Guide for Technology Qualification Processes

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GENERAL CONDITIONS

Definitions:

"*Administration*" means the Government of the State whose flag the Ship is entitled to fly or under whose authority the Ship is authorized to operate in the specific case.

"IACS" means the International Association of Classification Societies.

"*Interested Party*" means the party, other than the Society, having an interest in or responsibility for the Ship, product, plant or system subject to classification or certification (such as the owner of the Ship and his representatives, the ship builder, the engine builder or the supplier of parts to be tested) who requests the Services or on whose behalf the Services are requested.

"*Owner*" means the registered owner, the ship owner, the manager or any other party with the responsibility, legally or contractually, to keep the ship seaworthy or in service, having particular regard to the provisions relating to the maintenance of class laid down in Part A, Chapter 2 of the Rules for the Classification of Ships or in the corresponding rules indicated in the specific Rules.

"Rules" in these General Conditions means the documents below issued by the Society:

(i) Rules for the Classification of Ships or other special units;
(ii) Complementary Rules containing the requirements for product, plant, system and other certification or containing the requirements for the assignment of additional class notations;
(iii) Rules for the application of statutory rules, containing the rules to perform the duties delegated by Administrations;
(iv) Guides to carry out particular activities connected with Services;
(v) Any other technical document, as for example rule variations or interpretations.

"*Services*" means the activities described in Article 1 below, rendered by the Society upon request made by or on behalf of the Interested Party.

"Ship" means ships, boats, craft and other special units, as for example offshore structures, floating units and underwater craft.

"*Society*" or *"TASNEEF"* means Tasneef and/or all the companies in the Tasneef Group which provide the Services.

"*Surveyor*" means technical staff acting on behalf of the Society in performing the Services.

Article 1

1.1. The purpose of the Society is, among others, the classification and certification of ships and the certification of their parts and components. In particular, the Society:
(i) sets forth and develops Rules;
(ii) publishes the Register of Ships;
(iii) issues certificates, statements and reports based on its survey activities.

1.2. The Society also takes part in the implementation of national and international rules and standards as delegated by various Governments.

1.3. The Society carries out technical assistance activities on request and provides special services outside the scope of classification, which are regulated by these general conditions, unless expressly excluded in the particular contract.

Article 2

2.1. The Rules developed by the Society reflect the level of its technical knowledge at the time they are published. Therefore, the Society, although committed also through its research and development services to continuous updating of the Rules, does not guarantee the Rules meet state-of-the-art science and technology at the time of publication or that they meet the Society's or others' subsequent technical developments.

2.2. The Interested Party is required to know the Rules on the basis of which the Services are provided. With particular reference to Classification Services, special attention is to be given to the Rules concerning class suspension, withdrawal and reinstatement. In case of doubt or inaccuracy, the Interested Party is to promptly contact the Society for clarification.
The Rules for Classification of Ships are published on the Society's website: www.tasneef.ae.

2.3. The Society exercises due care and skill:
(i) in the selection of its Surveyors
(ii) in the performance of its Services, taking into account the level of its technical knowledge at the time the Services are performed.

2.4. Surveys conducted by the Society include, but are not limited to, visual inspection and non-destructive testing. Unless otherwise required, surveys are conducted through sampling techniques and do not consist of comprehensive verification or monitoring of the Ship or of the items subject to certification. The surveys and checks made by the Society on board ship do not necessarily require the constant and continuous presence of the Surveyor. The Society may also commission laboratory testing, underwater inspection and other checks carried out by and under the responsibility of qualified service suppliers. Survey practices and procedures are selected by the Society based on its experience and knowledge and according to generally accepted technical standards in the sector.

Article 3

3.1. The class assigned to a Ship, like the reports, statements, certificates or any other document or information issued by the Society, reflects the opinion of the Society concerning compliance, at the time the Service is provided, of the Ship or product subject to certification, with the applicable Rules (given the intended use and within the relevant time frame).
The Society is under no obligation to make statements or provide information about elements or facts which are not part of the specific scope of the Service requested by the Interested Party or on its behalf.

3.2. No report, statement, notation on a plan, review, Certificate of Classification, document or information issued or given as part of the Services provided by the Society shall have any legal effect or implication other than a representation that, on the basis of the checks made by the Society, the Ship, structure, materials, equipment, machinery or any other item covered by such document or information meet the Rules. Any such document is issued solely for the use of the Society, its committees and clients or other duly authorised bodies and for no other purpose. Therefore, the Society cannot be held liable for any act made or document issued by other parties on the basis of the statements or information given by the Society. The validity, application, meaning and interpretation of a Certificate of Classification, or any other document or information issued by the Society in connection with its Services, is governed by the Rules of the Society, which is the sole subject entitled to make such interpretation. Any disagreement on technical matters between the Interested Party and the Surveyor in the carrying out of his functions shall be raised in writing as soon as possible with the Society, which will settle any divergence of opinion or dispute.

3.3. The classification of a Ship, or the issuance of a certificate or other document connected with classification or certificate on and in general with the performance of Services by the Society shall have the validity conferred upon it by the Rules of the Society at the time of the assignment of class or issuance of the certificate; in no case shall it amount to a statement or warranty of seaworthiness,

structural integrity, quality or fitness for a particular purpose or service of any Ship, structure, material, equipment or machinery inspected or tested by the Society.

3.4. Any document issued by the Society in relation to its activities reflects the condition of the Ship or the subject of certification or other activity at the time of the check.

3.5. The Rules, surveys and activities performed by the Society, reports, certificates and other documents issued by the Society are in no way intended to replace the duties and responsibilities of other parties such as Governments, designers, ship builders, manufacturers, repairers, suppliers, contractors or sub-contractors, Owners, operators, charterers, underwriters, sellers or intended buyers of a Ship or other product or system surveyed.

