NORSOK STANDARD U-102

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Remotely operated vehicle (ROV) services

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace client specifications and serve as references in the authorities regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standards will be withdrawn.

The NORSOK standards are developed according to the consensus principle, generally applicable standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Manufacturing Industries). NORSOK standards are administered and published by NTS (Norwegian Technology Centre).

Annex A is for information only. Annex B forms a normative part of this NORSOK standard.

Introduction

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

This NORSOK standard has been produced to establish a single common standard for ROV operations.

1 Scope

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

2 Normative and informative references

The following standards include provisions and guidelines, which, through reference in this text, constitute provisions and guidelines of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet or exceed the requirements and guidelines of the standards referenced below.

2.1 Normative references

AODC 035,	*Code of practice for the safe use of electricity underwater.*
IMCA R005,	*High Voltage Equipment - Safety procedures for working on remotely operated vehicles*
ISO 9001:2000,	*Series quality systems model for quality assurance in design, development, production, installation and servicing.*
ISO 13628-1:1999,	*Petroleum and natural gas industries – Design and operation of subsea production systems – Part 1: General requirements and recommendations.*
NORSOK U-100,	*Manned underwater operations.*

2.2 Informative references

IMCA R 14/01,	*Competence Assurance & Assessment Scheme*
ISO 13628-8,	*Petroleum and natural gas industries – Design and operation of subsea production systems – Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

3 Terms, definitions and abbreviations

For the purposes of this NORSOK standard, the following terms, definitions and abbreviations apply.

3.1 Terms and definitions

3.1.1
shall
verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.2
should
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

3.1.3
may
verbal form used to indicate a course of action permissible within the limits of the standard

3.1.4
can
verbal form used for statements of possibility and capability, whether material, physical or casual

3.1.5
client
purchaser of ROV services

3.1.6
accident
event which causes personal injury, fire, environmental/material damage or loss of production

3.1.7
contractor
the same as contractor group

3.1.8
contractor group
contractor, his affiliated 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

3.1.9
ROV system
system which comprises the ROV, the handling system, the surface control system and all associated equipment

3.1.10
ROV
common term for ROV, AUV, UUV/UUUV and similar equipment, where ROV is equipment used in water with an ability to observe the surroundings and positioning itself remote controlled from the surface through a cable

NOTE AUV is equipment used in water with an ability to positioning itself without interference from surface control. UUV/UUUV is equipment used in water with an ability to positioning itself without cable to the surface.

3.1.11
lifting appliances
any part of load bearing equipment used in conjunction with ROV
systems equipment for lifting/handling

3.1.12
high voltage
voltage values above 999 V

3.2 Abbreviations

AC	alternating current
AODC	Association of Offshore Diving Contractors (now part of IMCA, and also named International Association of Underwater Engineering Contractors)
AUV	autonomous underwater vehicle
CCD	charged couple device
CD	compact disc
CP	cathodic protection
DC	direct current
DVD	digital versatile disc
HES	health, environment and safety
IMCA	The International Marine Contractors Association
UfD	Utdanning- og forskningsdepartementet (Ministry of Education and Research)
LP	low pressure
NTS	Norsk Teknologisenter (Norwegian Technology Centre)
QA	quality assurance
ROV	remotely operated vehicle
TMS	tether management system
TOC	top of backfill cover
TOP	top of pipe
UUV	unmanned underwater vehicle
UUUV	unmanned untethered underwater vehicle
WLL	work load limit

4 Remotely operated vehicle (ROV) classification

4.1 Class I – Pure observation

Pure observation vehicles are physically limited to video observation. Generally they are small vehicles fitted with video camera, lights and thrusters. They cannot undertake any other task without considerable modification.

4.2 Class II – Observation with payload option

Vehicles capable of carrying additional sensors such as still colour cameras, cathodic protection measurement systems, additional video cameras and sonar systems. Class II vehicles should be capable of operating without loss of original function while carrying at least two additional sensors.

4.3 Class III – Work class vehicles

Vehicles large enough to carry additional sensors and/or manipulators. Class III vehicles commonly have a multiplexing capability that allows additional sensors and tools to operate without being “hardwired” through the umbilical system. These vehicles are larger and more powerful than Classes I and II.

Class III A – Workclass vehicles < 100 Hp
Class III B – Workclass vehicles 100 Hp to 150 Hp
Class III C – Workclass vehicles >150 Hp

4.4 Class IV – Seabed-working vehicles

Seabed-working vehicles manoeuvre on the seabed by a wheel or belt traction system, by thruster propellers or water jet power, or by combinations of any of these propulsion methods.

Class IV vehicles are typically much larger and heavier than Class III work class vehicles, and are configured for special purpose tasks. Such tasks typically include cable and pipeline trenching, excavation, dredging and other remotely operated seabed construction work.

4.5 Class V – Prototype or development vehicles

Vehicles in this class include those being developed and those regarded as prototypes. Special-purpose vehicles that do not fit into one of the other classes are also assigned to Class V. AUV is currently assigned to Class V.

5 Administrative requirements

5.1 General

Contractor shall establish and maintain a quality management system in accordance with ISO 9001:2000. Contractor shall utilise the system to continuously search for improvements to its processes both with respect to 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 such as:

- compliance to relevant regulations and standards;
- compliance to project specifications;
- 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.

5.2 Documentation

Contractor shall establish necessary routines to document that the quality system meets the requirements outlined in ISO 9001:2000, 4.2.2. The documentation requirements shall aim at collecting data to ensure that quality standards and client requirements are met.

As a minimum, the contractor shall define, document and make available prior to mobilisation, the following:

- mobilisation plan;

- list of services required from work-site;
- structured plan for system acceptance test;
- procedure for normal and emergency operation of the equipment;
- procedure for maintenance of all equipment under the services;
- minimum list for spare parts;
- personnel competency matrix for allocated personnel.

5.3 Document availability

As a minimum, contractor shall ensure availability of updated editions of the following documents on the work site:

- contractors project QA manual/plan;
- contractors HES plan for the work-site;
- contractors operational manuals, pertaining to relevant contract;
- contractors contingency plan for the relevant contract, interfaced with clients plan for the relevant area;
- procedures for all activities pertaining to the relevant contract;
- relevant risk analysis;
- log to document operational activities;
- maintenance programmes and records for last 12 months.

5.4 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.

5.5 Maintenance system

5.5.1 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. Contractor shall on regular interval review the maintenance system in order to meet the requirements in ISO 9001:2000, 8.5.

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 required for the system. The spare part list shall be defined based on failure mode and effect analysis. The stock level shall be sufficient to support the system for minimum 30 days of normal operation.

The maintenance program shall include a system for updating of certificates, covering all ROV related equipment, systems and machinery.

5.5.2 Time for maintenance

Contracts shall specify time allowed for scheduled maintenance and the maintenance intervals as required by the maintenance program relevant for the specific system and the type of activity at hand.

Contracts shall further define the functionality requirement relevant for the system as follows:

- ROV system available on request;
  Maintenance and change outs to be agreed between client and ROV supplier at times convenient with respect to the activity.

- ROV system in water at all times minus maintenance intervals;
  Maintenance and change outs to be performed in accordance with agreed intervals and time allowances.

