

OFFSHORE STANDARD DNV-OS-E402

OFFSHORE STANDARD FOR DIVING SYSTEMS

OCTOBER 2010

DET NORSKE VERITAS

FOREWORD

DET NORSKE VERITAS (DNV) is an autonomous and independent foundation with the objectives of safeguarding life, property and the environment, at sea and onshore. DNV undertakes classification, certification, and other verification and consultancy services relating to quality of ships, offshore units and installations, and onshore industries worldwide, and carries out research in relation to these functions.

DNV service documents consist of amongst other the following types of documents:

- Service Specifications. Procedual requirements.
- Standards. Technical requirements.
- Recommended Practices. Guidance.

The Standards and Recommended Practices are offered within the following areas:

- A) Qualification, Quality and Safety Methodology
- B) Materials Technology
- C) Structures
- D) Systems
- E) Special Facilities
- F) Pipelines and Risers
- G) Asset Operation
- H) Marine Operations
- J) Cleaner Energy
- O) Subsea Systems

The electronic pdf version of this document found through <u>http://www.dnv.com</u> is the officially binding version © Det Norske Veritas

Any comments may be sent by e-mail to rules@dnv.com

For subscription orders or information about subscription terms, please use distribution@dnv.com Computer Typesetting (Adobe Frame Maker) by Det Norske Veritas

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of Det Norske Veritas, then Det Norske Veritas shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million. In this provision "Det Norske Veritas" shall mean the Foundation Det Norske Veritas as well as all its subsidiaries, directors, officers, employees, agents and any other acting on behalf of Det Norske Veritas.

CHANGES

• General

As of October 2010 all DNV service documents are primarily published electronically.

In order to ensure a practical transition from the "print" scheme to the "electronic" scheme, all documents having incorporated amendments and corrections more recent than the date of the latest printed issue, have been given the date October 2010.

An overview of DNV service documents, their update status and historical "amendments and corrections" may be found through http://www.dnv.com/resources/rules_standards/.

• Main changes

Since the previous edition (January 2004), this document has been amended, most recently in October 2009. All changes have been incorporated and a new date (October 2010) has been given as explained under "General".

CONTENTS

| Se | c. 1 | General9 | |
|---------|---------------|---|--|
| A. | Gener | al9 | |
| A | 100 | Introduction | |
| А | 200 | Objectives | |
| А | 300 | Application and scope | |
| A | 400 | Other codes9 | |
| A | 500 | Deviations | |
| В. | Norma | ative References10 | |
| В | 100 | Offshore Service Specifications10 | |
| В | 200 | Offshore Standards | |
| B | 300 | Recommended practices | |
| В | 400 | Rules | |
| В | 500 | Standards for Certification and Classification notes 10 | |
| в В | 700 | Other normative references | |
| C. C | Inforn 100 | native References | |
| n | Varba | forms and Definitions 11 | |
| D. D | 100 | Auxiliary Varbal forms | |
| D | 200 | Definitions | |
| - | | | |
| E. | Abbre | viations and Symbols (Guidance) | |
| E E | 200 | Abbreviations | |
| So | c 7 | Design Philosophy and Promises 16 | |
| | c. 2 | besign 1 mosophy and 1 remises 10 | |
| A. | Gener | al | |
| A | 200 | Application and soons | |
| A | 200 | Application and scope | |
| A | 300 | Documentation | |
| B. | Safety | Philosophy16 | |
| В | 100 | General | |
| В | 200 | Safety objective | |
| В | 300 | Systematic review | |
| В | 400 | 'Safety class' methodology16 | |
| B | 500 | Quality assurance | |
| В | 600 | Health, safety and environment | |
| C. | Gener | al Premises17 | |
| С | 100 | Concept development17 | |
| Ç | 200 | Execution plan | |
| С | 300 | Plan for Manufacture, Installation and Operation 17 | |
| D. | Syster | n Design Principles18 | |
| D | 100 | System integrity | |
| D | 200 | Monitoring and inspection during operation | |
| D | 300 | Pressure Control System | |
| E. | Diving | g system arrangement layout and location18 | |
| Е | 100 | General | |
| E | 200 | Layout of the diving system | |
| E | 300 | Location of the diving system | |
| E | 400 | Supports and Foundations for Pressure vessels for | |
| Б | 500 | Fuman Occupancy and for Gas Storage | |
| Е | 500 | lifting appliances | |
| Е | 600 | Supports and Foundations for other equipment | |
| F. | Positio | on Keeping and Stability and Floatation | |
| - | (for in | stallations on Ships and Mobile Offshore Units) 19 | |
| F | 100 | General | |
| G. | Enviro | onmental Conditions | |
| G | 100 | General | |
| G | 200 | Collection of environmental data | |
| G | 300 | Wind | |
| G | 400 | 11de | |
| U C | 500 600 | waves | |
| G | 700 | Lee 20 | |
| Ğ | 800 | Air and sea temperatures 20 | |
| - | * | r | |

| G | 900 | Marine growth | 20 |
|---|---|--|--|
| H. | Exterr | nal and Internal System Condition | 20 |
| Η | 100 | External operational conditions and outer area. | 20 |
| Η | 200 | Submerged components | 21 |
| Н | 300 | Internal conditions | 21 |
| Н | 400 | Internal operational conditions | 21 |
| T | Docur | mentation | 21 |
| I. I | 100 | General | 21 |
| Ī | 200 | Documentation of Arrangement etc | 21 |
| I | 300 | Documentation for systems in operation | 21 |
| I | 400 | Filing of documentation | 22 |
| т | Increa | ation and Tasting | าา |
| J. I | 100 | General | 22 |
| J | 200 | Testing at the manufacturers | 22 |
| J | 300 | Testing after completed installation | 22 |
| | | | ~~ |
| К. V | Marki | ng and Signboards | 23 |
| ĸ | 200 | Gas containers | 23 |
| K | 300 | Other pressure vessels than gas containers | 24 |
| K | 400 | Handling system | 24 |
| ~ | - | | |
| Se | c. 3 | Pressure Vessels for Human Occupancy, | 25 |
| | | Gas Storage and other Purposes | 25 |
| A | Gener | al | 25 |
| A | 100 | Objectives | 25 |
| A | 200 | Application and scope | 25 |
| A | 300 | Documentation | 25 |
| A | 400 | Testing and marking after completion | 25 |
| A A | 500 | Design loads | 25 |
| A | 000 | Design loads | 20 |
| Β. | Gener | al Principles for Design of Chambers and Bells | 26 |
| В | 100 | Chambers | 26 |
| B | 200 | Bell | 26 |
| | | | |
| в | 300 | Doors, natches, windows, branches etc. | 27 |
| в С. | Welde | ed Pressure Vessels. Materials and Fabrication | 27 |
| в С. С | 300 Welde 100 | ed Pressure Vessels, Materials and Fabrication | 27 27 27 |
| в С. С | Welde 100 200 | d Pressure Vessels, Materials and Fabrication Materials Fabrication | 27 27 27 28 |
| В С. С С | Welde 100 200 300 | Doors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances | 27 27 27 28 28 |
| в С. С С С | Welde 100 200 300 | Poors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances with of Welded Pressure Vessels | 27 27 27 28 28 28 |
| в С. С С D. D. | Welde 100 200 300 Streng 100 | Poors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances eth of Welded Pressure Vessels Structural analysis | 27 27 28 28 28 28 28 |
| в С. С С D. D | Welde 100 200 300 Streng 100 200 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure | 27 27 28 28 28 28 28 28 28 |
| C. CC CC D. D D | Welde 100 200 300 Streng 100 200 300 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows | 27 27 28 28 28 28 28 28 28 28 |
| C. CCCC D. DD | Welde 100 200 300 Streng 100 200 300 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows | 27 27 28 28 28 28 28 28 28 28 28 28 |
| B C. CC C D. D D D E. | Welde 100 200 300 Streng 100 200 300 Gas C | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders | 27 27 28 28 28 28 28 28 28 28 28 28 28 28 28 |
| B C.CCC D.DD E.E E | Welde 100 200 300 Streng 100 200 300 Gas C 100 200 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication tolerances eth of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders General Heat treatment | 27 27 27 28 28 28 28 28 28 28 28 28 28 29 29 29 |
| B CCCC DDD E E E E | Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Loerances eth of Welded Pressure Vessels Structural analysis. Vessels subjected to external pressure Flanges for windows ylinders General Heat treatment Tolerances and surface conditions | 27 27 28 28 28 28 28 28 28 28 28 28 29 29 29 29 |
| B CCCC DDDD EEEEE | Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 | A pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure. Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests | 27 27 28 28 28 28 28 28 28 28 28 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE E | Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 | A pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.F | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acrylii | A pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests | 27 27 28 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acrylit 100 200 | A pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment. Tolerances and surface conditions. Production tests ic Plastic Windows General. Materials | 27 27 28 28 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acrylit 100 200 300 | A pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment. Tolerances and surface conditions. Production tests ic Plastic Windows General. Materials Manufacturers of cast material | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acrylii 100 200 300 400 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis. Vessels subjected to external pressure. Flanges for windows ylinders. General Heat treatment. Tolerances and surface conditions. Production tests ic Plastic Windows General. Materials. Manufacturers of cast material Certification of cast material | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE FFFFFFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 200 300 400 200 300 400 200 300 400 500 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis. Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment. Tolerances and surface conditions. Production tests ic Plastic Windows General. Materials. Manufacturers of cast material Certification of cast material Certification of windows | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.FFFFFFFFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 500 600 700 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.FFFFFFFFFFFFFFFFFFFFFFFFFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 500 600 700 800 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication Fabrication tolerances th of Welded Pressure Vessels Structural analysis. Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests ic Plastic Windows General Materials Manufacturers of cast material Certification of windows Geometry and thickness. Fabrication In service inspection | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFFFFFFFFFFFFFFFFFFFFF | S00 Welde 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 500 600 700 800 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFFFFFFF Se | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 500 600 700 800 c. 4 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFFFFFFF Se | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 500 600 700 800 c. 4 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFFFFFFF Se A. | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 400 500 600 700 800 c. 4 Gener | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.FFFFFFFFF S AAA | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 400 500 600 700 800 c. 4 Gener 100 200 200 200 200 200 200 200 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication | 27 27 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B C.CCC D.DDD E.EEEE F.FFFFFFFFFF Se A.AAA | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 400 500 600 700 800 c. 4 Gener 100 200 300 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication tolerances Fabrication tolerances Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests c Plastic Windows General Materials Manufacturers of cast material Certification of windows Geometry and thickness. Fabrication In service inspection Life Support Systems Application and scope. Documentation. | 27 27 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEEE F.FFFFFFFFF S AAAA D | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 Gas C 100 200 300 Acryli 100 200 300 400 500 600 700 800 c. 4 Gener 100 200 300 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication tolerances Fabrication tolerances Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests c Plastic Windows General. Materials Manufacturers of cast material Certification of east material Certification of east material Certification of windows Geometry and thickness Fabrication In service inspection Life Support Systems Objectives Application and scope. Documentation. | 27 27 27 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.FFFFFFFFF S AAAA B. | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 500 600 700 800 c. 4 Gener 100 200 300 Gas S 100 200 300 Gas S | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication tolerances Fabrication tolerances Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests c Plastic Windows General. Materials Manufacturers of cast material Certification of windows Geometry and thickness. Fabrication In service inspection Life Support Systems Application and scope. Documentation. torage | 27 27 27 28 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |
| B CCCC DDDD EEEEE F.FFFFFFFFF S AAAA BBB | Welda 100 200 300 Streng 100 200 300 Gas C 100 200 300 400 Acryli 100 200 300 400 C. 4 Gener 100 200 300 Gas S 100 200 300 Gas S 100 200 300 Control 200 200 200 200 200 200 200 20 | boors, natches, windows, branches etc. ed Pressure Vessels, Materials and Fabrication Materials Fabrication tolerances Fabrication tolerances Structural analysis Vessels subjected to external pressure Flanges for windows ylinders. General Heat treatment Tolerances and surface conditions Production tests c Plastic Windows General. Materials Manufacturers of cast material Certification of windows Geometry and thickness Fabrication In service inspection Life Support Systems al. Objectives Application and scope. Documentation. Capacity Shut-off pressure relief and drainage | 27 27 28 28 28 28 28 28 29 29 29 29 29 29 29 29 29 29 29 29 29 |

| Č. | Gas d | istribution |
|---|---|--|
| C | 100 | General |
| C | 200 | Bell |
| č | 400 | Stand-by diver at surface |
| - | | |
| D. | Oxyg | en Systems |
| D | 100 | General |
| Б | Dining | x Systems 22 |
| с. F | 100 | General 33 |
| Ē | 200 | Bell 33 |
| Ē | 300 | Chambers |
| _ | | |
| F. | Envir | onmental Conditioning in Bell and Chambers |
| F | 100 | Heating of bell |
| F E | 200 | Heating and cooling of chambers |
| F | 400 | Noise reduction 34 |
| F | 500 | Gas circulation systems for chambers 34 |
| F | 600 | Removal of carbon dioxide |
| F | 700 | Regeneration of pure helium |
| C | 0 0 | |
| G. | Gas C | Control Systems |
| G | 100 | Control stands |
| G | 200 | direct supply for breathing 34 |
| | | uneet suppry for breathing |
| H. | Close | d Circuit Breathing Systems (CCBS) |
| Η | 100 | General |
| | | |
| I. | Divin | g Crew Facilities |
| I | 100 | General |
| I | 200 | Wet-bell and diving basket (DSV-SURFACE) |
| I | 300 | Saturation diving systems (DSV-SAT) |
| Se | c. 5 | Electrical, Instrumentation and |
| | | Communication Systems |
| | | |
| A. | Gener | al |
| ۸ | 100 | |
| A | 100 | Objective |
| A | 200 | Application and scope |
| A A A | 100 200 300 | Objective 36 Application and scope 36 Documentation 36 Colored by the last last last last last last last last |
| A A A A | 100 200 300 400 500 | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Sarviae definitions 36 |
| A A A A | 100 200 300 400 500 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36 |
| A A A A B. | 100 200 300 400 500 System | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Service definitions 36 m Design 37 |
| A A A A B. B | 100 200 300 400 500 System 100 | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Service definitions 36 m Design 37 System voltages and distribution systems types 37 |
| A A A A B. B B B | 100 200 300 400 500 System 100 200 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37 |
| A A A A B. B B B B B | 100 200 300 400 500 System 100 200 300 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37 |
| A A A A B. B B B B B B B B B B B B B B B | 100 200 300 400 500 System 100 200 300 400 | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Service definitions 36 m Design 37 System voltages and distribution systems types 37 Power supply systems 37 Distribution systems 37 Capacity 38 |
| A A A A B. B B B B B B B B B B B B B B B | 100 200 300 400 500 System 100 200 300 400 500 | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Service definitions 36 m Design 37 System voltages and distribution systems types 37 Power supply systems 37 Distribution systems 37 Capacity 38 Environmental Requirements 38 Incomposition and station and stati |
| A A A A B B B B B B B B B B B B B B B B | 100 200 300 400 500 System 100 200 300 400 500 600 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38 |
| A A A A A B B B B B B B B B B C | 100 200 300 400 500 Syster 100 200 300 400 500 600 | Objective 36 Application and scope 36 Documentation 36 Codes and standards 36 Service definitions 36 m Design 37 System voltages and distribution systems types 37 Power supply systems 37 Distribution systems 37 Capacity 38 Environmental Requirements 38 Inspection and testing requirements 38 ment selection and installation 38 |
| A A A A A B B B B B B B B B B B C. C | 100 200 300 400 500 Systen 100 200 300 400 500 600 Equip 100 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38ment selection and installation38General38 |
| A A A A A B B B B B B B B B B B B C C C | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38ment selection and installation38General38Enclosures38 |
| A A A A A B B B B B B B B B B B C C C C | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38ment selection and installation38General38Enclosures38Earthing38 |
| A A A A A A B B B B B B B B B B B B B B | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38ment selection and installation38General38Earthing38Batteries38Batteries38Batteries38 |
| A A A A B. B B B B B B B B B B B B C. C C C C C | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 500 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Enclosures38Batteries38Cables and penetrators39 |
| A A A A A B B B B B B B B B B B B B B C C C C | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Enclosures38Batteries38Cables and penetrators39Lighting, inner area39 |
| A A A A B. B B B B B B B B B B B C. C C C C C C | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 500 600 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39 |
| A A A A A B. B B B B B B B B B B B B C. C C C C C | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Benclosures38Earthing38Batteries38Cables and penetrators39Lighting, inner area39General39General39 |
| A A A A A B. B B B B B B B B B B B C. C C C C C C | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Benclosures38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39 |
| A A A A A B. B B B B B B B B B B B B B C.CCCCCC D. D D D | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Benclosures38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39 |
| A A A A A B. B B B B B B B B B B B B B B | 100 200 300 400 500 System 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39 |
| A A A A A B. B B B B B B B B C. C C C C C C C D. D D D E. | 100 200 300 400 500 Systen 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 Equip 100 200 300 400 500 800 800 800 800 800 800 800 800 8 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Benral38Earthing38Earthing38Batteries39Lighting, inner area39Visual observation of divers39Voice communication systems39Mentation40 |
| A A A A A B B B B B B B B B C C C C C C | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 Suster 100 200 300 400 500 Syster 100 200 300 400 500 Syster 100 200 300 400 500 Syster 100 200 300 400 500 Suster 100 200 300 400 500 Suster 100 200 300 400 500 Suster 100 200 300 400 500 Suster 100 200 300 400 500 Suster 100 200 300 400 500 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 Suster 100 200 Suster 100 200 Suster 100 200 Suster 100 200 Suster 10 Suster 10 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 100 Suster 10 Suster 100 Suster 100 Suster Suster Suster Suster 10 Suster | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39mentation40General40General40General40General40 |
| AAAAA BBBBBBBB CCCCCCCC DDDD EEEE | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 500 Equip 100 200 300 400 500 500 500 500 500 500 500 500 5 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39mentation40General40Control stands40Control stands40 |
| AAAAA BBBBBBBB CCCCCCCC DDDD EEEEF | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 500 500 Equip 100 200 300 400 500 500 500 500 500 500 500 500 5 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Voice communication systems39Woice communication systems39mentation40General40Control stands40Pressure indicators in bell and chambers41 |
| AAAAA BBBBBBBB CCCCCCCC DDDD EEEEEE | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 500 Solo 400 Solo 400 500 Solo 400 Solo 500 Solo 400 Solo 400 Solo 500 Solo 400 Solo 500 Solo 400 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 500 Solo 50 S | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Voice communication systems39Mentation40General40Control stands40Pressure indicators in bell and chambers41Oxygen analysing systems41 |
| AAAAA B.BBBBBBB C.CCCCCCC D.DDD E.EEEEEE | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Unstru 100 200 300 400 500 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Voice communication systems39Mentation40General40Cancel stands40Pressure indicators in bell and chambers41Oxygen analysing systems41Other gases41 |
| AAAAA B.BBBBBBB C.CCCCCCC D.DDD E.EEEEEEEE | 100 200 300 400 500 Syster 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Too 200 300 400 500 500 800 800 800 800 800 800 800 8 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38General38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Voice communication systems39Mentation40General40Cables in dicators in bell and chambers41Oxygen analysing systems41Oxter gases41Other gases41Other gases41Other gases41 |
| AAAAA B.BBBBBBB C.CCCCCCC D.DDD E.EEEEEEEE | 100 200 300 400 500 Systen 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Too 800 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Beneral38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Voice communication systems39Wisual observation of divers39Voice communication systems39mentation40General40Control stands41Oxygen analysing systems41Automatic environmental control systems41 |
| AAAAA B.BBBBBBB C.CCCCCCC D.DDD E.EEEEEEEE Se | 100 200 300 400 500 Systen 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 500 Comm 100 200 300 400 500 500 Comm 100 200 300 400 500 500 Comm 100 200 300 400 500 500 Comm 100 200 300 400 500 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Comm 100 200 500 600 Comm 100 200 500 600 Comm 100 200 500 600 Com 600 Com 600 Com 600 Com 600 Com 600 600 Com 600 600 600 600 600 600 600 60 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types37Power supply systems37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements38Batteries38Earthing38Earthing38Batteries38Cales and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39mentation40General40Control stands40Pressure indicators in bell and chambers41Oxygen analysing systems41Contaminants41Automatic environmental control systems41Fire Prevention, Detection and Extinction42 |
| AAAAA B.BBBBBB C.CCCCCC D.DDD E.EEEEEEEE Se A.A | 100 200 300 400 500 Systen 100 200 300 400 500 600 Equip 100 200 300 400 500 600 Comm 100 200 300 400 500 600 Equip 100 200 300 400 500 600 700 800 Equip 100 100 100 100 100 100 100 10 | Objective36Application and scope36Documentation36Codes and standards36Service definitions36m Design37System voltages and distribution systems types.37Distribution systems37Capacity38Environmental Requirements38Inspection and testing requirements.38Enclosures38Earthing38Batteries38Cables and penetrators39Lighting, inner area39Visual observation of divers39Voice communication systems39Voice communication systems41Oxygen analysing systems41Other gases41Automatic environmental control systems41Fire Prevention, Detection and Extinction42Objective42 |

| A A A | 200 300 400 | Application and scope42Documentation42Control Stands42 |
|---|--|--|
| B. B B | Fire p 100 200 | rotection |
| C. C C C | Fire D 100 200 300 | Detection and Alarm System.42Outer Area.42Inner area.43Fault detection.43 |
| D. D D | Fire E 100 200 | Attinguishing43Outer area43Inner area43 |
| E. E E | Misce 100 200 | Ilaneous equipment 43 Fire-fighter's outfit 43 Portable fire extinguishers 43 |
| Se | c. 7 | Launch and Recovery Systems 44 |
| A. A A A | Gener 100 200 300 | al |
| B. B B B B B | Desig 100 200 300 400 500 | n Principles44Function44Alternative recovery45Emergency arrangements45Power45Umbilical45 |
| C. C C | Streng 100 200 | th |
| Se | c 8 | Pines Hoses Valves Fittings Compressors and |
| 50 | | Umbilicals |
| A. A A A A A | Gener 100 200 300 400 500 | Implication 47 al |
| A. A A A A A B. B B B B | Gener 100 200 300 400 500 Pipes 100 200 300 | Umbilicals47al |
| A. A A A A A B. B B B C. C | Gener 100 200 300 400 500 Pipes 100 200 300 Valve 100 | Implication and scope 47 Objectives 47 Application and scope 47 Documentation 47 Materials 47 Protection 47 and hoses 47 General 47 Hoses and components for gases containing oxygen 48 Valve design 48 |
| A. A A A A A B. B B B C. C D. D | Gener 100 200 300 400 500 Pipes 100 200 300 Valve 100 Fitting 100 | Imposes inoses, varies, ritings, compressors and Umbilicals 47 ral |
| A. A A A A A A B. B B B B C. C D. D E. E | Gener 100 200 300 400 500 Pipes 100 200 300 Valve 100 Fitting 100 Comp 100 | Implication 47 val. 47 Objectives 47 Application and scope 47 Documentation 47 Materials 47 Protection 47 and hoses 47 General 47 Hoses 48 Interview 48 Interview 48 Interview 48 |
| A.A.A.A.A.A.B.B.B.B.B.C.C.D.D.E.E.F.F.F.F.F.F.F.F.F.F.F.F.F.F.F.F | Gener 100 200 300 400 500 Pipes 100 200 300 Valve 100 Fitting 100 Comp 100 Umbi 100 200 300 400 500 700 | Inposes, Precision and Second Pressons and Topologic Compressons and Topologic Pressons and Second |
| A. A A A A A B. B B B C. C D. D E. E F. FFFFFFFFFFFFFFFFFFFFFFFFFF | Gener 100 200 300 400 500 Pipes 100 200 300 Valve 100 Fitting 100 Comp 100 Umbi 100 200 300 400 500 c. 9 | Inposes, Precision and Compression and Complexity |

| А | 700 | Contingency Planning and Emergency Instructions | 49 |
|---|------|---|------|
| А | 800 | Purpose | 50 |
| А | 900 | Application | . 50 |
| А | 1000 | Definitions | 50 |
| А | 1100 | Design and construction Principles | 50 |
| А | 1200 | Equipment for connection to support and | |
| | | rescue vessels (HEU) | . 51 |
| А | 1300 | Crew facilities (HEU) | . 51 |
| А | 1400 | Hyperbaric evacuation units | 51 |
| А | 1500 | Life-support system | 51 |
| А | 1600 | Electrical systems and arrangements | 52 |
| А | 1700 | Fire protection and extinction | 52 |
| А | 1800 | Launch and Recovery Systems General | 52 |
| А | 1900 | Launch and recovery of Hyperbaric Evacuation Units. | 52 |
| А | 2000 | Fittings | 53 |
| А | 2100 | Communications | 53 |
| А | 2200 | Location Systems | 53 |
| А | 2300 | Markings | 53 |
| А | 2400 | Stability and buoyancy | 53 |
| А | 2500 | Self-Propelled Hyperbaric Evacuation Lifeboat | 53 |
| А | 2600 | Testing, Surveys and Drills - General | 54 |

| 54 |
|--------|
| ems 55 |
| 55 |
| |
| |
| |
| |
| |
| 56 |
| 56 |
| |
| |
| 57 |
| |
| |

SECTION 1 GENERAL

A. General

A 100 Introduction

101 This standard gives criteria and guidance on design, fabrication, installation, testing and commissioning of diving systems. Procedural requirements for operation, maintenance, and re-qualification of diving systems are normally specified in the Classification rules but the technical requirements in this offshore standard do generally apply.

A 200 Objectives

201 The objectives of this standard are to:

- a) provide an internationally acceptable standard of safety for diving systems by defining minimum requirements for the design, materials, fabrication, installation, testing, commissioning, operation, repair, and re-qualification
- b) serve as a technical reference document in contractual matters between purchaser and contractor
- c) serve as a technical reference document for verification services
- d) serve as a guideline for designers, purchaser, and contractors.

202 The objectives of this section are to outline the functionality of the standard and it's related codes, standards and recommended practices.

203 General guidance is provided as to the use and interpretation of the standard.

A 300 Application and scope

301 This standard applies to diving systems for any fixed location. The diving system may thus be located on and operated from a ship, barge, mobile offshore platform, fixed offshore installation or an onshore site (in the latter case e.g. for training and research purposes).

302 Requirements for the support vessels are included such as the requirements for stability, floatation and positioning ability.

303 The Standard also applies to transferable diving systems as defined in C.

304 The design of arrangements, systems and individual components may alternatively or supplementary to the Standard be based on recognized standards, codes, national regulations and other methods of safety and strength evaluation than specified in the Standard. The basis shall be equivalent to the requirements given in this Standard.

305 This standard primarily applies to diving systems used in the petroleum and natural gas industries.

For application in other industries, special considerations may need to be agreed by the parties to the contract and or involved statutory regulators.

306 This standard is applicable to various diving systems such as:

- a) diving systems with deck decompression chambers and a ladder or basket for deployment of divers
- b) for 'open bell' deployment of divers
- c) for 'closed bell' deployment of divers and 'bounce-diving techniques

d) 'saturation diving' systems.

307 This standard is <u>not</u> applicable to submersibles or submarines.

Upon special consideration, part of a submersible may be verified against parts of this standard.