These documents and activities do not relieve such parties from any fulfilment, warranty, responsibility, duty or obligation (also of a contractual nature) expressed or implied or in any case incumbent on them, nor do they confer on such parties any right, claim or cause of action against the Society. With particular regard to the duties of the ship Owner, the Services undertaken by the Society do not relieve the Owner of his duty to ensure proper maintenance of the Ship and ensure seaworthiness at all times. Likewise, the Rules, surveys performed, reports, certificates and other documents issued by the Society are intended neither to guarantee the buyers of the Ship, its components or any other surveyed or certified item, nor to relieve the seller of the duties arising out of the law or the contract, regarding the quality, commercial value or characteristics of the item which is the subject of transaction.

In no case, therefore, shall the Society assume the obligations incumbent upon the above-mentioned parties, even when it is consulted in connection with matters not covered by its Rules or other documents.

In consideration of the above, the Interested Party undertakes to relieve and hold harmless the Society from any third party claim, as well as from any liability in relation to the latter concerning the Services rendered.

Insofar as they are not expressly provided for in these General Conditions, the duties and responsibilities of the Owner and Interested Parties with respect to the services rendered by the Society are described in the Rules applicable to the specific Service rendered.

Article 4

4.1. Any request for the Society's Services shall be submitted in writing and signed by or on behalf of the Interested Party. Such a request will be considered irrevocable as soon as received by the Society and shall entail acceptance by the applicant of all relevant requirements of the Rules, including these General Conditions. Upon acceptance of the written request by the Society, a contract between the Society and the Interested Party is entered into, which is regulated by the present General Conditions.

4.2. In consideration of the Services rendered by the Society, the Interested Party and the person requesting the service shall be jointly liable for the payment of the relevant fees, even if the service is not concluded for any cause not pertaining to the Society. In the latter case, the Society shall not be held liable for non-fulfilment or partial fulfilment of the Services requested. In the event of late payment, interest at the legal current rate increased by 1.5% may be demanded.

4.3. The contract for the classification of a Ship or for other Services may be terminated and any certificates revoked at the request of one of the parties, subject to at least 30 days' notice to be given in writing. Failure to pay, even in part, the fees due for Services carried out by the Society will entitle the Society to immediately terminate the contract and suspend the Services.

For every termination of the contract, the fees for the activities performed until the time of the termination shall be owed to the Society as well as the expenses incurred in view of activities already programmed; this is without prejudice to the right to compensation due to the Society as a consequence of the termination.

With particular reference to Ship classification and certification, unless decided otherwise by the Society, termination of the contract implies that the assignment of class to a Ship is withheld or, if already assigned, that it is suspended or withdrawn; any statutory certificates issued by the Society will be withdrawn in those cases where provided for by agreements between the Society and the flag State.

Article 5

5.1. In providing the Services, as well as other correlated information or advice, the Society, its Surveyors, servants or agents operate with due diligence for the proper execution of the activity. However, considering the nature of the activities performed (see art. 2.4), it is not possible to guarantee absolute accuracy, correctness and completeness of any information or advice supplied. Express and implied warranties are specifically disclaimed.

Therefore, except as provided for in paragraph 5.2 below, and also in the case of activities carried out by delegation of Governments, neither the Society nor any of its Surveyors will be liable for any loss, damage or expense of whatever nature sustained by any person, in tort or in contract, derived from carrying out the Services.

5.2. Notwithstanding the provisions in paragraph 5.1 above, should any user of the Society's Services prove that he has suffered a loss or damage due to any negligent act or omission of the Society, its Surveyors, servants or agents, then the Society will pay compensation to such person for his proved loss, up to, but not exceeding, five times the amount of the fees charged for the specific services, information or opinions from which the loss or damage derives or, if no fee has been charged, a maximum of AED5,000 (Arab Emirates Dirhams Five Thousand only). Where the fees charged are related to a number of Services, the amount of the fees will be apportioned for the purpose of the calculation of the maximum compensation, by reference to the estimated time involved in the performance of the Service from which the damage or loss derives. Any liability for indirect or consequential loss, damage or expense is specifically excluded. In any case, irrespective of the amount of the fees charged, the maximum damages payable by the Society will not be more than AED5,000,000 (Arab Emirates Dirhams Five Millions only). Payment of compensation under this paragraph will not entail any admission of responsibility and/or liability by the Society and will be made without prejudice to the disclaimer clause contained in paragraph 5.1 above.

5.3. Any claim for loss or damage of whatever nature by virtue of the provisions set forth herein shall be made to the Society in writing, within the shorter of the following periods: (i) THREE (3) MONTHS from the date on which the Services were performed, or (ii) THREE (3) MONTHS from the date on which the damage was discovered. Failure to comply with the above deadline will constitute an absolute bar to the pursuit of such a claim against the Society.

Article 6

6.1. These General Conditions shall be governed by and construed in accordance with United Arab Emirates (UAE) law, and any dispute arising from or in connection with the Rules or with the Services of the Society, including any issues concerning responsibility, liability or limitations of liability of the Society, shall be determined in accordance with UAE law. The courts of the Dubai International Financial Centre (DIFC) shall have exclusive jurisdiction in relation to any claim or dispute which may arise out of or in connection with the Rules or with the Services of the Society.

6.2. However,

(i) In cases where neither the claim nor any counterclaim exceeds the sum of AED300,000 (Arab Emirates Dirhams Three Hundred Thousand) the dispute shall be referred to the jurisdiction of the DIFC Small Claims Tribunal; and

(ii) for disputes concerning non-payment of the fees and/or expenses due to the Society for services, the Society shall have the

right to submit any claim to the jurisdiction of the Courts of the place where the registered or operating office of the Interested Party or of the applicant who requested the Service is located.
In the case of actions taken against the Society by a third party before a public Court, the Society shall also have the right to summon the Interested Party or the subject who requested the Service before that Court, in order to be relieved and held harmless according to art. 3.5 above.

Article 7

7.1. All plans, specifications, documents and information provided by, issued by, or made known to the Society, in connection with the performance of its Services, will be treated as confidential and will not be made available to any other party other than the Owner without authorization of the Interested Party, except as provided for or required by any applicable international, European or domestic legislation, Charter or other IACS resolutions, or order from a competent authority. Information about the status and validity of class and statutory certificates, including transfers, changes, suspensions, withdrawals of class, recommendations/conditions of class, operating conditions or restrictions issued against classed ships and other related information, as may be required, may be published on the website or released by other means, without the prior consent of the Interested Party.
Information about the status and validity of other certificates and statements may also be published on the website or released by other means, without the prior consent of the Interested Party.

