FOREWORD

DNV GL standards contain requirements, principles and acceptance criteria for objects, personnel, organisations and/or operations.

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Any comments may be sent by e-mail to rules@dnvgl.com
CHANGES – CURRENT

General
This document supersedes DNV-OS-E407, October 2012.

Text affected by the main changes in this edition is highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

On 12 September 2013, DNV and GL merged to form DNV GL Group. On 25 November 2013 Det Norske Veritas AS became the 100% shareholder of Germanischer Lloyd SE, the parent company of the GL Group, and on 27 November 2013 Det Norske Veritas AS, company registration number 945 748 931, changed its name to DNV GL AS. For further information, see www.dnvgl.com. Any reference in this document to "Det Norske Veritas AS", "Det Norske Veritas", "DNV", "GL", “Germanischer Lloyd SE”, “GL Group” or any other legal entity name or trading name presently owned by the DNV GL Group shall therefore also be considered a reference to “DNV GL AS”.

Main changes March 2016

• General
The following have been implemented in this revision of the document:

— The introduction has been re-written for improved explanation, and the supplementary explanation of technology qualification has been moved to App.D.
— Emphasis is put on reliability as the focus of this standard in order to clarify that safety is covered in the way that it depends on system reliability and that safety of operations needs to be catered to separately.
— The explanation of documentation requirements for delivery and for designated service has been improved.
— Previous Ch.3 Classification and Certification is published separately as a service specification: DNVGL-SE-0056 Certification of rope based deployment and recovery systems for designated service.
— Roles and responsibilities have been clarified.

Editorial corrections
In addition to the above stated main changes, editorial corrections may have been made.
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SECTION 1 INTRODUCTION

1.1 Objective

1.1.1 Safe and reliable operations

1.1.1.1 The safety and reliability of operations depend on having equipment, devices and facilities that function as intended.

1.1.1.2 This standard provides the structure for assuring that rope based deployment and recovery systems will function as intended until discarded.

1.1.2 Assuring reliability for delivery (before use)

1.1.2.1 In order to function as intended, equipment, devices and facilities need to be

1) engineered properly (build the right thing),
2) made properly (build the thing right), and
3) integrated properly (put together right)

This standard stipulates how adequate acceptance criteria for delivery should be established in terms of 1, 2, and 3.

1.1.3 Assuring reliability in service (after delivery)

1.1.3.1 To continue to function as intended, equipment, devices and facilities need to be

a) applied correctly (used for the right thing),
b) operated appropriately (used in the right way), and
c) maintained adequately (kept in the right condition)

This standard stipulates how adequate limits to operations should be established in terms of a, b, and c.

1.1.3.2 These six basic premisses for achieving system reliability are illustrated in Figure 1-1.

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Figure 1-1 Universal premisses for achieving intended functionality of technology in use
1.1.3.3 The adequate combination of acceptance criteria for delivery and limits to operations are called validated requirements.

1.1.3.4 The adequate limits to operations define the designated service.

1.1.3.5 The above principle forms the basis for this standard.

1.2 About this standard

1.2.1 Scope

This standard covers rope based deployment and recovery systems that are integrated by defining the adequate acceptance criteria for delivery and the adequate limits of designated service:

— The acceptance criteria shall be met when the system is delivered.
— Operations with the deployment and recovery system shall comply with the designated service.

1.2.1.1 It addresses the reliable performance of integrated deployment and recovery systems that are mounted on a vessel or a floating unit with the main purpose of placing or removing objects underwater.

1.2.1.2 Conventional and innovative solutions are treated equally by this standard because of the required assurance of functions.

1.2.1.3 The documentation shall be presented as an assurance case for the reliability of the integrated deployment and recovery system when in use. The documentation requirements cover the system integration and the component systems with their engineering dimensioning, materials, and methods of manufacture and testing; all of which shall be verified with respect to the designated service.

1.2.1.4 This standard can also be used for integrated deployment and recovery systems that operate in air or from a fixed platform.

1.2.1.5 This standard does not cover equipment or devices in the lifted mass, or the subsea tool. However, lifted mass, suspended mass, added mass and drag will influence system response and will have to be considered in order to derive load cases.

**Guidance note:**
The subsea tool and connection elements should be managed with the same goal of assuring reliability and associated safety as inferred from this standard.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.2.2 Deviations

1.2.2.1 Substantiated deviations from provisions of a normative reference are permitted due to the assurance case approach required by this standard.

**Guidance note:**
Compliance with informative references or other references is not mandatory under this standard.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.2.3 Safety

1.2.3.1 This standard does not cover the safety of operations which needs to be addressed with an adequate safety case akin to the reliability case (assurance case for reliability) required by this standard.

1.2.4 Contractual reference

1.2.4.1 This standard is intended to be used as reference for contracts between parties and it explains responsibilities of the roles involved with deployment and recovery systems for designated service:

— system integrator
— owner
— responsible roles for component systems
1.2.4.2 It shall be used as reference for assurance agreements that govern technology qualification strategies in compliance with this standard.

Guidance note:
The assurance agreements between recipients and suppliers should govern provisions for remuneration (milestones for payment).

---end---of---guidance---note---

1.2.5 Certification

1.2.5.1 This standard provides the technical basis for DNV GL certification in accordance with service specification DNVGL-SE-0056 Certification of deployment and recovery systems for designated service.

1.2.6 Structure and contents of this standard

1.2.6.1 Sec.1 (this section) provides a general introduction with overview, definitions, general provisions and references relevant for Sec.2 - Sec.5 and for service specification DNVGL-SE-0056.

1.2.6.2 Sec.2 - Sec.5 provides the requirements of this standard and the associated role responsibilities.

Guidance note:
This issue is based on requirements derived from phase 1 and phase 2 of the joint industry project ‘Certification of Deepwater Installation Systems’. This standard is intended to be updated based on phase 3; however the first issue and this current issue together with DNVGL-SE-0056 are complete, accurate, and fulfilling for the purpose.

---end---of---guidance---note---

1.3 Application of the technology

1.3.1 General

1.3.1.1 The integrated deployment and recovery system is used in order to place or remove objects underwater, including on the sea bed in several thousand metres of water. The technology can also be used for operations in air.

1.3.1.2 The system needs to be relied upon in operations in which the use and the condition of the system are important to the reliability of the system and thus also to the safety of operations.

Guidance note:
Why:
The need for an all-encompassing standard for rope based deployment and recovery systems for designated service arises from the complexity of such devices. It will not be possible to assure and verify the functionality of the integrated system through the service life by just assuring and verifying its parts in delivery condition. This is because these parts interact when the device performs its functions, and therefore the way the interaction takes place in a well-used system is critical to the reliability of operations and the associated aspects of safety.

In this way, these devices are comparable to an automobile, a device which also is designed, built and verified as a whole; it includes operating interfaces, mechanical parts, rotating machinery and controls, sensors and software. The reliability is provided by the integrated system and the limits to operations as defined by driver capability, traffic law, road conditions, maintenance programme, etc.

How:
The method for technology qualification defines a structured work process to assure that operations can be performed reliably with an integrated deployment and recovery system within certain limits. Those agreed limits might address the loading, operating time, maintenance, the motions of the floating platform, and other factors relating to the application of the system, and are referred to as the limits of designated service in this standard.

---end---of---guidance---note---

1.3.1.3 The functions of the integrated deployment and recovery system shall be qualified to be reliable, so system interaction and external action are analysed to find out what test results, other evidence and associated assurance argument will be required.

1.3.1.4 The validation of the complete set of requirements for functional reliability and associated aspects of safety of operations shall be provided as an assurance case.
1.4 System variants

1.4.1 General

1.4.1.1 Deployment and recovery systems (DRS) can be of various types, depending on the component systems. Reference is made to Figure 1-2.

1.4.1.2 A deployment and recovery system can utilise fibre rope, steel-wire rope, or hybrid rope. The reach of the system can be extended by using pendant lines in a hang-off mode of operation.

Figure 1-2 Illustration of some variants of deployment and recovery systems for designated service

Note: The same requirements to documentation of assured reliability apply to all variants of integrated deployment and recovery systems for compliance with this standard.

---e-n-d---of---n-o-t-e---

1.4.1.3 System variants are discussed further in App.B.

1.5 Assuring reliable functionality

1.5.1 Introduction

1.5.1.1 This standard defines system-level requirements to documentation for any variant of deployment and recovery systems for designated service.

1.5.1.2 Operations involve external actions on the system as indicated in Figure D-3.

1.5.1.3 The provision of system functionality relies on the component systems providing their functions through system interaction as indicated in Figure D-4 for the rope.