Guidance note:

The above limitation is due to the additional equipment needed for the propulsion and navigation of the submersibles. Some tethered submersibles are simple in nature and may be seen as a closed bell operated in observation mode with an internal pressure equivalent to one atmosphere.

Other submersibles contain a capsule rather like a closed bell. In these cases this standard may be applied upon special consideration and in agreement between the parties.

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

308 Tourist submersibles are <u>not</u> included in this standard.

309 The scope is defined in each section for the various disciplines and may refer to standards that apply to the discipline in general, such as for electrical systems. In these cases this Offshore Standard (OS) only contains requirements that are particular to diving systems, whereas the generic requirements are given in the referred standard or code. The combined requirements shall then constitute the scope.

310 This section bears impact on all other sections.

A 400 Other codes

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

402 Where reference is made to codes other than DNV documents, the valid revision shall be taken as the revision that was current at the date of issue of this standard.

403 This standard is intended to comply with the requirements given in:

- a) IMO Code of Safety for Diving Systems, 1995 Resolution A.831(19)
- b) IMO Guidelines and Specifications for Hyperbaric Evacuation Systems, 1991 Resolution A.692(17).

404 The requirements in this standard are based on requirements given in DNV Rules for Certification of Diving Systems, DNV Rules for Classification of Ships, and principles outlined in DNV Offshore Standards.

Guidance note:

Additional requirements for the diving system may be applicable due to the statutory requirements given in certain geographic areas, or onboard ships flying certain flags.

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

A 500 Deviations

501 There are no known major deviations to the IMO Code of Safety for Diving Systems, 1995 Resolution A.831(19).

502 There are no known major deviations to the IMO Guidelines and Specifications for Hyperbaric Evacuation Systems, 1991 Resolution A.692(17).

B. Normative References

B 100 Offshore Service Specifications

 $101\,$ The latest revision of the following documents may apply:

| Table B1 Offshore Service Specifications | | |
|--|--|--|
| Reference | Title | |
| DNV-OSS-305 | Rules for Certification and Verification of Diving Systems | |

B 200 Offshore Standards

201 The latest revision of the following documents apply:

| Table B2 Offshore Standards | | |
|-----------------------------|---|--|
| Reference | Title | |
| DNV-OS-A101 | Safety Principles and Arrangements | |
| DNV-OS-D201 | Electrical Systems and Equipment | |
| DNV-OS-D202 | Instrumentation and Telecommunication systems | |
| DNV-OS-D301 | Fire Protection | |

B 300 Recommended practices

301 The latest revision of the following documents apply:

| Table B3 Recommended practices | | |
|--------------------------------|--|--|
| Reference | Title | |
| DNV-RP-A201 | Plan Approval Documentation Types – Definitions | |

B 400 Rules

401 The latest revision of the following documents apply:

| Table B4 Rules | |
|---------------------------------------|--|
| Title | |
| DNV Rules for Classification of Ships | |

B 500 Standards for Certification and Classification notes

The latest revision of the following documents apply:

| Table B5 Standards for Certification and Classification notes |
|---|
| Title |
| Standard for Certification No. 2.22 Lifting Appliances |

B 600 Guidelines

The latest revision of the following documents apply: (Empty)

B 700 Other normative references

| Table B5 Other norma | tive references |
|------------------------------------|--|
| Reference | Title |
| ASME VIII Div.1 | ASME Boiler and Pressure Vessel Code |
| ASME PVHO-1-1997 | Safety Standard for Pressure Vessels for |
| edition | Human Occupancy |
| (or latest) | C. C. C. L. J. C. Durren ver Warrele for |
| ASME PVHO-2-2002 | Safety Standard for Pressure Vessels for Human Occupancy in Service Guidelines |
| (or latest) | for PVHO Acrylic Windows. |
| ASTM G93-96 | Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments |
| API | Codes for hoses |
| API 17E | Specification for Subsea Production Con- trol Umbilicals |
| BS 5355 | Specification for filling ratios and devel- oped pressures for liquifiable and perma- nent gases. |
| EN 738-1, -2 and -3: 1997/1998 | Pressure regulators for use with medical gases |
| EN-1964-1:2000 | Transportable gas cylinders (part 1:1999, part 2:2001 or part 3:2000) |
| EN 1968 :2002 | Periodic Inspection and testing of Seam- less gas cylinders |
| EN ISO 11120:1999 | Gas cylinders - Refillable seamless steel tubes for compressed gas transport, of water capacity between 150 l and 3000 l - Design construction and testing (ISO 11120:1999): |
| EN 13445 | Unfired pressure vessels |
| EN 1708-1:1999 | Welding - Basic weld joint details in steel |
| IMO | Code of Safety for Diving Systems, 1995 Resolution A.831(19), |
| IMO | Guidelines and Specifications for Hyper- baric Evacuation Systems, 1991 Resolu- tion A.692(17) |
| IMO MSC/Circ.645 of 6 June 1994 | Guidelines for Vessels with dynamic posi- tioning systems |
| IMO Resolution A.809(19) | In reference to SOLAS Regulation III/ 6.2.1 and III/6.2.2. |
| IMO res. MSC.61(67) | (FTP Code) |
| IMO resolution A.468 (XII) | Code on noise levels onboard ships. |
| IEC No.79-10 | International Electrotechnical Commis- sion's Publication No.79-10, and IMO (MODU) Code chapter 6, |
| ISO 6385-1981 | Ergonomic Principles in the Design of Work Systems |
| ISO 9000 | guidance on the selection and use of qual- ity systems, and |
| ISO 10013 | guidance on developing quality manuals. |
| ISO 10 380, BS6501 | Flexible metallic hoses |
| ISO 10474 | Steel and Steel Products - Inspection Doc- uments /EN 10204 Metallic Products - Types of Inspection Documents |
| ISO 13628-5 | "Petroleum and natural gas industries – Design and operation of subsea production systems – Part 5: Subsea control umbili- cals" |
| PD5500:2000 | Specification for Unfired Fusion Welded Pressure Vessels |
| SAE J 517, DIN EN 853, 856, 857 | Rubber Hoses and Hose Assemblies |

Guidance note:

The latest revision of the DNV documents may be found in the publication list at the DNV website www.dnv.com.

For other sources see DNV-OSS-305 appendix C.

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

C. Informative References

C 100 General

| Table C1 Informative References | | |
|---------------------------------|--|--|
| Reference | Title | |
| | DNV Rules for Certification of Diving Sys- tems, 1988 | |
| NORSOK Stand- ard U-100 | Manned Underwater Operations | |
| EN 849:1996 | Transportable Gas Cylinders - Cylinder Valves - Specification and Type Testing | |
| EN ISO 11114- 3:1997 | Transportable Gas Cylinders - Compatibility of Cylinder and Valve Materials with Gas Con- tents - Part 3: Autogenous Ignition Test in Oxy- gen Atmosphere | |
| EN ISO 2503:1998 | Gas Welding Equipment - Pressure Regulators for Gas Cylinders used in Welding, Cutting and Allied Processes up to 300 bar | |
| ILO Convention 133, 1970 | Accommodation of crews | |
| (NFPA) Codes | National Fire Protection Agency | |
| SOLAS 1974 | (International Convention for the Safety of Life at Sea). | |

D. Verbal forms and Definitions

D 100 Auxiliary Verbal forms

101 *"Shall"*: Indicates requirements strictly to be followed in order to conform with this standard and from which no deviation is permitted.

102 *"Should"*: Indicates 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. Other possibilities may be applied subject to agreement.

103 *"May"*: Verbal form used to indicate a course of action permissible within the limits of the standard.

104 *"Agreement", "by agreement"*: Unless otherwise indicated, this means agreed in writing between manufacturer, contractor and purchaser.

D 200 Definitions

201 *As-built survey*: Survey of the installed and completed diving system, which is performed to verify that the completed installation work meets the specified requirements, and to document deviations from the original design, if any.

202 *Bell:* The diving bell (submersible decompression, pressure or compression chamber, SDC) is a submersible chamber including appendages, for transfer of divers between the underwater work site and the surface chamber (TUP or DDC).

203 Built In Breathing System (BIBS): A system of gas delivery to masks located in the decompression chambers and bells. This system facilitates breathing in the event of a contaminated atmosphere, and allows for the use of therapeutic gases during decompression. (see Sec.4)

204 *Certification:* Used in this document to mean all the verification activities associated with a process leading up to the issue of a Certificate. A manufacturer's works certificate (W), 3.1B in accordance with ISO10474/EN10204, will normally be required as a minimum level of certification.

Guidance note:

In this OS when *Certification* is used it designates the overall scope of work or multiple activities for the issue of a *Certificate*, whilst *Verification* is also used for single activities associated with the work. This in essence means that *Certification* is *Verification* for which the deliverable includes the issue of a *Certificate*.

Other (related) definitions are:

BS 4778: Part 2: *Certification*: The authoritative act of documenting compliance with requirements.

EN 45011: *Certification of Conformity*: Action by a third party, demonstrating that adequate confidence is provided that a duly identified product, process or service is in conformity with a specific standard or other normative document.

ISO 8402: 1994: *Verification*: Confirmation by examination and provision of objective evidence that specified requirements have been fulfilled.

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

205 *Chamber:* Surface decompression, pressure or compression chambers (see also DDC), hereafter called the chambers, are pressure vessels for human occupancy.

206 *Closed Circuit Breathing System (CCBS)* ': A system for supply of breathing gas to the diver and saving of his exhaled gases for re-circulation after scrubbing and replenishing. (see Sec.4)

207 *Commissioning*: In relation to diving systems, refers to activities which take place after installation and prior to operation, comprising the tests and trials outlined in Sec.2 J.

208 *Compact umbilical* :Umbilical consisting of composite bundles of hoses, cables and strength members in a braiding or sheathing. (see Sec.8)

209 *Compartment* :Part(s) of a chamber sufficiently large to contain at least one person and which may have an internal pressure different from adjacent compartments. (see Sec.3)

210 *Construction phase*: All phases during construction, including fabrication, installation, testing and commissioning, up until the installation or system is safe and operable for intended use. In relation to diving systems, this includes manufacture, assembly, testing, commissioning and repair.

211 *Contractor*: A party contractually appointed by the Purchaser to fulfil all, or any of, the activities associated with design, construction and operation.

212 *Corrosion allowance*: Extra wall thickness added during design to compensate for any reduction in wall thickness by corrosion (internally and externally) during operation.

213 *Deck Decompression Chamber (DDC)*: Deck mounted chamber for decompression. (see Sec.3)

214 *Design life*: The initially planned time period from initial installation or use until permanent decommissioning of the equipment or system. The original design life may be extended after a re-qualification.

215 *Design premises*: A set of projects specific design data and functional requirements which are not specified or which are left open in the standard.

216 *Design*: All related engineering to design the diving including both structural as well as material and corrosion.

217 Design temperature, maximum: The highest possible temperature to which the equipment or system may be exposed to during installation and operation. Environmental as well as operational temperatures shall be considered.

218 *Design temperature, minimum*: The lowest possible temperature to which the equipment or system may be exposed to during installation and operation, irrespective of the pressure. Environmental as well as operational temperatures shall be considered.

219 *Diver heating:* A system for actively heating the divers

in the water or in the inner area.

220 *Divers:* Personnel subjected to higher ambient pressure than one atmosphere.

221 *Diving system:* The whole plant and equipment necessary for safe conduct of diving operations where compression and decompression of divers are taking place.

For classification purposes, diving systems are categorized as follows:

| DSV-SURFACE | DSV-BOUNCE | DSV-SAT |
|--|--|---|
| d _{max} < 60msw* T _{op} < 8 hours | d _{max} < 125msw* T _{op} < 24 hours | None, except those imposed by the requirements and assumptions in the certifi- cate, appendix to Classifica- tion certificate and Data Sheet (20.201a) |

msw is metres of sea water

222 *dmax:* Maximum operating depth of the diving system. This is the depth corresponding to the maximum pressure for pressurizing divers. (For Classified systems this may be specified in DNV-OSS-305 Sec.3 D303.) For pressure equivalents to depth, see Sec.2 H107.

223 *DSV*: Class Notation in DNV representing 'Diving Support Vessel'.

224 *ECU*: Environmental Control Unit. Maintains Temperature, reduces humidity and may include removal of carbon dioxide. (see Sec.4)

225 *Fabrication*: Activities related to the assembly of objects with a defined purpose. In relation to diving systems, fabrication refers to e.g. Deck Decompression Chambers, Bells, Pressure vessels for gas storage, Environmental Control Systems, Handling Systems etc.

226 Fabricator: The party performing the fabrication.

227 *Failure*: An event affecting a component or system and causing one or both of the following effects:

— loss of component or system function

 deterioration of functional capability to such an extent that the safety of the installation, personnel or environment is significantly reduced.

228 *Fatigue*: Cyclic loading causing degradation of the material.

229 *Gas containers:* Cylinders, bottles and pressure vessels for storage of pressurized gas. (see Sec.3 and 4)

230 *Handling system:* The system and equipment necessary to connect and disconnect the bell to the chambers as well as transport the bell between the surface support unit and the underwater working site, including any guide rope systems and cursor systems. (see Sec.7)

231 *Hydrogen Pressure Induced Cracking (HPIC)*: Internal cracking of wrought materials due to a build-up of hydrogen pressure in micro-voids (Related terms: hydrogen induced cracking, stepwise cracking)

232 Hydro-test or Hydrostatic test: See Pressure test

233 *Hyperbaric Evacuation System (HES):* System for evacuating divers under pressure. This includes the Hyperbaric Evacuation Unit (HEU), the handling and control systems. (See Sec.9)

234 *Hyperbaric Rescue Vessel (HRV):* IMO uses the term Hyperbaric Evacuation Unit (HEU). See above.

235 *Inner area:* The areas which are inside the chambers and bell.

236 *Inspection*: Activities such as measuring, examination, testing, gauging one or more characteristics of a product or service and comparing the results with specified requirements

for determine conformity.

Installation (activity): The operations related to installing the equipment, diving system or support structure, e.g. mounting chambers, gas cylinders, ECUs, panels, interconnecting piping, handling systems etc., including final testing and preparation for operation.

Installation Manual (IM): A document prepared by the Contractor to describe and demonstrate that the installation method and equipment used by the Contractor will meet the specified requirements and that the results can be verified.

Life support systems: The systems comprising gas supply systems, breathing gas systems, pressure regulating systems, environmental control systems, and systems required to provide a safe habitat for the divers, in the bell and compartments under normal conditions during diving operation. (see Sec.4)

Living compartment: A compartment which is intended to be used as the main habitation for the divers and which is equipped as such.

Load: Any action causing stress, strain, deformation, displacement, motion, etc. to the equipment or system.

Load effect: Effect of a single load or combination of loads on the equipment or system, such as stress, strain, deformation, displacement, motion, etc.

Load effect factor: The partial safety factor by which the characteristic load effect is multiplied to obtain the design load effect.

Lot: A number of components from the same batch. E.g. same heat, the same heat treatment batch and with the same dimensions.

Manufacture: Making of articles or materials, often in large volumes. In relation to diving systems, refers to activities for the production of pressure vessels, panel, life support systems etc., performed under contracts from one or more Contractors.

Manufacturer: The party who is contracted to be responsible for planning, execution and documentation of manufacturing.

Manufacturing Procedure Specification (MPS): A manual prepared by the Manufacturer to demonstrate how the specified properties may be achieved and verified through the proposed manufacturing route.

Material resistance factor: Partial safety factor transforming a characteristic resistance to a lower fractile resistance.

Material strength factor: Factor for determination of the characteristic material strength reflecting the confidence in the yield strength.

NDT level: The extent and acceptance criteria for the NDT of the components.

Nominal outside diameter: The specified outside diameter. This shall mean the actual outside diameter.

Nominal wall thickness: The specified non-corroded wall thickness, which is equal to the minimum steel wall thickness plus the manufacturing tolerance.

253 Normal cubic meters: (Nm^3) is taken as cubic meters of gas at standard conditions of 0°C and 1.013 bar.

Observation dive: A diving operation using the diving bell with an internal pressure of one atmosphere.

Operation, Incidental: Conditions that are not part of normal operation of the equipment or system. In relation to diving systems, incidental conditions may lead to incidental pressures.

256 Operation, Normal: Conditions that arise from the

intended use and application of equipment or system, including associated condition and integrity monitoring, maintenance, repairs etc. In relation to diving systems, this should include, start and finish of dives (pre- and post-dive checks), treatment of decompression-related incidents, gas transfer and changing out of consumables.

Out of roundness: The deviation of the perimeter from a circle. This can be stated as ovalisation (%), or as local out of roundness, e.g. flattening, (mm).

Outer area: Those areas of the diving system that are exposed to atmospheric conditions during operation, i.e. outside the inner system and the room or area that surrounds or contains the diving system.

Ovalisation: The deviation of the perimeter from a circle. This has the form of an elliptic cross section.

Owner: The party ultimately responsible for design, construction and operation.

Oxygen systems: Systems intended for a gas with a higher oxygen percentage than 25.

Partial safety factor: A factor by which the characteristic value of a variable is modified to give the design values.

Personal diving equipment: Equipment carried by the diver on his person including his diving suit, self-contained breathing apparatus, gas bottles, supply hoses and cables between the diver and the bell. This is normally not included in the diving system specified in this standard.

Planned Maintenance System (PMS): A system for planning and recording of maintenance activities.

Pressure control system: In relation to diving systems, this is the system for control of the pressure in the various systems, comprising the pressure regulating system, pressure safety system and associated instrument and alarm systems.

Pressure regulating system: In relation to diving systems, this is the system which ensures that, irrespective of the upstream pressure, a set pressure is maintained (at a given reference point) for the component.

Pressure safety system: The system which, independent of the pressure regulating system, ensures that the allowable set pressure is not exceeded.

Pressure test: The hydrostatic pressure test, initially performed at the manufacturer of the pressure vessel in accordance with requirements in the design code.

Pressure, Collapse: Characteristic resistance against external over-pressure.

Pressure, Design: In relation to diving system assemblies, this is the maximum internal pressure during normal operation, referred to a specified reference point, to which the component or system section shall be designed. The design pressure must take account of the various pressurised components in the adjoining systems, and their relative design pressures.

Pressure, System test: In relation to diving systems, this is the internal pressure applied to the component or system during testing on completion of installation work to test the diving system for tightness (normally performed as hydrostatic testing).

Purchaser: The owner or another party acting on his behalf, who is responsible for procuring materials, components or services intended for the design, construction, installation or modification of a diving system.

Quality Assurance (QA): Planned and systematic actions necessary to provide adequate confidence that a product or service will satisfy given requirements for quality.

Quality Plan (QP): The document setting out the specific quality practices, resources and sequence of activities rel-

evant to a particular product, project or contract. A quality plan usually makes reference to the part of the quality manual applicable to the specific case.

275 *Reliability*: The probability that a component or system will perform its required function without failure, under stated conditions of operation and maintenance and during a specified time interval.

276 *Re-qualification*: The re-assessment of a design due to modified design premises and or sustained damage.

277 *Resistance*: The capability of a structure, or part of a structure, to resist load effects.

278 *Risk:* The qualitative or quantitative likelihood of an accidental or unplanned event occurring, considered in conjunction with the potential consequences of such a failure. In quantitative terms, risk is the quantified probability of a defined failure mode times its quantified consequence.

279 *Safety Class:* Generically; a concept sometimes adopted to classify the significance of a particular component or system with respect to the consequences of failure.

280 Self Propelled Hyperbaric Lifeboat (SPHL): (see HEU and Sec.9)

281 *Significant wave height:* When selecting the third of the number of waves with the highest wave height, the significant wave height is calculated as the mean of the selection.

282 Specified Minimum Tensile Strength: The minimum tensile strength prescribed by the specification or standard under which the material is purchased.

283 Specified Minimum Yield Stress: The minimum yield stress prescribed by the specification or standard under which the material is purchased.

284 *Submersible Decompression Chamber (SDC)*: (see Bell and Sec.3)

285 *Suitable breathing gas:* A gas or gas mixture that is breathable to divers for the pressure and duration they are exposed to it.

286 Supplementary requirements: Requirements for material properties of component that are additional to the basic requirements, and that are intended to apply to components used for specific applications.

287 T_{op} : Maximum operation time, i.e. the time from start of pressurization of the diver, until the diver is back to atmospheric conditions.

288 *Transfer compartment:* Compartment that is intended to be used for a lock-in or -out operation of divers between other compartments, bell or outer area. Also known as TUP (Transfer Under Pressure)

289 *Transferable diving system:* A diving system designed to be easily transferable in one or more units and which may be installed onboard a ship, barge or offshore platform for a short period of time not exceeding one year. A transferable diving system may be assembled from different units into a particular configuration suitable for a specific working operation.

290 *Ultimate Tensile Strength:* The measured ultimate tensile strength.

291 *Umbilical:* A link between support vessel and the diving bell, which may contain gas hoses, hot water hose, power sup-

ply cables and communication cables. (see Sec.8)

292 *Verification*: An examination to confirm that an activity, a product or a service is in accordance with specified requirements.

293 *Work*: All activities to be performed within relevant contract(s) issued by owner, Operator, Contractor or Manufacturer.

294 Working weight: (See Sec.7 C103).

295 Yield Stress: The measured yield tensile stress.

E. Abbreviations and Symbols (Guidance)

E 100 Abbreviations

| API | American Petroleum Institute |
|-------|---|
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| AUT | Automatic Ultrasonic Testing |
| BS* | British Standard (Note: Now PD - Public document) |
| C-Mn | Carbon Manganese |
| CE | Conformité Européene (European Conformity) |
| CRA | Corrosion Resistant Alloy |
| DNV | Det Norske Veritas |
| DP | Dynamic Positioning |
| EBW | Electronic Beam Welded |
| FMEA | Failure Mode Effect Analysis |
| HAZ | Heat Affected Zone |
| HAZOP | Hazard and Operability Study |
| HFW | High Frequency Welding |
| HPIC | Hydrogen Pressure Induced Cracking |
| IM | Installation Manual |
| ISO | International Organisation for Standardisation |
| KV | Charpy value |
| LBW | Laser Beam Welded |
| MPQT | Manufacturing Procedure Qualification Test |
| MPS | Manufacturing Procedure Specification |
| MSA | Manufacturing Survey Arrangement |
| NACE | National Association of Corrosion Engineers |
| NDE | Non-Destructive Examination |
| NDT | (Non-Destructive Testing) see NDE |
| NPD | Norwegian Petroleum Directorate |
| Р | Production |
| Q | Qualification |
| QA | Quality Assurance |
| QC | Quality Control |
| QP | Quality Plan |
| QRA | Quantitative Risk Analysis |
| ROV | Remotely Operated Vehicle |
| UTS | Ultimate Tensile Strength |
| WPS | Welding Procedure Specification |
| YS | Yield Stress |

E 200 Symbols

201 Latin characters

| А | = | Cross section area |
|--|------------------|---|
| D | = | Nominal outside diameter. |
| D_{\max} | = | Greatest measured inside or outside diameter |
| D _{min} | = | Smallest measured inside or outside diameter |
| D_{i} | = | D - 2 t_{nom} = Nominal internal diameter |
| Е | = | Young's Modulus |
| f_0 | = | Ovality, $\frac{D_{\max} - D_{\min}}{D}$ |
| Н | = | Wave height |
| 11 | | Significant wave height |
| $H_{\rm S}$ | = | Si Binite and that a margine |
| H _s ID | = | Nominal inside diameter |
| H _s ID O | = | Nominal inside diameter Out of roundness, $D_{max} - D_{min}$ |
| H _s ID O OD | = = = | Nominal inside diameter Out of roundness, $D_{max} - D_{min}$ Nominal outside diameter |
| H _s ID O OD T | = = = | Nominal inside diameter Out of roundness, $D_{max} - D_{min}$ Nominal outside diameter Operating temperature |
| $H_{\rm s}$ ID O OD T $T_{\rm max}$ | = = = = | Nominal inside diameter Out of roundness, $D_{max} - D_{min}$ Nominal outside diameter Operating temperature Maximum design temperature |

SECTION 2 DESIGN PHILOSOPHY AND PREMISES

A. General

A 100 Objectives

101 The purpose of this section is to present the safety philosophy applied in this standard.

102 It also identifies and provides a basis for definition of relevant system design characteristics. Further, key issues required for design, construction, operation and re-qualification of diving systems are identified.

103 This section also refers to minimum requirements for documentation for design, manufacture, installation and some operational aspects.

104 Some general guidance is given, such as safety philosophy and design premises.

A 200 Application and scope

201 This section applies to all diving systems, which shall be built in accordance with this standard.

202 Requirements for testing are included here.

203 This section bears impact upon all other sections in this standard.

A 300 Documentation

301 Specific lists are given in A300 under each section.

302 For general requirements, see I.

B. Safety Philosophy

B 100 General

101 The integrity of a diving system constructed to this standard is ensured through a safety philosophy integrating different parts as illustrated in Figure 1.

B 200 Safety objective

201 An overall safety objective shall be established, planned and implemented, covering all phases from conceptual development until demobilisation and scrapping.

Guidance note:

All companies have some sort of policy regarding human aspects, environment and financial issues. These are typically on an overall level, but more detailed objectives and requirements in specific areas may follow them. These policies should be used as a basis for defining the safety objective for a specific diving system. Typical statements can be:

- There shall be no serious accidents or loss of life during the construction period;

Statements such as the above may have implications for all or individual phases only. They are typically more relevant for the work execution (i.e. how the contractor executes his job) and specific design solutions. Having defined the safety objective, it can be a point of discussion as to whether this is being accomplished in the actual project. It is therefore recommended that the overall safety objective be followed up by more specific, measurable requirements.

If no policy is available, or if it is difficult to define the safety objective, one could also start with a risk assessment. The risk assessment could identify all hazards and their consequences, and then enable back-extrapolation to define acceptance criteria and areas that need to be followed up more closely.

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





B 300 Systematic review

301 As far as practical, all work associated with the design, construction and operation of the diving system shall be such as to ensure that no single failure shall lead to life-threatening situations for any person, or to unacceptable damage to the facilities or the environment.

302 A systematic review or analysis shall be carried out at all phases in order to identify and evaluate the consequences of single failures and series of failures in the diving system, such that necessary remedial measures can be taken. The extent of the review or analysis shall reflect the criticality of the diving system, the criticality of a planned operation and previous experience with similar systems or operations.

Guidance note:

A methodology for such a systematic review is quantitative risk analysis (QRA). This may provide an estimation of the overall risk to human health and safety, environment and assets and comprises:

- hazard identification
- assessment of probabilities of failure events
- accident developments
- consequence and risk assessment.

It should be noted that legislation in some countries requires risk analysis to be performed, at least at an overall level to identify critical scenarios that might jeopardise safety and reliability. Other methodologies for identification of potential hazards are Failure Mode and Effect Analysis (FMEA) and Hazard and Operability studies (HAZOP).

```
---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---
```

303 Special attention shall be given to the risk of bell handling, fire and evacuation.

B 400 'Safety class' methodology

Guidance note:

Safety of the diving system may be ensured by use of a safety class methodology. The diving system is then classified into one or more safety classes based on failure consequences, normally given by the particular operation. For each safety class, a set of partial safety factors is assigned to each limit state.

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

B 500 Quality assurance

501 The safety format within this standard requires that gross errors (human errors) shall be controlled by:

- a) requirements for organisation of the work,
- b) competence of persons performing the work,
- c) verification of the design, and
- d) quality assurance during all relevant phases.