- ROV system in water 24 h per day.
  Requires back-up system at site. The status of the back-up system is irrelevant as long as it is ready when needed for change out with main system.

Downtime in excess of what is allowed and agreed (see above) shall be considered as breakdown.

5.6 Reporting

5.6.1 General

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.

5.6.2 Contractors reporting responsibilities

5.6.2.1 Daily report

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

Daily report should as a minimum include the following:
- date /reference to contract no/job no;
- name of installation/vessel;
- name of personnel performing the work;
- arrival/departure of personnel
- time tagged activities and description of same;
- time table giving summary of hours in water, hours on standby, hours of maintenance and breakdown;
- list of additional equipment
- total working hours and reimbursable overtime
- a plan for the next 24 h.

5.6.2.2 Video log

During execution of the work, the crew shall 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 contend the following:
- date of recording reference to contract no/job no;
- name of support vessel;
- reference to daily log and dive log;
- real time reference to the tape;
- description of recorded event;
- reference to first hand report on special events.

5.6.2.3 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.

5.6.2.4 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.

5.6.2.5 Equipment failure

Contractor shall have an established system for registration of equipment failures. This system shall meet the requirements in ISO 9001:2000, clause 8.

5.6.2.6 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. See clause 10.

5.6.2.7 Experience reporting

By the turn of the year or 30 days after the operation, the contractor should produce an experience report that evaluates the operation, procedures and equipment used.

6 Personnel qualification requirements

6.1 General

This clause of the standard addresses the personnel and crew requirements. The personnel operating ROV systems require training in a wide range of specialised fields.
The requirements below are set out to ensure that the operations are executed in a safe and efficient manner.

The personnel qualification requirements will be specified
- as crew qualification requirements,
- as qualification requirements for the individual positions.

6.2 Crew requirements

6.2.1 Manning level

The system manning level shall be based on the planned tasks and duties that are required to perform the work.

The manning levels for basic ROV operations are:

	12 h	24 h
Class I system	2	4
Class II system	2	4
Class III systems	3	6
Class IV systems (trencher)	4	8

Furthermore, job specific requirements may demand additional crew members due to
- requirements for maintenance and repair of additional tooling packages,
- specialised personnel for operating temporary sensors and equipment,
- overall offshore management of ROV operations,
- maintenance of eventual stand-by systems.

Sufficient, qualified personnel shall be allocated for scheduled maintenance work that shall take place outside the operational team's normal working hours.

6.2.2 Crew qualification requirements

The ROV crew in general shall as a minimum be able to maintain and operate the system.
When planning for a specific project, the overall crew competence should be obtained by proper planning and training.

6.3 Remotely operated vehicle (ROV) personnel requirements

6.3.1 General requirements

Due to the nature and complexity of ROV systems, the personnel operating and maintaining these systems require a broad based training to understand the various parts of the systems.

As a basis, the ROV personnel shall have a formal technical education within one of the following areas:

- electronics;
- automations;
- remote systems;
- hydraulics;
- electric.

NOTE In addition reference is made to IMCA R 14/01 "*Competence Assurance & Assessment Scheme* ". Furthermore, this paragraph will be subject to revision after the enforcement of the coming formal Fjernstyrte undervannsoperasjoner (remote underwater operations) -Education/Graduate Diploma, effectuated by Oljeindustriens landsforening (The Norwegian Oil Industry Association) (OLF) and Utdannings- og forskningsdepartementet (Ministry of Education and Research) (UfD).

6.3.2 Personnel category requirements

6.3.2.1 Remotely operated vehicle (ROV) superintendent

The ROV superintendent shall as a minimum have the same qualifications and experience as ROV supervisor in addition to the following:

- experience in overall planning and management of offshore operations;
- two years as an ROV supervisor.

6.3.2.2 Remotely operated vehicle (ROV) supervisor

The ROV supervisor shall as a minimum have the same qualifications and experience as ROV pilot in addition to the following:

- formal administrative/leadership management training;
- training in first line of contract management;
- be fully conversant with all applicable legislation at the work-site;
- have training in first hand and task reporting;
- have a minimum of 3 years experience with relevant ROV operations.

6.3.2.3 Remotely operated vehicle (ROV) pilot

The ROV pilot shall as a minimum have the same qualifications and experience as ROV trainee in addition to the following:

- training in particular additional equipment planned for the work;
- be fully conversant with project manual and all applicable procedures for the work;
- have demonstrated knowledge in the type of intervention tasks planned;
- capable of keeping area views and guide other combined operations;
- minimum 200 h experience with relevant ROV operations;
- have training in task reporting;
- have knowledge in the type of intervention tasks planned;
- demonstrate dextrous use of master/slave manipulator;
- formal training in operation and maintenance of system in question;
- training in maintenance and repair of particular additional equipment planned for the work;
- have a documented knowledge of maintenance, repair, mobilisation and testing of ROV systems.

6.3.2.4 Remotely operated vehicle (ROV) trainee

The ROV trainee shall as a minimum have qualifications in accordance with 6.3.1 and have a agreed skill development plan, including

- formal training in operation and maintenance of system in question,
- training in maintenance and repair of particular additional equipment planned for the work,
- training in the use of master / slave manipulator.

NOTE The composition of a crew should make way for the inclusion of a trainee. Tthis in order to enable training of inexperienced personnel and recruitment of new competence to the ROV industry.

6.4 Personnel qualifications – High voltage system

The majority of ROV systems have a power distribution system that operates with voltage above 999 V. In order to maintain these systems the personnel shall have undertaken training in high voltage safety procedures and be familiarised with the protection gear for system in question.

Personnel responsible for maintenance and repair of high voltage system shall, as a minimum be qualified as follows:

- qualified as ships electrician, electrician group A or L, automation technician or equivalent;
- additional recognised training in maintaining high voltage systems in question;
- courses held by the ROV high voltage equipment manufacturer;
- be familiar with AODC 035 and IMCA R005.

6.5 Personnel qualifications – Operation of handling systems

In conjunction with operation of ROV systems, personnel operating the handling system shall have accomplish formal training in use of such systems and have understanding of the limitations for such systems. The training shall cover all safety aspects of lifting operations and give background for daily inspection of the lifting equipment in question.

7 Interface requirements

7.1 Work site requirements

The work site (i.e. vessel, barge, installation or other) shall constitute a stable work platform from where the operations can be performed safely and efficiently.
The contract shall define and allow for sufficient space and access to required facilities, such as means of communication, offices, conference rooms, copying machines etc.

Contractor's personnel shall be allowed living conditions and catering that is suitable for the actual rotation schedules and working hours required by the contract. Cabin standards and catering services shall as a minimum be in accordance with relevant legislation and shall not be inferior to the standard relevant in the geographical area where the operations are going to take place.

Contractors work-site facilities shall be agreed and described in the contract.

7.2 Remotely operated vehicle (ROV) system interface requirements

The interface between ROV system and support vessel/installation is defined as critical for efficient mobilisation and use of ROV systems. These interfaces should be defined prior to issue scope of work to the contractor. All interfaces shall be addressed and agreed between client and contractor prior to mobilising equipment to site.

