NORSOK STANDARD

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Manned underwater operations

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Revision information

Major changes from revision 3 to 4 are listed below.

Removed:

- Standards for use of ADS (atmospheric diving system) is removed, information may be found in edition 3.

Edited:

- 2.1 Normative references list has been evaluated and revised.
- 2.2 Informative reference list has been replaced with bibliographies (last Annex).
- Edition 3 subclause 4.6.3.1 has been modified. This is covered in edition 4 subclause 4.8.3.3 and in Styringsforskriften/management regulations.
- 5.1.5.3 has been changed from “access to telecommunication” to “Telemedicine”.
- 5.2.3 Chemical working environment and subclauses have been modified.
- 6.3 Requirements for diving personnel – some subclause content has been modified.
- 7.2.3 Chambers for surface oriented diving have been modified.
- 7.2.4.3 Emergency connectors for diving bells, habitats and SPHLs – table and figure have been modified.
- 7.4 and clause 9 are upgraded to match new IMCA documents D051, 052 and 053, and OGP-478.
- 7.7.2 Normal operation have been modified.
- 7.11.3.4 The support vessel has been modified (edition 3 subclause 7.12.2.2).
- 7.17 Maintenance have been modified. Reference to NORSOK Z-008).
- 8.1.2.6 Log books. Included requirements of medical and stamped photo.
- 8.2.1 General – text edited.
- 8.2.2 Surface oriented diving – text modified.
- 8.2.4 Deeper saturation diving – text modified. All references to additional depth requirements are changed to 180 msw ref. aktivitetsforskriften para 94.
- 8.5.1 Manning of control room – text modified.
- 8.5.5 Stand-by diver and contingency diver – text modified.
- Annex B – new build up and content.

Edited and moved:

- Risk management is moved from subclause 5.3 to new 4.2.

New and added text:

- 1 Scope – added text deeper than 180 msw.
- 4.5 Management of Change – new.
- 5.1.4 Short and long term health monitoring – added text.
- 5.2.3 Chemical environment – added new subclauses.
- 6.3 Diving personnel: Use of simulator as part of training.
- 6.3.6 Divers, requirements for health and approved certificate included, as well as advanced first aid training for surface oriented diving teams.
- 6.3.7 Diving technician/maintenance engineer – new text added.
- 6.3.11 Hyperbaric trained Nurse – new text added.
- 7.1.1 Implementing new technology – new.
- 7.3.1 general – added text with reference to NORSOK R-002.
- 7.6 Gas supply systems, color coding for gas.
- 7.8.1 General – text added regarding disinfection and microbiological sampling/control of BA.
- 7.11 Diving support vessel (DSV) – several new subclauses.
- 8.3.1 General – text added regarding PLC controlled dive systems.

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 standardisation work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by the Norwegian Oil and Gas Association (Norwegian Oil and Gas), The Federation of Norwegian Industries, Norwegian Ship owners' Association and The Petroleum Safety Authority Norway.

NORSOK standards are administered and published by Standards Norway.

Annex A and B are informative.

Introduction

This NORSOK standard is the result of an industry-wide effort to establish a standard for manned underwater operations (MUOs).

1 Scope

This NORSOK standard defines basic requirements for personnel, equipment and systems for MUOs within the petroleum industry. Main focus for this NORSOK standard has been diving down to 180 msw. For diving deeper than 180 msw, special consideration, evaluations and mitigation actions, some of which are specified in this standard, are required.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this text and are indispensable for the application of this NORSOK standard. Latest issue of the referenced documents (including any amendments) applies unless otherwise agreed. Other recognised standards may be used provided it can be shown that they meet the requirements of the referenced standards.

CEN/TR 15321	*Guidelines on the selection, use, care and maintenance of protective clothing*
EN 482	*Workplace exposure – General requirements for the performance of procedures for the measurement of chemical agents*
EN 689	*Workplace atmospheres – Guidance for the assessment of exposure by inhalation to chemical agents for comparison with limit values and measurement strategy*
EN 1089-3	*Transportable gas cylinders – Gas cylinder identification (excluding LPG) – Part 3: Colour coding*
EN 13921	*Personal protective equipment – Ergonomic principles*
EN 14042	*Workplace atmospheres – Guide for the application and use of procedures for the assessment of exposure to chemical and biological agents*
HSE-MA1	*The medical examination and assessment of divers (MA1)*
IMCA D 045	*Code of practice for the safe use of electricity underwater*
IMO 808E	*Code of safety for diving systems* (resolution A.536(13) as amended by resolution A.831(19)) and any further amendments. As printed in ISBN 978-92-801-14324 (Sales number IMO 808E, London: IMO,1997) or later edition
ISO 9001	*Quality management systems – Requirements*
ISO 19901-7	*Petroleum and natural gas industries – Specific requirements for offshore structures – Part 7: Stationkeeping systems for floating offshore structures and mobile offshore units*
NBH IK-2708	The Norwegian Board of Health IK-2708. *Norwegian guidelines for medical examination of occupational divers.* (Statens helsetilsyns veiledningsserie; vol 2000;1-00. Oslo, 2000 or any later edition)
NORSOK R-002	*Lifting equipment*
NORSOK R-003	*Safe use of lifting equipment*
NORSOK U-101	*Diving respiratory equipment*
NORSOK U-102	*Remotely operated vehicle (ROV) services*
NORSOK U-103	*Petroleum reated manned underwater operations inshore*
NORSOK Z-008	*Risk based maintenance and consequence classification*
NORSOK Z-013	*Risk and emergency preparedness assessment*

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

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

3.1.2

assistant life support technician
ALST
person with the proper theoretical qualifications who is undergoing a period of planned work experiences for his training to become a LST

3.1.3

bail-out
emergency breathing gas supply that contains sufficient breathing gas for the diver to be able to reach a place of safety where more breathing gas is available, such as the surface or a diving bell

3.1.4

bell run
time from when depressurisation of the lock between the bell and the compression chamber is commenced (and the divers in the bell consequently do not have access to the chamber complex), and until the bell again has been connected to the chamber complex and the pressure in the lock has been equalised (so that the divers again have access to the chamber complex)

3.1.5

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

3.1.6

competent person
person with authorisation/documented qualifications for performing a specified function

3.1.7

compression period
compression commences at the start of pressurisation and is completed upon arrival at the working depth, or for saturation diving, the planned living depth including stand-off periods and HPNS screening time

3.1.8

contingency diver
nominated diver as part of the contingency preparedness, which has diving equipment ready for use on surface but is not dressed

3.1.9

decompression period
a) *during saturation diving:* from the start of build-up of the pO_2 in preparation for the final decompression phase, until arrival at atmospheric pressure
b) *during surface oriented diving*: from starting final ascent until arrival at surface pressure

3.1.10

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

3.1.11

diving basket
devise used to lower and recover divers to and from work-sites subsea, which do not protect against contact with surrounding water

3.1.12

duty diving doctor
medical doctor, approved as duty diving doctor, who is on call during diving operations

3.1.13

diving bell
submersible compression chamber designed for transport of personnel between the surface and the work site at atmospheric pressure or under increased pressure

3.1.14

diving contractor
diving company or firm undertaking petroleum related MUOs

3.1.15

diving operation
activity where the diver is directly exposed to increased ambient pressure

3.1.16

diving superintendent
person who is qualified and has been appointed in writing by the diving contractor to be the person in charge of, and responsible for, a MUO

3.1.17

diving supervisor
person who has been appointed in writing by the diving contractor to be in charge of a MUO or parts of such operation

3.1.18

diving work-site
site from which the diving is performed
NOTE Also referred to as diving platform.

3.1.19

excursion
any descent or ascent from pressure at living depth

3.1.20

incident
generic term covering any undesired event

3.1.21

life support supervisor
LSS
person who has been appointed in writing by the diving contractor to act as ”person in charge” of the operation of a chamber complex with associated equipment

3.1.22

life support technician
LST
qualified person operating a chamber complex with associated equipment

3.1.23

living depth
pressure/depth at which the saturation divers stay in the chamber complex following the compression period and intermediate compressions/decompressions, and prior to final decompression period

NOTE Also called "storage depth".

3.1.24

manned underwater operation
MUO
activity when humans stay below surface and/or are exposed to increased ambient pressure

3.1.25

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

3.1.26

meters 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

3.1.27

near-accident
event that, under slightly different circumstances, could have caused personal injury, fire, environmental/material damage or loss of production

NOTE Also called "near miss".

3.1.28

offshore manager
the diving contractor's representative at the worksite and is generally appointed on larger projects.

3.1.29

operator
oil company, responsible as the obligated party

3.1.30

safety critical element
a safety critical system is a system whose failure or malfunction can result in death or serious injury to people, or loss or severe damage to equipment or environmental harm

3.1.31

SCUBA (Self Contained Underwater Breathing Apparatus) diving
is a form of underwater diving in which a diver uses SCUBA to breathe underwater

3.1.32

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

3.1.33

small diving craft
small boat equipped as a complete dive station and operating from a mother vessel of opportunity

3.1.34

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

3.1.35

stand-by diver
diver who is prepared, dressed and equipped to give immediate assistance to the diver

NOTE: For saturation diving the bell-man is the stand-by diver.

3.1.36

stay at working depth
period of time between completed compression, or first compression if work is to take place at several levels of pressure, and commencement of the final decompression excluding stabilising period and O_2 build up which is part of the decompression

3.1.37

submerged habitat
submerged chamber or device positioned below surface and designed so as to allow personnel to work there under dry conditions

3.1.38

supervisory personnel
personnel on the diving team acting in a supervisory role

NOTE Diving supervisors, LSSs, superintendents, etc.

3.1.39

surface oriented diving
diving where the diver enters and leaves the water at normal ambient pressure

NOTE: The term “surface supplied diving” is also used in the industry

3.1.40

time in water, bell diving
period of time from when a diver leaves the bell on a lock-out until he returns to the bell after completed lock-out, including any rest periods required during the lock-out, but not including mandatory rest period

3.1.41

trainee diving supervisor
diver undergoing a period of planned work experiences for his training to become a diving supervisor

3.1.42

transfer under pressure
TUP
intervention method used in non-saturation diving shallower than 50 msw, where the divers 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 oriented air/nitrox diving techniques (in-water decompression-stops). The term TUP has different meaning in different contexts. Sometimes it is used for any process where divers 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.

3.1.43

verification
confirmation, through provision of objective evidence, that specified requirements have been fulfilled

NOTE 1 The term “verified” is used to designate the corresponding status.
NOTE 2 Confirmation may comprise activities such as
- performing alternative calculations,
- comparing a new design specification with a similar proven design specification,
- undertaking tests and demonstrations,
- reviewing documents prior to issue.

3.1.44

wet bell
open unit with an upper section containing a pocket of breathable gas, used to lower and recover divers to and from work-sites subsea, and equipped with on board contingency breathing gas, and a diver’s panel for diver’s umbilical.

3.1.45

working depth
actual water depth on the diver’s worksite

3.2 Abbreviations

ALST	assistant life support technician
Ar	argon
BA	breathing apparatus
BIBS	built in breathing system
CO	carbon monoxide
CO_2	carbon dioxide
DMAC	Diving Medical Advisory Committee
DNV	Det norske Veritas
DP	dynamic positioning
DSV	diving support vessel
EDTC	European Diving Technology Committee
FMEA	failure mode and effects analysis
FMECA	failure mode, effects and criticality analysis
FRC	fast rescue craft
HAZID	hazard identification
HEL	hyperbaric exposure limit
HPNS	high pressure nervous syndrome
HSE	Health and Safety Authority (UK)
IMCA	The International Marine Contractors Association
IMO	International Maritime Organisation
kPa	kilopascal
LARS	launch and recovery system
LSP	life support package
LSS	life support supervisor
LST	life support technician
msw	meters of sea water
MUO	manned underwater operation
N_2	nitrogen
NO_x	mono-nitrogen oxides
NBH	Norwegian board of health
NAV	the Norwegian Labour and Welfare Administration
NPD	Norwegian Petroleum Directorate
O_2	oxygen
O_3	ozone
OEL	occupational exposure limit
OGP	The International Assosiation of Oil and Gas Producers
pAr	partial pressure of Ar
pN_2	partial pressure of N_2
pCO_2	partial pressure of CO_2
pO_2	partial pressure of O_2
ppm	parts per million
PLC	programmable logic controller
PSA	Petroleum Safety Authority (Petroleumstilsynet)
QA	quality assurance
ROV	remotely operated vehicle
SCUBA	Self-contained underwater breathing apparatus
SHE	safety, health and environment
SPHL	self-propelled hyperbaric life boat
STEL	short term exposure limit
TUP	transfer under pressure
UV	ultraviolet

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 standard is imposed on anyone engaged in MUO.

The contractor shall set internal requirements that put these NORSOK requirements into concrete terms, and that contribute to achieving the objectives for SHE. If the internal requirements are expressed as functional requirements, achievement criteria shall be set.

The contractor's organisation shall include administrative functions responsible for areas that ensure a safe and efficient operation. As a minimum, these functions are

- diving discipline,
- SHE,
- emergency preparedness,
- QA,
- personnel,
- management of diving equipment and systems,
- competent controls engineering group responsible for safekeeping of software.

4.2 Safety

The contractor shall during all activities and on all levels in the organisation strive to enhance safety.

Responsibility for safety is in the line organisation, and each individual shares this responsibility. However, top management holds a particular responsibility for creating an atmosphere and a psychosocial working environment within the organisation that enhances safety, places safety issues on the daily agenda and rewards the safe conduct of work.

All critical equipment, and operational and emergency procedures, shall be subject to thorough risk analyses to disclose consequences of single failures and series of failures, and to evaluate the possibilities for such failures. Operational and technical expertise and experience shall be brought into these assessments. The results shall be compared to the acceptance criteria, and on this basis, risk-reducing measures shall be taken. These analyses and resulting measures shall be documented.

Risks analyses shall be performed using recognised methods, e.g. failure mode and effect analysis, fault tree analysis, event tree analysis, hazard and operability studies, hazard identification studies and safe job analysis, in accordance with NORSOK Z-013.

Technical risk analyses (FMECA, FMEA, HAZID) should provide a single, consistent top-down approach for all diving related risks, ensuring there are no gaps in the suite of risk documentation and that human interaction and operator error risks are accounted for. Risk analyses, including FMECA`s should be routinely updated based on changing conditions, equipment, assumptions, knowledge etc. Feedback from updated risk analysis (FMECA`s) should be used to improve the emergency preparedness. Likewise, if operational experience uncover gaps in the emergency preparedness this should be fed back to the FMECA process to ensure that the next FMECA revision consider these findings and evaluate risks and mitigations.

4.3 Documentation

The contractor shall document the diving methods, diving equipment operation and dive system maintenance relevant for the scope of work to be conducted under a contract. This documentation shall be based on the contractor's general diving procedures for MUO and, if relevant, include a description of DP-operations, and be in accordance with ISO 19901-7.

Management systems and QA shall be implemented in accordance with ISO 9001. Technical and operational documentation shall be in accordance with national legislation and this NORSOK standard.

The contractor shall have a documented system for systematic, preventive and criticality based maintenance, including updating of certificates, covering all diving related equipment, systems and machinery, in accordance with NORSOK Z-008.

As a minimum, the contractor shall define, document and make available procedures covering

a) normal and emergency operation of the equipment,
b) function and verification testing, including acceptance parameters,
c) limits for monitoring parameters, including early warning,
d) check lists for routine operation, for technical equipment and operational aspects,
e) manning requirements for competence in accordance with normal and emergency operation checklists and procedures,
f) detailed job descriptions for all personnel categories involved in the MUO,
g) SHE activities related to the work-site (if relevant)/diving activities,
h) individual equipment criticality rating system including overall system accept criteria for use, ref. 7.18.

These procedures shall include minimum requirements in order to commence an operation, criteria for suspension and emergency procedures.

Findings/reports from relevant risk analyses, including resulting risk reducing measures shall be available to operational personnel, see 4.2 and 9.

Personnel certification status and qualifications shall be presented in the form of a personnel qualification matrix.

Check lists are part of the operational documentation, and shall be an aid to ensure that the preconditions for initiation, implementation and termination of a safe operation are met. Check lists should have a simple and straightforward lay-out and should cover both normal operations and emergency situations.

Emergency procedures shall be specific to the equipment and work-site. Detailed emergency procedures covering all emergency scenarios shall be available e.g. FMECA. The scenarios shall include provision of medical care for a critically injured/sick diver under pressure.

4.4 Compliance and deviations

The contractor shall prepare in-date compliance measurement matrix with regards to this NORSOK standard and relevant regulatory requirement s. The matrixes shall be available to the operator. Compliance shall be documented and the contractor shall evaluate all items of non-compliance. Qualified alternative solutions may be suggested, and shall be documented. The compliance matrix shall state the administrative function responsible for handling a non-compliance.

Exceptions from NORSOK standards have to be evaluated and accepted by the parties involved, including representatives from the diving personnel, their safety delegates and the operator. A risk analysis shall be performed.

Non-compliances to regulatory requirements shall be evaluated by the operator before an application for exemption may be forwarded to the applicable authority.

4.5 Management of change

The procedure for management of change shall include a risk assessment of the proposed change (change to procedures, or modifications to equipment and plant), peer acceptance of the modification (including class approval as required), documented implementation, testing and verification (7.18) after implementation and final close-out. All modifications shall be documented and included in the affected system as-built documentation (4.3). Affected compliance measurements, (4.4), and certificate status, (4.6), shall continuously reflect the current as-built status of the system.

4.6 Certification/verification

Documentation shall be provided to demonstrate that equipment for MUO has been manufactured, function tested and, where relevant, type approved in accordance with the requirements of this NORSOK standard.

The contractor shall document that procedures and equipment critical to SHE, and used in connection with MUOs at any given time, comply with functional and technical requirements in this NORSOK standard.

Prior to commencement of any MUO, the contractor shall ensure that the above documentation, in addition to certificates for the diving system, including all relevant components, auxiliary and emergency equipment, is issued and valid. Certificates issued shall be specific and identify the equipment they cover. Limiting

factors for the above shall be included in the operating instructions. The contractor shall have a system for ensuring that the documentation is kept valid for the duration of the operation.

4.7 Document availability

As a minimum, the contractor shall ensure availability of updated editions of the documentation referred to in Table 1.

Table 1 – Documentation required

Description	Contractor	Work-site
Contractor's project QA manual/plan	X	X
Contractor's SHE plan for the operation/work-site	X	X
Contractor's operational manuals, pertaining to the relevant contract	X	X
Contractor's contingency plan for the relevant contract, interfaced with operator's plan for the relevant concession areas	X	X
Contractor's personnel documentation matrix (including sub-contractors)	X	X
Experience reports from previous, relevant operations.	X	X
All relevant regulations	X	X
All normative references applicable for the operation to be undertaken	X	X
Relevant bibliography references listed in Bibliography or equivalent	X	
Updated crew-lists and shift schedules, including sub-contracted personnel	X	X
Documentation to satisfy 6.3	X	
Certificates to satisfy 6.3	X	X
Suppliers instructions for maintenance and operation of all equipment	X	X
Procedures for all activities pertaining to the relevant contract	X	X
All relevant safety notices	X	X
Copies of contracts relating to the operation	X	X
Applicable classification rules	X	X
Copies of any dispensations granted from operator and/or authority requirements, together with documentation for which the dispensation is granted	X	X
Relevant risk analysis	X	X
Log books to document operational activities		X
Updated compliance measurement	X	X

4.8 Reporting

4.8.1 General

The contractor shall have a system for recording, storage and retention of diver exposure data, ref. clause 8.3. The contractor's reporting of manned underwater activities shall be structured to provide the operator with data to meet regulatory and operator's requirements for reporting.

