

Petroleum related manned underwater operations inshore

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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 oil company 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 Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

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

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF), The Federation of Norwegian Industry, Norwegian Shipowners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

Introduction

This NORSOK standard is the result of an industry-wide effort to establish a standard for inshore petroleum related MUOs.

1 Scope

This NORSOK standard defines basic requirements for personnel, equipment and systems for petroleum related MUO and caisson work inshore.

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 recognized standards may be used provided it can be shown that they meet the requirements of the referenced standards.

2.1 Normative references

AODC 035	(IMCA) Code of Practice for the Safe Use of Electricity Under Water
DNV OS-E402	DnV Offshore standard for diving system
EN 15333-1	Respiratory equipment - Open-circuit umbilical supplied compressed gas diving apparatus - Part 1: Demand apparatus
EN 15333-2	Respiratory equipment - Open-circuit umbilical supplied compressed gas diving apparatus - Part 2: Free flow apparatus
ISO 6385	Ergonomic principles in design of work systems. (Corresponds to NS 4640 Ergonomiske prinsipper for utforming av arbeidssystemer)
ISO 8995	Lighting of indoor work places
NORSOK S-006	HSE evaluation of contractors
NORSOK U-100	Manned Underwater Operations
NORSOK U-101	Diving Respiratory Equipment
NDTT	Norwegian diving and treatment tables, ISBN:82-992411-3-8
NLIA 361	The Norwegian Labour Inspection Authority. Administrative standards for contamination in the working atmosphere. (In Norwegian). Ordering No 361
NUI 2008-07	Emergency air in heavy helmet (In Norwegian. "Nødluft i standard dykkehjelme")

2.2 Informative references

NUI 2007-09	Noise reduction in heavy helmet (In Norwegian. "Støydemping i standard dykkehjelme")
OGP 411	Diving Recommended Practice

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

can

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

3.1.2

caisson work

work operations where personnel are exposed to changes in ambient pressure, e.g. tunnel workers passing from one atmosphere to another

3.1.3

Contractor

company which carries out or arranges for the carrying out of MUO at inshore petroleum related plants and installations

3.1.4

diving basket

part of the diving winch where the underwater worker(s) can stand/sit safely and in an ergonomically correct manner

3.1.5**diving winch**

appliance used to transport underwater worker(s) between the sea and the diving platform, as well as to stabilise underwater worker(s) during in-water decompression

NOTE The diving winch will normally consist of the following elements: diving basket, crane/lift unit, fastenings, wires, chain etc., and will be certified as one unit.

3.1.6**equivalent air depth****EAD**

depth at which air would provide the same nitrogen partial pressure as the actual nitrox mix at a given depth

3.1.7**free-flow helmet**

diving helmet where the breathing gas circulates freely in helmet and/or suit, and does not have any oral nasalmask

3.1.8**heavy free-flow helmet**

free-flow helmet connected to dry suit (e.g. Siebe Gorman and MarkV)

3.1.9**heavy helmet equipment**

complete personal diver equipment package including heavy free-flow helmet, dry suit, chest plate and heavy boots (also called "Standard gear", "John Brown rig" or "Hard-hat equipment")

3.1.10**inshore MUO**

MUO carried out inside territorial waters (normally within 12 n miles or 19,25 km from shore), including docks, harbours, canals, culverts, rivers, estuaries, lakes, reservoirs, dams, flooded tunnels, and tanks

3.1.11**light free-flow helmet**

free-flow helmet where there is no open connection to the suit where gas can move in or out

3.1.12**light MUO winch**

device for use in water only and which is not required to meet requirements/certification for personnel transport

3.1.13**manned underwater operation****MUO**

activity when humans stay below the surface and/or exposed to increased ambient pressure

3.1.14**may**

verbal form used to indicate a course of action permissible within the limits of this NORSOK standard

3.1.15**metre of sea water****msw**

pressure unit equal to 10 kPa (making 10 msw exactly 1 bar or 100 kPa), implies a relative density of 1,01972

3.1.16**nitrox**

a gas mixture of oxygen and nitrogen

3.1.17**non-compliance**

inadequate compliance with specified requirements

3.1.18**Operator**

oil company, responsible as the obligated party

3.1.19**petroleum related inshore MUO**

inshore MUO carried out in connection with petroleum installations, exploration and pipeline works

3.1.20**shall**

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

3.1.21**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

3.1.22**standby diver**

underwater worker who is dressed and ready to assist immediately in an emergency situation

3.1.23**surface oriented diving**

diving operation where the underwater worker enters and leaves the water at normal ambient pressure

3.1.24**transfer under pressure****TUP**

intervention method used in non-saturation diving shallower than 50 msw, where the underwater workers are transferred from their working depth to a surface decompression chamber in a closed bell maintaining pressure greater or equal to the first decompression stop

NOTE By removing in-water decompression-stops, surface intervals and re-compression, TUP is generally considered as a healthier, safer and more efficient alternative to other traditional surface supplied air/nitrox diving techniques (in-water decompression-stops and SD). The term TUP has different meaning in different contexts. Sometimes it is used for any process where underwater workers are kept at a pressure above the surrounding, while they move or are moved. In other cases the term is used to designate the facility that is used for the transfer, e.g. the bell or a special surface chamber used by the underwater workers passing from the bell to another chamber.