502 For the purpose of this standard, it is assumed that the owner of a diving system has established a quality objective. The owner shall, in both internal and external quality related aspects, seek to achieve the quality level of products and services intended in the quality objective. Further, the owner shall provide assurance that intended quality is being, or shall be, achieved.

503 A quality system shall be applied to assist compliance with the requirements of this standard.

Guidance note:

ISO 9000 gives guidance on the selection and use of quality systems, and ISO 10013 gives guidance on developing quality manuals.

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

B 600 Health, safety and environment

601 The objective of this standard is that the design, materials, fabrication, installation, commissioning, operation, repair, and re-qualification, of diving systems are safe and conducted with due regard to public safety and the protection of the environment.

C. General Premises

C 100 Concept development

101 Data and description of system development and general arrangement of the diving system shall be established.

102 The data and description shall include the following, as applicable:

- a) safety objective
- b) locations, foundations and interface conditions
- c) diving system description with general arrangement and system limits
- d) functional requirements including system development restrictions, e.g., significant wave height, hazardous areas, fire protection
- e) installation, repair and replacement of system elements and fittings
- f) project plans and schedule, including planned period for installation
- g) design life including specification for start of design life, e.g. final commissioning, installation
- h) data of contained liquids and gases
- i) capacity and sizing data;
- j) geometrical restrictions such as specifications of diameter, requirement for fittings, valves, flanges and the use of flexible hoses
- k) second and third party activities.

C 200 Execution plan

201 An execution plan shall be developed, including the fol-

lowing topics:

- a) general information, including project organisation, scope of work, interfaces, project development phases and production phases
- b) contacts with Purchaser, authorities, third party, engineering, verification and construction Contractors
- c) legal aspects, e.g. insurance, contracts, statutory requirements.

C 300 Plan for Manufacture, Installation and Operation

301 The design and planning for a diving system shall cover all development phases including manufacture, installation and operation.

302 Manufacture

For a documentation overview, see I. Documentation.

303 Installation

Detailed plans, drawings and procedures shall be prepared for all installation activities. The following shall as a minimum be covered:

- a) diving system location overview (planned or existing)
- b) other vessel (or fixed location) functions and operations
- c) list of diving system installation activities
- d) alignment rectification
- e) installation of foundation structures
- f) installation of interconnecting services
- g) installation of protective devices
- h) hook-up to support systems
- i) as-built survey
- j) final testing and preparation for operation.

304 Operation

Plans for diving system operation, inspection, maintenance and repair shall be prepared prior to start of operation. All operational aspects shall be considered when selecting the diving system concept.

The diving system operational planning shall as a minimum cover:

- a) organisation and management
- b) start-up and shut-down (pre- and post dive)
- c) operational limitations
- d) emergency operations
- e) maintenance
- f) corrosion control, inspection and monitoring
- g) general inspection
- h) special activities.

305 Demobilisation

Demobilisation shall be planned and prepared. Evaluation shall include the following aspects:

- a) safety aspects, during and after demobilisation
- b) environmental aspects, e.g. pollution
- c) impact on other structures
- d) possible reuse of equipment at a later stage (re-qualification and certification).

D. System Design Principles

D 100 System integrity

101 Diving systems shall be designed, constructed and operated in such a manner that they:

- a) fulfil the specified operational requirements
- b) fulfil the defined safety objective and have the required support capabilities during planned operational conditions
- c) have sufficient safety margin against accidental loads or unplanned operational conditions.

102 The possibility of changes in the operating conditions and criteria during the lifetime of the system.

103 Any re-qualification deemed necessary due to changes in the design conditions shall take place in accordance with provisions set out in each section of the standard.

D 200 Monitoring and inspection during operation

201 Parameters that could jeopardise the safety of the divers, and or violate the integrity of a diving system, shall be monitored and evaluated with a frequency that enables remedial actions to be carried out before personal harm is done or the system is damaged.

Guidance note:

As a minimum the monitoring and inspection frequency should be such that the diving system, and consequently the diving operation, shall not be endangered due to any realistic degradation or deterioration that may occur between two consecutive inspection intervals.

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

202 Instrumentation may be required when visual inspection or simple measurements are not considered practical or reliable, and available design methods and previous experience are not sufficient for a reliable prediction of the performance of the system.

203 The various pressures in a diving system shall not exceed the design pressures of the components during normal steady-state operation.

D 300 Pressure Control System

301 A pressure control system is be used to prevent the internal pressures at any point in the diving system rising to excessive levels, or falling below prescribed levels. The pressure control system comprises the pressure regulating systems, pressure safety systems and associated instrumentation and alarm systems.

302 The purpose of the pressure regulating system is to maintain the operating pressures within acceptable limits during normal operation. The set pressures of the pressure regulating system shall be such that the local operational pressures are not exceeded at any point in the diving system. Due account shall be given to the tolerances of the pressure regulating system and the associated instrumentation.

303 The purpose of the pressure safety systems is to protect the systems during abnormal conditions, e.g. in the event of failure of the pressure regulating systems. The pressure safety systems shall operate automatically in accordance with the "fail safe" principles and with set pressures such that there is a low probability for:

- a) the internal pressure at any point in the diving system to exceed the design pressure (maximum operating pressure). (see Sec.4 B200), or
- b) the unintentional loss of pressure at any point in the diving system to exceed set values (see Sec.4 E300).
- 304 The diving system may be divided into sections with dif-

ferent design pressures provided the pressure control system ensures that; for each section, the local operational pressure cannot be exceeded during normal operations and that the design pressure cannot be exceeded during abnormal operation.

The pressure control shall also ensure that unwanted loss of pressure in one section does not occur as a result of an abnormal condition in another section.

E. Diving system arrangement layout and location

E 100 General

101 The systems shall be so designed that the effect of a single failure cannot develop into hazardous situations for the divers.

Guidance note:

Whereas this is a general requirement for the systems, it is recognised that certain components cannot fulfil this requirement in and of themselves. A typical example of this is the Pressure Vessel for Human Occupancy with acrylic windows.

In these cases the applicable standards will specify stringent safety factors. For other cases a formal safety assessment may be required.

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

102 The diving system shall be so designed that the divers and assisting personnel are provided with safe and comfortable operating conditions. Ergonomic principles shall be applied in the design of working systems. (i.e. in accordance with ISO 6385-1981.)

103 The diving system shall contain a minimum of two compartments. The smaller of the two compartments shall be large enough for two persons. One of the compartments shall be a living compartment. For **DSV-BOUNCE** and **DSV-SAT** diving systems, a minimum of two compartments shall be designed for keeping the pressure independent of the pressure in the other compartment(s).

104 When the diving system is taken onboard and mobilised for use, equipment related to the diving system shall be permanently attached to the hull structure (e.g. by welding, screwed connection or similar). Fitting by means of lashing is not considered as permanent fitting.

E 200 Layout of the diving system.

201 The layout of the diving system on board shall ensure protection from accidental damage and accessibility for:

- a) safe operation
- b) maintenance
- c) inspection.

E 300 Location of the diving system.

301 The location of a **DSV-SAT** diving system on a ship, mobile unit or fixed offshore structure, or land site, shall be in a safe area with respect to explosive gas-air mix.

Safe areas are in this context areas which are not defined as hazardous zones in International Electro technical Commission's Publication No.79-10, and IMO (MODU) code, chapter 6, as follows:

- Zone 0: in which an explosive gas-air mixture is continuously present or present for long periods.
- Zone I: in which an explosive gas-air mixture is likely to occur in normal operation.
- Zone 2: in which an explosive gas-air mixture is not likely to occur, and if it occurs it will only exist for a short time.

Upon special consideration and agreement in each case, however, **DSV-SAT** diving systems may be located in spaces which normally would be defined as Zone 2.

302 When any part of the diving system is sited on deck, particular consideration shall be given to providing reasonable protection from sea, icing or any damage which may result from other activities onboard the ship or floating structure. This includes the Hyperbaric Evacuation System (HES).

303 The diving system shall be so located that diving operations shall not be affected by propellers, thrusters or anchors.

Guidance note:

Some national regulations will limit the length of umbilicals so that the diver, or his umbilical, cannot be drawn into the propellers or thrusters. Requirements to the use of 'wet-bell' may also apply in some regions.

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

E 400 Supports and Foundations for Pressure vessels for Human Occupancy and for Gas Storage

401 Pressure vessel(s) exposed to static and dynamic loads while allowing contraction and expansion of the pressure vessel(s) under pressure variations, temperature variations and hull deflections, shall be supported in a proper manner. The stress level in the pressure vessel(s), connected pipes, the supports and foundations shall be kept within acceptable level.

402 The part of the hull structure supporting the diving system, is to be evaluated with respect to deflection, in order not to expose the diving system to excessive deflections. The evaluation shall take into consideration defined acceptable level of deflection for the diving system.

Guidance note:

Supports are generally understood to be part of the pressure vessels, whereas the foundations are generally understood to be part of the ship's structure/hull.

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

403 The supports and foundations shall be calculated for values of accelerations determined as shown in DNV Rules for Classification of Ships Pt.3 Ch.1 Sec.4 or other acceptable standards. The values reflect a probability level of 10^{-8} .

404 The pressure vessels with supports shall be designed for a static inclination of 30° without exceeding the allowable stresses as specified in E603.

405 Suitable supports and foundations shall be provided to withstand a collision force acting on the pressure vessels corresponding to one half the weight of the pressure vessels in the forward direction and one quarter the weight of the pressure vessels in the aft direction.

406 The loads mentioned in 404 and 405 need not to be combined with each other or with wave-induced loads.

407 Unless removal of the pressure vessel(s) is a simple operation, the foundation(s) shall be able to sustain the static load of the pressure vessel(s) during periodic hydro testing or it shall be possible to shore/support the foundations in order to avoid unacceptable deflections.

E 500 Supports and Foundations for handling systems and lifting appliances

501 Supports and foundations for handling systems and lifting appliances shall be determined according to DNV Rules for Classification of Ships Pt.3 Ch.3 Sec.5 or according to other recognised standards.

502 The dynamic coefficient shall be taken as 2.2 or more when the lifting appliance is used for handling manned objects such as bells, baskets or Hyperbaric Evacuation Systems. For other lifting appliances, not used for lifting people, the

dynamic coefficient shall be 1.5 or more.

503 The side structure of the moon pool is to be strengthened with respect to possible impact loads from diving equipment guided through the moon pool.

E 600 Supports and Foundations for other equipment

601 The support of other equipment, not categorised under E400 or E500, shall be considered. Drawings showing the deck structure below the foundation shall be submitted for approval when the static forces exceed 50 kN or when the resulting bending moments at deck exceed 100 kNm. The drawings shall clearly indicate the relevant forces and bending moments acting on the structure.

602 When considering the structural strength of the deck structure the static loads shall be multiplied by a dynamic factor equal to 1.6 or more.

603 Acceptable stress levels may be taken as follows

| Bending stresses: | 160 f ₁ N/mm². |
|-------------------|---------------------------------------|
| Shear stresses: | 90 f ₁ N/mm ² . |

604 To obtain satisfactory transfer of heavy loads from the diving equipment foundations, the structure below deck shall be in line with the foundation structure. This may be obtained by fitting adequate brackets, intercostals, rings or similar fittings.

605 Regarding material qualities, reference is made to DNV Rules for Classification of Ships Pt.3 Sec.2 B300 and B500 or to the applied standard.

606 The welding shall be considered with respect to the actual stress level.

F. Position Keeping and Stability and Floatation (for installations on Ships and Mobile Offshore Units)

F 100 General

101 The vessel shall be able to keep its position safely during diving operations. This implies a system with built in redundancy for position keeping. The position keeping system may be a mooring system with anchors or a dynamic positioning system.

102 The requirements for mooring systems with anchors shall be especially considered.

103 A dynamic positioning system shall, as a minimum, comply with the notation **AUTR** or equivalent. Alarms shall be initiated and set accordingly.

Guidance note:

In this context, equipment class 2 in accordance with IMO MSC/ Circ.645 of 6 June 1994 "Guidelines for Vessels with dynamic positioning systems" will be considered as equivalent to **AUTR**. Some diving operations may require a higher class, which then should be stated in the contract.

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

104 Between the operation centre for the dynamic positioning system and the dive operation centre there shall be:

- a communication system
- a manually operated alarm system.

105 The vessel shall comply with the requirements to Stability and Floatation given in DNV Rules for Classification of Ships Pt.5 Ch.7 Sec.3 D and Sec.4 B for additional class notation **SF**.

G. Environmental Conditions

G 100 General

101 Systems and components shall be designed for the environmental conditions expected at their installed location (on the vessel or otherwise) and their geographic site of operation.

102 All systems and components shall be able to operate satisfactorily and safe in accordance with their specifications at the environmental conditions stated in H.

103 Additional requirements for various systems and components may, however, be given elsewhere in the Standard.

104 The effects of environmental phenomena relevant for the particular location and operation in question shall be taken into account.

105 Environmental phenomena that might impair proper functioning of the system or cause a reduction of the reliability and safety of the system shall be considered, (including fixed and land-based installations):

- temperature
- wind, tide, waves, current
- ice, earthquake, soil conditions
- marine growth and fouling.

G 200 Collection of environmental data

201 The environmental data should be representative for the geographical areas in which diving systems may be operated. Estimates based on data from relevant locations may be used.

202 Environmental parameters may be described using characteristic values based on statistical data or long-term observations.

203 Statistical data may be utilised to describe environmental parameters of a random nature (e.g. wind, waves). The parameters should be derived in a statistically valid manner using recognised methods.

G 300 Wind

301 Where appropriate, wind effects shall be considered in the design of handling systems, including the possibility of wind induced vibrations of exposed free spans.

302 For spans adjacent to other structural parts, possible effects due to disturbance of the flow field shall be considered when determining the wind actions. Such effects may cause an increased or reduced wind speed, or a dynamic excitation by vortices being shed from adjacent structural parts.

G 400 Tide

401 Tide effects shall be considered when this is a significant parameter, e.g. handling systems on shore based installations.

402 The assumed maximum tide shall include both astronomic tide and storm surge. Minimum tide estimates should be based upon the astronomic tide and possible negative storm surge.

G 500 Waves

501 Maximum sea-state, defined by maximum significant wave height, shall be specified and used in the design calculations. Calculations may be done in accordance with specifications in Appendix A.

502 The wave data to be used in the design of handling systems are in principle the same as the wave data used in the design of the structure supporting the system.

503 Direct and indirect wave effects may need to be taken into consideration.

504 When appropriate, consideration should be given to wave refraction and shoaling, shielding, and reflecting effects.

505 Where the handling system is positioned adjacent to other structural parts, possible effects due to disturbance of the flow field should be considered when determining the wave actions. Such effects may cause an increased or reduced velocity, or dynamic excitation by vortices being shed from the adjacent structural parts.

506 Where appropriate, consideration should be given to wave direction and short crested waveform.

G 600 Current

601 The effect of current shall be taken into consideration.

602 Current velocities shall include contributions from positioning systems, tidal current, wind-induced current, storm surge current, and other possible current phenomena. For near-shore fixed installations, long-shore current due to wave breaking shall be considered.

603 The variations in current velocity magnitude and direction as a function of water depth may need to be considered. For fixed installations, the current velocity distribution should be the same as the one used in the design of the offshore structure supporting the system.

G 700 Ice

701 For areas where ice may develop or drift, consideration shall be given to possible effects, including:

- a) ice forces on the system (added loads may be due to increased diameters or surface area)
- b) impacts from drifting ice
- c) icing problems during construction and installation.

G 800 Air and sea temperatures

801 Air and sea temperature statistics may be provided giving representative design values specified in the terms of delivery.

802 Monitoring of temperature may be required during construction, installation and commissioning phases if the effect of temperature or temperature variations has a significant impact on the safety of the diving system.

803 The interactive effects of temperature and humidity shall be considered.

G 900 Marine growth

901 The effect of marine growth on diving systems may need to be considered, taking into account both biological and other environmental phenomena relevant for the location.

902 The estimation of hydrodynamic loads may need to be considered in the cases where marine growth might have an impact on the effective surface area or surface roughness.

H. External and Internal System Condition

H 100 External operational conditions and outer area.

101 Design inclinations shall be according to Table IA.

| Table A1 Design inclinations | | | | |
|--|----------|-------------------|--------|--------|
| Location | Roll | Permanent list | Pitch | Trim |
| Chambers and other surface installations: On a ship | +/-22.5° | +/-15° | +/-10° | +/-5° |
| On a mobile off- shore unit | | +/-15° | | +/-15° |
| Components in a bell | +/-45° | +/-22.5° | | |

Guidance note:

For handling systems the operational design sea-state is given in Sec.7 C100.

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

102 Range of ambient temperature: -10°C to 55°C, unless otherwise specified. For greater temperature ranges, temperature protection shall be provided.

103 Humidity: 100%.

104 Atmosphere contaminated by salt (NaCl):

Up to 1 mg salt per 1 m³ of air, at all relevant temperatures and humidity conditions.

H 200 Submerged components

201 Range of ambient temperature: -2°C to 30°C.

202 Range of ambient pressure: 1 bar to 1.3 times the pressure corresponding to maximum operating depth.

203 Salinity of ambient water: 35 parts per thousand.

204 The pressure equivalent to depth of seawater at 0° C with 3.5% salinity may be taken as 1.006 bar per 10 msw (meter seawater), as a mean value between 0 and 200 m depth.

For saltwater, the density may be taken to vary as follows:

- 0.05% increase for each 100 m of depth increase
- 0.4% increase for an increase in salinity from 3.5% to 4.0%
- 0.3% decrease for an increase in temperature from 10°C to 20°C.

205 For the selection and detailed design for external corrosion control, the conditions relating to the environment shall be defined.

H 300 Internal conditions

301 Range of ambient pressure: 1 bar to 1.3 times the pressure corresponding to d_{max} with pressurisation and depressurisation rates as specified in Sec.4 C100.

302 Range of ambient temperature: 5°C to 55°C, unless otherwise specified.

303 Relative humidity: Up to 100%.

304 Atmosphere contaminated by salt (NaCl):Up to 1 mg salt per 1 m^3 of air, at relevant temperatures and humidity conditions.

305 A description of the internal conditions during storage, construction, installation, pressure testing and commissioning shall be prepared. The duration of exposure to seawater or humid air, and the need for using measures to control corrosion shall be considered.

When choosing materials, paints etc. the potential for emission of hazardous compounds shall be considered.

Statutory requirements apply for determination of exposure limits such as:

- a) American Conference of Governmental Industrial Hygienists, Documentation of the Threshold Limit Values and Biological Exposure
- b) European Commission Directive on Occupational Exposure Limit Values
- c) Health and Safety Executive Occupational Exposure Limits

H 400 Internal operational conditions

401 In order to assess the need for internal corrosion control, including corrosion allowance and provision for inspection and monitoring, the following conditions shall be defined:

a) maximum and average operating temperature and pressure

profiles of the components, and expected variations during the design life

- b) expected content of dissolved salts in fluids, residual oxygen and active chlorine in sea water)
- c) chemical additions and provisions for periodic cleaning
- d) provision for inspection of corrosion damage and expected capabilities of inspection tools (i.e. detection limits and sizing capabilities for relevant forms of corrosion damage)
- e) the possibility of wear and tear, galvanic effects and effects in still water pools shall be considered.

I. Documentation

I 100 General

101 This section specifies the requirements for documentation during diving system design, manufacturing, fabrication, installation, commissioning and operation.

102 In accordance with quality system requirements, such as those outlined in ISO 9001:1994-4.4 (especially 4.4.5) and 4.5 (especially 4.5.2), design output shall be documented and expressed in terms that can be verified and validated against design input requirements.

The supplier shall establish and maintain documented procedures to control all documents and data.

This may in part be done in accordance with the DNV document requirements lists (DOCREQ).

103 All documentation requirements shall be reflected in a document register. The documentation shall cover design, manufacturing, fabrication, installation and commissioning. As a minimum, the register shall reflect activities from the start of design to operation of the diving system.

104 The documentation shall be submitted to the relevant parties for acceptance, verification or information as agreed in ample time before start of fabrication.

105 Verified documentation shall be available at the work site before manufacturing commences.

I 200 Documentation of Arrangement etc.

- a) Plans showing general arrangement of the diving system, location and supporting arrangement
- b) Plans showing the lay-out of control stand(s)
- c) Proposed program for tests and trials of systems for normal operation and for emergency use.

201 List stating the following particulars for the diving system:

- a) Maximum operating depth ${\rm d}_{\rm max}$ and maximum observation depth for the bell
- b) Maximum operation time T_{op}
- c) Maximum number of divers in the bell
- d) Maximum number of divers in the chamber(s) and bell(s)
- e) Maximum operational sea-state
- f) Extract from the operation manual, stating the operational procedures, which are to be the basis for the design.

I 300 Documentation for systems in operation

301 In order to carry out periodical surveys, the minimum documentation shall include:

- a) personnel responsible for the operation of diving system
- b) history of diving system operation with reference to events which may have significance to design and safety

- c) a log of the total number of dives and hours of saturation in the periods between annual surveys
- d) records of new equipment installed and old equipment removed
- e) installation condition data as necessary for understanding diving system design and configuration, e.g. previous survey reports, as-built installation drawings and test reports
- f) inspection and maintenance schedules and their records.

302 In case of mechanical damage or other abnormalities that might impair the safety, reliability, strength and stability of the diving system, the following documentation shall, as a minimum, be prepared prior to start-up of the diving system:

- a) description of the damage to the diving system, its subsystems or components with due reference to location, type, extent of damage and temporary measures, if any
- b) plans and full particulars of repairs, modifications and replacements, including contingency measures
- c) further documentation with respect to particular repair, modification and replacement, as agreed upon in line with those for the manufacturing or installation phase.

I 400 Filing of documentation

401 Maintenance of complete files of all relevant documentation during the life of the diving system is the responsibility of the owner.

402 The engineering documentation shall be filed by the owner or by the engineering contractor for a minimum of 10 years.

403 Design basis and key data for the diving system shall be filed for the lifetime of the system. This includes documentation from design to start-up and also documentation from possible major repair or modification of the diving system.

404 Files to be kept from the operational and maintenance phases of the diving system shall, as a minimum, include final in-service inspection reports from start-up, periodical and special inspections, condition monitoring records, and final reports of maintenance and repair.

J. Inspection and Testing

J 100 General

101 When a diving system is built according to this standard, an inspector or surveyor shall verify that:

- a) the design and scantlings comply with the approved plans and the requirements in this standard and other specified recognized standards, codes, and national regulations
- b) that the materials and components are certified according to this standard and the terms of delivery
- c) that the work is carried out in accordance with the specified fabrication tolerances and required quality of welds etc.
- d) that piping systems conducting gas in life support systems are cleaned in accordance with an approved cleaning procedure conforming to requirements given in ASTM G93-96 Standard Practice for Cleaning Methods and Cleanliness Levels for Materials and Equipment Used in Oxygen-Enriched Environments
- e) that gas cylinders are clean and sealed
- f) that all required tests are carried out.

102 The inspection shall be carried out at the manufacturers, during the assembly and during installation. The extent and method of examination shall be agreed in the terms of delivery.

103 The tests to be carried out are stated in 200 and 300. Additional tests may, however, be required. The testing after completed installation shall be in compliance with an approved program.

J 200 Testing at the manufacturers

201 Pressure tests

- a) Welded pressure vessels and seamless steel gas containers for internal pressure shall be hydrostatic tested to an internal pressure in accordance with the design code. Each compartment in chambers shall be tested separately.
- b) Bells and pressure vessels for external pressure shall, in addition to the internal pressure testing, be hydrostatic tested to an external pressure in accordance with the design code.
- c) Acrylic plastic windows shall be tested in accordance with ASME PVHO-1a-1997 Article 7. The applied hydrostatic test pressure shall be the greater of;
 - i) 1.3 times the design pressure, or
 - ii) the test pressure of the bell/chamber for which the window is intended,but shall not exceed 1.5 times the design pressure of the window.
- d) Compressor components subjected to pressure shall be hydrostatic tested in accordance with the design code.
- 202 Compressors.
- a) Compressors shall be tested for the gas types, pressure and delivery rate intended
- b) The tests shall incorporate measurements of humidity and possible, contaminants in the gas delivered.
- **203** Closed circuit breathing system (CCBS).

CCBS shall be tested according to an approved test program incorporating the following:

- a) Breathing resistance at work
- b) Simulation of the most probable failures and recording of the resulting system responses
- c) Performance of the system with regard to gas composition, pressure and temperature as function of the variables
- d) The results of the tests shall be made available for approval.

204 Flexible hoses.

- Flexible hoses shall be tested as specified in Sec.8.
- **205** Umbilicals.

Umbilicals shall be tested as specified in Sec.8.

206 Electrical pressure vessel penetrators.

Electrical penetrators shall be tested as specified in Sec.5.

- 207 Bell.
- a) The working weight and the buoyancy shall be ascertained
- b) The stability in normal and emergency modes shall be tested
- c) A shallow water ballast release test shall be carried out if fitted
- d) Emergency release systems for hoisting rope and umbilical shall be tested.

J 300 Testing after completed installation

301 Pressure tests

Piping for the life support systems shall be pressure tested to 1.5 times the maximum working pressure. Hydraulic systems may, however, be tested to the smaller of 1.5 times the maximum working pressure, or 70 bar in excess of the maximum working pressure.

302 Purity tests

Piping systems intended to be used in breathing gas and oxygen systems shall be tested for purity in accordance with requirements given in ASTM G93-96 Standard Practice for Cleaning Methods and Cleanlieness Levels for Materials and Equipment Used in Oxygen-Enriched Environments.

The tests shall comprise:

- a) measurement of contamination of the cleaning agent used at the last stage of the cleaning
- b) tests for possible traces of cleaning agents left in the piping system.

303 Gas leakage tests

- a) The gas storage, chambers, bell and life support systems for gas shall be tested for leakage at the maximum working pressure. The test shall be carried out with the gas type the system is supposed to contain and which has the highest leakage rate properties, or a gas with equivalent properties. Chambers and bells may be tested for leakage using a test gas with only 10% Helium providing a thorough inspection of all penetrations is carried out using leak detection ('snooper') liquid recommended by the industry.
- b) A leakage rate up to 1% pressure drop in 24 hours for the whole chamber system can be accepted. The gas leakage test time shall be minimum 6 hours.

Guidance note:

Note that for systems with max. pressure between 20 bar and 30 bar and chamber temperatures between 20°C and 30°C, a temperature drop of about 3°C will cause a pressure drop of about 1%. (See BS 5355 Specification for filling ratios and developed pressures for liquefiable and permanent gases).

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

304 Handling systems

Handling systems shall be subjected to tests for structural strength and for function and power.

- a) A static load test to a load equal to the design load (see Sec.7 C100) shall be carried out
- b) Functional and power testing of normal and emergency systems shall be carried out with a functional test load of 1.25 times the working weight in the most unfavourable position. It shall be demonstrated that the systems are capable of carrying out all motions in a safe and smooth manner
- c) Monitoring of functional parameters during the test, e.g. pressure peaks in hydraulic systems may be required
- d) A recovery test of the bell shall be carried out simulating emergency operations conditions.

305 Life support systems

Life support systems for normal and emergency operation shall be tested for proper functioning.