1.5.1.4 It shall be substantiated that the functions of the integrated system are reliable in the designated service.

1.5.1.5 An explicit argument shall explain the system reliability based on the qualification evidence. Reference is made to App.B and App.C.

1.5.2 Technology qualification

1.5.2.1 This standard takes the premiss that the principles of DNV-RP-A203 Technology Qualification shall be followed.
1.5.3 Existing requirements

1.5.3.1 This standard further takes the premisses that:

- Relevant requirements from existing standards shall be used.
- Irrelevant requirements from existing standards shall not be used.

1.5.4 Technology assurance

1.5.4.1 The reliability of system functions - and the associated aspects of safety - are demonstrated by compliance with an adequate set of requirements in the form of acceptance criteria for delivery and agreed limits to operations.

1.5.4.2 The combination of requirements developed in technology qualification with validation of requirements that exist from before is illustrated in Figure 1-3.

Figure 1-3 Requirements validation combines relevant existing requirements with technology qualification in a technology assurance process

1.5.4.3 Requirements validation is further performed in order to warrant disregard of existing requirements that are irrelevant to the case at hand.

Guidance note:

Should a component system supplier require deviating from a normative reference, then requirements validation can be used to substantiate the specific case. This standard requires assurance documentation (evidence and argument) in order to substantiate the system reliability claim, and associated aspects of safety.

Some form of graphical presentation of the technology qualification documentation may be used for the sake of overview and traceability; however this is not mandatory under this standard. The assurance case can be provided in a graphical structure that describes the relationship between the qualification evidence and the claim through the argument. Goal Structure Notation (GSN) /1/ or KAOS /2/ can be used for this purpose. See also App.E.

1.5.5 Validated requirements

1.5.5.1 The adequate set of acceptance criteria for delivery and limits for operations are called validated requirements.
1.5.5.2 Compliance with validated requirements is required for the system to be qualified for designated service.

Guidance note:
For certification of rope based deployment and recovery systems for designated service based on validated requirements see DNVGL-SE-0056. For other technologies see DNVGL-SE-0160.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.6 References

1.6.1 General

1.6.1.1 In case of conflict between a requirement of this standard and a reference document, the requirement of this standard shall prevail.

1.6.1.2 The current, official issue of this standard and other DNV GL service documents are available at https://www.dnvgl.com/rules-standards/index.html.

1.6.1.3 The latest edition of referenced documents (including amendments and corrections) should apply.

1.6.2 Normative references

1.6.2.1 The DNV GL and DNV documents listed in Table 1-1 - Table 1-3 include provisions, which through reference in the text constitute requirement of this standard.

Table 1-1 DNVGL standards

<table>
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<td>Marine and machinery systems and equipment</td>
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<tr>
<td>DNVGL-OS-D201</td>
<td>Electrical installations</td>
</tr>
<tr>
<td>DNVGL-OS-D202</td>
<td>Automation, safety and telecommunication systems</td>
</tr>
<tr>
<td>DNVGL-OS-D203</td>
<td>Integrated software dependent systems (ISDS)</td>
</tr>
<tr>
<td>DNVGL-OS-E303</td>
<td>Offshore fibre ropes</td>
</tr>
<tr>
<td>DNVGL-ST-0378</td>
<td>Offshore and platform lifting appliances (planned published 2016)</td>
</tr>
<tr>
<td></td>
<td>Until the publication of DNVGL-ST-0378 the Standard for Certification 2.22 'Lifting Appliances' is applicable.</td>
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Table 1-2 DNV and DNV GL recommended practices

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<td>Technology Qualification</td>
</tr>
<tr>
<td>DNV-RP-D201</td>
<td>Integrated Software Dependent Systems</td>
</tr>
<tr>
<td>DNVGL-RP-E305</td>
<td>Design, testing and analysis of offshore fibre ropes</td>
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Table 1-3 DNV programmes for approval of manufacturers

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<td>Manufacturers of Offshore Fibre Ropes</td>
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<tr>
<td>322</td>
<td>Manufacturers of Offshore Fibre Yarns</td>
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1.6.3 Informative references

1.6.3.1 In addition to non-referenced parts of the documents in Table 1-1 - Table 1-3, the DNV GL and DNV service documents listed in Table 1-4 contain information that may be of value to the reader of this standard.
1.6.4 Other informative references

1.6.4.1 The following references provide guidance on graphical presentation of arguments that may be of value to the reader of this standard. See also App.D.

Table 1-5 D3

| /1/ Origin Consulting (York) Ltd., on behalf of the Contributors | GSN Community Standard Version 1, November 2011 |
| /2/ Respect-IT | A KAOS Tutorial V1.0, Oct. 2007 |

1.7 Definitions

1.7.1 Verbal forms

Table 1-6 Definitions of verbal forms

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<tr>
<td>shall</td>
<td>verbal form used to indicate requirements strictly to be followed in order to conform to the document</td>
</tr>
<tr>
<td>should</td>
<td>verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required</td>
</tr>
<tr>
<td>may</td>
<td>verbal form used to indicate a course of action permissible within the limits of the document</td>
</tr>
</tbody>
</table>
1.7.2 Terms

1.7.2.1 The following tables provide general definitions pertaining to the assurance of technology and specific definitions pertaining to integrated deployment and recovery systems.

1.7.2.2 In addition, terms defined in DNV-RP-A203 Technology Qualification, DNVGL-SE-0056 Certification of rope based deployment and recovery systems for designated service, and DNVGL-SE-0160 Technology qualification management and verification apply under this standard.

Table 1-7 Terms pertaining to assurance of technology

<table>
<thead>
<tr>
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<tr>
<td>argument</td>
<td>explanation of how evidence supports a claim</td>
</tr>
<tr>
<td>assurance agreement for designated service</td>
<td>agreement entered into between owner and system integrator to agree on the governing principles for substantiating fitness for designated service</td>
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</table>
| assurance case                            | explanation that relies on evidence  
The evidence are organised into an argument structure to demonstrate that some claim about a system is substantiated. |
| assurance proposal for designated service  | basis for the assurance agreement for designated service as issued by system integrator to owner                                        |
| basic claim                               | that equipment, device or facility will have defined performance in designated service                                                   |
| component system                          | system that forms part of the integrated, larger system  
Also: sub-system.                                                                 |
| component system supplier                 | role that is responsible for the delivery of a component system such as the rope guide path or the furnished rope                          |
| contribution                              | what is provided from an element on one side of an interface, in order that the system delivers its functions applicable to that interface |
| critical parameter                        | parameter used to express quantitatively the difference between function and failure                                                      |
| designated service                        | agreed limits to operations to assure reliable functionality  
Also: permissible service context.                                                      |
| external interface                        | interfaces at which a system is subjected to external influence, such as where it is connected to the vessel or to the lifted mass  
For a component system such as the furnished deployment and recovery rope, the interaction with the rope guide path takes place on external interfaces, which in turn are internal interfaces of the integrated system. |
| evidence                                  | facts shown by an argument to support a claim in context                                                                                   |
| failure                                   | insufficient function                                                                                                                                 |
| fit for designated service                | capable of functioning reliably with adequate performance within the agreed limits to operations  
The agreed limits pertain to application, operation and maintenance.                                                                  |
| fit for designated purpose                | properly engineered, properly made and properly integrated in delivery condition, so that functionality will be as agreed in designated service |
| function                                  | performance for purpose                                                                                                                  |
| functionality                             | delivered function                                                                                                                                 |
| functional description                    | description of functions and sub-functions of the integrated system                                                                       |
| functional policies                       | the defined ways that the equipment, device or facility shall function including in events of failure                                       |
| functionality request                     | request by recipient for how the system or component system should perform                                                              |
| independent verifier                      | role that verifies the qualification documentation and satisfaction of the claim of system reliability on behalf of the system integrator |
| integrated system                         | system for which the reliability is assured for designated service                                                                       |
Table 1-7 Terms pertaining to assurance of technology (Continued)

