to be submitted for approval, demonstrating the availability of propulsion, steering and power generation in case of single failure. Risk analysis is to consider: • steering capability • auxiliary systems serving the propulsion systems • fire or flooding casualty in machinery space • electrical installations • (required sea trials tests).	NR 467, Pt F, Ch 2, Sec 3
BATTERY SYSTEM	FMEA	Mandatory	**Battery** For other batteries than lead-acid batteries, Ni-Cd batteries, a risk analysis is to be submitted for approval, covering: • battery packs, battery compartment and BMS (battery management system).	NR 467, Pt F, Ch 11, Sec 21
		Mandatory if	**Propulsion and energy** A failure analysis is to be submitted regarding the availability of ship propulsion and energy.	NR 467, Pt F, Ch 11, Sec 21
BWT	HAZOP, QRA	Recommended	**Active substance** Risk assessment of active substances should include: • risks to the aquatic environment (potential toxic effects) • risks to the human health (potential toxic effects) • risks to the ship safety. Risk analysis according to GESAMP Ballast Water Working Group (GESAMP-BWWG)	NI 538, Sec 1
COLD CARGO	RA	Mandatory	**General** Risk analysis is to be submitted covering at least: • cargo overheating (creation of an explosive atmosphere) • freezing of the heating medium • ice built-up in the ballast tanks.	NR 467, Pt F, Ch 11, Sec 11
DYNAPOS - R DYNAPOS - RS	FMEA, fault tree	Mandatory	**DP installation** Qualitative risk analysis may be required for R or RS assignment. FMEA is to be submitted for approval considering all systems together (machine, power system, DP system): • consequences of a failure of the communication network and programmable controller units are to be included in the FMEA • UPS (Uninterrupted Power System) installation in accordance with results of FMEA analysis.	NR 467, Pt F, Ch 11, Sec 6
GAS-PREPARED	HAZID	Mandatory	**Use of gas fuel** HAZID analysis is to be submitted for information. Risks arising from the use of gas fuel are to be addressed.	NR 627, Sec 1

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
POLAR CLASS Ice class	FMEA	Mandatory	**Propulsor in ice and polar waters** FMEA is to be submitted for approval covering: • propulsion and steering functions of the propulsor.	NR 584, Sec 1
REGAS	HAZID, HAZOP	Mandatory	**Regasification installation** In addition to typical HAZID and HAZOP study for liquefied natural gas storage unit, relevant hazard and risks scenarios with respect to regasification operation are to be identified (which might not be addressed by recognized code and Rule).	NR 645, Sec 10
	RA	Mandatory	**Regasification installation** Documentation to be submitted for information: Risks assessment and analysis study reports	NR 645, Sec 10
	FRA, ERA DORA, SCA	Mandatory	**Regasification installation** According to the results of the HAZID and HAZOP study, specific risks analyses are to be carried out, if they are relevant.	NR 645, Sec 10
SAS (supply at sea)	FMEA	Mandatory	**Steering control** FMEA is to include: • steering control systems.	NR 467, Pt F, Ch 11, Sec 18
SCRUBBER READY	FMEA, HAZID	Mandatory	**Scrubber** Documentation to be submitted: Risk analysis about availability of essential systems of ship related to failure of EGCS system. List of the additional treatment products needed for the proper operation of the EGCS, the Material Safety Data Sheet of these products and recommendations of the Manufacturer and the associated risk analysis	NR 644, Sec 1
STAR-MACH	RCM	Guidance	**Additional notation** Definition of risk analysis • identification of critical equipment in compliance with ISM code, Section 10.	NR 467, Pt F, Ch 1, Sec 3
		Mandatory	**Propulsion and steering system** RCM study is to be performed covering: • ship propulsion and steering systems and auxiliaries (machinery, electrical). RCM study documentation is to be submitted. (If RCM study is no documented, the Society may perform a RCM study based on submitted documentation).	NR 467, Pt F, Ch 1, Sec 3