3.1.25**underwater worker (diver)**

person holding a diving certificate and a valid medical certificate issued by an approved authority or by institutions/organizations accredited by an approved authority

3.1.26**verification**

confirmation based on the examining and collecting of objective proof of compliance with specified requirements

3.2 Abbreviations

AODC	Association of Offshore Diving Contractors (NOTE Now part of IMCA)
CE	Communauté Européenne
CO ₂	carbon dioxide
DNV	Det Norske Veritas (The Norwegian Veritas)
EAD	equivalent air depth
EN	European Standard
HAZID	hazard identification
HAZOP	hazard and operability studies
HBO	hyperbaric oxygen

IMCA	The International Marine Contractors Association (former AODC)
ISO	International Organization for Standardization
msw	metre of sea water
MUO	manned underwater operation
NBU	Norsk Bransjeforening for Undervannsentreprenører (the Norwegian Association of Underwater Contractors/Entrepreneurs)
NDTT	Norwegian diving and treatment tables
NLIA	The Norwegian Labour Inspection Authority
NUI	Norwegian Underwater Intervention AS
O ₂	oxygen
OGP	International Association of Oil & Gas Producers
OTU	O ₂ -tolerance unit
pCO ₂	partial pressure of CO ₂
pO ₂	partial pressure of O ₂
PSA	The Petroleum Safety Authority Norway
ROV	remotely operated vehicle
RUH	report on an undesirable incident
SJA	safe job analysis
SD	surface decompression
SDO ₂	SD using O ₂
SHE	safety, health and environment
STPD	standard temperature and pressure - dry
TUP	transfer under pressure

4 Administrative requirements

4.1 General

If there are safety aspects not covered in this NORSOK standard, an independent responsibility to maintain the safety level indicated by this NORSOK standard is imposed on anyone engaged in MUO.

Inshore MUO covered by this NORSOK standard is subject to the national authority requirements, statutes and regulations that apply in the area in which the MUO is to take place.

Contractor shall submit a compliance assessment, which identifies compliance and any non-compliances between the requirements of the local authorities and this NORSOK standard. Any non-compliances shall be dealt with in accordance with 4.3.

Where a specific standard is referred in the text of this NORSOK standard, the requirements of that standard are to be regarded as the recommended, preferred solution.

Contractor shall be qualified by Operator.

This NORSOK standard shall be included in all enquiries and contracts for inshore petroleum related MUOs.

NOTE Commercial pre-qualification entails registration in the Achilles database in accordance with the applicable requirements. The requirement for registration in Achilles applies to direct suppliers to Operator only and contracts valued at more than NOK 3,2 million.

4.2 Documentation

All documentation shall as a minimum satisfy the applicable national authority requirements.

Contractor shall describe all activities that are directly or indirectly involved in the work, either in the actual execution of the operation or in support of its safe and efficient performance. Examples of necessary supporting activities include

- risk analyses (HAZID, HAZOP, SJA etc.),
- health services (responsible diving doctor etc.),
- safety delegate service (established safety delegate organisation etc.),
- emergency response system (notification plans, drills etc.),
- system for planned maintenance,
- system for collecting and storing diver-exposure data,

g) limits for monitoring parameters, including early warning, to be approved by Contractor's diving doctor.

4.3 Compliance, deviations and dispensations

Deviations and dispensations shall first be processed and approved internally by Contractor.

Contractor shall forward all non-compliances to Operator for acceptance. Only non-compliances accepted by Operator can be forwarded to the authorities as an application for exemption. Dispensations have to be granted by the parties involved, including representatives from the diving personnel, their safety delegates and the Operator. A risk analysis shall be performed.

4.4 Document availability

Contractor shall have a system that ensures that the applicable version of relevant documentation is available at the operation site, and that this documentation is continuously revised. The relevant documentation shall be reviewed by the diving superintendent, diving supervisor, diving doctor and the safety delegate. On request, Contractor shall also submit a copy of the documentation to Operator for consideration and acceptance.

Contractor shall inform Operator of all planned changes to diving-related documentation that take place during the contract period. Operator shall accept the changes prior to their implementation.

Contractor shall present

- a) a compliance matrix based on this NORSOK standard and relevant regulations, in accordance with UCM-31 of Annex A,
- b) a plan for the handling of any non-compliances through implementing corrective actions or alternative solutions (alternative solutions shall be based on documented analyses covering all relevant aspects),
- c) a description of the diving methods planned to be used during the operation,
- d) assessment of whether saturation diving and/or TUP could be applied if the MUO lasts for more than one month with depth continuously exceeding 25 msw,
- e) outline of Contractor's applicable document structure,
- f) a plan describing the internal auditory activities intended to ensure that legal and contractual requirements are met.

4.5 Reporting and notification

4.5.1 Operational reporting

4.5.1.1 Daily report

Copies of all logs and reports shall be made available to Operator's representative on request.

4.5.1.2 Weekly report

Contractor shall send Operator weekly statistics of the previous week's and the project's accumulated data in accordance with URF-31 of Annex A.

4.5.1.3 Experience report

If Contractor have had contract with Operator during the calendar year he shall within January 31st following year, submit to Operator an experience report, see URF-32 of Annex A. For projects with duration more than 14 working days, Contractor shall additionally within three weeks after completion of work, submit to Operator an experience report for the actual project, also according to URF-32 of Annex A.

These reports shall be prepared in cooperation with the safety delegate and Contractor's diving doctor. Relevant matters and factors relating to safety, occupational hygiene, equipment and operational experience shall be assessed and included.

4.5.2 Reporting of accidents, near-misses, non-compliances, failures and damage/injury

Contractor shall have a reporting system that ensures that all undesirable incidents such as accidents, near-misses, quality non-compliances, material damage and equipment failure etc. are reported, registered and dealt with by Contractor.

4.5.3 Notification

Operator shall be notified immediately of any serious injuries to personnel and any serious near misses. For all other injuries and near misses Operator shall be informed as soon as possible and always within 12 h. For MUO related incidents notification shall also be given through the emergency response line. Operator shall also be given copies of all reports from Contractor to the authorities.