<table>
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<th>Term</th>
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<td>internal interface</td>
<td>interface between component systems within an integrated system for example between the rope guide path and the rope, or between the power system and the positioning system</td>
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<td>malfunction</td>
<td>wrong function</td>
</tr>
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<td>margin</td>
<td>measure against insufficient function for a given failure mode or combination of failure modes. The margins are usually expressed as the ratio between the critical parameter at failure and the critical parameter in the present state. There will be one margin for each of the relevant failure modes and combination of failure modes.</td>
</tr>
<tr>
<td>narrow designated service</td>
<td>designated service for a system which is not in its final qualification state. A narrow designated service will have more restrictions in order to substantiate the claim, i.e. tighter limits to operations than the designated service for the final qualification state.</td>
</tr>
<tr>
<td>owner</td>
<td>role that owns the equipment, device or facility such as an integrated deployment and recovery system</td>
</tr>
<tr>
<td>performance</td>
<td>quantified expression of function</td>
</tr>
<tr>
<td>proven</td>
<td>shown not to malfunction unless adequate acceptance criteria for delivery or adequate limits for operations are violated. The degree to which something is proven depends on the extent of service exposure and the extent to which the actual service has challenged failure margins. A proven technology might be unknown to a particular supplier or recipient and therefore require qualification for the case at hand.</td>
</tr>
<tr>
<td>qualification</td>
<td>demonstrating that equipment, devices or facilities comply with adequate acceptance criteria for delivery with associated adequate limits to operations</td>
</tr>
<tr>
<td>qualification documentation</td>
<td>qualification evidence and the associated argument to claim that the technology is qualified</td>
</tr>
<tr>
<td>qualification evidence</td>
<td>results from testing or analyses acquired based on the principles described in DNV-RP-A203 that can be used to assure that a technology will be reliable within defined limits to operations</td>
</tr>
<tr>
<td>qualification stage</td>
<td>basic technology qualification process as performed to improve the designated service</td>
</tr>
<tr>
<td>requirements validation</td>
<td>assessment of existing requirements or recommendations for relevance in a technology qualification process. It is usually preferable to exclude existing sets of requirements or recommendations that are marginally relevant and perform technology qualification independently, instead of being restricted by irrelevant provisions that do not add value to the technology assurance processes.</td>
</tr>
<tr>
<td>reliability</td>
<td>ability of operations, systems or components to perform intended functions under stated conditions for a specified period of time</td>
</tr>
<tr>
<td>safety</td>
<td>ability of operations, systems or components to avoid harm to people or to the environment</td>
</tr>
<tr>
<td>service context</td>
<td>circumstances or factors related to provision of function by the system. The service context needs to be kept within the agreed limits of designated service as defined by the application, the operation and the condition management of the system</td>
</tr>
<tr>
<td>Service context request</td>
<td>request from the owner to the system integrator for the application (marine operations), operation and condition management pertaining to the qualification of the integrated deployment and recovery system</td>
</tr>
</tbody>
</table>
### Table 1-7 Terms pertaining to assurance of technology (Continued)

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>solution</td>
<td>equipment, device or facility with its intended use and maintenance</td>
</tr>
<tr>
<td>sub-system</td>
<td>component system</td>
</tr>
<tr>
<td>‘Sub-system’ was used in the DNV-OS-E407, December 2012.</td>
<td></td>
</tr>
<tr>
<td>system integrator</td>
<td>role that is responsible for how a system will deliver its functions when assembled, in the context of designated service</td>
</tr>
<tr>
<td>system description</td>
<td>document which describes the system and its functions</td>
</tr>
<tr>
<td>system performance description</td>
<td>document which describes the performance of the system with basis in system functionality</td>
</tr>
<tr>
<td>system variant</td>
<td>type of system based on how functions are provided such as how tension is applied or how the rope is stored</td>
</tr>
<tr>
<td>technology assurance</td>
<td>combined approach of establishing new requirements and validation of existing requirements to assure that a technology is fit for designated purpose</td>
</tr>
<tr>
<td>technology qualification</td>
<td>process of establishing an adequate set of acceptance criteria for delivery and associated limits to operations so that equipment, devices or facilities will be fit for designated purpose</td>
</tr>
<tr>
<td>technology qualification state</td>
<td>assured functionality and ranges of applicability</td>
</tr>
<tr>
<td>test design</td>
<td>process of defining required testing in the qualification plan in order to produce defined evidence, as needed for the argument to claim the technology qualified</td>
</tr>
<tr>
<td>use</td>
<td>application and operation of equipment, device or facility</td>
</tr>
<tr>
<td>user</td>
<td>role that performs operations with equipment, device or facility such as an integrated deployment and recovery system</td>
</tr>
<tr>
<td>utilisation</td>
<td>extent to which the performance capability has been exhausted with respect to margins</td>
</tr>
<tr>
<td>validated requirements</td>
<td>adequate set of acceptance criteria for delivery and limits to operations to assure reliable functionality</td>
</tr>
</tbody>
</table>

### Table 1-8 Terms pertaining to deployment and recovery systems designated service

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>crane</td>
<td>lifting appliance that accommodates simultaneous vertical and horizontal movement of objects</td>
</tr>
<tr>
<td>defined break tension</td>
<td>break strength of the rope as verified by testing according to a defined procedure, which includes the rate of loading at prescribed temperature</td>
</tr>
<tr>
<td>deployment and recovery system</td>
<td>lifting system suited to place or remove objects underwater</td>
</tr>
<tr>
<td>design verification report</td>
<td>report issued by the independent verifier on basis of review of submitted documentation for delivery e.g. in the certification process</td>
</tr>
<tr>
<td>DRS</td>
<td>deployment and recovery system</td>
</tr>
<tr>
<td>DVR</td>
<td>design verification report</td>
</tr>
<tr>
<td>hybrid rope</td>
<td>rope made from both synthetic yarns and steel wires</td>
</tr>
<tr>
<td>IDR S</td>
<td>integrated deployment and recovery system</td>
</tr>
<tr>
<td>integrated deployment and recovery system</td>
<td>deployment and recovery system where the reliability is assured for designated service</td>
</tr>
<tr>
<td>lifted mass</td>
<td>suspended mass excluding the rope and terminations</td>
</tr>
<tr>
<td>lifting</td>
<td>raising and lowering</td>
</tr>
<tr>
<td>lifting line</td>
<td>rope furnished for service on a winching system for the lifting of objects</td>
</tr>
<tr>
<td>line</td>
<td>rope furnished for a designated purpose</td>
</tr>
</tbody>
</table>
Table 1-8 Terms pertaining to deployment and recovery systems designated service

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum system tension</td>
<td>highest permissible, momentary tension measured in real-time at the suspension point</td>
</tr>
<tr>
<td>maximum working depth</td>
<td>maximum permissible water depth</td>
</tr>
<tr>
<td>mechanical lifting appliance (MLA)</td>
<td>winching system and positioning system, combined ‘Mechanical lifting appliance’ was used in the DNV-OS-E407, December 2012.</td>
</tr>
<tr>
<td>offshore fibre rope</td>
<td>synthetic-filament rope for designated offshore service See also DNVGL-OS-E303 and DNVGL-RP-E305.</td>
</tr>
<tr>
<td>payload</td>
<td>object that is deployed or recovered as task objective</td>
</tr>
<tr>
<td>pendant line</td>
<td>fibre rope furnished to suspend an object independently</td>
</tr>
<tr>
<td>phase difference</td>
<td>time difference between two waves having the same frequency, for example between force action and resulting displacement</td>
</tr>
<tr>
<td>positioning system</td>
<td>component system (including the rope guide path) which positions the suspension point in relation to the floating platform</td>
</tr>
<tr>
<td>reverse bend cycle</td>
<td>two single bend cycles in opposite direction</td>
</tr>
<tr>
<td>rope</td>
<td>assembly of strands that constitute the (long length of) rope without termination See also DNVGL-OS-E303 and DNVGL-RP-E305.</td>
</tr>
<tr>
<td>rope guide path</td>
<td>routing interfaces towards the rope between the winching system and the suspension point</td>
</tr>
<tr>
<td>rope performance description</td>
<td>document describing the performance of the rope as part of the deployment and recovery system</td>
</tr>
<tr>
<td>rope twist</td>
<td>torsional deflection of the rope</td>
</tr>
<tr>
<td>rope unit</td>
<td>rope furnished to perform the lifting of objects as part of an integrated deployment and recovery system including end terminations and termination hardware Also: furnished deployment and recovery rope.</td>
</tr>
<tr>
<td>RPD</td>
<td>rope performance description</td>
</tr>
<tr>
<td>safety factor</td>
<td>margin</td>
</tr>
<tr>
<td></td>
<td>Use of the term ‘safety factor’ is discouraged since it might not be an adequate measure of safety. The term has traditionally been used to refer to the ratio between minimum strength and highest occurring force, and used in engineering dimensioning as one of many measures of achieving reliability by accounting for uncertainties.</td>
</tr>
<tr>
<td>suspension point</td>
<td>rope exit from the over-boarding sheave or similar</td>
</tr>
<tr>
<td>suspended mass</td>
<td>mass of elements below the suspension point including the suspended length of the rope, the payload and loose gear such as slings, lifting beams, frames, tools, connectors</td>
</tr>
<tr>
<td>tension ratio</td>
<td>ratio between actual tension and the defined break tension for the rope</td>
</tr>
<tr>
<td>termination</td>
<td>mechanical transition for transfer of tension between the rope and something else For fibre rope termination of other type than spliced eye an appropriate level of qualification is required, ref. DNVGL-OS-E303.</td>
</tr>
<tr>
<td>theoretical weight limit</td>
<td>maximum static weight applied at the suspension point for the purpose of dimensioning The theoretical weight limit is a force in kN.</td>
</tr>
</tbody>
</table>

