Observation:

Decompression Sickness Assessment

within a

Two-Person Two-Compartment DDC

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Review History & Distribution	
01 Rev April 2024	First issue
02 August 2024	Added NORSOK DDC requirements
3.1 September 2024	Tidy up. Changed some wording to align with IMO
3.2 February 2025	Added some supplementary information from IMCA D85
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5.3 September 2025	Added Suggestion/Action 9.2.2
5.4 April 2026	Review. A few minor changes to grammar.

Acronyms, Initialisms, Glossary of Terms & Brief Explanations

AGE	Arterial Gas Embolism	
BIBS	Built In Breathing System	
DCS	Decompression Sickness	To keep the report simple the author is using Decompression Sickness (DCS) throughout this report , not 'illness'.
DCI	Decompression Illness	
DDC	Deck Decompression Chamber. This abbreviation is used throughout this document when referencing to a two-person two-compartment chamber for recompression and treatment of an IP with or with suspected decompression sickness	
DMAC	Diving Medical Advisory Committee- an independent committee, formed in 1974 to provide advice about medical and certain safety aspects of commercial diving.	
DMAC001	*Aide Mémoire for Recording and Transmission of Medical Data to Shore* Industry standard for recording medical examination of a diver with or with suspected DCS. DMAC001 is based on Appendix 5A of the USN Diving Manual	
DMAC 15	Medical Equipment to be Held at the Site of an Offshore Diving Operation Industry standard for minimum medical equipment required on a diving site	
DMP	Diving Medicine Physician. A doctor who has the experience background and training (competence) to manage the treatment of diving accidents and illnesses. Such a doctor will have undergone specialised training and have demonstrated experience in this field. Appointed by the diving organisation with contact details in the diving emergency response plan.	
DMT	Diver Medical Technician. Also known as a Diver Medic or DMT. A member of the dive team who is trained in advanced first aid and basic paramedical techniques.	
DSMS	Diving Safety Management System	
DVD	Digital Versatile Disc Within this document DVD is used as a generic abbreviation for digital formatted presentation	
ERP	Emergency Response Plan.	
HRF	Hyperbaric Reception Facility. This is an onshore DDC used in case the offshore DDC is comprised, such as a dive platform fire/flood/ whilst divers are undergoing routine surface supplied diving decompression or therapeutic treatment.	
IMCA	International Marine Contractors Association	
IMCA DESIGN	*Diving Equipment System Inspection Guidance Note* The DESIGN suite of documents tubulises the minimum acceptable requires on a dive site. The DESIGN documents are the system 'Audit'	
IMCA D36	Notes Accompanying the IMCA DVD Neurological Assessment of a Diver. IMCA D36 explains how to carryout neurological examinations that are in the DVD	
IMCA 36 DVD	*Neurological Assessment of a Diver* Used to aid formal training and refresher training on undertaking a neurological assessment of a diver https://www.youtube.com/watch?v=sB6MGcX4jGI Note: This instructional presentation has been produced and is available in many formats, within this document it is referred to as a DVD	
IMO	International Maritime Organization. The United Nations specialized agency with responsibility for the safety and security of shipping (includes a Diving Safety Code)	
IP	Injured Person	
USN	United States Navy	

1.0 Executive Summary

Emergencies are, by nature, unexpected and differ from routine failures in that they require prompt, correct action to recover and prevent further deterioration of the situation. However, an IP with DCS (and/or a dysbaric injury) is always a potential event at any diving site regardless of depth, and the correct equipment and procedures should be planned for and in place.

A diver or divers could have life-changing injuries upon completing treatment for a DCS, including a permanent reduction in psychological, social or cognitive function, that can lead to an end to their diving career and livelihood.

Any resulting legal case could quickly establish that industry best-practice guidance (IMCA 36/DMAC001) cannot be applied in a two-person, two-compartment DDC, as demonstrated and described in industry standards. This is because the constraints of the environment, ergonomics, and allowable occupancy (in some cases) make most industry DCS diagnostic examination guidance impossible to perform in a two-person DDC. This breach of duty of care exposes the diving supervisor and the diving organisation to legal action.

2.0 Introduction

Diving operations involve unique occupational health and safety issues in an unforgiving environment.

Although diving types differ significantly in their decompression risks, a serious incident can arise after any exposure to pressure, no matter how safe it may have seemed.

A suite of project procedures for site-specific contingency plans supported by risk assessments must be in place before diving operations for all foreseeable emergencies. These procedures provide references to personnel responsible or involved in a diving project in the event of an emergency. The main document is the ERP.

When planning surface-supplied diving operations, the ERP should address scenarios including;

1. Recovery of an incapacitated diver from working depth to a safe place for treatment
2. Treatment of decompression illness or dysbaric injury
3. The evacuation of a surface-supplied diver from a stricken vessel or fixed/floating structure with omitted decompression, a chamber for recompression , and medical treatment

Dive teams practice for these worst-case events so they and the equipment are prepared and the team members understand individual and team roles.

Some readers may consider that some suggestions within this report go beyond ALARP or best practice.

2.1 Background to this Report

During offshore continuation training and ongoing competency assessment, a surface-supplied (air) diver rescue and subsequent decompression sickness drill was conducted. The diving organisation's drill matrix and procedures were followed during the drill. This report communicates the findings and lessons from that drill.

2.2 Limitations of the Report

The lessons learned and subsequent suggested improvements are based on commercial surface-supplied divers at an offshore diving site, using industry-accepted equipment, including the DDC. Other scenarios, such as onshore hyperbaric treatment facilities, may render some suggestions less relevant.