5 Safety, health and environment (SHE) requirements

5.1 General

Data and statistics relating to SHE shall be used systematically to achieve continuous improvement of the planning and performance of the operations covered by this NORSOK standard.

Contractor shall meet the SHE requirements set out in NORSOK S-006. Noise level shall be as required in relevant parts of NORSOK U-100, 5.2.2.6, and for the breathing gas generated ("self-induced") noise EN 15333-2, 5.20.

5.2 Diving doctor

Contractor's organization shall include a qualified doctor specialized in diving medicine. The diving doctor shall give advice in matters of ergonomics, physiology, medicine and hygiene relevant for underwater workers' health and safety. The doctor shall approve the health-related aspects of Contractor's MUO manual.

There shall be a job description for the doctor.

5.3 First aid

Contractor shall have first aid equipment minimum to the specifications given in Annex B. There shall be sufficient O₂ for treatment of an ill or injured underwater worker until public health service can take over the responsibility. First aid equipment shall be approved by Operator's diving doctor.

5.4 Threshold values for pO₂ and O₂ exposure

Threshold values for pO₂ and O₂ exposure given in NDTT shall be adhered to. See Annex C for examples of calculation.

6 Personnel and crew requirements

6.1 General

All personnel directly or indirectly involved in a MUO shall be familiar with the applicable operation procedures, emergency procedures, emergency response plans, reporting routines, RUH etc. that are relevant to the function of the person in question, and be trained and certified in accordance with recognised norms where such exist.

Contractor shall document that the personnel are familiar with the emergency procedures prior to start of MUO.

6.2 Familiarisation

Contractor shall have a system to ensure that personnel participating in operations have been given adequate training before actively participating in the operation.

Familiarisation shall be carried out in accordance with a pre-planned programme and it shall be possible to document it. The programme shall include operation of chamber.

6.3 Requirements for personnel

6.3.1 Diving superintendent

This position is required under the conditions described in 6.6. The diving superintendent shall as a minimum be a qualified diving supervisor.

6.3.2 Diving supervisor

The diving supervisor shall lead all MUO from the surface. The diving supervisor shall be appointed by Contractor in writing and have the following qualifications:

- a) qualified pursuant to NORSOK U-100, Clause 6, or equivalent, with the exception that if a vessel with dynamic positioning (DP) is not directly involved in the MUO, the requirement that 25 of the 100 dives shall be from vessel operating in DP, need not be adhered to;
- b) thorough knowledge of Operator's requirements and Contractor's procedures, equipment, routines and the work tasks to be carried out.

6.3.3 Assistant diving supervisor

There shall also be an assistant diving supervisor to relieve the diving supervisor when needed. The assistant supervisor shall have the following qualifications:

- a) qualified pursuant to NORSOK U-100, Clause 6, or equivalent, with the exception that if a vessel with dynamic positioning (DP) is not directly involved in the MUO, the requirement that 25 of the 100 dives shall be from vessel operating in DP, need not be adhered to;
- b) thorough knowledge to Operator's requirements and Contractor's procedures, equipment and routines.

6.3.4 Underwater workers (divers)

Underwater workers shall have an approved diving certificate and a valid medical certificate appropriate to the nature of the work and the equipment being used.

When special tasks require special training, the qualifications of the underwater worker shall be documented.

6.3.5 Standby diver

The standby diver shall have the same qualifications as underwater workers and be familiar with the relevant rescue techniques.

6.3.6 Technical personnel

Personnel carrying out maintenance of diving systems and equipment shall have documented, relevant training for the tasks to be performed.

6.3.7 Diving assistant

The diving assistant shall have the minimum theoretical knowledge required for an underwater worker and be able to

- a) run the dive,
- b) help the underwater worker with tools and equipment,
- c) see that the safety of the underwater worker is well maintained,
- d) run a SD,
- e) initiate treatment of underwater worker in agreement with medical doctor.

6.4 Minimum crew without TUP

The minimum crew shall consist of

- a) one diving supervisor,
- b) one assistant diving supervisor,
- c) one underwater worker,
- d) one standby diver,
- e) one diver assistant.

6.5 Minimum crew with TUP

The minimum crew shall consist of

- a) one diving supervisor,
- b) one assistant diving supervisor,
- c) two underwater workers,
- d) one standby diver,
- e) one diver assistant.

All shall be formally qualified to NORSOK U-100, B.2, or equivalent and be qualified for diving from closed bells. See also OGP 411.

6.6 MUO at large plants

At large, complicated plants where MUO activities are affected by other activities (e.g. boat traffic, blasting, dumping of sediment, crane lifts etc.), the minimum crew shall be extended with a diving superintendent. The diving superintendent shall participate in the plant's daily management meetings where the diving superintendent can receive and give information affecting the safety of the MUO.

6.7 Saturation diving/bell diving

For saturation diving/bell diving, relevant parts of NORSOK U-100 shall apply.

7 Technical requirements

7.1 Requirements for diving systems

7.1.1 General

Diving systems and equipment shall be constructed in accordance with recognised standards such as ISO 6385 and ISO 8995. Equipment for which certification is not required shall be tested by a competent person or institution in accordance with a recognised standard. Such testing shall be documented.

7.1.2 Hyperbaric chambers

All chambers shall be in compliance with the technical requirements in DNV OS-E402 or an equivalent standard. Chamber systems to be used for planned SD should be certified by classifying society. A class certificate is required for all new systems (after 2011-01-01). All chambers shall be twin lock type and the main chamber shall be at least 1,8 m long.

During operations involving planned SD or with use of TUP, the chamber shall have a minimum interior diameter of 1,8 m.

For other MUO, and when the hyperbaric chamber is on standby only, a smaller hyperbaric chamber (standby chamber) may be approved by Operator. The standby chamber should have an interior diameter of at least 1,4 m. The main chamber shall be equipped and designed so that a doctor/assistant can efficiently carry out any first-aid required.