The theoretical weight limit is a force in kN.
### Table 1-8 Terms pertaining to deployment and recovery systems designated service

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>single bend cycle</td>
<td>bending and straightening once (on a sheave or drum)</td>
</tr>
<tr>
<td>underwater operations</td>
<td>application of devices, equipment and facilities to manipulate an object to or from an underwater position and to secure it</td>
</tr>
<tr>
<td>VMO standard</td>
<td>all the DNV offshore standards covering marine operation I.e. DNV-OS-H101, DNV-OS-H102 and DNV-OS-H201 through DNV-OS-H206, which have replaced “DNV - Rules for planning and execution of marine operations.</td>
</tr>
<tr>
<td>winching system</td>
<td>component system that actuates the linear position of the rope through the rope guide path</td>
</tr>
</tbody>
</table>
SECTION 2 GENERAL REQUIREMENTS

2.1 Introduction

2.1.1 Objective

2.1.1.1 This chapter describes how an integrated deployment and recovery system should be documented in order to warrant that the system is reliable within the agreed limits to operations called the designated service.

2.1.1.2 An assurance case shall be provided which shows how the basic claim of qualified technology is substantiated by qualification documentation.

2.1.1.3 The qualification documentation consists of evidence and associated arguments that tie the evidence and the basic claim together.

Guidance note:
The substantiated evidence – argument – claim relationship is referred to as an assurance case. In short, an assurance case is an evidence-based explanation.

App.B provides more information about assurance cases.

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2.1.1.4 Deployment and recovery systems shall be qualified with respect to their component systems, interaction on interfaces between component systems, external action and their service context. Thus, the requirements for integrated deployment and recovery systems will be of three types:

— Designated service (agreed limits to operations)
— Requirements to the integrated system (acceptance criteria of system integration)
— Requirements to the component systems (acceptance criteria for component systems)

Reference is made to Figure D-2.

Guidance note:
The component systems, parts and mode of operation of integrated deployment and recovery systems will not be fixed, since these details will depend on their engineering dimensioning and functional policies.

Hence, the extent of analyses and testing required for establishing qualification documentation will not be fixed. The limits of designated service as defined by system operation, condition management and marine operations (application) will vary accordingly.

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2.2 Qualification documentation

2.2.1 Qualification evidence and argument

2.2.1.1 The qualification documentation consists of the qualification evidence and the argument that supports the basic claim that the technology is covered by an adequate set of acceptance criteria for delivery and limits to operations (designated service), and that this set of validated requirements are met.

2.2.1.2 The system integrator shall formulate an argument to demonstrate how the qualification evidence relate to the claim. This should be done according to the basic process as outlined in DNV-RP-A203 to provide a structured presentation of how the qualification evidence relates to the claim.

2.2.1.3 In the context of the designated service, the failure modes of the integrated system shall be identified. It shall be explained how they are managed within the scope of the condition management programme for the system, the system operating procedures, and the marine operations limitations.

2.2.1.4 All documentation shall be available electronically as secured pdf documents, traceable with respect to version and issue date and with signatures from the issuing party.

2.2.1.5 All documents should be indexed with bookmarks and enabled for commenting.
2.3 Roles and responsibilities

2.3.1 User, owner, system integrator, independent verifier and component-system suppliers

2.3.1.1 The user is responsible for the application and operation of the integrated deployment and recovery system.

2.3.1.2 The user shall share all use information with the owner as relevant for the system fitness for designated service.

2.3.1.3 The owner is responsible for ensuring that the use and condition management of the system is in accordance with the limits of the designated service. The owner shall share all service context information with the system integrator which is relevant for progressing technology qualification.

Guidance note:
The sharing of service context information with system integrator is mandatory for technology qualification strategies, i.e. where the technology qualification is updated based on experience from service.

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2.3.1.4 The system integrator is responsible for documenting that the component systems will work together to provide the agreed functionalities of the integrated system.

2.3.1.5 The necessary documentation shall be provided to the independent verifier and as agreed with the owner.

2.3.1.6 The role of the independent verifier is to verify that the assurance case for reliability is adequate, and to perform compliance verification for delivery and of designated service of the integrated system.

2.3.1.7 Component system suppliers shall provide adequate documentation of delivery to the system integrator, and in accordance with agreement.

2.3.1.8 Basic lines of responsibility for system integration and for delivery of component systems and products are shown in Figure 2-1, with indication of technology assurance agreements.
2.3.1.9 The system reliability in service shall be substantiated with adequate acceptance criteria for delivery and adequate limits to operations (application, operation and condition) that are developed by the system integrator in the technology assurance process.

2.4 Qualification strategy

2.4.1 Main unknown elements

2.4.1.1 The optimal qualification strategy will depend on which are the main unknowns for the particular system within its particular designated service.

Guidance note:
When the qualification strategy is being established then the owner and the system integrator should liaise closely in order to define the balance between initial qualification state and the required qualification state for the final designated service, and to establish the best plan for progressing the qualification state based on technology qualification principles according to DNV-RP-A203 where in-service experience can be used in the technology assurance case.

2.4.1.2 The use of in-service experience shall be covered in the assurance agreement for designated service.

2.4.2 Assurance agreement between owner and system integrator

2.4.2.1 An assurance agreement for designated service shall be entered into between owner and system integrator.
2.4.2.2 The assurance agreement for designated service shall state the governing principles for technology qualification (and continued technology qualification during designated service) and shall thus not be prescriptive about qualification results. Reference is made to App.A.

2.4.2.3 The management of interfaces is of particular importance, see App.D.

2.4.3 Documentation

2.4.3.1 With a staged qualification strategy rather than full, initial qualification prior to service, the objective of the qualification documentation is to demonstrate reliability and associated safety within the limits of designated service that shall be defined for each state in the qualification strategy.

2.4.3.2 A plan for expansion of the service context should be established for each qualification stage, after which the qualification documentation should be updated to reflect the achieved qualification state. Reference is made to the Figure D-5.

2.4.3.3 The progression from one qualification state to the next can depend on the collection of evidence from preceding service, or on the results of tests that take a long time to complete.

2.4.3.4 Definition of the optimal qualification strategy will in a large part consist of striking the right balance between knowledge of the condition of the rope and other component systems during service and how accumulation of damage will be progressing in continued service. More information on qualification strategy can be found in App.B.

2.4.3.5 The qualification documentation shall demonstrate that operations can be performed reliably and thus safely within the context of the designated service for the integrated deployment and recovery system.

**Guidance note:**
The service context documents (operating procedures, marine operations limitations and condition management programme) should address the effects of parameters such as lift speed, depth, vessel stability and motions of the suspension point, static and dynamic loading, monitoring capabilities and alarms, etc.

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SECTION 3 DESIGNATED SERVICE

3.1 Documentation requirements

3.1.1 General

3.1.1.1 As illustrated in Figure D-2 the integrated deployment and recovery systems will operate in a designated service which is defined by the programme for condition management, operating procedures for the deployment and recovery system and the limitations related to the marine operations associated with operations with the system.

3.1.1.2 It is the responsibility of the owner to submit the service context request to the system integrator.

3.1.1.3 It is the responsibility of the system integrator to submit to the owner the designated service for the integrated deployment and recovery system in the current qualification state, and when fully qualified for the designated purpose (i.e. intended capability with associated designated service). The designated service sets the limits to operations that are the boundary conditions for the technology qualification of the integrated deployment and recovery system.

Guidance note:
In this current issue of this standard the owner and the system integrator are required to establish the service context request and agree on the designated service on basis of own methods.
The system integrator is responsible for the system interaction, and to liaise closely with all component system suppliers and the independent verifier. Reference is made to App.A concerning the assurance agreements.
Methods to match the designated service with the service context request in a technology qualification programme can be published by DNV GL later. Information about on-going research and development programmes at DNV GL can be obtained by sending an e-mail to rules@dnvgl.com.
It is recommended to apply the VMO Standard for verification of relevant compliance when the operating procedures for the integrated deployment and recovery system and the marine operations limitations are developed.