Risk analysis for additional equipment or specific arrangement - Additional class notation				
Application	Type	Required status	Descriptions	References
STAR-MACHSIS	RCM	Mandatory	**Propulsion and steering system** RCM study is to be performed covering: • ship propulsion and steering systems and auxiliaries (machinery, electrical). RCM is to be periodically up-dated. RCM study documentation is to be submitted. (If RCM study is not documented, the Society may perform a RCM study based on submitted documentation).	NR 467, Pt F, Ch 1, Sec 3
STAR-CARGO	RCM	Mandatory	**Cargo handling installation** RCM study is to be performed in order to support and validate the maintenance plan in the operating context, covering: • cargo handling installation and its associated systems.	NR 467, Pt F, Ch 1, Sec 5
STAR-REGAS	RCM	Mandatory	**Regasification installation** RCM study is to be perform covering: • regasification installation and its associated systems. RCM study documentations are to be submitted for review. The Society can carry out the RCM study.	NR 467, Pt F, Ch 1, Sec 4
SYS-COM	FMEA, FMECA	Mandatory	**Communication system** A FMEA/ FMECA on the communication equipment availability and redundancy capability is to be performed and be used as the input of security risk analysis. Documentation to be submitted for information: • FMEA or FMECA report.	NR 467, Pt F, Ch4, Sec 3
	safety risk analysis	Mandatory	**Communication system** A safety risk analysis of communication system and its immediate environment is to be performed and be used as the input of security risk analysis. Documentation to be submitted for information: • safety risk analysis report.	NR 467, Pt F, Ch4, Sec 3
	security risk analysis	Mandatory	**Communication system** A security risk analysis on communication system and its immediate environment is to be: • performed by an independent third party recognised by the Society • in compliance with IEC61162-460. The security risk analysis methodology is to comply with ISO 27005 or equivalent Documentation to be submitted for approval: • security report.	NR 467, Pt F, Ch4, Sec 03

Table 4 : Risk analysis for Naval ships

Application	Type	Required status	Description	References
Service notation				
Auxiliary Naval Vessel	FMEA	Mandatory	**Steering control systems** Risk analysis is to be performed on: • Steering control systems	NR 483, Pt D, Ch 4, Sec 8
Additional notation				
AUT-IAS	FMEA	Mandatory	**A FMEA study is to be submitted for approval**	NR 483, Pt E, Ch 4, Sec 3
AVM-APM	FMEA	Mandatory	Alternative propulsion system Risk analysis is to be submitted for approval, demonstrating: • availability of the alternative propulsion system in case of a single failure (required sea trials tests)	NR 483, Pt E, Ch 3, Sec 1
AVM-DPS	FMEA	Mandatory	**Operating conditions** Risk analysis is to be submitted for approval, demonstrating: • availability of the operating conditions in case of a single failure (required sea trials tests)	NR 483, Pt E, Ch 3, Sec 2
AVM-IPS	FMEA	Mandatory if	**Cooling system** For cooling system, if FMEA demonstrates the availability of one cooling system serving all propulsion systems in case of single failure, cooling systems may not to be provided for each main propulsion system.	NR 483, Pt E, Ch 3, Sec 3
STAR-MACH	RCM	Mandatory	**Inspection and maintenance plan** Granted to vessels on which a maintenance plan taking into account a risk analysis review of the installation is implemented. Inspection and Maintenance Plan (IMP) for the machinery is based on risk analysis review of the installation Risk analysis is to assess the inspection and maintenance process if a system fails, including: • machinery and equipment • other equipment or systems which are considered critical. • Improve the planned maintenance scheme (PMS) The Society performs the risk analysis for the ship and its plants, based on the documentation submitted. Maintenance of the STAR-MACH notation is based on the risk analysis review.	NR 483, Pt A, Ch 1, Sec 2
Propulsion general				
Surface Naval Ships	FMEA	BV satisfaction	**Power plant control systems** FMEA may be requested to: • demonstrate the reliability of the power plant control systems (blackout due to electric propulsion operation to be eliminated)	NR 483, Pt C, Ch 2, Sec 14
		Mandatory	**Steering gear** The following analysis are to be submitted for steering gear: • analysis in relation to risk of single failure • analysis in relation to risk of hydraulic locking	NR 483, Pt C, Ch 1, Sec 11

SECTION 3 RISK ANALYSIS IN IMO RULES

1 General

1.1 General

1.1.1 Risk analyses in IMO regulations are regrouped by reference IMO publication:

- SOLAS convention, given in Tab 1
- IGC code, given in Tab 2
- IGF code, given in Tab 3
- HSC code 2000, given in Tab 4
- Polar code, given in Tab 5.