When using the standby chamber, permission shall be obtained from Operator before commencing the operation.

7.1.3 Diving bells

For TUP the closed diving bell shall be designed for minimum 2 underwater workers, and have a minimum volume of 2,5 m³.

7.1.4 Handling systems

7.1.4.1 General

It shall be considered whether a diver lift is needed. When using a diver lift, there shall be direct communication between the diving supervisor and the lift operator. All lifting appliances for underwater workers shall be certified for man riding.

Diver lift or light diving winch shall be used for

- a) all dives with planned decompression stops,
- b) all dives deeper than 20 msw,
- c) all dives with hazard of fall under water (helmet squeeze).

7.1.4.2 Certified diver lift

A diver lift shall be used when

- a) surface decompression is planned,
- b) heavy helmet equipment is used (see 8.3.3) and the distance between the surface of the water and the deck of the diving platform is greater than 1,5 m.

Diver lifts require that winches are certified as man riding winches relating to personnel transport. The diving basket, crane/lift unit, fastenings, wires, chain etc. shall be certified as one unit.

7.1.4.3 Diving bells

Handling systems for diving bells to be used for TUP shall include means of safe guidance through the surface of the water. The design load for the facility shall be calculated on the basis of maximum loads under specified maximum operational limits. The design load shall be at least twice the maximum static load. Ship motions shall be taken into consideration when estimating the maximum operational limits.

The handling facility shall be secured against uncontrolled pay-out as a result of technical failure, i.e. be equipped with automatically applied mechanical breaking devices providing primary and secondary protection. The facility shall also be equipped with limit switches preventing the handling outside defined limits.

Handling systems for diving bells to be used for saturation diving shall comply with NORSOK U-100.

7.2 Respiratory equipment

7.2.1 General

Respiratory equipment shall comply with NORSOK U-101 or applicable harmonized EN standard and be CE marked.

7.2.2 Gas supply system

It shall be possible to document that gas supply systems deliver sufficient gas volume and pressure to satisfy the requirements set by the manufacturer of the respiratory equipment used.

Sufficient sources of gas, of breathing quality, shall be available and suitably arranged so that if the on line supply to the underwater worker fails, an alternative supply can be immediately switched on. Failure of the supply line to one underwater worker shall not interfere with the supply to another.

All parts of the gas system, bail-out included, shall be properly O₂ cleaned when used for gas mixes containing 25 % O₂ or more.

7.2.3 Helmets/masks

Umbilical-supplied demand-regulator-systems shall comply with EN 15333-1 and free-flow systems with EN 15333-2.

The spare gas system shall be in accordance with NUI 2008-07 or documented better.

Noise levels shall be in accordance with the requirements in 5.1.

NOTE A recommended method for noise reduction is described in NUI 2007-09.

7.2.4 Emergency gas stores

All calculations used to qualify the volume of emergency gas stores shall be based on a respiratory minute volume (available, breathable gas) of 62,5 l/min at ambient pressure.

7.2.5 Bail-out

The underwater worker shall carry a spare supply of breathing gas (bail-out) with a capacity sufficient to allow the underwater worker to reach a place of safety and at least with 10 min of breathing at the maximum planned work depth.

7.2.6 Emergency gas stores for surface-supplied diving

A sufficient store of breathing gas shall be available at the site to ensure that the underwater worker can be brought to the surface, including any decompression from the maximum depth planned for the dive. The spare (emergency) gas supply shall be isolated from the normal supply and the minimum volume shall be twice that of the dive's planned gas consumption.

7.2.7 Reserve gas bank

In addition there shall be a separate reserve bank available for the stand by diver, with the same capacity as the diving banks.

7.2.8 Emergency gas supply when using a hyperbaric chamber

There shall be sufficient gas supply for the planned operation, plus a minimum spare supply sufficient to blow down the chamber to 50 msw. There shall be at least two separate gas supplies/sources that can be used for chamber atmosphere compression.

There shall be sufficient O₂ for the planned surface decompression dive (20 l/min at 1 bar pr. underwater worker). In addition there shall be sufficient O₂ to carry out treatment table 6 of NDTT for two underwater workers (20 l/min at 1 bar ≈ 20 000 n litre.) The O₂ shall be stored in two separate banks.

7.2.9 Marking of the umbilical line

The diver's umbilical shall be marked as follows:

- 5 m: 1 red ring around the umbilical
- 10 m: 1 black ring around the umbilical
- 50 m: 1 wide black ring around the umbilical

EXAMPLES 15 m are marked with 1 red and 1 black ring, and 45 m are marked with 1 red and 4 black rings.

7.3 Equipment/tools requirements

7.3.1 General

All tools used in connection with MUO shall be assessed with a view to safe responsible use. Necessary procedures and safety measures shall be implemented where called for by the conditions or situation. Equipment shall be subject to functional testing before use.

All power-operated tools shall be equipped with a "dead man's switch" which automatically isolates or shuts down the power supply when the underwater worker releases the control handle. Emergency stop can alternatively be placed by the dive supervisor when adequate. Tools shall also be evaluated according to relevant regulations.

7.3.2 Electrical equipment

All use of electricity during MUO shall comply with AODC 035, or equivalent.

7.3.3 Maintenance

Contractor shall have an established maintenance system for equipment that as a minimum meets the following requirements:

- a) documented maintenance procedures/ routines;
- b) detailed maintenance logs;
- c) check lists with function checks.

8 Operational requirements

8.1 General

Gas mixes containing 25 % O₂ or more shall be considered as pure O₂ with regard to fire and explosion, and be treated thereafter and systems intended for such mixes shall be O₂ clean.