3.1.2 Application of the system

3.1.2.1 The limitations for marine operations shall be in place for the deployment and recovery system.

3.1.2.2 It is the responsibility of the owner to submit the marine operations limitations to the user.

3.1.2.3 It is the responsibility of the user to ensure that provisions stated in document ‘marine operations limitations’ are adhered to and to submit the use history back to the owner. Owner shall pass on the use history to the system integrator as relevant for the technology qualification.

3.1.3 System operation

3.1.3.1 Operating procedures shall be in place for the deployment and recovery system.

3.1.4 System condition management

3.1.4.1 A condition management programme shall be in place for the deployment and recovery system.

3.1.4.2 That condition management programme shall specify how input from service shall be used in order to assure the reliability of the integrated system.

Guidance note:
It is further possible to adopt a qualification strategy by which service experience is utilised to successively build up confidence where evidence may be lacking for qualification for designated service, which is gradually expanded as more experience is gained. See App.D.

---end---of---guide---note---
SECTION 4  SYSTEM INTEGRATION FOR DESIGNATED SERVICE

4.1  Documentation requirements

4.1.1  Introduction

4.1.1.1  This section covers the documentation requirements for the integration of deployment and recovery systems for designated service.

4.1.1.2  The documentation shall demonstrate assured reliability and associated safety in the designated service as defined by system operation procedures, condition management programme and marine operations limitations.

4.1.1.3  It is the responsibility of the system integrator to provide the system integration documentation.

4.1.2  Functional description

4.1.2.1  A functional description shall be submitted for the integrated deployment and recovery system. It shall provide an overview of the system in general.

4.1.2.2  The functional policies of the integrated system shall be clearly defined.

4.1.2.3  The functional description shall explain how the system functions as an integrated whole by the functionality at the interfaces.

4.1.2.4  Interface function analysis should be performed to explain how each function is delivered.

4.1.2.5  The external interaction between the system and the surroundings shall be described. Aspects of particular importance shall be identified for each external interface (Figure D-3); and it shall be explained how these aspects are managed by system qualification in order to warrant the claim for assured reliability and associated safety.

4.1.2.6  The functional interaction between the various component systems (i.e. sub-systems) shall be described. Aspects of particular importance shall be identified for each internal interface (Figure D-4); and it shall be explained how these aspects are managed by system qualification in order to warrant the claim for assured reliability and associated safety.

Guidance note:
The current version of this standard requires the system integrator and component-system suppliers to apply own methods to describe system functions for use in the technology qualification programme. Methods can be published by DNV GL later. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com

4.1.3  Failure modes

4.1.3.1  Failure modes shall be managed through technology qualification principles as outlined in DNV-RP-A203.

4.1.3.2  Failure modes that are well understood and covered by existing standards can be claimed sufficiently managed through adherence to standards. The appropriate claim shall be substantiated, and the relevant parts of listed reference standards shall be validated. It shall further be substantiated why the other parts of listed reference standards are not relevant for the case at hand.

Guidance note:
Reference is made to the requirements validation indicated in Figure 1-3. The relevance or irrelevance of certain requirements of an existing standard should be substantiated by application of technology qualification principles with basis in DNV-RP-A203 and expressed in the assurance case for system reliability.
4.1.4 Critical parameters

4.1.4.1 The critical parameters shall be related to the functional description of the integrated deployment and recovery system, which shall explain how the failure modes are controlled.

4.1.4.2 The control with failure modes can be substantiated in part by limits that are defined in the designated service documentation for the integrated system.
SECTION 5 COMPONENT SYSTEMS

5.1 Introduction

5.1.1 Documentation requirements

5.1.1.1 This section covers requirements for documentation of the component systems (i.e. sub-systems) of integrated deployment and recovery systems.

5.1.1.2 Each of the component systems that make up the integrated deployment and recovery system shall be documented according to relevant parts of standards listed in Table 1-1.

5.1.1.3 Technology qualification shall be performed where standards are lacking or insufficient. A requirements validation is indicated in Figure 1-3 to show that standards need to be checked for applicability.

Guidance note:
Should a component system supplier require deviating from a normative reference for the specific case, then requirements validation can be used to substantiate such request.

5.1.1.4 The documentation shall demonstrate assured reliability and associated safety considering internal and external interfaces and internal and external actions.

5.1.1.5 It is the responsibility of the component system suppliers to provide the agreed documentation to the system integrator.

5.1.1.6 The provisions that are applicable to defined component systems are presented in the following.

5.2 Rope

5.2.1 Technology qualification of rope performance

5.2.1.1 The qualification documentation (evidence and argument) for the rope should be compiled into a rope performance description.

5.2.1.2 The rope performance description should describe the relationship between tension (on the rope), bending and twisting (of the rope) and load sharing (within the rope). It should further address wear performance, temperature performance and external damage tolerance.

5.2.1.3 For fibre rope the performance description shall be according to DNVGL-OS-E303. For steel-wire rope and hybrid rope the same principles shall be followed.

5.2.2 Rope performance in the service context

5.2.2.1 The rope performance description shall be linked to the functional description of the integrated deployment and recovery system. The functional description shall explain how failure modes are controlled.

5.2.2.2 It shall be explained how the designated service (operating procedures, the condition management programme and the marine operations limitations) will assure the rope reliability and associated safety.

5.2.3 Condition management

5.2.3.1 The condition management programme for the rope shall fit the condition management programme for the rope guide path and for the terminations.

5.2.3.2 Due consideration shall be given to the handling and storage of the rope.
5.2.4 Fibre rope

5.2.4.1 Fibre rope for deployment and recovery systems - and pendants - shall comply with DNVGL-OS-E303, which provides the technical requirements and documentation requirements for offshore fibre rope including terminations with termination hardware.

5.2.5 Steel-wire rope

5.2.5.1 The same principles to assuring reliability, and associated safety, apply to steel-wire rope in a technology qualification process.

Guidance note:
Validated requirements for steel-wire ropes can be developed with basis in the documentation requirements for fibre rope as stated in DNVGL-OS-E303. The requirements stated in DNV-OS-E304 should be considered in the requirements validation.

---end---of---guidance---note---

5.2.6 Hybrid ropes

5.2.6.1 The same principles to assuring reliability, and associated safety, apply to hybrid ropes in a technology qualification process.

Guidance note:
Validated requirements for hybrid ropes can be developed with basis in the documentation requirements for fibre rope as stated in DNVGL-OS-E303. The requirements stated in DNV-OS-E304 should be considered in the requirements validation.

---end---of---guidance---note---

5.2.7 Generic failure modes for the rope

5.2.7.1 A brief summary of failure modes for fibre ropes is provided in App.C for the following key interfaces:

— Rope guide path (internal interface)
— Lifted mass (external interface)

5.2.7.2 The overview is not exhaustive and it will depend on system variant.

5.2.7.3 Other external interfaces such as water column and external objects shall be duly considered.

5.2.7.4 The failure modes shall be accounted for in the assurance case for qualified technology, which entails that they are reflected in the condition management programme.

Guidance note:
Summaries of failure modes for steel-wire ropes, hybrid ropes and fibre rope pendants can be published later. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com.

---end---of---guidance---note---

5.3 Positioning system

5.3.1 General

5.3.1.1 The positioning system shall comply with validated requirements with basis in DNVGL-ST-0378.

5.3.1.2 The interfaces with the rope can be qualified by means of a strategy as illustrated in principle in Figure D-5.

5.3.1.3 The interfaces with the power, control, winching and monitoring systems shall be duly addressed.

5.4 Winching system

5.4.1 General

5.4.1.1 The winching system shall comply with validated requirements with basis in DNVGL-ST-0378.
5.4.1.2 The interfaces with the rope can be qualified by means of a strategy as illustrated in principle in Figure D-5.

5.4.1.3 The interfaces with the power, control, positioning and monitoring systems shall be duly addressed.

5.5 Power system

5.5.1 General

5.5.1.1 The power systems shall comply with validated requirements with basis in DNVGL-ST-0378.

5.5.1.2 The interfaces with the positioning, winching, control and monitoring systems shall be duly addressed.

  Guidance note:
  The requirements of DNVGL-OS-D201 Electrical installations should be observed in the requirements validation.

5.6 Control system

5.6.1 General

5.6.1.1 Control systems shall comply with validated requirements with basis in DNVGL-ST-0378.

  Guidance note:
  The requirements of DNVGL-OS-D201 Electrical installations should be observed in the requirements validation.

