

Observation: Decompression Sickness Assessment within a Two-Man Two-Compartment DDC

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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



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-man 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	<i>Aide Mémoire for Recording and Transmission of Medical Data to Shore</i> 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	<i>Diving Equipment System Inspection Guidance Note</i> 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	<i>Neurological Assessment of a Diver</i> 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, and the correct equipment and procedures should be planned for and in place.

A diver or divers could have life-changing injuries after treatment for a DCS. Any resulting legal case could quickly identify that industry best practice guidance (IMCA 36/DMAC001) cannot be performed in a two-man, two-compartment DDC as demonstrated and described in industry standards. This is because the DDC is too small in height and allowable occupancy (in some cases), and much of industry DCS diagnosis examination guidance is impossible in a two-man DDC.

This breach of duty of care leaves the diving supervisor and diving organisation exposed 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;

- ◆ recovery of an incapacitated diver from working depth to a safe place for treatment
- ◆ treatment of decompression illness or dysbaric injury
- ◆ 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.

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 were carried out. The diving organisations drill matrix and procedures were followed during the drill. This report communicates the findings and lessons from that drill.

2.2 Limitations of 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. There will be other scenarios, such as onshore hyperbaric treatment facilities, where some suggestions might not be relevant.

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

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

2.3 Referenced Material

There are many documents referenced within this report. However, the primary documents/materials that are 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

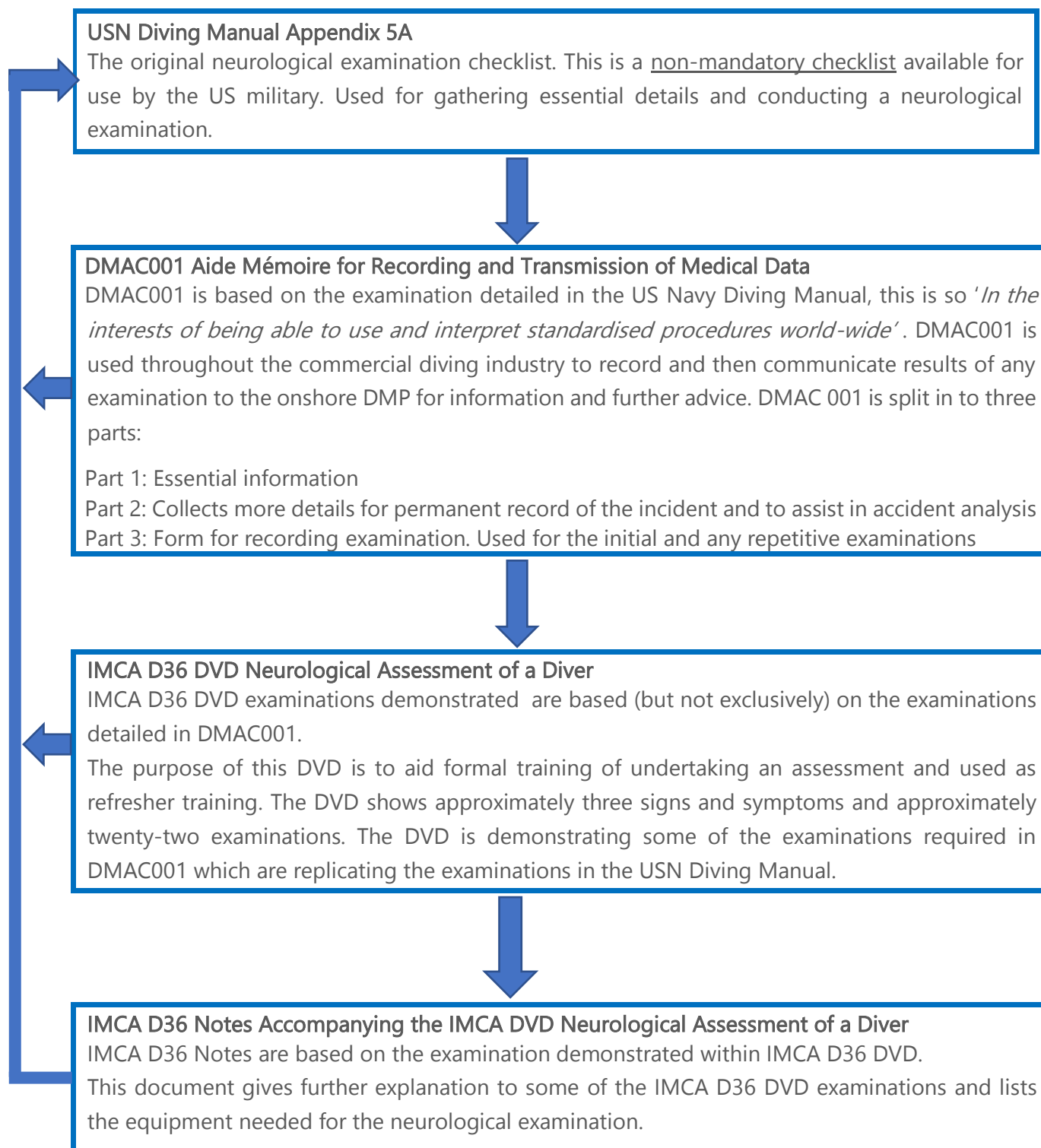
3.0 Aims of this Report

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

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



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 and in charge of the IP's diagnosis, care and treatment, including any drugs that may be administered.

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

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(s) will be available with the necessary knowledge to advise on suitable treatment of divers. The diving organisation-appointed DMP and their contact details will be stated in the project documentation.

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

The DMP advises the diving supervisor on appropriate treatment.