4.8.2 Contractor's scheduled reporting responsibilities

4.8.2.1 Daily operation

A daily progress report shall include MUO data. Copies of all logs and reports shall be made available for the operator's representative upon request.

4.8.2.2 Experience feedback reporting

Experience gained during operation shall be systematically reported back to the discipline department, where it shall be analysed and evaluated by competent personnel. If required, corrective actions shall be implemented as a result of this process.

4.8.2.3 Monthly activity report

The contractor shall, if relevant, at the end of each calendar month submit to the operator a summary of the previous month's activities, specifying abnormalities, technical and operational problems of relevance to the safety or health of the personnel, and detailing corrective actions taken.

An evaluation of the medical aspects of the operation shall be included. The working environment committee shall have reviewed this evaluation report.

4.8.2.4 Annual/final experience report

Within three weeks after completed demobilisation, or other defined work period (e.g. season), the contractor shall submit to the operator a complete evaluation report, prepared in co-operation with the safety delegates and the responsible diving doctor. All aspects relevant to the applicable regulations, safety, occupational health and technical/operational issues shall be included.

4.8.3 Notification and reporting, accident/near-accident/illness

4.8.3.1 General

The contractor shall have an established system for alert/notification, reporting and investigation of accidents, near-accidents and illness, which satisfies regulatory as well as operator requirements.Equipment failures detected during routine, pre-dive checks (documented in checklists/logs) should be registered as equipment failures (see 4.8.3.6), and are not considered to be near-accidents.

4.8.3.2 Special requirements for MUO under the Norwegian Petroleum Act

During MUO under the Norwegian Petroleum Legislation, special requirements shall be observed. All notification and reporting to Norwegian authorities shall be done by the operator (with the exception of the NAV form). For further guidance on these requirements, see annex A.

4.8.3.3 Alert/notification

The operator's on board/onsite representative shall be notified immediately of all accidents/illnesses involving first aid or medical treatment and all near-accidents at the work-site (see annex A), in accordance with the emergency preparedness plan. As a minimum, following details shall be included:

a) location and time;
b) name of any injured/sick persons;
c) details of the incident;
d) plans for following up the injury/illness;
e) name of contact person.

For MUO the following additional information shall be included with the alert/notification when relevant:

f) planned depth;
g) depth at which the first symptoms occurred;
h) gas mixture;
i) purpose of the ongoing operation;
j) location of personnel;
k) operational method;
l) name of persons in the operation management;
m) wind and wave conditions, visibility, etc.

4.8.3.4 Reporting

Every fatal accident, accidents/illnesses that require first aid and/or medical/hyperbaric treatment and near-accidents (see 4.8.3.1) shall, without delay, be reported to the operator representative, and subsequently, as required, to the authorities. For MUO, the specialized form in A.3 shall be used. All reporting shall comply with national legislation to preserve anonymity of the individual patient (medical confidentiality).

For MUO the following additional details shall be reported, where relevant:

a) planned depth;
b) depth at which the first symptoms occurred;
c) gas mixture;
d) purpose of the ongoing operation;
e) location of personnel;
f) operational method;
g) name of persons in the operation management;
h) wind and wave conditions, visibility, etc.

With respect to injury or illness, the following should be included in the report:

i) a description of the injury or illness;
j) the first symptom;
k) type of first aid;
l) who administered first aid;
m) further treatment;
n) location of the injury or presenting symptoms;
o) an assessment of contributing causes to the injury or illness.

4.8.3.5 Use of medication

All use of medication shall be logged and reported to the health service.

4.8.3.6 Equipment failure

The contractor shall have an established system for registration/notification and correction of equipment failures.

4.8.3.7 Investigation

Serious accidents and near-accidents shall be investigated in accordance with an established procedure, and the conclusions drawn from this investigation shall be reported to the operator, together with planned measures to prevent reoccurrence. The method used for investigation shall ensure that operational, human, technical and organisational aspects are considered when defining the causes of the occurrence.

The investigation shall take place as soon as possible after the event. The scene of the accident/near-accident shall not be disturbed until all investigations are completed.

The investigation shall be carried out in addition to any investigation implemented by a public authority, or a public appointed accident commission.

5 Health and environment requirements

5.1 Health

5.1.1 General

The diving contractor shall establish, maintain and use procedures which prevent short and long term harmful effects on divers. The diving contractor shall regularly evaluate and update procedures based on empirical data from available sources.

The diving contractor shall establish an occupational health service covering MUO.

5.1.2 Health service

5.1.2.1 Organisation

The health service shall be organized so that it remains professionally and medically independent, and the lines of reporting shall be clear and unambiguous. The health service shall have access to all information necessary to enable it to carry out required tasks.

A responsible competent diving doctor shall be appointed as medically responsible for the health service.

5.1.2.2 Duties

5.1.2.2.1 The health service

The health service is responsible for

a) the supervision of all health-related aspects in all phases of MUO,
b) evaluating and accepting diving procedures,
c) reviewing diving related injuries and illnesses,
d) promoting safety through involvement in planning of MUO,
e) advising line management and personnel engaged in MUO on conditions of significance to health,

f) preparing medical contingency plans,
g) organising a duty diving doctor service to ensure diving medical treatment in cases of illness or injury,
h) supervision of all aspects of hygiene during MUO, (examples in STF78 A99123 [1]),
i) establishing a system for provision of adequate nutrition, including adequate fluids,
j) establishing a system for first aid training of offshore personnel involved in MUO,
k) Short and long term follow up of diver's health.

5.1.2.2.2 The medical contingency plan

The medical contingency plan shall address

a) handling of all acute medical problems in MUO,
b) procedures for hyperbaric evacuation,
c) how to return personnel to surface pressure and give required medical treatment during decompression period,
d) how qualified medical treatment can be given to personnel under pressure,
e) how drills are to be carried out in order to handle an accident or a hazardous situation.

5.1.3 Evaluation of medical fitness

Divers shall hold a valid certificate of medical fitness for personnel required to work under increased ambient pressure in accordance with national guidelines (ref. NBH IK-2708, HSE-MA1 or equivalent). The medical practitioner performing the examination shall be approved by national authority. The examination shall be performed in accordance with NBH IK-2708 or HSE-MA1. See also EDTC-FTD [2] or Wendling et al. (2004) [3] for information.
Proof of valid diver medical fitness certificate shall be logged, stamped and signed in the Divers Logbook by the issuing medical doctor.

The health service shall establish individual medical files for all divers, containing information on

a) health status,
b) previous work experience, including diving exposure data,
c) illnesses and injuries with relevance to diving.

5.1.4 Short and long term health monitoring

Pre- and post-dive medical checks, in accordance with procedures approved by the responsible diving doctor, shall be conducted routinely for all divers. For saturation divers these checks shall be performed upon entering and surfacing from saturation dives, and for surface oriented divers prior to and after completion of work periods.

Reports from these checks shall be part of the individual follow-up of the divers. A system for monitoring also long term health effects of diving shall be established. The health surveillance system shall provide a strategy for the early detection of adverse health changes related to exposure to hazardous substances or procedures in connection with diving. The general criteria for conducting health surveillance are:

a) There is an identifiable disease or other identifiable adverse health outcome.
b) The disease or health effect can be related to exposure.
c) There is a likelihood that the disease or health effect can occur.
d) There are valid techniques for detecting indications of the disease or health effects.

The health surveillance system shall be based on a health risk assessments and statutory requirements. The following exposures for divers could dictate health surveillance of organs at risk:

e) exposure to noise or other inner ear hazards;
f) exposure to pulmonary hazards;
g) use of hand-arm vibration tools;
h) exposure to central nervous system hazards.

Health surveillance techniques should be sensitive, specific, easy to perform and interpret, safe, non-invasive, and acceptable. Examples are hearing test (audiometry), lung function test (spirometry), and questionnaires.

Examinations shall be repeated at regular intervals not exceeding three years. When diving deeper than 180 msw, the divers shall be followed up in accordance with detailed examination as specified e.g. in NUI-1994-20 [4] or equivalent.

When following up the individual diver's health, diving exposure data is an important parameter. The contractor shall therefore maintain a system to collect and store such data in a manner enhancing a prompt retrieval of each individual diver's exposure data. The contractor shall further contractually require that the individual diver makes available to the health service (in the form of a self-declaration) all diving exposure data, including data from diving taking place outside the confines of employment/appointment with the contractor.

Sensitive individual medical data shall be protected, as a minimum, in accordance with national requirements.

5.1.5 Medical contingency

5.1.5.1 General

The contractor shall establish a system for handling medical contingencies in connection with MUO. A duty diving doctor system shall be established for this purpose.

5.1.5.2 Mandatory medical supplies

The contractor shall supply medical equipment and drugs according to applicable national guidelines or e.g. NOROG-073 [5]. The responsible diving doctor may deviate from this list if an equal or higher level of medical support/contingency can be assured by other means. Such changes shall be documented.

The contractor shall have a system ensuring that there always is a supply of the following materials:

a) first aid equipment, with user's manual, if necessary;
b) medical supplies and medical equipment intended for use during MUO, with user's handbooks;
c) medical supplies and other material for medical contingency.

The stores shall be checked regularly by competent personnel.

5.1.5.3 Telemedicine

The person performing advanced first aid shall have priority and unimpeded access to suitable telecommunication with the responsible diving doctor, the duty diving doctor or any other competent personnel as might be required. The saturation system should be equipped with facilities and penetrators to support telemedicine, monitoring equipment including 12 channel ECG (Electrocardiography).

5.2 Working environment

5.2.1 General

The contractor shall ensure a working environment that, in all respects, enhances the safety and well-being of all personnel. A working environment programme shall describe activities to improve the working environment. This programme shall be reviewed yearly based on findings from, amongst others, working environment mapping and shall involve active participation from the workers. Such participation shall be documented. For information, see relevant clauses in NORSOK S-002 [6] or equivalent. Relevant personal protective equipment (PPE) shall be provided for all personnel, including divers in water, chambers, bells, LDC and/or habitats. Relevance is dependent on: scope of work, environmental conditions and risk assessments. PPE used shall be documented to be in accordance with relevant parts of EN 13921 and EN/TR 15321.

5.2.2 Physical work environment

5.2.2.1 General

The physical environment for divers in water, chambers, bells, LDC and/or habitats, shall be subject to particular and close monitoring, with control of all parameters relevant to the safety and health of the diver.

Methods to achieve optimum conditions shall be implemented by the contractor by actively seeking and evaluating new knowledge.

5.2.2.2 Ergonomics

The design and lay-out of plant and equipment shall aim to reduce negative effects from environmental factors on the users' safety, efficiency or comfort. This may be obtained by the incorporation of ergonomic principles, such as system models, into the design process. For information, see ISO 6385 [7].

Mapping of ergonomic conditions in chambers, diving bells, welding habitats, control rooms, and the divers' working conditions, shall be performed initially and repeated following modifications. Mapping shall be initiated and followed up by contractors' health service with input from the users, and performed by competent personnel. Recommended corrective actions shall be evaluated and followed up.

5.2.2.3 Temperature

Thermal control systems for divers in water, in hyperbaric chambers, bells and habitats shall have the capacity and the accuracy to ensure thermal balance and comfort for the divers/occupants during all phases of a normal dive, see 7.7.

In emergency situations, where the divers/occupants cannot be returned to a safe environment, the environmental control systems shall ensure a thermal status within safe limits for the time required to perform the rescue operation, see 7.8.3 and 9.3.

5.2.2.4 Humidity

Environmental control systems for living chambers shall have the capacity to control the relative humidity to between 40 % and 60 % relative humidity at operational depth of the system and with a full complement of divers in the chambers.

5.2.2.5 Lighting

Lighting shall be adequate (see Table 2) for the tasks to be performed, including, but not limited to the chambers, bells (internal and external), habitats, handling systems and at the divers' work site.

It shall be possible to adjust and shade the light to a comfortable level where relevant. Light sources should be positioned so that reflections and glare are avoided.

Table 2 – Recommendations for lighting relevant in areas for safety and well being

Place	Lux
Living chamber, general	100
Living chamber, reading light	300
TUP	150
Diving bell, general	150
Diving bell, at panels	300
Control rooms, general	300
Control rooms, panels/desk	500

For information, see EN 12464-1 [8] and ISO 8995 [9].

5.2.2.6 Noise and vibration

The noise exposure shall be as low as practically possible. Personnel exposed to harmful levels of noise (exceeding 83 dB (A)) shall use protective equipment. The use of noise protection equipment shall not reduce the quality of oral communication.

In living chambers and in control rooms during normal operations, noise levels should be in accordance with relevant parts of NORSOK S-002 [6]. The levels corrected for depth and gas composition shall not exceed the following values:

Sleeping chambers	60 dB (A)
Living chambers	65 dB (A)
Control room	65 dB (A)
Diving bell	65 dB (A)
Habitats	65 dB (A) (see NOTE)
Diver in water	70 dB (A) (see NOTE)

NOTE This does not include self-induced noise.

Exposure to vibrations should be kept as low as possible, for information see relevant parts of NORSOK S-002 [6].

5.2.2.7 Radiation

Use of radioactive sources, ionising and non-ionising radiation shall be kept as low as practicably possible and in accordance with national legislation and applicable guidelines and standards.

5.2.3 Chemical working environment

5.2.3.1 General

The content of breathing gases (O_2 and inert gases) and trace substances (contaminants) shall be kept within acceptable limits.

Sources for contamination and potential hazardous substance shall as far as practically possible be identified, documented and controlled through established programs. Definition of such programs shall involve the health service (5.1.2).

The program shall include risk assessment, in line with relevant recommendations and requirements in EN 14042, EN 482 and EN 689 with references. Because of the special conditions connected to staying and breathing gas under pressure, all general (normobaric) requirements for indoor, ambient and workplace air shall be adhered to. Normobaric OEL values shall be replaced by HELs, see below.

The program should be linked to the short and long term health monitoring (5.1.4) so that any possible health effect can be identified as early as possible and pertinent preventive actions instigated.

The program shall include a system for data systemization and storage, to facilitate experience feedback. This shall also be part of the annual/final experience report (see 4.8.2.4), and made available to the workers and/or their representatives and publically so that other diving contractors can gain from “the lessons learned”. Since the total experience from diving in this respect in foreseeable future will be limited, any possible experience and research results that can be useful shall be sought, including in general, environmental, indoor and work atmospheres especially the knowledge from space cabins, submarine and aviation.

In addition to health risk, the flammability risk and explosion hazard shall also be controlled.
O_2 and other gases representing a fire or explosion hazard shall be stored in a suitable place. The pressure in supply pipelines from the place of storage shall be as low as possible. The routing of such gas lines shall be given special attention, regarding the effects of leakages. Mixtures of gas where O_2 represents more than 22 % shall be treated as pure O_2 with regard to fire and explosion hazard.

Suitable materials and components shall be used for transportation of the appropriate gas mixtures at the relevant pressures. Use of flexible hoses shall be reduced to a minimum.

About marking of gas cylinders see 7.6.

5.2.3.2 Sources

As a minimum the following sources for contamination of the breathing atmospheres shall be evaluated in a documented and systematic order, including enduring accumulation of data/information:

a) endogenous production (CO_2, CO, isoprene etc.);
b) food, drinks, medicines, hygiene, microbiology;
c) fume, dust, micro particles;
d) welding, grinding and cutting (material certificates with specification of content shall be available);
e) other work processes;
f) produced/natural gas (hydrocarbons, H_2S, Hg etc.);
g) produced water (benzene etc.);
h) other contamination of seabed or seawater;
i) unusual events, emergencies, contingencies.

The contractor shall document a system to ensure that all materials utilised in chambers, bells and breathing circuits etc., do not contain or produce gases or vapours that can be harmful to the divers during normal

operational conditions. Prior to introducing new materials, verification shall be performed in accordance with e.g. NUI-1994-05 [10].

5.2.3.3 Monitoring

Any potential hazardous substance should be identified and controlled, following the principles given in EN 14042, EN 482 and EN 689 with references.

As many substances as practical possible shall be analysed on-site, and others in on shore laboratory. The frequency of sampling shall follow the principles given in EN 689.
For additional guidance, see NUI-1995-27 [11].

Breathing gases shall be accompanied by an analysis certificate. Certificates should not be accepted as correct until a competent member of the dive team has analysed it for O_2 and CO content, as a minimum. Results for contaminants shall be < 0,1 HEL at actual pressure.

Any new calibration gas should be checked against another calibration gas with similar content, before taken in use, see ISO 6143 [12], ISO 13752 [13], ISO 16664 Annex A [14], ISO/IEC 17025 [15] and ISO Guide 35 [16].

Every gas breathed by diver(s) during normal operation, shall as a minimum continuously be analysed online for O_2 and CO_2 content (8.3.2).

An O_2 analyser with audio and visual hi/low alarm shall be fitted to the diver's downstream gas supply.

Where a diver gas reclaim system is used, a CO_2 analyser with audio and visual hi alarm shall be installed into the diver downstream gas supply.

Reclaimed chamber gases shall be analysed for O_2 and CO_2 content and other possible contaminants (including, but not limited to N_2, CO, VOC) prior to their re-use. Results shall be < 0,1 HEL at actual pressure.

When there is danger of contamination of the bell from natural/produced gas, there shall be online indication with alarm of hydrocarbons, Hg and H_2S.

For saturation/living compartments there shall be on-site periodic monitoring of at least CO and N_2.

As it is not possible to electronically/chemically monitor for all possible contaminants, the benefits of human sensation by olfactometry (odour, smell) shall be facilitated, by having at least two trained persons from the surface crew, checking the gas of each living compartment at least once a day, according to guidance in EN 13725 [17], ISO 13301 [18].

Contaminated seabed/seawater shall be analysed to document the level of contamination as a basis for minimising the exposure to the contaminants. If the analysis is done at the surface, a sampling technique that allows the gas-tight seabed sampling to be brought to surface maintaining the content of possible contaminants, shall be applied.

Required analysis in habitat when welding: CO, Ar, NOx (not required if welding atmosphere is documented free of N_2), O_3, fumes and dust (with metal identification).

Required analysis in habitat when grinding: fumes and dust (with metal identification).

As an extra indicator for post-exposure evaluation, biological monitoring shall be used when justified. Exhaled breath, urine, blood, spit, hair-sampling shall be considered (ref ACGIH [19]).