5.6.1.2 The interfaces with the positioning system, winching system, power and monitoring systems shall be duly addressed.

5.7 Monitoring system(s)

5.7.1 General

5.7.1.1 Monitoring Systems shall comply with validated requirements as developed in the technology qualification processes, based on DNVGL-OS-D202 to the extent relevant.

5.7.1.2 The interfaces with the rope guide path and the rest of the positioning system, the winching system, power system and control systems shall be duly addressed.

5.8 Condition management system and other software systems

5.8.1 General

5.8.1.1 It is recommended to follow the DNV-RP-D201 Integrated software dependent systems.

5.8.1.2 Whether the integrated deployment and recovery system is software dependent or software redundant shall be demonstrated in the qualification documentation.

  Guidance note:
  ‘Software dependent’ implies that critical functionality might fail if the software fails. ‘Software redundant’ means that despite a potential software failure the system will still deliver required critical functionality.

5.8.1.3 The integration with the control and monitoring system(s) shall be duly addressed.
5.8.2 Software dependent systems

5.8.2.1 Software dependent deployment and recovery systems that are software dependent shall comply with DNVGL-OS-D203 *Integrated Software Dependent System (ISDS).*
APPENDIX A  THE ASSURANCE AGREEMENTS

A.1 Assurance agreement for designated service

A.1.1 Assuring the fitness for designated service

A.1.1.1 The qualification strategy for deployment and recovery systems shall be formulated by system integrator and agreed between owner and system integrator. The assurance agreement for designated service shall ensure that the strategy is implemented.

A.1.1.2 Due to the nature of development processes for solutions, DNVGL-ST-E407 (this standard) encourages that a qualification strategy be followed in order to increase the assured system performance in a staged approach. A staged approach as indicated in Figure D-5 is recommended independent of type of rope and system variant.

A.1.1.3 The qualification state of the system is defined by what the DRS can do in operations, and how use and condition should be managed in order to maintain - and develop - that assurance case.

A.1.1.4 The first qualification state to be defined for designated service is called TQ1. The final qualification state is called TQF.

A.1.1.5 The assurance agreement for designated service should be specific about qualification state TQ1; however it is recommended to outline the further and final qualification states as well.

A.1.1.6 The assurance agreement for designated service is subject to independent verification of system integration for designated service.

A.1.2 Requirements to the assurance case

A.1.2.1 The assurance case shall substantiate why the system will be reliable in operations, and what defines that designated service, and how this is documented. The assurance case should incorporate, but not be limited to:

- operating the DRS, training and skills
- incorporation of requirements to user
- monitoring of the rope and rope guide path
- determination of performance margins for the rope for upcoming operations
- boundary conditions for the qualification state and associated assumptions
- monitoring of the fault-free functionalities of the integrated system
- policies for redundancy in order to be able to state the limits to operations that can be performed within the scope of the current assurance case
- how condition management (monitoring, inspection and maintenance) of the component systems will ensure fault-free functioning of the integrated DRS with evidence thereto, including but not limited to:
  - rope
  - winching system
  - rope path
  - spooling and storage
  - tension – time – temperature endurance, for synthetic fibre rope
  - temperature stability of lubrication, for steel-wire rope
  - power systems
  - control systems
  - monitoring system
  - structural elements.
A.1.2.2 In practice, this means that there can be two separate, but dependent assurance cases:
- assurance case for delivery with description of capability (TQ0)
- assurance case for designated service with description of use and condition management (TQ1 – TQF)

A.1.2.3 The contents and organisation of the assurance case for designated service shall be governed by the strategy adopted for the system qualification, and the tactic for each of the stages as reflected in the assurance agreement for designated service. The adequate acceptance criteria for the system and the limitations of its use and condition in designated service shall be defined in the closing of the assurance case.

A.1.3 Assurance proposal for designated service

A.1.3.1 Information needs to be available in advance in order to establish a suitable assurance agreement for designated service between the system integrator and the owner. This information should be compiled into an assurance proposal by the system integrator.

A.1.3.2 The information in the assurance proposal shall come from the roles that are responsible for the various component systems and from the system integrator, and shall cover but not be limited to:
- Performance descriptions for component systems (Delivery)
- Performance description for the integrated system (Delivery)
- Condition management requirements (Designated service)
- Use of service information in the qualification strategy (Designated service)

A.1.3.3 The assurance proposal shall be submitted to the owner for review, comments and implementation of comments. This process is iterative by nature, and the system integrator might need to go back to the roles responsible for component systems in order to revise the assurance proposal.

A.1.3.4 In the process of system development, similar iterations should be made between the parties responsible for component systems and the system integrator in order to tailor the integrated system to the specific needs of the user, as communicated by the owner.

A.2 Delivery assurance agreements

A.2.1 Assuring the fitness for purpose

A.2.1.1 Delivery assurance agreements should be entered into between the system integrator and the providers of the component systems.

A.3 Roles and responsibilities in technology qualification strategy

A.3.1 User

A.3.1.1 To use the system in the way set forth by owner and to feedback use-data accordingly

A.3.2 Owner

- Owner of the system
- implementation of the condition management programme
- setting requirements to user for correct operation and to ensure use-data feedback for condition management
- to maintain the serviceability of the deployment and recovery system
- provide input and use feedback to the system integrator for the purpose of progressing the qualification state of the deployment and recovery system
- assurance agreement for designated service jointly with the system integrator.
A.3.3 System integrator

— Define the qualification state (system capability) and documenting it for certification:
  — for delivery TQ0 (with assurance proposal)
  — for designated service TQ1 – TQF (with assurance agreement jointly with the owner).
— to define the strategy for developing the qualification state and the requirements to documentation of compliance with designated service
— to define the condition management programme as determined by the technology qualification state.

A.3.4 Suppliers of component systems

— Component system performance descriptions for use in the assurance case for delivery
— substantiated condition management information for use in the assurance case for designated service.

A.3.5 Independent verifier

— Verification of the assurance case for system integration (for delivery) with requirements to use and condition management programme (for designated service), and issuance of independent verification report that state (or reference) the qualification state of the integrated deployment and recovery system.
— independent qualification activities as requested
— marine warranty as requested.

A.4 About the process

A.4.1 General

A.4.1.1 When developing the finalised assurance agreement for designated service, the tactical aspects of qualification that need to be considered will involve trade-offs such as:
  — the optimal technology qualification programme vs. available time
  — the required evidence for a certain branch of the argument vs. the effort of obtaining that evidence
  — the existing evidence that might be available vs. the ideal evidence sought for the branch of the argument
  — the time at which a given TQ state needs to be achieved vs. the most cost-effective tempo for provision of the required evidence
  — the level of uncertainty and risks of one approach vs. another approach.

A.4.1.2 The many ways of defining a target technology qualification state require that the system integrator and the owner communicate unambiguously about the expectations to functionality, timeline, uncertainty and risk.

A.4.1.3 The same applies to the processes between the system integrator and the roles that are responsible for the component systems.
APPENDIX B  ARGUMENTATION IN QUALIFICATION STRATEGY

B.1  Establishing an Assurance Case

B.1.1  General

B.1.1.1  This appendix provides supplementary information on the establishment of an assurance case.

B.1.1.2  The assurance case is an effective tool for:

— expressing complex interrelations between claims, arguments and qualification evidence
— facilitating definition of qualification activities shown in Figure D-1 and Figure D-5
— facilitating test design by formulating expectations to the test results in the complete setting
— structured qualification documentation.

B.1.1.3  The claims identified during the technology and threat assessments (of the basic technology qualification process) are organized in an assurance case that builds the justification to provide confidence for the stakeholders.

B.1.1.4  The principle of an assurance case is shown in Figure B-1. Both the argument and the associated evidence are needed to justify that reliability (or safety) can be claimed.

![The anatomy of an assurance case](image)

Figure B-1  The anatomy of an assurance case

B.1.1.5  Arguments can be based on sub-claims that in turn can be based on more specific sub-claims, until factual evidence exists or can be provided by for example testing or analysis.

B.1.1.6  The GSN community standard /1/ provides suggestions for how to establish assurance cases, with emphasis on graphical presentation. Reference is made to App.D.

Guidance note:
Graphical presentation of the assurance case as provided by GSN /1/ or KAOS /2/ is not mandatory under this standard; however it is recommended for the sake of precision and overview.

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B.2  Qualification strategy

B.2.1  General

B.2.1.1  This section provides supplementary information concerning application of an incremental to technology qualification. Here, strategy means that instead of aiming for complete, initial qualification for the full designated service, the qualification effort and the service context are balanced out in technology
qualification stages such that implementation to service can happen sooner, or at lower cost compared to performing the basic technology qualification process just once.