7.2. Notwithstanding the general duty of confidentiality owed by the Society to its clients in clause 7.1 above, the Society's clients hereby accept that the Society may participate in the IACS Early Warning System which requires each Classification Society to provide other involved Classification Societies with relevant technical information on serious hull structural and engineering systems failures, as defined in the IACS Early Warning System (but not including any drawings relating to the ship which may be the specific property of another party), to enable such useful information to be shared and used to facilitate the proper working of the IACS Early Warning System. The Society will provide its clients with written details of such information sent to the involved Classification Societies.

7.3. In the event of transfer of class, addition of a second class or withdrawal from a double/dual class, the Interested Party undertakes to provide or to permit the Society to provide the other Classification Society with all building plans and drawings, certificates, documents and information relevant to the classed unit, including its history file, as the other Classification Society may require for the purpose of classification in compliance with the applicable legislation and relative IACS Procedure. It is the Owner's duty to ensure that, whenever required, the consent of the builder is obtained with regard to the provision of plans and drawings to the new Society, either by way of appropriate stipulation in the building contract or by other agreement.
In the event that the ownership of the ship, product or system subject to certification is transferred to a new subject, the latter shall have the right to access all pertinent drawings, specifications, documents or information issued by the Society or which has come to the knowledge of the Society while carrying out its Services, even if related to a period prior to transfer of ownership.

Article 8

8.1. Should any part of these General Conditions be declared invalid, this will not affect the validity of the remaining provisions.

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1 GENERAL AND APPLICATION

The objective of this Guide is to provide a systematic approach to the qualification of novel technology, to ensure that it is fit for its intended service.

This Guide applies to the Technology Qualification Processes (TQP) of novel designs.

Some examples of novel aspects in innovative projects are given in Appendix A.

2 DEFINITIONS

2.1

2.1.1 Novel Technology

Novel technology is a technology that is not proven, i.e. there is no documented track record for a defined application. This implies that the definition of novel technology encompasses the application of both a proven technology in a new environment and an unproven technology in a known environment. The extent of the novel technology follows the classification provided in 8.3.

2.1.2 Fitness for Service

A novel technology is considered fit for service when the supporting evidence demonstrates that the technology fulfils all the requirements of functionality, safety, reliability, availability and maintainability defined in the qualification basis.

2.1.3 Third party

A third party is an organisation in charge of assessing and witnessing the TQ process to confirm compliance with this procedure; such organisation may be a classification society, a certification/verification body or any other approved third party.

2.1.4 Owner

The Owner is the physical or legal person that owns the technology and/or the unit on which the technology is fitted.

3 SCOPE

This procedure is applicable for components, equipment and systems which can be defined as novel technology.

4 PURPOSE

Novel technology is generally not adequately covered by established codes and procedures. Novel technology may therefore be required to be qualified through an approach herein denominated Technology Qualification (TQ). TQ is the process of verification that the novel technology meets the specified requirements for its intended service, through a systematic and documented process of qualification that will include examination of the design, engineering analyses and testing programs.

Engineering systems may comprise known and novel technology. The TQ process is aimed at identifying the novel elements and novel application of known technology, on which to focus the qualification program.

5 TQ PROCESS

TQ is to be based on specified safety, availability and reliability criteria, boundary conditions and interface requirements defined in the TQ basis.

TQ should be consistent with the following general philosophy:

- The TQ process is to be based on a systematic approach.
- A risk assessment is to be conducted to identify, rank and control failure modes affecting the fitness for service of the novel technology.
- Engineering analyses can be used to demonstrate that the design fulfils the specified requirements for its intended service.
- Measurements and tests are to be used to document that the novel technology fulfils the specified requirements for its intended service.

Alternative methods to demonstrate the fitness for service may be used provided that they are supported by proper justification. An example is the case when the novel technology is constituted by, or includes, software. Although the general steps of this Guide may be applied, more specific references are available (see 7) and should be used.

6 TQ RESULTS

6.1

6.1.1 The final result of TQ is an official statement, supported by appropriate documentation, of fitness for service consistent with the TQ basis. The statement may be in the form of a certificate, class notation or other equivalent document which is issued following the evaluation of the supporting evidence (drawings, technical reports, applicable rules and standards etc.), the survey for construction, installation and commissioning. The statement will confirm that the novel technology meets the specified requirements for its intended service.

6.1.2 Definitions

ALARP: As Low As Reasonably Practicable

Failure: Termination of the ability of an item to perform its intended function

Failure rate: Frequency (probability per unit time) of failures

Failure mode: The way in which an item may fail

FMECA: Failure mode, effects and criticality analysis

HAZOP: Hazard and operability study

Novel technology: Technology not proven

Proven technology: Technology with a documented track record in a defined environment

Qualification: Confirmation through documentary and physical evidence that the novel technology is fit for service

Fitness for service: Ability of the novel technology to meet the specified requirements for its intended use.

7 REFERENCES

EN 1474-1:2008, “Installation and Equipment for liquefied natural gas – Design and testing of marine transfer systems”

EN 1474-2:2008, “Installation and Equipment for liquefied natural gas – Design and testing of transfer hoses”

EN 1474-3:2008, “Installation and Equipment for liquefied natural gas – Offshore transfer systems”

IEC 61508, “Functional safety of electrical/electronic/programmable electronic safety related systems, parts 1-7, 2002

IEC 61511, “Functional safety - Safety instrumented systems for the process industry sector”, parts 1-3, 2006

BS 5760, Part 8, “Guide to assessment of reliability of systems containing software”, 1998

IMO MSC/Circ. 1002 “Guidelines for alternative design and arrangements for fire safety”

IMO MSC.1/Circ.1212 “Guidelines on Alternative Design and Arrangements for SOLAS Ch II-1 and III”.