The documents referenced are 'industry standard': IMCA, DMAC, and USN. The author has not reviewed every global document on this topic.

This report does not suggest that current DCS treatments, such as pressure and oxygen, are inadequate.

2.3 Referenced Material

There are many documents referenced in this report. However, the primary documents/materials referred to are:

IMCA D36	DVD Neurological Assessment of a Diver Rev 0.1 Feb 2024
IMCA D36	Notes Accompanying the IMCA DVD Neurological Assessment of a Diver Feb 2024
DMAC001	Aide Mémoire for Recording and Transmission of Medical Data to Shore July 2015
USN	Diving Manual Rev 7

3.0 Aims of this Report

The primary aim of this observation report is to persuade industry leaders and influencers to:

1. Identify, evaluate, and, where practical, mitigate gaps in neurological examination practices for surface-supplied diving and in the available guidance within a two-person, two-compartment DDC.
2. Provide basic background information on the needs and requirements of a surface-supplied diver with decompression illness.
3. Encourage and consider developing a specific instructional presentation that clearly and consistently demonstrates neurological assessments for surface-supplied diving in a two-person, two-compartment DDC.
4. When supporting surface-supplied diving operations, give second DDCs, both offshore and onshore, a fresh perspective.

4.0 Industry Guidance Interrelationship

Throughout this report there are references to industry guidance in regard to neurological assessment. This section gives insight to the relationship between the guidance material and its use. The reader needs to understand the relationship between these documents and the training presentation's history.

USN Diving Manual Appendix 5A

The original neurological examination checklist. This is a non-mandatory checklist available for use by the US military. Used for gathering essential details and conducting a neurological examination.

DMAC001 Aide Mémoire for Recording and Transmission of Medical Data

DMAC001 is based on the examination detailed in the US Navy Diving Manual, this is so '*In the interests of being able to use and interpret standardised procedures world-wide*'. DMAC001 is used throughout the commercial diving industry to record and then communicate results of any examination to the onshore DMP for information and further advice. DMAC 001 is split in to three parts:

Part 1: Essential information
Part 2: Collects more details for permanent record of the incident and to assist in accident analysis
Part 3: Form for recording examination. Used for the initial and any repetitive examinations

IMCA D36 DVD Neurological Assessment of a Diver

IMCA D36 DVD examinations demonstrated are based (but not exclusively) on the examinations detailed in DMAC001.

The purpose of this DVD is to aid formal training of undertaking an assessment and used as refresher training. The DVD shows approximately three signs and symptoms and approximately twenty-two examinations. The DVD is demonstrating some of the examinations required in DMAC001 which are replicating the examinations in the USN Diving Manual.

IMCA D36 Notes Accompanying the IMCA DVD Neurological Assessment of a Diver

IMCA D36 Notes are based on the examination demonstrated within IMCA D36 DVD.

This document gives further explanation to some of the IMCA D36 DVD examinations and lists the equipment needed for the neurological examination.

Note:

There are examinations within DMAC001 Part 3 Section D that are not demonstrated in the IMCA 36 DVD or explained in the IMCA D36 supporting notes.

5.0 Responsibilities During a Decompression Sickness Diagnosis & Treatment

The hierarchy for the diagnosis and treatment of a suspected DCS case is as follows:

1. Diving Supervisor

The diving supervisor signed on to the Diving Operations Log is responsible for the IP's diagnosis, care and treatment, including any drugs that may be administered.

Diving supervisors are responsible for the health and safety of divers participating in the diving operations they are appointed to supervise. Regardless of company structure, the on-shift diving supervisor is in charge unless they formally hand over control to an appropriately qualified person who signs the Diving Operations Log.

Others at the offshore site, such as other supervisors and possibly a superintendent, will also assist.

The UK Commercial Diving Projects Offshore-Diving at Work ACoP L103 states: *The supervisor remains in overall control when a diver inside a deck chamber requires medical treatment, whether medical personnel are present or are communicating by long distance.*

2. Chamber Attendant

All treatments require an attendant to be present within the chamber. At a minimum, the attendant should know the symptoms and treatment of acute oxygen poisoning and be competent to conduct neurological checks. In practice, the dive team is usually arranged so that the attendant is a DMT. IMCA D85 states that a DMT must attend all treatments. The USN manual states that it must be a suitably trained tender.

The DMT conducts neurological checks and reports findings directly to the supervisor on the outside or notes findings on a company checklist that is forwarded to the DMP. The checklist is usually based on DMAC001.

3. DMP

A suitably qualified medical doctor will be available, with the necessary expertise to advise on appropriate treatment for divers. The project documentation will state the diving organisation-appointed DMP and their contact details.

The DMP will advise the diving supervisor based on the information in the completed neurological checklist and will speak directly with the DMT, IP, or on-site supervisor. Information will be communicated from the dive site to the DMP for advice.

The DMP advises the diving supervisor on appropriate treatment.

IMCA D85 requires that the diving organisation *prepare a medical plan with its medical adviser, covering initial first-aid requirements and specialist medical advice as needed*.

Note that this commercial diving hierarchy differs from the USN military hierarchy. The USN Diving Medical Officer is typically on-site and locks in and out of the DDC as the IP's condition dictates.