306 Various systems

The following systems shall be tested for proper functioning:

- a) sanitary
- b) communication
- c) fire detection
- d) fire alarm

- e) fire extinction
- f) evacuation systems
- g) diver heating.

Other systems onboard the surface installations, significant for the safety of the diving system, are also to be tested.

- **307** Electrical systems
- a) A test for insulation resistance shall be applied to every circuit between all insulated poles and earth, and between individual insulated poles. A minimum value of 1 megaohm shall be attainable.
- b) Main and emergency power supplies shall be tested.

308 Instrumentation

The correct calibration of all essential instrumentation (compartment and bell pressure gauges, gas analysis instruments etc.) shall be checked.

309 Environmental control systems

Monitoring system:

a) Failure conditions shall be simulated as realistically as possible, if practicable by letting the monitored parameters pass the alarm and safety limits. Alarm and safety limits shall be checked.

Automatic control systems:

- a) Normal alterations of the environment shall be imposed and the functions of the system tested..
- b) A copy of the approved test program shall be completed with final set points and endorsed by the Surveyor.
- 310 Sea trials

The normal handling system shall be tested with the working weight of the bell or basket to the maximum depth. For **DSV-SAT** diving systems the bell shall be checked for leakage, and the communication system shall be tested.

K. Marking and Signboards

K 100 General

101 Labels (nameplates) of flame retardant material bearing clear and indelible markings shall be placed so that all equipment necessary for operation (valves, detachable connections, switches, warning lights etc.) can be easily identified. The labels are to be permanently fixed.

All gas containers shall be marked with a consistent colour code visible from the valve end, showing the name, chemical formula of the gas it contains and the percentage of each gas. Piping systems shall be marked with a colour code, and there shall be a chart posted in the control room explaining the code.

Guidance note:

| ISO 32-1977 (E) code proposes: | | | |
|--|---|-----------------------------------|--|
| Name of gas | Chemical formula | Colour code | |
| Oxygen Nitrogen Air | O ₂ N ₂ | White Black White and Black | |
| Helium Oxygen/Helium mixed gas Carbon dioxide | He O ₂ /He CO ₂ | Brown White and Brown Grey | |

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

K 200 Gas containers

201 Each container shall be permanently and legibly marked on the collar or neck ring (where the thickness of the material is greater than the design minimum) as follows:

- a) The design code
- b) the manufacturer's mark or name
- c) the manufacturer's serial number
- d) the test pressure (bar) and date of hydrostatic test
- e) surveyor's mark and identification
- f) settled pressure (bar) at 15°C
- g) volumetric capacity of the container, in litres
- h) tare weight, i.e. the mass of the container including valve, in kg.

In addition marking of gas content shall be carried out according to E100.

K 300 Other pressure vessels than gas containers

301 Each pressure vessel shall be permanently and legibly marked at a suitable location in accordance with the requirements in the design code. As a minimum the following information shall be present:

- a) The design code
- b) the manufacturer's mark or name
- c) the manufacturer's serial number
- d) the test pressure (bar) and date of hydrostatic test
- e) the maximum working pressure
- f) the inspection body's mark and identification.
- g) the maximum set pressure of the Safety Relief Valves.

K 400 Handling system

401 The handling system shall, in an easily visible place, be fitted with a nameplate giving the following particulars:

- a) identification number
- b) static test load
- c) functional test load
- d) working weight
- e) surveyor's mark and identification.

The above loads shall be specified for each transportation system involved.

SECTION 3 PRESSURE VESSELS FOR HUMAN OCCUPANCY, GAS STORAGE AND OTHER PURPOSES

A. General

A 100 Objectives

101 This section aims to give general guidance on:

- a) conceptual and detailed design of pressure vessels for human occupancy, for gas storage and for other purposes
- b) manufacturing of such pressure vessels
- c) quality control during manufacturing and fabrication of such pressure vessels including documentation requirements
- d) load conditions
- e) interlock arrangements for doors and hatches.

102 For quantitative design parameters and functional requirements, reference is made to relevant standards and guidelines, including normative references given in Sec.1B and DNV Rules for Classification of Ships.

 $103\,$ Further requirements for piping and pipe connections can be found in Sec.8\,

A 200 Application and scope

201 This section applies to all pressure vessels in diving systems designed to comply with this standard. Note that in addition to this standard, and the applied design standards, further national requirements may apply.

202 ASME PVHO-1-1997 edition (or latest) "Safety Standard for Pressure Vessels for Human Occupancy", shall be used for design of acrylic plastic windows, regardless of which standard is used for the design of the pressure vessel.

203 Material specifications are given in the applied codes and standards (EN/ASME).

204 Welding of pressure vessels and general workmanship requirements are not specified herein. Further requirements for welding and workmanship are given in the relevant codes and rules.

205 Installation of pressure vessels is specified as general requirements found in A601 and in Sec.2 E.

Further requirements for installation are given in the relevant classification rules for the support vessel.

206 This section has impact upon Sec.9, insofar as it provides the basis for design of the pressure vessels in the hyperbaric evacuation system.

A 300 Documentation

301 Pressure vessels shall be documented as follows:

Plans showing structural arrangement, dimensions, welding seams, attachments and supports of the bell, the chamber and other pressure vessels, with details of doors, locks (medical locks and equipment locks), view ports, penetrations, flanged and welded connections.

Plans showing expansion allowances under working conditions for interconnected multi-vessel systems.

Documents stating:

- a) Grade of material
- b) Welding methods, type and size of filler metal
- c) Design pressure
- d) Particulars of heat treatment

- e) Fabrication tolerances
- f) Extent and type of non-destructive testing of welded connections
- g) Type of thermal insulation materials and particulars, i.e.: flammability and specific heat conductivity
- h) Type of buoyancy materials and particulars, i.e. maximum permitted water depth, specific weight, specific water absorption and buoyancy dependent on water depth and exposure time
- i) Drawings and specifications of all windows with detailed drawings and specifications of the penetration which the appropriate window is to fit. It shall be determined that the tolerances are sufficient including gaskets, O-rings and retainer rings
- j) Calculations of thicknesses and or stresses
- k) Fatigue evaluation and if necessary fatigue analysis.

For seamless steel gas cylinders and vessels:

a) Plans showing proposed dimensions and details such as valves and safety devices shall be made for each type and size of vessel.

Details shall include:

- a) Production method
- b) Heat treatment.

Material specifications for the completed vessel with information on the following:

- a) Chemical composition
- b) Tensile strength
- c) Yield strength
- d) Elongation
- e) Impact test values
- f) Brinell hardness.

The following particulars shall be provided for information:

- a) Type of gas
- b) Filling pressure at 15°C.
- c) Safety Relief Valve setting
- d) Weight of empty vessel and volumetric capacity.

A 400 Testing and marking after completion

401 The required testing and marking of pressure vessels are specified in Sec.2 J and 2 K and the applied standard found in B102.

402 Materials selection associated with the production of pressure vessels is covered in the applied standard and or in DNV Rules for Classification of Ships.

Requirements and guidance on inspection and monitoring associated with the production of pressure vessels can be found in the applied standard and DNV-OSS-305.

A 500 Material protection

501 Areas of steel pressure vessels that can be subjected to corrosion shall be protected by approved means. 'The surface of the window seats cavity shall be protected against corrosion.

502 Windows mounted on chambers shall be protected to avoid damage by impact and to prevent chemicals, which can deteriorate the acrylic plastic, to come in contact with the window from the outside.

Guidance note:

Many solvents for paints, acetone and other agents will deteriorate the acrylic plastic and reduce the strength significantly.

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

503 All penetrators in pressure vessels for human occupancy, shall be designed to minimise corrosion from any fluid passing through them.

Guidance note:

In some cases this requirement may best be met by the use of a sleeve passing through the hull penetration.

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

A 600 Design loads

601 The design pressure for chambers and bell shall not be less than that corresponding to the maximum operating depth as defined in Sec.1 D219. The effects of the following loads shall be considered and shall be taken into account if significant:

- a) Dynamic loads due to movements of the support vessel
- b) Local loads
- c) Loads due to restrictions in expansions
- d) Loads due to weight of content during normal operation and pressure testing
- e) Loads due to rough handling
- f) Loads due to bell and escape tunnel clamped on to the chamber
- g) The stress evaluation shall apply the distortion theory (von Mises criterion).

Guidance note:

Multipurpose vessels may carry heavy deck loads, which can cause stresses and strains on the mountings of the diving system components. If this cannot be avoided through design of the installed diving system, it should be monitored during such operations.

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

602 The design load is normally to correspond to the design pressure applied for at least 5000 load cycles unless otherwise agreed and specified.

B. General Principles for Design of Chambers and Bells

B 100 Chambers

101 The dimensions of the living compartment shall be sufficient for the diving crew facilities required by Sec.4.

Guidance note:

Statutory requirements may require larger dimensions.

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

102 All pressure vessels for human occupancy shall be designed, constructed and tested according to one of the following codes and standards:

a) EN 13445 "Unfired pressure vessels".

b) ASME VIII Div.1 "Boiler and Pressure Vessel Code".

103 Diving bells and chambers shall be classified in the

highest category in the applied code or standard.

104 Other codes and standards may be evaluated and accepted on a case by case basis.

105 All pressure vessels for human occupancy shall be certified.

106 For diving systems with an operational period exceeding 12 hours, the living compartment is normally to have a size sufficient for installation of bunks with length and breadth equal to $198 \text{ cm} \times 80 \text{ cm}$. (see Sec.4 I101). The minimum inner dimensions measured as free height above the deck plates in the middle of the chamber, shall be as given in Table B1. The definitions involved are given in Table B2.

| Table B1 Free height above the deck plates | | | |
|--|-------------|------------|-------------|
| | DSV-SURFACE | DSV-BOUNCE | DSV- SAT |
| Free height in centimetres (cm) | 170* | 183 | 200 |
| * May be less if the chamber is only used for stand-by purposes and if na- tional regulations allow it. | | | |

| Table B2 Definitions | | |
|---|---|---|
| DSV-SURFACE | DSV-BOUNCE | DSV-SAT |
| d _{max} < 60 msw* T _{op} < 8 hours | d _{max} < 125 msw* T _{op} < 24 hours | None, except those imposed by the requirements and assumptions in the certifi- cate, appendix to Classifica- tion certificate and Data Sheet (20.201a) |
| * msw = metres sea water d = maximum denth rating | | |

107 Where **DSV-SURFACE** systems are used for diving operations with decompression stops, or as stand by for **DSV-SAT** systems, the inner diameter should be more than 180 cm and the length shall be more than 200 cm. It shall be possible for the occupants to lie down in the chamber.

108 All windows in pressure vessels for human occupancy shall be certified.

Guidance note:

3.1C certificates may be required in the contract or the terms of delivery.

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

109 All compartments shall be fitted with windows, which allow internal areas to be viewed from outside.

110 For diving systems, the living compartment and other compartments that can be used for decompression including the bell, shall be provided with means for locking in provisions, medicine and equipment necessary for the operation of the system. The divers in each living compartment shall have access to toilet facilities.

Paints, cabling and other materials shall be considered for toxic or noxious properties as specified in Sec.1 H305.

B 200 Bell

201 The bell shall be provided with proper protection against mechanical damage.

202 The bell shall be provided with windows that as far as practicable allow the occupants to observe divers outside the bell.

203 The bell shall be equipped with one extra external lifting fastening.

Guidance note:

Note that the design and location of the extra lifting fastening needs to be considered in view of the need to bring the bell back to a mating trunk on the decompression chambers as required by Sec.7 A401.

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

204 Internally there shall be an attachment at the top for lifting of divers.

205 Bells shall have possibilities for entry and exit when landed on the seafloor in an arbitrary manner, in an emergency. When the bell is fitted with drop weights, release of these in two stages may be accepted, when the first stage allows the bell to rise sufficiently for entry and exit. (NOTE guidance to Sec.7 B301)

B 300 Doors, hatches, windows, branches etc.

301 Minimum dimensions of doors, hatches and medical locks.

Doors and hatches for human transportation shall in general be:

- a) minimum diameter 600 mm, and
- b) minimum diameter 800 mm for lock-out and lock-in hatches on the bell. The length of the bell hatch trunk shall not exceed the diameter.

Guidance note:

For doors and hatches in between chambers, standard pipe with nominal bore 24" may be acceptable.

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

302 The medical locks shall be large enough to allow lock-in and lock -out of CO_2 absorption material and necessary supplies for the divers.

Guidance note:

National rules and requirements may be more stringent and thereby take precedence (i.e. Norwegian Petroleum Directorate).

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

303 Means enabling the doors to be opened from either side shall be provided.

Guidance note:

As the above requirement also applies to the internal doors in chamber complexes, it does follow that locking devises are not allowed on the pressurised side of these doors unless they can be operated from the other side. 'Clip' locks are frequently used on these doors to prevent slamming due to the vessels movement in the sea. However, the 'clip' setting must be such that they can be pushed/pulled open from either side without the use of excessive force.

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

304 For:

- a) doors
- b) hatches
- c) mating arrangements
- d) pressurised locks and trunks
- e) pressurised containers
- f) accompanying equipment under pressure

where opening or unintentional pressure drop may entail danger or cause injury, the closing mechanisms shall be physically secured by locking mechanisms (interlocks).

This applies to units which do not seal by pressure and includes, but is not limited to:

- a) mating arrangements between bells and transfer compartments
- b) mating arrangements between hyperbaric lifeboats and escape trunks where these are installed
- c) equipment locks
- d) medical locks

e) soda lime (CO₂ scrubber) containers for external regeneration of the chamber environments.

305 The closing mechanisms with accompanying locking mechanisms shall be arranged so that:

- a) opening cannot take place unless the pressures are equal on both sides or unless the pressures in the units are at ambient level
- b) correct position of the closing mechanisms and the locking mechanisms shall be ensured before it is possible to apply pressure
- c) the pressures in the units, shall directly control the locking mechanisms, and
- d) the penetrators and piping for pressure sensing shall be arranged so that blockage is avoided.

306 Trunks between doors shall be equipped with pressure equalising valves. Penetrators for pressure equalising shall be arranged so that blockage is avoided.

307 Where mountings are secured by studs, these shall have full thread holding in the shell for a length of at least one diameter. Holes for studs shall not penetrate the shell.

308 Windows with a diameter above 500 mm and thickness less than 90 mm shall be protected against impact. Impact protection may be provided by:

- a) recessing the external surface of the window at least 50 mm below the surrounding structure
- b) one or more external bumpers extending across the window.

309 Damage control plugs may be provided to enable the divers to seal off windows to prevent damage or leakage developing. One plug for each size window in each compartment may be sufficient.

310 For pressure vessels where fatigue can be a possible mode of failure, attention shall be given to the possible adverse effects of the following design features:

- a) pad type reinforcement of openings
- b) set-on branches
- c) partial penetration welds of branches.

C. Welded Pressure Vessels, Materials and Fabrication

C 100 Materials

101 Steel grades shall comply with the applied design code and standard.

102 Other material grades may be acceptable after special consideration. In such cases, additional testing may be required and qualification procedures shall be reconsidered.

103 Materials for main pressure retaining parts are normally to be delivered with the manufacturer's works certificates (W), (3.1B) as a minimum.

Guidance note:

Product certificates, 3.1C certificates, may be required in the contract or the terms of delivery.

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

104 Stainless steel cladding, stainless steel tubes, fittings etc. which are welded to pressure vessels of non-stainless steel shall be of a stabilised or low-carbon grade. Acceptable grades are given in the applicable standards or in DNV Rules for Classification of Ships Pt.2 Ch.1 Sec.4.

C 200 Fabrication

201 Pressure vessels for diving systems shall be manufactured by works approved by a recognised body, for the production of the type of pressure vessels being delivered.

202 Welding shall be carried out according to approved drawings.

Qualification of welders, welding procedure specifications, welding procedures and testing shall be according to the applied design code or standard.

203 The following tests have to be carried out in addition to the tests specified in the applied design code or standard:

- a) all butt welds in diving bells and chambers shall be radiographed over their full length
- b) branches and reinforcement of openings, including all weld connections to the shell, shall be subjected to 100% magnetic particle testing.

204 When the applied code or standard requires heat treatment of dished ends after hot or cold forming, mechanical testing may be required after the final heat treatment. The details between intermediate heads and cylindrical shells of chambers may be done in accordance with requirements given in,

- a) EN 1708-1:1999 *Welding Basic weld* joint details in steel Table 9:Internal diaphragms and separators, or
- b) ASME Section VIII Division I Fig. UW-13.1.

The outside diameter of the head skirt shall have a close fit to the cylinders.

The butt weld and filled weld shall be designed to take shear based on 1.5 times the maximum differential pressure that can exist. The allowable stress value for the butt weld shall be 70% of the nominal design stress for the shell material and that of the fillet weld 50%. The area of the butt weld in shear shall be taken as the width at the root of the weld times the length of the weld. The area of the fillet weld shall be taken as the minimum leg dimension times the length of the weld.

205 The surface dimensions and finish of sealings and seals for hatches and windows are generally to comply with the tolerances specified by the manufacturers of the windows and the sealing systems.

206 Flat disc windows shall have a bearing gasket between the window and its seat. This gasket shall serve as a secondary seal. The gasket shall be bonded to the seat.

The retainer ring shall provide adequate initial compression of the sealing arrangement to compensate for the displacement of the window due to the pressure. The minimum seating diameter in relation to window dimensions shall be specified.

The included conical angle of the seating surface of conical flanges shall be within + 0.00 or -0.25 degrees of the nominal value.

The surface finish of seats of metallic materials for conical-, double bevelled disc and spherical shell windows shall have an average roughness less than $R = 1.5 \ \mu m$.

207 Before installation of a window in its flange, complete cleanliness of the seating surfaces shall be ensured. The seating surface and any o-ring grooves shall be lubricated with an oxygen compatible lubricant. Mineral oil lubricants shall, under no circumstances, be used for this purpose.

C 300 Fabrication tolerances

301 Fabrication tolerances are to meet the requirements in the applied codes and standards.

302 Local tolerance requirements for ring frames are given in Figure 1, for vessels subject to external pressure.



Figure 1 Maximum deviations for ring stiffeners.

D. Strength of Welded Pressure Vessels

D 100 Structural analysis

101 Pressure vessels shall be documented by structural analysis for specified design conditions according to the applied codes and standards.

102 For details not covered by the applied codes and standards, finite element analysis may be acceptable if properly planned, modelled and documented.

Alternatively, by applying strain gauges, stress measurements may be carried out according to an approved programme and shall be properly documented. The tests shall be planned, and carried out during the first pressure test.

103 Fatigue evaluation and, if necessary, fatigue analysis shall be carried out for the number of full pressure cycles given in A602. The evaluation and analysis shall be carried out according to the applied design code and standard.

D 200 Vessels subjected to external pressure

201 Frames and panels supporting pressure-retaining parts shall be designed for a force of minimum 1.2 times the actual load.

202 Additional stresses shall be within the limits given in the applied design code or standard, for combined stresses.

D 300 Flanges for windows

301 Flanges for windows with conical seating shall have dimensions preventing the flange deformations to exceed the following limits when window and pressure vessel is subjected to the design pressure :

- radial: 0.002 times the smaller diameter of the acrylic plastic window, and
- angular: 0.5°.

E. Gas Cylinders

E 100 General

101 Gas cylinders shall be produced by manufacturers authorised for such production and certified by a competent inspection body when:

$$p \times V \ge 1.0$$

where:

p = design pressure in bar.

 $V = volume in m^3$.

The certification level shall as a minimum be manufacturer's works certificates (W)/(3.1B). Other levels of certification may be required by the terms of delivery.

Smaller gas cylinders shall be certified if they provide an essential function in the system.

Guidance note:

Cylinders on-line in a system providing breathing gas to the divers will be considered essential.

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

102 The materials applied shall be certified as a minimum by the manufacturer's works certificates (W), (3.1B). Other material certificates may be required by the terms of delivery.

103 They shall be designed, constructed and tested according to one of the following standards, norms or directives:

- a) EN-1964-1:2000 Transportable gas cylinders (part 1:1999, part 2:2001 or part 3:2000)
- EN ISO 11120:1999 Gas cylinders Refillable seamless steel tubes for compressed gas transport, of water capacity between 150 l and 3000 l - Design construction and testing (ISO 11120:1999):

Other codes and standards may be evaluated and accepted on a case by case basis.

Guidance note:

For permanent installations within EU, the directives apply as regulations. (ref. EU directive 1999/36/EEC.)

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

104 Shell thickness shall meet the criteria given in the applied code or standard for test pressure. The working pressure for a given geographical area is given by reference to a standard such as BS 5355 Specification for filling ratios and developed pressures for liquefiable and permanent gases.

105 Corrosion allowance shall be specified in the terms of delivery reflecting the intended use of the gas cylinder, but shall not be less than 1 mm.

E 200 Heat treatment

201 Heat treatment shall follow the requirements given in the applied code or standard, and shall be documented.

E 300 Tolerances and surface conditions

301 Tolerances and surface condition shall meet the criteria given in the applied code or standard, and shall be documented in the design documentation. If the applied code or standard does not specify requirements for tolerances and surface conditions, then it may be necessary to specify this in the terms of delivery.

E 400 Production tests

401 Production tests shall be carried out in accordance with the requirements given in the applied code or standard. Further production tests, and required attendance during testing, may be specified through the terms of delivery.

F. Acrylic Plastic Windows

F 100 General.

101 The following requirements apply to windows made from cast stock of unlaminated polymethyl methacrylate plastics, in the following denoted acrylic plastic, with a design life of 10 years, suitable for:

- a) 10.000 load cycles
- b) sustained temperatures in the range -18°C to +66°C
- c) pressurisation or depressurisation rates not exceeding 10 bar/second
- d) use in environments that cannot cause chemical or physical deterioration of the acrylic plastic (i.e. resistant against saltwater and gases used in life support systems).

F 200 Materials

201 Materials for acrylic plastic windows shall be manufactured and tested in accordance with ASME PVHO-1-1997 "Safety Standard for Pressure Vessels for Human Occupancy". A later edition may be specified in the terms of delivery.

F 300 Manufacturers of cast material

301 Manufacturers wishing to supply cast acrylic plastic for diving systems, shall be approved for such production. The material shall have an approved chemical composition and to be produced, heat treated and tested according to the ASME PVHO-1-1997 "Safety Standard for Pressure Vessels for Human Occupancy". Approval shall be granted on the basis of a thorough test of material from the current production and a report after inspecting the works, and verification of QA and QC against requirements given in ASME PVHO-1.

F 400 Certification of cast material

401 Each delivery of cast material shall be accompanied by a certificate issued by the manufacturer. The certificate shall (as a minimum) contain the following:

- a) name and address of manufacturer
- b) certificate number and date
- c) designation of product
- d) numbers and dimensions of the pieces covered by the certificate
- e) material test results and properties
- f) signature.

402 The following text shall be printed in the right uppermost corner of the certificate :

403 "This certificate will be accepted by (approval body) on the basis of completed approval tests and the (approval body's) surveillance of production control and products. The manufacturer guarantees that the product meets the requirements of (approval body) and that inspection and tests have been carried out in accordance with (code or standard) ".

404 The cast material shall be marked with the manufacturer's name and with the number and date of the certificate.

405 If a later edition of the ASME standard requires further documentation and markings, the ASME requirements shall be met.

F 500 Certification of windows

501 Each batch of acrylic plastic windows used in diving systems shall have a certificate issued by the approval body, showing the test results and the annealing conditions according to the standard.

502 Each window shall have an identification marked on it for traceability. Identification of each window shall include;

design pressure, maximum temperature, initials for 'P.V.H.O.', window fabricator's identification mark, fabricators serial number and year of fabrication.

For ease of viewing, the above information shall be located on the windows seating surface with an indelible marker. Acceptable marking methods are given in ASME PVHO-1.

Stamping or marking that can cause crack propagation is not permitted.

F 600 Geometry and thickness

601 Windows shall be of the standard designs according to the ASME PVHO-1-1997 "Safety standard for pressure vessels for human occupancy".

602 Windows for two-way pressurisation shall meet the requirements applicable to one-way windows in both directions. For double bevelled disc windows, not more than 50% of the thickness shall be utilised in determination of short term critical pressure.

603 O-ring grooves shall not be located in window bearing surfaces serving primarily as support or in the acrylic window itself.

F 700 Fabrication

701 The included conical angle of the seating surface of a window shall be within +0.25/-0,00 degrees of the nominal value.

702 The deviation of a spherical window from an ideal sphere shall be less than 0.5% of the specified nominal external radius of the spherical section.

703 Each window shall be annealed after all forming and polishing operations are completed. The annealing process shall be according to the annealing schedule in ASME PVHO-1.

704 During the manufacturing process each window shall be equipped with identification and a manufacture process rider for recording of all pertinent data.

F 800 In service inspection

801 In service inspection and testing shall be carried out in accordance with requirements given in ASME PVHO-2 guide-lines.

SECTION 4 LIFE SUPPORT SYSTEMS

A. General

A 100 Objectives

101 This section aims to give general guidance on:

- a) conceptual and detailed design of life support systems
- b) manufacturing of life support systems
- c) quality control during manufacturing and fabrication of components and subsystems for life support systems.

102 The section presents key-issue requirements for gas distribution capacities, environmental conditioning and oxygen systems. Documentation requirements are identified.

103 Design and acceptance criteria include capacities for gas storage, choice of valves and fittings for certain applications, environmental control parameters, breathing resistance for CCBS and diving crew facilities.

104 Requirements for the design of oxygen systems are aimed at reducing the hazards posed by flash fires.

105 This section contains requirements to ensure safe arrangements in pressurised systems and control stations.

106 Further requirements for pipes, hoses, valves and fittings are given in Sec.8.

107 Requirements for shut off valves, pressure relief and drainage are aimed at ensuring the safeguard of personnel and plant, as are the requirements for alarm systems.

A 200 Application and scope

201 For quantitative design parameters and functional requirements, reference is made to relevant standards and guidelines, including DNV Rules for Classification of Ships.

202 The requirements apply to all systems, except the requirements for bell systems that do not apply to **DSV-SUR-FACE**.

203 Requirements for testing are given in Sec.2 J.

204 Requirements for installation are only rudimentary.

205 This section has an impact on all other sections in this standard.

A 300 Documentation

301 Life support systems shall be documented as follows:

- a) Plans showing schematic arrangement of all piping systems.
- b) Documents stating:
 - material specifications
 - maximum working pressure
 - dimensions and thickness
 - contained fluids
 - type of valves and fittings
 - specifications of flexible hoses.
- Plans (diagrams) showing arrangement and giving specifications of the gas storage and supply (gas banks, compressors, boosters etc.).
- d) Plans showing the arrangement and giving specifications on environmental control systems and equipment)heating, CO₂-absorption, circulation), diving crew facilities, sanitary and drainage systems.
- e) Component lists, with specifications on make and type and

documentation on any tests carried out on all equipment used in the life support system. Plans showing cross-section and giving particulars on materials and dimensions of umbilical.

- f) Calculations showing the heat and cooling consumption for the system under given environmental temperatures.
- g) Description of proposed cleaning procedure for breathing gas system.

B. Gas Storage

B 100 Capacity

101 There shall be a permanently installed gas storage plant or suitable space for portable gas containers. The size of the containers or space shall be sufficient to provide the divers with adequate quantities of gases for operation at maximum operating depth for both normal and emergency modes.