In addition, the alternative design is treated in Article [8] and the formal safety assessment (FSA) in Article [8].

2 SOLAS

2.1 Risk analysis as required by SOLAS

2.1.1 Risk analysis in SOLAS are listed in Tab 1.

3 IGC code

3.1 Risk analysis as required by IGC

3.1.1 Risk analysis in IGC code are listed in Tab 2.

4 IGF code

4.1 Risk analysis as required by IGF code

4.1.1 Risk analysis in IGF code are listed in Tab 3.

5 High speed craft - HSC 2000

5.1 Risk analysis as required by HSC 2000 code

5.1.1 Risk analysis in HSC code are listed in Tab 4.

6 Polar code

6.1 Risk analysis as required by Polar code guidance

6.1.1 Risk analysis in Polar code are listed in Tab 5.

Table 1 : Risk analysis as required by SOLAS

Application	Type	Required status	Description	References
Ships				
Equipment	HAZOP, PHA, FMEA, what-if	If requirement adapted	**LSA** For alternative design, risk assessment is part of engineering analysis and include: • identification of the potential faults and hazards associated with the proposal of alternative design	Ch03, Part C, Reg38, [3.7]
Machinery	HAZID	If requirement adapted	**Alternative design and equivalent** For alternative design, risk assessment is part of engineering analysis and include: • identification of the potential faults and hazards associated with the proposal of alternative design	Ch02-1, Part F, Reg 55, [3.7]
	RA	Administration satisfaction	**Steam boilers and boiler feed systems** Risk assessment may confirm: • adequate protection against overpressure, for redundant requirement of safety valves for steam boilers and unfired steam generators	Ch02-1, Part C, Reg 32, [1]
Safety	HAZOP, PHA, FMEA, what-if	If requirement adapted	**Alternative design** For alternative design, engineering analysis is to include: • identification of the fire and explosion hazards of the ship or the space(s) concerned Reference to Guidelines on alternative design and arrangements for fire safety (MSC/Circ.1002).	Ch02-2, Part F, Reg17, [3.3]
Oil tanker				
Electricity and automation	RA	Administration satisfaction	**Electrical equipment** Risk assessment is to ensure an equivalent level of safety for: • electrical equipment, cables and wiring which do not conform to the standards, installed in hazardous locations	Ch02-1, Part D, Reg 45, [.11]

Table 2 : Risk analysis as required by IGC

Application	Type	Required status	Description	References
Liquefied gas carrier				
Safety	RA	If requirement adapted	**Arrangement and systems** Alternative arrangement may be accepted after risk assessment	[3.1.1]
	FRA, ERA	Mandatory	**Arrangement and systems** Risk analysis is to evaluate: • risk of fire propagation from turret compartments to adjacent spaces • turret compartments structural integrity in case of explosion or uncontrolled high-pressure gas release (considering the capabilities of the pressure relieving devices).	[3.1.5]
Electricity and automation	FMEA	Mandatory	**Electrical system** FMEA is to include: • electrical generation and distribution systems, and associated control systems (maintain cargo tank pressures and hull structure temperature, within normal operating limits) • FMEA with a standard not inferior to those acceptable to the Administration (IEC 60812, Edition 2.0 2006-01 "Analysis techniques for system reliability – Procedure for failure mode and effects analysis (FMEA)").	10.2.[6]
	HAZID	Mandatory	**Automation system** Processes for the development and maintenance of integrated systems shall include appropriate risk identification and management.	[13.8]
	HAZID	Mandatory	**Integrated system** Key hazards of the integrated system shall be identified using appropriate risk-based techniques.	[13.9]
Structure	HAZID	Mandatory	**Membrane tanks** For membrane tank in accidental design conditions, risk analysis is to: • determine additional relevant accident scenarios (particular attention to securing devices inside tanks).	[4.24.7.2]