5.2.3.4 Gas purification

All living compartments, welding habitat and breathing gas reclaim system shall in addition to O_2, temperature and humidity control, be equipped with gas purification that as a minimum removes CO_2 (e.g. sodalime), CO (e.g. catalyst), VOC (activated charcoal) and odorous compounds (e.g. Sofnofil). For guidance on configuration and practical implementation see SINTEF STF78 F021047 [20].

Water traps for gas reclaim shall be designed for simplicity of cleaning, disinfecting and drying, to prevent microbiological contamination.

5.2.3.5 Personal protection

BIBS is the primary personal protection equipment for situations where gas contamination above HELs is suspected in ambient gas. Use of BIBS for this purpose shall not be planned for; it shall be used for contingencies only.
If there is risk for contaminated seabed or seawater, measures shall be taken to ascertain that contamination do not come in contact with the divers' skin, breathing gas or is in any way carried in to the diving system.

5.2.3.6 Hyperbaric exposure limits

Impurities in the breathing gas shall be kept as low as possible, and always below the OELs stipulated in recognised norms, and national regulations. For information, see also relevant parts of NORSOK S-002 [6], ACGIH [19], NASA-JSC-20584 [21] or equivalent.

Normobaric OELs shall be replaced by HELs that take into consideration the special conditions including high pressure, elevated pO_2, long (semi-continuous) exposures and the effects of multiple contaminations (additive/synergistic effects). Generally, norms for contamination in hyperbaric living chambers, HELs (in the unit μbar) are calculated as 1/5 of a recognised 8 h surface norm (e.g. the national OEL) in air (in ppm). When substances are detected where no recognised OEL exist, or where there is reason to believe that the general rule of 1/5 is inadequate, a stipulation shall be justified, documented and be made publicly available. An example for benzene is described in Djurhuus et al. (2011) [22].

In the case of substances where a STEL has been indicated, this is applied as maximum concentration over a 15 min period. In the case of substances without STEL or ceiling value, the excess factors of national norms shall be used.

The 8 h upper limit for unspecified welding smoke/dust particles from hyperbaric welding shall be 5 mg/m^3.

For the assessment of combination effect of several substances, and of skin absorption, acknowledged methods shall be used.

In the case of the substances CO_2, CO, Ar, N_2 and benzene, exception is made from the general rule of 1/5 of the recognised 8 h surface norm and specific HELs have been set below.

5.2.3.6.1 Oxygen

The pO_2 levels shall be kept at a level as close as possible to 21 kPa (210 mbar), balanced against the diver's need for a higher than normal pO_2. The pO_2 shall not be lower than 20 kPa or higher than 150 kPa.

For medical treatment, a higher pO_2 may be used.

For other exposures of short duration (e.g. bailout) the maximum pO_2 limits may be relaxed according to the following equation, Morrison and Reimers (1982) [23].

$$T = 108 \ln 109 \cdot \langle pO_2 \cdot [(DO_2 + D_I)/ DO_2]^{0,21} \cdot [Y/2]^{0,35} - 122\rangle^{-1}$$

where
T = maximal exposure time in minutes
pO_2= allowable partial pressure of O_2 in kPa
DO_2 = partial density of O_2 in gas mixture
D_I = partial density of inert gas in gas mixture
Y= diver workload measured in oxygen-uptake (l/min STPD)

Based on the formula above and assumptions on maximal endurance times at each workload, Table 3 indicates maximal duration for higher pO_2 at different depths for heliox breathing gas.

Table 3 – pO_2 in heliox limitations given in minutes

Maximal depth [msw]	Up to 160 kPa pO_2	Up to 170 kPa pO_2	Up to 180 kPa pO_2
50	60 minutes	52 minutes	37 minutes
100	53 minutes	37 minutes	1 minute
150	41 minutes	3 minutes	0 minutes
200	31 minutes	0 minutes	0 minutes

Inert gases used in support of diving operations shall contain a minimum O_2 content of 2 % unless special arrangements have been made to prevent pure inert gases being fed into the breathing gas lines.

5.2.3.6.2 Carbon dioxide

a) Exposure > 15 min: maximum 1 kPa (10 mbar).
b) Exposure < 15 min: maximum 3 kPa (30 mbar).

5.2.3.6.3 Carbon monoxide

Table 4 – Hyperbaric exposure limits for CO

	Duration of exposure	HELs
Breathing gas at work or at rest in bell, chamber, welding habitat etc.	Continuos	0,5 Pa (5 μbar)
	<12 h	2,0 Pa (20 μbar)
	<15 min	5,0 Pa (50 μbar)
Ambient gas when diver is using BA		10 Pa (100 μbar)
Breathing gas in emergency situations	No exposure planned, but system to be active for minimum 24 h	5,0 Pa (50 μbar)

5.2.3.6.4 Argon and nitrogen

The presence of Ar and N_2 in the breathing gas produces additive narcotic effects.

For HELs, see Table 5.

Table 5 – Hyperbaric exposure limits for Ar and N_2

	When not in saturation decompression			During decompression after saturation
	Ceiling value	8 h time weighted average	Continuous	Continuous
pN_2	350 kPa (3,5 bar)		150 kPa (1,5 bar)	80 kPa (0,8 bar) and <10 %
pAr	150 kPa (1,5 bar)	100 kPa (1,0 bar)	50 kPa (0,5 bar)	1 kPa (10 mbar)
(2 pAr) + pN_2	350 kPa (3,5 bar)			

5.2.3.6.5 Benzene

HEL= 0,001 Pa (0,01 μbar)

5.2.3.6.6 Other contaminants

Other contaminants for which HELs should be available include, but are not limited to

a) other VOCs than benzene detected in saturation systems,
b) aerosols,
c) O_3,
d) H_2S,
e) NO,
f) NO_2 and other NO_xs,
g) NH_3,
h) Hg,
i) other metals/dust.

6 Personnel qualification requirements

6.1 General

Contractor shall provide sufficient personnel to ensure safe and efficient performance of the work.

Personnel engaged in MUOs shall have job descriptions detailing their authorities and responsibilities. They shall be educated in and qualified for, the work they are asked to perform. Qualifications shall be kept up to date and documented. Crews shall be selected to ensure the necessary experience on all levels and within all specialities. Personnel competence shall be reviewed and assessed against specified criteria (e.g. IMCA-C003 [24]) and a formal record should be made (e.g. as in IMCA-C006 [25]).

All personnel shall be familiar with the installed systems, equipment, tools and diving methods (including gas-mixes) etc. that they are going to use and with the tasks they are going to perform. Required courses and familiarisation programmes shall include emergency procedures; see e.g. PSA-YA-539 [26].

Supervisory personnel shall have documented leadership training (course syllabus as in accordance with annex B) and be familiar with QA principles. Good leadership and the ability to co-operate and communicate with team members are required. In addition, supervisors and others with responsibility for decisions affecting the working environment shall have the same or equivalent training as safety delegates and members of the working environment committee.

Personnel going offshore shall have safety training in accordance with national requirements. During all offshore diving operations, medical personnel with hyperbaric competence shall be on board.

The qualifications required for personnel listed in this document shall be regarded as minimum requirements. Personnel involved in lifting operations shall have a relevant course in the use of lifting appliances, minimum NORSOK R-003.

An approved diving qualification is not required for personnel providing emergency medical treatment in a chamber.

Operator representative overseeing the diving operations shall have adequate competence on relevant diving methods and their limitations in accordance with e.g. OGP-431 [27].

6.2 Special requirements for marine personnel on board diving support vessel

Marine personnel on board a DSV shall have sufficient knowledge of diving operations enabling them to understand the relation between their own job performance and the safety of the divers.

This knowledge shall be documented for critical positions such as master, DP operator, chief engineer, electrician, crane operator and ROV operator.

The duties, responsibilities and authorities of senior personnel shall be described in accordance with ISO 9001.

6.3 Requirements for diving personnel

6.3.1 General

Diving supervisors and life support personnel shall be at least 24 years old while divers shall be at least 18 years old, all shall hold valid certificates recognised by national authority.

Certificates shall be issued based on documented training at qualified schools, where the course syllabus is in accordance with annex B. For information on minimum qualifications, see EDTC-PCS [28].

The personnel qualification requirements listed below shall be regarded as minimum requirements. If any of the below positions are combined (i.e. if one person covers more than one position), this person shall fulfil the requirements for all positions that he covers.

Use of simulators in training of diving personnel shall be in accordance with IMCA-C014 [29].

6.3.2 Offshore manager

Offshore managers have overall responsibility for the project execution and their responsibilities and task include:

a) Ensuring that activities are carried out in accordance with the requirements in the diving project plan and the applicable laws and regulations;
b) Ensuring that personnel are competent, qualified and familiar with the work procedures, safety precautions to be taken, laws and regulations and relevant guidelines and information notes.

The offshore manager will normally be the primary contact point offshore with the client. The offshore manager may, but need not not have diving background.

6.3.3 Diving superintendent

The superintendent shall

a) comply with the requirements applicable to a diving supervisor with regard to the operation he is responsible for,
b) have at least 4 years of practical experience as a diving supervisor,
c) have at least 8 years of practical experience in the diving industry.

Additional requirements are as follows:

d) minimum two years technical or administrative education, or similar level of career development;
e) introductory DP-course.

6.3.4 Diving supervisors

6.3.4.1 Surface oriented diving supervisor

Trainee surface oriented diving supervisor shall

a) be a qualified surface oriented diver (does not require valid certificate of medical fitness for divers),
b) be at least 24 years of age,
c) have at least two years practical experience as a commercial diver and have carried out at least 100 commercial dives where at least 25 of these dives shall have been carried out from a DSV operating on DP,
d) have undergone a training course at a qualified institution and have passed the course examination for trainee surface oriented diving supervisors.

Surface oriented diving supervisor shall

e) comply with the requirements for a trainee diving supervisor,
f) have at least one work year of practical experience as a trainee diving supervisor. At least 200 h of this practical experience shall have been served at an surface oriented diving control panel,
g) have carried out at least 200 commercial dives,
h) have received leadership training,
i) have completed introductory DP-course
j) have passed the examination for surface oriented diving supervisors.

6.3.4.2 Bell diving supervisor

Trainee bell diving supervisor shall

a) hold a nationally recognised bell diving qualification in accordance with annex B of this NORSOK standard and EDTC-PCS [28], (does not require valid certificate of medical fitness for divers),
b) be at least 24 years of age,
c) have at least three years of practical experience as a bell diver and have carried out at least 50 commercial dives where at least 25 of these dives shall have been carried out from a DSV operated by DP,
d) have undergone a training course at a qualified institution and have passed the course examination for trainee bell diving supervisors.

Bell diving supervisor shall

e) comply with the requirements for a trainee bell diving supervisor,
f) have at least 350 h of practical experience at a bell diving control panel as a trainee bell diving supervisor,
g) have at least 30 days of practical experience as an ALST,
h) have acted as trainee surface oriented diving supervisor during at least 10 surface oriented dives,
i) have completed a course in advanced first aid in accordance with IMCA-D020 [30] or equivalent (see NOTE)
j) have received leadership training,
k) have passed the course examinations for surface oriented diving supervisor and for bell diving supervisor,
l) have introductory DP-course.

NOTE: A refresher in advanced first aid is not deemed necessary as the medical care duty shall be taken care of by the hyperbaric nurse and the dedicated deck divers that shall have a valid advanced first aid certificate.

6.3.5 Life support supervisor

LSS shall

a) comply with the requirements applicable to an LST,
b) have at least 200 days of practical experience as an LST,
c) have at least 4 years of practical experience from the diving industry,
d) have documented knowledge of operation and maintenance of gas supply and monitoring systems and other specialised equipment,
e) have received leadership training.

6.3.6 Life support technician

An ALST shall have undergone a training course at a qualified institution in accordance with minimum requirements, alternatively be trained as a bell diver, and have passed the ALST examination.

LST shall

a) comply with the requirements for an ALST,
b) have at least 200 days of practical experience as an ALST,
c) alternatively, if he is a trained bell diver with a total of 5 years of diving experience and at least 3 years' experience as a bell diver, he shall have at least 30 days of practical experience as an ALST,
d) have completed the examination for LSTs,
e) have completed a course in advanced first aid according to IMCA-D020 [30] or equivalent.

6.3.7 Divers

All divers shall hold a valid certificate of medical fitness for personnel required to work under increased ambient pressure in accordance with national guidelines (ref. NBH IK-2708, HSE-MA1 or equivalent).

Divers shall hold a diving certificate recognised by PSA.

Surface oriented divers shall hold a nationally recognised diving qualification in accordance with annex B of this NORSOK standard and EDTC-PCS [28].
At any given time, a minimum of 50 % of the divers on a surface oriented diving team shall hold a relevant current advanced first aid certificate (see NORSOK U-103 Annex D).

Saturation/bell divers shall hold a nationally recognised saturation/bell diving qualification in accordance with annex B of this NORSOK standard and EDTC-PCS [28].
At any given time, a minimum of 80 % of the divers in saturation shall hold a current advanced first aid certificate according to IMCA-D020 [30] or equivalent. During operations, minimum two of the divers at each pressure level shall possess this qualification.

Requirements for diver training are outlined in Annex B.

6.3.8 Diving technician/maintenance engineer

The diving technician / maintenance engineer shall:

a) have an electrical or mechanical trade education. Both trades shall be covered at a work-site at any given time;

b) have sufficient documented knowledge of or experience with diving operations/systems enabling them to understand the relation between their own job performance and the safety of the divers;
c) have adequate supplier training or formal education for specialised systems (i.e. rebreather, PLC and bail-out), they could be responsible for;
d) have certified and valid qualifications for high voltage electrical systems as required;
e) have detailed knowledge of QA and surveillance systems (site queries, non-conformance, inspection and test plans, management of change), compliance, contractors documentation system, site as-built status, class approval and certification of systems.

Dive technicians who are maintaining and fault finding on dive systems that are automated PLC driven shall have a level of manufacturer training undertaken by the relevant technicians discipline to prove competency. This should cover all aspects of security, operation, familiarisation, fault finding. If the equipment manufacturer's training is not obtainable, the diving contractor needs to have a system in place for equivalent training.

This does not include changes to operational software or safety systems. This would be the responsibility of the recognised and competent controls engineering group who are responsible for the safe keeping of the software.

The diving technician should not have work tasks apart from the diving system which can involve priority confusion.

6.3.9 Gasman

The gasman shall

a) have sufficient documented knowledge of, or experience with, diving operations/systems enabling them to understand the relation between their own job performance and the safety of the divers,
b) be competent and fulfil requirements for bell diver or LST.

The gasman shall not have work tasks apart from the diving system which can involve priority confusion.

6.3.10 Responsible competent diving doctor

The responsible competent diving doctor shall

a) be recognised as a specialist in occupational medicine,
b) have documented adequate theoretical background in diving medicine, see e.g. EDTC-TDM [31],
c) have documented practical experience in diving medicine corresponding to at least five years of work.

6.3.11 Duty diving doctor

The duty diving doctor shall

a) have documented adequate theoretical background in diving medicine (minimum 60 h),
b) have documented practical experience in diving medicine corresponding to at least 1 year of work,
c) have more than 3 years practice after national authorization as a physician,
d) be medically fit to work under increased ambient pressure.

6.3.12 Hyperbaric trained nurse

The hyperbaric trained nurse shall:

a) be authorized as a nurse by national authorities;
b) have documented training (formal, both initial and refresher) in emergency medicine, that as a minimum comply with International Liaison Committee on Resuscitation (ILCOR) guidelines as given in "Section 4. Adult advanced life support" of the "European Resuscitation Council Guidelines for Resuscitation 2010", see Deakin et al. (2010) [32], or any later revision;
c) have documented training (formal, both initial and refresher) in hyperbaric medicine, including diagnosis and treatment of injuries and illness related to diving;
d) be medically fit to work under increased ambient pressure;
e) have competence in occupational hygiene related to diving;
f) have minimum 2 years' experience in handling medical emergencies, or 1 year experience in handling medical emergencies and 1 year experience in occupational health.

7 Technical requirements

7.1 Principles

7.1.1 General

Plant and equipment including PLC systems used in MUO shall be designed, constructed, tested (for information see NUI-THB [33] and IMCA-D018 [34]), and maintained in compliance with current regulatory requirements and normative references. It shall be certified by a recognised classification society. Auxiliary equipment, (i.e. SPHLs), shall be verified to meet available pertinent requirements of a recognised classification society and where relevant, NORSOK R-002. The design shall ensure efficient integration between the users and all parts of the plant and equipment, according to anthropometric dimensions and other human factor aspects in accordance with e.g. ISO 6385 [7].

Safety related equipment, not covered by the rules of a classification society, shall be certified/controlled and/or verified to a standard compatible with national regulations.

Further it is a prerequisite that the plant is in compliance with requirements laid down in IMO 808E.

Diving systems shall be designed to give early warning of abnormal conditions with significance to safety. When a warning is given it shall be possible to make corrective actions before an emergency situation occur.

7.1.2 Implementing new technology

If obvious safety advantages can be achieved through the use of new technology, provisions should be made for this.

If planned MUO exceeds limits of existing plant, equipment and procedures, resulting in the use of new technology and/or procedures, the contractor shall prepare a plan for the development, testing and introduction of such new technology/procedures. The certification/verification process shall be documented.

Technological development is a continuous process within all industries and also diving. Such developments shall be encouraged, but is also a potential safety threat if introduced without control. New technology therefore needs to be subjected to the following steps prior to be implemented:

a) definition of international requirements and standards to which the technology has to prove conformity;
b) necessary technical and operational risk evaluations to prove the technology is fit for purpose;
c) assurance process for acceptance of this technology by the technology's end user (divers / supervisors);
d) an implementation plan including, but not limited to, training and familiarization of personnel, necessary technical upgrades of the diving system etc.

7.1.3 Electricity

All use of electricity in diving operations shall comply with IMCA D 045.

7.2 Dimensions and lay-outs

7.2.1 Chambers

Chamber complex size, architecture, lighting and lay-out shall support and optimise all the functions planned to take place in the chambers for the maximum number of occupants. It shall be possible to bring personnel, equipment and provisions into and out of the chamber complex (see NORSOK S-002 [6]).

Interior design, decor and colours should be carefully selected to promote safety, efficiency and comfort for the users.

Each section of a chamber complex used in MUO shall have or be connected to a primary and a secondary environmental control system maintaining correct and uniform atmosphere. This does not apply to smaller locks where personnel are not staying for any length of time, i.e. passing through.

Each pressure compartment where divers could be staying shall be provided with one BIBS for each occupant plus one spare. It shall be possible to exhaust the exhaled BIBS gases out of the chamber.

It shall be possible to close all pipe penetrations both internally and externally as close as practically to the chamber wall.

7.2.2 Chambers for saturation diving

The saturation chamber complex shall

a) have toilet facilities, shower and wash basin at each living depth,
b) be designed for simplicity of cleaning,
c) allow divers to be evacuated,
d) allow divers undisturbed rest periods, and
e) have a designated chamber for medical treatment.