6.0 Repeatability of Examinations

When a diver is suspected of having decompression sickness or arterial gas embolism, evaluating him for symptoms in accordance with the diving organisation's treatment procedures will help establish the diagnosis. However, the time that treatment can be delayed depends on the urgency of beginning treatment, which in turn depends on the IP's condition. The diving organisation's treatment procedures should state when a neurological examination should begin.

Industry documentation states :

> DMAC001 Part 3: *This part will need to be used initially for the first examination and may be used repetitively at the onshore doctor's request*.
>
> Part 3 – Section D: Nervous System: This may be the most frequently repeated of the examinations, and this section may need to be used and transmitted several times
>
> IMCA D36 Introduction: *The tests should be repeated periodically at depth and after surfacing*.
>
> USN 17-4.3 Treatment of Type I Decompression Sickness. *Type I Decompression Sickness is treated in accordance with Figure 17-2. If a full neurological exam is not completed before initial recompression, treat it as Type II DCS.*
>
> USN 17-2.6…… *Observation of the patient, including the performance of repeat neurological exams, is the principal method of diagnosing the patient's illness, and the depth and time of their relief help determine which treatment table is used.*
>
> USN 17-6.2 Type I DCS ….*After arrival at 60 fsw, a neurological exam shall be performed to ensure no overt neurological symptoms (e.g., weakness, numbness, loss of coordination) are present.*
>
> USN 17-6.3 Type I DCS symptoms where relief is not complete within 10 minutes at 60 feet or where pain is severe and immediate recompression must be instituted before a neurological examination can be performed

The neurological examination should be conducted several times before, during, and after treatment. Ideally, the examinations should be repeatable so that comparisons can be made to identify whether treatment is effective.

7.0 Overview of DCS and Treatment Process

This section gives a simple overview of the DCS treatment process. It is targeted at non-diving personnel.

7.1 Simplified Mechanics of DCS

A diver's blood and tissues absorb additional nitrogen from the lungs when at depth. If a diver ascends too fast this excess gas will separate from solution and form bubbles. These bubbles produce mechanical and biochemical effects that lead to a condition known as decompression sickness. Decompression Sickness is a systemic disease that can result in severe neurologic consequences.

7.2 Decompression Sickness, Categorisation

Generalisation of decompression sickness types for the purposes of this report. They may manifest as either:

- Type I musculoskeletal pain
- Type II involvement of the central nervous system and organs of special sense

The treatment of Type I and Type II symptoms may be different, so it is important to distinguish between these two types.

7.3 Distinguishing between DCS Types

The diver may exhibit certain signs that only trained observers will identify as decompression sickness. Some of the symptoms or signs will be so pronounced that there will be little doubt as to the cause. Others may be subtle and some of the more important signs could be overlooked in a cursory examination. Type I and Type II symptoms may or may not be present at the same time.

7.4 Pre-Treatment Assessment

The way all doubt is removed and to confirm the diver has and what type of DCS, is by assessment and/or examination. The diving industry standard to be followed is DMAC 001, for the initial (if any), and subsequent examinations to determine (general) category of DCS, and therefore, appropriate treatment. The pre-treatment examination usually depends on the severity of symptoms and severity of pain being experienced.

7.5 Therapeutic Treatment

Treatment will be in accordance with the diving organisation's diving manual, however, most treatment tables are based on the suite of US Navy recompression treatment tables contained within the latest revision of the USN Diving Manual.
Treatment of de will be pressure and raised oxygen levels. This is always the priority.

7.6 Examinations during Treatment

Further examinations are carried out at pressure, in the DDC, during the treatment to determine if the IP has relief or if symptoms are worsening. DMAC 001 is used for these further examinations. The results should then be communicated to the onshore DMP.

7.7 Communication with Diving Organisation's Onshore DMP

The results of any examination and assessments along with any photographs are communicated from the worksite to the diving organisation's DMP using DMAC 001 *Aide Mémoire for Recording and Transmission of Medical Data* (or the diving organisations version approved by their DMP*)* If examinations at depth indicate worsening symptoms or no relief, the treatment table might be extended or changed.
The method of communication should be in the diving organisations DSMS and project specific procedures.

8.0 Findings

The following section shows relevant industry standards and highlights some differences and demonstrates that it is currently not possible to give all divers the same level of examination when treatment is required within a two-person, two-compartment DDC, due to the ergonomics of the DDC environment.

1. Overview of some differences between the different industry standards and the practical application of the examination within a two-person, two compartment DDC.
2. Overview to whether the IMCA D36 / DMAC001 examination can be accurately replicated, as demonstrated in the DVD, within a two-person two-compartment DDC.
3. There are several statements within current documentation and within the DVD that give conflicting advice. The following identifies a selection of these. This is not intended to be a definitive gap analyses of all reference material.

8.1 Gap Analysis of Industry Standard Examinations for Suitability within a Two-Person DDC

The photographs below, are screen grabs taken from IMCA D36 DVD.

8.1.1 Mental Status

1

DMAC 001 Part 1 Section A Item 8 State of consciousness

DMAC 001 Part 3 Section D Item 3 State of consciousness

IMCA 36 DVD demonstrates: Standing

IMCA D36 Section 4 Mental Status

It is unlikely that the three examples demonstrated will manifest within a two-person two compartment DDC whilst under pressure.	✗
Potential Mitigation:	Develop a new digital presentation showing a diver showing these signs/symptoms at work, post dive; such as acting as a tender, operating a DDC or in the mess room.

2

3

8.1.2 Co-ordination Tests

1

Heel to Toe

DMAC 001 Part 3 Section D Item 21.States: Standing.