Table 3 : Risk analysis as required by IGF code

Application	Type	Required status	Description	References
Gas fuelled ship				
Machinery	FMECA, FRA, ERA	Mandatory	**Flashpoint fuel systems** Risk assessment shall be conducted for all flashpoint fuel systems to ensure that risks affecting persons on board, environment, structural strength or integrity of the structure are addressed. Risk shall be analysed using recognized risk analysis considering: • Loss of function • component damage, • fire, explosion and electric shock	Part A [4.2]
Structure	HAZID	Mandatory	**Fuel containment system** Risk analysis is to determine: • additional relevant accident scenarios	Part A-1 Annex [6.8]
	HAZID	Mandatory	**Bunkering station** Risk assessment is to include: • bunkering station	Part A-1 [8.3.1.1]
	HAZID, HAZOP	If requirement adapted	**Fuel containment system** Risk analysis is to justified a reduction of consequence class factor value for the fuel containment system, including; • provision of full or partial secondary barrier to protect hull structure from the leakage and less hazards associated with intended fuel.	Part A-1 Annex [4.4]
		Mandatory	**Fuel containment system** Risk assessment is to include: • ship's liquefied gas fuel containment system	Part A-1 [6.4.1.1]
		Mandatory	**Fuel containment system** For ship using natural gas as fuel, risk analysis is to determine: • additional relevant accidental scenarios applicable to the containment system and the supporting hull structure (attention on securing devices inside of tanks).	Part A-1 [6.4.15.4.7.2]
	Leakage Consequence Analysis	Mandatory	**Tank connection space** Risk assessment is to include: • tank connection space	Part A-1 [13.4.1]
	SGDA	Mandatory	**Airlock** Risk analysis is to include airlocks: • no gas released to safe spaces	Part A [5.12.3]
		Mandatory	**Ventilation inlet to accommodation and machinery space** Risk assessment is to include: • ventilation inlets to accommodation and machinery space	Part A-1 [15.8.1.10]

Table 4 : Risk analysis as required by HSC 2000 code

Application	Types	Required status	Description	Reference
High Speed Craft (HSC)				
General	FMEA	Mandatory	**Survey** FMEA is required during: • initial survey	Ch 01, [1.5.2.1.3]
Electricity and automation	FMEA	Mandatory	**Control system** FMEA is to include: • directional control system	Ch 05, [5.2.5]
		Mandatory	**Electrical system** FMEA is to include: • electrical system, taking into account the effects of electrical failure on the systems being supplied	Ch 12, Part A, [12.1.1]
Machinery	FMEA	Mandatory	**Gas turbine** FMEA is to include: • automatic safety devices to guard against hazardous conditions arising in the event of malfunction in the turbine installation	Ch 09, Part A, [9.3.8]
		Mandatory	**Machinery systems** FMEA is to include: • machinery system and their associated controls	Ch 09, Part A, [9.1.10]
		Mandatory	**Stabilization system** FMEA is to include: • stabilization system.	Ch 16, [16.2.6]

Table 5 : Risk analysis as required by Polar code Guidance

Application	Type	Required status	Description	Reference
Ships intended for navigation in polar waters				
Operation	HAZID	Guidance	**Ice operation** Risk analysis is to determine limitations for operation in ice Steps for an operational assessment: • identify relevant hazards • develop a model to analyse risks: - accident scenarios; - probability - consequences • assess risk and determine acceptability.... Reference to appendix 3 of the Revised guidelines for Formal Safety Assessment (FSA) for use in the IMO Rule-Making Process (MSC-MEPC.2/Circ.12) and standard IEC/ISO 31010 "Risk management – Risk assessment techniques"	Part I-B, [2.1.1]
	FSA	Mandatory	**Ice operation** An assessment of the ship and its equipment shall be carried out in order to establish procedures or operational limitations, taking into consideration: • the anticipated range of operating and environmental conditions • hazards.	Part I-A, [1.5]

7 Alternative design

7.1 General

7.1.1 An alternative design approach consists in carrying out an analysis of a non-conventional design and comparing results to evaluation criteria or to the performance of a conventional ship. The demonstration is based on performance metrics and/or risk metrics. Alternative design and equivalents can be found in SOLAS, MARPOL, LOAD LINES conventions as well as most of the IMO codes BV Rules and, in particular in the following IMO guidelines:

- MSC1./Circ.1455, Guidelines for the approval of alternatives and equivalents as provided for in various IMO instruments
- MSC1./Circ.1212, Guidelines on alternative design and arrangements for SOLAS Chapter II-1 and III
- MSC/Circ.1002, Guidelines on alternative design and arrangements for fire safety.