Inner height of the chambers shall be no less than 200 cm over the deck plates (measured in the middle of the chamber).

The inner volume shall be at least 4 m^3 per diver. The specified volume shall be usable, i.e. apportioned where there is normally sufficient space and height for the occupants. The distribution of the specified minimum volumes between living, sleeping and TUP compartments shall meet the requirements for normal personal comfort.

Chambers used as living and sleeping accommodation shall be equipped with seating and individual bunks for the number of divers who are to make use of this part of the chamber complex. The dimensions of a bunk should be minimum 200 cm x 70 cm.

Permanently installed equipment shall be of non-flammable materials. In general, flammable materials shall be kept at a minimum inside the chamber, i.e. loose items such as newspapers etc.

7.2.3 Chambers for surface oriented diving

During surface oriented diving operations a double-lock decompression chamber shall always be available at the work-site.

The chamber shall be manufactured under the specification of, and certified by a recognised classification society.

The main chamber shall be minimum 1,6 m inner diameter and 2,0 m length, with possibility for the occupants to lie down. It shall be equipped and designed so that a doctor/assistant can efficiently carry out any first-aid required.

When surface oriented diving with decompression stops are planned, the chamber shall have an inside diameter of minimum 1,8 m. The diameter may be less if ergonomic principles that improve the entry and egress and possibility for treatment etc. are implemented.

7.2.4 Diving bell

7.2.4.1 Diving bell ergonomics

The diving bell, including all assemblies, components and equipment shall be designed to support the divers in their operational functions inside and outside the bell as described in e.g. STF23 A92011 [35]. Principles of ergonomics shall be duly taken into account with regard to the location of equipment in the diving bell.

Diving bells intended for two divers shall have an inside volume of at least 4,5 m^3. Diving bells intended for more than two divers shall have an extra inner volume of 1,5 m^3 per diver in excess of two. The specified volume should be usable, i.e. apportioned around what is normally within the height required for a diver to stand up. The bottom trunk for entry into and exit from the diving bell shall have an inner diameter of minimum 80 cm.

It shall be possible to close all pipe penetrations both internally and externally. Diving bell trunks shall either be equipped with internal and external doors or a double acting door.

The diving bell shall be adequately equipped for the bell-man to bring unconscious or injured divers into the bell and to a position where first aid can be administered.

7.2.4.2 Diving bell supply

The diving bell shall contain equipment that will ensure that vital functions are maintained in situations when the primary supply is not available. These functions shall be maintained until the situation has been brought under control. The functioning time shall be at least 24 h.

Diving bells shall have on-board gas supply for use in emergency situations. The minimum capacity shall be 1 250 usable litres of breathing gas for each diver, calculated at ambient pressure and temperature of 37° C (see NORSOK U-101), (equals 20 min at a breathing rate of 62,5 l/min).

7.2.4.3 Emergency connectors for diving bells, habitats and SPHLs

An emergency connector panel shall be provided in accordance with industry standards (see IMO 808E and IMCA D051 [36]) and with requirements as given in Table 6 and Table 7.

Table 6 – Emergency connectors for diving bells and habitats

Item	Diver operable (IMO)	Diver and ROV operable
Breathing gas	1/2” NPT Female	1/2” Male Snaptite SVHN-8
Hot water/heating	3/4” NPT Female	3/4” Male Snaptite SVHN-12
Depth	1/4” NPT Female	1/4” Male Snaptite SVHN-4
Communication	8-contact-4-pins-EO connector (Contacts 1 and 2 used, others n.c.)	8-contact-4-pins-EO-connector (Contacts 1 and 2 used, others n.c.)
Emergency power	4-contact-4-pins-EO-connector (Pin1:24V, pin2:0V, pin3: ground, pin4:n.c.)	4-contact-4-pins-EO-connector (Pin1:24V, pin2:0V, pin3: ground, pin4:n.c.)
Gas analysis	1/4” NPT Female	1/4” Male Snaptite SVHN-4

Key:

EO: "Electro Oceanics"- trade mark - underwater electrical connector
n.c. : not connected
NPT: National (standard) Pipe Tapered (threads)
Snaptite SVHN: trade mark and type designation

Table 7 – Emergency connectors for SPHL and LSP

SPHL	DESCRIPTION	LSP
4 PIN 8 CONN EO (51F8F-1) or 4 PIN 8 CONN EO (53F8F-1)	COMMS	4 PIN 8 CONN EO (51F8M-1)
4 PIN 4 CONN EO (51E4M-1) or 4 PIN 4 CONN EO (53E4M-1)	POWER	4 PIN 4 CONN EO (51E4F-1)
SVHN 12-12F	HOT WATER SUPPLY	SVHC 12-12F
SVHC 12-12F	HOT WATER RETURN	SVHN 12-12F
BVHN 6-6F	OXYGEN MAKE UP	BVHC 6-6F
SVHN 4-4F	DEPTH	SVHC 4-4F
SVHN 4-4F	ANALYZE	SVHC 4-4F
SVHN 12-12F	BLOW DOWN	SVHC 12-12F
SVHN 12-12F	EXHAUST	SVHC 12-12F
BVHN 12-12F	BIBS SUPPLY	BVHC 12-12F

Key
CONN EO:
"Electro Oceanics" -trade mark - underwater electrical connector. Also called "Crouse_Hinds Underwater Electrical Connectors WATERMATE™, EO (alternatively E/O, E-O or E.O.) type S/BVHN and S/BVHC:
Snap-tite™ type designation

For better illustration both sides of the connection are shown as "in-line-mounted". Normally the SPHL-side will be "bulkhead mounted" and therefore the catalogue no. "53" is shown for COMMS and POWER instead of no. "51".
To be in compliance with IMCA D051 [36] new dimension is used for BIBS and BLOWDOWN. Existing SPHL’s will have to carry adapters and verify adequate capacity.

7.2.5 Locking mechanisms

Any pressurised compartment, container or other equipment under pressure, where opening can be dangerous to personnel, shall be physically secured to prevent unintentional pressure drop and/or injury to personnel, i.e. equipped with an interlock. Locking mechanisms shall be designed so that pressure cannot be applied unless the locking device is in the correct position. The internal pressure shall directly control the interlocking mechanism, preventing unintentional opening unless the pressure is at ambient level.

7.2.6 Wet bell and diving basket

Wet bells and diving baskets shall be of adequate size, be equipped for the number of divers intended to man them and for handling of unconscious and/or injured divers.

Wet bells and diving baskets shall be designed to prevent the diver from falling out and to avoid rotation and tilting. The basket should be equipped with suitable overhead protection and handholds.

Wet bells and diving baskets shall have an on-board gas supply for emergency situations. The minimum gas capacity shall be calculated as for diving bells as specified in 7.2.4.2.

A wet bell shall contain equipment to monitor the following parameters:

a) depth;
b) pressure of gas supplied from surface;
c) pressure of on-board emergency gas supply.

7.2.7 Submerged habitat

The habitat shall provide a dry and safe working area for the divers, be equipped with an adequate number of breathing masks (see 7.2.1) and include a non-contaminated compartment.

Habitats shall be designed to prevent complete flooding, leaving sufficient gas volume to allow personnel to dress into survival equipment and to allow personnel occupancy in an emergency situation.

The habitat-umbilical shall have a quick-disconnect system on the DSV allowing for controlled disconnection and re-connection.

It shall be possible to close all pipe penetrations both internally and externally.

Habitats shall be equipped to maintain vital functions for a minimum of 48 h when primary supplies are not available. It shall have an outside panel for emergency connections including gas, heat and communication. Connectors shall be in accordance with 7.2.4.3.

It shall be possible to rescue personnel from a submerged habitat even if the normal access cannot be used. Entrances/exits shall be clearly marked.

7.2.8 Control rooms

Control rooms shall be designed in accordance with accepted ergonomic principles. For information, see EN 12464-1 [8], ISO 6385 [7], ISO 8995 [9], and NORSOK S-002 [6].

The need for hi/low O_2 monitoring with alarm installed in control and gas storage rooms shall be assessed.

It shall be possible to carry out work and to communicate efficiently even if there is no normal breathable atmosphere in the room.

7.3 Handling systems (diving bell, wet bell and basket)

7.3.1 General

The handling system for diving bells shall include means of safe guidance through the surface of the water, such as a moon-pool cursor or a bell cursor tower system. It shall be subjected to the same risk evaluation procedures as for other safety related systems (4.2).

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.

Certification of handling systems shall be in accordance with NORSOK R-002.

The safe workload of the main lifting wire shall be calculated using a minimum safety factor of 4,0 related to the maximum design load. Both static and dynamic loads shall be taken into consideration.
Cross hauling equipment shall fulfil the same requirements for strength as the rest of the handling system.

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

Where direct visual monitoring of the winch drums from the winch control station is not practical, video monitoring shall be fitted.

Records shall be maintained of umbilical and wire cut-backs, re-termination, end-for-ending and replacements.

The main handling facility shall be operable even if a power source or a winch motor is out of action.

In event of main handling facility break down, an alternative handling system shall be ready for immediate use. This system shall have the capacity to recover the bell back to mating position, wet bell and diving basket back to deck. The alternative handling system shall comply with the same requirements for load strength as the main handling system.

Guide wire equipment shall ensure a controlled movement of the device in the water and should also provide an arrangement for preventing the device from uncontrolled descents underwater in the event of failure in the primary lifting wire.

7.4 Self-propelled hyperbaric lifeboat (SPHL)

Saturation diving systems shall be equipped to enable adequate evacuation of the divers under pressure by SPHL. For further information see IMO-A.692 [37], IMCA-D051 [36], IMCA-D052 [38] and IMCA-D053 [39].

Evacuation shall be possible also in cases of loss of main power on the DSV/system. The SPHL shall be constructed to withstand loads incurred during launch and shall be equipped for safe and efficient recovery. SPHLs shall be equipped with lifting/towing arrangements for rescue. Operational procedures for SPHLs shall contain information on limitations in connection with launching, towing and recovery operations for different weather conditions.

Control and monitoring of the SPHL's pressure chamber shall be possible from the outside of the chamber, and it shall be possible to lock material in and out of the chamber. While connected to the saturation chamber complex, control and monitoring of the SPHL's pressure chamber shall be possible from the saturation system control room.

The SPHL shall be equipped to maintain an acceptable environment for a minimum of 72 h, both for the chamber occupants and for the support personnel on the outside of the chamber. Systems for handling human waste products (such as, but not limited to stool(s), H_2S, preservation of vomit, urine and gas for locking in/out bags and scrubbing materials) shall be available. It shall be possible to maintain vital functions even if the main power unit of the SPHL is out of function. The SPHL shall be equipped with adequate navigational aids such as relevant charting, compass and global positioning system (GPS).

The SPHL shall be equipped with a propulsion unit capable of functioning for a minimum of 72 h. The effect of the propulsion unit shall be sufficient for proper manoeuvring of the SPHL, taken into account its mass and size when fully equipped and manned. Equipment to enable communication with other vessels shall be available, e.g. a two-way marine very high frequency radio (VHF radio).

The SPHL shall be equipped with an easily accessible panel for connection of supplies, monitoring and control functions between the SPHL pressure chamber and an external control and supply source. The panel shall be in accordance with common industry standards described in IMCA-D051 [36].

In a case where the support personnel have to leave the SPHL, arrangements shall be available to ensure that the chamber occupants can take control.

The SPHL shall be marked so that anyone who discovers it gets information on how to act. For information see IMO-A.692 [37] and IMCA-D027 [40].

7.5 Emergency life support package

An emergency LSP, facilitating external supply, monitoring and control of the SPHL's pressure chamber shall be available at a convenient location(s). Proper maintenance of the LSP shall be performed to ensure that it is ready for use at any time during a saturation diving operation. Compatibility between the LSP and the receiving panel on the SPHL shall be verified through physical testing of all functions, see 7.2.4.3. Gas sources of acceptable quality and minimum volumes according to Table 8 shall be available.

Table 8 – Minimum LSP gas volumes

% O_2	m^3 (STPD)	Quads
100	128	1
10	128	1
2	384	3
Remaining gas in mixes shall be helium. Quads refer to 16 bottles á 50 litres and pressure 160 bar (16 MPa)		

Arrangements shall be in place for the mobilisation of the LSP on board a suitable rescue vessel capable of reaching the SPHL within 12 h of the launch of the SPHL, see OGP-478 [41].

Procedures for use of the LSP shall be included in the vessel/systems contingency plan and shall be available both at the LSP and inside the SPHL.

Emergency procedures shall be available inside the pressure chamber of the SPHL, inside the SPHL itself and at the LSP, see IMO-A.692 [37].

7.6 Gas supply systems

The gas supply installation shall ensure correct and adequate gas supply during normal operation and in an emergency situation (according to NORSOK U-101). The installation shall have

a) at least two independent sources of supply to the diving bell/wet bell/habitat,
b) at least two independent sources of supply to each diver, and separate additional supply to stand-by diver, which should all be arranged so that interruption of supplies to one diver will not affect other divers' supplies,
c) gas supplies to divers which should be arranged so that interruption of supplies to one diver will not affect other divers' supplies,
d) two independent sources of gas supply to each section of a chamber complex where divers could be staying (all sections that could be isolated by pressure),
e) Verification test for maximum gas flow capacity to full user compliment need to be verified for the depth rating of the system, ref. section 4 in this standard.

Gas cylinders shall be marked according to EN 1089-3, but with the option stating that O_2 and helium mixtures intended for breathing, always shall be marked white + brown on the neck/shoulder (as for gas for medical use), never green or light blue. This is illustrated in Table 9.

Table 9 – Colour coding of cylinder necks/shoulder for breathing/medical gas

Gas type	Symbol	Colours
Air / synthetic air 20%<O_2<23,5%		White RAL 9010 Black RAL 9005
Helium / oxygen	He/O_2	White RAL 9010 Brown RAL 8008
Oxygen / nitrogen	O_2/N_2	Bright green RAL 6018

O_2<20%		
Oxygen / nitrogen O_2>23,5%	O_2/N_2	Light blue RAL 5012

NOTE IMCA-D043 [42] deviates from this and EN 1089-3, as it specifies Black and White for all O_2/N_2 mixtures, regardless of O_2 content.

EN 1089-3 does not apply to quads/bundles. Where the colour coding involves two colours, these may be marked on the quad frame in addition to / instead of the shoulder, for the cases where all the cylinders in the quad/bundle contain the same gas. For the case of large gas storage banks, where the gas cylinders are completely encapsulated within the framework and only the valves/connection points protrude through the "face" of the bank, there shall be a round flag of at least 200 mm diameter painted in quarters/thirds with the appropriate colour coding, immediately adjacent to the valve/connection point of each cylinder.
O_2/helium/N_2 ("trimix") is not relevant under this NORSOK-standard.
Marking of pipes, panels and valves shall as far possible follow the same colour coding as indicated above.

Gas cylinders, quads or piping containing a pressure in excess of 20 MPa (200 bar) shall be specially marked at the outlet connection point and at control panel connection points.

Two independent gas supplies are required to the panel supplying the main umbilical. One supply shall be dedicated for emergency. It shall be activated if the downstream gas analyser to the diver gives an alarm signal and/or the supply pressure drops below set values. The pre-set pressure on the emergency gas supply shall be lower than the main supply.

The bell-man shall have easy access to operate the gas panel in the diving bell. No more than two operations should be required to activate the spare on board gas supply.

If leakage into enclosed spaces could produce a hazardous atmosphere, equipment giving necessary warning of such conditions shall be installed.

O_2 and gases representing a fire or explosion hazard shall be stored in a suitable place. The pressure in supply pipelines from the place of storage shall be as low as possible. The routing of such gas lines shall be given special attention, regarding the effects of leakages. Mixtures of gas where O_2 represents more than 22 % shall be treated as pure O_2 with regard to fire and explosion hazard (5.2.3.1).

Suitable materials and components shall be used for transportation of the appropriate gas mixtures at the relevant pressures. Use of flexible hoses shall be reduced to a minimum.

Inert gases used in support of diving operations shall contain a minimum O_2 content of 2 % unless special arrangements have been made to prevent that pure inert gases can be fed to the breathing gas lines.

Water traps for gas reclaim shall be designed for simplicity of cleaning, disinfecting and drying, to prevent microbiological contamination.

Reclaimed chamber gases shall be analysed for O_2 and possible contaminants prior to their re-use.

7.7 Systems for thermal balance

7.7.1 General

Facilities for MUO shall be equipped to maintain thermal balance of the divers, so that functional capability is maintained within safe limits. For surface orientated diving operations where active heating need not be available, it shall be possible to compensate for this and ensure that divers working in water maintain the correct thermal balance.

7.7.2 Normal operation

The environmental control system of chambers, bells and habitats shall have the capacity to control temperature variations during compression and decompression, and to maintain any selected temperature between 22 °C and 33 °C at relevant operational depths. The temperature control for divers in the water and the atmosphere of chambers, bells and habitats shall be sufficiently accurate to ensure thermal balance and comfort for the divers/occupants at all times.

Divers' primary breathing systems shall be equipped for heating the divers' breathing gas when diving deeper than 150 msw as required in NORSOK U-101.

Actively heated suits shall be used whenever necessary to maintain thermal balance, comfort and efficiency. The actively heated suits shall have a thermal control system preventing local burns or local cooling.

7.7.3 Emergency systems

A survival system for diving bells and habitats shall be installed. It shall have the capacity to maintain safe thermal condition. The survival system shall ensure the occupants' ability to participate in the rescue operation. The minimum capacity of these systems shall be in accordance with 9.3.

The survival system shall comprise a through water transfer suit to allow wet transfer to a rescue system.

7.8 Breathing apparatus

7.8.1 General

The BA, including bail-out system, stand-by diver system, welders' masks and BIBS, shall fulfil the requirements and recommendations of NORSOK U-101.

Diver helmets/masks shall have two separate gas inlets. One of these inlets may be a free-flow inlet.

BA shall have individual documentation providing information on the history and the status of the equipment.

Disinfection and microbiological sampling/control of BA shall be performed frequently. Microbiological sampling/control of the disinfection regime efficiency shall be performed on a regular basis with particular attention to re-breathers.

Rubber and plastic materials used in breathing loops and oral-nasal masks provides excellent habitats for biofilm and bacteria growth that can cause allergic reactions, skin irritation or infections and shall have special attention.

The disinfection regime shall be designed not to cause harm to the respiratory tract, allergic reactions, skin irritations or infections from cleaning- and disinfection agents used.

7.8.2 Stand-by diver system

The stand-by diver's BA shall be designed to allow the diver to dress and enter the water without assistance within 1 min.

The stand-by diver's BA shall have adequate quantity of breathing gas from a dedicated source, see 7.2.4.2. The stand-by diver's BA gas supply shall be independent of the diver's gas supply.

7.8.3 Bail-out system

A bail-out system shall be ergonomically adapted to the primary system, and it shall be possible to activate with no more than two operations. When a diving bell is used, the bail-out system shall be designed to ensure easy entrance.

