

Published: 2020-11-27

Language: English

Remotely operated vehicle (ROV) services

Fjernopererte undervannsfarkoster (ROV)

ICS: 75.180.01, 913.15

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Foreword

NORSOK U-102:2020 was adopted as NORSOK Standard 2020-09-30 and published 2020-11-27.

NORSOK U-102:2020 supersedes NORSOK U-102 Ed. 3, January 2016.

NORSOK is an acronym for the competitive position of the Norwegian continental shelf and comprise petroleum industry standards in Norway. The collaboration initiative in 1993 between the authorities and the petroleum industry initiated the development of NORSOK standards.

Reducing the project execution time and developing and operating cost for petroleum installations on the Norwegian shelf was the target.

The intention for the Petroleum industry is to develop and use standards providing good technical and cost effective solutions to ensure that the petroleum resources are exploited and managed in the best possible way by the industry and the authorities. The industry will actively contribute to the development and use of international standards in the global market.

The NORSOK standards shall:

- bridge the gap based on experiences from the Norwegian continental shelf where the international standards are unsatisfactorily;
- replace oil company specifications where possible;
- be available as references for the authorities' regulations;
- be cost effective; and
- promote the Norwegian sector as an attractive area for investments and activities.

Developing new NORSOK standards and regular maintenance of existing standards shall contribute to maintain the competitiveness both nationally and internationally for the Norwegian petroleum industry.

The NORSOK standards are developed by experts from the Norwegian petroleum industry and approved according to the consensus principles as laid down by the guidelines given in NORSOK A-001 N directive.

The NORSOK standards are owned by the Norwegian Oil and Gas Association, the Federation of Norwegian Industries and the Norwegian Shipowners' Association. They are managed and published by Standards Norway.

Annex A and Annex B are informative. Annex C was made normative in this edition (2020).

New since last revision;

This revision of NORSOK U-102 is capturing feedback from the industry since last revision. Description of new technology has been included in the standard as seen applicable.

The ROV classes have been aligned with the classes as defined by IMCA. New classes have also been added to capture systems that are not defined in the previous revision of this document.

The technical requirements have been put into a tabular form, enabling users to better understand the differences between the classes.

Introduction

This document is a consequence of an industry wide effort to make a NORSOK standard for remote operated vehicles (ROV) services.

This document has been produced to establish a single common standard for ROV operations. Users of this document will typically be Companies involved in oil and gas production, and the renewable energy industry. Relevant information and requirements included in this document may also be used for other services which have similarities to the ROVs and the way they are operated.

This document focuses on typical requirements, deliveries and documentation expected between Companies and Contractors.

The bibliography lists standards, norms, laws, regulations and other literature that may be relevant to the use of this document.

Normative text contains the requirements of the standard. Informative text is only guidance to the reader. All text in foreword, introduction and notes is informative text. Note to entries in section 3 and annexes to the document may be either normative or informative.

Remotely operated vehicle (ROV) services

1 Scope

This document defines basic requirements for personnel, equipment and systems for ROV operations related to the petroleum industry.

2 Normative references

The following referenced documents contain text which fully or in part is part of the requirements in the document. For dated references, only the edition cited applies. For undated references, the latest edition of the cited document applies (including amendments).

NS-EN ISO 9001, *Quality management systems*

NS-EN ISO 13628-1:2005, *Petroleum and natural gas industries - Design and operation of subsea production systems - Part 1: General requirements and recommendations*

NORSOK U-100, *Manned underwater operations*

IMCA D054-R020, *Remotely Operated Vehicle Intervention During Diving Operations*

IMCA R018, *Guidelines for Installing ROV Systems on Vessels or Platforms*

IMCA R009, *ROV Mobilisation*

3 Terms and definitions

In this document, the following terms and definitions apply.

3.1

shall (requirement)

expression in the content of a document conveying objectively verifiable criteria to be fulfilled and from which no deviation is permitted if compliance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.2 Table 3.

3.2

should (recommendation)

expression in the content of a document conveying a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.3 Table 4.

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but it is not prohibited.

3.3

may (permission)

expression in the content of a document conveying consent or liberty (or opportunity) to do something

Note 1 to entry: Permissions are expressed using the verbal forms specified in ISO/IEC Directives Part 2 clause 7.4 Table 5.