IMCA 36 DVD demonstrates: Standing.

IMCA D36 Section 5.1 Walking. States: Standing.

(USN Manual 5A-3.2 : Standing)

Cannot be performed as stated/demonstrated within a two-person two-compartment DDC.	X

Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whist on deck.

2

Romberg

DMAC 001 Part 3 Section D Similar to Item 22/23 ,but not the same as demonstrated.

IMCA 36 DVD demonstrates: Standing.

IMCA D36 Section 5.2 States: Standing.

(USN Manual 5A-3.2: Standing)

Cannot be performed as stated/demonstrated within a two-person two-compartment DDC.	X

Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whist on deck.

3

Finger -to-Nose Test (1)

DMAC 001 Part 3 Section D Similar to Item 19 but not the same as demonstrated.

IMCA 36 DVD demonstrates: Standing.

IMCA D36 Section 5.4 Finger to nose. States: Standing.

(USN Manual 5A-3.2 : Standing)

Cannot be performed as stated/demonstrated within a two-person two-compartment DDC.	X

Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whist on deck.

4

Finger -to-Nose Test (2)

DMAC 001 Part 3 Section D Item 19. States: Standing.

IMCA 36 DVD demonstrates: Sitting.

IMCA D36 Section 5.4 Finger to nose. States: Standing.

Cannot be performed as stated/demonstrated within a two-person DDC. This exam can only be performed when not on BIBS.	X

Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted within a two-person DDC.

Note: There might not be two bunks, if there are, they are very close together.

5

Heel Shin Slide Test

DMAC 001 Part 3 Section D Item 20. States: Lying flat

IMCA 36 DVD demonstrates: Standing

IMCA D36 Guidance 5.5 states: Standing

(USN Manual 5A 3.2: Standing)

Cannot be performed as demonstrated, within a two-person DDC	✗

Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted lying flat in a two-person DDC

6

Rapid Alternating Movement (dysdiadochokinesis)

DMAC 001. This examination is not stated

IMCA 36 DVD demonstrates: Sitting

IMCA D36 Guidance Section 5.3 States: Neither Sit nor Stand

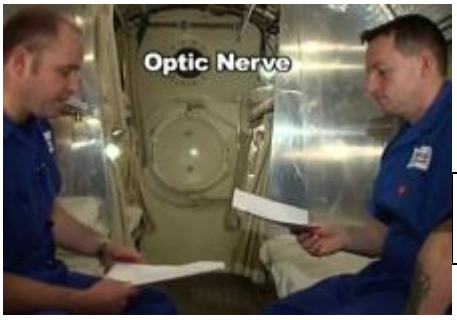
This can be performed as demonstrated, within a two-person DDC	✓

This exam is not specifically stated in DMAC001, however it is stated within the USN Diving Manual.

Develop a new digital presentation showing this examination being conducted in a two-person DDC. Add to DMAC001.

8.1.3 Cranial Nerves

1



Optical Nerve

DMAC 001 Part 3 Section D Item 6. The stated test is different to the one demonstrated for normal vision.

IMCA 36 DVD demonstrates: Sitting.

IMCA D36 Guidance Section 5.8

This can be performed as demonstrated/stated, within a two-person DDC. This exam can only be performed when not on BIBS.	✓

This exam is not specifically stated in DMAC001. Develop a new digital presentation showing this examination being conducted in a two-person DDC. Consideration needed for contact lens/glasses, level of literacy (and possibly ability to read English) and level of lighting in DDC. Consider introducing a benchmark for this test during pre-dive medical

2

Field of Vision

DMAC 001 Part 3 Section D Item 6. The stated test is different to the one demonstrated for normal vision.

IMCA 36 DVD demonstrates: Sitting.

IMCA D36 Guidance Section 5.8

Cannot be performed as demonstrated, within a two-person DDC. Depending on the DDC ergonomics the 12 o'clock check of peripheral vision might not be as demonstrated. This exam can only be performed when not on BIBS.	✗

Potential Mitigation: Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-person DDC.

3

Oculomotor, Trochlear & Abducens

DMAC 001 Part 3 Section D Item 1/4/6/9. The stated test is different to the one demonstrated for normal vision.

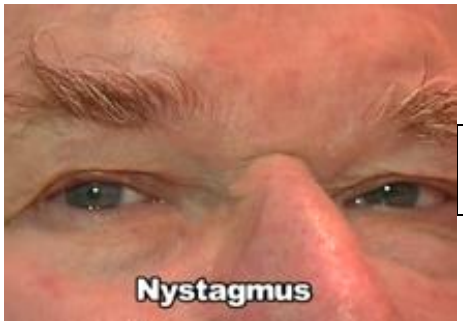
IMCA 36 DVD demonstrates: Sitting (Tender Standing)

IMCA D36 Guidance Section 5.8

Cannot be performed as demonstrated, within a two-person DDC. Depending on the DDC ergonomics the 12 o'clock check might not be as demonstrated. These exams can only be performed when not on BIBS.	✗

Potential Mitigation: Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-person DDC.