A standby diver shall always be appointed. During the MUO, the standby diver shall be fully dressed (mask off) and, irrespective of the diving method/equipment or other factors, be capable of entering the water within 1 min.

A hyperbaric chamber shall be available at the worksite.

For special circumstances/conditions, Contractor may apply to Operator for approval to place the hyperbaric chamber in an alternative location. The application shall be based on a detailed evaluation of the operation. The transport time to the standby chamber shall never exceed 2 h.

Transportation shall not be based on air travel and shall be independent of weather conditions and other unpredictable factors. Procedures and emergency response plans shall take account of the alternative chamber location.

8.2 Mobilisation/demobilisation

8.2.1 General

Contractor shall have a documented system ensuring that the mobilisation of personnel and equipment is systematic and in accordance with requirements. This shall be confirmed with plant management before MUO is commenced, and the checklist in UCL-31 of Annex A shall be filled in and signed.

If equipment supplied/paid for by Operator is used, Contractor shall prepare a demobilisation plan that covers inspection, maintenance, storage if applicable, and return of such equipment.

8.2.2 Verification before start-up

Before the start-up of MUO, Contractor shall ensure and document that all equipment to be used is in compliance with applicable requirements.

Any restrictions relating to equipment shall be stated in the operation procedures for the equipment or system.

8.3 Diving procedures

8.3.1 Scuba diving

Scuba diving shall not be utilised, provided that it is practically possible to utilise other diving methods. If the conditions are such that it is not possible to use other diving methods, scuba diving may be used. In such case, thorough risk analyses shall be carried out and used as the basis for the preparation of procedures. Emergency procedures and emergency response shall be emphasised.

Operator's written consent shall be obtained before such diving can be commenced.

8.3.2 Surface-supplied diving

In relation to surface-supplied diving, a distinction is made between diving without planned decompression stop(s) and in-water, surface or TUP decompression.

All MUO shall be planned and carried out in accordance with NDTT, but adhering to the restrictions of maximum bottom time exposure limits given in Table 1.

Table 1 – Maximum bottom times limitations for SDO₂, in-water decompression and TUP decompression (from NDTT)

Depth (msw)	0 -12	15	18	21	24	27	30	33	36	39	42	45	48	51
SDO ₂ and in-water (min)	240	180	120	90	70	60	50	40	35	30	30	25	25	20
TUP (min)	240	240	180	180	180	130	110	95	85	75	65	60	55	50

After three days of MUO the underwater worker shall not dive, or dive to maximum 9 msw (EAD), for one day.

When using nitrox, the maximum allowed bottom time shall be calculated from EAD. Decompression stops when using nitrox and where the bottom time exceeds the bottom time exposure limit for the actual diving depth, shall nevertheless be carried out in accordance to table depth equal or deeper than the maximal actual diving depth, see Annex C, example 6.

Dive computers shall not be used to calculate and/or control decompression and/or depth profiles.

8.3.3 Saturation diving/ bell diving

For inshore saturation diving/ bell diving, relevant parts of NORSOK U-100 shall be adhered to.

8.4 Monitoring

8.4.1 General

Equipment which allows for the control and monitoring of important parameters in accordance with NORSOK U-100, 8.3, shall be utilized.

8.4.2 Depth monitoring

The underwater-worker's depth and elapsed time shall be continuously monitored with the help of an electronic depth monitoring system. The electronic sensor shall be placed on the worker. It shall be possible for the diving supervisor to read the data continuously. The following data shall be saved electronically:

- operation depth (water and chamber, see NOTE);
- maximum depth (water and chamber, see NOTE);
- bottom time;
- total time in water;
- surface interval, see NOTE;
- total time in chamber, see NOTE;
- total dive time (from normal pressure till normal pressure).

NOTE In connection with SD.

Data shall be stored for the entire contract period and made available to Operator if required.

For shallow underwater work, where it is possible to maintain the depth monitoring in other ways and if the electronic depth monitoring is impractical, Operator may approve alternative solutions. Applications shall be based on a detailed evaluation of the operation and with compensational measures given.

8.4.3 Visual monitoring

When in the water, the underwater worker shall either be equipped with a camera or monitored by a ROV.

8.4.4 Monitoring of the chamber

The following shall be monitored when using a chamber:

- a) visual monitoring of all the chamber's compartments from the operators' position;
- b) internal pressure ("depth");
- c) relative humidity;
- d) pO_2 ;
- e) pCO_2 ;
- f) temperature.

If a) is not possible without the operator leaving the control panel, video monitoring shall be used and it shall be recorded and stored together with the communication, see 8.5.

8.5 Communication

A communication system that clearly communicates speech and breathing sounds from the underwater worker, without interference, shall be used. This also applies to chambers and scuba diving.

At facilities where several people are able to communicate with the underwater worker, the diving supervisor shall have control of all communication and be able to interrupt non-essential communication if necessary.

All communication with the underwater worker while under pressure shall be recorded and stored for at least 24 h. In the event of undesirable incidents, the recordings shall be kept and made available in connection with any investigations/inquiries.

In cases where equipment such as cranes, ROVs etc. are used in connection with MUO, direct lines of communication shall be established between the diving supervisor and the operator of the equipment.

8.6 Control of breathing gas

A system shall be established to ensure that the underwater worker receives breathing gas of satisfactory quality at all times. As a minimum, breathing gas from compressors, gas banks, etc. shall be checked at least monthly. Partial pressures of contaminants shall not exceed levels in NLIA 361.

Premixed gas shall be checked on site before use.

If online mixing of gas is used, a monitoring system with alarm functions shall be used to continuously monitor the O_2 content of the breathing gas.

If a closed or semi closed breathing system is used, O_2 and CO_2 shall be continuously monitored.