Table 6 : Recommended analysis

		Type
Qualitative analysis	LSA	FMEA, HAZID
	MVZ	What-if, event trees, fault trees
	LFD	What-if, event trees, fault trees
Quantitative analysis		FEM, CFD, Evacuation First principle tools
		Tests
		QRA

Note 1:
CFD : Computational Fluid Dynamics
FEM : Finite Element Model
LSA : Life Saving Appliance.

8 Formal Safety Assessment (FSA)

8.1 General

8.1.1 FSA is a tool to help in the evaluation of new regulations for maritime safety (or protection of environment) or in making a comparison between existing and possibly improved regulations with a view to achieving a balance between the various technical and operational issues, (incl. the human element), and between maritime safety (or protection of environment) and costs.

FSA should comprise the following steps:

- identification of hazards
- risk analysis
- risk control options
- cost-benefit assessment, and
- recommendations for decision-making.

FSA is recommended when there is a need for risk reduction but the required decisions regarding what to do are unclear" and/or if proposals may have far-reaching implications in terms of either costs or the legislative and administrative burdens.

Appendix 3 of MSC-MEPC.2/Circ.12 provides examples of hazard identification and risk analysis techniques (to be chosen according to the problem in question).

The Revised Guidelines for Formal Safety Assessment (FSA) for use in the IMO rule-making process (MSC-MEPC.2/Circ.12) contains information on risk acceptance evaluation criteria, which are sometimes required in risk assessment and alternative designs and equivalents (MSC.1/Circ.1455).

SECTION 4 RISK ANALYSIS IN INDUSTRY

1 General

1.1 General

1.1.1 The risk analysis for Industry best practices (OCIMF, SIGTTO, and BIMCO) are regrouped by reference publication:

- Ship to ship transfer guide, given in Tab 1
- Tanker Management and Self-Assessment (TMSA2), given in Tab 2.

2 Ship to ship transfer guide

2.1 Risk analysis as required by Ship to ship transfer guide

2.1.1 Risk analysis in Ship to ship transfer guide are listed in Tab 1.

3 TMSA2

3.1 Risk analysis as required by TMSA2

3.1.1 Risk analysis in TMSA2 are listed in Tab 2.

Table 1 : Risk analysis - Ship to ship transfer guide

Application	Type	Required status	Description	Reference
Ship to ship transfer				
General	RA	Recommended	**General** For ship to ship operation, risk analysis is to include: • all aspects of the STS transfer for the terminal and vessels alongside.	[1.9]
Operation	RA	Recommended	**Manoeuvres** For manoeuvres with one ship at anchor, risk assessment is to • evaluate the necessity of tug assistance for the manoeuvring ship (risk assessment should be undertaken by the organisers).	[6.3]
			Manoeuvres For manoeuvres with one ship alongside a terminal, risk assessment is to be conducted before double banking operation (if berths have not traditionally been used for such operations).	[6.5]
			Simultaneous operations Risk assessment is to be conducted if bunkering and cargo operations take place at the same time.	[7.6]
			Fenders Risk assessment is to evaluate: • handling of the fenders when primary fenders are rigged on the discharging ship.	[9.1.1]
			Personnel transfer For personnel transfers at sea, risk assessment is to verify: • the safest means of transfer, considering the prevailing circumstances and conditions.	[9.4]
			Personnel transfer For personnel transfers in port, a formal risk assessment should identify • the safest means of personnel transfer between the vessels.	[9.5]
			Reverse lightering Risk assessment is to be performed: • before committing to a reverse lightering operation.	[Appendix I]
			General Pre-operation risk assessment may identify: • crew additional roles and responsibilities than routine operation • emergency scenarios that are not included in the vessel's regular exercise program.	[1.8]