102 The minimum gas storage capacity of fixed installed containers or space for portable containers intended for emergency operations shall be sufficient to:

- a) Pressurise the inner area once and the bell(s) and transfer compartments once more to maximum depth, d_{max}, with suitable breathing gas, and
- b) For diving systems with an operational time exceeding 12 hours it shall provide suitable gas to pressurise the largest compartment once, to d_{max}.
- c) Maintain a proper oxygen partial pressure in the inner area and supply for masks for at least:
 - i) 24 hours, diving systems with an operational time not exceeding 12 hours or
 - ii) 48 hours, diving systems with an operational time exceeding 12 hours.
- d) For pure oxygen, the minimum volume may be taken as:
 - i) 2 Nm³ for each diver for a diving system with an operational time not exceeding 12 hours or
 - ii) 4 Nm³ for each diver for diving systems with an operational time exceeding 12 hours.

 1 Nm^3 is given as 1 cubic metre of the gas at 0° C and 1.013 bar standard condition.

103 For emergency use of masks there shall be sufficient facilities to supply adequate quantities of gases. The facilities shall be capable of providing a relevant delivery rate both at maximum depth and during decompression. The containers required by 102 may be used also for these emergency purposes.

Adequate quantities may be taken as a minimum of:

- a) 2 m³ at the pressure of the inner area with an oxygen partial pressure between 0.18 and 1.25 bar for each diver, and in addition
- b) 15 m³ at the pressure of the inner area with an oxygen partial pressure between 1.5 and 2.5 bar at depths greater than 18 m, to each of the maximum number of divers in one of the living compartments for diving systems with an operational time exceeding 12 hours.
- 104 The storage capacity for emergency gas shall be pro-

vided in separate containers, and shall not be included in the containers for current gas supply.

105 The bell shall have a self-contained emergency gas storage with minimum capacity to supply the following:

- a) 1 Nm³ oxygen for each diver, and
- b) Suitable breathing gas mixtures. The capacity shall be the greater of the two:
 - that which is sufficient to empty a bell filled with 40% water at d_{max} or
 - that which is sufficient to supply each of the bell divers with suitable breathing gas for 15 minutes.

The gas volume respirated by one diver in 15 minutes may be taken equivalent to 0.8 m^3 at ambient pressure d_{max} .

The minimum gas storage volume, V_g (m³), of deep mix on the bell considering a minimum overpressure in the containers, and sufficient time for the operations to avoid significant temperature differences, may be estimated as follows:

$$V_g = \frac{V \times p_b}{p_g - p_b - 3}$$

where

- V = volume (m³) at ambient pressure dmax of the supply to the divers or 0.4 times the internal volume of the bell.
- p_g = pressure (bar) in gas storage containers.

 p_b° = pressure (bar) in the bell corresponding to the depth.

B 200 Shut-off, pressure relief and drainage.

201 Pressure vessels shall be fitted with over pressure relief devices and shut off valves except as provided for in E 202 and E 303.

202 Pressure vessels without individual shut-off values and with: pV < 50, installed in groups with a total

pV < 100, can have a common overpressure relief device and shut-off valve.

p = design pressure in bar

V = volume in m³ (standard conditions)

203 For gas storage of breathing gases and oxygen, the pressure relief device shall be a safety valve. Safety valves shall be set to open at a pressure approx. 3% above the developed pressure at 55°C, based on filling the cylinders at 15°C to maximum filling pressure. The total relieving capacity shall be sufficient to maintain the system pressure at not more than 110% of design pressure.

Developed pressure under above-mentioned conditions may be taken as given in reference to a standard such as

BS 5355 Specification for filling ratios and developed pressures for liquefiable and permanent gases.

204 Containers where water can accumulate shall be provided with drainage devices. (e.g. volume tanks and filters)

C. Gas distribution

C 100 General

101 The gas distribution system consists of all components and piping necessary for distribution of gas for normal and emergency operations.

Piping for gas and electrical cables shall be separated.

102 The distribution system to each compartment shall facilitate:

- a) two independent alternatives for pressurisation with a minimum pressurisation rate of 2 bar/minute to 2 bar and at 1 bar/minute thereafter
- b) depressurisation
- c) decompression rate of minimum 1 bar/minute at pressures exceeding 2 bar for DSV-SURFACE diving systems and for transfer compartments in DSV-BOUNCE and DSV-SAT diving systems
- d) maintenance of a suitable breathing atmosphere in the inner area. (When adding pure oxygen to the compartments, a separate piping system shall be provided.)
- e) supply of suitable breathing gas for masks. (For DSV-SAT diving systems this supply shall be independent for each living compartment.)
- f) exhaust from masks intended for oxygen if a closed circuit breathing gas system is not used.

103 There shall be two independent supplies of gas to the bell umbilical.

104 Filters and automatic pressure reducers shall be so arranged that they can be isolated without interrupting vital gas supplies.

105 Valves in piping systems to masks, bells and divers in water shall be so arranged that:

- a) leaking valves cannot cause unintentional gas mixtures
- b) oxygen cannot unintentionally be supplied to other piping systems than that intended for oxygen.

106 The discharge from overpressure relief devices and exhaust shall be led to a location where hazard is not created.

107 Where gas mixtures with an oxygen content less than 20% are stored in enclosed spaces, there shall be an oxygen analyser with an audio-visual low level alarm in addition to the ventilation requirements in Sec.6 B203.

C 200 Bell

201 The bell and the lock-out diver(s) shall have a normal supply and an independent self-contained emergency supply from the bell.

202 The breathing gas system supplying the personal umbilical to the stand-by diver in the bell shall be arranged for an alternative supply, independent of the lock-out diver(s)'s normal supply. The bells onboard gas supply may be accepted for this purpose.

203 The bell shall be equipped with two alternatives for exhausts. One shall be arranged so that a diver who intends to aid his entering by a partial flooding of the bell can operate it from the lower part inside the bell. The exhaust systems shall not permit a flooding above electrical equipment when the bell is in an upright position.

204 The exhaust system shall be designed to enable removal of the water in case of a tilted bell with closed hatch and trapped water inside.

Guidance note:

The degree of tilt envisaged may vary from one bell design to another and will therefore need to be considered in each case. Side mated bells will most likely tilt more than bottom mated bells. As this requirement is normally simple to fulfil by means of a flexible hose, it is thought that a 60° list should be considered minimum.

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

205 The exhaust system not intended for partial flooding of the bell shall be fitted with a spring-loaded valve that closes when the valve handle is released.

206 The bell shall be equipped with masks corresponding to

the number of divers plus one. The masks shall be arranged for supply from normal and emergency supply alternatively. Diving masks and diving helmets with gas supply are accepted as masks.

207 The emergency oxygen supply system shall be designed to enable the maintaining of a proper partial pressure of oxygen inside the bell by a dosage system.

208 Automatic pressure reducers for breathing apparatuses shall be fitted.

209 Bell shall be fitted with an emergency manifold at a suitable point close to the main lifting attachment which shall include connections for the following services:

a) 3/4 inch NPT (female) -for hot water

b) 1/2 inch NPT (female) -for breathing mixture.

The manifold shall be clearly marked and suitably protected.

C 300 Chambers.

301 Each living compartment shall be equipped with breathing masks corresponding to the maximum number of divers for which the chamber is rated plus one. The masks shall be arranged for breathing from each bunk. For diving systems with an operational time exceeding 12 hours, transfer compartments to the bell(s) shall be equipped with a number of masks at least corresponding to the maximum number of divers in the bell plus one. Other compartments shall have at least 2 masks.

302 The masks shall be permanently connected or easily connectable to piping systems for supply of the gases according to B103.

303 The exhaust sides of the masks intended for oxygen shall be connected to external dump, or to be of a closed circuit type.

304 The mask systems shall be secured against inadmissible pressure drop on the exhaust side.

305 The gas supply system shall be arranged to ensure homogenous gas content in the inner area.

C 400 Stand-by diver at surface.

401 A piping system for supply of breathing gas to a possible stand-by diver at surface shall be arranged separated from the divers' supply.

D. Oxygen Systems.

D 100 General

101 Oxygen shall be stored and distributed in containers and piping systems exclusively intended for oxygen systems.

102 Containers for oxygen shall be stored in open air or in rooms exclusively intended for oxygen. The rooms shall be separated from adjacent spaces and ventilated according to Sec.6 and shall be fitted with an audio-visible oxygen alarm, at a manned control station.

103 The pressure in the oxygen systems shall be reduced from storage pressure to the minimum pressure necessary for proper operation. The pressure reduction shall be arranged as close as possible to the storage containers.

Guidance note:

A maximum pressure of 40 bar will normally be accepted when d_{max} is less than 350 m.

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

104 Components fitted in oxygen systems shall be of types especially designed and tested for this purpose. (see Sec.8 A102 and B400).

105 Oxygen shall not be stored or ducted in any form close

to combustible substances or hydraulic equipment.

106 Oxygen dumped from the diving system shall be ducted to a safe dumping place.

E. Piping Systems

E 100 General

101 Low-pressure systems supplied from high-pressure system shall be provided with pressure relief valves. The total relieving capacity shall be sufficient to maintain the system pressure at not more than 110% of design pressure. The relief device shall be located adjoining, or as close as possible, to the reducing valve.

102 All systems shall be provided with means of manually relieving the pressure.

103 Filters shall be provided on the high-pressure side of gas systems.

104 Pipe ends in chamber and bell shall be arranged so that injuries due to suction are avoided.

105 All pipe penetrations in the chambers and bells shall be fitted with external and internal shut-off valves mounted directly on the shell plating. Valves may be mounted close to chamber shells, provided that the piping between the chamber and valve is well protected and has a minimum thickness according to the rules.

E 200 Bell

201 Bells shall be fitted with an overpressure alarm.

E 300 Chambers

301 In addition to the requirements in E105 all penetrations for lines designed for gas distribution (e.g. supply, exhaust and equalisation) shall be fitted with non-return valves or flow fuses as approriate for the direction of gas flow. Lines specifically designed for non distribution purposes (e.g. analysis) shall be kept to the minimum diameter possible and limited to a maximum of 5 mm.

302 The piping between externally mounted non-return valve or flow-fuse and the external shut-off valve shall be well protected and have minimum thickness according to Sec.8.

303 The compartments shall be fitted with a safety valve or a visual and audible overpressure alarm alerting the operators at the control station.

Penetrations for safety valves shall be provided with shut-off valves on both sides of the shell plating. These shut off valves shall be sealed in the open position. Any safety valves shall be set to open at a pressure of approx. 3% above the design pressure.

304 Valves in chambers designed for holding water (i.e. hyperbaric training centres) shall be considered in each case.

F. Environmental Conditioning in Bell and Chambers

F 100 Heating of bell

101 Bells shall have a normal heating system with controls and capacity sufficient to maintain a comfortable temperature for the divers in the bell and in water. The heating system shall be fitted with a temperature indicator.

102 For deep diving, provision for heating the divers' gas shall be provided.

103 For diving systems with an operational time exceeding 12 hours, the heating supply systems shall be provided with

full redundancy. This includes full redundancy in the event of a possible loss of main power (Sec.5 B401).

104 Bells shall have emergency means of preventing excessive heat loss by the divers for a period of 24 hours at d_{max} , and shall be independent of the main umbilical.

Guidance note:

This can be achieved by heating the bell environment, the divers directly by heated suits, or by passive thermal insulation as well as heating the divers' breathing gas by active or regenerative methods.

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

F 200 Heating and cooling of chambers

201 Systems for heating the living compartments shall be arranged.

202 For saturation diving systems, all compartments shall have an arrangement for heating. The living compartments shall be provided with a system for heating and cooling, enabling temperature regulation within +/-1 °C from set point under steady conditions. Heating and cooling systems shall be provided with full redundancy.

203 Heating coils on the outside of the chambers shall have a minimum of two independent temperature controls of the power circuit.

F 300 Humidity reduction in chambers

301 A system to reduce the humidity in the living compartments shall be provided. For saturation diving systems, a relative humidity of 50% shall be maintainable under steady conditions.

Guidance note:

For certain geographical regions this requirement is hard to fulfil unless additional coolers supplement the regular environmental control systems or some other compensation is provided for. This needs to be considered in each case.

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

F 400 Noise reduction

401 Silencers shall be fitted and the system shall be so designed that the divers cannot be exposed to harmful noise levels.

Guidance note:

IMO resolution A.468 (XII) code on noise levels onboard ships.

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

402 Silencers shall be fitted with shields which provide protection against possible fragmentation but which do not affect the gas flow.

F 500 Gas circulation systems for chambers

501 Internal circulation systems for gas in the chambers shall be such that a homogeneous gas content is ensured.

502 Pressurising and exhaust systems shall be arranged to ensure an even mixing of gas.

503 The circulation system shall have sufficient capacity to avoid stratification of gas layers in the chambers and maintain a homogenous gas mix at the set operational parameters.

504 Materials shall be considered for toxic or noxious properties as specified in Sec.2 H305.

F 600 Removal of carbon dioxide

601 Carbon dioxide removal systems or atmospheric renewal systems shall be arranged for the bell and each living compartment. For **DSV-BOUNCE** and **DSV-SAT** diving systems, all compartments shall be arranged with redundancy in carbon dioxide removal systems.

602 Carbon dioxide removal systems or atmospheric renewal systems for normal operation shall have the capacity to maintain the partial pressure of carbon dioxide below 0.005 bar continuously based on a production rate of 0.05 Nm³ per hour per diver.

603 The bell shall have a self-contained, self-powered emergency absorption system with a capacity to keep the partial pressure of carbon dioxide below 0.02 bar for 24 hours.

F 700 Regeneration of pure helium

701 Systems for regeneration of pure helium for further use in the system shall ensure only a limited content of contaminants. The system shall be capable of maintaining the nitrogen content below a partial pressure of I bar at the maximum operating depth of the diving system. For welding operations the collective argon and nitrogen content shall be considered.

702 Water traps for gas reclaim shall be designed for simplicity of cleaning, disinfecting and drying.

G. Gas Control Systems

G 100 Control stands

101 Requirements for instrumentation are given in Sec.5.

102 The control stands shall have means for:

- a) choice between gas storage containers
- b) pressurising and pressure regulation of each compartment independently
- c) decompression of each compartment independently
- d) equalising the pressure between compartments
- e) controlling oxygen flow to compartments independently
- f) controlling oxygen and mix gas supply to masks in each individual compartment
- g) controlling gas supply to bell.

G 200 Helium and oxygen mixing systems for direct supply for breathing

201 Systems for mixing of helium and oxygen for subsequent direct supply for breathing shall be automatic, to have an automatic control system, an automatic alarm system and an automatic safety system.

202 As an alternative to G201, the inclusion of a large volume tank is considered to provide an equivalent level of safety as that prescribed by the requirements for 'automation' and 'independence' in G204. The remaining requirements shall be met.

The volume tank shall be such that the prescribed tolerances for partial pressures downstream are not deviated from within the first hour after the analysers have alerted the operator that the upstream mixture is out of the tolerated range. The Alarm shall be audio-visual at a manned control station.

Guidance note:

"Prescribed tolerances" is normally understood to be gas having an oxygen partial pressure in the range 0.21 bar to 1.7 bar as required by NPD whereas the dive control alarm will be a tolerance of $\pm/-0.03$ bar about the desired set point.

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

203 The control system shall keep the mixture at a pre-set value within the prescribed tolerances. Maximum tolerances: +/-0.03 bar, partial pressure O₂.

204 The safety system shall be independent of the control system and shall incorporate changing of the supply automatically to a premixed suitable breathing gas if tolerances are exceeded. The safety system shall ensure a constant delivery of

suitable breathing gas to the diver during all operating conditions, taking into account the characteristics of components in the systems such as response time for gas analysers etc.

H. Closed Circuit Breathing Systems (CCBS)

H 100 General

101 Installation of CCBS is not required as a condition for the standard. If such system is installed, it is, however, to comply with the following requirements.

Reference: Guidelines for minimum performance requirements and standard unmanned test procedures for underwater breathing apparatus by: U.K. Department of Energy and Norwegian Petroleum Directorate. Tests may be carried out in accordance with the guidelines.

102 System particulars:

a) The maximum work of breathing (w) shall not exceed 3.0 Joules/litre measured at a standard breathing rate, respiratory minute volume (RMV) of 62.5 litres/minute.

Guidance note:

Work of breathing should be as low as possible. A preferred level would be below 1.75 Joules/litre at an RMV of 62.5 litres/ minute.

```
---e-n-d---of---G-u-i-d-a-n-c-e---n-o-t-e---
```

- b) The system shall be able to work satisfactorily over a range of RMV's up to 75 litres/minute. For test purposes the system should function to 90 litres/minute.
- c) The variation in respiratory pressure (ΔP) should be limited to 1.5 kPa and shall not exceed 2.5 kPa relative to the Reference Pressure (PR). Reference pressure(P_R) is the equilibrium pressure measured at the level of the divers mouth when there is no gas flow. Respiratory pressure (ΔP) is the differential pressure measured at the divers mouth, during inhalation and exhalation, measured relative to the system Reference Pressure.
- d) The hydrostatic imbalance $(P_R P_{LC})$ varies with the orientation of the diver and the position of the demand valve (or equivalent device) and has an effect on the work of breathing. The hydrostatic imbalance shall not be outside the range of -3.5 kPa to + 2.0 kPa.

Guidance note:

Ideally, the hydrostatic pressure imbalance should be between - 2.0 kPa and + 1.0 kPa. PR is the reference pressure at the divers mouth and PCL is the lung centroid pressure, which is defined as the pressure which restores the lungs to their normal resting volume. PCL is measured at a position 19 cm inferior and 7 cm posterior to the suprasternal notch.

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

e) The system shall be designed so as to minimise the build up of carbon dioxide. Dead space volume should be as low as possible. The partial pressure of carbon dioxide (ppCO₂) shall be limited to 1 kPa.

Guidance note:

The volume of oronasal mask or equivalent device should be less than 200 ml.

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

103 CCBS shall be automatic with normal and safety functions according to G200 including automatic control of carbon dioxide partial pressure.

104 If the equipment fails, the lung over or under pressure should be as low as possible, but shall not exceed 6.0 kPa relative to the lung centroid pressure.

105 CCBS shall have an emergency mode by free exhalation, i.e. without the use of the exhaust line.

106 CCBS shall incorporate temperature regulation system for inhaled gases.

Guidance note:

1 kPa = 1000 Pascal

1 Pascal = 1 N/m² = 10^{-5} bar

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

I. Diving Crew Facilities

I 100 General

101 One bunk shall be provided for each diver in the living compartment permitting the diver to rest comfortably. For DSV-SAT systems the bunks shall measure at least 198×80 centimetres (ref. ILO Convention 133).

102 Proper lighting shall be provided in all compartments and bell.

103 The bell shall be fitted with emergency lighting.

104 If flush type toilets are installed, the systems shall be designed so that drainage cannot take place during sitting use. (See also the requirements for safety locks given in Sec.3 B304 and B305.)

105 Sanitary systems connected to external systems shall be designed to avoid an unintentional pressure rise in the external system in case of malfunction or rupture of the diving systems' sanitary systems.

I 200 Wet-bell and diving basket (DSV-SURFACE)

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

202 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.

203 A wet bell shall contain equipment to monitor important parameters in all situations, such as depth, pressure of gas supply from surface, pressure of on-board emergency gas supply and length of diving umbilical in use.

I 300 Saturation diving systems (DSV-SAT)

301 The living compartment shall provide space for a table.

302 One toilet and one shower with hot and cold water are required per pressure level. The toilet may be flush type or disposable bag type. In connection with the toilet there shall be a scavenging or cleaning facility to get rid of bacteria and odour. The shower and the toilet shall be located in a room separated from the living compartment.

SECTION 5 ELECTRICAL, INSTRUMENTATION AND COMMUNICATION SYSTEMS

A. General

A 100 Objective

101 The purpose of this section is to specify additional requirements for electrical systems and equipment serving diving systems. Emphasis is placed on the special needs associated with the design and manufacture of diving systems, whereas general requirements for electrical systems and components are given in DNV-OS-D201 "Electrical Installations" and DNV-OS-D202 "Instrumentation and Telecommunication systems".

102 The key issues are identified in:

- a) the service definitions by defining 'essential', 'emergency' and 'non-important' services
- b) the power supply systems and capacity by specifications for emergency supply
- c) cables and penetrators
- d) documentation requirements.

103 Specific references to other relevant standards are given.

104 Design criteria for electrical penetrators are outlined. Philosophy on earthing is specified, in that hull return is not allowed.

A 200 Application and scope

201 These requirements apply to all bell diving systems (**DSV-SAT** and **DSV-BOUNCE**). Some requirements are not applicable for surface supplied diving systems (**DSV-SUR-FACE**) as they relate to bell diving. The text should be clear enough to enable distinction to be made in each case.

202 Material specification is included for insulation of cables in the inner area.

203 Some testing is included in this section. For further requirements for testing, see Sec.2J.

204 Recognised production standards include those provided by the International Electro technical Commission (IEC).

205 This section bears impact on Sec.2 (location of diving system in hazardous zones), Sec.4, Sec.6, Sec.7 and Sec.9.

A 300 Documentation

301 General.

For electrical systems the following shall be documented:

Single line distribution system diagrams for the whole installation. The diagrams shall give information on full load, cable types and cross sections, and make, type and rating of fuse- and switchgear for all distribution circuits.

Calculations on load balance, including emergency consumption and battery capacities.

Complete multi-wire diagrams, preferably key diagrams, of control and alarm circuits for all motors or other consumers.

Plans showing arrangements of batteries with information about their make, type and capacity.

Plans showing arrangement and single line diagrams of the communication system.

Complete list of components and documentation on any tests carried out on all electrical equipment to be permanently installed within the chamber and the bell.

that the divers are safely recovered in the decompression

A 400 Codes and standards.

401 General.

The following codes and standards are applicable:

- a) DNV Offshore Standard DNV-OS-D201 "Electrical Installations"
- b) DNV Offshore Standard DNV-OS-D202 "Instrumentation and Telecommunication systems"
- c) A.O.D.C.'s "Code of practice for the safe use of electricity underwater"
- d) Relevant IEC equipment construction and design standards.

A 500 Service definitions

501 Service Definitions.

a) <u>Essential</u> services are herein defined as those services that need to be in continuous operation for maintaining the diving system's functionality with regard to sustaining the safety, health and environment of the divers in a hyperbaric environment. This includes services required by the crew monitoring the divers. Essential services shall be maintained for the period

Essential services shall be maintained for the period required by safely terminating the diving operation, including time for decompression of the divers.

For services supporting divers in the water, all services are essential. 20 minutes is considered to be the minimum time required ensuring that the divers are safely recovered in the bell or basket, or to the surface.

For services supporting divers in a bell, all services are essential. 24 hours is considered to be the minimum time required ensuring that the divers are safely recovered into the decompression chambers or to the surface.

For services supporting divers in the decompression chambers, all required services are essential. The normal decompression schedule is considered to be the minimum time required ensuring that the divers are safely brought to the surface.

- b) <u>Emergency</u> services are herein defined as those services that are essential for safety in an emergency condition. Examples of equipment and systems for emergency services include:
 - i) condition monitoring of emergency batteries
 - ii) emergency lighting
 - iii) emergency communication
 - iv) emergency life support systems
 - v) emergency heating systems
 - vi) emergency handling of the bell(s)/basket(s)/diver(s) (if electrical)
 - vii) alarm systems for the above emergency services.

For services supporting divers in the water, all the above services may be considered emergency services and 20 minutes is considered to be the minimum time required to ensure that the divers are safely recovered in the bell or basket or to the surface.

For services supporting divers in a bell, all the above services may be considered emergency services and 24 hours is considered to be the minimum time required to ensure chambers or to the surface. For services supporting divers in the decompression chambers, with the exception of handling systems, all the above services may be considered emergency services and the capacities given in B402 apply.

Services to the hyperbaric evacuation system are considered separately in accordance with the IMO guidelines given in Sec.9.

c) Non-important services are those which are not essential according to the above.

B. System Design.

B 100 System voltages and distribution systems types.

101 Types of distribution systems.

Electrical systems with hull return shall not be applied. Electrical distribution systems shall have insulated neutral (IT).

102 System voltages.

For installations within the inner area (see definitions under Sec.1D), the following maximum system voltages are permitted:

- a) The chamber:
 - i) For power and heating equipment: max. 250 V A.C. if protected against accidental touching or insulation failures and fitted with a trip device as outlined in B307.
 - ii) For lighting, socket outlets, portable appliances and other consumers supplied by flexible cables and for communication and instrumentation equipment: max. 30 V D.C. These systems shall be supplied by isolating transformers.
- b) The bell:
 - i) For all electrical equipment, voltages will be accepted up to max 30 V D.C., and shall be supplied by isolating transformers.
 - ii) Higher voltages than specified above may be acceptable upon special consideration, provided additional precautions are taken in order to obtain an equivalent safety standard, e.g.: by use of earth fault circuit breakers. (See Guidance note to B307)

Electrical circuits and equipment used in water shall be considered in each separate case and in accordance with IMCA/ AODC "Code of practice for the safe use of electricity underwater". (see also C102) Provisions shall be made to reduce the possible fault currents, to which a diver can be exposed, to a harmless level.

B 200 Power supply systems

201 General.

The electrical systems and installations supplying essential services related to the divers and or the diving operation (as defined in A501a), shall be supplied from a main and an emergency or transitional source of power as required by B302, DNV-OS-D201 and by DNV-OS-D202.

202 Emergency supply.

- a) The diving system shall have a source of emergency power and an emergency power supply system independent of the main source of power and the main power supply system, as required by DNV-OS-D201 Ch.2 Sec.2 A101 that outlines the SOLAS II-1 Part D Regulation 43 requirements.
- b) The emergency source of power shall be a self-contained,

independent source of power. It shall immediately supply at least those services specified as emergency consumers in A501b. It shall be either:

- i) a generator, driven by a suitable prime mover, or
- ii) an accumulator battery, or
- iii) the ship's emergency switchboard, or
- iv) a combination of the above.

Where this source of power is a generator, it shall be started automatically upon failure of the electrical supply from the main source and shall be automatically connected within 45 sec., thereby providing emergency services.

Where this source of power is an accumulator battery, it shall be automatically connected to an emergency power supply system in the event of failure of the main source of electrical power. It shall be capable of carrying the maximum emergency load for a time specified under A501b without excessive voltage drop, carrying the emergency electrical load without recharging while maintaining the voltage of the battery throughout the discharge period within 12 % above or below its nominal voltage.

If emergency consumers must be available in the switchover period from main to emergency power, either for operational reasons or to avoid malfunction of the service, a transitional power source (battery back up) for these consumers shall be provided. The capacity of this transitional power shall be minimum 30 minutes.

(See SOLAS II-1 Part D Regulation 43 para.4.)

B 300 Distribution systems

301 General, Arrangement.

The distribution system shall be such that, the failure of any single circuit cannot influence or set other services out of function for longer periods.

302 If the main power to the diving system is supplied via a distribution board, this board shall have two separate supply circuits from different sections of the main switchboard.

303 Control gear in the inner area shall normally not be fitted. However, special arrangement may be acceptable after consideration in each case, based on special precautions (e.g. The equipment may be pressurised with pure helium (purging) or there may be other explosion protection concepts).

304 Devices for easy disconnection of all electrical installations in the decompression chambers in an emergency situation shall be fitted. These devices shall be located on the control stand. It shall be possible to disconnect each chamber separately.