The bail-out system should in general have sufficient capacity to allow the diver to reach a place of safety. As a minimum the bail-out system shall provide the diver with gas for 10 min based on an average consumption of 62,5 l/min, correlated to the ambient pressure and temperature of 37 °C (see NORSOK U-101).

7.8.4 Welding mask

The design of the welder's mask shall ensure that atmospheric contaminants within the habitat do not penetrate into the welder's respiratory system, i.e. over-pressure in the mask. The welding mask shall be designed in accordance with ergonomic principles.

7.9 Diver umbilical

The umbilical shall

a) ensure necessary supplies to the diver,
b) provide necessary transmission of communication,
c) be of sufficient strength to ensure intact vital functions during emergency recovery.

The divers' umbilical shall in addition be marked as follows:

5 m: red ring around the umbilical;
10 m: black ring around the umbilical;
50 m: wide black ring around the umbilical;
(i.e. 15 m are marked with 1 red and 1 black, and 45 m are marked with 1 red and 4 black).

Supply and communication lines shall not be subjected to loads which can cause failure during operations

7.10 Tools

No tools shall be used that can cause harm to the user under predictable conditions, provided that proper procedures are followed for operation and maintenance.

Weight and buoyancy of diver hand-held tools shall be adjusted to ensure efficient handling.

All power tools shall have control systems that automatically isolate or divert the power, when the diver releases the operator handle. The control room shall have the possibility to de-activate the energy source.

Detailed procedures for the operation of any underwater tools, with emphasis on the safe operation of the equipment, shall be available. It shall be possible to carry out function tests of the underwater tools on deck or in shallow water.

7.11 Diving support vessel

7.11.1 General

The DSV shall be in class with a recognised classification society for vessels and conform to ISO 19901-7.

7.11.2 Diving from the diving support vessel

When divers (whether in water or in the diving bell) are inside or close to structures etc., the DSV shall at all times be in DP equipment class 3, as defined in ISO 19901-7. In this respect a submerged (welding) habitat is considered a "structure". For all other diving in water, the DSV shall be at least in DP equipment class 2. If there are divers under pressure on board, and the DSV is for any other reason, operated in DP, this shall also be at least in DP equipment class 2.

If other vessels are in the vicinity of the DSV, the requirements for their positioning systems shall be evaluated with respect to the safety of the divers.

7.11.3 Diving from small diving craft

7.11.3.1 General

Small- or light dive craft operations are conducted by use of a small boat equipped as a complete dive station operated from a mother vessel of opportunity. The technique is suitable for no-decompression-stop diving. This diving method should not be planned deeper than 30 msw. Special consideration should be given to the quantity of gas available and the proximity of the recompression chamber on board the mother vessel (ref. IMCA-D015 [43]).

7.11.3.2 The small diving craft

It shall be documented that the small diving craft is safe and suitable for the purpose. Crafts used as dive platforms shall be type approved by a recognised classification society, and have a dive system complying with industry standards (this document and NORSOK U-103).

7.11.3.3 Diving system

Surface oriented diving systems shall comply with technical requirements in NORSOK U-101 and as set forth by industrial guidelines and best practice (e.g. IMCA-D040 [44]).
Sufficient amount of diving gas for work scope and depth shall be stored on board the craft in a safe gas cylinder configuration designed for the applicable number of divers including a described safety case. Divers and the stand-by diver shall have their own dedicated primary gas supplies. A separate, secondary gas source shall be immediately available to supply either diver as back-up. If using gas mixtures other than air the stand-by diver breathing gas shall have a lower O_2 content than the divers.

Each diver shall be provided with an adequate emergency supply (like bail-out bottle or rebreather) dimensioned for minimum 10 minutes breathing at maximum depth, ref 7.8.3.
Diving may be conducted as “online diving” with gas supplied from installation or mother vessel. In such case the routing of gas supply lines and gas storage shall be risk assessed. The divers breathing gas shall be routed through the small diving craft dive control panel. On board gas banks shall be used as contingency gas immediately available for the divers.
The diving control panel shall be designed in accordance with requirements in NORSOK U-101 and also with considerations to relevant requirements and recommendations given in ISO 6385 [7], EN 12464-1 [8], EN 12464-2 [45], NORSOK S-002 [6] and established guidelines (e.g. IMCA-D023 [46], IMCA-D024 [47], IMCA-D037 [48] and IMCA-D040 [44]). Special attention shall be given to the requirements to pipework, valves and panel intended for nitrox use. A diver monitoring system shall be provided for each diver.
Communication to divers shall be recorded. Any recorded dive data and communication shall be stored in a safe and easily retrievable manner.
An efficient recovery mechanism including appropriate harnessing to allow safe recovery of the diver shall be in place on board the craft. The use of electrical recovery mechanism shall demonstrate sufficient working capacity on battery power.

7.11.3.4 The support vessel

The support- or mother vessel for small diving craft diving operations shall be equipped with facilities for providing efficient assistance to the dive craft, and shall fulfil general operational requirements for vessels in diving support such as medical stores and hospital according to DMAC-15 [49] or equivalent.
Vessel shall have facility for safe and efficient launch and recovery of FRCs in support of small dive craft while in MUO. FRC shall be demonstrated suitable for towing of small dive craft, injured diver transport and safe transfer of personnel.
Safe distance between vessel and small dive craft work site to be based on local criteria and evaluations taking transport time of diving casualty and safe recompression in chamber into consideration.
The support vessel shall have a lifting device that is type approved by a recognised classification society, certified for launch and recovery of small dive craft (such as davit or crane). If the small dive craft is to be lifted/launched with personnel on board then the lifting device shall be approved for such, and personnel conducting these lifting operations specifically trained and familiarized.
There shall be alternative means of communication established between mother vessel bridge and small dive craft.
If the support vessel is an active part of the MUO (i.e. used as mooring etc.), the station keeping systems shall conform to ISO 19901-7.

7.11.3.5 Manning of small diving craft operations

Stand-by diver shall be on board small diving craft dressed in and ready for deployment. A diving supervisor on board shall be responsible for running the dives. Other manning is as required and based on complexity of craft in use.
Qualifications of personnel manning FRC and small dive craft as skippers shall be according to relevant requirements due to size and class.

7.12 Monitoring and control panels

Control and monitoring panels shall allow efficient supervision of the operations. See e.g. ISO 6385 [7].

Parameters being monitored shall be displayed with appropriate units and a suitable scale. Standard metric units shall be used.

All instrumentation shall allow easy viewing and shall be clearly identified and labelled in English and other relevant language as required.

7.13 Communication system

Communication shall be provided between divers in water/bell/habitat and chambers and their supervisor. The supervisors shall have the possibility to control all communication to and from the divers under their supervision.

Two independent main systems shall be installed for efficient communication between personnel engaged in MUO and the dive operation control room. An alternative facility for communication between personnel working below surface and the operation management shall also be provided. This facility shall be independent of the main communication systems.

The above requirements for two independent systems do not apply to the communication links in divers' umbilical.

In addition to hardwired communication lines between the surface and personnel positioned in water (e.g. diving bell, submerged habitat), equipment shall be provided based on wireless communication ("through-water-communication").

The communication system shall provide the possibility for relevant personnel to call the attention of dive control.

The communication system for divers in both water and hyperbaric chambers shall be tested for intelligibility under as realistic operational conditions as possible. For heliox diving, a modified rhyme test (MRT) shall be used to verify that the operational communications systems are in accordance with the requirements in Table 10.

Means for processing of speech (unscrambling) shall be available when using helium mixtures and used when required. These requirements apply to verbal communication from diver's helmets, bells, chambers, habitats and between divers in water. Communication other than verbal may be acceptable for emergency communication, provided sufficient quality can be achieved.

Table 10 – Intelligibility criteria for voice communication systems (from MIL-1472 [50])

Communication requirement	MRT Score
Exceptionally high intelligibility; separate syllables understood.	97 %
Normally acceptable intelligibility; about 98 % of sentences correctly heard; single digits understood.	91 %
Minimally acceptable intelligibility; limited standardized phrases understood; about 90 % sentences correctly heard (not acceptable for operational equipment).	75 %

Switching of communication channels shall be possible so that all persons who need to communicate have the possibility to do so uninterrupted and independent of other communication channels. The panel containing the communication system shall be arranged in a logical and ergonomic manner. A traffic flow matrix of the system shall be documented and available on board.

7.14 Fire protection

Facilities for MUO shall have fire detection and firefighting equipment covering the entire plant both internally and externally. The equipment shall have adequate capacity to put out fires that might occur. Activation shall be possible both internally in the chamber and externally in chamber control independently. There shall be facilities to maintain chamber cooling and control of the temperature for the occupants in the chamber complex during an external fire. The above includes the SPHLs and the SPHL launch areas.

7.15 Remotely operated vehicle system used in conjunction with manned underwater operations

ROVs used in connection with MUO shall conform to NORSOK U-102.

7.16 Water supply

The fresh water supply system (potable water) should be designed to tolerate weak acidification of the water.

All potable water to the dive system shall be controlled by minimum 2 hygienic barriers (applies also to potable water by-pass), e.g. be chlorinated and exposed to UV radiation. To ensure efficiency of the UV treatment, particle filter trains, should be installed prior to the UV radiation source. To avoid biofilm build up and bacteria growth it is recommended that designs take into account hot and cold potable water ring mains to all dive system consumers and that pipework deadlegs are kept to a minimum. For further details of acceptable system designs see e.g. NIPH-120 [51] .

A specific and customised microbiological examination of the fresh water supply to saturation chambers shall be performed prior to initial pressurisation of the system. Systematic microbiological testing for coliform and other relevant bacteria shall be performed on the fresh water, e.g. see NIPH-120 [51].
Specific and customised microbiological examination of hot water to suits prior to saturation operations shall be performed. Seawater to the divers hot water supply shall be disinfected to minimise skin infections. The seawater, filtered for particles, should be heated to more than 90 °C and/or exposed to UV radiation.

7.17 Maintenance

Facilities and equipment for MUO shall be maintained in accordance with a risk based planned maintenance programme (NORSOK Z-008). This programme shall be based on design, construction and operation. Test conditions for components and the facility in general, shall be specified.

The maintenance programme should describe necessary maintenance and planned testing of single components or entire plants, and shall be based on manufacturer's recommendations and the contractor's experience of component wear and tear. The maintenance programme shall seek to avoid unforeseen equipment malfunction through routine checking and replacement of components.

Maintenance records shall be kept in accordance with NORSOK Z-008.

Critical equipment being maintained and/or repaired on board shall be tested and verified to meet requirements (e.g. from classification societies) after maintenance/repair has been carried out and prior to use.
Modifications to the system, sub-systems or components, shall be executed in accordance with a modification procedure, minimum following the same principles as for the "management of change" process (4.5). The procedure shall include a risk assessment of the proposed change, peer acceptance of the modification (including class approval as required), documented implementation, testing and verification (7.19) after implementation and final close-out. All modifications shall be documented and included in the affected system as-built documentation (4.3). Affected compliance measurements (4.4) and certificate status (4.5) shall continuously reflect the current as-built status of the system.

7.18 Testing and verification

Components and facilities for MUO shall be tested during fabrication and operation in accordance with the recognised standards to which the facility has been designed.

Vital functions shall be checked immediately prior to the commencement of the operation, as well as during the actual operation. Functional tests shall be carried out on all components that are used or that can be used during normal operation and in emergency situations.

If visual inspection discloses conditions that might reduce the quality of the facility, further investigation shall be carried out. Measures shall be taken in order to ensure adequate quality of the facility.

In the event of failure during operation, the component and the plant in question shall be functionally tested after repair. Also following modifications, necessary testing shall be performed to verify the proper function of the system (7.17).

For information on intervals and detailed methods of testing, see NUI-THB [33] and IMCA-D018 [34].

When new equipment is developed for MUO, tests shall provide the basis for the evaluation as to whether the equipment shall be deemed safe for use in operations.

8 Operational requirements

8.1 Planning and execution

8.1.1 General requirements

Operations shall be carried out in accordance with procedures as specified in clause 4. For additional information see OGP-411 [52].

During MUOs all relevant data shall be recorded (8.3).

8.1.2 Responsibilities

8.1.2.1 Management on installations and DSVs

It shall be ensured that other activities will not endanger those who are engaged in the MUO. Furthermore it shall be ensured that information concerning matters that might affect safety is passed on to the operation management and to the shift management.

The master/installation manager has the overall responsibility for the safety of all personnel on the work-site.

The chief engineer has the overall responsibility for the technical status of all plant and equipment integrated in the DSV/installation.

An electrician at the work-site shall be appointed the overall electrical co-ordinator. In this function he is entitled to request documentation that all electrical equipment brought on board, is properly certified and maintained, and that all personnel working on electrical circuits are properly qualified.

8.1.2.2 Operation management

In operations with more than one shift per day, a designated qualified diving superintendent in addition to the supervisors shall manage the operation.

In operations with only one shift, the shift supervisor may assume the duties of the operation management.

The operation management shall be responsible for the implementation of the MUO, and may, in consultation with and with the consent of the shift management, commence an operation. All participants have the right and the duty to suspend operations in the event that the activities are not conducted in a safe manner.

The diving superintendent has the overall responsibility to ensure that the activities are carried out in accordance with current laws, regulations and applicable procedures. It is the superintendent's responsibility to ensure that all personnel are qualified and familiar with current laws, regulations, procedures and equipment applicable to the operation.

The offshore manager will represent the diving contractor on larger projects at the work site.

8.1.2.3 Shift management

Shift management is carried out by the diving supervisor. The diving supervisor shall have the responsibility for the safe conduct of diving on his shift.

A MUO may only be commenced if the diving supervisor agrees. The diving supervisor is responsible to ensure that the necessary equipment is available and that laws, regulations and procedures are complied with.

8.1.2.4 Operation management of chamber complex

The LSS shall be responsible for the safe and proper operation of the chamber complex.

8.1.2.5 Working environment committee

The contractor shall establish a system for follow-up of the working environment pertaining to the diving operations that meets relevant acts and regulations. A working environment committee consisting, as a minimum, of on board management and safety delegates shall be established in this respect.

The working environment committee members shall receive the necessary training to perform their duties in a satisfactory manner. Time shall be allocated so that the members can perform their duties satisfactorily, preferably within their working period.

The working environment committee shall focus on items relating to safety and working environment. Reported accidents and near misses shall be evaluated. The working environment committee shall have an advisory function and shall recommend necessary preventive measures.

If the working environment committee members are unable to reach an agreement, the various views shall be recorded and decision taken at diving contractor management level. The members shall sign the minutes of meetings, and a copy shall be supplied to the operator's representative.

8.1.2.6 Personnel subjected to hyperbaric conditions or work under water

Work under water and stay under pressure shall only be carried out if the diver feels fit to do so.
The divers shall maintain personal logbooks and hold these in safekeeping. The line management shall verify the logbooks.

The log books shall contain the following:

a) name and signature of the diver;
b) picture of diver stamped by a diving contractor;
c) diver medical signed by diving doctor;
d) name and address of the diving contractor;
e) date to which entry relates;
f) location of the diving operation, including the name of any vessel or installation from which diving is taking place;
g) the maximum depth reached on each occasion;
h) the time the diver left the surface, the bottom time, and the time the diver reached the surface on each occasion;
i) where the dive includes time spent in a compression chamber, details of any time spent outside the chamber at a different pressure;
j) BA and breathing mixture used by the diver;
k) any decompression schedules followed by the diver on each occasion;
l) any work done by the diver on each occasion, and the plant (including any tools) used in that work;
m) any episode of barotrauma, discomfort or injury suffered by the diver, including details of any decompression illness and the treatment given;
n) any emergency or incident of special note which occurred during the diving operation;
o) other factors relevant to the diver's health or safety;
p) name and signature of the authorised representative of the diving contractor (this will normally be the diving supervisor) who confirms the details recorded. Names and addresses should be printed and in block capitals.

8.1.2.7 Technical work

All technical personnel involved in maintenance of the diving plant and equipment shall be familiar with the applicable procedures, see also 7.17. The operation and shift management shall at all times be familiar with the status of the plant and equipment in use.

8.1.3 Mobilisation/demobilisation

8.1.3.1 General

Mobilisation/demobilisation shall be carried out in accordance with a defined plan. When the contractor considers mobilisation/demobilisation to be completed, notification shall be submitted to the operator for acceptance.

8.1.3.2 Mobilisation of personnel

The contractor’s system for mobilisation of personnel shall ensure that all personnel employed by the contractor meet their job requirements, and are familiar with and trained in carrying out their regular assigned duties and any special procedures related to safe execution of the work.

The mobilisation plan shall allow sufficient time for necessary familiarisation of all personnel.

8.1.3.3 Familiarisation

Familiarisation for the planned operation(s) shall include all personnel involved in the diving operation (also e.g. DP-officers, crane operators, ROV operators, technical management and the master / installation manager), and shall be conducted in accordance with a specified programme defining time schedules and content.

The programme shall be adapted to the level of previous knowledge of the work-site and work tasks of the individual participants. Familiarisation shall be documented and verified.

8.1.3.4 Supervisory personnel

All offshore supervisory personnel shall have the duty to and be allowed adequate time for familiarising with contract specifications, job procedures and current regulations. They shall also be familiarised with, and in agreement with, the documented risk analyses performed and the resulting risk reducing measures.

8.1.3.5 New personnel

New personnel being mobilised during the operation shall receive a familiarisation of the same standard as those taking part in the initial familiarisation programme.

8.2 Diving procedures

8.2.1 General

Procedures for compression, decompression and treatment of decompression sickness shall ensure safe conduct of the underwater operation.
Procedures shall be based on recognised standards and systematic records shall be kept of the experience gained with particular procedures.
Statistical material shall be maintained in order to evaluate the quality of procedures.
Decompression procedures shall allow for therapeutic treatment to be carried out without increased risks for involved personnel.

8.2.2 Surface oriented diving

Diving procedures in accordance with NDTT [53] should be used, but adhering to the restrictions of maximum bottom time exposure limits given in Table 11.

The diving schedule shall be arranged so that the divers have one day in every four, free from dives deeper than 9 msw, or the equivalent air depth.
For surface oriented diving deeper than 20 msw the stand-by diver shall be placed in basket/wet-bell.

Table 11 – Maximum bottom times limitations for in-water decompression and TUP decompression (from NDTT [53])

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

For O_2 limitations, see 5.2.3.6.1.

Diving that requires decompression stops shall not be planned when diving from small diving crafts. For further information on operational recommendations, see e.g. IMCA-D015 [43] or PSA-YA-545 [54].

8.2.3 Saturation diving

8.2.3.1 General

The framework conditions in 8.2.3.2 to 8.2.3.5 are extracted from PSA-OD-91-88 [55].

8.2.3.2 Compression

Compression to 180 msw shall be at a rate of maximum 1 msw /min. There shall be a stop at 10 msw (2 bar) for a minimum of 20 min for checks.

In the depth range from 0 msw to 89 msw, the diver shall have a rest period (non-diving) of minimum 1 h after end of the compression period.