8 QUALIFICATION PROCESS

8.1 General

The qualification of novel technology is a systematic process consisting of various steps:

- definition of qualification basis
- Technology Assessment
- selection of qualification methods
- data collection (analysis and testing)
- functionality assessment.

8.2 Qualification Basis

The purpose of the qualification basis is, in the possible absence of fully relevant codes and procedures, to define the objectives of the novel technology, the fulfilment of which are to be proved through the TQ process.

The qualification basis will be used as the input for the TQ process, through the establishment of criteria that are to be shared by the stakeholders (i.e. at least the Contractor and the Owner) and the third party. It should include at least the following key items:

- Description of the technology to be qualified with the system boundaries defining the scope of the TQ
- Operational conditions and limitations
- Functional requirements
- Safety, reliability, availability and maintainability criteria
- Codes and standards.

They will be used as the basis for establishing the design, manufacturing and installation specifications and the test and maintenance policy throughout the lifecycle.

8.3 Technology Assessment

The purpose of the Technology Assessment is to divide the technology into manageable elements in order to assess those elements that involve aspects of novel technology and identify the key challenges and uncertainties. The Technology Assessment should include the following issues:

- division of the technology into manageable elements (i.e. subsystems and components, processes or operations, manufacturing, installation etc.)
- assessment of the technology elements with respect to novelty (see Table 1)
- identification of the main challenges and uncertainties related to the novel technology aspects.

The level of detail in the subdivision of the technology should be appropriate to focus on the novel or uncertain aspects that subsequently will be subjected to risk assessment.

The technology is to be classified according to its degree of novelty.

Table 1

Application area	Technology		
	Proven	Limited field history	New or unproven
Known	1	2	3
New	2	3	4

This classification implies the following:

1) No new technical uncertainties
2) New technical uncertainties
3) New technical challenges
4) Demanding new technical challenges.

This classification applies to the totality of the applied technology as well as each separate part, function and subsystem forming it. It is to be used to highlight the points of concern due to limited field history.

Technology in Class 1 is proven technology where proven methods for qualification, tests, calculations and analysis can be used. Technology defined as Class 2 to 4 is defined as novel technology, and for this reason it is likely that no recognised standard for the design exists or is fully applicable; thus, such technology is to be qualified according to the procedure described in the following section. The distinction between 2, 3 and 4 makes it possible to focus on the area of concern.

8.4 Qualification Methods

8.4.1 General

The objective of this step is to select methods that adequately address the key issues of the technology subject to qualification. Such methods will likely consist of a proper combination of engineering analyses and test programs, aimed at increasing the confidence in the novel technology and reducing the uncertainties. The selected qualification methods will become mandatory for the TQ process.

A prominent aspect of the engineering analyses is the risk assessment process, which is mandatory in the framework of the TQ process.

8.4.2 Risk Assessment Process

A risk assessment of the novel technology is to be conducted according to the techniques dealt with in the applicable standards. 'Risk' in this context is related to the events that may affect the fitness for service of the novel technology, with the proper attention to the interfaces with the proven technology. In general, the study will be aimed at the following objectives:

• evaluation of the design and operational procedures

• assessment of the safety and operability of the novel technology

• determination of regulatory compliance (certification, classification).

The study is to be endorsed by the various stakeholders in the project and approved by the third party.

It is recommended that the study should be subdivided into the following main tasks:

- Hazard identification
- Risk assessment against the defined acceptance criteria and interfaces
- Definition of risk control options
- Documentation of the study.

These tasks are detailed in the following.

1) This task aims at identifying and screening hazards with the potential to threaten the safety of personnel, the integrity of the system, the environment and the efficiency of the service provided. The hazard identification is to include all normal and emergency operations. A typical, but not necessarily exhaustive, list of hazards includes:
   - Extreme weather
   - Collision
   - Dropped objects
   - Extreme temperatures
   - Fire/explosion
   - Release of flammable or toxic gas
   - Release of cryogenic liquids or gases
   - Rollover
   - Loss of stability
   - Failures in station keeping systems
   - Loss of electrical power supply
   - Failures in process systems
   - Failures in cargo systems.

   It is recommended that the hazard identification should be conducted with a view to screening out hazards that are trivial or of minor significance, by means of a qualitative or semi-quantitative approach: a quantitative approach is premature in this phase and in any case reliability data are not usually available for novel applications.
2) Risk is the combination of probability and severity of the consequences relevant to each significant failure mode, at the level of detail relevant for the development phases. The risks from the significant hazards selected from the above task are to be assessed and considered together in order to show the relative contribution of different hazards to the total risk. The acceptance criteria (for safety, availability, reliability, downtime etc.), the proposed risk assessment methodologies and the tools to be used should be agreed among the stakeholders at the beginning of the project. It is recommended that the third party should be involved early in the risk assessment process, and its participation ensured in the main tasks with the purpose of monitoring and validating the various steps.

   When the novelty of the technology simply consists in a deviation from the applicable prescriptive codes (as may be the case for technology Classes 2 and 3), the safety criteria should be based on the spirit and criteria of the codes. Therefore, it is to be demonstrated that the novel technology provides a level of safety equivalent to a standard design resulting from the direct application of the codes.

Guidance on the philosophy of this approach may be found in the “Guidelines for alternative design and arrangements for fire safety”, IMO MSC/Circ. 1002 and “Guidelines on Alternative Design and Arrangements for SOLAS Ch II-1 and III”, IMO MSC.1/Circ.1212.

The risk assessment carried out for the purpose of TQ should be based on recognised techniques as far as possible. In the quantitative analysis, particular attention is to be given to the proper treatment of uncertainties. An overview of the most common risk assessment techniques in the offshore field is given in the Tasneef Guide for Risk Assessment.

3) Risk control options can be preventive, mitigative or a combination of the two. Risk reduction is to be based on the ALARP principle. A typical hierarchical approach to risk reduction is:
   - Minimisation of hazards inherent in the design
   - Prevention
   - Detection
   - Control
   - Mitigation of consequences
   - Escape, Evacuation and Rescue.
4) The whole process consisting of tasks 1 to 3 above is to be properly documented and reviewed when necessary. It is to include, as a minimum, the specified criteria, the minutes of the hazard identification sessions, tables and graphs obtained from software tools, the treatment of uncertainties and the list of the risk control options along with their rationale and any other additional material to support the conclusions of the study.