Typical interfaces/issues are

a) weight of each unit shall be within the deck loading limit at the installation site. The weight of all major components shall be verified and registered prior to mobilisation,
b) sufficient clean electric power available and terminated in J-box at installation site,
c) connection for signal from hydro acoustic system available at installation site,
d) connection point for communication,
e) connection point for data transmission,
f) connection point for video distribution,
g) easy and safe access between control station and launch site,
h) launch position free of obstructions,
i) motion characteristic for launch area,
j) safe distance between launch position and vessel thruster propellers,
k) outlet of fresh water to be used for wash down of the system,
l) possibility of protected area for maintenance work,
m) system deck area shall be kept tidy and free for hazards,
n) all hoses on deck shall be secured and protected,
o) zone II interface requirements (if required),
p) interface requirements for company provided item.

8 Technical requirements

8.1 General

This clause specifies the minimum technical requirements for ROV systems in the various classes, measurement requirements and units to be used.

A table for definition of client's ROV system requirements is included in Annex B.This table is based on the minimum requirements outlined in the standard for the relevant ROV classes, and shall be used as a description of the clients minimum and additional requirements and the contractors compliance to this. Also see ISO 13628-8.

8.2 ROV Class I – Pure observation vehicles

8.2.1 Operational depth

Maximum operational depth shall be specified. The ROV system shall satisfy all operational depth requirements. Length of umbilical shall be appropriate to the operational depth, included extra length for re-termination.

8.2.2 Buoyancy

Buoyancy shall ensure stability of the vehicle with neutral trim.

8.2.3 Ability to move in the horizontal and vertical plane.

The ability to move in the horizontal and vertical plane is the most important performance criteria.
Speed shall be given in m/s for forward, backward, lateral and vertical directions.
Speed testing shall be performed with standard equipment installed.
Speed measurement shall be carried out at a relevant depth.
Verification of speed in horizontal plane can be performed by using vessel positioning system, or measured distance.

If required, speed can be verified as follows:

Procedure using vessel positioning system:
- the average speed shall be measured moving towards the current and with the current;
- the ROV shall be given 5 m to accelerate up to speed;
- the measurement shall be over minimum 30 m in order to reduce influence of distance measurement accuracy;
- average of minimum two measurement to be used as the achieved speed of the ROV.

Procedure using measured distance:
- the distance shall meet a known length, i.e. quay side, subsea structure, pipeline;
- the ROV shall be given 5 m to accelerate up to speed;
- the measurement shall be over minimum 10 m;
- the current shall be taken into account; preferably the measurement shall be performed moving towards and against current.

Verification of speed in vertical plane shall be measured using the ROV depth gauge over a minimum of 20 m. The ROV shall be given 5 m to accelerate up to speed.Average of minimum two measurement to be used as the achieved speed of the ROV.

8.2.4 Cameras and lights

8.2.4.1 General

The cameras and lights constitute the viewing system. Acceptance criteria for the viewing system shall be as follows:
- interference-free pictures;
- the video system shall be able to record a minimum of 400 lines;

The quality of the viewing system can be verified in accordance with the following:
- the picture quality shall be tested in water using a test sheet with artificial light;
- the test sheet shall be made to meet the requirements in ISO-13628-1:1999, 5.5.11 (typical test sheets exist on the internet using key words as video resolution chart or test pattern).

The cameras and lights are specified as listed below.

Standard outfit of cameras shall include
- 1 ea. low light navigation camera,
- 1 ea. colour CCD camera.

8.2.4.2 Low light navigation camera

The camera is used primary for navigation. The camera is placed in front of the vehicle and shall provide high quality images enabling safe navigation with a wide angle view over long distances.

Low light cameras shall satisfy the following technical requirements:
- minimum light sensitivity: 3 $x10^{-2}$ lux at face plate and 3 $x10^{-1}$ lux at scene;
- horizontal resolution > 400 lines;
- field of view minimum 60 degrees diagonal;
- depth of focus 150 mm to infinity.

8.2.4.3 Charged couple device (CCD) colour camera

CCD colour camera is primarily used for inspection. The camera shall provide high inspection quality images at typical inspection ranges 0,2 m to 2 m generally with good quality lighting, with zoom and focus capability for optimum performance, and satisfy the following requirements:
- sensitivity 1 lux;
- extended shuttered sensitivity 0,1 lux;
- horizontal resolution > 400 lines.

8.2.4.4 Lights

The light system

- shall be designed to give optimum and even illumination of areas viewed through the camera lenses,
- shall preferably have possibility for both spot and flood lighting,
- shall have variable intensity. The lights shall be distributed on minimum two independent circuits.

8.2.5 Instrumentation

Following instruments shall be included:
- depth gauge (with accuracy specified both for full range and relative to the depth variations);
- compass.

8.2.6 Auto functions

The following auto functions shall be available:
- auto depth;
- auto heading.

8.2.7 Transponders

The observation ROV shall be equipped with a mini transponder preferably continuously charged from ROV, and if relevant compatible with system onboard the platform/vessel for navigational purposes and emergency recovery.

8.3 ROV Class II – Observation vehicles with payload option

8.3.1 General

Requirements as for ROV Class I, with additions specified in 8.3.2 to 8.3.6.

8.3.2 Buoyancy

The buoyancy elements shall be sized to give sufficient buoyancy for the vehicle with standard and additional equipment.

8.3.3 Cameras and lights

It shall as a minimum be possible to view two cameras simultaneously.

8.3.4 Sonar

8.3.4.1 General

Sonars shall be specified for the work to be performed.
Testing of the different sonar types shall be performed by installing a target of specified size, to be identified at the maximum range as specified in the scope of work.

Sonars can be divided into three groups, see 8.3.4.2 to 8.3.4.4.

8.3.4.2 Type 1 - Obstacle avoidance/navigation sonar

Sonar normally used for construction and drill support.
Typically running at low frequency 325 kHz giving longer range and high scanning rate. Typical verification can be to find a 19 mm wire deployed at 20 m from the ROV

8.3.4.3 Type 2 - Sonar used for measuring purposes

Sonar normally used for construction and survey.
Sonars can be used for measuring distances. Such sonars will have a different scanning frequency (i.e. typically 625 kHz or higher) and lower scanning rate.

Typical test will be to measure a given distance between two points.

Typical performance is as follows:

- minimum detection range of mid water target of 20 db at 325 kHz 130 m;
- minimum detection range of mid water target of 20 db at 675 kHz 40 m.

8.3.4.4 Type 3 – Side scanning sonar

Mostly used for survey work and mapping of areas. This type of sonar have high update rate and good resolution. Same test procedure as for measuring sonar.

8.3.5 Minimum of plug-in connection points for additional equipment

8.3.5.1 Electrical

- 12, 24 and/or 250 VDC; 5 A
- 110 and/or 220 VAC; 1 A

8.3.5.2 Signal

1 quad or 2 data channels through optical fiber (typically RS 232/485)

8.3.5.3 Video

1 x video connections for additional cameras
It shall as a minimum be possible to view two cameras simultaneously.

8.3.6 Transponders

See 8.2.7

8.4 ROV Class III – Work class vehicles

8.4.1 Operational depth

Maximum operational depth shall be specified. The ROV system shall satisfy all operational depth requirements. Length of umbilical shall be appropriate to the operational depth, included extra length for re-termination.