305 Emergency circuits wiring shall be fire proof in accordance with the requirements in Sec.6 B202.

Guidance note:

Allowances are given to IEC 60331 cables protected by A0 division trays or piping.

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

306 Fuses or circuit breakers shall not be installed within the chamber and the bell, except for emergency battery power-supply circuits.

Guidance note:

Fuse-gear may be installed outside the bell or chamber. Installation inside may be arranged as mentioned above in B303, however, fuse-gear shall not be operable by divers

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

- **307** Insulation monitoring.
- a) Each insulated supply system, including the secondary side of step-down or isolating transformers (or converters)

shall be provided with an automatic insulation monitoring device, actuating switch-off and alarm by insulation faults. Alarm only may be used if a sudden switch-off of the equipment may cause danger for the divers. This insulation monitoring shall be continuous.

b) The indicator shall be located at the control stand, except that indication in the bell may be accepted for equipment in the bell.

Guidance note:

Protection against insulation failures may be achieved by double insulated apparatus or earth fault circuit breakers.

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

308 Electric motors placed in the inner area shall be provided with overload alarms or be inherently safe. The alarms may be initiated by over current, or by temperature detector in the motor itself. For motors in the bell, alarms in the bell may be accepted. The normal over current protections (short circuit protection) on the motor shall also be in place.

Guidance note:

The requirement provides safety against overheating, with the possible development of toxic gasses, and or danger of flash fire in oxygen enriched environments. In special cases there may be other risks involved in overheating of the motors. However, if the motor is considered inherently safe, the requirement for the overload alarms may be revoked. This is considered preferable in cases where the number of alarms should be kept at a minimum so as to avoid stressful operating conditions and or confusion.

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

B 400 Capacity

401 Capacity of main source of power:

All services for normal operations are according to A501a. defined as essential services, and shall be included in the services to be supplied by the main source of power as described in DNV-OS-D201 Ch.2 Sec.2 B.

402 Capacity of emergency source of power:

All services for emergency operations are according to A501b defined as emergency services, and shall be included in the services to be supplied by the emergency source of power as described in DNV-OS-D201 Ch.2 Sec.2 C.

Also:

- a) Power supplies required for the operation of life support systems and other essential services shall be sufficient for the life-support duration in order to cater for safe termination of the diving operation.
- b) Each compression chamber shall be provided with a main and emergency source of lighting sufficient for the lifesupport time and of sufficient luminosity to allow the occupants to read gauges and operate essential systems within the chamber.
- c) The emergency source of power and the emergency power distribution shall be capable of handling peak loads.

B 500 Environmental Requirements

501 General.

All electrical equipment and installations, including power supply arrangements, shall be constructed and installed to operate satisfactorily under all environmental conditions for which the diving system is designed. See DNV-OS-D201 Sec.3 B, C and D.

502 Electrical equipment within the compression chamber shall be designed for hyperbaric use, oxygen-enriched atmospheres, high humidity levels and marine application. Reference is made to:

- a) DNV-OS-D202 "Instrumentation and Telecommunication systems",
- b) NFPA53M (National Fire Protection Agency) "Manual on Fire Hazards in Oxygen-Enriched Atmospheres 1990",
- c) A.O.D.C. 043 "Code of practice for the safe use of electricity underwater", and
- d) A.O.D.C. 062 "Use of battery operated equipment in hyperbaric conditions.

503 All materials of submerged systems shall be such that their electrical and mechanical properties are not influenced by water absorption.

Guidance note:

Reference is also given to A.O.D.C.'s "Code of practice for the safe use of electricity underwater", and to DNV-OS-D201 and DNV-OS-D202.

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

B 600 Inspection and testing requirements.

601 All switchboards shall be designed, constructed and certified in accordance with the requirements given in DNV-OS-201 Sec.4.

602 Testing shall be carried out in accordance with the requirements given in DNV-OS-D201 Sec.10 D.

C. Equipment selection and installation

C 100 General

101 Arrangements.

- a) All electrical equipment and installation shall be designed and arranged in order to minimise the risk of fire, explosion, electrical shock, emission of toxic gases to personnel, and galvanic action of the surface compression chamber or diving bell.
- b) The electric power supply arrangement shall be designed to minimise the risk of electrical capacity depletion as a result of a fault, fire or explosion, electric shock, the emission of toxic gases and galvanic action.

C 200 Enclosures

201 Pressure resistant enclosures in the inner area or on the bell shall be designed for 1.3 times the design pressure of the diving system. Tests to be carried out with gas or water as applicable.

202 In the water, all metal enclosures shall be earthed by means of a copper earth conductor incorporated in the supply cable, with cross-section at least of the same size as the supply conductors and not less than 1 mm^2 . For cables having metal wire braid or armour this may alternatively be used as earth conductor, provided that the braiding cross section is sufficient.

C 300 Earthing

301 All pressure vessels for human occupancy (P.V.H.O. - chambers and bells) shall be provided with earthing connection devices for external main protective earth bonding.

C 400 Batteries

401 Batteries shall not be installed within the inner areas (chamber or bell).

402 Battery housings shall be provided with adequate protection in accordance with DNV-OS-201 Sec.2 I300, so that an accumulation of generated flammable gases is avoided.

C 500 Cables and penetrators

501 Cables.

sheet.

- a) Cables for use in the outer area (see definition under Sec.1D) shall comply with DNV-OS-D201 Ch.2 Sec.9 B and Sec.10C.
 All cables shall have an earthed braiding or screen around the conductors and be equipped with an insulating outer
- b) Cables for use in the inner area (see definition under Sec.1 D) shall comply with the requirements given in C501a, with exception to the materials used. The materials shall be designed for the purpose of being installed into an hyperbaric atmosphere.
- c) Electrical cables in the inner area shall be halogen free and shall not give off toxic, noxious or flammable gases even when overheated. Dismantled ends of insulated conductors shall be protected with sleeves of a non-combustible material (e.g. glass fibre weave). Ordinary ship cables with insulation of a halogenated material (e.g. P.V.C.) shall not be accepted. Synthetic insulation materials based on P.T.F.E. (Polytetrafluoroethylene) may be accepted.
- d) Flexible cables for transmission of electrical power and signals from the surface support to the bell shall be constructed as "dry-core cable" (i.e. water shall not reach the insulation of the individual conductors).
- e) The submerged cables shall be able to withstand an external hydrostatic pressure of 1.3 times the actual external pressure.
- f) Unless installed in pipes, electrical cables shall be readily accessible for visual inspection.
- g) Tensile loads shall not be transferred to the electrical cables.
- **502** Electrical penetrators for pressure vessels.
- a) All electrical penetrators in pressure containing structures shall be purpose designed and bear a manufacturer's certificate (the terms of delivery may require a higher level of certification) and shall be arranged with separate fittings.
- b) Penetrators in pressure vessels shall be gas and water-tight even in the event of damage to the connecting cables.
- c) Electrical penetrators shall be tested at the manufacturers as specified below in d. Tests shall be made between each conductor and screen and tests shall be carried out on penetrators from the same production batch. The tests shall be carried out in the sequence they are listed. The penetrators shall show no sign of deficiency during and after the testing.
- d) Tests to be carried out include:
 - a voltage test, by applying 1 kV plus twice the design voltage for 1 minute between each conductor and screen separately
 - a hydrostatic test to a pressure of twice the design pressure, repeated 5 times
 - a gas leakage test with the cables cut and open (Testing with air to twice the design pressure or with helium to 1.5 times the design pressure.)
 - an insulation test to 5 Megaohms at the design pressure, applying saltwater.

C 600 Lighting, inner area

601 Protection against possible bursting of electrical bulbs shall be in place.

D. Communication

D 100 General

101 Communications systems shall comply the relevant requirements given in DNV-OS-D202 "Instrumentation and Telecommunication systems".

D 200 Visual observation of divers

201 Visual observation of divers in each compartment shall be possible.

202 For saturation diving systems, suitable means (e.g. TV) shall be arranged for visual observation of the divers in the bells from the control stand for the bells and for the divers in the chamber compartments at the control stand for the chambers.

D 300 Voice communication systems

301 Communication systems shall be arranged for direct voice communication between the control stand and:

- a) divers in the water
- b) divers in the bell
- c) each compartment
- d) other control stands
- e) the bridge (operational command centre).

302 Alternative means of communication with the divers in the chamber compartments and the divers in the bell shall be available in an emergency.

303 Diving systems intended for use of helium shall be provided with helium unscramblers. The sound quality shall be of such a level that the breathing pattern of the diver in water can be easily recognised.

The control stand for the bell shall be provided with equipment for audio-recording of all communications with the divers in the bell and in the water.

304 The bell shall be fitted with a self-contained emergency through-water communication system.

305 A diving bell shall have an emergency-locating device, preferably with a frequency of 37.5 kHz, designed to assist personnel on the surface in establishing and maintaining contact with the submerged diving bell if the umbilical to the surface is severed. This is in accordance with the IMO Code of Safety for Diving Systems, 1995 (Resolution A.831(19)). The device includes the following components:

1. Transponder

1.1 The transponder should be provided with a pressure housing capable of operating to a depth of at least d_{max} containing batteries and equipped with salt-water activation contacts. The batteries should be of the readily available "alkaline" type and, if possible, be interchangeable with those of the diver and surface interrogator or receiver.

1.2 The transponder should be designed to operate with the following characteristics:

| 37.5 kHz |
|--------------------------------------|
| |
| 38.5 +/-0.05 kHz 39.5 +/-0.05 kHz |
| +15 dB referred to 1 μ bar |
| 4 ms |
| 125.7 +/-0.2 ms |
| 37.5 +/-0.05 kHz |
| |

| Maximum interrogation rates: | |
|---|--|
| - More than 20% of battery life remaining | once per second |
| - Less than 20% of battery life remaining | once per 2 seconds |
| Minimum transponder output power | 85dB referred to 1 μ bar at 1 |
| | m |
| Minimum transducer polar diagram | - 6 dB at +/-135° solid angle, centred on the transponder vertical axis and transmitting toward the surface |
| Minimum listening life in water : | 10 weeks |
| Minimum battery life replying at: | 85 dB 5 days |

2. Diver-held interrogator or receiver

2.1 The interrogator or receiver should be provided with a pressure housing capable of operating to a depth of at least d_{max} with pistol grip and compass. The front end should contain the directional hydrophone array and the rear end the 3 digit LED display readout calibrated in metres. Controls should be provided for "on and off receiver gain" and "channel selection". The battery pack should be of the readily available "alkaline" type and, if possible, be interchangeable with that of the interrogator and transponder.

2.2 The interrogator or receiver should be designed to operate with the following characteristics:

| Common emergency reply frequency | 37.5 kHz |
|--|-------------------------------------|
| Individual interrogation frequencies : - Channel A - Channel B | 38.5 kHz 39.5 kHz |
| Minimum transmitter output power | 85 dB referred to 1 μ bar at 1m |
| Transmit pulse | 4 ms |
| Directivity: | +/-15° |
| Capability to zero range on transponder | |
| Maximum detectable range | More than 500 m |

306 In addition to the communication systems referred to above, a standard bell emergency communication tapping code should be adopted as given below for use between persons in the bell and rescue divers.

A copy of this tapping code should be displayed inside and outside the bell and also in the dive control room.

| Table D1 Bell emergency communication tapping code | | |
|--|--|--|
| Tapping code | Situation | |
| 3.3.3 | Communication opening procedure (inside and outside) | |
| 1 | Yes or affirmative or agreed | |
| 3 | No or negative or disagreed | |
| 2.2 | Repeat please | |
| 2 | Stop | |
| 5 | Have you got a seal ? | |
| 6 | Stand by to be pulled up | |
| 1.2.1.2 | Get ready for through water transfer (open your hatch) | |
| 2.3.2.3 | You will NOT release your ballast | |
| 4.4 | Do release your ballast in 30 minutes from now | |
| 1.2.3 | Do increase your pressure | |
| 3.3.3. | Communication closing procedure (inside and outside) | |

E. Instrumentation

E 100 General

101 In general, instrumentation shall comply with the relevant requirements in DNV-OS-D202 and DNV Rules for Classification of Ships Pt.4 Ch.9.

E 200 Control stands

201 In the design of control rooms, attention shall be given to ergonomic matters such as communication and a systematic arrangement of equipment, according to a documented traffic flow chart. Further, it should be ensured that noise or other disturbance when working does not occur (see Guidance note to Sec.4 F401).

202 Indication and operation of all vital life support conditions to and from the chamber(s) and the bell(s) shall be arranged at a single control stand or divided between suitably located control stands. The control stands shall be equipped for easy operation and control of the diving system. There shall be schematic indication of gas flow lines. For saturation diving systems the control stand for the bell shall be separated from other control stands.

203 The control stands shall have indicators showing continuously:

- a) the pressure in the gas containers connected
- b) the pressure after all pressure reducers
- c) the pressure in each chamber compartment
- d) the pressure externally and internally of the bell.

Pressure indicators on the control stand for the bell and compartments shall be arranged for a possible comparison between each other or with a permanently installed master indicator. If cross-connections are incorporated, these shall be arranged in such a way as to give the operators an indication when crossconnection is being conducted.

Instrumentation for pressure measuring for bell and compartments shall have an accuracy of +/-0.3% of full scale. In addition pressure indicators for the chambers shall facilitate depth measurements with an accuracy of +/-0.25 msw. in the depth range from 30 msw. to 0. For other instrumentation for pressure measuring, +/-1% of full scale.

204 The control stands shall have a system for continuous indication of:

- a) oxygen content in each compartment individually,
- b) oxygen content in bell for saturation diving systems
- c) oxygen content in the supply to the:
 - i) umbilical
 - ii) compartments
 - iii) masks in compartments.

The monitoring systems shall be fitted with audible and visual high and low level alarm.

205 Permanent provisions for calibration of and comparison between oxygen analysing instruments shall be arranged on the control stand.

206 There shall be a system for continuous monitoring of oxygen content in supply to the bell's umbilical and masks in the bell. The monitoring systems shall be fitted with audible and visual high and low level alarm. There shall be an audio-visual gas flow indicator in the oxygen supply to the chambers.

207 The control stands shall have a system for regular indication of:

a) carbon dioxide content in each compartment individually,

and

b) carbon dioxide content in the bell for saturation diving systems.

208 There shall be systems for indication of temperature and humidity in the inner area. For DSV-SAT saturation diving systems, temperature and humidity indicators for the living compartments shall be located at the control stand.

209 Alarms for abnormal conditions are required at the control stand, if automatic environmental control systems are arranged for regulation of gas composition, pressure and temperature in the inner area.

210 It shall be possible to carry out work and to communicate effectively in the control room even if there is no normal breathable atmosphere in the room. Release of dangerous quantities or mixtures of gas from chamber or gas plant shall never take place in the control room.

E 300 Pressure indicators in bell and chambers.

301 The bell shall be fitted with indicators visible to the divers inside, showing :

- a) external pressure
- b) internal pressure
- c) pressure of gas stored on the bell.

302 The chamber compartments shall be fitted with indicators visible to the divers inside, showing internal pressure.

303 Means shall be provided for isolating all pressure indicators without interrupting vital functions in the gas distribution system.

E 400 Oxygen analysing systems

401 Oxygen analysing systems shall have an accuracy of at least +/-0.015 bar partial pressure oxygen.

402 The bell and the living compartments shall have separate oxygen analysers inside.

E 500 Carbon dioxide analysing systems

501 Carbon dioxide analysing systems shall have an accuracy of \pm -0.001 bar partial pressure.

502 Carbon dioxide gas for calibration shall be available.

503 The bell shall have self-contained carbon dioxide analysing systems.

E 600 Other gases

601 The instrumentation for systems intended for other gases than air or helium and oxygen mixes shall be considered in each case.

Guidance note:

Operations in connection with exploration of oil, may require instrumentation for the analysis of hydrocarbon gases and H_2S .

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

602 Calibration gases shall be available for each relevant gas mix.

E 700 Contaminants.

701 For DSV-SAT diving systems, a system for sampling and analysing of trace contaminants shall be arranged. Analysing by test tubes may be acceptable.

E 800 Automatic environmental control systems

801 The following requirements apply when systems for automatic regulation of gas composition, pressure and temperature in the inner area are installed.

802 The design principles given in DNV-OS-D202 and DNV Rules for Classification of Ships Pt.4 Ch.9, apply on a general basis.

803 The most probable failure in the systems shall result in the least critical of any possible new conditions (fail to safety).

804 Automatic control systems shall keep process variables within the limits specified during normal working conditions and the alarm systems shall be activated when the limits are exceeded.

805 Alarm at the control stand is required for abnormal conditions. The alarm system is also to be activated by failures in the alarm system such as broken connections to measuring elements. The alarm system shall be independent of the automatic control system so that failure in one of the systems cannot inhibit operation of the other system.

806 A manual back-up system for the automatic control system is required.

SECTION 6 FIRE PREVENTION, DETECTION AND EXTINCTION

A. General

A 100 Objective

101 The purpose of this section is to specify additional requirements for fire protection serving diving systems. Emphasis is placed on the special needs associated with the design and manufacture of diving systems, whereas general requirements for fire protection are given in DNV-OS-D301 "Fire Protection".

102 Key issues are identified through requirements for materials, insulation and separation from adjacent spaces, sprinkler systems and extinction agents. Reductions in hazards are ensured through these issues.

103 For quantitative design parameters and functional requirements, reference is made to the relevant standards and guidelines, including DNV-OS-D301 "Fire Protection".

A 200 Application and scope

201 These requirements apply to all systems. However, some **DSV-SURFACE** and **DSV-BOUNCE** systems may be located on open deck. In these cases the requirements for insulation against adjacent spaces and requirements for sprinkler systems may be more lenient.

202 In addition to the basis requirements in DNV-OS-301 "Fire Protection", supplementary information is found in the National Fire Protection Agency Codes' chapters on hyperbaric systems and oxygen enriched environments.

203 Further requirements applicable to the support vessel are given in SOLAS.

204 Requirements for testing are given in Sec.2 J.

205 This section bears impact on Sec.5 (build-up of static electricity, degree of protection provided by enclosure IP for equipment on chambers covered by sprinkler systems, power to alarms) and Sec.9.

A 300 Documentation

301 Fire prevention, detection and extinction shall be documented as follows:

- a) A List of all materials to be installed in the inner area, where possible with data on and or evaluation of flammability in conditions under which the materials can be used.
- b) Plans and specifications of fire detection, fire alarm and fire extinction equipment for both the inner and outer area.

A 400 Control Stands

401 Control rooms for diving systems located in hazardous zone 2 shall comply with the requirements given in DNV Offshore Standard OS-A101 "Safety Principles and Arrangements" Sec.4.

Other control stands, essential to the function of the diving system, shall be protected such that the controls may be maintained whilst the divers are being evacuated in the event of a fire.

B. Fire protection

B 100 Materials.

101 The use of combustible materials shall be avoided wherever possible. Combustible materials include materials which may be brought to explode, or burn independently in the resulting gas environment, applicable to:

- a) The outer area: air at a pressure of 1 bar
- b) The inner area: air at applicable maximum pressure.

102 Structural components, furniture and knobs, paints, varnishes and adhesives applied to these, shall be of non-hazardous materials., i.e. they shall be tested in accordance with relevant parts of IMO res. MSC.61(67) (FTP Code) or other acknowledged standard.

Guidance note:

In order to comply with B101, materials for use in inner area should be tested at an elevated pressure. Where such materials are not available, fitting a fixed fire extinguishing system in the inner area may be considered as an alternative.

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

103 Materials and arrangements are wherever possible to be made so as to avoid build-up of static electricity and to minimise the rise of spark production due to electrical failures or combination of materials. In inner areas without electrical equipment, the furniture and floors of electrically conductor materials may be used. For inner areas where electrical equipment is used, the materials and arrangements shall be made so as to minimise contact with earthed metalwork.

A specific electrical resistance between 10^7 and 10^{10} ohm⁻¹ is considered to be suitable for avoiding build-up of static electricity.

B 200 Arrangement

201 The diving system shall be located in a safe area as defined in Sec.2 E300. Diving systems situated on open decks shall not be located in the vicinity of ventilation openings from machinery spaces, exhausts or ventilation outlets from galley.

202 Outer areas situated in enclosed spaces shall be separated from adjacent spaces, by means of A-60 class bulkheads or decks. Piping and cables essential for the operation of the diving system are regarded as part of the system and should be laid in separate structural ducts insulated to A-60 class standard.

203 For diving systems situated on open decks, the outer area shall be separated from adjacent machinery spaces by A-60 class fire divisions except when the machinery space has little or no fire risk.

204 Outer area fitted in enclosed spaces shall be fitted with separate mechanical ventilation with minimum 8 air changes per hour.

205 Oxygen dumped from the diving system shall be ducted for dumping at a safe place.

206 Liquid fuel burning machines shall be fitted with either alarms or shut-off valves to ensure that day-tanks, if fitted, cannot be filled to overflow.

C. Fire Detection and Alarm System

C 100 Outer Area

101 When situated in enclosed spaces the outer area shall be equipped with an automatic fire detection and alarm system complying with DNV Rules for Classification of Ships Pt.4 Ch.10 Sec.9. The section or loop of detectors covering the outer area shall not cover other spaces.

C 200 Inner area

201 The inner area should be equipped with automatic fire detection and alarm system complying with DNV Rules for Classification of Ships Pt.4 Ch.10 Sec.9. The section or loop of detectors covering the inner area should not cover other spaces.

C 300 Fault detection

301 Provisions shall be made for warning of faults; e.g., voltage failure, broken line, earth fault, etc., in the fire alarm and detection system.

D. Fire Extinguishing

D 100 Outer area.

101 When situated in enclosed spaces, the outer area shall be equipped with a fixed, manually actuated fire extinguishing system with such a layout as to cover the complete system.

102 The extinguishing system shall be either:

- a) a pressure water spraying system approved for use in machinery spaces of cat.A, or
- b) a gas system approved for use in machinery spaces of cat.A.

103 If a gas system is selected, the agent shall be of a type not hazardous to humans in the concentration foreseeable in the protected space. The concentration shall be below the NOAEL as defined in IMO MSC/Circ.848.

Guidance note:

No fire suppression agent should be used which is carcinogenic, mutagenic, or teratogenic at concentrations expected during use. No agent should be used in concentrations greater than the cardiac sezitisation NOAEL (no observed adverse effect level), nor the ALC (approximate lethal concentration). (See IMO MSC/ Circ.776)

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

104 Enclosed spaces intended for pressurised gas storage containers that are certified in accordance with Sec.3, shall be fitted with a fixed pressure water-spraying system of capacity not less than 10 litres/m² per min of the horizontal projected area, in order to cool and protect such pressure vessels from an external fire.

105 When situated on open deck, the outer area shall be provided with fire extinguishing equipment, which shall be considered in each case. Hyperbaric Evacuation Systems shall be provided with fire extinguishing systems enabling launching of the Hyperbaric Evacuation Unit in the event of a fire.

D 200 Inner area

201 Each compartment in the inner area shall be equipped with a fire-fighting extinguisher, which will ensure rapid and efficient distribution of fire extinguishing agent to any part of

the chambers, under all foreseeable compartment conditions. It shall be possible to actuate the extinguisher both from within the compartment and from outside.

202 The extinguishing agent shall be water, unless an approved alternative exists.

203 The fire-fighting device in the inner area shall be rechargeable without depressurising.

204 Provisions shall be made for possible discharge of less than the total supply of extinguishing agent.

E. Miscellaneous equipment

E 100 Fire-fighter's outfit

101 A complete set of fire-fighter's outfit complying with DNV Rules for Classification of Ships Pt.4 Ch.10 Sec.11 for each person required for operation of the diving system during a fire should be located at the main control stands. The sets are additional to other sets on board.

Breathing apparatus are required for control stations manned during recovery of bell or launching of hyperbaric evacuation unit.

Guidance note:

Fire-fighter's outfit is recommended in consideration of the time it may take for recovery of the divers from the water, into the bell and all the way up to the Hyperbaric Evacuation System. The operator(s) of the diving system may be exposed to hot environments which render evacuation impossible unless they are protected whilst performing their work.

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

E 200 Portable fire extinguishers

201 Portable fire extinguishers shall be of approved type and comply with DNV Rules for Classification of Ships Pt.4 Ch.10 Sec.4

202 Portable fire extinguishers shall be distributed throughout the space containing the diving system so that no point in the space is more than 10 m walking distance from an extinguisher.

203 One of the portable fire extinguishers shall be fitted near each entrance.

204 A portable fire extinguisher shall be fitted at the control stand.

205 Spare charges or extinguishers shall be provided on board as follows:

100% for the first 10, and 50% for remaining extinguishers.

The same type of portable extinguisher shall be used throughout the system, one type for the outer area and one type for the inner area. Compatibility with the remaining extinguishers, used elsewhere on the vessel, is recommended for extinguishers used in the outer area.

SECTION 7 LAUNCH AND RECOVERY SYSTEMS

A. General

A 100 Objectives

101 Launch and recovery systems shall be certified by a competent person as lifting appliances in accordance with the procedures applicable for the issue of an ILO Form 2 certificate (International Labour Organisation) or equivalent. Operational limitations shall be stated in an appendix to the certificate.

The purpose of this section is to specify additional requirements for lifting appliances serving diving systems. Emphasis is placed on the special needs associated with the design and manufacture of diving systems, whereas general requirements for lifting appliances are given in DNV Standard for Certification No. 2.22 Lifting Appliances.

102 Key issues are identified through requirements for alternative recovery of divers. Further, requirements for interlocking of the mating system between bell and transfer compartment shows the emphasis placed on these essential systems. As this standard allows for the use of buoyant ascent, emphasis is placed on the secure arrangement of such systems.

103 Load conditions need to be defined through the use of Appendix A, if the maximum allowable significant wave height is to exceed 2 m.

104 Launch and recovery systems shall be certified in accordance with statutory requirements applicable to the Flag State where the support vessel is registered, geographic area of operation and terms of delivery.

A 200 Application and scope

201 This section applies to all systems. However, requirements for handling of divers baskets may be more lenient with respect to emergency recovery, if it is possible for the surface supplied divers to ascend independent of the divers basket.

202 For quantitative design parameters and functional requirements, reference is made to relevant standards and guidelines, including DNV Standard for Certification No. 2.22 Lifting Appliances.

203 Limitations are given in the rating of the handling systems with respect to a given, specified, sea-state.

204 Requirements for testing are given in Sec.2 J.

205 This section has impact on the requirements for strength with respect to deck loading on the support vessel and to the services (see Sec.5) from the support vessel.

A 300 Documentation

301 Handling systems shall be documented as a lifting appliance in accordance with the applied code or standard. In addition, plans and supplementary documentation shall be made available as follows:

- a) Plans showing the arrangement of the handling system with specifications of loads, and dimensions of strength members.
- b) Plans showing the function of the systems, and giving particulars of the systems. The plans shall show a schematic arrangement of the hydraulic or pneumatic piping systems and specification of controls and power supply.
- c) Calculation of the design load according to C100.
- d) Calculation of necessary design load for umbilical and guide ropes.