4



Nystagmus

DMAC 001 Part 3 Section D Item 7

IMCA 36 DVD demonstrates: Sitting

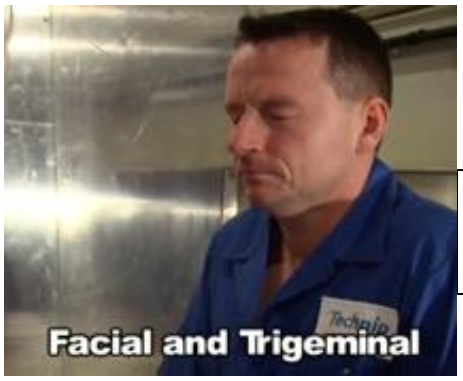
IMCA D36 Guidance Section 5.8

This can be performed as demonstrated/stated, within a two-person two-compartment DDC.	✓

Note: DMAC 001 states, *"You may be able to get a video of this movement and send it to the onshore doctor."*

How important is this video? It is very unlikely any quality video can be achieved in a two-person DDC as the video would be taken from outside the chamber through the view port.

5



Facial and Trigeminal

DMAC 001 Part 3 Section D Item 9 The stated tests are similar but different to the ones demonstrated.

IMCA 36 DVD demonstrates: Sitting

IMCA D36 Guidance Section 5.9

These examinations can be performed within a two-person two-compartment DDC. These exams can only be performed when not on BIBS.	✓

6

Acoustic Nerve

DMAC 001 Part 3 Section D Item 8

IMCA 36 DVD demonstrates: Sitting (Tender Standing)

IMCA D36 Guidance Section 5.11

There are several methods stated, most of them are not possible to achieve within a two-person two-compartment DDC. Documents acknowledge how difficult these exams are. Cannot be performed as demonstrated, within a two-person DDC These exams can only be performed when not on BIBS.	✗

Potential Mitigation: Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-person DDC.

7

Vagal and Hypoglossal

DMAC 001 Part 3 Section D Item 9

IMCA 36 DVD demonstrates: Sitting

IMCA D36 Guidance Section 5.9

These examinations can be performed within a two-person two-compartment DDC. These exams can only be performed when not on BIBS.	✓

8.1.4 Extremity Strength (Motor Nerves)

1

Head

DMAC 001 Part 3 Section D Item 10/11. Doesn't state head

IMCA 36 DVD demonstrates: Sitting (Tender Standing)

IMCA D36 Guidance Section 7

There are several body parts that require examination however head strength isn't stated. Due to chamber ergonomics this cannot be performed as demonstrated, within a two-person DDC These exams can only be performed when not on BIBS.	✗

Potential Mitigation:	Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-person DDC.

2

Shoulders/Shrug

DMAC 001 Part 3 Section D Item 9/10/11.

IMCA 36 DVD demonstrates: Sitting (Tender Standing)

IMCA D36 Guidance Section 5.10

Due to chamber ergonomics this cannot be performed as demonstrated, within a two-person two-compartment DDC	✗

Potential Mitigation:	Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-person DDC.

3

Pull Test & Hand Squeeze

DMAC 001 Part 3 Section D Item 10/11(not specifically this test)

IMCA 36 DVD demonstrates: Sitting

IMCA D36 Guidance Section 7

A version of this examinations should be able to be performed within a two-person two-compartment DDC.	✓

DMAC001 lists several more joints/strength examinations than those demonstrated in the DVD.

4

Leg Strength

DMAC 001 Part 3 Section D Item 11

IMCA 36 DVD demonstrates: Tender standing.

IMCA D36 Guidance Section 7.

A version of this examinations should be able to be performed within a two-person two-compartment DDC..	✓

DMAC001 lists several more joints/strength examinations than those demonstrated in the DVD.

The USN Manual 5A 3.4.1.2 requires the IP to walk on their heels then a duck walk

8.1.5 Sensory

1

Sharp/Blunt

DMAC 001 Part 3 Section D Item 15a/15b

IMCA 36 DVD demonstrates: Tender standing.

IMCA D36 Guidance Section 6

A version of this examinations should be able to be performed within a two-person two-compartment DDC.	✓

Note: The IP has now changed clothing for these examinations. Getting undressed in a two-person DDC can be problematic, it would most likely have to be carried out during an air break.

Diving organisation/DMP to advise on IP clothing/state of dress

8.1.6 Deep Tendon Reflexes

1

Reflexes

DMAC 001 Part 3 Section D Item 12; How to perform is not stated

IMCA 36 DVD demonstrates: Sitting

IMCA D36 Guidance Section 8. How to perform is not stated

The knee and ankle reflex cannot be performed as demonstrated, as a bunk, if fitted, is usually too low to the deck. To perform these examinations '*the patient sits on table or bench with his feet off the deck' (USN Manual 7 Appendix 5A Table 5A-2)*	✗
The other reflex examinations demonstrated can be performed within a two-person two-compartment DDC.	✓

Potential Mitigation:

Consider either:

- Raising bunk heights/sit on something to raise the IP
- Give alternative method to achieve desired outcome

8.2 Contributing Factors

Several factors may affect the outcome of a diagnosis that takes time to notice, as the focus is usually on medical equipment, personnel certification, and procedures rather than the assessment environment.

DCS and a dysbaric injury are the same, regardless of the diving technique used. Therefore, the duty of care for an IP should be the same and, as far as reasonably practicable, should follow the DDC set-up. Treatment will involve pressure and raised oxygen levels. This is always the priority. However, the constraints of the environment and the ergonomics within a two-person, two-compartment decompression chamber may affect the diagnosis of type and the progress of treatment, as indicated in Section 8.1 of this report.

8.2.1 Chamber Internal Diameters

IMCA has different minimum chamber diameters. The larger the DDC, the more accessible the IP is, and therefore the greater the potential for a thorough examination and correct diagnosis.