9 Emergency preparedness requirements

Notification routines, emergency and treatment procedures, including the transportation of injured underwater workers, shall be configured for each individual workplace.

Where to find the approved diving doctors, local health services and local hospitals, and localization of the pressure chambers for HBO treatment shall be known. List of approved diving doctors in Norway is found on the homepage of the Chief County Medical officer in Rogaland.

In Norway when calling 113 one will be connected on to the nearest diving doctor or "Diving doctor on call". "Diving doctor on call" in Bergen has a national advisory role and may be reached directly by calling: +47 55 36 45 00.

In the event of an emergency, there shall be a plan for evacuation of personnel under pressure to a safe place. The emergency preparedness plan shall include a description of the procedure for evacuation, and how to bring the personnel back to atmospheric pressure.

The evacuation method of ill/injured underwater worker shall be documented. Contractor shall describe how an unconscious underwater worker can be lifted out of the water. When a contingency chamber is required, the underwater worker shall be in the chamber ready for recompression within 10 min after surfacing. Prior to

start-up of MUO, drills evaluating the chosen evacuation method shall be performed. For assignments of longer duration a plan for regular drills on emergency procedures shall be established.

Annex A (Normative) Forms

URF-31	Weekly report
URF-32	Experience report
UCL-31	Check list for coordination
UCM-31	Compliance Matrix

NORSOK U-103 Edition 1 Petroleum related manned underwater operations (MUO) inshore		Weekly report Report form (RF)		URF-31 Ed. 1 Page 1 of 1	
Operator:		Contractor:		Project:	
Year:	Week No.:	Place:		Date:	
Subject			Value this week	Accumulated value for this year/project	
Number of dives					
Number of dives with decompression in water					
Number of dives with decompression in chamber					
Total time spent in chamber (min)					
Bottom time (min)					
Total diving time spent in water (min)					
Working hours for project personnel related to MUO (h)					
Working days, including mobilizing/demobilizing (d)					
Number of SJAs					
Number of drills related to MUO					
Number of RUHs related to MUO activities					
Number of injuries/accidents					
Comments:					
Responsible leader:		Sign.			

NORSOK U-103 Edition 1 Petroleum related manned underwater operations (MUO) inshore		Experience report Report form (RF) Annual for all contractors and for each project of more than 14 working days duration		URF-32 Ed. 1 Page 1 of 2
Operator:	Contractor:		Project/year:	
Place:			Date:	

	Experience
Project (s) Type of assignment	
Experience from familiarisation	
Experience from mobilisation/demobilisation	
Diving method and tools used	
SHE aspects	
Working environment	
Recommendations	
Additional comments	

NORSOK U-103 Edition 1 Petroleum related manned underwater operations (MUO) inshore	Experience report (continued) Annual for all contractors and for each project of more than 14 working days duration	URF-32 Ed. 1 Page 2 of 2
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Statistical summary		Total
Number of dives		
Number of dives with decompression in water		
Number of dives with decompression in chamber		
Total time spent in chamber (min)		
Bottom time (min)		
Total diving time spent in water (min)		
Working hours for project personnel related to MUO (h)		
Working days, including mobilizing/demobilizing (d)		
Number of SJAs		
Number of drills related to MUO		
Number of RUHs related to MUO activities		
Number of injuries/accidents		
Signature: Responsible supervisor	Signature: Safety delegate	Signature: Diving doctor

NORSOK U-103 Edition 1 Petroleum related manned underwater operations (MUO) inshore	Check list (CL) for coordination between the MUO station and main plant		UCL-31 Ed. 1 Page 1 of 1
Operator:	Contractor:	Project:	
Main plant:	MUO station:	Date:	

Checklist for MUO station		Status			Sign.
		Checked OK	Not checked	Not ap- plicable	
1	Safe Job Analysis (SJA) performed				
2	Work permit obtained				
3	Plant management notified of MUO				
4	Harbour master informed				
5	Water quality – i.e. contamination?				
6	Parallel activities:				
6a	- Sluices, lock gate operation etc				
6b	- Pumps				
6c	- Boat traffic				
6d	- Crane operations				
6e	- Pile driving operations				
6f	- Blasting				
6g	- Traffic at plant (dump trucks, excavators)				
6h	- Securing loose sediments				
7	Other matters:				
7a					
7b					
7c					
Comments:					
Diving superintendent / supervisor		Plant management			
Signature:		Signature:			

NORSOK U-103 Edition 1 Petroleum related manned underwater operations (MUO) inshore		Compliance matrix (CM)			UCM-31 Ed. 1 Page 1 of 1	
Operator:		Contractor:		Project:		
Revision:	Date:	Prepared by:		Verified by:		Approved by:
Clause/ §	Requirement	c / nc	Documentation (reference etc)	Description / Corrective action		Deadline
			• • • •			

Annex B (Normative)

Medical equipment to be held at the site of inshore MUO

B.1 General

The equipment shall be packed ruggedly and appropriately and clearly marked with "Førstehjelpsutstyr" (First aid equipment). Equipment stored outside sheltered locations shall be packed in water-protected cases. The equipment shall be inspected according to a schedule at least monthly.