8.4.3 Data Collection (Analyses and Testing)

The objective of this phase is to collect the results of the selected qualification activities.

Supporting evidence of the design, construction, operations and maintenance of the novel technology in its lifetime is to be provided. Means of catering for confidentiality issues are to be agreed up front among the stakeholders.

The typical documentation, as far as applicable, to be provided in this phase is listed in the following.

- Design criteria
- Applicable normative framework
- Detail drawings
- Technical specification
- Manufacturing and installation
- Material specifications and certificates
- Operating manuals
- Test and maintenance procedures
- Engineering analyses
- Risk assessment reports.

8.4.4 Functionality Assessment

The objective of this phase is to obtain confirmation that the functional requirements and the safety, reliability, availability and maintainability criteria are fulfilled, by providing the evidence of the results of the relevant TQ activities.

8.5 Deliverables

As supporting evidence of the TQ, the following technical reports are to be issued.

1) Technology Assessment Report

   This report is to detail the tasks ‘qualification basis’ and ‘Technology Assessment’.
2) Technology Qualification Plan

   This report is to detail the task ‘qualification methods’, which is to include full details of the risk assessment performed on the novel technology.
3) Technology Qualification Report

   This report is to detail the tasks ‘data collection’ and ‘functionality assessment’.

A different organization of deliverables can be adopted upon agreement among the stakeholders and the third party.

The deliverables are to be verified, commented on and approved by the third party upon closure of all comments. A prominent aspect of the engineering analyses is the risk assessment process, which is mandatory in the framework of the TQ process.

8.6 Certificates

Once the TQ deliverables have been approved and the technology has been found fit for service, the relevant certificate is to be issued.

APPENDIX A - EXAMPLES OF NOVELTY ASPECTS IN MARINE PROJECTS

A.1 TQ Process applied to FSRUs

A.1.1 Table A.1 includes a non-exhaustive list of items which, as a minimum, should be covered by a TQ process.

Table A.1

Item	Novelty aspects of the design	Potentially critical aspects for the fitness of service
Tri-Ex Vaporiser	– Relative unit motions; – Vibration levels experienced	– Reduced thermal exchange affecting production capacity – Structural problems – Locked-in thermal stresses due to need for marine securing
Side-by-side mooring	– Relative unit motions – Need to accommodate a wide range of visiting ships	– Operating limitations – Mooring operations safety – Dynamic response of the system (lines, fenders)
Loading arms for transfer of LNG from ship to unit	– Offshore LNG transfer arms so far used on jetties and not on FSRUs – Need to accommodate a wide range of visiting ships	– Low availability of offloading windows – Possible clash of arms in extreme motions – Interruption of the process

A.1.2 Qualification Methods and Mitigation Measures

Table A.2 shows the main qualification methods or mitigation measures that were adopted for the critical issues identified in Table 1.

Table A.2

Novelty factor	Possible Critical Issue	Qualification method / Mitigation measure
Relative unit motions	Sloshing and structural issues in Tri-Ex vaporisers	– Installation of large bilge keels for improving stabilisation – Sloshing, FEM and fatigue studies – Improvement of structural design and details – Review of thermal expansion / contraction and effects on securing of vessel to hull
	Uncertainties of the behaviour of the side-by-side mooring during the contractual operating envelope	– Seakeeping analyses – Sea trials for the seakeeping software calibration – Mooring HAZOP
Need to accommodate a wide range of visiting ships	Layout of mooring equipment	– Dynamic analysis with modelling of the 3 most representative units – Review of each new vessel through studies such as OPTIMOOR
Offshore LNG transfer arms so far used on jetties and not on FSRUs	Possibility of clash among loading arms in some points of the operating envelope	– 3D and clash studies
	Automation system (in particular, the ESD) to be adjusted to the relative motions	– FMECA and factory tests
	Structural issues affecting the loading arms	– Structural and fatigue analysis
	Equipment failures during offloading	– Qualitative Risk Assessment studies (HAZID, FMECA) – Emergency procedures

A.2 TQ Process applied to FLNG units

Floating Liquefying Natural Gas (FLNG) systems are, at the date of issue of this Appendix, considered new technology: in fact, so far only one offshore plants have been developed.

For this reason, Technology Qualification (TQ) is deemed a valid tool to qualify FLNG systems.

The present Appendix has been developed with the aim of providing preliminary guidelines for Designers, Owners and Operators of FLNG units while selecting the items that should be covered by the TQ process, due both to their criticality for the functionality of the plant and to their degree of novelty.
The list of issues in this Appendix is not to be considered exhaustive: up to date, many different designs have been envisaged for FLNG systems, depending on many aspects, including the FLNG unit location, the well characteristics and the feed gas composition. In any event, the final choice of the items to be covered by the TQ certification is to be agreed by the Owner/Designer/Operator in conjunction with Tasneef at an early stage. This is deemed useful to assist in the selection of items and in the subsequent process.

Table A.2 includes a non-exhaustive list of items that are recommended to be covered by the TQ process; they have been identified based on:
- the presence of novelty aspects in the technology, which are to be confirmed through the Technology Assessment process (8.3 of the TQ Guide)
- preliminary considerations about the critical aspects for the fitness of service. It is intended that they are to be studied in detail through the qualification methods (notably, but not only, the various risk assessment techniques, as detailed in the 8.4 of the TQ Guide).

In general, the processes involved in the liquefaction of natural gas offshore on board an FLNG unit are based on those processes used to perform the same function on a shore-based installation.
Natural gas found at the wellhead, composed primarily of methane, is not pure. Raw natural gas comes from three types of wells: oil wells, gas wells and condensate wells. It is important to highlight that the characteristics of the gas depends on the type, location and characteristics of the extraction field.
The first step in the process is the removal of the contaminants from the feed gas, after which the gas can be liquefied and stored.
Therefore, a typical scheme for the plant can be divided into two main blocks:
- a pre-treatment module (typically consisting of acid gas removal, dehydration and mercury removal)
- a liquefaction module (typically consisting of a refrigerant cycle, recovery and fractionation processes).