In the depth range between 90 msw to 180 msw, this period shall be a minimum of 2 h. Rest periods shall not take place more than 1 msw shallower than the planned living depth. The ambient pressure and established diurnal rhythm shall be taken into account in the evaluation of when personnel are ready to start work.

8.2.3.3 Decompression

Decompression shall be performed in accordance with validated procedures aiming to avoid decompression sickness and other negative short or long-term health effects on the divers, see Table 12.

Decompression shall not start with a pressure reducing (upward) excursion. The pO_2 shall be in the range of 40 kPa to 50 kPa (400 mbar to 500 mbar).

There shall be a night stop every night between 24:00 h and 06:00 h. The last stop shall not be shallower than 3 msw. The divers should be encouraged to perform some light physical activity during the decompression.

The shallowest saturation storage depth is 14 msw.

Table 12 – Saturation decompression

Depth msw	Minutes/msw	msw/day
> 180	to be specified	to be specified
180 to 60	40	27
60 to 30	50	21,6
30 to 15	60	18
15 to 0	80	13,5

8.2.3.4 Excursions

Procedures for excursions shall be prepared. If excursions are extended compared to Table 13, longer stays at living depth prior to start of decompression should be considered. Decompression shall not start with an upward excursion. There shall be a minimum 8 h hold at living depth prior to decompression after an excursion.
The hold period is to be considered as part of the decompression and not the "stay at living depth".

Table 13 – Excursions

Living depth msw	Excursion msw	
	Upward	Downwards
14	0	3
15	1	3
16	2	3
17	3	3
18 to 22	4	4
23 to 29	5	5
30	6	6
31 to 39	7	7
40 to 59	8	8
60 to 79	9	9
80 to 99	10	10
100 to 119	11	11
120 to 139	12	12
140 to 180	13	13
>180	to be specified	to be specified

As a minimum, the procedures shall define

- living depth,
- working depth,
- limitations of excursion after change of living and/or working depth,
- maximum rates for compression and decompression during excursion,
- maximum pressure increase and decrease during the excursion.

It is of special importance to restrict the use and distance of upward excursions.

The maximum ascent rate during excursion is 10 msw/min.

8.2.3.5 Living depth

Dive planning shall be based on minimum change of living depth and excursion exposures.

The living depth shall be as close to the working depth as possible, based on a total evaluation of all safety aspects.

Living depth changes are permitted, but it is not allowed to compress, decompress, and then recompress.

8.2.4 Deeper saturation diving

For diving at depths deeper than 180 msw, special attention shall be given to selection of divers, compression and decompression procedures.

For working depths deeper than 180 msw the diving contractors validated diving procedures shall be followed. These procedures shall prevent decompression sickness and any other harmful effects.

Evaluation of HPNS symptoms shall be performed, e.g. in accordance with NUI-1993-21[56].

For MUO deeper than 180 msw requirements to additional medical examinations has been defined (5.1.4).

For MUO deeper than 180 msw provisions regarding time has been defined (8.4.5).

8.3 Monitoring

8.3.1 General

All diving systems shall have equipment allowing monitoring of important parameters and conditions. There shall be primary and secondary systems for monitoring of parameters, to verify that a correct atmosphere is maintained, see 4.8.1.

Monitoring equipment shall be arranged to give time for corrective measures before any loss of safety. The design of the monitoring equipment shall allow the setting of limit values with alarm signals when measured values exceeds defined limits.

PLC controlled dive systems with a digitally controlled supervisor interface and on-line data acquisition is accepted as an official log of the dive and dive system operations.
All forms of electronic logging shall be equipped with backup functions to prevent loss of information.

8.3.2 Monitoring of parameters

An on-line data system shall be used for recording of diver exposure data, such as: diver, bell, habitat and chamber parameters. Sensors for depth monitoring shall be located on the bell and on the diver.

The following parameters shall be measured, displayed, and logged and retained on a continuous basis:

a) time;
b) divers depth;
c) pO_2 and pCO_2 in the diver's breathing gas;
d) hot water temperature and flow, or heating power to the bell;
e) bell internal and external pressure;
f) bell internal pO_2, pCO_2 and temperature;
g) chamber internal pressure, humidity, pO_2, pCO_2 and temperature;
h) habitat internal and external pressure;
i) habitat internal pO_2, pCO_2 and temperature.

For diving deeper than 200 msw hot water temperatures at the bell and at the diver's suit, and hot water flow, or heating power, to the diver at the bell shall be measured, displayed and logged.

The following substances shall be measured and logged on a routine basis:

j) potentially toxic gases in the hyperbaric environment;
k) in habitat when welding: CO, Ar, NOx, O_3, fumes, dust (not required on-line);

l) bacterial growth/content in all critical places

8.3.3 Visual monitoring

All chamber compartments, bells and habitats shall be equipped with video monitoring system, enabling the surface support crew to visually monitor the occupants and operations.

Before deploying a bell near structures, inside another vessel's anchor pattern, etc., the work-site shall be visually checked by an ROV.

A diver in the water shall be monitored by an ROV or a second diver's camera.

8.3.4 Recordings during operations

Recordings of video and communication with diver in water/bell/basket/wet bell/habitat shall be made. Recordings from the last 48 h shall be available and shall include the check of equipment and personnel prior to the commencement of the operation.

In case of accidents or serious near incidents, recordings of communication and video shall be kept and made available for later investigation.

8.4 Provisions regarding time

8.4.1 Stay at living depth

During saturation diving stay at living depth shall not exceed 14 days.

The planning shall take into consideration the strain that the divers will be exposed to during the operation when the time period for stay at living depth is determined. The strain on the divers shall be continuously considered during the operation with regard to whether a shorter period should be applied. It is a prerequisite that the total length of stay under pressure is the subject of discussions with the representatives of the personnel including safety delegates.

8.4.2 Time between saturation periods

The time between saturation periods shall at least be equal to the duration of the preceding saturation period.

8.4.3 Bell run

Maximum time for a bell run is 8 h for saturation diving. Workloads shall be assessed during planning of the diving operations, and if applicable, a shorter bell run may be chosen. If the divers request that the dive should be suspended before the maximum permissible time is up, this shall be decisive.

A bell run shall be calculated continuously from when the clamp between the bell and the chamber is first loosened and stops when the clamp is reconnected, ready for pressure equalisation and final transfer of the divers back to the chamber complex.

8.4.4 Time in water

During a two-man bell-run, total time in water during a 12 h period shall not exceed 4 h for each diver.

For bell-runs with more than two divers, the total time in water during a 12 h period may be extended for each diver (see definition of time in water, bell diving) on the following conditions:

a) the diver returns to the bell in the course of the third or fourth working hour in the water for a break of at least 30 min with the diving helmet off, i.e. the divers' 30 min break shall start between 2 h and 4 h after lock-out;
b) total in water time shall not exceed 5 h 30 min;
c) the break in the bell to be logged;
d) each diver shall be given a dry day as bell-man every third day.

Reports from the divers with regard to work conditions need for rest periods and/or suspension of the dive should, however, normally determine the length of stay in the water, up to the maximum time stipulated.

8.4.5 Provisions regarding time for deeper saturation diving

The following provisions apply:

a) for diving deeper than 180 msw stays at working depth shall not exceed 10 days;
b) in the case of diving deeper than 180 msw the time between saturation periods shall be at least twice the duration of the last saturation period;
c) bell run duration shall not exceed 6 h for diving deeper than 180 msw;
d) for bell diving deeper than 180 msw total time in water during a 12 h period shall not exceed 3 h for each diver.

8.4.6 Diving supervisor

The diving supervisor shall have a rest period from the direct communication control after a period of 4 h. The rest period shall be at least 30 min. The total time for this function shall be limited to 8 h in the course of a 12 h period. The workload should determine the length of the rest periods. Inside a 24 h period supervisory personnel should normally have a 12 h period of continuous rest.

The direct communication control may be assigned to a trainee diving supervisor, provided the diving supervisor supervises the trainee.

8.4.7 Time in submerged habitat

The bell run including the time in the habitat shall not exceed 8 h. When a breathing mask is used continuously, the personnel shall have a rest period after 4 h in a safe atmosphere without using a breathing mask. This break shall be at least 30 min.

8.4.8 Daily rest period

A continuous work free period of at least 12 h shall be included in any 24 h period for personnel working under water or under increased ambient pressure. Work and rest periods shall be specified in a shift programme and shall be planned at regular hours.

In the case of unforeseen delays in diving operations, the need for minor changes in the original shift plan may be considered. If changes are to be made, the parties involved, including representative of the personnel and safety delegate, shall approve them.

All personnel engaged in MUO, and whose work have an influence on safety during the operation, shall have a continuous rest period of at least 8 h during the course of a 24 h period.

8.4.9 Observation time following completed diving operation

After completed saturation decompression, divers shall have a 24 h rest period with immediate access to therapeutic re-compression. During this period, the diver should not perform hard physical work.

In the case of surface oriented diving divers shall have immediate access to therapeutic re-compression for a minimum of 12 h following a completed dive.

Limitation regarding flying after diving shall be regulated in the diving tables. For information, see NDTT [53] and PSA-OD-91-88 [55].

8.5 Operational measures

8.5.1 Manning of control room

During operations at least two qualified persons shall be present in a control room attending to safety related functions. For short periods (e.g. in connection with meal breaks) at least one competent person (e.g. trainee diving supervisor) in addition to one qualified person shall be present in the control room, see annex B.

8.5.2 Depth limitation

Diving from small dive craft should not exceed 30 msw, ref 7.11.3.
Surface oriented diving using wet bell shall not be carried out at depths exceeding 50 msw.

When diving deeper than 50 msw a closed diving bell and saturation procedures shall be used.

8.5.3 Surface decompression chamber

For all surface oriented diving operations a double-lock decompression chamber shall be ready for use. It shall be possible for the diver to reach maximum depth in the chamber within time limits as specified in diving

tables. For therapeutic purposes it shall be possible to bring an injured diver into the chamber within 10 minutes.

8.5.4 Tendering the diver's umbilical

Diver's umbilical shall at all times be under supervision of a tender. The height from the water surface to the tender's work position shall not exceed 5 m.

8.5.5 Stand-by diver and contingency diver

The stand-by diver shall be able to enter the water within 1 min.

For surface oriented diving at depths shallower than 20 msw the stand-by diver may be located at the surface, provided the location is less than 5 m above the water level.

For surface oriented diving at depths deeper than 20 msw the stand-by diver shall be located below surface in suitable position in water/bell/wet-bell/basket.

During bell diving, the stand-by diver situated in the bell is not required to carry bail-out system during emergency interventions.

During every diving operation a contingency diver shall be appointed and located at surface. Necessary equipment shall be ready for use. When diving from small diving crafts, the contingency diver may be located on board the mother vessel.

8.5.6 Length of diver's umbilical

The length of the diver's umbilical shall be limited to the length considered necessary at any given time, and shall not exceed 45 m from point of tending in the bell/wet bell/basket.

When determining maximum umbilical length, the following hazard points shall be taken into consideration:

a) the distance from the diver to the nearest hazard point (e.g. thrusters, sea water intake etc.) shall be minimum 5 m;
b) duration of bail-out equipment;
c) breathing resistance;
d) thermal conditions;
e) umbilical storage, deployment, handling and recovery;
f) wet tendering;
g) ROV survey with mapping of debris/ obstructions;
h) positioning and stability of the work-site.

The stand-by diver's umbilical shall be at least 2 m longer than the diver's umbilical.

8.5.7 Diving operation from a DP vessel

Specific safety measures shall be taken in the planning and implementation of MUO carried out from DP vessels, see ISO 19901-7.

The operation manual for DP vessels shall give guidance and procedures concerning the transfer of information, along with a description of the communication systems and alarm systems available, and shall define the meaning of commonly used terms, particularly where they refer to emergency situations.

The operational manual for the DP vessel shall include an up-to-date description of the diving system(s) and guidance on the conduct of diving operations as they can be affected by the DP vessel itself.

Procedures shall comprise

a) actions to be taken in case of changes in alert level status,
b) vessel operations in enclosed spaces and at free heading,
c) activity specific operating guidelines (ASOG) or location specific operating guidelines (LSOG), see e.g. DNV-RP-E307 [57]
d) vessel operations where divers enters areas with physical obstacles,
e) precautions to guard against thruster wash or suction effect,
f) surface support and down-line handling,
g) preparations and use of emergency plans,

h) moving vessel.

Communications between the dive control position and the DP console shall be regular and frequent. They shall inform each other about any change in operational circumstances.

When surface oriented diving is performed from a DP vessel, careful consideration shall be applied in the planning and execution to minimise the effect from thrusters. Specific consideration shall be given to the diver's umbilical lengths and deployment method.

A DP audio-visual slave alarm shall be installed in the diving control rooms.

8.5.8 Welding process

During the welding process the divers shall use effective respiratory protective equipment (see also 7.8.4). The respiratory protective equipment shall not be removed before it has been verified that the habitat atmosphere is within the limits as specified in 5.2.3.

8.5.9 Radioactive sources

Relevant national authority shall accept procedures for use of radioactive sources. Activation of radioactive sources when a diver is inside the habitat shall not be possible.

9 Emergency preparedness requirements

9.1 Emergency preparedness plan

An emergency preparedness plan shall describe measures to limit the effects of hazards and accidents and cover DSHA – Defined Situations of Hazards and Accidents. It shall include a Hyperbaric Evacuation Procedure (HEP) listing all Safety Critical Elements (SCE), see OGP-478 [41].

Risk analyses shall constitute the basis for the emergency preparedness plan. Experience feedback shall be considered.

The measures to be implemented in the event of specific accidents or hazard situations shall be described based on these processes. Use of equipment, personnel and other resources shall be included.

The emergency preparedness plan shall include an organisation plan showing the lines of communication, responsibility and reporting, as well as a description of equipment and procedures. Authority and responsibilities shall be clearly defined.

The emergency preparedness plan for the specific project or operation shall be interfaced with the operator's emergency preparedness plan for the area, and with the overall contingency plan applicable to the operator's activities.

9.2 Emergency preparedness training

The requirements for emergency preparedness training shall be assessed by the diving contractor during the planning stage of any MUO. Risk analyses shall constitute the foundation for the emergency training to be performed. Experience feedback shall be used as the basis for training changes.

Prior to start and during the operation, all relevant personnel shall undergo training to ensure they are conversant with and drilled in potential emergencies that can occur during diving operations.

The diving contractor shall have a system that can control and document all training including training and drills carried out on board the DSV.

Diving personnel with medical duties in an emergency situation shall be trained according to IMCA-D020 [30] or equivalent.

9.3 Emergency preparedness equipment

Diving bell and submerged habitat shall be equipped to ensure that personnel can maintain vital functions in emergency situations. Emergency equipment shall have sufficient capacity to ensure that personnel are brought to safety.

The minimum capacity for emergency situations shall be as follows:

a) divers in the water : 10 min;
b) diving bells : 24 h;
c) chamber and SPHLs : 72 h;
d) habitats : 48 h.

When conducting a MUO, means to effectively locate, assist and recover the bell/habitat shall always be available. Such means shall be an additional diving bell for depths exceeding 200 msw, or, for shallower depths, an ROV capable of assisting units in distress.

Diving bell and submerged habitat shall be equipped with a transponder, permanently fixed and operating at a frequency of 37,5 kHz. Vessels and mobile facilities that might be called upon to assist in diving emergencies shall have equipment to locate a diving bell/habitat/diver in distress.

9.4 Contractor's contingency centre

While in operation, the contractor shall maintain, in immediate readiness, a contingency room with adequate communication facilities, documentation and other necessary facilities for the contingency team.

9.5 Hyperbaric evacuation

9.5.1 General

In the event of an emergency it shall be possible to evacuate divers under pressure to a safe place.

The emergency preparedness plan shall include a description of the procedure for hyperbaric evacuation, and how to bring the divers back to atmospheric pressure.

The plan for hyperbaric evacuation shall be based on risk analyses covering the launch, stabilisation, recovery and normalisation phases of an evacuation.

9.5.2 Saturation divers

Saturation divers shall, if necessary, as quickly as possible, be evacuated to an SPHL and transported to a dedicated reception facility for decompression.

The following three phases shall be described in the contingency plan:

Phase 1: Transfer of divers to- and launch of the SPHL.

Phase 2: The SPHL in the water, including a description of how the life support functions are planned to be maintained, where and how the SPHL is to be moved and, taken out of the water – transferred to a defined safe haven.

Phase 3: SPHL under control, transferred to reception facility and decompression of divers.

If there is more than 1,8 MPa (18 bar) difference in pressure between divers who are to be evacuated, it shall be possible to maintain a difference in pressure during evacuation.

The time from when the last diver enters the SPHL until it is 100 m away from the diving launch site, shall not exceed 15 min. The total period between notification of evacuation, with divers in the chamber complex, and until the time when the SPHL is 100 m away from the diving platform, should not exceed 30 min. This includes the time required to bring the system to a pressure enabling transfer of divers into the SPHL using emergency procedures as in e.g. NUI-1984-34 [58] or equivalent. This recommendation shall be seen with reference to the time required to bring the divers to the same pressure using emergency procedures as in e.g. NUI-1984-34 [58] or equivalent.

The selection of SPHL reception facilities shall be based on an evaluation of the time it will take, under the prevailing weather conditions, to transport the SPHL to the centre from the operational location, and the centre's proven capability to receive the SPHL. Compatibility shall be confirmed through a test between the reception facility and the different types of SPHLs. This shall be documented. Maximum accepted time for bringing the SPHL to the Hyperbaric Reception Facilities is within 54 h after launch or 75 % of the SPHL survival endurance capability, ready for transfer of all occupants. This is to be based on vessel's best speed in median weather conditions for the region and the time of year. See IMCA-D052 [38] and OGP-478 [41].

Annex A
(Informative)
Accident/illness/near-accident alert/notification and reporting in diving activity under Norwegian petroleum law

A.1 General requirements under the Norwegian petroleum law

General requirements for alert/notification and reporting of undesired events in petroleum activities, including MUO, are regulated by «Regulations relating to management and the duty to provide information in the petroleum activities and at certain onshore facilities (The Management Regulations), CHAPTER VIII, NOTIFICATION AND REPORTING.

Website: (http://www.ptil.no/report-about-situation-of-hazard-and-accident/category935.html).

A.2 Additional requirements for manned underwater operations, alert/notification

In conjunction with MUO in the petroleum activity there are additional requirements to alert/notification and reporting of incidents/accidents.

In addition to what is generally required, following types of serious accidents and near-accidents require alert/notification and reporting to authorities during MUO's:

a) every case of fire in the plant; also where chamber complex is not occupied by divers and whether the complex is pressurized or not;
b) unintentional halt in the function of any unit necessary to maintain life and health of personnel working under water; regardless of number of barriers to total failure;
c) every form of unconsciousness;
d) accidental change of ambient pressure;
e) decompression illness;
f) gas supply cut-off;
g) faulty gas mixture.

Verbal alert/notification shall be followed up by a written confirmation report using the specialised form (see A.3) in addition to the form found on PSA website, see A.1.