8.4.2 Buoyancy/ballast

The buoyancy elements shall be sized and configured to give sufficient buoyancy and stability for the vehicle with standard and additional equipment.

8.4.3 Ability to move in the horizontal and vertical plane

The ability to move in the horizontal and vertical plane is the most important performance criteria.
Speed shall be given in m/s for the following directions: forward, backward, lateral and vertical.
Speed testing shall be performed with standard equipment installed.
Speed measurement shall be carried out at a relevant depth.
Verification of speed in horizontal plane can be performed by using vessel positioning system, or measured distance.

If required, speed can be verified as follows:

Procedure using vessel positioning system:
- the average speed shall be measured moving towards current and with current;
- the ROV shall be given 5 m to accelerate up to speed;
- the measurement shall be over minimum 30 m in order to reduce influence of distance measurement accuracy;
- average of minimum two measurement to be used as the achieved speed of the ROV.

Procedure using measured distance:
- the distance shall meet a known length, i.e. quay side, subsea structure, pipeline;
- the ROV shall be given 5 m to accelerate up to speed;
- the measurement shall be over minimum 10 m;
- the current shall be taken into account; preferably the measurement shall be performed moving towards and against current.

Verification of speed in vertical plane shall be measured using the ROV depth gauge over a minimum of 20 m, The ROV shall be given 5 m to accelerate up to speed.
Average of minimum two measurement to be used as the achieved speed of the ROV.

If force measurements are required, the following guidance shall be used.
Force shall be given in Newton (N) for forward, backward, lateral and vertical directions. The test shall be performed with standard equipment installed.
Force measurement shall be carried out with calibrated equipment and at a specified depth. The measurements will be relevant for test depth and deeper.
Verification shall be measured using a calibrated force measuring device. Typically mechanical load cell connected to a subsea structure, i.e. clumpweight.

The measurements shall include the x, y, z planes.

8.4.4 Electrical or hydraulic power

The overall power available on the vehicle shall be given in watt (W), as input or output effect (kW).
Maximum available power for propulsion and tooling shall be separately given in W.

All hydraulic circuits shall be measured in pressure (bar) and flow (l/min).

8.4.5 Cameras and lights

8.4.5.1 General

The cameras and lights constitute the viewing system. Acceptance criteria for the viewing system shall be as follows:

- interference-free pictures;
- the video system shall be able to record a minimum of 400 lines.

The quality of the viewing system can be verified in accordance with the following:

- the picture quality shall be tested in water using a test sheet with artificial light;
- the test sheet shall be made to meet the requirements set out in ISO-13628-1:1999, 5.5.11 (typical test sheets exist on the internet using key words as video resolution chart or test pattern).

The cameras and lights are specified as listed below.

Standard outfit of cameras shall include

- 1 ea. low light navigation camera,
- 1 ea. colour CCD camera.

8.4.5.2 Low light navigation camera

The camera is used primary for navigation. The camera is placed in front of the vehicle and shall provide high quality images enabling safe navigation with a wide angle view over long distances.

Low light cameras shall satisfy following technical requirements:

- minimum light sensitivity: 3 $x10^{-2}$ lux at face plate and 3 $x10^{-1}$ lux at scene;
- horizontal resolution > 400 lines;
- field of view minimum 60 degrees diagonal;
- depth of focus 150 mm to infinity.

8.4.5.3 Charged couple device (CCD) colour camera

CCD colour camera is used primary for inspection.
The camera is placed in front of the vehicle and shall
provide high inspection quality images at typical inspection ranges 0,2 m to 2 m generally with good quality lighting, with zoom and focus capability for optimum performance.

The cameras shall satisfy the following technical requirements:

- sensitivity 1 lux;
- extended shuttered sensitivity 0,1 lux;
- horizontal resolution > 400 lines.

8.4.5.4 Lights

The light system

- shall be designed to give optimum and even illumination of areas viewed through the camera lenses,
- shall preferably have possibility for both spot and flood lighting,
- shall have variable intensity. The lights shall be distributed on minimum two independent circuits.

8.4.6 Manipulators

8.4.6.1 General

The vehicle shall be equipped with at least two manipulators. A grabber manipulator installed at the port side and a working manipulator at the starboard side.

8.4.6.2 Grabber manipulator

The grabber shall have a grip capacity of 0 mm to 200 mm and satisfy the following requirements:

- minimum five functions;
- minimum out reach 1 300 mm;
- lift capacity (full out reach) 100 kg.

8.4.6.3 Working manipulator

The working manipulator shall have master/slave control with

- minimum seven functions,
- minimum out reach 1 600 mm,
- lift capacity (full out reach) 60 kg,
- minimum wrist torque 70 Nm.

Type of claw(s) to be specified in Annex B.

8.4.7 Sonar

8.4.7.1 General

Sonars shall be specified for the work to be performed.
If required testing of the different sonar types shall be performed by installing a target of specified size, to be identified at the maximum range as specified in the scope of work.

Sonars can be divided into three groups, see 8.4.7.2 to 8.4.7.4.

8.4.7.2 Type 1 - Obstacle avoidance/navigation sonar

Sonar normally used for construction and drill support.
Typically running at low frequency 325 kHz giving longer range and high scanning rate. Typical verification can be to find a 19 mm wire deployed at 20 m from the ROV.

8.4.7.3 Type 2 - Sonar used for measuring purposes

Sonar normally used for construction and survey.
Sonars can be used for measuring distances. Such sonars will have a different frequency (i.e. typically 625 kHz or higher) and lower scanning rate.

Typical test will be to measure a given distance between two points;

Typical performance:

- minimum detection range of mid water target of 20 db at 325 kHz 130 m;
- minimum detection range of mid water target of 20 db at 675 kHz 40 m.

8.4.7.4 Type 3 - Side scanning sonar

Mostly used for survey work and seabed mapping. This type of sonar have high update rate and good resolution. The test requirement shall be the same as for a measuring sonar.

8.4.8 Instrumentation

The following instruments shall be included:

- depth gauge (the accuracy shall be specified both for full range and relative to the depth variations);
- compass;
  - for general navigation - magnetic compass for navigation and orientation;
  - for survey and accurate navigation - north seeking gyro or equivalent. Update rate and accuracy is to be specified.

8.4.9 Auto functions

The following auto functions shall be available:

- auto depth;
- auto heading.

8.4.10 Minimum of plug-in connection points for additional equipment

8.4.10.1 Electrical

- 12, 24 and/or 250 VDC; 5 A
- 110 and/or 220 VAC; 1 A

8.4.10.2 Signal

1 quad or 2 data channels through optical fiber (typically RS 232/485).

8.4.10.3 Video

1 x video connections for additional cameras.
It shall as a minimum be possible to view three cameras simultaneously.

8.4.10.4 Hydraulics

3 x 2 way low flow valves.
Additional high flow hydraulic output (typical flow is 30 l/min).

8.4.11 Transponders

The work ROV shall be equipped with a mini transponder preferably continuously charged from the ROV, and if relevant compatible with system onboard the platform/vessel for navigational purposes and emergency recovery.

8.5 ROV Class IV - Seabed – working vehicles

8.5.1 General

All requirements in this NORSOK standard, of relevance to seabed-working vehicles, shall apply.