The pre-treatment module features are strictly related to the composition of the feed gas.
The equipment involved in the above processes is required to undergo a “marinisation” qualification.
The following paragraphs describe the principal phases of the process and the related systems.

A.2.1 Oil Separator and Removal

The gas is to be separated from the oil dissolved in the gas itself. This separation of natural gas from oil/condensate on an FLNG facility is generally carried out using equipment installed as soon as it is received on board the unit. The most basic separator consists of a simple closed tank where the gravity allows the separation process of heavier oil from lighter gases. In the case of wells producing high pressure gas together with light crude oil or condensate, a more complex system is necessary to perform the separation, an example of which could be a low temperature separator.

A.2.2 Acid Gas Removal (AGRU)

The feed gas is required to be purified from the contamination of different acids, notably H_2S and CO_2. Large volumes of ammine and tall contact columns are used to purify acid gases. Alternatively, technologies such as adsorption, membranes or hybrid systems should be considered depending on the feed gas composition and unit motions.

A.2.3 Dehydration

It is necessary to remove most of the water associated with the gas. Generally, most of the water is removed by simple separation methods in proximity to the wellhead. The removal of the water vapour that is dissolved in natural gas requires a more complex treatment based on absorption/adsorption technologies.

A.2.4 Mercury removal

Mercury is harmful to aluminium components, such as heat exchangers; consequently, it is necessary to remove it from the gas. Purification of the gas from mercury is carried out by means of adsorbent beds.

A.2.5 Liquefaction of Natural Gas

Refrigerant technologies currently used in marine LNG liquefaction systems are generally based on turbo-expander using nitrogen. This technology is conventional for small scale onshore liquefaction plants, characterised by a high degree of safety, simple operability and limited encumbrance and weight. Large scale plants are based on hydrocarbon refrigerants, which can pose more fire safety risks.

A.2.6 Natural Gas Liquid Recovery and Fractionation

NGL components, ethane, butane and propane need to be recovered and separated from each other (fractionation). The fractionation process is based on the different boiling points of the different hydrocarbons.

A.2.7 Offshore unit-to-ship transfer of products

Transfer of LNG could be performed through marine loading arms or cryogenic hoses. Marine loading arms are already used onshore on jetties or on board FSRUs, while cryogenic hoses are still in the development phase.
Transfer of LPG or oil is generally performed by means of more traditional hoses.

A.2.8 Items to be covered by the TQ Process

When undertaking the TQ process, it is intended that the above-mentioned qualification basis (defined in 8.2 of the TQ Guide) is to be established up front.
Table A.3 includes a non-exhaustive list of items that are recommended to be covered by the TQ process; they have been identified based on:

- the presence of novelty aspects in the technology, which are to be confirmed through the Technology Assessment process (Sec 8.3)
- preliminary considerations about the critical aspects for the fitness of service. It is intended that they are to be studied in detail through the qualification methods (notably, but not only, the various risk assessment techniques, as detailed in the Sec 8.4).

Table A.3

Item	Novelty aspects that may impact on the design	Potentially critical aspects for the fitness of service
Oil separator plant	– Relative unit motions – Marine environment	– Poor quality of gas – Reduced production capacity – Corrosion – Structural problems
Acid Gas Removal plant	– Relative unit motions – Marine environment	– Poor quality of gas effecting downstream equipment – Reduced production capacity – Corrosion – Structural problems
Dehydration plant	– Relative unit motions – Marine environment	– Poor quality of gas effecting downstream equipment – Reduced production capacity – Corrosion – Structural problems
Mercury removal	– Relative unit motions – Marine environment	– Structural problems – Reduction of process efficiency – Corrosion – Poor quality of gas effecting downstream equipment
Liquefaction plant	– Relative unit motions – Limited available space	– Reduced production capacity – Reduction of safety and access for operation

Appendix A

Item	Novelty aspects that may impact on the design	Potentially critical aspects for the fitness of service
	(especially critical for cryogenic pipework). – Marine environment – Vibrations	and maintenance – Corrosion – Structural problems – Vibration damage to high speed rotating equipment
Recovery and fractionation plant characterised by tall, heavy and motion sensitive items	– Relative unit motions – Limited available space, especially critical for cryogenic pipework – Marine environment	– Structural problems – Reduction of process efficiency – Corrosion – Means of securing against accelerations whilst taking into account expansion / contraction
Loading arms for transfer of LNG from ship to unit	– Offshore LNG transfer arms so far used on jetties and not on FSRUs – Transfer to be carried out in conjunction with transfer of other products (oil, LPG); overall safety and operability philosophy is to take into account the interaction between the different systems	– Low availability of offloading windows – Interruption of the process
Cargo Containment System	– Normally cargo tanks either full or empty – Vibrations	– Damage to containment system due to high loads – Fatigue damage
Transfer of oil or other fluids from unit to ship and vice versa	– Transfer to be carried out in conjunction with transfers of other products (LNG, LPG); overall safety and operability philosophy is to take into account the interaction between the different systems	– Low availability of offloading windows – Interruption of the process
Transfer of liquid gas from unit to ship (see also aspects identified for FSRUs above)	– Transfer to be carried out in conjunction with transfer of other products (LNG, LPG)	– Low availability of offloading windows – Interruption of the process

A.2.9 Qualification Methods and Mitigation Measures

Table A.4 shows a non-exhaustive list of typical qualification methods or mitigation measures for the critical issues identified in Table A.2. They are listed only for illustration purposes; the actual effectiveness and exhaustiveness of such methods in relation to the fitness for service are to be proved for the specific technology through the full-scope TQ process.