Application	Type	Required status	Description	Reference
General	RA	Recommended	**General** Risk assessment is to be performed before an STS transfer operation, including: • identification of potential sources and consequences of risk • physical and operational hazards.	[1.4]
			Location Risk assessment is to be performed for each STS location, including: • identification of hazard specific to the location • mooring analysis.	[1.4]
Safety	RA	Recommended	**Emergency scenarios** For ship to ship operation, risk assessment is to identify: • potential emergency scenarios that are not already covered by the ships' emergency response plans.	[10.1]
			Control measures Risk assessment is to determine: • control measures when working in areas with gas accumulation on open deck.	[3.6]
Equipment	RA	Recommended	**Fenders** For in port transfers, risk assessment should determine: • requirements to have adequate fenders considering velocity and energy absorption.	[9.1.4]
Safety	RA	Recommended	**Sloshing impacts** For ship to ship transfers involving liquefied natural gas cargoes, risk assessment is to be performed for STS operation at anchor or underway, covering: • risk from sloshing impacts.	[Appendix D]

Table 2 : Risk analysis in good practice - TMSA2

Application	Type	Required status	Descriptions	Reference
Oil tanker				
Safety	HAZID	Recommended	**Changes** Risk assessment is to: • evaluate the impact of changes on all routine and non routine task • include all temporary and permanent changes to procedure or equipment on board the vessel. If proposed change is not completed within a set time frame, the initial hazard observation/risk assessment must be revisited.	[7.2]
	HAZID, RAM	Recommended	**Critical systems and equipment** Risk assessment or hazard identification are to help: • identification of on-board critical systems, alarms and equipment • maintenance on critical equipment. Further risk assessment is undertaken if circumstances change.	[4.4]
			Spare parts Hazard identification studies is to: • established spare parts inventory.	[4.4]

SECTION 5 RISK ANALYSIS FOR INLAND NAVIGATION VESSELS

1 General

1.1 General

1.1.1 The risk analysis for Inland navigation Vessels are regrouped by reference publication:

- Society documents, in Tab 1
- Industry Guide ISGINTT, in Tab 1.

Table 1 : Risk analysis applicable to Inland vessel

Application	Type	Theme	Description	Reference
Inland navigation vessel				
Electricity and automation	HAZID	Mandatory	**Computer based system** Risk analysis serves as basis for computer systems assignment of requirement classes	NR 217, Pt C, Ch 2, Sec 16
Machinery	FMEA	For type approval	**Diesel engine electronic control** FMEA is to be submitted for type approval and is to: • demonstrate the availability of an electronic control system (where engines incorporate electronic control system) • help to select cases for integration test of electronically controlled diesel engines.	NR 217, Pt C, Ch 1, Sec 2
Inland oil tanker				
Safety	HAZID	Recommended	**Hot work** Risk assessment should be performed for hot work: • outside a designated space, to identify hazards and risks to fire watch personnel and their means of evacuation in an emergency • in a dangerous or hazardous area, (presence of hydrocarbon vapours in the atmosphere and potential ignition source) • in cargo tanks, (extend of the cleaned area)	ISGINTT [9.4.3.1]
	HAZID, HAZOP	Recommended	**Operations** For terminals and seagoing tankers, a risk analysis should include: • all aspects of the tanker's and terminal's operations in order to determine which parts of them are more susceptible and/or more likely to be the subject of a security incident.	ISGINTT [6.2]
	RA	Recommended	**Aluminium equipment** Risk assessment should substantiate: • use of aluminium equipment other than gangways, step ladders or other heavy portable structures, in cargo tanks and on cargo decks	ISGINTT [4.6]
			Spread loading Risk assessment is to consider spread loading, including: • terminal's piping configuration, including flow control capability. • tanker's piping configuration. • tanker's cargo tank condition • product to be loaded and the potential for generating a flammable atmosphere	ISGINTT [11.1.7.7]
	HAZID, HAZOP, RA	Recommended	**Terminal** For terminal safety management, Hazard identification and risk assessment are to be addressed Formal risk assessment should determine: • design case • terminal fire-fighting equipment capability Risk assessment of the terminal should determine: • potential hazards • the rate of discharge for terminal fire fighting systems (below deck fixed protection system), including the type of operations and the jetty lay-out.	ISGINTT [15.2]

SECTION 6 INDEX

1 Reference documents

2 Index