B.2.1.2 A staged qualification strategy will be particularly useful when evidence that can be obtained after implementation has impact on the argument, or even the technology itself.

B.3 Simplification by qualification strategy

B.3.1 General

B.3.1.1 One main reason for working out a qualification strategy is the need to reduce the complexity of the tasks and to gain experience as soon as possible. Thus, the establishment of a qualification strategy very much becomes a question of simplification, and in this light the following questions should be asked when establishing the qualification strategy:

— What do we need to document before the integrated system can be used for the first time, with additional restrictions?
— What defines first time use; which operations can be performed then?
— What is the level of detail needed in the rope performance description?
— Is the system dependent or redundant of control systems, monitoring systems or software?

The answers to the above simplification questions should be analysed with respect to type of winching system, the type of rope with type of load-bearing material and coating. It will then be possible to develop the details of the argument for how to qualify the rope as part of the integrated deployment and recovery system.

B.4 Characterisation of system variants with fibre rope

B.4.1 General

B.4.1.1 In order to establish the qualification strategy for a specific, integrated deployment and recovery system it should be characterised with respect to (system) variant.

B.4.1.2 There are certain key technologies in fibre rope based deployment and recovery systems. The key technologies exist in categories:

— the type of winching system:
  — friction pull winch
  — direct pull winch
— the type of rope:
  — braided arrangement of strands
  — helical arrangement of strands
— the type of fibre:
  — 3-T performance
  — the coating on filaments, yarns and strands
— type of termination:
  — spliced
  — socket
  — other type

B.4.1.3 The type and characteristics of the rope coating should be allied to the type of winching system due to the fundamentally different means of actuating the rope position.
Guidance note:
Parallel-subrope rope can be used for lifting pendants; but unless specifically engineered for purpose, ropes for deployment and recovery should not be made from parallel subropes. See Figure 1-2.
It is intended to provide more information in a revision of this standard. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com.

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B.5 Characterisation of system variants with steel-wire rope

B.5.1 General

B.5.1.1 In order to establish the qualification strategy for a specific system it should be characterised with respect to (system) variant.

Guidance note:
It is intended to provide more information in a revision of this standard. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com.

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B.6 Characterisation of system variants with hybrid rope

B.6.1 General

B.6.1.1 In order to establish the qualification strategy for a specific system it should be characterised with respect to (system) variant.

Guidance note:
It is intended to provide more information in a revision of this standard. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com.

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B.7 Test design

B.7.1 General

B.7.1.1 The process for technology qualification sets requirements for how testing is defined and performed. The way testing should be defined and performed is governed by the required qualification evidence as inferred by the argument, and by the timeline by which evidence is needed. The cost of testing is also important and might have significant bearing on the choice of strategy.

B.7.1.2 Test design in qualification programmes will depend on the strategy and available time for the first, incremental qualification and certification.

Guidance note:
The appropriate qualification strategy will be tightly allied to the type and variant of integrated deployment and recovery system. Methods for definition of testing in alternative qualification strategies for system types and variants can be reflected in later versions of this standard or in DNVGL-RP-E305 concerning fibre ropes. Spare part philosophy should be included in the qualification strategy for designated service.

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B.7.1.3 The available timeline might, in turn, have significant bearing on the possibility to perform tests which affects the qualification strategy as well as the assurance argument.
APPENDIX C  QUALIFYING THE ROPE FOR SYSTEM INTEGRATION

C.1 Introduction

C.1.1 General

C.1.1.1 The objective of a technology qualification programme is to show that the chosen solutions will be reliable provided adequate acceptance criteria are met for delivery and the limits of the designated service are adhered to.

C.1.1.2 For compliance with this standard, an assurance case is required in order to substantiate that the technology qualification has been adequately performed to render the system reliable, provided the resulting, adequate set of validated requirements are complied with.

C.1.1.3 The objective of the technology qualification will be to balance the designated service with available qualification documentation (evidence and argument) as illustrated in Figure C-1.

![Figure C-1 Using the service context to balance the technology qualification](image)

C.1.1.4 For the purpose of illustration, Figure C-1 indicates that the resulting operation time will be somewhere between the two extremes:

— use the system once and then discard the rope
— use the system for 10 years without any maintenance or monitoring of the rope or anything else.

C.1.1.5 The actual service life shall be substantiated by the solidity of the assurance argument and available evidence for the case at hand.

C.1.2 Approaches

C.1.2.1 Successful qualification of the rope involves description of how it behaves.

C.1.2.2 In the following the qualification of ropes for deployment and recovery is discussed on basis of a certain approach.
Note:
There will be many viable routes to qualifying the rope for a deployment and recovery system, which for fibre ropes may or may not include the definitions of critical parameters and failure modes that are mentioned below.

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Guidance note:
The distinction between various approaches can be reflected in a revision of this standard. Information about ongoing joint industry projects and other research at DNV GL can be obtained by contacting rules@dnvgl.com.

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C.2  The performance of ropes

C.2.1  General

C.2.1.1  The largest, general uncertainties for the integration of deployment and recovery systems are currently believed to pertain to:

— the performance of the rope in repetitive bending, including coating durability
— the ability of the system to curtail peak tensions
— how the shape of the rope changes
— tension vs. stretch performance
— torque and twist characteristics.

Guidance note:
The second point will depend on whether the system is compensating for motions, and the principles by which the control system operates.
The inertia of the moving parts governs the aggregate phase difference through the rope guide path. The phase difference through the rope and added mass are equally important together with other factors.

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C.3  Types of ropes

C.3.1  General

C.3.1.1  In the following, fibre ropes in deployment and recovery systems are discussed.

Guidance note:
A similar discussion is intended to be provided for steel-wire rope and hybrid rope in a revision of this standard.
A joint industry project is ongoing in order to further the knowledge about the behaviour and performance of steel-wire ropes in designated service as part of integrated deployment and recovery systems. More information can be obtained by contacting rules@dnvgl.com.

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C.4  Critical parameters

C.4.1  Introduction

C.4.1.1  In the following a discussion is provided on critical parameters relating to the failure modes for fibre ropes. It shall be the objective of the system engineering – with the associated designated service – to at all times maintain sufficient margin against failure.

C.4.1.2  Critical parameters can be defined as:

— local stresses in the rope
— temperature in the rope
— time under tension
— the wear of the rope.
C.4.1.3 The combination of tension, time, wear and temperature will need to be within the agreed limits to operations that are referred to as the designated service.

C.4.1.4 The rope performance description can be based on the testing or modelling which is performed to address the critical parameters.

Guidance note:
The following questions should be addressed for fibre ropes:
— What is the limiting temperature, and how is the margin to the critical temperature defined?
— What is the limiting local stress, and how is the margin to the critical stress defined?
— What happens to local stresses when the rope is twisted?
— What happens to local stresses when the rope is bent?
— What is the limiting amount of twist?

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C.5 Failure modes

C.5.1 Introduction

C.5.1.1 Generic failure modes that can be exerted on the rope by the internal interfaces with the rope guide path and winching system are:
— overloading
— expenditure of 3-T endurance
— processes pertaining to bending
— twisting
— kinking
— external wear.

C.5.1.2 Generic failure modes from external action by the lifted mass are:
— twisting
— concentrated bending at the termination
— failure of termination, e.g. the spliced eye.

C.5.2 Overloading

C.5.2.1 Overloading occurs when the rope is loaded to break, or to a tension resulting in a very short 3-T endurance. Overloading occurs when the local stresses in the rope are too high.

C.5.3 Time-dependent failure

C.5.3.1 Time-dependent failure modes in fibre are related to time under tension, the magnitude of tension, the associated temperatures, and processes that reduce the load-carrying capability of the rope:
— 3-T endurance
— wear and loss of area.

The magnitude of tension, temperature and time under tension is important. Reference is made to DNVGL-RP-E305 concerning 3-T.

C.5.4 Processes pertaining to bending

C.5.4.1 A general concern for the integration of deployment and recovery systems is how long the rope will last in repeated bending. Repeated bending can occur when the system is compensating for motions; or it can occur over time, as the rope is extended or retracted.
C.5.4.2 Repeated bending which is concentrated in time is of highest concern, as sufficient margin against failure needs to exist in the prevailing operational condition. When the rope is bent over a sheave, the structure of the rope is affected:

— the rope geometry is altered
— internal movement occurs between strands in the rope
— the geometry of individual strands in the rope are altered
— internal movement occurs between yarns in the strands
— coatings may diminish due to localized pressure or environmental conditions.