Table A.4

Novelty factor	Possible Critical Issue	Qualification method / Mitigation measure
Relative unit motions	Sloshing and fluid motion in tanks, separators and components	– Optimisation of hull shapes for motion reduction – Installation of large bilge keels and zero speed stabilisation systems – Decoupling of hydrodynamic behaviour of tanks/systems/components from the unit motions – Optimisation of the position of the most critical components, e.g. close to the COG unit or in the aft part, under-deck, etc. – Multi-pass processes
	Structural: strength and fatigue	– Optimisation of hull shapes for motion reduction – Installation of large bilge keels and zero speed stabilisation systems – Improvement of structural design and details – Re-verification of components with offshore Rules and standard.
Limited available space, coexistence of different systems, safety and availability goals	Arrangement, operation, strength, inspection and maintenance	– Clash studies – Dedicated operational procedures, connected to the overall operability and safety philosophy – Arrangement optimisation – Inspection and maintenance specific plans – Proper location of tall, heavy and motion sensitive items to reduce motion effects – Condition based maintenance – Reliability-Centred Maintenance – Risk Assessment (qualitative and qualitative, including HAZID, HAZOP, FMECA, Fire and blast analysis, toxic clouds, domino effects etc.)
Marine environment	Corrosion of components Strength of components Inspection and maintenance	– Inspection and maintenance specific plans and studies – Condition based maintenance – Re-verification of components with offshore Rules and standard – Improvements of structural design and details
Transfer of liquid gas from unit to ship	Interference among the various operations causing additional risks	– Review of safety and operability philosophy to take into account the interaction between the different systems

A.3 TQ Process Applied to Compressed Natural Gas (CNG) Units

A.3.1 These criteria are related to a preliminary design involving the transportation of CNG in large pressure vessels to be secured on a properly modified cargo ship.

Table A.5 includes a non-exhaustive list of items that are recommended to be covered by the TQ process; they have been identified based on:

- the presence of novelty aspects in the technology, which are to be confirmed through the Technology Assessment process (8.3)
- preliminary considerations about the critical aspects for the fitness of service. It is intended that they are to be studied in detail through the qualification methods (notably, but not only, the various risk assessment techniques, as detailed in 8.4).

Table A.5

Item	Novelty aspects of the design	Potentially critical aspects for the fitness of service
Pressure vessels	– Dimensions – Materials (composite vs. steel)	– Structural problems – Handling
	– Storage in cargo holds	– Inspectability – Securing – Effects of ship motions and thermal expansion/ contraction. – Safety issues (resistance to fire, collision etc.) – Domino effects of containment failure
	– Storage on deck	Compliance with the principles of the IMDG Code
	– Blow-down system	Not normally allowed on ships
Ship arrangements	– Heavy Cargo Containment System – Cargo discharge at pressure – Cargo filling limits	Effect on tank top structure Docking arrangements Jet fires as opposed to pool fires Jet cooling of adjacent structures; traditional drip trays may not contain leaks Relief valve sizing for fire cases

A.3.2 Qualification Methods and Mitigation Measures

Table A.6 shows a non-exhaustive list of typical qualification methods or mitigation measures for the critical issues identified in Table A.6. They are listed only for illustration purposes; the actual effectiveness and exhaustiveness of such methods in relation to the fitness for service are to be proved for the specific technology through the full-scope TQ process.

Table A.6

Novelty factor	Possible Critical Issue	Qualification method / Mitigation measure
Dimensions	Possibly not covered by current codes and standards	– Review of the principles inherent in codes and standards for pressure vessels in order to obtain an ad hoc framework – Seeking acceptance from the relevant Administrations
Materials	If a non-conventional solution (i.e. composite materials) is selected: – not covered by current codes and standards – manufacturing – quality control	– Review of codes and standards – Review of the available manufacturing processes – Establishment of structural calculation and test methods suitable for the marine environment
Storage in cargo holds	Resistance of clamping to sea motions	– Structural and fatigue analysis
	Inspectability (internal/external)	– Depending on the materials and manufacturing
	Vessel integrity in case of collision/contact/grounding, fire or cryogenic spills	– Risk control options stemming from qualitative and quantitative risk assessment
	Loading/unloading vessels in/from cargo hold	– Qualitative Risk Assessment studies (HAZID, FMECA) – Definition of the appropriate lifting appliances and procedures
Storage on deck	Compliance with the principles of the IMDG Code, which gives requirements for much smaller packages	– Layout studies – Qualitative Risk Assessment studies
Blow-down system	Normally not allowed on ships	– Gas dispersion models

A.4 TQ Process Applied to Innovative Fuels for Marine Propulsion

A.4.1 The marine field is nowadays nurturing a number of innovative projects of internal combustion engines for propulsion and power generation that use non-conventional fuels, so far not contemplated in regulations (not even in the draft IGF Code), alternative to methane that now is becoming more and more consolidated: the most promising (at least for specific applications) being gaseous like ethane and low flashpoint liquids such as methanol.

Such substances have been so far used mainly in the chemical industry (even if methanol has long been used to fuel a niche of land vehicles); the idea to employ them as alternative fuels is mainly due to increasingly stringent environmental rules on NO_x and SO_x emissions, in navigation and in port areas; they may also bring economic benefits in some specific cases, given the increasing cost of more refined fuels like low-sulphur diesel oils. The idea of fuelling an ethylene/ethane carrier with cargo ethane is quite natural, and so is the use of methanol for internal combustion engines already experimented in the automotive industry. In addition, transport and storage of methanol can be handled by the traditional infrastructure already existing. The maximum flexibility would be achieved with engines that can be fuelled by multiple fuels (dual-fuel engines handling both LNG and diesel oil are already consolidated).

However, such new fuels and the engines fed by them pose additional safety and legal issues. One of such issues is obviously represented by the need to obtain approval by the Flag Administration. Several others are related to performance as well as to safety and reliability. Aspects like the changeover (if fitted) to other fuel types, which has to rely on electronics to work properly, the high-pressure injection system for ethane and the noxious effects of methanol require thorough scrutiny to ensure that hazards like fire, explosion and loss of propulsion are minimized to a level at least equal to conventional ships.

Technology Qualification is an appropriate framework to demonstrate not only safety equivalency (which can follow the consolidated IMO process), but also availability and cost-effectiveness of various proposals, which may also satisfy investors and authorities called respectively to finance and approve new designs.