The minimum diameters provided are not the actual 'head height' available. The diameter doesn't account for the deck height, protruding valves, or deck-head cable trays, so the effective working height is lower.

Below are the industry standards for DDC diameters.

Note: The average height of a Western male is 1770mm. (SE Asian male 1620mm)

1. **Saturation Diving: IMCA D24.** 'Any surface compression chamber used for saturation diving and manufactured after 1 January 2015 should have a minimum internal diameter of **1800 mm'** (preferably 2150mm).

   Chambers manufactured before that date do not need to meet this size requirement.

2. **Surface Mixed Gas Diving: IMCA D37.** *' If only one diver is in the water and only one diver is planned to require decompression at one time, the minimum internal diameter of the chamber should be **1370mm.'***
   *'If there is more than one diver in the water and more than one diver is planned to require decompression at one time, the minimum internal diameter of the chamber should be **1500 mm.'***

3. **Surface Air Diving: IMCA D23.** *'Any chamber manufactured after 1 January 2015 should have a minimum internal diameter of **1500 mm**.'*
   'Chambers manufactured before the 1st of January 2015 do not need to meet this size requirement.'

4. **NORSOK U100**
   *When surface-oriented diving where decompression stops are planned, the chamber shall have an inside diameter of **2000mm**. This requirement may be modified using chambers with improved accessibility and internal ergonomics, improving entry and egress from the DDC.*

   *DDC use for non-decompression operations shall be a minimum of **1600mm** in diameter and 2000mm in length, with the possibility for occupants to lie down; ergonomic principles in DDC design may modify these requirements to size.*

Comments on DDC Internal Diameters

Adequate internal headroom is required for saturation chambers; therefore, all the neurological examinations demonstrated and described can be performed easily.

DMAC 28 prefers the DDC to be **2150mm** internal diameter '*for any saturation chamber within which medics may have to work'.*

IMO and IMCA state that saturation chambers should be large enough for most divers to stand in. IMO goes a bit further, stating that where a surface compression chamber is to be used and a person is intended to remain under pressure for a continuous period of more than 12 hours, *it should be arranged to allow most divers to stand upright…*

Neither the 1370mm nor the 1500mm surface-supplied diving DDCs have sufficient internal height for the IP or tender to stand during the following examinations. Therefore, these examinations cannot be performed as demonstrated in the IMCA D36 DVD or as described in DMAC001 or IMCA D36 guidance:

- Heel to toe
- Romberg
- Finger to nose
- Heel shin slide
- Oculomotor, Trochlear & Abducens
- Acoustic nerve
- Extremity strength-Head
- Extremity strength- Shoulders/Shrug

As demonstrated in IMCA D36 DVD within a saturation chamber

The reality of an IMCA compliant two-person two-compartment chamber

NORSOK DDC requirement of an internal diameter of 2000mm for planned decompression will be suitable for neurological examinations, as demonstrated and described in the relevant IMCA D36. (However, a dive site with no planned decompression only needs a DDC with an internal diameter of 1600mm) The fact that DDCs are available with a 2 metre internal diameter is positive; they need to become more commonplace. The diving organisation's risk assessment should identify this nee

8.2.2 Chamber Maximum Occupancy

Each DDC will have a stated maximum occupancy, usually based on Class Society rules. This maximum is generally stated on the DDC. Regardless of the maximum occupancy, there should always be one BIBS mask per person, plus one spare, in each compartment.

International code of safety for diving :
Compartments should have a specified maximum number of occupants. This capacity will define the required outfitting of the compartment or chamber, including the number of bunks, built-in breathing systems (BIBS) and the ergonomic design.

1. Saturation Diving: IMCA D24. 'The chamber must have a specified maximum number of occupants. This capacity will establish the required number of bunks, BIBS, etc'.
2. Surface Mixed Gas Diving: IMCA D37.' If only one diver in the water and only one diver planned to require decompression at one time….more than one diver in the water and more than one diver planned to require decompression at one time….'
3. Surface Air Diving: IMCA D23. 'The chamber must have a specified maximum number of occupants. This capacity will be used to establish the required number of BIBS.'

Comments on Chamber Occupancy

When surface-supplied diving occurs, and more than one working diver is deployed, a two-person, two-compartment DDC is insufficient for treatment. The DDC will need to accommodate three personnel: two divers and an attendant. The project risk assessment might identify a scenario where there are two working divers, a standby diver and a tender in a two-man chamber.

What determines maximum occupancy: Class, PVHO, or the number of BIBS masks? It cannot be the DDC internal volume, as a 1500mm DDC generally has an internal volume of about 6m^3; however, a 4.5m^3 closed bell can accommodate three divers (there will be four BIBS).

Maximum occupancy is determined by the number of available BIBS masks, as stated in the IMO diving safety code. Note that IMO requires not only a spare mask but also a spare inlet and outlet connection for it. (Therefore, each main lock must have at least four masks and four inlet/outlet connections, with a proven system capable of delivering and exhausting gas for the maximum number of occupants).

An IMCA DESIGN inspection requires the maximum occupancy to be known and stated.

The example shown is IMCA D23.

2.3	Occupancy	The chamber must have a specified maximum number of occupants. This capacity will be used to establish the number of BIBS etc. which are required.	A	Designated number of occupants: 2 Man.

In this case, the maximum number of occupants is two; therefore, there should be only a single diver in the water, allowing a tender to be in the DDC. USN and IMCA require that a patient in the DDC be accompanied by a designated medical team member (DMT).