B.2 Minimum equipment

1	ea	Pocket mask for rescuer breathing with a spare tubing for O ₂ supply
4	ea	Protective (e.g. Latex) glove,"Large"
4	ea	Elastic bandage
1	ea	Ambulance dressing (combined sterile dressing/elastic bandage)
2	ea	Sterile dressing 20 cm x 40 cm (approximately)
4	ea	Sterile burn dressing (e.g. metalized, see below) approximately 35 cm x 45 cm
5	pack	Sterile dressing 10 cm x 10 cm (package containing 2 to 5 dressings)
1	pack	Adhesive wound dressing
1	roll	Adhesive tape, 2,5 cm (~ 5 m)
1	roll	Plastic bags (e.g. domestic bags, clear plastic)
1	ea	Tough cut scissors
1	ea	Forceps, anatomical, ~ 12 cm
1	ea	Eye rinsing bottle
1	ea	Flashlight (preferably high-intensity "penlight" or similar.)
1	bottle	Skin disinfectant (e.g. Chlorhexidine 1 mg/ml) 100 ml
1	bx	Paracetamol tablets 500 mg, 20 ea
1	bx	Nose decongestants (Nasal drops, minims)

B.3 O₂ therapy unit

There shall be sufficient O₂ to allow 60 min treatment, based on 15 l/min ventilation (unless otherwise could be specifically qualified), i.e. a total supply of 900 n litre. The O₂ supply could be divided on multiple bottles, but the bottles shall have a size that allows transportation with the patient. The unit shall include a demand regulator as well as an outlet for fixed or adjustable free flow. If the free flow outlet delivers a fixed flow, this shall be at least 10 l/min.

The unit shall include a mask ("Hudson mask") with a gas line that can be connected to the free flow outlet, and a gas tubing that can be connected between the pocket mask and the free flow outlet.

NOTE There are certain bandages for use on burn wounds (e.g. Water Jel and Burn Shield) with very beneficial properties that combine cooling, antimicrobial and analgetic properties. Such bandages should be considered for use in projects with increased risk of burn injuries.

Annex C (Informative)

Examples on how to calculate bail-out gas and equivalent air depth

Some practical examples on how to apply specified clauses of this NORSOK standard are given below.

To 5.4 Threshold values for pO_2 and O_2 exposure

Example 1

A nitrox dive with staged water decompression is planned with maximum diving depth of 34 m using full face mask (not free-flow helmet). Which of the standardised nitrox mixtures (32, 36 or 40) are allowed, and what is the maximum allowed bottom time for the most hyperoxic (highest pO_2) mixture? How should the staged decompression take place (if staged decompression is required)?

Answer – Example 1

P_{O_2} at 34 m with various nitrox mixtures:

Nitrox 32: $pO_2 = 0,32 \times 4,4 \text{ bar} = 1,41 \text{ bar}$

Nitrox 36: $pO_2 = 0,36 \times 4,4 \text{ bar} = 1,58 \text{ bar}$

Nitrox 40: $pO_2 = 0,40 \times 4,4 \text{ bar} = 1,76 \text{ bar}$

When diving with full face mask or light free-flow helmet diving, the maximum $pO_2 = 1,6 \text{ bar}$ (for heavy free-flow diving (Siebe Gorman) maximum $pO_2 = 1,8 \text{ bar}$). Nitrox 32 and Nitrox 36 could be used, but not Nitrox 40. Maximum bottom time for $pO_2 = 1,6 \text{ bar}$ with light free-flow helmet or full face mask is 30 min (NDTT, page 26, serial 7). EAD is 26 m using Nitrox 36 at the actual diving depth of 34 m. Accordingly a staged decompression stop shall be completed at 3 m lasting 5 min (NDTT air decompression table, 27 m/30 min).

Example 2

A dive to 24 m is planned with air as the breathing gas, and SDO_2 . Maximum allowed exposure is planned for. Which O_2 toxicity dose (in OTU) will this cause?

Answer – Example 2

NDTT allow a maximum bottom time of 180 min at 24 m with SDO_2 . Table 1 Maximum bottom times limitations for SDO_2 , in-water decompression and TUP decompression (from NDTT) (see 8.3.2) tabulate a maximum allowed bottom time of 70 min at this depth. Maximum allowed bottom time is the shortest one of these two: 70 min.

NDTT stipulate in-water decompression for 2 min at 9 m followed by 17 min of O_2 breathing at 12 m.

pO_2 breathing air at 24 m: $0,21 \times 3,4 \text{ bar} = 0,71 \text{ bar}$

Pressure dependant constant (k_p) for $pO_2 = 0,71 \text{ bar}$ is 0,65

NOTE The pressure dependent constant (k_p) is calculated as a function of pO_2 . A table for estimating k_p is printed on page 24, serial 11 in NDDT. In this example, the actual $pO_2 = 0,71 \text{ bar}$. k_p is calculated based on the closest higher tabulated value of pO_2 which in this example was 0,8 bar.

O_2 exposure during immersion: $0,65 \times 70 = 46 \text{ OTU}$

pO_2 while breathing O_2 at 12 m (chamber recompression): $1 \times 2,2 \text{ bar} = 2,2 \text{ bar}$

k_p for $pO_2 = 2,2 \text{ bar}$ is 2,77

O_2 exposure during the dry/chamber part of the dive: $2,77 \times 17 = 47 \text{ OTU}$

Total O_2 exposure: $46 \text{ OTU} + 47 \text{ OTU} = 93 \text{ OTU}$

This is less than the maximum allowed 300 OTU stipulated as the maximum highest daily exposure. (2100 OTU/week). O_2 exposure during decompression and during air breaks is not included due to the marginal effects on the final exposure.

To 7.2.4 Emergency gas stores and 7.2.5 Bail-out

Minimum requirements for emergency bail-out gas is stipulated in these subclauses. The requirement calls for a minimum of 10 min of breathing gas based on a ventilatory requirement of 62,5 litre/min at the actual pressure.

Example 3

A dive to a maximum of 45 m, using air as a breathing gas, is planned for. What is the minimum volume of the air tanks required for emergency purposes if the tank pressure is 200 bar? Assume that 12 bar is the lowest usable gas pressure in the tanks. Tanks filled to 200 bar or 300 bar will accordingly have 188 bar and 288 bar available for use to the underwater worker.