In addition to general requirements concerning QA, HES, administration, reporting, personnel, maintenance and ROV system interfaces, relevant specific technical requirements for parameters common to ROV systems shall apply.

Such common parameters typically include

- operating depth, buoyancy/ballast, speed, bollard pull etc. as relevant,
- handling system,
- control room and umbilical system,
- cameras and lights,
- instrumentation, sonar, video and signals.

Specific requirements over and above those specified above depend upon the intended function of the seabed-working vehicle, and shall be stipulated on a case-by-case or project-specific basis.

8.5.2 Instrumentation

The trenching vehicle shall include the following standard instrumentation as a minimum:

- cameras and lights forward and aft for navigation and condition monitoring of trench as well as critical vehicle functions;
- sonar forward and aft for long range navigation and vehicle docking on pipe;
- pipe tracker (optional) for vehicle docking on pipe and track position monitoring;
- pitch and roll sensors;
- altitude and depth sensors;
- proximity sensors or equivalent to verify correct vehicle straddling on pipe forward and aft;
- gyro compass;
- transponder and responder;
- speed odometer or equivalent for precise indication of speed along pipe;
- jetting sword depth, width and angle indicators (if applicable).

The system shall enable continuous transmittal of real time data (in a string format to be agreed) for all sensors to an online survey suite for further logging and processing. Conversely, real time position data for trenching vehicle and support vessel shall be made available to the trenching vehicle operators, preferably in the form of a helmsman or navigation display where also geographical field maps and seabed items of interest are graphically displayed.

Video presentation shall include overlay text displaying critical data such as pipeline identification, kilometre point (kp), date and time, sword depth, vehicle speed and heading, vehicle pitch and roll. 24 h black box video records shall be maintained throughout.

Note Trenching provides guidelines for specifications of trench dimensions, backfill and soil characteristics, see Annex A.

8.6 Tether management system (TMS)

8.6.1 General

The TMS shall be capable of lifting the ROV with additional load of tooling packages up to 1 metric ton at 3G as a minimum. The system shall have docking facility for the vehicle to safely dock with the TMS in weather conditions agreed in contract.

8.6.2 Work load limit (WLL)

The TMS shall have a WLL that correspond with the weight of the vehicle including its standard equipment and additional equipment as specified in the contract.

8.6.3 Length of tether management system (TMS) tether

The TMS shall have a tether length in accordance with agreed scope of work.

8.7 Umbilical/tether cables

8.7.1 Umbilical

The umbilical shall be designed and certified in accordance with applicable regulations for lifting appliances. The minimum length shall be based on the water depth as stated in the agreed scope of work. The umbilical shall withstand dynamic loads and environmental impacts, i.e. deep water operations. The umbilical shall in addition to the vehicle requirements be capable of additional signal and power transfer as required in the scope of work.

8.7.2 Tether

The tether shall be designed to limit mechanical damage during normal operations. Bending characteristics/ tether water weight shall not hamper the ROV during its operation. The tether shall in addition to the vehicle requirements be capable of additional signal and power transfer as required in the scope of work.

8.8 Handling system

8.8.1 General

The handling system shall

- be designed and constructed to meet regulatory requirements and standards applicable for the work sites specified in contract,
- include a crane, A-frame or similar for safe launch and recovery of the ROV.

8.8.2 Handling system work load limit (WLL)

The WLL of the handling system shall cover the weight of the ROV with TMS and additional equipment as specified in the agreed scope of work.

8.8.3 Launching criteria

The handling system shall meet launching and recovery criteria agreed in contract, see interface criteria in 7.2 i).

8.8.4 Umbilical winch

The umbilical winch is part of the handling system and shall meet both structural and electrical certification requirements that apply to the work site stated in the contract. The umbilical winch shall have a line speed of minimum 30 m/min.

8.9 Control facilities

8.9.1 Control room

The equipment in the control room shall be designed and installed to withstand shaking and shock which will be imposed during transportation, handling, installation and operation.

The ROV control room is the operation room for ROV systems and shall be considered a workplace where personnel are present over longer periods.

Even though that the environment is regulated through regulations it is important to emphasise the following:

- the noise level in the control room shall, as a minimum, conform with current legislation and further minimised as much as possible;
- the ROV control room shall be equipped to enable a stable climate control both to keep the temperature down during operations and to maintain a dry atmosphere during non operational periods. The outlet from an air-conditioning unit shall not be directed directly towards the ROV operator;
- the lights shall be dimmable. The positions of the lights shall be considered to minimise reflections in the ROV operator's computer and video monitors.

8.9.2 Remotely operated vehicle (ROV) operator station

The ROV operator station shall be designed to minimise the physical stress. There shall be adjustment possibilities to enable good end ergonomic correct working position for each individual ROV operator.

Considerations such as radiation from video- and computer monitors and quality of monitors shall be taken into account in the selection of the displays.

8.9.3 Communication

The following communication systems shall be available:

- open line communication system between ROV control and launch and recovery system, bridge and other entities directly involved in the operation;
- polyamide speaker;
- telephone system.

8.9.4 Video

The following video systems shall be available:

- two video recorders;
- video overlay and annotation unit to overlay and annotate the video recording with information such as time, date, ROV heading, ROV depth, client logo, contractors logo and information about the work;
- view, four camera pictures simultaneously. If the system is equipped with more than four cameras there shall be a video switcher option;
- one video signal amplifier to enable video distribution to other locations onboard the ROV platform/ vessel.

8.9.5 Condition monitoring

The ROV operator station shall have provision of status monitoring during operation, including, but not limited to

- earth fault detection and shut down system on high voltage,
- earth fault detection system on ROV low voltage system,
- electric/hydraulic motor voltage and current,
- hydraulic pressure,
- hours run indicator,
- ROV turns counter,
- depth readout,
- water ingress alarms,
- volume in the electric compensation system,
- volume and temperature in the hydraulic compensation system,
- failure alarm system,
- diagnostic system.

9 Operational requirements

9.1 Planning and execution

9.1.1 General requirements

Detailed operational procedures covering planning, preparations and execution of the operation shall be available to personnel involved.

Documentation required for safe execution of the operation, including relevant rules and regulations shall be updated and easily accessible at the work-site.

9.1.2 Risk assessment

Risk assessments shall be actively used in preparations for the operation and shall be performed in accordance with recognized methods. Prior to shift changes, tool box meeting shall be held in order to ensure that the ongoing shift is made aware of the situation at the work site, status of the work, any incidents on the previous shift and any other information with relevance to the safe and efficient performance of the work.

9.1.3 Operational log

An operational log, detailing all relevant data and events, shall be kept in accordance with 5.6.2.1

9.1.4 Operational management

A superintendent/supervisor shall be appointed the operational responsibility/supervision. He shall ensure that the execution of the operation is in accordance with all applicable rules, regulations and operational procedures.

The platform/vessel chief engineer has the overall responsibility for the technical interfaces between the platform/vessel and the ROV system(s).

The platform/vessel electrician shall be the overall electrical equipment coordinator. As such it is his responsibility to ensure that all electrical equipment brought onboard is well maintained and certified, and that all personnel working on electrical equipment are qualified for the work.