- e) Plans and specification of structural parts, ropes, sockets, blocks, sheaves, winches, and emergency ascent arrangement for the diving bell and mating arrangement.
- f) Specifications of materials and welds, and extent of non-destructive testing.
- g) Specifications of wire ropes and their end connections.
- h) Specification of safety devices (limit switches, automatic stop of operating handle, automatic locking of winch in case of power failure, etc).
- i) Specification of buoyancy of the bell at d_{max} . and correction formulas when the buoyancy is measured at the surface.
- j) Plans and specifications for systems used for emergency ascent and retrieval of the bell.
- k) information on specification of working weight, displacement and stability of the bell, with all hydrostatic properties accounted for.

B. Design Principles

B 100 Function

101 The normal handling system shall be designed for a safe, smooth and easily controllable transportation of the bell in the design sea-state.

The lowering of bells is, under normal conditions, to be controlled by the drive system for the winches, and not by mechanical brakes.

Bell and guide-wire winches used for dry transfer into a habitat shall include a heave compensation and constant tension system.

Guidance note:

Care must be taken when designing handling systems with heave compensation and constant tension systems incorporated, as the added systems often contribute to the increase in the stiffness of the overall system.

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

102 Manoeuvring systems shall be arranged for automatic stop when the operating handle is not operated (dead man's handle).

103 Hoisting systems shall be fitted with a mechanical brake, which shall be engaged automatically when the hoisting motor stops. In the event of failure of the automatic brake a secondary means shall be provided to prevent the load from falling. This may be manual in operation and should be simple in design.

104 The handling system shall be designed so that the systems are locked in place if the energy supply fails or is switched off.

105 If the hoisting rope can enter the drum with an angle exceeding 2° from the right angle to the drum axis (the "fleet angle"), a spooling arrangement shall be fitted. The rope handling system shall not permit ropes to squeeze in between, or introduce permanent deformation to ropes in underlying layers on the drum.

106 The hoisting system shall be equipped with a device which stops the bell at its lowermost and uppermost positions. Travelling cranes and trolleys shall be equipped with mechanical stops at their end positions. The system shall be equipped

with limit switches preventing the handling of the bell, wet bell or basket outside of the handling area.

107 Precautions shall be taken to avoid exceeding the design load in any part of the handling system including hoisting ropes and umbilical due to:

- a) large capacity of the power unit
- b) motions of the supporting vessel when the bell or weights are caught or held by suction to the sea floor
- c) failure on umbilical winch during launching of bell.

108 Structural members of the handling system might be subjected to forces imposed by separate units of a power system. (e.g. A-frame tilted by hydraulic actuator on each leg.) The structural members are therefore either to be strong enough to sustain the resulting forces when one of the power units fails, or the power units shall be synchronised and an automatic alarm and stop system shall be activated when the synchronising is out of set limits.

109 A locking arrangement shall be fitted to the mating system between the bell and the transfer compartment in accordance with the requirements given in Sec.3 B304 and B305.

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

111 Primary and emergency lighting in all critical handling areas shall be provided.

B 200 Alternative recovery

201 There shall be at least <u>one</u> normal system and <u>two</u> independent emergency systems for recovery of the divers with return to the chambers. The alternative systems shall comply with the same requirements for load strength as the main system.

One of the emergency systems shall be independent of the hoisting and guide ropes, as well as the umbilical.

Guidance note:

The requirement for an emergency recovery system independent of the hoisting ropes, guide ropes and umbilical is a reminder of the fatal incidents where all these regular means of lifting the bell were severed due to snagging by anchor wires or other obstructions. More recent systems are fitted with two bells, enabling emergency recovery by wet transfer if necessary.

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

- a) One emergency system may be made for recovery by aid of the normal hoisting or guide rope(s) or umbilical. This system shall be independently powered from the normal system, and shall incorporate all transportation necessary to mate the bell to the transfer chamber.
- b) One system shall also provide an arrangement for stopping the bell from falling or descending, in the event of failure in the primary lifting wire.
- c) The other emergency system may consist of an arrangement on the bell that permits the divers inside to activate a buoyant ascent of the bell, (see B301) and shall incorporate all transportation necessary to mate the bell to the transfer chamber.
- d) Alternatively, the diving system may be equipped with a separate handling system and a second bell or submersible. Provisions shall be available for recovery of the divers to the chambers.

202 Guide wire equipment may, in addition to ensuring controlled movements of the bell in the water, function as an alternative handling facility.

B 300 Emergency arrangements

301 Bells equipped for buoyant emergency ascent shall be specially considered. They shall be fitted with emergency release of hoisting rope(s), guide wires, umbilical and ascent system, that shall be activated in sequence from inside the bell.

Guidance note:

Although this standard allows buoyant ascent as a means of emergency retrieval, it should be chosen only as a last resort when all alternatives have been considered and abandoned.

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

302 Release mechanisms for hoisting rope, guide wires, umbilical and ascent system shall be so designed that two separate operations shall be necessary to activate them. If hydraulic or pneumatic actuation systems are used, possible penetration of helium into the systems shall be taken into account.

Primary strength members shall be designed for a load not less than 3 times the expected maximum load during operation. Secondary strength members such as securing mechanisms shall be so designed that they cannot activate the release system in the event of their failing.

303 Bells equipped for emergency ascent shall have positive buoyancy without ballast of minimum 3% of the displacement with working weight (the trunk filled with water) at maximum depth.

304 The bell shall have means enabling it to be located when submerged, and in the case of a buoyant bell also at the surface (see Sec.5 D305).

B 400 Power

401 The bell hoisting powersystem shall be designed and tested to lift a load of 1.25 times the working weight.

402 The power of horizontal transportation systems shall be designed and tested for safe handling at list and trim as specified in Table C1.

403 The strength of the mechanical brake for the bell hoisting system shall be based on holding of the design load. After the static test, however, the brake may be adjusted to the working weight of the bell plus 40%.

B 500 Umbilical

501 The length of the umbilical if separated from the hoisting rope is at least to allow an excursion of the bell to:

- a) d_{max} plus 5%, or
- b) actual bottom depth plus 5%.

502 The termination points, where the umbilical enters connectors and penetrators, shall not be subjected to significant loads or flexing.

503 The ultimate tensile strength of the umbilical shall not be less than twice the maximum load expected during normal and emergency operations.

The design load of the umbilical shall be sufficient for the maximum loads expected during normal operation.

C. Strength

C 100 Design loads

101 If the handling system is designed for operation in seastates with significant wave heights (see definitions in Sec.1 C) not exceeding 2 metres, the design load may be taken as the load resulting from the following:

a) 2 times the working weight in air of bell and attachable members,

- b) weight of structural members of the handling system multiplied by a factor of 1.3 in the vertical direction and 0.3 in the horizontal direction,
- c) list and trim during operation as given in Table C1,
- d) list and trim in locked position as given in Sec.2 H100.

102 Alternatively to C101, or for sea-states with significant wave heights exceeding 2 metres, the design load shall be taken as the largest most probable, resultant load over 24 hours in the operational design sea-state due to the following:

- a) working weight of bell and structural members of the handling system,
- b) dynamical amplification due to list, trim and motion of the vessel,
- c) operation and response of the handling system,
- d) hydrodynamic forces,
- e) jerks in the hoisting ropes and impact on the system.

103 The working weight of the bell shall be taken as the maximum weight of the fully equipped bell, including each fully equipped diver of 150 kg. The load from this weight applies to:

- a) handling in air, and
- b) handling submerged, combining the maximum negative buoyancy of the wire rope, umbilical and bell at maximum operating depth.

104 In locked positions on a vessel, the handling system shall have a structural strength at least sufficient for the environmental conditions described in Sec.2. In addition to the motions and accelerations in the operational design sea-state, the minimum inclinations given in Table C1 shall be taken into account:

| Table C1 Permanent inclinations | | | | |
|---------------------------------|----------------|----------------|--|--|
| Vessel type | Permanent list | Permanent trim | | |
| Ship | 5° | 2° | | |
| Semi-submersible | 3° | 3° | | |

105 Dynamic loads due to start, stop, or a slack wire rope followed by a jerk, and hydrodynamic loads shall be determined. This may be done as stated in Appendix A.

C 200 Dimensions

201 The tension in ropes, due to the design load, shall not exceed that:

- a) for steel wire ropes:
 - i) SF = 4 times design load factor (for design loads not exceeding 1.5 times working weight) or
 - ii) SF = 3.33 times design load factor (for larger design loads).
- b) for synthetic fibre ropes:
 - i) SF = 5 times design load factor where design load factor is defined as the design load divided by the working weight.

Ropes shall be of a type that minimises rotation.

202 Blocks, sheaves, shackles etc. shall comply with recognised national codes. Drums and pulley diameters shall correspond to the type of rope. For steel wire ropes this diameter shall not be taken less than specified by the rope manufacturer, and normally not less than 18 times the rope diameter. In the case of cross hauling, such equipment shall fulfil the same requirements for strength as the rest of the handling system.

203 Structural members shall be fabricated from certified materials and shall be designed with safety against:

- a) excessive yielding
- b) buckling
- c) fatigue fracture.

in accordance with technical requirements in DNV Standard for Certification No. 2.22 Lifting Appliances, or equivalent accepted standards. Safety factors at design load shall be taken as specified for Case 1 (Safety against yield: 1.5) in this reference.

SECTION 8

PIPES, HOSES, VALVES, FITTINGS, COMPRESSORS AND UMBILICALS

A. General

A 100 Objectives

101 The purpose of this section is to specify additional requirements for pipes, hoses, valves and fittings serving diving systems. Emphasis is placed on the special needs associated with the design and manufacture of diving systems, whereas general requirements for such systems are given in DNV Rules for Classification of Ships Pt.4 Ch.6.

102 Key issues include the requirements for oxygen systems and to the limited use of hoses except hoses used in umbilicals.

103 This section does not cover general requirements given in manufacturing codes and standards for particular components, such as API codes for hoses etc.

A 200 Application and scope

201 This section applies to all systems essential for the safe operation of the diving system.

202 Manufacturing standards applicable to individual components shall be supplementary to this standard.

203 Testing after completion is included here and in Sec.1, but testing during manufacture shall be in accordance with applicable manufacturing codes for the particular component.

204 This section has impact on Sec.3, Sec.4, Sec.6, Sec.7 and Sec.9.

A 300 Documentation

301 Pipes, Hoses, Valves, Fittings, Compressors and Umbilicals shall be documented as follows:

Flexible hoses
 Plans and specifications showing suitability of the hose in relation to its intended use.
 For information, documentation of tests which have been carried out, as required.
 Umbilical
 Plans and specifications giving particulars of conductors, minimum breaking load and minimum diameter of pulley and drums.
 For information, specification of max. design loads, elastic properties and weight

302 Documentation of tests verifying the properties listed above and as required by F.

per unit length.

303 See also DNV document requirement lists (DOCREQ) for DSV and LIAP.

A 400 Materials

401 Materials used in the breathing gas system shall not produce noxious, toxic or flammable products.

402 In systems conducting oxygen, all materials in contact with this gas shall be oxygen shock tested according to *EN* 738-1, -2 and -3:1997/1998 "Pressure regulators for use with medical gases" or equivalent standard applicable to the particular component. (See also EN 849:1996, EN ISO 11114-3:1997 and EN ISO 2503:1998 in informative references)

403 For piping systems of copper, copper alloys and austenitic steels with chromium-nickel content above 22%, the test can be waived.

404 Precautions shall be taken to avoid galvanic corrosion.

405 Non-metallic materials retaining pressurised gas shall be considered for gas-permeability.

A 500 Protection

501 Piping systems shall be well protected against mechanical damage.

B. Pipes and hoses

B 100 General

101 Piping systems shall comply with the technical requirements in DNV Rules for Classification of Ships Pt.4 Ch.6.

102 Welding of joints shall be carried out by qualified welders using approved welding procedures and welding consumables. Technical requirements are given in DNV Rules for Classification of Ships Pt.2 Ch.3.

103 The following requirements given in DNV Rules for Classification of Ships Pt.4 Ch.6, shall be followed:

- a) Bending and welding procedures
- b) welding joint particulars
- c) preheating
- d) heat treatment after welding and forming
- e) non-destructive testing and production weld testing
- f) bracing of copper and copper alloys.

104 Hydrostatic testing shall be in accordance with the technical requirements and as for corresponding pipe class in breathing gas systems pertaining to class I piping systems.

B 200 Hoses

201 In addition to umbilicals, short lengths (up to 2 m) of flexible hose may be used when necessary to admit relative movements between machinery and fixed piping systems. For assemblies incorporating specially approved hoses and securing arrangements, lengths up to 5m may be permitted if fixed piping is not practicable. In such cases the securing arrangements shall be in place at 1m intervals of the length of the hose.

In addition to the couplings, the hoses shall be secured in such a way as to prevent the hose from whip lashing in the event that the coupling fails. When applicable, couplings shall incorporate bends so that kinks in the hoses are avoided.

- 202 Flexible hoses shall not replace fixed piping.
- 203 Flexible hoses with couplings shall be certified.
- 204 The bursting pressure of synthetic hoses shall be at least:
- a) For hoses for fluids: 4 times the maximum working pressure
- b) For hoses for gases: 5 times the maximum working pressure.

205~ Hot water hoses shall be designed for conveyance of fluids of temperatures not less than $100^\circ C$

206 Each hose for use in umbilical shall be pressure tested to 1.5 times the design pressure before fitting in the umbilical. After hose end fittings have been mounted, a gas leakage test to design pressure shall be performed.

207 Flexible metallic hoses shall comply with ISO 10 380, BS6501 or equivalent. These types of hoses shall not be installed in systems subject to excessive vibrations or movements.

208 Flexible synthetic hoses shall comply with SAE J 517,

DIN EN 853, 856, 857 or equivalent. The internal oil resistance test may be omitted for hoses intended for gas and water only.

B 300 Hoses and components for gases containing oxygen

301 Hoses and components for systems conducting gases containing more than 25% oxygen shall be able to sustain the pressure shock tests as specified in A402.

Guidance note:

Oxygen pressure shock tests are described in the standards referred to in A402. However, the test includes the following principles:

Commercial grade oxygen (99% pure) test gas is applied as follows for 3 identical test specimens:

The test pressure is not less than the design pressure.

The test specimen is preheated to 60° C and exposed to a gas pressure shock up to the specified test pressure with test gas preheated to 60° C.

Each test consists of 20 pressure shocks at approximately 30 seconds intervals. The total exposure time to each pressure shock is 10 seconds, and the gas pressure is released after each shock.

The pressure increase rate during each pressure shock is obtained by a valve with an opening time less than 10 milliseconds.

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

302 Any length of hose conducting oxygen shall be secured from flailing in the event of rupture of the hose or failure of the coupling.

C. Valves and Pressure Regulators

C 100 Valve design

101 Pressure ratings for valves shall be in accordance with a recognised national standard.

102 Design and arrangement of valves shall be such that open and closed positions are clearly indicated.

103 Valves are normally to be closed by clockwise rotation.

104 Shut-off valves for oxygen shall be of types which need several turns to close. On chamber penetrators, ball valves may be accepted for emergency use only.

105 Pressure regulators shall have more than one full rotation from fully closed to fully opened position.

D. Fittings and Pipe Connections

D 100 Detachable connections

101 Bite and compression type couplings and couplings with brazing, flared fittings, welding cones and flange connections shall be designed according to a recognised standard.

E. Compressors

E 100 General

101 Compressors shall be certified.

102 Compressors shall be equipped with all the accessories and instrumentation which are necessary for effective and dependable operation.

103 Compressors shall be designed for the gas types, pressure rating and delivery rates as specified by the operation and so designed that the gas is protected against contamination by lubricants.

104 The content of contaminants in delivered air from compressors shall not exceed:

- a) 50 mg water
- b) 1 mg oil per m^3 air STP (standard conditions)
- c) 500 ppm CO_2 , and
- d) 10 ppm CO.

105 Suitable protection shall be provided around moving parts, and the Safety Relief Valves shall exhaust to a safe place.

F. Umbilicals

F 100 General

101 Umbilicals shall be designed, tested and certified in accordance with the most recent edition of one of the following codes:

- a) ISO 13628-5 "Petroleum and natural gas industries Design and operation of subsea production systems – Part 5: Subsea control umbilicals", or
- b) API Specification 17E "Specification for Subsea Production Control Umbilicals."

F 200 Hoses

201 Hoses for umbilicals shall comply with the requirements given in B200. Hoses intended for operation with a larger external pressure than the internal pressure, shall be able to withstand 1.5 times this pressure difference without collapsing or shall be able to collapse without signs of permanent deformation.

F 300 Electrical cables

301 Electrical cables for umbilicals shall comply with requirements given in Sec.5.

302 The minimum average thickness of insulating walls and temperature classes shall be in accordance with DNV-OS-D201.

F 400 Sheathing

401 Any sheathing of a compact umbilical shall be of a design which avoids build-up of an inside gas pressure in the event of a small leakage from a hose.

F 500 Strength members

501 The strength members of umbilicals shall have sufficient stiffness to avoid plastic yielding of electrical conductors at design load, and shall be properly secured.

F 600 Testing of mechanical properties

601 Samples of the completed umbilicals shall be tested according to a manufacturer's test programme complying with relevant requirements in the design code. The test programme shall as a minimum include tensile testing and fatigue testing to 5000 load cycles without the umbilical showing any sign of permanent deformation of electrical conductors and or significant permanent deformations of other parts.

F 700 Tests after completion.

701 A pressure test to the design pressure of all hoses simultaneously and verification of the specified properties by insulation tests of electrical conductors as well as impedance measurements of signal cables to specified properties shall be carried out.

SECTION 9 HYPERBARIC EVACUATION SYSTEMS

A. General

A 100 Objectives

101 The purpose of this section is to outline general requirements for hyperbaric evacuation systems serving diving systems. Emphasis is placed on the special needs associated with the design and manufacture of such systems, including requirements given by IMO. Specific requirements for pressure vessels, life support systems etc. are given in each applicable chapter preceding this.

102 Key issues are identified by specifically adding to the IMO text in relation to self-propelled hyperbaric evacuation lifeboats, equipment for connection to support and rescue vessels and launch and recovery systems.

A 200 Application and scope

201 This section applies to all **DSV-BOUNCE** and **DSV-SAT** systems. **DSV-SURFACE** systems may have alternative contingencies planned.

202 SOLAS requirements shall be applied as far as practicably possible. This is particularly relevant to the launch and recovery systems.

203 These requirements may also be applicable as Flag State requirements.

204 Some testing requirements are given, limited to those specified in the original IMO text. Additional testing may be relevant depending on the type of evacuation system installed.

A 300 Documentation

301 See the relevant chapters in this Offshore Code for documentation requirements to the applicable equipment and systems.

For type approved lifeboats, relevant to SPHLs, particular document requirements are issued in connection with the type approval.

A 400 General Requirements and Preamble

401 The requirements in this subsection are in compliance with the IMO guidelines and specifications for hyperbaric evacuation systems - Resolution A.692(17), in the following referred to as the 'IMO guidelines. Much of the text in this chapter 9 is IMO text. If any parts of the rules are subject to discussion or misunderstanding, the IMO text shall prevail.

402 Hyperbaric evacuation units that are permanently connected to a certified diving system will, as a minimum, be regarded as deck decompression chambers and shall be certified as such. (See Sec.3). However, the minimum size requirements given in this standard shall be considered in each case.

Guidance note:

For split level diving, and diving operations deeper than 200 m, two hyperbaric evacuation systems may be required to cover the various pressure levels.

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

A 500 Introduction

501 These Guidelines and Specifications for Hyperbaric Evacuation Systems have been developed with a view to promoting the safety of all divers in saturation and achieving a standard of safety for divers which corresponds, so far as is practicable, to that provided for other seagoing personnel, and which will satisfy chapter 3 of the Code of Safety for Diving Systems (resolution A.536(13), as amended by resolution

A.583(14)).

A 600 Hyperbaric Evacuation Methods

601 It is recognised that there are various methods available for evacuating divers in an emergency and that the suitability of the various options for a safe hyperbaric evacuation depends on a number of factors including the geographical area of operation, environmental conditions, and any available offshore or onshore medical and support facilities.

Options available to diving contractors will include:

- 1) hyperbaric self-propelled lifeboats;
- 2) towable hyperbaric evacuation units;
- 3) hyperbaric evacuation units which may or may not be towable suitable for offloading on to an attendant vessel;
- 4) transfer of the diving bell to another facility;
- 5) transfer of the divers from one diving bell to another when in the water and under pressure;
- 6) negatively buoyant unit with inherent reserves of buoyancy, stability and life support capable of returning to the surface to await independent recovery.

The Guidelines and Specifications do not therefore attempt to specify which particular type of hyperbaric evacuation system should be employed and recommend that clients and diving contractors examine and identify the option most suited for the area and type of operation in which they are engaged. Consideration may have to be given to the provision of separate evacuation facilities for divers in saturation at significantly different depths.

A 700 Contingency Planning and Emergency Instructions

701 A potentially dangerous situation can arise if a floating unit, from which saturation diving operations are being carried out, has to be abandoned with a diving team under pressure. While this hazard should be reduced by pre-planning, under extreme conditions consideration may have to be given to hyperbaric evacuation of the divers. The hyperbaric evacuation arrangements should be studied prior to the commencement of the dive operation and suitable written contingency plans made. Where, in the event of diver evacuation, decompression would take place in another surface compression chamber the compatibility of the mating devices should be considered.

Once the hyperbaric evacuation unit has been launched, the divers and any support personnel may be in a precarious situation where recovery into another facility may not be possible and exposure to seasickness and accompanying dehydration will present further hazards. It is, therefore, necessary that diving contractors ensure that any such contingency plans include appropriate solutions. It should be emphasised that hasty or precipitate action may lead to a premature evacuation situation, which could be more hazardous in the final analysis.

In preparing the contingency plans, the various possible emergency situations should be identified taking into consideration the geographical area of operation, the environmental conditions, the proximity of other vessels, and the availability and suitability of any onshore or offshore facilities. The facilities for rescue, recovery and subsequent medical treatment of divers evacuated in such circumstances should be considered as part of the contingency plan. In the case of unattended hyperbaric evacuation units, consideration should be given to providing equipment to transfer the towline to an attendant vessel before launch of the evacuation unit. Such an arrangement would enable the unit to be towed clear immediately after launching. Copies of contingency plans should be available on board the parent vessel, ashore and in the hyperbaric evacuation unit.

A 800 Purpose

801 The purpose of these Guidelines and Specifications is to recommend design and construction criteria, equipment, survey standards and contingency planning for the evacuation systems referred to in chapter 3 of the Code of Safety for Diving Systems (resolution A.536(13)).

A 900 Application

901 The Guidelines and Specifications apply to new hyperbaric evacuation units which are constructed more than twelve months after the date on which the Assembly of the International Maritime Organization adopts these guidelines and specifications for units which can be mated to a surface compression chamber. However, any existing system which, complies with the provisions of these Guidelines and Specifications may be considered for endorsement of the safety equipment certificate in accordance with 4.2. (I 2502)

A 1000 Definitions

1001 "Self-propelled hyperbaric lifeboats" are in this text understood to mean hyperbaric evacuation units installed in self-propelled lifeboats operated by crew members and life support technicians located outside the hyperbaric environment.

1002 Definitions:

For the purpose of these Guidelines and Specifications the terms used have the meanings defined in the following paragraphs unless expressly provided otherwise:

| "Administration" | means the Government of the State whose flag a ship or floating struc- ture which carries a diving system is entitled to fly or in which the ship or floating structure is registered. |
|---------------------|---|
| "Bottle" | means a pressure container for the storage and transport of gases under pressure. |
| "Breathing mixture" | means air or any other mixture of gases used for breathing during evacuation and, if applicable, during decompression. |
| "Depth means" | the pressure, expressed in metres of seawater, to which the diver is exposed at any time during a dive or inside a surface compression cham- ber or a diving bell. |
| "Diving bell" | means a submersible compression chamber, including its ancillary equipment, for transfer of divers under pressure between the work location and the surface compres- sion chamber, and vice versa. |
| "Diving system" | means the whole plant and equip- ment necessary for the conduct of diving operations using transfer- under-pressure techniques. |

| "Hyperbaric evacuation system" | means the whole plant and equip- ment necessary for the evacuation of divers in saturation from a sur- face compression chamber to a place where decompression can be carried out. The main components of a hyperbaric evacuation system include the hyperbaric evacuation unit, handling system and life-sup- port system. |
|-----------------------------------|--|
| "Hyperbaric evacuation unit" | means a unit whereby divers under pressure can be safely evacuated from a ship or floating structure to a place where decompression can be carried out. |
| "Handling system" | means the plant and equipment nec- essary for raising, lowering and transporting the hyperbaric evacua- tion unit from the surface compres- sion chamber to the sea or on to the support vessel, as the case may be. |
| "Hazardous areas" | means those locations in which an explosive gas-air mixture is contin- uously present, or present for long periods (zone 0); in which an explo- sive gas-air mixture is likely to occur in normal operation (zone 1); in which an explosive gas-air mix- ture is not likely to occur, and if it does it will only exist for a short time (zone 2). |
| "Life-support system" | means the gas supplies, breathing gas system, decompression equip- ment, environmental control sys- tem, heating or cooling and other equipment required to provide a safe environment for the divers in the hyperbaric evacuation unit under all ranges of pressure that they may be exposed to during evac- uation and, if applicable, during the decompression stages |
| "Mating device" | means the equipment necessary for connecting and disconnecting a hyperbaric evacuation unit and a surface compression chamber. |
| "Maximum operating depth" | (of the diving system) is the depth in metres of seawater equivalent to the maximum pressure for which the diving system is designed to oper- ate. |
| "Pressure vessel" | means a container capable of with- standing an internal maximum working pressure greater than or equal to 1 bar. |
| "Compression chamber" | means a pressure vessel for human occupancy with means of control- ling the differential pressure between the inside and outside of the chamber. |

A 1100 Design and construction Principles

1101

1) The design and construction of the hyperbaric evacuation system should be such that it is suitable for the environmental conditions envisaged, account being taken of the horizontal or vertical dynamic snatch loads that may be imposed on the system and its lifting points particularly during evacuation and recovery. 2) The hyperbaric evacuation unit should be capable of being recovered by a single point lifting arrangement and means should be provided on the unit to permit a swimmer to hook on or connect the lifting arrangement.

Guidance note:

This standard interprets "single point lifting" as applicable to the lifting appliance and not the Hyperbaric Evacuation Unit. Further, it is interpreted to imply that only one hook-up is required to secure the load.

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

3) In the design of pressure vessels including accessories such as doors, hinges, door landings, closing mechanisms, penetrators and view ports, the effects of rough handling should be considered in addition to design parameters such as pressure, temperature, vibration, operating and environmental conditions. In general, piping penetrations through the chamber should have isolating valves on both sides.

4) Materials used in the construction of hyperbaric evacuation systems should be suitable for their intended use.

5) Component parts of a hyperbaric evacuation system should be designed, constructed and tested in accordance with standards acceptable to the Administration.

6) Components in the hyperbaric evacuation system should be so designed, constructed and arranged as to permit easy inspection, maintenance, cleaning and, where appropriate, disinfection.

7) The hyperbaric evacuation system should be provided with the necessary control equipment to ensure its safe operation and the well-being of the divers.

8) Special arrangements and instructions should be provided externally to enable the hyperbaric evacuation unit to be recovered safely. The instructions should be located where they will be legible when the hyperbaric evacuation unit is floating.

9) Hyperbaric evacuation systems should not be located in zone 0 or zone 1; hazardous areas and high fire risk areas should be avoided as far as is reasonably practicable.