Answer – Example 3

Ambient pressure at 45 m: 5,5 bar

Ventilation: 62,5 l/min/bar x 10 min x 5,5 bar = 3437,5 litre

Air tank volume required for 200 bar tank: 3437,5 litre / 188 = 18,3 litre

For all practical purposes, the underwater worker should carry a bail-out of 2x10 litre.

Examples for minimum quantity of emergency breathing gas, based on maximum depth are shown in the table below.

Max depth	Tank pressure	
	200 bar	300 bar
21 msw	1 x 10 l	1 x 7 l
36 msw	1 x 15 l	1 x 10 l
50 msw	2 x 10 l	1 x 15 l

To 7.2.6 Emergency gas stores for surface supplied diving

The requirements call for “sufficient store of breathing gas”. This can be interpreted so that for an underwater worker, using a heavy free-flow helmet and e.g. being lifted to surface or when connected to an alternative breathing gas source in the water, he shall not get careless, unconscious or react with panic. This condition can be assumed to occur with $pO_2 < 14$ kPa and/or $pCO_2 > 8$ kPa. The requirements do not stipulated the exact volume of the total breathable volume of the helmet and diving suit, but an average figure for the calculation could be 46 litres, (underwater worker significantly negatively buoyant on the bottom, as when working hard) with a range of 36 litres to 66 litres. The respiratory rate 62,5 l/min (see 7.2.4) is normally estimated to correspond to an O_2 consumption of 2,5 l/min (STPD) and for simplicity the CO_2 production is set to the same.

Example 4

A free-flow helmet underwater worker works at 10 m and loses breathing gas supply. How long time will it take before pO_2 and pCO_2 reaches threshold value?

Answer – Example 4

Available breathable volume of suit: 46 l x 2 bar = 92 litres (STPD)

CO_2 content of suit when losing gas supply: 0 % x 92 l = 0 litres

O_2 content of suit when losing gas supply: 21 % x 92 l = 17,8 litres

CO_2 volume of the suit at $pCO_2 = 0,08$ bar (8 kPa): 92 l x (0,08 bar/2 bar) = 3,7 l

O_2 volume of the suit at $pO_2 = 0,14$ bar (14 kPa): 92 l x (0,14 bar/2 bar) = 6,4 l

Time until $pCO_2 = 0,08$ bar: (3,7 – 0) l/2,5 l/min = 1,5 min

Time until $pO_2 = 0,14$ bar: (17,8 – 6,4) l/2,5 l/min = 5 min

Example 5

A free-flow helmet underwater worker works at 40 m and experience gas cut. How long time will it take before pO_2 and pCO_2 reaches threshold value?

Answer – Example 5

Available breathable volume in the suit: 46 l x 5 bar = 230 litres (STPD)

CO_2 content in the suit when loosing gas supply: $0\% \times 230 \text{ l} = 0 \text{ litres}$
 O_2 content in the suit when loosing gas supply: $21\% \times 230 \text{ l} = 48,3 \text{ litres}$
 CO_2 volume in the suit at $p\text{CO}_2 = 0,08 \text{ bar}$ (8 kPa): $230 \times (0,08 \text{ bar}/5 \text{ bar}) = 3,7 \text{ l}$
 O_2 volume in the suit at $p\text{O}_2 = 0,14 \text{ bar}$ (14 kPa): $230 \text{ l} \times (0,14 \text{ bar}/5 \text{ bar}) = 6,4 \text{ l}$
 Time until $p\text{CO}_2 = 0,08 \text{ bar}$: $(3,7 - 0) \text{ l} / 2,5 \text{ l/min} = 1,5 \text{ min}$
 Time until $p\text{O}_2 = 0,14 \text{ bar}$: $(48,3 - 6,4) \text{ l} / 2,5 \text{ l/min} = 17 \text{ min}$

To 8.3.2 Surface-supplied diving

Example 6

A dive to 28 m using a heavy free-flow helmet is planned for. How long bottom time is allowed using air as the breathing gas? What is the maximum allowed bottom time using nitrox as a breathing gas? How should the decompression be executed?

Answer – Example 6

Maximum allowed bottom time at 28 m using air is 50 min (Table 1 Maximum bottom times limitations for SDO₂, in-water decompression and TUP decompression (from NDTT) (see 8.3.2). This could either be done using staged in-water decompression using the standard air table (NDTT) for 30 m/50 min (a total of 30 min decompression in water) or with SDO₂ according to the table (NDTT) for 30 m/50 min (3 min in-water decompression followed by 17 min of O₂ breathing at 12 m in the chamber).

When considering nitrox, the maximum allowed $p\text{O}_2$ should not be exceeded. Maximum allowed $p\text{O}_2$ with heavy free-flow helmet/Siebe Gorman and unlimited bottom time is 1,5 bar.

The O₂-fraction at 28 m with $p\text{O}_2 = 1,5 \text{ bar}$: $1,5 \text{ bar} / 3,8 \text{ bar} = 39,5\%$

Of the available standardised nitrox mixtures, the highest allowable mixture is Nitrox 36 (Nitrox 40 would have been marginally too "rich").

EAD using Nitrox 36 at 28 m: 20,8 m

Maximum allowed bottom time at EAD 20,8 m (rounded to 21 m): 90 min (see Table 1).

The requirement is that staged decompression-stops should be taken according to the procedure for the actual depth and bottom time.

Diving with staged decompression stops in water, the maximum allowed bottom time for a table depth of 28 m is 55 min (NDTT). Decompressing in water using the 30 m/55 min table would call for a total of 35 min of decompression. If alternatively surface decompression with O₂ is chosen, the decompression should be completed according to the table for a 30 m/90 min dive, i.e. 4 min of decompression in water followed by 43 min of O₂ breathing in the chamber.