3.4

can (possibility and capability)

1: expression in the content of a document conveying expected or conceivable material, physical or causal outcome

2: expression in the content of a document conveying the ability, fitness, or quality necessary to do or achieve a specified thing

Note 1 to entry: Possibility and capability is expressed using the verbal forms specified in in ISO/IEC Directives, Part 2 clause 7.5 Table 6.

3.5

client

purchaser of ROV services

3.6

competent person

1: person performing certification in accordance with the applicable rule or code applied

2: person possessing the knowledge and experience required for the performance of thorough examinations and tests if lifting appliances and loose gears and who is acceptable to the competent authority

Note 1 to entry: The person shall be qualified in accordance with the same rule or code for certification of offshore cranes or other relevant approval for certification of cranes subject to dynamic loads.

3.7

competent authority

means a minister, government, department or other authority empowered to issue regulations, orders or other instructions having the force of law

3.8

contractor group

contractor

main company and companies participating in the work, his subcontractors and their contractors and subcontractors, participating companies in a joint venture established for the performance of the work, and the employees of the aforementioned companies

3.9

high voltage

voltages higher than 1000 VAC and 1500 VDC

3.10

launch and recovery system

LARS

all load bearing equipment, guiding included, from (and including) the winch to (and including) the umbilical & umbilical bullet (end termination)

3.11**lifting appliances**

any part of load bearing equipment used in conjunction with ROV systems equipment for lifting/handling

3.12**remotely operated vehicle****ROV**

an unmanned, underwater vehicle that is controlled from the surface by a pilot via a cable and is, in itself, a collection of equipment used in water with an ability to observe the surroundings and, in certain circumstances, intervene/interact with underwater infrastructure

Note 1 to entry: The ROV as described in Annex C includes ROV Vehicle, TMS/Cage (as applicable).

Note 2 to entry: The ROV includes ROV frame structure, connection points for underslung skid and bullet/locking dogs for the TMS (as applicable). The TMS includes frame structure and bullet/locking dogs for ROV and A-frame or Cursor

3.13**ROV system**

system which comprises of the ROV (3.12), the handling system, the surface control system and all associated equipment.

Note 1 to entry: For Annex C, ROV system is defined to consist of LARS (3.10) and ROV (3.12)

4 Abbreviations

For this document, the following abbreviations apply.

AUV	autonomous underwater vehicle
CAT	client acceptance test
CP	cathodic protection
DAF	dynamic amplification factor
FPROV	fall pipe ROV (remotely operated vehicle)
FSE	Regulations on safety when working in and operating electrical installations (Norwegian only: Forskrift om sikkerhet ved arbeid i og drift av elektriske anlegg)
GA	general arrangement
HD	high definition
HSE	health, safety and environment
Hmax	maximum wave height
Hs	significant wave height
HSE	health safety environment
IMCA	the International Marine Contractors Association
LARS	launch and recovery system
LC	load case
LP	low pressure
NDT	non-destructive testing

PA	public announcement
RAO	response amplitude operator
ROV	remotely operated vehicle
RS	recommended standard
SF	safety factor
SWL	safe working load
TMS	tether management system (top hat or cage)
Tz	wave period
VAC	volt alternating current

5 Remotely operated vehicle classification

5.1 Classification of ROV

Each ROV shall be assigned to one of the classes (I-VIII) as defined in sub-clause 5.2 to 5.10.

5.2 Class I – pure observation

These vehicles are fitted with ancillary equipment consisting of a camera, lights and (possibly) sonar only. They are primarily intended for pure observation tasks, but they can carry one additional sensor (such as a cathodic protection (CP) probe), as well as a second video camera. This type of ROV have a displacement between 10 and 50 kg.

5.3 Class II – observation with payload option

5.3.1 Class II A - observation class vehicles with payload option

These vehicles are capable of carrying additional sensors such as digital still colour cameras, cathodic protection (CP) measurement systems, additional video cameras and sonar systems. Class IIA vehicles are capable of operating without the loss of original function whilst carrying at least two (2) additional sensors and are not capable of conducting intervention type operations without major modification(s). This type of ROV have a displacement between 50 kg and 500 kg.

5.3.2 Class II B - observation class vehicles with light intervention, survey and construction capabilities

These vehicles are capable of carrying additional sensors such as digital still colour cameras, cathodic protection (CP) measurement systems, additional video cameras and sonar systems. Class IIB vehicles are capable of operating without the loss of original function whilst carrying at least two (2) additional sensors. Class IIB vehicles are capable of carrying light duty manipulators (see 9.4.8) and tooling skids so as to be able to perform light construction support, intervention, survey and inspection tasks. This type of ROV have a displacement between 500 kg and 2500 kg. This class of systems have typically a through frame lift capacity of approximately 200 kg.