If the DMT has recently been exposed to pressure, they will most likely have residual inert gas in their tissues. The diving organisation should have procedures to ensure that a DMT conducting a repetitive dive is safely decompressed.

8.2.3 Chamber Bunks

There are differences between the diving technique and bunk and mattress requirements.

International code of safety for diving :
Compartments should have a specified maximum number of occupants. This capacity will determine the required fittings for the compartment or chamber, including the number of bunks, built-in breathing systems (BIBS), and ergonomic design.

1. Saturation Diving: IMCA D24. Each intended occupant must have one bunk in the living compartment. Each bunk should be well-designed and firmly supported. It should also be wide and long enough for a normal person to lie comfortably.

   Facilities must be available to use one compartment of the chamber system to provide emergency medical treatment to an injured diver under pressure. Such arrangements should comply with DMAC 28. DMAC 28 requires, amongst other things, the following:

   A bunk for the patient, which should:

   - Be waist high
   - Be provided with a mattress
   - Have suitable extra lighting for the area of the casualty
   - A means for suspending IV drips overhead the patient (Hydration of Type II)
   - Have access from preferably both sides, from the head end, have a firm base and be able to tilt the patient to 30° both at the foot and head ends

2. **Surface Mixed Gas Diving: IMCA D37.** 'In a 1500mm diameter (or larger) chamber, there must be at least one fixed bunk, at least 1800mm long. The main compartment should have facilities for two divers to lie comfortably.'

   'At a minimum, there should be one mattress such that an injured diver can be given medical treatment while lying prone in the main compartment.'

3. **Surface Air Diving: IMCA D23.** 'There should be facilities in the main lock for two divers to lie comfortably.'

   'Any bunks fitted should be securely mounted.'

Comments on Chamber Bunks

In a surface-mixed gas chamber with a diameter of less than 1500mm, it is acceptable industry practice to have a mattress on the DDC floor. Rules change for chambers with a diameter of 1500mm or greater, where only one bunk and one mattress are required, although the same DDC will be used by two persons during a treatment. A surface-supplied mixed-gas treatment can result in saturation techniques, but each potential occupant doesn't necessarily get a bunk.

During surface-supplied air diving, bunks are not necessary; only facilities for two divers to lie down comfortably are required; this can be a blanket or towel on the deck.

DnV Class requires that all pressure vessels with an operational period exceeding 12 hours, including the living compartment (Main Lock), have sufficient space for 2000mm x 700mm bunks. This class rule could be used as the best working practice; a DCS treatment in a two-person DDC could last 40+ hours

8.2.4 Summary of Contributing Factors

It can be seen that, for DDCs, not all diving techniques provide an equal level of diagnostic examination for DCS due to environmental factors, ergonomics, and the built-in chamber equipment.

Chamber internal diameters vary significantly. It is recognised that, because divers may spend extended periods in a saturation system, age-related diseases or existing health issues might develop, requiring care until the diver surfaces, which could take several days. However, more basic care requirements for casualties are also necessary. These differences could negatively impact the initial diagnosis, lead to misdiagnosis of treatment progress, or result in the incorrect choice of treatment profile.

If a diver suffers from DCS, their diagnosis, treatment, and care will be significantly enhanced in a saturation system with a large chamber, spacious bunks, a mattress at a suitable height, easy access, adequate lighting, and convenient areas to hang medical equipment. The other extreme is surface mixed-gas diving, where a 1370mm DDC doesn't require a bunk, but a 1500mm DDC does.

All of the examinations demonstrated on the IMCA D36 DVD *Neurological Assessment of a Diver,* as described in the IMCA D36 *Notes Accompanying the IMCA DVD*, can be satisfactorily performed in a saturation chamber.

Statistically*, saturation diving is the least likely technique of diving where a diver will suffer DCS. Still, it has the best facilities (and a supporting DMAC note for additional requirements) for examination, diagnosis, and care.

The chamber environment is more challenging in surface-supplied diving than in a saturation chamber, as the chamber is likely to be smaller. Therefore, due to chamber ergonomics, delivering examinations will be more challenging.

It should be noted that some treatment tables can take longer than 48 hours.

The internal diameter of a surface-supplied diving chamber will limit the examinations demonstrated in the *IMCA D36 DVD Neurological Assessment of a Diver* and described in the *accompanying IMCA D36 Notes*, as the tender and the IP cannot stand up. If fitted, the bunk(s) are low to the deck (usually to allow the door to open inwards) and close together.

* Based on the author's experience

9.0 Suggested Actions / Improvements

9.1 Instructional Digital Presentation Demonstrating: Neurological Examination in a Two-Person DDC

9.1.1 Industry leaders and influencers should consider the development of an instructional digital presentation demonstrating:

1. Signs and symptoms on deck, or in accomodation, of a diver suffering a potential DCS, showing stages of mental status and agitated state etc
2. Signs and symptoms of an AGE after surfacing
3. Signs and symptoms of other dysbaric injury, post dive
4. Pre-treatment neurological assessment and equipment required (and when required)

9.1.2 Any instructional digital presentation should also show a real time neurological examination within a two-person two-compartment DDC, demonstrating:

1. Examinations that should be, and can only be, performed during an air break and state which DMAC001 examination (item number) is being performed.
2. Other examinations that can be accurately performed when not on an air break

9.1.3 There are several examinations that involve feet and toes such as the Babinski reflex (DMAC001 Part 3, Section D Items 10, 13, 15a, 17, 18). The instructional digital presentation should show these examinations .