When undertaking the TQ process, it is intended that the above-mentioned qualification basis (defined in 8.2 of the TQ Guide) is to be established up front.
Table A.7.1 and A.7.2 include a non-exhaustive list of items that are recommended to be covered by the TQ process; they have been identified based on:

- the presence of novelty aspects in the technology, which are to be confirmed through the Technology Assessment process (item 8.3)
- preliminary considerations about the critical aspects for the fitness of service. It is intended that they are to be studied in detail through the qualification methods (notably, but not only, the various risk assessment techniques, as detailed in item 8.4).

Table A.7.1

Item	Novelty aspects that may impact on the design	Potentially critical aspects for the fitness of service
Ethane	Safety issues (Cryogenic hazard, flammability)	Leak detection, fire protection, health & safety procedures
Ethane-fuelled internal combustion engine	Gas not covered by current regulations and not normally used even by land vehicles	– Alternative design is required to demonstrate safety equivalency with conventional fuels – Limited background information on the behavior of ethane as fuel
	Lower methane number than natural gas	Possible negative effects on performance or consumption
Ethane injection system	High-pressure gas injection	Definition of arrangements, controls, ESD etc.
	Dual/triple fuel switch (if fitted)	Reliability of the changeover system
	Infrastructures for refueling	Safety issues
Ethane tanks	Not contemplated by Rules	Tanks location

Table A.7.2

Item	Novelty aspects that may impact on the design	Potentially critical aspects for the fitness of service
Methanol	Safety issues (toxicity, flammability)	Leak detection, fire protection, health & safety procedures
Methanol-fuelled internal combustion engine	Use of Low flashpoint fuels on ships not yet covered by international conventions	Alternative design is required to demonstrate safety equivalency to conventional fuels
Methanol-fuelled internal combustion engine	Use of Low flashpoint fuels on ships not yet covered by international conventions	Alternative design is required to demonstrate safety equivalency with conventional fuels
Methanol injection system	Dual/triple fuel switch (if fitted)	Reliability of the changeover system
	Peculiar issues of methanol with respect to conventional fuels (Lower calorific value, lower lubricating power, corrosivity to metals and gaskets)	Impact on performance Material selection Definition of survey schemes
	Infrastructures for refueling	Safety issues
Methanol tanks	Not contemplated by Rules	Tanks location

A.4.2 Qualification Methods and Mitigation Measures

Tables A.8.1 and A.8.2 show a non-exhaustive list of typical qualification methods or mitigation measures for the critical issues identified in Table A.7.1 and A.7.2. They are listed only for illustration purposes; the actual effectiveness and exhaustiveness of such methods in relation to the fitness for service are to be proved for the specific technology through the full-scope TQ process.

Table A.8.1

Novelty factor for ethane-fuelled engines	Possible Critical Issue	Qualification method / Mitigation measure
Ethane not covered by current regulations	Approval by the flag administration	Alternative design process to demonstrate safety equivalency to conventional fuels
Ethane not normally used even by land vehicles	Little background information on the behavior of ethane as fuel	1) Holistic approach, to be carried out within the alternative design process, in particular risk assessment activities are to cover, as a minimum: – Process failures – Ethane tank location on the basis of internal and external events – Human errors – Interfaces with the other ship systems, in particular the other fuel supplies that can be used – Loss of containment of tanks/pipes – Refueling hazards Tests and surveys agreed with stakeholders (in particular yards and manufacturers) to verify: – Effectiveness and reliability of control, detection and ESD systems – Effectiveness and reliability of changeover system – Fire and leak detection systems 2) HSE risk assessment for health & safety hazards, to define PPE and procedures, consistently with ISM Code and MLC requirements
Dual/triple fuel switch (if fitted)	Reliability of the changeover system, which will be necessarily based on electronic systems	
High-pressure gas injection	Definition of arrangements, controls, ESD etc.	
Safety issues	Adverse effects on health and safety: cryogenic hazards, flammability Potential to initiate or escalate fire events	
Tank location	Definition of safe position with respect to internal and external accidents	
Infrastructures for refueling	Safety and reliability aspects according to the selected systems (from tank trucks or fixed installations)	
Lower methane number than natural gas	Negative impact on performance and consumption	Studies, tests and surveys agreed with stakeholders (in particular yards and manufacturers) to analyze and verify the issues related to the engine, e.g. wearout, performance and consumption

Table A.8.2

Novelty factor for methanol-fuelled engines	Possible Critical Issue	Qualification method / Mitigation measure
Use of Low flashpoint fuels on ships not yet covered by international conventions	Approval by the flag administration	Alternative design process to demonstrate safety equivalency to conventional fuels
Dual/triple fuel switch (if fitted)	Reliability of the changeover system, which will be necessarily based on electronic systems	1) Holistic approach, to be carried out within the alternative design process; in particular risk assessment activities are to cover, as a minimum: – Process failures – Methanol tank location on the basis of internal and external events – Human errors – Interfaces with the other ship systems, in particular the other fuel supplies that can be used – Loss of containment of tanks/pipes – Refueling hazards Tests and surveys agreed with stakeholders (in particular yards and manufacturers) to verify: – Effectiveness and reliability of control, detection and ESD systems – Effectiveness and reliability of changeover system – Fire and leak detection systems 2) HSE risk assessment for health & safety hazards, to define PPE and procedures, consistently with ISM Code and MLC requirements
Safety issues	Adverse effects on health and safety: toxicity, flammability Potential to initiate or escalate fire events	
Tank location	Definition of safe position with respect to internal and external accidents	
Infrastructures for refueling	Safety and reliability aspects according to the selected systems (from tank trucks or fixed installations)	
Peculiar issues of methanol with respect to conventional fuels (Lower calorific value, lower lubricating power, corrosivity to metals and gaskets)	Material selection Negative impact on performance	Studies, tests and surveys agreed with stakeholders (especially yards and manufacturers) to transfer the experience of methanol as vehicle fuel on ships, e.g.: – Issues related to the engine, e.g. wearout, performance and consumption – Adequacy of auxiliaries (pumps , seals, etc.) – Adequacy of materials to corrosion