A.3 Reporting

A.3.1 General

In addition to the general requirements (see 4.8) the following shall be reported by the operator to PSA on enclosed form:

a) every incident requiring first aid;
b) every incident requiring hyperbaric treatment;
c) near-accident, including situations when no person is present in the system used for the MUO
d) aborted operation due to illness;
e) external ear infection.

The information reported is used by PSA for input to the dive database DSYS.

In case of accident resulting in personal injury in conjunction with MUOs the form NAV 13-06.05 (Norwegian Labour and Welfare Organisation, www.nav.no) shall be submitted to PSA by the diving contractor directly, as this form contains protected personal data.

A.3.2 Guidance to enclosed form

NOTE If it is required to tick off more than one item in the same column, the most significant item should be marked with a circle.

A.3.2.1 Information related to the incident

Operator:	Name of operator
Field/area:	Name of oil-field and location where incident took place
Contractor:	Name of diving contractor
Work-site:	Name of vessel/platform/barge from where the MUO took place
Date:	Date of incident
Reported by:	Name of person reporting incident
Date reported:	Date of issuing report of incident
Incident category:	Tick off in correct box
Depth:	The depth in chamber/water when incident took place
Breathing gas:	Air/Nitrox/Heliox/Trimix/etc.
Dive type:	Tick off in correct box or state method in use
Purpose of dive:	Tick off correct box or state purpose
Injured body part:	Tick off correct box or state other body parts
Type of injury:	Tick off correct box or state other types of injury
Treatment and follow up:	State briefly the first symptom, type of first aid, who administered the first aid, further treatment and follow up.

A.3.2.2 Analysis for cause

Phase of the diving operation:	Tick off correct phase in the operation when incident took place
Activity:	Activity of involved personnel when incident took place
Place of occurrence:	Tick off for correct place where incident took place. In arena means areas on the work-site outside the diving facility, but in close conjunction with the diving operation, e.g. chamber control room, dive control, DP-control, gas-bag room, gas-storage room, compressor room, external life support room and rooms where equipment in conjunction with MUO is tested and/or stored. All other areas on the work site
System fault:	Tick of correct system directly involved in the cause of incident
Equipment:	Tick of correct cause of incident with regards to equipment
Personnel:	Tick of correct cause of incident with regards to personnel
Other contributing factors:	Tick off other contributing factors or state type

A.3.2.3 Comments/follow up/signature

Corrective actions on long and short term:	List both implemented and planned corrective actions
Comments from safety delegate:	Safety delegate states his comments to the incident as relevant
Signature:	Signature of person reporting incident

Accidents/near-accidents during manned underwater operations under the Norwegian petroleum law

OPERATOR:	FIELD/AREA:	CONTRACTOR(S):	
WORK-SITE:	DATE OF INCIDENT:	REPORTED BY/DATE REPORTED:	
Incident category: □ Near-accident □ Accident with personal injury		Depth:	Breathing gas:

INFORMATION RELATED TO THE INCIDENT

PURPOSE OF DIVE	TYPE OF DIVE	PHASE OF THE DIVING OPERATION	ACTIVITY
□ Inspection □ Construction □ Repair □ Welding □ Maintenance □ Other (describe):	□ Saturation dive □ Surface oriented diving □ Monobaric diving □ Other (describe):	□ Pre-dive □ Compression □ Bottom phase □ Decompression □ Post dive	□ Preparations □ During transport □ At work □ Post work □ At rest

PLACE OF OCCURRENCE	INJURED PART OF BODY	TYPE OF INJURY
□ In chamber □ In diving bell/basket □ In water □ In habitat □ In rescue unit □ In other hyperbaric unit □ In monobaric unit □ In arena □ Outside arena	□ Head/neck □ Eye □ Ear □ Sinuses □ Shoulder/arm □ Hand/finger □ Chest/stomach □ Back □ Hip/knee/thigh/leg □ Ankle/foot/toe □ Skin □ Other (describe):	□ Decompression sickness □ Barotraumas during compression □ Barotraumas during decompression □ Outer ear infection □ Other infection □ Wounds □ Fracture □ Heat injury □ Cold injury □ Unconsciousness □ Death □ Other (describe):

TREATMENT (describe):

ANALYSIS FOR CAUSE

SYSTEM FAULT

□ Chamber complex system □ Bell system □ Control rooms □ Handling system □ Gas supply system
□ Environmental control plant □ Hot water system □ Tools □ Personal diving equipment
□ DP system □ Vessel/installation outside diving plant (describe):
□ Others (describe):

EQUIPMENT	PERSONNEL	OTHER CONTRIBUTING CAUSES
□ Construction/design/ Ergonomics □ Mechanical failure □ Poor maintenance	□ Poor organisation □ Lack of or poor procedures □ Lack of training/skills □ Unawareness □ Incorrect use of equipment □ Illness/personal injury	□ Pollution/contamination □ Weather conditions □ Fire □ Other subsea operations (describe): □ Others (describe):

Accidents/near-accidents during manned underwater operations under the Norwegian petroleum law

CORRECTIVE ACTIONS	
SHORT TERM (describe):	LONG TERM (describe):

COMMENTS FROM SAFETY DELEGATE:	
SIGNATURE SAFETY DELEGATE:	

SIGNATURE:	

Annex B
(Informative)
Training requirements for personnel engaged in manned underwater operations

B.1 General

The main goal of training diving personnel are to provide the diving industry with reflecting employees who takes the initiative to plan, organize and carry out MUOs in a safe and professional manner.
This annex can be useful for students, employers and educational institutions in the diving industry.
The training requirements described in this document are minimum requirements to achieve competence as a certified diver and qualified diving support personnel as referred to in this NORSOK standard, clause 6.
The content in this annex is mainly based on EDTC-PCS [28] , PSA-YA-047 [59] and IMCA guidelines.
The student competence is based on his learning outcomes, understood as statement of what the student knows, understand and are able to demonstrate after completion of the training. The student competence shall be assessed in accordance with achieved level of knowledge and skills at the end of the course.
The education shall reflect that the diving industry is a global industry and the working language offshore is English.
SCUBA diving technique is not recommended within the petroleum industry; however the technique will still be included in training of professional divers, based on international requirements.

B.1.1 Definition

In the context of this annex, the leading words are as defined in accordance with Bloom's Taxonomy:

NOTE Bloom's taxonomy is a classification of learning objectives within education proposed in 1956 by a committee of educators chaired by Benjamin Bloom and is considered to be a foundational and essential element within the education community.

Theory.

SOME KNOWLEDGE:	The student shall have the knowledge to reproduce, define, explain, express the subject, and show the differences, similarities and characteristics.
KNOWLEDGE:	The student shall have the knowledge to interpret, adapt, transmit, use, divide, identify, compare and examine.
DETAILED KNOWLEDGE:	The student shall have the knowledge to generalize, organize, summarize and draw conclusions, judge, discuss, criticize and decide in relation to internal/external criteria.

Practice.

SOME SKILLS:	The student shall be able to observe, note, record, prepare, show interest, use and participate in.
SKILLS:	The student shall be able to repeat, imitate, try and practice under supervision – implement, customize, debug and execute independently.
ADVANCED SKILLS:	The student shall be able to processing, produce, display precision, performing with the flow, combine, innovate, improvise and develop.

B.2 Surface oriented diver

B.2.1 Aim

The aim is to obtain understanding and knowledge of basic skills required in order to perform various underwater tasks safely, and further qualify the student to continue practical training as a member of a commercial diving team. The diver training shall comprise depths to 50 msw using surface oriented diving technique. SCUBA diving is restricted to 30 msw and no-decompression-stops dives, and requires use of full-face mask with two-ways communication.
Surface oriented diving shall include use of dive basket and wet bell. Breathing gas shall be either air or enriched air. The operation of a compression chamber and use of surface decompression procedures shall be a part of the training program.

B.2.2 Entry requirements

The surface oriented diver candidates shall

a) be at least 18 years old,
b) hold a valid certificate of medical fitness in accordance with national guidelines (ref. NBH IK-2708, HSE-MA1 or equivalent) which applies to all trainees undergoing diver training,
c) have sufficient elementary education to be able to carry out the necessary calculations, communicate and understand written instructions in English language,
d) pass the training institutes assessment as required to commence a commercial diving career.

B.2.3 Syllabus

The study plan shall contain content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry, including up to date equipment and relevant work tasks.

B.2.3.1 Theory

Number of lessons shall be minimum 95 h.

Table B1 – Surface oriented diving theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Diving physics**	• Noise in water	• The relationship between volume and temperature (Charles' Law) • Buoyancy (Archimedes' Principle)	• The relationship between pressure and volume (Boyle's Law) • Partial pressure of gases (Dalton's Law) • Solubility of gases (Henry's Law)
2.	**Diving physiology and first aid**	Structure and function of the human body • Muscle /skeletal systems • Nervous system • Heart, blood vessels, blood circulation • Lungs • Ears, sinuses and vestibular organs	First aid: causes, prevention, symptoms and management under normal and hyperbaric conditions for • bleeding; • fractures, sprains and muscle trauma; • shock; • burns; • electrocution; • asphyxia; • pulmonary oedema; • respiratory arrest; • cardiac arrest; • hypothermia; • hyperthermia; • underwater blast injury; • iImportance of personal hygiene in the management of injuries; • measures at the casualty site and	Diving related injuries and side effects: Cause, symptoms and treatment of • decompression sickness, • pressure related injuries, • pressure equalization - ear and sinuses, • drowning, • vomiting under water, • gas embolism and pulmonary barotraumas, • CO_2 poisoning, • CO poisoning, • O_2-toxicity, • anoxia and hypoxia, • N_2 narcosis.

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
			during transportation of injured person; • first aid equipment and its use during a MUO.	
3.	**Legislation, statutory instruments**	• NORSOK standard U-101 • NORSOK standard U-102 • EDTC Personnel Competence Standard • OGP 411 • Relevant IMCA / guidelines • Relevant DMAC guidelines	• Relevant legislation including national regulations • national and international standards • Guidelines • Safety notices • NORSOK standard R-003 • NORSOK standard R-005	• NORSOK standard U-100 • NORSOK standard U-103
4.	**SHE**	• Safety delegate requirements and functions	• Methods to identify and manage risks • Non-conformances reporting routines • Hazard observation reporting routines • Permit to work procedures	• Personal protective equipment
5.	**QA**	• Management of change procedures	QA program relevant to the diving industry	
6.	**Surface oriented diving plant**	• Air compressors and cylinders • Hydraulic power pack unit	• Divers' gas supply system • Hot water system • LARS, • Dive basket and wet bell system	• Diver recovery equipment • Firefighting equipment
7.	**Diving equipment**	• BA / rebreathes closed and semi-closed	• Divers gas panel • Gas analysers and calibration procedures • Diver communication systems • Umbilical • Video camera and recorder • Electronically diver depth monitoring systems	• Diving helmets and masks • Bail-out system • SCUBA gear, including secondary gas supply • Diving suits
8.	**Diving methods and diving routine operations**	• TUP diving procedures	• SCUBA diving operation • Wet bell / basket diving procedures	• Surface supplied diving operation • Surface decompression procedure • Nitrox diving procedures

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
9.	**Diving tables, compression, bottom time and de-compression**		• NDTT • Bottom time restrictions	• Standard decompression tables • Surface decompression tables • Therapeutic tables
10.	**Diving emergency procedures**		• Emergency response plans • Contingency plans	Emergency procedures for: • vessel/dive station; • diver in water; • communication, including hand and line signals; • deployment of stand-by diver; • compression chamber.
11.	**Compression chamber**	• Compression chamber system configuration	• Chamber operation procedures	• Compression chamber emergency procedures
12.	**Seamanship**	• Nautical chart and navigation	• Rigging in general • Rigging equipment	• Safety equipment
13.	**Underwater hazards**	• Underwater explosion	• Underwater structures • Tides and current • Oxy-arc cutting / use of O_2 under water • Underwater welding	• Use of electricity under water
14.	**DP**	• DP system • Position reference • Station keeping	• Surface oriented diving from DP vessels • Umbilical management during DP operations	• Understand the hazards of diving from a DP vessel
15.	**Underwater tasks**	• Be familiar with tasks undertaken by surface orientated diver and / or as a member of a surface dive team	• Work procedures and task plans • Lifting operations	• Safety aspects related to rigging and lifting tasks
16.	**Tools and equipment**	Be familiar with the safe use of: • Underwater welding • high pressure water jetting equipment • Grit blasting • Air lift • Winches • Bolt gun	Be familiar with the safe use of: • pneumatically/hydraulically powered tools; • oxy-arc	• Safety aspects related to operation of powered tools

B.2.3.2 Practical training

The following minimum times in open water shall be achieved during controlled practice training. The listed dive times are minimum times for each depth range. Maximum depth shall be limited to 50 msw.
In water decompression stops shall be included in the times, whilst time in decompression chamber shall not be included.

0 msw to 10 msw:	20 h 00 min
11 msw to 20 msw:	6 h 40 min
21 msw to 30 msw:	2 h 30 min
31 msw to 40 msw:	1 h 40 min
41 msw to 50 msw:	2 h 30 min

Undertake minimum two dives in compression chamber to respectively 18 msw and 50 msw.
A predominant part of the practical training exercises shall be conducted with the use of surface oriented diving technique. The majority (approximate 75 %) of the dives deeper than 20 msw shall be conducted utilizing diving basket or wet bell. The student shall undergo training as a stand-by diver for wet bell in depth range 0-20m.The practical training shall include tasks which are relevant for surface oriented diving offshore and the student shall be familiar with offshore terminology relevant to his work.

Table B2 – Practical training

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
1.	**Routine diving operations**		• Understand and be able to assist in preparing work plan for a dive • Operate under supervision a surface oriented dive panel with divers in water • Work as a member of a diving team including developing suitable relationships with others in the team	• Carry out pre- and post-dive checks as well as daily maintenance on diving equipment • Use communication systems effectively, both as a diver and as surface attendant
2.	**Surface orientated diving equipment**		• Prepare all the equipment that is needed • Correctly remove all equipment and undress on completion of a dive • Assist another diver to remove equipment and undress after a dive • Carry out all necessary post dive equipment checks	• Carry out the pre-dive checks properly on all equipment • Carry out pre-dive operational/function checks on a surface oriented dive panel • Assist a diver to dress correctly and put on all equipment ready to enter the water • Dress themselves and don all equipment needed to enter the water as a diver • Correctly clean equipment after use, carry out simple maintenance and store ready for subsequent use
3.	**Diving in open water**		• Be familiar with safe use of a range of relevant and appropriate tools, including hydraulic, pneumatic and cutting tools	• Dive in open water, in a variety of conditions to depth of 50 msw • Cope with variations in visibility and different seabed conditions • Understand and use

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
				decompression procedures, including surface decompression
4.	**Chamber operations**		• Assist in the pre-dive procedures necessary for operating a double-lock compression chamber • Under supervision, operate a double-lock compression chamber • Assist in post dive checks and the user maintenance required after operation of a double-lock compression chamber	• Undertake minimum two compression chamber dives to (respectively) 18 msw and 50 msw • Act as an inside attendant in a double-lock compression chamber • Assist in therapeutic recompression
5.	**Wet bell operations**		• Check and prepare equipment for a wet bell diving operation • Operate wet bell diver supply panel • Operate wet bell deployment and recovery systems • Carry out post dive equipment checks on wet bell system	• Dive in open water to minimum 20 msw using a wet bell, both as a diver and stand-by diver (bell-man) • As a diver, diving from a wet bell, recover dive partner as in an emergency • Act as surface stand-by diver diver during wet bell diving operations • Decontaminate and clean all relevant equipment on wet bell system
6.	**Hot water systems**		• Carry out post dive checks on the hot water equipment • Decontaminate and clean relevant hot water equipment • Ensure proper care and storage of hot water equipment • Operate surface hot water supply system both as a diver and as a member of the dive team on the surface	• Undertake surface oriented diving operations using hot water suits • Check and prepare diver's hot water suit equipment • Dress correctly in a hot water suit ready for entering the water • Assist another diver to dress correctly in a hot water suit ready for diving • Dive in open water to minimum 20 msw dressed in a hot water suit
7.	**Emergency procedures**			• Carry out self-rescue as a diver in an emergency situation • Act as a surface stand-by diver • Act as an in water stand-by diver in basket / wet bell

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
				• Act as a surface stand-by diver during basket/wet bell operation • Act as a member of the surface team in an emergency
8.	**Seamanship**		• Small boat handling • Use of rigging and lifting equipment	
9.	**Maintenance and repairs**		• Daily maintenance of diving equipment	

B.3 Bell / saturation diver

B.3.1 Aim

The aim of the training shall be to enable experienced surface oriented divers to carry out work safely as bell/saturation divers and stand-by divers in a closed diving bell.

B.3.2 Entry requirements

The bell / saturation diver candidate shall

a) have been qualified as a surface oriented diver for at least one year and have logged at least the following diving work:
   i. at least 50 h of bottom time (i.e. from leaving surface to start of ascent);
   ii. 10 h of that bottom time at depths greater than 20 msw;
   iii. 6 h of that 10 h at depths greater than 30 msw.
b) hold a valid certificate of medical fitness in accordance with the national guidelines (ref. NBH IK-2708, HSE-MA1 or equivalent),
c) have sufficient elementary education to be able to carry out the necessary calculations, communicate and understand written instructions etc.

B.3.3 Syllabus

The training establishment shall develop training program specifying content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry and up to date equipment. Training shall be conducted in English.

B.3.3.1 Theory

Number of lessons shall be minimum 84 h.