Any additional tools or equipment (third party or client) shall be accepted for use by the ROV supervisor/superintendent who has a particular responsibility to ensure compatibility with the ROV and associated systems. Maintenance arrangements and operational procedures for such additional tools and/or equipment shall be agreed prior to use.

9.2 Mobilisation/demobilisation

Mobilisation shall be conducted in accordance with a defined mobilisation plan. When the mobilisation has been completed, notice shall be given to the client for acceptance.

The mobilisation plan shall ensure that all equipment is mobilised, installed and tested in a manner ensuring conformance with rules, regulations, equipment specifications and functional requirements.

The personnel mobilisation procedures shall ensure that all personnel are qualified for the work at hand.

Demobilisation shall be conducted in accordance with a defined demobilisation plan.

9.3 Function testing prior to use

All equipment shall be function tested prior to use. Function testing shall be performed in accordance with a defined test program. Such testing will normally be documented in a separate mobilisation acceptance test formular.

Additional performance testing/demonstration may be required by the client, and shall be agreed prior to start of mobilisation.

9.4 Familiarisation

All personnel shall be familiarised with the work they are going to perform and with the HES requirements relevant for the operation. Familiarisation shall be performed in accordance with a defined program. The familiarisation program shall be adapted to the individuals competence level and tasks to be performed by the individual. Completion of the familiarisation shall be documented for each individual.

9.5 Procedures

Procedures shall be based on recognised best practices and previous experience.

9.6 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.

9.7 ROV observation of divers

ROVs used for observation of divers shall be in accordance with NORSOK U-100. A safe distance between divers and ROV shall be maintained. The purpose of the ROV in such cases is to provide the best possible overview of the divers and the work-site for the diving supervisor. The ROV personnel shall in such cases report to the diving supervisor and follow his instructions. Any anomalies observed shall immediately be reported to the diving supervisor.

10 Health, environment and safety (HES) requirements

10.1 Health and the working environment

10.1.1 Occupational illnesses

The risk of developing occupational illnesses as a result of influences in the working environment shall be identified and evaluated in all phases of the operations, including the potential effects of chemicals, noise, vibration, radiation, ergonomic and organisational factors.
Preventive (risk-reducing) measures shall be implemented which embrace technical and administrative solutions, modifications to work processes and personal protective equipment. It shall be possible to document the desired effects of these measures.
Illnesses and health problems caused by conditions at work shall be identified, reported, studied, followed up and reported.

10.1.2 Working environment

Contractor shall ensure that the working environment is satisfactory and seek to operate in a manner conformable with contractors overall objectives of a zero mindset and sustainable development. The working environment concept embraces all relevant physical and organisational conditions.
Routines shall be established to ensure that working environment requirements are met in the various phases. Status and conformity shall be documented. In the event of non-conformances, measures will be implemented on the basis of a risk assessment.
A programme for monitoring the working environment shall be established. Conditions which could pose a risk of health damage or an unacceptable load shall be followed up with counter-measures. The effect of such measures shall be assessed.
Personnel with relevant health and working environment expertise shall participate in verifications. Participation by the employees shall be ensured.

10.1.3 Chemical health hazards

Choice of chemicals will be based on technical functionality, efficiency, economics and an overall HES assessment, so that use of the chemical does not involve a health hazard or damage to health.

10.2 The environment

10.2.1 General

Contractor shall protect the external environment against damage and aim to operate in a manner conformable with the group's overall objectives of the zero mindset and sustainable development. Management and employees shall ensure that environmental considerations are taken into account in all phases of the activity.

10.3 Safety

10.3.1 General

Contractor shall ensure an acceptable level of safety and aim to operate in conformity with overall goals and the zero mindset. Built-in safety will be sought by giving emphasis to simple and robust solutions. Management and employees shall ensure that safety requirements are adhered to in all phases of the operation.

10.3.2 Principles for safety management

The following principles should apply:

- prevailing safety requirements and criteria to be defined;
- potential hazards and accidental events to be evaluated;
- risk-reduction measures to be identified and implemented;
- performance during operation to be evaluated;
- current regulatory and client safety requirements to be identified in an early phase;
- solutions in all activities which minimise the probability that undesirable events and accidents could occur to be identified;
- necessary measures to minimise negative effects and avoid damage to be identified and implemented.

10.3.3 Preventing accidents and injuries/damage

Routines shall be implemented to prevent accidents and injuries/damage. These routines will cover the identification and assessment of potential accidents and risks to personnel and assets. Results will be evaluated against established acceptance criteria for risk.

On the basis of the assessed total or individual risk, preventive (risk-reducing) measures will be identified and implemented. These can embrace technical and administrative solutions, individual modifications to work processes, and safety measures and equipment which ensure that internal and external events do not escalate into hazards or accidents.

10.3.4 Risk analyses and major accident risk

Risk analyses shall be carried out to identify, assess and determine the risk for loss, injury and damage. Results from such analyses shall be implemented into technical solutions and operational procedures.

10.4 Requirements for recording, reporting and using health, environment and safety (HES) data

Contractor shall have routines which provide effective registration, reporting, quality control, trend assessment and onward reporting of HES data.

HES data are recorded and reported for two reasons:

- to provide quantitative documentation of developments over time in injuries/damage, losses and near-misses;
- to implement measures systematically and purposefully on the basis for the documented developments.

HES data comprise information on undesirable events (stated as number of instances), figures (stated as days, hours, volumes, quantities, consumption, environmental overviews, etc) and descriptions (text).

Annex A
(informative)
Trenching

A.1 Trench dimensions and backfill

Trench dimensions and protection/insulation backfill should be specified as follows:
- trench depth (m), measured from natural seabed level to bottom of trench;
- trench width (m);
- pipe (or cable etc.) depth (m), measured from natural seabed level to TOP;
- backfill cover depth (m), measured from natural seabed level to TOC;
- minimum or average backfill (m), TOP – TOC.

A.2 Soil characteristics

Soil characteristics are governing parameters for trenching, and are key criteria for selection of a suitable trenching vehicle for any specific trenching task. Performance of a trenching vehicle is largely dependent on how accurately the prevailing soil conditions on the work location(s) have been established, and how well the actually experienced conditions correspond to the inherent as-designed trenching capacity of the vehicle.

Geotechnical soil investigation for trenching is often limited to obtaining very general soil characteristics at intermittent locations along the trenching route. Undrained shear strength (S_u) (for cohesive soil) and grain size distribution and cementation (for non-cohesive soil) are considered the most important parameters for trenching ability.

Undrained shear strength (S_u) values are commonly calculated from the results of core penetration testing, by pocket penetrometer or lab vane testing on soil samples or through other laboratory tests. Grain size distribution is determined by performing particle size distribution analysis on soil samples. The terms used to describe soil characteristics should be as defined by Norges Geotekniske Forbund (NGF) Classification System 1982.

Specific undrained shear strength (S_u) ranges are:
- very soft < 12,5 kPa;
- soft 12,5 kPa to 25 kPa;
- medium 25 kPa to 50 kPa;
- stiff 50 kPa to 100 kPa;
- very stiff 100 kPa to 200 kPa;
- hard 200 kPa to 400 kPa;
- very hard > 400 kPa.