9.1.4 Consideration should be given to what format the instructional digital presentation is produced. It might be beneficial if the presentation, with commentary and referencing line item in DMAC001 was capable of being downloaded on a smart phone.

9.2 Improvements by Industry Leaders: Neurological Examination in a Two-Person DDC

9.2.1 Consider revising the DMAC001 content and lay-out to suit commercial diving and the ergonomics and equipment in use, based on industry (not military) requirements.

There should be one set of standard examinations that can be performed in any size DDC.

The layout of any revised DMAC001 could:

1. Start with pre-treatment assessment
2. 1st ‘at depth’ assessment (and repeatable when required)
3. Examinations that can be conducted whilst on BIBS
4. Examinations during the air break/off BIBS
5. Examinations carried out on the feet

9.2.2 When revising DMAC001 consider adding:

1. Line item confirming if the IP was ever in suspension and for how long during the rescue phase .

9.2.3 As with an HLB and bell there is a maximum occupancy stipulated by Class/PVHO. Consideration should be given to the size and maximum occupancy within a surface supplied diving DDC. This is an IMO International code of safety for diving, requirement.
It is a common practice that when surface supplied diving that two divers are deployed together, however if the worst case scenario was realised there would have to be a three-person DDC, to allow a DMT attendant in the chamber. As a minimum where two divers are deployed together:

1. DDC (Main Chamber) occupancy for two IPs treatment, plus the attendant
2. DDC to keep the spare BIBS mask requirement (i.e. 4 BIBS masks fitted in Main Lock)
3. BIBS that can supply and exhaust gas with the planned amount of occupants at maximum treatment depth.

9.2.4 Improvements to DDC internal requirements to facilitate neurological assessments and treatments.
One fixed bunk and mattress per IP as a minimum, plus consideration of comfort of the attendant.
Consideration to be given to equipment within a two-person DDC that is recommended in DMAC and IMCA guidance, such as:

- Have suitable extra lighting for the area of an IP in the DDC.
- A means for suspending IV/IO drips overhead of the patient.
- Method to video and/or photograph the patient.

9.3 Improvements by Industry Leaders: Specification of the Surface Supplied Diving Onshore DDC

9.3.1 Consideration should be given to the surface supplied diving onshore DDC. If used, the divers will require treatment for omitted decompression, the DDC will need occupancy for the maximum personnel identified in the risk assessment. Therefore :

1. Consider the size and maximum occupancy of the onshore DDC, as the potential worst case will require a greater number than two occupants. (Note1)
2. Consideration should be given to the onshore DDC layout such as bunks and additional items such as those stated in DMAC 28.
3. Consideration should be given to the potential duration of a treatment such as changing out of the tender; a treatment could last 40+ hours. Best working practice would be to follow IMO requirements and supply a DDC of adequate size to allow (most) divers to stand upright and have appropriate toilet facilities. IMO requires fixed toilet facilities that discharge outside to be provided where a DDC is intended to be occupied for more than 8 hours.
4. The onshore DDC should be fitted with (or available) medical equipment that is capable of measuring: blood pressure, temperature, heart rhythm, and SPO_2, and able to transmit this information from inside the chamber to a doctor remote from the worksite, such that the information can be viewed in real time.
5. The ERP should state how medical information is passed to the DMP from the onshore site. This might require a dedicated communication system such as a satphone.
6. Align DDC requirements for all DDCs where medical treatments will take place.
7. When examining a diver at the HRF onshore, consider that the diver might have just completed a period of time in a small rescue craft or transfer vessel. The results of a Romberg test might be false due to ‘sea-legs’

Note 1 Consider a scenario where there are two DDCs at the dive site. One DDC is occupied carrying out either routine Sur-D-O2 or a treatment on two divers. Diving can continue as there is a second DDC. If the dive platform is compromised and a vessel abandonment is required immediately, the worst case could be 4 divers and a tender in a two-person HRF DDC.

APPENDIX A Reference Material

The following documents/video are referenced in this review;	
DMAC 01	Aide Mémoire for Recording and Transmission of Medical Data to Shore 2025
DMAC 15	Medical Equipment to be Held at the Site of an Offshore Diving Operation Rev
DMAC 28	The Provision of Emergency Medical Care for Divers in Saturation
IMCA D23	DESIGN for Surface Orientated (Air) Diving Systems
IMCA D24	DESIGN for Saturation (Bell) Diving Systems
IMCA D36	DVD Neurological Assessment of a Diver Rev 0.1 Feb 2024
IMCA D36	Notes Accompanying the IMCA DVD Neurological Assessment of a Diver Feb 2024
IMCA D37	DESIGN for Surface Supplied Mixed Gas Diving Systems
IMCA D61	Guidance on Health, Fitness and Medical Issues in Diving Operations
IMCA D85	Guidance on Deck Decompression Chamber Operations for the Therapeutic Treatment of Divers
USN	Diving Manual Rev 7
IMO	International Code Of Safety For Diving Operations (2023 Diving Code)
L103	Diving at Work Regulations 1997 Approved Code of Practice
IMCA CPD	Various modules
	Rescue of an Incapacitated Surface-Supplied Air Diver: A Review of Practices and Equipment
Photographs	
	Screen grabs from IMCA D36 DVD
	Wikipedia
	https://www.flickr.com/photos/navcent/
	Grab from IMCA D23