Table B3 – Bell/ saturation diver theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Diving physics** (properties of liquids and gases as they apply to diving and use of mixed gases)	• Noise in water	• The relationship between volume and temperature (Charles' Law) • Buoyancy (Archimedes' Principle)	• The relationship between pressure and volume (Boyle's Law) • Partial pressure of gases (Dalton's Law) • Solubility of gases (Henry's Law)

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
2.	**Diving physiology and first aid** (related to closed bell diving and mixed gases)	**Structure and function of the human body**. This shall include: • musculo/skeletal systems; • nervous system; • heart, blood vessels, blood circulation; • lungs; • ears, sinuses and vestibular organs.	**O_2-toxicity** This shall include • the cause, effects, symptoms, and management of O_2-toxicity, • calculation of pO_2 and the significance of this pressure to the safety of the divers. **First aid** The student shall possess knowledge of causes, prevention, symptoms and how to manage, under normal and hyperbaric conditions (including inside a diving bell and hyperbaric chambers), first aid in connection with following conditions: • bleeding; • fractures, sprains and muscle trauma; • shock; • burns; • injuries caused by electricity; • asphyxia; • pulmonary oedema; • respiratory arrest; • cardiac arrest; • hypothermia; • hyperthermia; • underwater blast injury. The student shall also have knowledge of: • Importance of personal hygiene in the management of injuries • Patient examination • Checking pulse, respiratory rate and temperature • Measures during	**Diving related injuries** The following injuries, including their side effects, cause, effect, symptoms and management shall be known: • pressure related injuries; • ear related injuries and illnesses; • drowning (both primary and secondary); • vomiting under water; • CO_2 poisoning; • CO poisoning; • HPNS; • N_2 narcosis; • anoxia and hypoxia. **Decompression related illness** Causes, effects, symptoms, diagnosis and management of illnesses requiring recompression, e.g. decompression sickness, gas embolism, pulmonary barotraumas and related conditions

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
			transfer of injured person from diving bell to chamber • Measures in the bell or chamber and during transportation of injured person • First aid equipment and its use during a MUO	
3.	**Legislation, statutory instruments** (related to closed bell diving and mixed gases)	• NORSOK standard U-101 • NORSOK standard U-102 • EDTC Personnel Competence Standard • OGP 411 guideline • Relevant IMCA guidelines • Relevant DMAC guidelines	• Relevant legislation including national regulations • National and international standards • Guidelines • Safety notices • NORSOK standard U-103 • NORSOK standard R-003 • NORSOK standard R-005	• NORSOK standard U-100
4.	**SHE**	• Relevant labour legislation • Casualty register	• Methods to identify and manage risks • Safety delegate requirements and functions	• Non-conformances reporting routines • Hazard observation reporting routines • Permit to work procedures
5.	**QA**	Principles for management systems and QA		
6.	**Diving plant and equipment**	• Environmental control system • Panels, regulators, pipes and fittings • Gas sources and compressors • PLC	• LARS • Analysis equipment, gas purity, cleaning for O_2 use	• Overall closed bell diving system configuration • Overall saturation dive system configuration • Hyperbaric evacuation system
7.	**Closed bell diving operations**		• Bell gas distribution system • Heating systems • Monitoring and recording • Handling system for diving bell	• Closed bell diving procedures • CO_2 absorption • Communication • Survival equipment • Emergency recovery procedures for diving

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
			• Checks, pre- and post-dive procedures • Breathing gas recovery systems • DP vessels • Surface team • Rebreather	bell
8.	**Chamber operations**	• Gas distribution system • Cleaning of gas distribution systems	• Gas monitoring and recording • Impurities in gas distribution systems • Gas purity	• Diving operation procedures • Emergency procedures • Compression and decompression • Diving tables • BIBS – functioning and operation • CO_2 absorption • Sanitary arrangements • Medical and equipment locks • Communications • Firefighting equipment
9.	**Hyperbaric rescue system**	• Hyperbaric reception facilities	• SPHL	• Hyperbaric evacuation and launch procedures

B.3.3.2 Practical training

The practical training shall comprise work both as diver and stand-by diver in a closed diving bell as well as a member of the surface dive team.

The following number of dives shall be completed in the depth range 5 msw to 10 msw:

a) 24 bell lockouts as diver,
b) 24 bell lockouts acting as bell-man (stand-by diver),
c) 12 complete bell-runs including TUP,
d) The trainee diver shall undergo training in all bell emergency procedures, including at least 5 simulated rescues of unconscious diver.

As a minimum, the first three bell-runs should be completed with the instructor in the bell. All subsequent bell runs should be made according to the procedures for TUP. The trainee diver may only make one lockout from the bell at any one depth during each bell run. However, the diver and the bell-man (stand-by diver) may change around so that each carries out one lockout at a particular depth. Further lockouts may be executed during the same bell-run provided the depth of the bell is changed and operation of the bottom door is included.

During saturation period each trainee diver shall as a minimum:

e) act as diver during three bell lock-outs at respectively 55 msw, 75 msw and minimum 100 msw;

f) act as bell-man (stand-by diver) during three bell lock-outs at respectively 55 msw, 75 msw and minimum 100 msw;
g) excursion in according to clause 8.2.3.4;
h) lock-out time minimum 15 min each time;
i) perform rescue of a simulated unconscious diver during one of these dives;
j) activate diver's bail-out system (rebreather) during one of these dives;
k) decompression from a living depth of minimum 50 msw in according to Norwegian recommended minimum standard for saturation decompression.

The trainee diver shall be familiar with all checklists which are used for operation of a closed diving bell and a saturation system. Each trainee diver shall:

l) perform at least 4 chamber pressurisations, including pre-dive checks of living- and transfer chamber;
m) under supervision, monitor the chamber atmosphere while occupants in saturation;
n) perform at least 4 bell pre-dive checks.

The diving system and equipment used for training purposes shall meet industry standards.

Table B4 – Practical training

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
1.	**Bell diving operations**	• Monitoring and recording • Under supervision, operation of the bell panel • Wet transfer (from a depth of 5 msw to 10 msw, practice wet transfer from the bell to e.g. dive basket, wet bell or surface, using dedicated suit)	• Bell gas distribution system • Heating systems • Handling system for diving bell • Practical application of diving physics in diving operations	• Operate gas panel, gas recovery system, BIBS, hot water system including bell heating, O_2 make up system, gas scubber, communication and electrical equipment • Use communication systems effectively, both as a diver and stand-by diver in bell • Carry out pre- and post-dive checks • Act as a diver and stand-by diver in a diving bell • Act as a member of the surface team during bell diving operation
2.	**Bell emergency procedures**			• Carry out self-rescue as a bell diver in an emergency situations • Act as a stand-by diver in the bell in an emergency situations • Act as a surface contingency diver during closed bell diving operation • Act as a member of the surface team in an emergency
3.	**Chamber operations**	• Gas distribution system • Impurities in gas distribution systems • Gas purity • Gas monitoring and recording • Practical application of diving physics in	• Gas purification • Environmental control system • Monitoring and recording of parameters during chamber operation • Dive log • Checks and maintenance	• BIBS – functioning and operation • Medical and equipment locks • Sanitary arrangements • Communications • Compression and decompression • Emergency procedures • Firefighting equipment

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
		diving operations • Under supervision, operation of a chamberpanel, during compression, TUP and decompression	• Support a closed bell diving operation as part of the surface team	
4.	**Hyperbaric rescue system**	• Hyperbaric reception facilities	• SPHL	• Hyperbaric evacuation and launch procedures

B.4 Trainee surface oriented diving supervisor

B.4.1 Aim

The aim of the training shall be to enable the trainee to carry out work safely as trainee surface oriented diving supervisor during MUOs.

B.4.2 Entry requirements

The trainee surface oriented diving supervisor candidate shall

a) hold an nationally recognised surface oriented diving qualification in accordance with as a minimum EDTC -PCS [31],
b) be at least 24 years of age,
c) have at least two years practical experience as a commercial diver and have carried out at least 100 commercial dives where at least 25 of these dives shall have been carried out from a DSV operating on DP,
d) have undergone a training course at a qualified institution and have passed the final examination for trainee surface oriented diving supervisors.

B.4.3 Syllabus

The training establishment shall develop training program specifying goals and content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry and up to date equipment. If simulator is used in the education, this shall adhere to IMCA-C014 [29]. Training shall be conducted in English.

B.4.3.1 Theory

Number of theoretical lessons shall be minimum 54 h.

Table B5 – Trainee surface oriented diving supervisor theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Diving physics**	• The principles of heat transfer by conduction, convection and radiation	• Basic calculations for the conversion of metric and imperial units • Basic physical units used in diving • Charles' Law (the relationship	• Boyle's Law (calculating gas volumes and diver's gas consumption) • Dalton's Law (partial pressure of gases at various depths) • Henry's Law (the effect of partial

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
			between pressure changes and temperature changes) • Archimedes' Principle (calculating the buoyancy and lifting requirements of various objects)	pressures on the solubility of gases in liquids and the corresponding effects on decompression)
2.	**Diving physiology and first aid**		• The respiratory, circulatory, basic skeletal and nervous systems of the body • The problems of maintaining divers in thermal balance and the symptoms and treatments of hypo- and hyperthermia • The effects of pressure on the body and the principles of decompression and therapeutic procedures • The contents, requirements and maintenance of various types of diving medical kits	• The effects of gases on the body and their limits under pressure (in particular, O_2, CO_2, CO and N_2 • The causes and symptoms of decompression sickness and barotrauma
3.	**Legislation and safety notices**	• Relevant labour legislation • Casualty register, casualties during surface oriented diving	Safety delegate requirements and functions	• Relevant diving regulations • Relevant safety notices • Breathing gas purity requirements • relevant legislation including national regulations
4.	**Management systems, QA**	• Regulations relating to management systems for compliance with statutory requirements in relation to safety, working environment and protection of the external environment in the petroleum activities. • Principles for management systems and QA	• Management of change procedures	• Methods to identify and manage risks • FMECA • Non-conformances reporting routines • Hazard observation reporting routines • Permit to work procedures

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
5.	**Advisory bodies and classification societies**		Relevant recommendations e.g. • IMCA, • DMAC, • DNV.	
6.	**Surface oriented diving plant and equipment**	• Symbols and schematics • Pipes, valves and fittings • Compressors and filters • Gas storage • Hot water machines	• Decompression chamber • Wet bell and diving basket • LARS	• Control panels and chambers, • use and maintenance BIBS, • operation and design of medical locks, including interlock systems • Gas analysis equipment • Air and gas requirements, handling, purity, O_2 cleanliness and analysis
7.	**Support equipment, tools and remote operated vehicle**	• Electrical equipment • Hydraulic equipment • Inspection equipment • Pneumatic equipment	• Commonly used tools and equipment • Liaison with ROV	• Lifting and handling gear
8.	**Diving methods and diving routine operations, procedures and tables**		• Different surface oriented diving methods • Planning, organizing and execute • SCUBA limitations	• Operational surface oriented diving procedures and checklists • Decompression tables • Log keeping of diving operation • Safety in the water, paying particular reference to currents and sea states etc. • The responsibilities of all members of the diving team
9.	**Emergency procedures**			• Emergency situation in water • Emergency situation in chamber • Therapeutic procedures • Emergency situation on diving work-sites / vessel
10.	**Surface oriented diving from a DP vessel**	• General safety requirements of DSV used in surface oriented diving operation	• DP references and DP limitations • Relevant standards • IMCA guidelines	• Calculation of length of umbilical when operating from DP vessel

B.5 Trainee bell diving supervisor

B.5.1 Aim

The aim of the training shall be to enable the trainee to function as trainee bell diving supervisor during MUOs.

B.5.2 Entry requirements

The trainee bell diving supervisor candidate shall

a) hold an nationally recognised surface oriented diving qualification in accordance with as a minimum EDTC-PCS [28],
b) be at least 24 years of age,
c) have at least three years of practical experience as a bell diver and have carried out at least 50 commercial dives where at least 25 of these dives shall have been carried out from a DP vessel,
d) have undergone a training course at a qualified institution and have passed the final examination for trainee bell diving supervisors.

B.5.3 Syllabus

The training establishment shall develop training program specifying content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry and up to date equipment. If a simulator is used in the education, this shall adhere to IMCA-C014 [29]. Training shall be conducted in English.

B.5.3.1 Theory

Number of lessons shall be minimum 56 h.

Table B6 – Trainee bell diving supervisor theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Diving physics**	• Repetition gas laws		• Consumption of gas and chemicals • Gas mixture and compression
2.	**Diving physiology and first aid**	• Diving medical conditions • Hypothermia and hyperthermia • Bacteriology	• Examination of patient • Medical equipment and first aid equipment	• Treatment tables
3.	**Legislation and safety notices**	• Relevant labour legislation • Casualty register, casualties during bell diving		• Relevant diving regulations • Relevant safety notices • Breathing gas purity requirements
4.	**Management systems, QA**		• QA systems • Management systems • Planned maintenance	
5.	**Advisory bodies and classification societies**	• DMAC guidelines • classification societies (e.g DNV)	• Relevant IMCA guidelines	• Relevant legislation including national regulations
6.	**Diving plant and equipment**		• Gas sources and compressors • Panels, regulators, pipes and fittings • Environmental control system • PLC	• Overall closed bell diving system configuration • LARS • Overall saturation dive system configuration • Hyperbaric evacuation system • Analysis equipment, gas

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
				purity, cleaning for O_2 use
7.	**Support equipment, tools and ROVs**		• Hyperbaric welding • Liaison with ROV • Radioactivity – hazards and hazard limit values • Electronic equipment, electricity in water	
8.	**Procedures, emergency procedures, tables**		• Compression, excursion and decompression tables • Operational bell diving procedures and checklists	• TUP procedures • equipment requirements • log keeping • Emergency situation in water • Emergency situation in a diving bell • Emergency situation in dive control / vessel • Hyperbaric evacuation
9.	**Bell diving from a DP vessel**		• Relevant standards • IMCA guidelines	

B.6 Assistant life support technician

B.6.1 Aim

The aim of the training shall be to enable the trainee to function as ALST during MUOs.

B.6.2 Entry requirements

The ALST trainee shall

a) be at least 18 years old,
b) be medical fit for work offshore (applies to all trainees),
c) have sufficient elementary education to be able to carry out the necessary calculations, communicate and understand written instructions in English language,
d) pass the training institute's assessment as required to commence a career in commercial diving.

B.6.3 Syllabus

The training establishment shall develop training program specifying content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry and up to date equipment. Training shall be conducted in English.

B.6.3.1 Theory

Number of lessons shall be minimum 76 h.

Table B7 – Assistant life support technician theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Diving physics**	• Buoyancy (Archimedes' Principle) • Solubility of gases (Henry's Law) • Consumption of gas and chemicals	• The relationship between volume and temperature (Charles' Law) • Gas mixture and compression	• Partial pressure of gases (Dalton's Law)

2.	**Diving physiology and first aid**	Structure and function of the human body
		• Muscle /skeletal systems
		• Nervous system
		• Heart, blood vessels, blood circulation
		• Lungs
		• Ears, sinuses and vestibular organs
		• Diving medical conditions
		• Hypothermia and hyperthermia
		• Bacteriology
			• Examination of patient
			• Medical equipment and first aid equipment
			• Causes, prevention, symptoms and management under normal and hyperbaric conditions for:
			  • bleeding;
			  • fractures, sprains and muscle trauma;
			  • shock;
			  • burns;
			  • electrocution;
			  • asphyxia;
			  • pulmonary oedema;
			  • respiratory arrest;
			  • cardiac arrest;
			  • hypothermia;
			  • hyperthermia;
			  • underwater blast injury;
			  • importance of
				• Treatment tables
				• Diving related injuries and side effects (cause, symptoms and treatment) of:
				  • pressure related injuries;
				  • pressure equalization - ear and sinuses;
				  • drowning;
				  • vomiting under water;
				  • decompres-sion sickness;
				  • gas embolism and pulmonary barotraumas;
				  • CO_2 poisoning,
				  • CO poisoning,
				  • O_2-toxicity,

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
			personal hygiene in the management of injuries.	• anoxia and hypoxia; • N_2 narcosis.
3.	**Legislation and safety notices**	• Relevant labour legislation • Casualty register, casualties during bell diving	• Relevant legislation including national regulations	• Relevant diving regulations • Relevant safety notices • Breathing gas purity requirements • NORSOK standard U-100
4.	**Management systems, QA**		• QA systems • Management systems • Planned maintenance system	• Hazard observation reporting routines
5.	**Advisory bodies and classification societies**	Examples of relevant standards: • NORSOK standard U-101; • EDTC Personnel Competence Standard; • OGP 411.	Recommendations relevant to saturation diving e.g.: • IMCA; • DMAC; • classification societies (e.g DNV).	
6.	**Diving plant and equipment**	• LARS	• Overall closed bell diving system configuration • Environmental control system • Panels, regulators, pipes and fittings • Gas sources and compressors • Gas recovery systems • Gas distribution system • Gas purity • Analysis equipment • PLC	• Overall saturation dive system configuration • Typical gas schematics, incl. symbols and function • BIBS system • Sanitary system • Cleaning for O_2 use • Monitoring and recording system • Firefighting system • Hyperbaric evacuation system • Medical and lock run
7.	**Procedures, emergency procedures, tables**	• Operational bell diving • Emergency situation in water • Emergency situation in a diving bell	• Checks, pre- and post-dive procedures • Survival equipment	• Saturation tables including compression, excursion and decompression • Relevant procedures and checklists • TUP procedures • Equipment requirements • Prohibited items inside a chamber • Log keeping • Emergency situation in saturation complex • Emergency situation in

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
				dive control / vessel • Hyperbaric evacuation

B.6.3.2 Practical training

The practical training shall include operation of a functional saturation system. If a simulator is used in parts of the training, this shall adhere to IMCA-C014 [29].

Number of lessons shall be minimum 40 h.

Table B8 – Practical training

ID	TOPICS	OBJECTIVES		
		SOME SKILLS	SKILLS	ADVANCED SKILLS
1.	**Saturation complex operation** (under direct supervision)	• Calibration of monitoring and recording equipment • Use of treatment tables	• Compression and decompression of chamber complex • Transfer of personnel under pressure • Principles of gas mixing • Analysis of stored gas and chamber atmosphere • Calibration of analysis equipment • Gas supply to control panels and chambers • Practice of emergency procedures	• Checks, pre- and post-dive procedures • Monitoring and recording of depth, temperature and humidity • Operation of communication equipment • Operation of sanitary arrangements and locks, incl. inter lock system • Cleaning • Hygiene

B.7 Leadership training

B.7.1 Aim

The aim of the training shall be to enable the trainees to function as supervisory personnel during MUOs.

B.7.2 Entry requirements

The leadership trainees shall

a) be at least 24 years old,
b) be medical fit for work offshore (applies to all trainees),
c) have sufficient education to be able to supervise in the intended function.

B.7.3 Syllabus

The training establishment shall develop training program specifying content of the course, learning and assessment methods, expected learning outcomes as well as other mandatory requirements. The training program shall include the latest knowledge within the industry. Training shall be conducted in English.

B.7.3.1 Theory

Number of lessons shall be minimum 16 h.

Table B9 – Leadership training theory

ID	TOPICS	OBJECTIVES		
		SOME KNOWLEDGE	KNOWLEDGE	DETAILED KNOWLEDGE
1.	**Leadership and communication**	• One-way/two-way communication • Types of communication, language and body language	**Role of leader** • Definition of leadership • Definition of the leader function • Ways of co-operation • Attitudes • Leadership over time **Communication** • Making people conscious of the matter in hand/the evolving process • Information • Instruction techniques **Conflicts** • Symptoms • Causes • Solutions • Preventive measures	• What is expected of a leader
2.	**Planning and organising work**		• Organising and assigning work tasks • Ways of co-operation	• Resource assessment • Definition of work • Team building • Transfer of experience
3.	**Organisation and administration**	• Mutual expectations • Organisational structure • Administration	• Duties and responsibilities, framework/requirements • Communication lines	
4.	**Leadership in emergency and stress situations**	• Leadership styles, ad hoc leadership	• Symptom recognition • Behaviour and reactions • Awareness, preventive measures, training/crisis preparation	• Expectations to leaders in time of crisis • Course of action • Debriefing

B.7.3.2 Practical training

There are no mandatory formal requirements for practical training, but it is advisable to include relevant practical rehearsals, in line with pedagogically good practice.

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