5.4 Class III – work class vehicles

5.4.1 Introduction

Work class or Class III vehicles are specifically designed from the outset to be able to carry additional sensors, and tooling, over and above its standard suite of navigation and camera sensors. All Class III vehicles have a minimum of two (2) manipulators (see 9.4.8) permanently installed/fitted. All Class III vehicles have a multiplexing capability that allows additional sensors and tools to operate without being 'hard-wired' through the umbilical system or causing any loss of original functionality from those sensors and equipment that are fitted as standard. Additional sensors and tooling are carried either in/on the vehicle or, by virtue of the inclusion of a 'through frame lift' capability in an underslung skid or back-pack arrangement, implying that they are sufficiently large to be configured as such.

5.4.2 Class III A –standard work class vehicle

Class IIIA work class vehicles are a relatively compact solution and have a power rating of ≤ 100 kW, with an onboard payload of ≤ 200 kg and a through frame lift capacity of 1000 kg. This type of ROV have a displacement between 2400 kg and 3600 kg.

5.4.3 Class III B –advanced work class vehicle

A Class IIIB work class vehicle have a power rating of ≥ 100 kW, with an onboard payload of ≥ 200 kg and a through frame lift capability of ≥ 1000 kg (typically 3000 kg). This type of ROV have a displacement higher than 3400 kg.

5.5 Class IV – towed and bottom crawling vehicle

5.5.1 Class IV A- towed vehicles

Towed vehicles, e.g. the remotely operated towed vehicle (ROTV) or plough, are designed to be pulled through the water by a surface craft or winch. Although they need not have propulsive power, they may be capable of limited manoeuvrability and be outfitted with instrumentation/ sensors that can transmit data signals from the vehicle to the surface control station. In the case of the ROTV the tow cable may also be considered as the signal cable; whereas a plough is likely to be hauled across the seafloor using dedicated rigging and tow cables as a consequence of the forces involved. Signals may be transmitted by acoustic means or alternatively by means of a dedicated/lightweight sensor cable. Deployment of towed vehicles may incorporate the use of a LARS but may also be considered as 'very basic', i.e. released over the stern of the support vessel.

5.5.2 Class IV B- bottom crawling vehicles

Bottom-crawling vehicles are fitted with a track system to move across the seafloor but may also be considered as 'wheeled'. Some bottom crawling vehicles may be able to 'swim' limited distances and to accomplish this they can be outfitted with a variable ballast system that would allow the vehicle to be trimmed to be negatively buoyant at the seabed, i.e. exert a specific ground pressure. These vehicles can typically be very large, heavy and operate with significant onboard power, and may often be designed for one specific task, such as cable and/or flowline burial, but they may also be utilized for seabed mining activities. Class IV B vehicles can generally carry a full suite of cameras and sensors to perform their operations and therefore may draw heavily on Class III technologies.

5.6 Class V – prototype or development vehicles

Vehicles that are still being developed regarded as prototypes, i.e. one-off versions and special-purpose/single-purpose vehicles that do not fit into one of the other classes shall be assigned to Class V.

5.7 Class VI – autonomous underwater vehicles

5.7.1 Description

AUVs are designed not to be directly operated or connected via cable. The vehicle moves in pre-programmed mission routes. The vehicle may wirelessly communicate with a tracking surface vessel, usually only short status updates. The vehicles are primarily be intended for seabed survey tasks.

5.7.2 Class VI A- AUVs weighing ≤ 100 kg

Class VI A- AUVs weigh less than 100 kg, may be launched and recovered manually and have a depth rating of ≤ 100 msw.

5.7.3 Class VI B- AUVs weighing ≥ 100 kg

Class VI B- AUVs weigh more than 100 kg, may be launched and recovered by a mechanical LARS of some description and have a depth rating of up to 6000 msw.