C.5.4.3 Bending may be concentrated on the rope, typically at the termination of the rope.

C.5.4.4 In a fibre rope under tension, the above effects may result in the following processes:

— transfer of loads between strands
— wear between strands due to sliding or scissoring
— generation of heat between strands
— wear internally in strands
— generation of heat internally in strands
— splice slippage.

C.5.5 Twisting

C.5.5.1 In principle, the processes inside the rope caused by twisting are similar to those for bending; only the actions on the interfaces are different. Twisting may occur over a long length of rope, or concentrated in a local spot. Further distinction – which will be rope construction dependent - should be made as part of the rope design process.

C.5.6 External wear

C.5.6.1 External wear occurs when there is relative movement between the rope and an external surface.

C.6 Interaction between failure modes

C.6.1 General

C.6.1.1 Interaction between failure modes implies that the detrimental effect of two failure modes that occur simultaneously is different from the sum of the detrimental effects of each failure mode acting alone. This shall be considered when expressing the difference between function and failure in terms of the critical parameters.

C.6.1.2 It shall be substantiated that interaction between failure modes is managed through qualification testing and argument as part of the technology qualification documentation for reliability within the designated service.

Guidance note: Due to the complexity of the issue, disallowing failure mode interaction that aggravates utilisation might be favourable in the earlier stages of a qualification strategy.

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D.1 Qualification tactics and qualification strategy

D.1.1 General

D.1.1.1 In order to arrive at adequate acceptance criteria for delivery and limits of use and condition for a technology which has not already been qualified, it is necessary to go through a technology qualification process.

Guidance note:
This can be due to the novelty of the technology itself, or the novelty of the service context.

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D.1.1.2 The main steps of the basic technology qualification process are illustrated in Figure D-1.

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![Figure D-1: The basic process for qualification of technologies based on DNV-RP-A203](image)

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D.1.1.3 Technology qualification activities can be performed in any phase of the development of a specific solution, not excluding formalised technology qualification after the development has been concluded. In order to optimise the processes of development and qualification it is recommended to perform technology qualification integrated with the development of the solution.

Guidance note:
Design and engineering processes contain large elements of technology qualification by their nature, which can be used in the formalised technology qualification process for establishment of qualification documentation. In fact, technology qualification is merely a certain systematic way of providing argument and evidence to substantiate the claim that the solution will perform as expected on certain conditions and within defined limits. One of the greatest advantages of formalised technology qualification is avoidance of tests that drain a limited budget or spend too much valuable time.

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D.1.2 Technology composition

D.1.2.1 The initial expression of technology composition is a key part of the methods for technology qualification. (The qualification basis.) A high-level overview based on component systems is shown in Figure D-2.

![Figure D-2 Technology composition for task performance with deployment and recovery system in designated service](image)

D.1.2.2 As illustrated in Figure D-2, several technical systems have to operate together in order to perform the intended task; and simultaneously, systematics have to be applied in interaction with the technical systems, being operating procedures (for the integrated deployment and recovery system), marine operations limitations involving vessels and objects, and a programme for condition management (of the deployment and recovery system).

D.1.2.3 Based on an overview as indicated in Figure D-2, the interfaces for the integrated deployment and recovery system should be analysed further.

D.1.3 Interfaces management

D.1.3.1 Interface analyses are effective with respect to identification of functions and failure modes.

D.1.3.2 There are two types of interfaces, as identified by

---

- external action on the integrated system
- interaction between component systems.
D.1.4 Interface analyses

D.1.4.1 External and internal interfaces should be analysed with respect to functions and how associated failure modes should be managed. Figure D-3 indicates some external actions on the integrated system.

Figure D-3 External action interfaces (arrows)

D.1.4.2 Figure D-4 indicate some internal interfaces towards the rope and its termination.

Figure D-4 Internal interfaces towards the rope unit (arrows)
D.1.5 Contributions

D.1.5.1 The interface functions will be provided by the contributions from the elements on each side of the interface.

D.1.5.2 For development of the required documentation to qualify a system, the contributions to functions across interfaces should be defined in the technology assessment.

**Guidance note:**
See DNV-RP-A203 for the recommendations pertaining to the qualification basis, technology assessment, and the use of critical parameters to describe functions.

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D.1.6 Selection of qualification strategy

D.1.6.1 The best qualification strategy will depend on the existing qualification state and on available time, budget and other factors. As discussed in DNV-RP-A203, an incremental qualification strategy can be advantageous, in particular for integrated technologies.

D.1.6.2 The principle of a qualification strategy in relation to the basic technology qualification process is shown in Figure D-5.

**Guidance note:**
In order to choose a suitable qualification strategy for a complex system, the following should be addressed:

- What would be the minimum qualification documentation required before entering into a narrow designated service?
- How can the experience from this service be used as qualification evidence?
- How will the argument for reliability and associated safety need to be modified and updated?
- Is the system controlling redundant or controlling dependent?
- Is the integrated system software redundant or software dependent?

![Figure D-5 Strategy with technology qualification stages instead of just the single, basic process](image)

Methods for management of the qualification stages from initial to final designated service can be reflected in later versions of this standard, or in revisions of DNVGL-RP-E305 for fibre ropes.

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D.1.6.3 Additional information on qualification strategy can be found in App.B.
APPENDIX E  GRAPHICAL PRESENTATIONS

E.1 Presenting arguments graphically

E.1.1 Introduction

E.1.1.1 An argument is used to link evidence to the claim in an assurance case demonstrating that a technology is qualified.

E.1.1.2 The claim represents the high-level goal for technology qualification in service context.

E.1.1.3 In order to link this goal to the evidence, it is necessary to define lower-level goals (sub-claims) that imply the parent goal is met. This results in a logical hierarchy that can be presented in a goal tree.

E.1.1.4 Graphical notations can be used to document the elements of the argumentation and the relationship between these elements. Graphical documentation of assurance cases can be achieved using for example Goal Structuring Notation (GSN) /1/ or KAOS /2/.

E.1.1.5 Assurance cases can be developed both top-down and bottom-up. The chosen strategy depends on the state of the evidence.

E.1.1.6 A bottom-up approach may be taken with basis in pre-existing evidence. This approach could however lead to the preferred claim on the top being impossible due to lacking evidence supporting the justification for the claim. A top-down approach may be taken with basis in the claim that needs to be substantiated. The required evidence needed to underpin the argument shall be a derivative of the top claim and the justification through the argument.

E.1.1.7 Top-down and bottom-up strategies will need to be combined. The required evidence may overlap evidence needed for showing compliance with requirements from prescriptive standards which can simplify the gathering of evidence.

E.2 Goal structuring notation (GSN)

E.2.1 General

E.2.1.1 GSN is a notation for graphical presentation of assurance-case arguments. GSN explicitly documents the elements and structure of an argument, and the argument’s relationship to evidence. GSN is described in a standard /1/.

E.2.1.2 In GSN, the claims of the argument are documented as goals and items of evidence are documented in solutions.

E.2.1.3 Strategy elements can be used to explain the reasoning between a goal and its sub goals.

E.2.1.4 Context elements should be used to define the context in which the argument shall be interpreted.

E.2.1.5 Assumption and Justification elements are used to explicitly document assumptions and justifications made in the argumentation.

E.2.1.6 The example in Figure E-1 uses the GSN notation.
E.3.1 General

E.3.1.1 KAOS is a notation for goal models that have been adapted for the purpose of assurance case formulation. KAOS originates from requirements engineering and follows the structure of a combined success/fault-tree.

E.3.1.2 Goal decomposition in KAOS is performed by using “AND” and “OR” operators to show either the case where several sub-goals together contribute to the satisfaction of the parent goal, or where alternative goals exist. The de-composition can be either full or partial. Full de-composition means that a parent goal has been completely refined and that no more sub-goals will be added to the de-composition, whereas partial de-composition means that more sub-goals may be added in the future.

E.3.1.3 Obstacles prevent the satisfaction of the parent goal. There are different types of obstacles, e.g. hazards that obstruct safety goals and threats that obstruct reliability goals. Obstacles are further broken down using sub-obstacles in a tree similar to a fault tree. Obstacles can be mitigated by goals that describe countermeasures.

E.3.1.4 Through the goal model environment assumptions can be described using ‘domain’ properties. These are statements that are expected to hold regardless how the system behaves.

E.3.1.5 Goals are met by lower-level goals until substantiated by factual evidence.
Figure E-2 Example of graphical presentation using KAOS
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