The upper limit for trenching by water jetting (i.e. the soil fluidisation principle) is normally considered to be in the region of 50 kPa to 100 kPa. For soil stiffer than 100 kPa, trenching by mechanical means (e.g. chain or wheel cutter, digger or plough) is presently most common, sometimes in combination with water jetting.

Grain size distribution is presented as percentages of the various grain sizes present in the soil as determined by sieving and sedimentation.

Soil investigations carried out prior to trenching should be carried out according to “Guidance Notes on Geotechnical Investigations for Marine Pipelines” issued by the Offshore Site Investigation Forum 1999.

The terms used to describe grain sizes are (see British Standard BS 1377:1975):

- cobbles 60 mm to 200 mm;
- gravel 2 mm to 60 mm;
- coarse gravel 20 mm to 60 mm;
- medium gravel 6 mm to 20 mm;
- fine gravel 2 mm to 6 mm;

- sand 0,06 mm to 2 mm;
- coarse sand 0,6 mm to 2 mm;
- medium sand 0,2 mm to 0,6 mm;
- fine sand 0,06 mm to 0,2 mm;
- silt 0,002 mm to 0,06 mm;
- coarse silt 0,02 mm to 0,06 mm;
- medium silt 0,006 mm to 0,02 mm;
- fine silt 0,002 mm to 0,006 mm;
- clay < 0,002 mm.

To specify the trenching capacity of a trenching vehicle in terms of soil characteristics, the following should as a minimum be stated for the relevant work location(s):

- for clay soil: undrained shear strength (S_u);
- for sandy soil: grain size distribution and cementation occurrence.

Additional soil characteristics and information of influence on trenching performance are:
- relative and min/max density and water content;
- total unit weight;
- strain rate effects;
- permeability (sands/silts);
- sensitivity (clay);
- plasticity;
- properties of backfilled material (strength, unit weight), cyclic behaviour of soil, relative density and compressibility;
- occurrence of gravel or cobble layers, boulders, cemented layers and corals;
- presence of steep seabed gradients and pockmarks;
- dilation;
- shallow gas.

The more of above parameters are specified along the trenching route, the better the trenching performance can be predicted.

A crucial consideration for Class IV seabed working vehicles is the trenching capacity. This is strongly related to the seabed conditions embracing mainly the sediment type, composition and degree of consolidation.

A fundamental soil division is the distinctions between cohesive and friction soil and sorted and unsorted sediments. Usually, shear strength capacity is applicable only to cohesive soils such as clayey seabed sediments. To classify the trenching capacity in friction soils such as sand, gravel (sorted sediments) and diamictons (unsorted sediments in which till belongs), the angle of friction properties are more applicable.

Specifying too generalised soil parameters for trenching capacity may be severely misleading in certain circumstances, e.g. a boulder clay may be strongly consolidated and exhibit high shear strength values. Even so, trenching may still be successful due to the clayey content of the boulder clay. Furthermore, friction soils may reveal highly varying characteristics due to local anomalies such as cementation of carbonates or other chemical alterations.

It is therefore essential to further determine the most important soil parameters and to index the seabed conditions relative to the expected trenching capacity. For this purpose, the concept of route seabed index should be adopted.

Route seabed index can be established by evaluating all available geological data in the surveyed pipeline route corridor. By cross-validation of parameters, the seabed index can be fixed as a numerical value indicative of the accessibility or “trenchability” along the route surface layers. The index is based on the dominant properties of the sediment conditions, from seabed surface down to an approximate depth of one meter or more. A typical route seabed index for a specific trenching route is shown in Table A.1.

Table A.1 - Example route seabed index definition

Seabed index	Geotechnical state	Sediment type
0	Not penetrable	Bedrock
1-2	Angle of friction 35 degrees to 45 degrees.	Till
2-6	Highly varying conditions. Commonly unsorted non-cohesive sediments. Also cohesive strata with varying influx of coarse material.	Diamicton
3-5	Angle of friction 25 degrees to 35 degrees.	Sand
4-8	Shear strength normally varying in the range 5 kPa to 30 kPa. Erroded layers will yield higher values. Developed dry crust will yield values > 50 kPa.	Clay
8-10	Low shear strength	Clay
10	Extremely low shear strength	Mud
	NOTE The seabed index presented in this table is based on the geophysical interpretation and results from the Boxcorer sampler, and should only be regarded as a guideline for trenching conditions.	

Annex B
(normative)
Remotely operated vehicle (ROV) system requirements

Refe-rence	Description ROV Class I	Unit	Client's requirement	Contractors data
8.2	**ROV Class I - Pure observation vehicle**			
	ROV			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	TMS			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.6.3	Tether length	m		
	Umbilical winch			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.7.1	Umbilical length	m		
	Line speed	m/s		
	Control container			
	Manufacturer/Type			
	Length	m		
	Width	m		

Refe-rence	Description ROV Class I	Unit	Client's requirement	Contractors data
	Height	m		
	Workshop container			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Handling system			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Total required deck space	m^2		
	Maximum weight			
	Vehicle	kg		
	TMS	kg		
	Umbilical winch	kg		
	Control container	kg		
	Workshop container	kg		
	Handling system	kg		
	Auxiliary power pack/Clean power unit	kg		
	Total Maximum overall weight	kg		
	Area classification (zone 1 or 2)			
	Power supply requirements			
	Vehicle	kVA		
	TMS	kVA		
	Umbilical Winch	kVA		
	Control Container	kVA		
	Workshop Container	kVA		
	Handling system	kVA		

Refe-rence	Description ROV Class I	Unit	Client's requirement	Contractors data
	Maximum total power consumption	kVA		
8.2.1	**Operational depth/depth rating**			
	Operational depth	m		
8.2.2	**Buoyancy**			
	Payload	kg		
	Vehicle frame carrying load	kg		
8.2.3	**Ability to move in the horizontal and vertical plane**			
	Forward	m/s		
	Backward	m/s		
	Vertical	m/s		
	Lateral	m/s		
	Number of thrusters and position	Number		
8.2.4	**Cameras and lights**			
8.2.4.2	Low light navigation camera			
	Manufacturer			
	Model			
8.2.4.3	CCD colour camera			
	Manufacturer			
	Model			
8.2.4.4	Lights			
	Number of lights on vehicle			
	Total lighting capacity			
	Lighting circuits			
	Model/Type			
8.2.5	**Instrumentation**			
	Depth gauge			

Refe-rence	Description ROV Class I	Unit	Client's requirement	Contractors data
	Manufacturer			
	Model/Type			
	Compass			
	Manufacturer			
	Model/Type			
8.2.6	**Auto functions**			
	Auto heading			
	Auto depth			
8.2.7	**Transponders**			
	Manufacturer			
	Model/Type			

Refe-rence	Description ROV Class I	Unit	Client's requirement	Contractors data

Reference	Description ROV Class II	Unit	Client's requirement	Contractors data
8.3	**ROV Class II - Observation vehicle with payload option** (requirements as for ROV class I)			
	ROV			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	TMS			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.6.3	Tether length	m		
	Umbilical winch			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.7.1	Umbilical length	m		
	Line speed	m/s		
	Control container			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Workshop container			
	Manufacturer/Type			
	Length	m		