A 1200 Equipment for connection to support and rescue vessels (HEU)

1201 The hyperbaric evacuation unit (HEU) shall have an arrangement for a possible connection of umbilical to the support vessel. The umbilical connection shall enable maintenance of proper environmental conditions in the chamber for an unlimited time, and contain aids for communication.

1202 Additional or emergency life support facility shall be provided for the HEU. The owner shall ensure that the facility is ready for use at all times during diving.

1203 This may be in the form of a Life Support Package (LSP) that shall be kept at a suitable location from where it can reach the HEU within reasonable time. A contingency plan, with risk analysis if necessary, shall be performed for verification. Compatibility of the LSP to the HEU shall be verified.

1204 Procedures for use of the LSP shall be included in the contingency plan and shall be available with the LSP and inside the HEU.

1205 Relevant emergency procedures shall be available in the HEU chamber, in the HEU control and with the LSP.

A 1300 Crew facilities (HEU)

1301 The chamber shall be equipped with one seat and one seatbelt for each diver.

1302 In case the HEU crew has to leave the HEU, it shall be possible to secure the chamber system in a way that makes it possible for the divers inside to take over the control of O_2 make-up and gas supply.

A 1400 Hyperbaric evacuation units 1401

1) The hyperbaric evacuation unit is to be designed for the rescue of all divers in the diving system at the maximum operating depth. The compression chamber should provide a suitable environment and adequate facilities, including, where appropriate, seat belts, for the maximum number of persons for which the unit is designed. The seating or other arrangements provided should be designed to provide an adequate degree of protection to the divers from impact collisions during launch and while the unit is afloat. Where the chamber is intended to be occupied for more than 12 h, arrangements for the collection or discharge of human waste should be provided. Where discharge arrangements are provided they should be fitted with suitable interlocks.

2) The means provided for access into the compression chamber should be such as to allow safe access to or from the surface compression chambers. Interlocks should be provided to prevent the inadvertent release of the hyperbaric evacuation unit from the surface compression chamber while the access trunking is pressurised. The mating flange should be adequately protected from damage at all times including during the launch and recovery stages.

3) Arrangement should be provided to enable an unconscious diver to be taken into the unit.

4) Compression chamber doors should be so designed as to prevent accidental opening while pressurised. All doors should be so designed that, where fitted, the locking mechanisms can be operated from both sides.

5) Arrangements should be provided to allow the occupants to be observed. If view ports are provided they should be situated so that risk of damage is minimised.

6) Where it is intended to carry out decompression of the divers after hyperbaric evacuation in another surface compression chamber, then consideration must be given to the suitability of the mating arrangements on that surface compression chamber. Where necessary, a suitable adapter and clamping arrangements should be provided.

7) A medical lock should be provided and be so designed as to prevent accidental opening while the compression chamber is pressurised. Where necessary, interlock arrangements should be provided for this purpose. The dimensions of the medical lock should be adequate to enable essential supplies, including CO_2 scrubber canisters, to be transferred into the compression chamber, and be of such dimensions as to minimize the loss of gas when the lock is being used.

A 1500 Life-support system

1501

1) Means should be provided to maintain all the occupants in thermal balance and in a safe and breathable atmosphere for all environmental conditions envisaged - air temperature, sea temperature and humidity - and with the maximum and minimum number of divers likely to be carried. In determining the duration and amount of life support necessary, consideration should be given to the geographical and environmental conditions, the \tilde{O}_2 and gas consumption and CO_2 generation under such conditions, the heat input or removal and the emergency services that may be available for the decompression of the divers. Gas losses as a result of using toilet facilities which discharge to outside the hyperbaric evacuation unit and medical lock operation should be taken into account in determining the amount of gases required. The effects of hypothermia should be considered and the effectiveness of the arrangements provided should be established as far as is reasonable and practicable under all conditions envisaged. However, in no such case should the duration of the unit's autonomous life-support endurance be less than 72 h.

2) In addition to any controls and equipment fitted externally, compression chambers should be provided with adequate controls within for supplying and maintaining the appropriate breathing mixtures to the occupants, at any depth down to the maximum operating depth. The persons operating the chamber, whether they are within or outside it, should be provided with adequate controls to provide life support. As far as practicable, the controls should be capable of operation without the person who operates them having to remove his/her seat belt.

3) Two separate distribution systems should be provided for supplying oxygen to the compression chamber. Components in the system should be suitable for oxygen service.

4) Adequate equipment should be provided and be suitably situated to maintain oxygen and carbon dioxide levels and thermal balance within acceptable limits while the life-support equipment is operating.

5) In addition to any instrumentation necessary outside the compression chamber, suitable instrumentation should be provided within the chamber for monitoring the partial pressures of oxygen and carbon dioxide and be capable of operation for the duration of the available life-support period.

6) Where it is intended that divers may be decompressed within the hyperbaric evacuation unit, provision should be made for the necessary equipment and gases, including therapeutic mixtures, to enable the decompression process to be carried out safely.

7) An adequate supply of food and water should be provided within the hyperbaric evacuation unit. In determining, in particular, the amount of water to be provided, consideration should be given to the area of operation and the environmental conditions envisaged.

8) A breathing system should be provided with a sufficient number of masks for all the occupants under pressure.

9) Provision should be made external to the hyperbaric evacuation unit, and in a readily accessible place, for the connection of emergency hot or cold water and breathing therapeutic mixture. The dimensions of the connections provided should be as follows:

3/4 in. NPT (female) - hot or cold water 1/2 in. NPT (female) - breathing mixture

The connections should be clearly and permanently marked and be suitably protected.

10) In hyperbaric evacuation units designed to pass through fires, the breathing gas bottles and piping systems and other essential equipment should be adequately protected. In addition, thermal insulation should be non-toxic and suitable for this purpose.

11) First-aid equipment, sickness bags, paper towels, waste disposal bags and all necessary operational instructions for equipment within the compression chamber should be available within the chamber, on board the parent vessel and ashore.

A 1600 Electrical systems and arrangements 1601

1) All electrical equipment and installation, including the power supply arrangements, should be designed for the environment in which they will be required to be operated and designed to minimize the risk of electrical capacity depletion as a result of a fault, fire or explosion, electric shock, the emission of toxic gases and galvanic action. Electrical equipment within the compression chamber should be designed for hyperbaric use, high humidity levels and marine application.

2) Power supplies required for the operation of life-support systems and other essential services should be sufficient for the life-support duration. The battery charging arrangements should be designed to prevent overcharging under normal or fault conditions. The battery storage compartment should be provided with means to prevent over-pressurisation and any gas released be vented to a safe place.

3) Each compression chamber should be provided with a source of lighting sufficient for the life-support time and of sufficient luminosity to allow the occupants to read gauges and operate essential systems within the chamber.

A 1700 Fire protection and extinction

1701

1) Materials used in the construction and installation should so far as is possible be non-combustible and non-toxic.

2) A fire-extinguishing system should be provided in the hyperbaric evacuation unit which should be suitable for exposure to all depths down to the maximum operating depth.

3) In hyperbaric evacuation units that are designed to float and may be used to transport divers through fires, consideration should be given, where practicable, to providing an external water spray system for cooling purposes.

4) Hyperbaric evacuation units on ships required to be provided with fire-protected lifeboats should be provided with a similar degree of fire protection.

Areas where Hyperbaric Evacuation Systems are located shall be protected so that effective evacuation can take place in the event of a fire. Control stands for Hyperbaric Evacuation shall be protected as specified in Sec.6 A400.

A 1800 Launch and Recovery Systems General

1801 The launching system shall comply with a recognised national code.

1802 An interlock system shall be fitted to the mating system between the evacuation unit and the evacuation-tunnel with functions as stated in Sec.3 B303 and B304 and Sec.7 B109.

A 1900 Launch and recovery of Hyperbaric Evacuation Units

1901 Where appropriate:

1) Means should be provided for the safe and timely evacuation and recovery of the unit and due consideration should be given to the environmental and operating conditions and the dynamic snatch and impact loadings that may be encountered. Where appropriate, the increased loadings due to water entrainment should be considered. Where the primary means of launching depends on the ship's main power supply, then a secondary and independent launching arrangement should be provided.

2) If the power to the handling system fails, brakes should be engaged automatically. The brake should be provided with manual means of release.

3) The launching arrangements provided should be designed to ensure easy connection or disconnection of the hyperbaric evacuation unit from the surface compression chamber and for the transportation and removal of the unit from the ship under the same conditions of trim and list as those for the ship's other survival craft.

4) Where a power-actuated system is used for the connection or disconnection of the hyperbaric evacuation unit and the surface compression chamber, then a manual or stored power means of connection or disconnection should also be provided.

5) The means provided for release of the falls or lift wire after the unit is afloat should provide for easy disconnection, particular attention being given to units not provided with an attendant crew.

6) Where the hyperbaric evacuation unit is designed to be recovered from the sea, or from a ship in a seaway, consideration should be given to the mode of recovery. Adequate equipment to enable a safe recovery of the unit should be provided on the unit. Permanently marked clear instructions should be provided adjacent to the lifting equipment as to the correct method for recovery, including the total weight of the hyperbaric evacuation unit. Consideration should be given to the effect which entrained water and any bilge water may have on the total weight to be lifted by the recovery vessel. Consideration should also be given to any means that can be provided for the absorption of the dynamic snatch loads imposed during the recovery of the hyperbaric evacuation unit from the sea.

A 2000 Fittings

2001 Fittings shall comply with Sec.8.

A 2100 Communications

2101

1) If breathing mixtures containing helium or hydrogen are used, a self-contained primary communication system fitted with an unscrambler device should be arranged for direct twoway communication between the divers and those outside the compression chamber. A secondary communication system should also be provided.

2) In addition to the communication system referred to in 12.1, a standard bell emergency communication tapping code should be provided which meets the requirements of that specified in the amendments to the Code of Safety for Diving Systems (resolution A.583(14)). Copies of the tapping code should be permanently displayed inside and outside the hyperbaric evacuation unit.

A 2200 Location Systems

2201

1) Hyperbaric evacuation units designed to be waterborne should be provided with a strobe light and radar reflector.

2) Hyperbaric evacuation units designed to be placed on the sea-bed to await independent recovery should be provided with an acoustic transponder. The transponder should be suitable for operation with a diver-held interrogator-receiver which will be retained on board the parent ship. The equipment provided should meet the requirements specified in the amendments to the Code of Safety for Diving Systems (resolution A.583(14)).

A 2300 Markings

2301

1) Dedicated hyperbaric evacuation units should be coloured orange and be provided with retro-reflective material to assist in their location during hours of darkness.

2) Each hyperbaric evacuation unit designed to be waterborne should be marked with at least three identical signs as shown below. One of these markings should be on top of the unit and be clearly visible from the air and the other two be mounted vertically on either side and as high as possible and be capable of being seen while the unit is afloat.



3) Where applicable, the following instructions and equipment should be clearly visible and be kept readily available while the unit is afloat:

- 1) towing arrangements and buoyant towline;
- all external connections, particularly for the provision of emergency gas, hot/cold water and communications;
- 3) maximum gross weight of unit in air;
- 4) lifting points;
- 5) name of the parent ship and port of registration; and
- 6) emergency contact telephone, telex and facsimile numbers.

4) *Warning instructions*. Where appropriate, the following instructions should be permanently displayed on every hyperbaric evacuation unit in two separate locations so as to be clearly visible while the unit is afloat:

"Unless specialised diving assistance is available:

- 1) do not touch any valves or other controls;
- 2) do not try to get occupants out;
- 3) do not connect any gas, air, water or other supplies;
- 4) do not attempt to give food, drinks or medical supplies to the occupants; and
- 5) do not open any hatches".

A 2400 Stability and buoyancy

2401

1) Hyperbaric evacuation units designed to float should be provided with adequate stability for all envisaged operating and environmental conditions and be self-righting. In determining the degree of stability to be provided, consideration should be given to the adverse effects of large righting moments on the divers. Consideration should also be given to the effect which equipment and rescue personnel, required to be placed on the top of the system to carry out a recovery from the sea, may have on the stability of the hyperbaric evacuation unit.

2) Towing attachment points should be so situated that there is no likelihood of the hyperbaric evacuation unit being capsized as a result of the direction of the tow line. Where towing harnesses are provided they should be lightly clipped or secured to the unit and, so far as is possible, be free from snagging when pulled free.

3) Hyperbaric evacuation units designed to float should have sufficient reserves of buoyancy to enable the necessary rescue crew and equipment to be carried.

4) Where hyperbaric evacuation units are designed to be placed on board a rescue vessel, attachment points should be provided on the unit to enable it to be secured to the deck.

A 2500 Self-Propelled Hyperbaric Evacuation Lifeboat

2501 If self propelled hyperbaric evacuation lifeboats are required by statutory regulations or installed to comply with operational criteria, the following requirements apply:

2502 The hyperbaric evacuation lifeboat's hull, machinery, equipment, manoeuvrability and seagoing properties shall comply with SOLAS 1974 (International Convention for the Safety of Life at Sea) and a relevant recognised national code.

Guidance note:

Lifeboats may be type approved.

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

2503 The hyperbaric evacuation lifeboat shall be fitted with seating arrangement sufficient to carry the maximum number of divers and crew members in a sitting position.

2504 The hyperbaric evacuation lifeboat shall have a sheltered area for at least 3 crew members in addition to the divers in the chamber. In this sheltered area the controls for the hyperbaric evacuation unit shall be located.

2505 The system shall be designed such that the time necessary to disconnect and launch the hyperbaric evacuation lifeboat shall not exceed 10 minutes, counted after all divers and crewmembers have entered the hyperbaric evacuation lifeboat and until it is free floating with the engine running.

2506 The chamber shall have windows towards the sheltered part in the lifeboat.

2507 The hyperbaric evacuation lifeboat shall have a self-contained support system with capacity for at least 72 hours.

2508 The hyperbaric evacuation lifeboat shall have emergency radio communication and location systems complying with requirements given in IMO Resolution A.809(19) in reference to SOLAS Regulation III/6.2.1 and III/6.2.2.

2509 The propulsion unit shall have sufficient power for 10 minutes running without using air from the atmosphere outside the boat. (Depending on the required level given in the safety certificate of the support vessel, this may also be a requirement for the HEU.)

2510 Masks for breathing or breathing apparatus shall be available for the crew members and life-support technicians at atmospheric pressure. The masks shall be connected to air storage sufficient for 30 minutes breathing.

A 2600 Testing, Surveys and Drills - General

2601 Testing of the hyperbaric evacuation system with hyperbaric evacuation unit and the handling system shall be carried out to the maximum possible extent to SOLAS requirements and to Sec.2 J.

A 2700 Maintenance and Testing

2701 The availability of any hyperbaric evacuation system provided is dependent on the regular testing and maintenance of the system. A planned maintenance and testing programme shall be devised with the responsibility for carrying out the maintenance tasks being allocated to specific crew members. Maintenance and testing schedules shall be available for

recording the execution of the tasks and the signatures of the persons allocated the tasks. Such schedules shall be maintained on board and be available for inspection.

A 2800 Surveys

2801 DNV scopes for surveys of diving systems are given in DNV-OSS-305 "Rules for Certification and Verification of Diving Systems" and in the relevant Classification Rules.

2802

1) Each hyperbaric evacuation system should be subject to:

- an initial survey before being put into service. This should comprise a complete and thorough examination of the hyperbaric evacuation system, equipment, fittings, arrangements and materials including functional tests which should be such as to ensure they are suitable for the intended service and in compliance with these guidelines and specifications;
- 2) a survey at intervals specified by the Administration but not exceeding 2 years; and
- 3) an annual inspection within 3 months of each anniversary date of the survey to ensure that the hyperbaric evacuation system, fittings, arrangements, safety equipment and other equipment remain in compliance with the applicable provisions of the Guidelines and Specifications and are in good working order.

2) Where a hyperbaric evacuation system complies with the provisions, as applicable, of the Guidelines and Specifications and has been duly surveyed, it may be recorded on the supplement to the Cargo Ship Safety Equipment Certificate as providing the life-saving appliances and arrangements for divers in compression.

A 2900 Training and Evacuation Drills

2901 Periodic training exercises should be carried out to test the operation of the hyperbaric evacuation system and the efficiency of the personnel responsible for the hyperbaric evacuation of the divers. Such training exercises should not normally be carried out while the chambers are pressurised, but should be carried out at each available opportunity.

APPENDIX A **DYNAMIC LOADS IN BELL HANDLING SYSTEMS**

sr

g

d

A. General

A 100 General

101 Approximate estimates of expected dynamic loads during handling of diving bell and any connected cursor from a vessel which is stationary and heading in the main direction of incoming waves in the design sea-state are given in B and C.

The specified methods for calculation of hydrodynamic forces are limited to the cases in which the vertical motions of the suspended bell may be taken equal to the corresponding motions of the support vessel. The conditions permitting such assumptions are specified in B102.

Other approximate or more accurate methods may be acceptable upon consideration in each case.

Reference should also be made to DNV-RP-C205 "Environmental Conditions and Enviromental Loads".

A 200 **Definitions and Abreviations**

201 Parameters applied for calculation of the forces.

- = mass of bell in air corresponding to its working weight m including trapped water {kg}
- mass density of seawater = 1030 kg/m^3 . =
- Ń volume of displaced water $\{m^3\}$.
- А = cross sectional area of bell with appendices projected on a horizontal plane $\{m^2\}$.
- coefficient for added mass (water). (For typical diving C_m = bells with appendages such as gas containers, bumper structure etc. the coefficient may be taken as $C_m = 1.0$).
- Above water $C_m = 0$. $C_d = drag$ coefficient. (For typical diving bells with appendages the coefficient may be taken as $C_d = 1.5$).
- maximum expected vertical acceleration of the = а
- bell $\{m/s^2\}$. maximum expected vertical relative acceleration a_r = between bell and water particles $\{m/s^2\}$
- = maximum expected vertical velocity of the bell $\{m/s\}$. v maximum expected vertical relative velocity between Vr
- bell and water particles $\{m/s\}$. reduction factor for the wave action on the bell, fw = depending on the submerged depth z of the bell, given by:

$$\left(-0.32\frac{z}{h_s}\right)$$

submerged depth of the bell $\{m\}$ when larger than h_s Z

= significant wave height $\{m\}$. hs

Guidance note:

Significant wave height: When selecting the third of the number of waves with the highest wave height, the significant wave height is calculated as the mean of the selection.

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

e =
$$2.72$$

 $f_a \text{ and } f_v =$ reduction factors due to wave action (see B102)
under the heading "Motions of ship shaped sup-
port vessels".

- stiffness of the handling system $\{N/m\}$. k
- CB = block coefficient of vessel.
- R_p horizontal distance from centre of mass (i.e. bell) to the axis of rotation, which may be taken at 0.45 L from the after perpendicular of the vessel $\{m\}$.
- cross sectional area of moon pool. A_w

- = maximum expected relative amplitude (+/-) of motion between sea surface and support vessel in way of moon pool {m}
- acceleration of gravity = 9.81 m/s^2
- draught of vessel at bottom of opening for moon- pool for $d > h_s \{m\}$

202 Parameters applied for correction of units in empirical formulae:

$$h_1 = 1 \text{ m}^{-1}$$

$$L_1 = 1 \text{ m}^{-1}$$

$$u_1 = 1 \text{ m/s}$$

$$u_2 = 1 m$$

B. Loads on Negative Buoyant Bell

B 100 Loads on bell clear of support vessel

101 Forces.

In a free flow field the maximum vertical hydrodynamic load F_n acting on a negative buoyant bell in the design sea-state may be taken as the smaller of the values obtained from the two following formulae:

$$F_n = \pm \sqrt{F_{aw}^2 + F_v^2} \qquad \{N\}$$

$$F_n = \pm \sqrt{F_a^2 + F_w^2 + F_v^2}$$
 {N}

 F_{aw} = force due to the combined acceleration of bell and water particles, given by:

$$F_{aw} = (m - \rho V)a + \rho V(1 + C_m)f_aa_r \quad \{N\}$$

= force due to the relative velocity between bell and Fv water particles, given by:

$$F_v = 0.5 \rho A C_d (f_v v_r)^2 \{N\}$$

Fa = force due to acceleration of bell, given by:

$$F_a = (m + C_m \rho V)a \qquad \{N\}$$

= force due to acceleration of water particles in the Fw deepest wave, given by:

$$F_w = 0.4(1 + C_m)f_w \rho V g$$
 {N

The parameters and principles applied for calculation of the forces are given in B102.

102 *Motions of ship shaped support vessels.*

The vertical motions of the bell may be taken equal to those of the support vessel when the natural oscillating period of the handling system is less than 3 seconds, as given by:

$$2\pi \sqrt{\frac{m+\rho VC_m}{k}} < 3$$

For calculation of the forces from the formulae given in B101 the launching or retrieval velocities are to be added to v and v_r .

The estimation method for a and a_r as well as v and v_r given in the following may be used for vessels with length between perpendiculars L {m} in the range:

operating in sea-states with significant wave heights h_s {m}of magnitude:

$$2 < h_s < 8$$

The heave acceleration a_z of the support vessel is given by the smaller of:

$$a_{z} = \frac{(5 h_{1} h_{s} - 0.02 h_{1} h_{s} L_{1} L + 1) \cdot g}{100} \{m/s^{2}\}$$

or a_z as obtained from the *Rules for Classification of Ships*. The pitch acceleration a_p of the support vessel is given by:

$$a_{p} = \frac{3.5}{C_{B}} \frac{R_{p}}{L} \cdot a_{z} \qquad \{m/s^{2}\}$$

The combined vertical acceleration from heave, pitch and roll is given by:

$$a = \sqrt{(r a_z)^2 + a_p^2} \{m/s^2\}$$

r = coefficient of roll

= 1.0 at centreline of vessel

= 1.2 at sides of vessel

The relative acceleration a_r between vessel and water particles at surface is given by:

$$\mathbf{a}_{\mathrm{r}} = (0.15q_{\mathrm{v}}/\overline{\mathbf{h}_{\mathrm{l}}\cdot\mathbf{h}_{\mathrm{s}}}) \cdot \mathbf{g} \qquad \{\mathrm{m/s}^{2}\}$$

q = coefficient for position of bell.

= 1.3 at stern.

- = 1.1 at sides amidship.
- = 1.0 at vessel's centreline amidship.

The vertical velocity of the vessel may be taken as:

$$\mathbf{v} = \left(14 - 4.5 \frac{R_p}{L}\right) \frac{\mathbf{a} \cdot \mathbf{u}_1}{g} \qquad \{m/s\}$$

The relative vertical velocity between vessel and water particles at surface is given by:

$$v_r = (0.04 \cdot L_1 \cdot L + 6) \frac{a_r \cdot u_1}{g}$$
 {m/s}

 f_a = reduction factor for vertical relative acceleration of bell due to wave action, given by:

$$f_a = \frac{a + (a_r - a)f_w}{a_r}$$

 f_v = reduction factor for vertical relative velocity of bell, given by:

$$f_v = \frac{v + (v_r - v)f_w}{v_r}$$

B 200 Hydrodynamic Loads on bell in moon pool

201 In the flow field of a moon pool (narrow well) the <u>maximum vertical hydrodynamic</u> load F_m acting on a negative buoyant bell may be taken as derived from B100, when C_m and C_d are substituted by $f_m \cdot C_m$ and $f_d \cdot C_d$ respectively, where:

$$f_{\rm m} = 1 + 1.9 (A / A_{\rm w})^{2.25}$$
$$f_{\rm d} = \frac{1 - 0.5 A / A_{\rm w}}{(1 - A / A_{\rm w})^2}$$

The factors f_m and f_d obtained from the above apply to moon pools of constant cross section and for the ratio $A/A_w < 0.8$

The relative accelerations a_r and velocities v_r refer to the flow field above the bell.

When A/A_w approaches 1, the hydrodynamic load on the bell approaches the dynamic part of the bottom pressure, and may be taken as:

$$F_{\rm m} = \pm As_{\rm r} \rho g e^{\left(-0.32\frac{\rm d}{\rm h_s}\right)} \{N\}$$

For a moon pool at the centreline of the support vessel s_r may be taken as:

$$s_r = (0.064 \cdot L + 1.6 \cdot u_2) \frac{a_r}{g}$$

where a_r is obtained from B102.

Symbols, see A200.

B 300 Impulse Loads

301 Impulse loads F_i caused by sudden velocity changes in the handling system by start, stop and snatch loads in hoisting ropes may be taken as :

$$F_i = v_i \sqrt{k (m + \rho V C_m)} \qquad \{N\}$$

 v_i = impulse velocity {m/s} obtained from B302 or B303.

Symbols defined in A200.

302 Impulse velocity

The impulse velocity v_i during start and stop may be taken as the maximum normal transportation velocity.

303 Slack

Slack hoisting rope may be expected when

$$|\mathbf{F}_{\mathbf{n}}| \ge (\mathbf{m} - \rho \mathbf{V}) \mathbf{g}$$

When F_n (obtained from B100) is mainly wave induced and a snatch load is of short duration relative to the wave period i.e. when the natural oscillating period of the handling system is less than 3 seconds as given in B102, then the impact velocity v_i may be taken as:

 $v_i = v_1 + v_2 C_i$ $v_1 = \text{free fall velocity } \{m/s\} \text{ in calm water}$

$$v_1 = \sqrt{\frac{2(m - \rho V) g}{\rho A C_d}}$$
 for symbols see A200.

 $_2 = v_r f_v$ as obtained from B102 for tight hoisting ropes

= probability coefficient obtained from the table below

| Table B1 C _i versus v ₁ /v ₂ | |
|---|--|
| $\frac{v_1}{v_2}$ | C_i |
| $\frac{v_1}{v_2} \le 0.2$ | 1 |
| $0.2 < \frac{v_1}{v_2} < 0.7$ | $\cos\!\left(\pi \; \frac{v_1}{v_2} - 0.2\pi\right)$ |
| $\frac{v_1}{v_2} \ge 0.7$ | 0 |

C. Loads on a Positive Buoyant Bell (at surface)

C 100 Impulse loads

01 Impulse loads Fi caused by sudden velocity changes in

the handling system by start, stop and snatch loads in hoisting ropes may be taken as follows:

$$F_i = v_i \sqrt{k(m + \rho V_e 0.6 C_m)} \{N\}$$

102 <u>Impulse velocity</u> is taken to be as follows:

$$v_i = v_r + v_{hoist}$$

 $v_r = from B102. \{m/s\}$ $v_{hoist} = normal transportation speed.$

D. Design loads

D 100 Maximum load

101 <u>The maximum load P</u> in the vertical direction may be taken as follows:

In water:

$$\mathbf{P} = (\mathbf{m} - \rho \mathbf{V})\mathbf{g} + \mathbf{F}$$

where F is the larger of F_n and F_i obtained from B100, B200 and B300.

In air:

$$P = mg + \sqrt{(ma)^2 + F_i^2}$$

102 The <u>design load in the vertical direction</u> may be obtained from the following table.

| Table D1 Design loads | | |
|-------------------------|---|--|
| $\frac{P}{m g}$ | Design load | |
| $\frac{P}{m g} \le 2$ | Р | |
| $2 < \frac{P}{m g} < 3$ | $\left(1.5 - 0.25 \frac{P}{m g}\right) P$ | |
| $\frac{P}{m g} \ge 3$ | 0.75P | |