5.8 Class VII – high speed survey vehicles

High speed Survey vehicles (SROV) are specifically designed from the outset to be fast, stable and quiet sensor carriers optimized for seabed mapping and pipeline inspection operations, capable of 3 knots or faster, whilst maintaining attitude and heading stability of ± 1 degree. Sensor payload may include, but not be limited to, inertial navigation systems, Doppler velocity logs, multiple still or video cameras, multibeam echo-sounders, sidescan sonars, sub-bottom profilers, depth sensors, lasers and pipe-tracking systems for buried pipelines. Additional sensors like contact or contactless CP and synthetic aperture sonars may also be utilized on this type of vehicle. The control system for a survey vehicle should support auto functions to maintain stability in heading, attitude and depth (optionally altitude). It should have sufficient power rating to maintain 3 knots forward propulsion with auto-depth and auto-attitude functions enabled. The control system should have an autopilot allowing the vehicle to navigate pre-planned routes automatically with minimum deviations.

5.9 Class VIII –fall pipe ROV

A FPROV are designed for rock-installation subsea and permanently installation onboard a vessel. As such it should be part of the production installation of a fall pipe vessel. The rock are transported to the seabed by a fall-pipe topside from the vessel and down to the FPROV, going through the FPROV itself. The FPROV's may be equipped with mechanical diverters or other equipment for precision installation of rock.

These FPROV's may be larger than Class III and connected to the vessel by more than one umbilical. The deployment of the FPROV is done by means of a fixed installation of winches and sheaves and not via a typical LARS as for free-flying ROV's.

The FPROV are equipped with a range of survey sensors for mapping the area, pre- and post-rock installation. The FPROV is not be free-flying and may therefore have very limited horizontal excursion range.

5.10 Emerging technologies

If an ROV is meant to reside for longer periods in water at or close to seabed (more resident) it should be designed to be more resilient to corrosion. The maintenance intervals and philosophy should also be adjusted accordingly.

Remote piloting from shore-based control room is also a tendency that will be more common in the future.

New technology for wireless communication in water can enable ROV's to operate without tether bringing along greater freedom, but also challenges. Due to this the ROV's should be equipped with batteries to enable tetherless manoeuvring.

Better sensors and increased computing power can also enable more autonomous features for piloting the ROV and/or manipulators during "flying" and interventions.

NOTE 1 One common term often used for these vehicles is Underwater Intervention Drones (UID).

NOTE 2 Information regarding wireless communications in water can be found through Subsea Wireless Group (SWiG). SWiG is an international oil and gas industry network promoting interoperability for subsea wireless communications (radio frequency, acoustic, free-space optic, inductive power, hybrid).

6 Administrative requirements

6.1 General

Contractor shall establish and maintain a quality management system in accordance with the latest edition of NS-EN ISO 9001.

Contractor shall utilise the system to continuously search for improvements to its processes with respect to both equipment and personnel. No activities shall start unless covered by appropriate procedures, plans or checklists. Furthermore, contractors shall establish and maintain matrixes for simple review by client e.g.:

- a) compliance to relevant regulations and standards;
- b) compliance to project specifications;
- c) compliance to personnel qualifications.

Contractor shall evaluate items of non-compliance. Qualified alternative solutions may be suggested. Contractor shall forward non-compliances to client for acceptance.

6.2 Responsibilities and authorities

An organogram shall be produced to outline reporting lines at the work-site and in the onshore organisation. Interfaces towards other work-site teams, i.e. marine crew on a vessel, shall be described.

Job descriptions shall be made for relevant onshore project personnel and for ROV personnel, detailing responsibilities and authorities.

6.3 Procedures

Procedures shall be based on recognised best practices and previous experience. Procedures shall be approved, and revision controlled under ROV contractor's standard routines. Standard Operating Procedures (SOP) shall be available to the crew together with site specific appendices describing both normal and emergency operations of all the equipment to be used.

6.4 Documentation

Contractor shall establish necessary routines to document that the quality system meets the requirements outlined in NS-EN ISO 9001. The documentation shall show enough data to ensure that quality standards and client requirements are met, according to Table 1.