Reference	Description ROV Class II	Unit	Client's requirement	Contractors data
	Width	m		
	Height	m		
	Handling system			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Total required deck space	m²		
	Maximum weight			
	Vehicle	kg		
	TMS	kg		
	Umbilical winch	kg		
	Control container	kg		
	Workshop container	kg		
	Handling system	kg		
	Auxiliary power pack/Clean power unit	kg		
	Total maximum overall weight	kg		
	Area classification (zone 1 or 2)			
	Power supply requirements			
	Vehicle	kVA		
	TMS	kVA		
	Umbilical winch	kVA		
	Control container	kVA		
	Workshop container	kVA		
	Handling system	kVA		
	Maximum total power consumption	kVA		
8.2.1	**Operational depth**			
	Operational depth	m		
8.3.2	**Buoyancy**			

Reference	Description ROV Class II	Unit	Client's requirement	Contractors data
	Payload	kg		
	Vehicle frame carrying load	kg		
8.2.3	**Ability to move in the horizontal and vertical plane**			
	Forward	m/s		
	Backward	m/s		
	Vertical	m/s		
	Lateral	m/s		
	Number of thrusters and position	Number		
8.2.4	**Cameras and lights**			
8.2.4.2	Low light navigation camera			
	Manufacturer			
	Model			
8.2.4.3	CCD colour camera			
	Manufacturer			
	Model			
8.2.4.4	Lights			
	Number of lights on vehicle			
	Total lighting capacity			
	Lighting circuits			
	Model/Type			
8.2.5	**Instrumentation**			
	Depth gauge			
	Manufacturer			
	Model/Type			
	Compass			
	Manufacturer			
	Model/Type			
8.2.6	**Auto functions**			

Reference	Description ROV Class II	Unit	Client's requirement	Contractors data
	Auto heading			
	Auto depth			
8.3.4	**Sonar**			
	Type (8.3.4.2 - 8.3.4.3 - 8.3.4.4)			
	Manufacturer			
	Model			
	Frequency			
	Range			
	Resolution			
	Scanning sector			
	Scanning speed			
8.3.5	**Minimum of plug-in connection points for additional equipment**			
8.3.5.1	Outlet (12, 24 and/or 250 VDC - 5 A)			
	Outlet (110 and/or 220 VAC - 1 A)			
8.3.5.2	Spare quad or two data channels through fiber			
8.3.5.3	Spare video lines			
8.3.6	**Transponder**			
	Manufacturer			
	Model/Type			
	Additional sensors and equipment			
	Altimeter			
	Pitch and roll sensors			
	Emergency flasher			
	Emergency beacon			
	Wire cutter			
	Torque tool			
	LP water jet			

Reference	Description ROV Class II	Unit	Client's requirement	Contractors data
	CP probe			
	Frame grabbing equipment			
	Digital recording system (DVD)			
	CD burner			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
8.4	**ROV Class III - Work class vehicles**			
	ROV			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	TMS			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.6.3	Tether length	m		
	Umbilical winch			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
8.7.1	Umbilical length	m		
	Line speed	m/s		
	Control container			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Workshop Container			
	Manufacturer/Type			
	Length	m		
	Width	m		

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
	Height	m		
	Handling system			
	Manufacturer/Type			
	Length	m		
	Width	m		
	Height	m		
	Total required deck space	m²		
	Maximum weight			
	Vehicle	kg		
	TMS	kg		
	Umbilical winch	kg		
	Control container	kg		
	Workshop container	kg		
	Handling system	kg		
	Auxiliary power pack/Clean power unit	kg		
	Total maximum overall weight	kg		
	Area classification (zone 1 or 2)			
	Power supply requirements			
	Vehicle	kVA		
	TMS	kVA		
	Umbilical winch	kVA		
	Control container	kVA		
	Workshop container	kVA		
	Handling system	kVA		
	Maximum total power consumption	kVA		
	Deck cables minimum length	m		
8.4.1	**Operational depth/depth rating**			
	Operational depth			
8.4.2	**Buoyancy**			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
	Payload	kg		
	Vehicle frame carrying load	kg		
8.4.3	**Ability to move in the horizontal and vertical plane**			
	Speed			
	Forward	m/s		
	Backward	m/s		
	Vertical	m/s		
	Lateral	m/s		
	Force			
	Forward	N		
	Backward	N		
	Vertical	N		
	Lateral	N		
	Number of thrusters and position	Number		
8.4.4	**Electrical or hydraulic power**			
	Overall available power	W		
	Propulsion	W		
	Tooling	W		
	Number of hydraulic circuits			
	Pressure	bar		
	Flow	l/min		
8.4.5	**Cameras and lights**			
8.4.5.2	Low light navigation camera			
	Manufacturer			
	Model			
8.4.5.3	CCD colour camera			
	Manufacturer			
	Model			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
	Utility camera 1			
	Manufacturer			
	Model			
	Utility camera 2			
	Manufacturer			
	Model			
8.4.5.4	Lights			
	Number of lights on vehicle			
	Total lighting capacity	W		
	Lighting circuits			
	Modell/Type			
8.4.6	**Manipulators**			
8.4.6.2	Grabber manipulator			
	Manufacturer			
	Type			
	Control method			
	Number of functions			
	Type of jaws			
	Size of recess for T-bars/handles	ϕ mm		
	Outreach	mm		
	Lift capacity	kg		
8.4.6.3	Working manipulator			
	Manufacturer			
	Type			
	Control method			
	Force feedback			
	Number of functions			
	Type of jaws			
	Size of recess for T-bars/handles			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
	Outreach	mm		
	Lift capacity	kg		
	Wrist torque	Nm		
8.4.7	**Sonar**			
	Type (8.4.7.2 - 8.4.7.3 - 8.4.7.4)			
	Manufacturer			
	Model			
	Frequency	Hz		
	Range	m		
	Resolution			
	Scanning sector	degree		
	Scanning speed	degree /s		
8.4.8	**Instrumentation**			
	Depth gauge			
	Manufacturer			
	Model/Type			
	Compass			
	General navigation			
	Manufacturer			
	Model/Type			
	Survey and accurate navigation			
	Manufacturer			
	Model/Type			
8.4.9	**Auto functions**			
	Auto heading			
	Auto depth			
	Auto altitude			
	Auto roll			
	Auto pitch			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
8.4.10	**Minimum of plug-in connection points for additional equipment**			
8.4.10.1	Outlet (12, 24 and/or 250 VDC - 5 A)			
	Outlet (110 and/or 220 VAC - 1 A)			
8.4.10.2	Spare quad or two data channels through fiber			
8.4.10.3	Spare video lines			
8.4.10.4	Hydraulics			
	Number of low flow outputs			
	Pressure	bar		
	Flow	l/min		
	Number of high flow hydraulic output			
	Pressure	bar		
	Flow	l/min		
8.4.11	**Transponders**			
	Manufacturer			
	Model/Type			
	Additional sensors and equipment			
	Altimeter			
	Pitch and roll sensors			
	Emergency flasher			
	Emergency beacon			
	Wire cutter			
	AX/VX ring tool			
	Torque tool			
	LP water jet			
	Dredge pump			
	Grinder			
	CP probe			
	Frame grabbing equipment			

Reference	Description ROV Class III	Unit	Client's requirement	Contractors data
	Digital recording system (DVD)			
	CD burner			