Table 1 – Minimum documentation requirements

As a minimum, contractor shall ensure availability of updated editions of the following documents at the work site ^a	ROV system mob/ demobilisation ^b	Project mob/ demobilisation ^c	During operations
Mob/demobilisation plan, see 10.4.	Y	Y	N
List of services required from work-site, see 8.	Y	Y	N
Structured plan for system acceptance test, see 10.5.	Y	Y	N
Contractors project quality assurance (QA) manual/plan.	Y	Y	Y
Contractors HSE plan for the work-site.	Y	Y	Y
Organogram, see 6.2.	Y	Y	Y
Contractors' operational manuals, pertaining to relevant contract.	Y	Y	Y
Procedure for normal and emergency operation of the equipment, see 6.3.	Y	Y	Y
Procedure for maintenance of all equipment under the services, see 6.3, 6.6 and 10.1.	Y	Y	Y
Minimum list for spare parts, see 6.6.	Y	Y	Y
Inventory list of spares, see 6.6.	(Y)	(Y)	Y
Contractors contingency plan for the relevant contract, interfaced with clients plan for the relevant area.	Y	Y	Y
Procedures for all activities pertaining to the relevant contract .	Y	Y	Y
Relevant risk analysis, see 10.2.	Y	Y	Y
Log to document operational activities, see 10.3.	(Y)	(Y)	Y
Maintenance programmes and records for last 12 months, see 6.6.	(Y)	(Y)	Y
Personnel competency matrix for allocated personnel.	Y	Y	Y
Certificates for ROV system, see 6.6, 10.9, C.3 & C.4.	Y	(Y)	Y

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Key

Y	Required
(Y)	Recommended
N	Not required

- a With reference to 6.4
- b When new ROV spread is mobilised onto vessel/installation.
- c When new project specific equipment is mobilised onto vessel/installation.

6.5 Reporting

6.5.1 General reporting requirement

Contractors reporting of ROV operations shall be structured to provide the client with data to meet both regulatory and administration requirements in addition to internal requirements. The level of reporting requirements above standard shall be described in scope of work.

6.5.2 Contractors reporting responsibilities

6.5.2.1 Daily report

A report with a brief summary of the last 24 h events shall be handed over to the client representative the following day, or according to the contract, and should be signed by both parties.

Daily report should as a minimum include the following:

- a) date/reference to contract no/job no;
- b) name of installation/vessel;
- c) name of personnel performing the work;
- d) arrival/departure of personnel;
- e) time tagged activities and description of same;
- f) timetable giving summary of hours in water, hours on standby, hours of maintenance and breakdown;
- g) list of additional equipment;
- h) total working hours and reimbursable overtime; and
- i) a plan for the next 24 h.

6.5.2.2 Video log

During execution of the work, the crew should make a video log for all recorded work. The log shall track all significant issues and have real time reference. The original log shall follow the video recording and be handed over to client as described in the scope of work.

As a minimum, the video log shall contain the following:

- a) date of recording reference to contract no/job no;
- b) name of support vessel;
- c) reference to daily log and dive log;
- d) real time reference to the recording;
- e) description of recorded event;
- f) reference to first hand report on special events.

6.5.2.3 First hand report

The ROV crew shall prepare first hand reports on special events as requested by client. These reports shall have a detailed description of the event, including sketches with possible measurements and supported by video recordings or pictures.

6.5.2.4 Maintenance report

Maintenance work performed shall be reported according to the established maintenance program. A copy of this report shall be made available to the client on request.

6.5.2.5 Equipment failure report

Contractor shall have an established system for registration of equipment failures in accordance with NS-EN ISO 9001.

6.5.2.6 Reporting of undesired events

Contractor shall have a system for reporting of undesired events such as accidents, non-conformances and near-accidents with potential for damage to personnel and/or equipment. The system shall meet requirements in relevant legislation and industry standards.

6.5.2.7 Experience reporting and transfer of experience

There shall be a system in place to ensure that new experience is gathered and used to continuously improve the operational procedures, the equipment, the maintenance procedures and/or the onboard spares lists.

By the turn of the year or 30 days after the operation, the contractor should produce an experience report that summaries and evaluates the operation, procedures and equipment used. Records any incidents, non-conformances, equipment breakdowns, Management of Change Process, improvement suggestions and lessons learned.

6.6 Maintenance system

6.6.1 General

A system for preventive maintenance shall be established, covering critical components comprising the ROV system. Historical data shall be logged to collect operational experience on critical components in order to ensure continuous improvements.

The maintenance program shall be based on manufacturer's recommendations and/or own experience. Test conditions and intervals for components and the facility in general, shall be specified. At regular intervals, contractor shall review the maintenance system in accordance with NS-EN ISO 9001.

All maintenance shall be performed according to the maintenance plan and recorded. Last year's maintenance records for the components comprising the system shall be available onboard.

As a part of the maintenance system, contractor shall establish and maintain an inventory and equipment database. This database shall clearly define the minimum spare parts and critical spare parts required for the system. The spare part list shall be defined based on failure mode and effect analysis and/or operational experience. The stock level shall be sufficient to support the system for minimum 30 days of normal operation.