Note that this commercial diving hierarchy is different 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 the diving organisation treatment procedures will help establish the diagnosis. However, the time that treatment can be delayed depends on the degree of urgency necessary in beginning treatment of depends on the IPs condition. The diving organisation's treatment procedures should state when a neurological examination should start.

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 time

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 organisations 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 Organisations 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*. 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-man, two-compartment DDC, due to the ergonomics of the DDC environment.

- ♦ Overview of some differences between the different industry standards and the practical application of the examination within a two-man, two compartment DDC.
- ♦ Overview to whether the IMCA D36 / DMAC001 examination can be accurately replicated, as demonstrated in the DVD, within a two-man two-compartment DDC.
- ♦ 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-Man DDC

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

8.1.1 Mental Status



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-man DDC whilst under pressure.	✘
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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 eating lunch
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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.

Cannot be performed as stated/demonstrated within a two-man DDC.	X
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Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whilst 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.

Cannot be performed as stated/demonstrated within a two-man DDC.	X
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Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whilst 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.

Cannot be performed as stated/demonstrated within a two-man DDC.	X
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Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted as part of a pre-treatment examination whilst 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-man DDC. This exam can only be performed when not on BIBS.	X
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Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted within a two-man 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

Cannot be performed as demonstrated, within a two-man DDC	✗
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Potential Mitigation: Develop a new digital presentation demonstrating this examination being conducted lying flat in a two-man 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-man DDC	✓
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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-man 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-man 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-man 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-man 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-man 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-man 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-man 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-man 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-man 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-man 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-man DDC. Documents acknowledge how difficult these exams are.

Cannot be performed as demonstrated, within a two-man 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-man 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-man 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-man 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-man 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-man DDC	✗
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Potential Mitigation: Develop a new digital presentation demonstrating alternative method to achieve desired outcome being conducted in a two-man 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-man DDC.	✓
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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-man DDC..



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

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-man DDC.



Note: The IP has now changed clothing for these examinations. Getting undressed in a two-man 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-man DDC.



Consider either:

- Potential
- ♦ Raising bunk heights/sit on something to raise the IP
- Mitigation:
- ♦ 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 or a dysbaric injury are the same regardless of the diving technique used. Therefore, the duty of care of an IP should be the same and, as far as reasonably practicable, should be the DDC set-up. Treatment will be pressure and raised oxygen levels. This is always the priority. However, the confines of the environment and ergonomics within a two-man, two-compartment decompression chamber might affect diagnosis of type and treatment progress, as indicated in section 8.1 of this report.

8.2.1 Chamber Internal Diameters

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

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

Below are the industry standards for DDC diameters.

Note: The average height of a Western male is 1770mm.

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-orientated 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 head height is one requirement 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 and states that where a surface compression chamber is to be used in circumstances in which a person is intended to remain under pressure for a continuous period of more than 12 hours, *it should be so arranged to allow most divers to stand upright...*

Neither surface-supplied diving DDCs, 1370mm or 1500mm diameters, have sufficient internal height for the IP or tender to stand for the following examinations. Therefore, these cannot be performed as demonstrated in IMCA D36 DVD or performed 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-man chamber

The NORSOK DDC requirement of 2000mm for planned decompression will be suitable for neurological examinations demonstrated and described in the relevant IMCA D36.

8.2.2 Chamber Maximum Occupancy

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

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.'

When surface-supplied diving occurs, and more than one diver is deployed at a time, a two-man, two-compartment DDC is insufficient for treatment, as the DDC will need to accommodate three personnel: two divers and an attendant.

What defines maximum occupancy, Class, PVHO, or number of BIBS masks? It cannot be DDC internal volume as a 1500mm DDC generally has an internal volume of about 6m³; however, it is acceptable for a 4.5m³ closed bell to accommodate three divers. (there will be 4 BIBS)

8.2.3 Chamber Bunks

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

1. **Saturation Diving: IMCA D24.** There must be one bunk in the living compartment for each intended occupant. Each bunk should be well-designed and firmly supported. They should also be wide and long enough to allow a normal person to lie in comfort.

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

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

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

8.2.4 Summary of Contributing Factors

It can be seen that, regarding DDCs, not all diving techniques allow for an equal level of diagnosis examination for a DCS due to the environment, ergonomics, and built-in chamber equipment.

Chamber internal diameters vary considerably. It is accepted that due to divers living for extended periods in a saturation system, there might be age-associated diseases or existing health issues requiring care until the IP reaches the surface, which could take several days. However, more basic requirements for caring for a casualty are needed. These differences could adversely affect the initial diagnosis, misdiagnosis of treatment progress, or incorrect treatment profile selection.

If a diver suffers a DCS, their diagnosis, treatment, and care will be much more significant in a saturation system with a large chamber, large bunks, a mattress at a good height, good access, areas for lighting, and hanging 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 in IMCA D36 DVD *Neurological Assessment of a Diver*, described in IMCA D36 *Notes Accompanying the IMCA DVD*, can be satisfactorily carried out in a saturation chamber. Statistically*, saturation diving is the least likely technique of diving where a diver will suffer a DCS. Still, it has the best facilities (and a supporting DMAC note for additional requirements) for examination, diagnosis, and care.

When surface-supplied diving, the chamber environment is more challenging than a saturation chamber, as the chamber will most likely be smaller. Therefore, due to chamber ergonomics, the delivery of examinations will be more challenging.

It should be noted that some treatment tables can be more 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 IMCA D36 *Notes Accompanying the IMCA DVD Neurological Assessment of a Diver*, 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 a Neurological Examination in a Two-Man 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 accommodation, 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-man 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-Man 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 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.

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-man DDC, to allow a DMT attendant in the chamber. As a minimum where two divers are deployed together:

1. DDC 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 cope with the planned amount of occupants at maximum treatment depth

9.2.3 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-man DDC that is recommended in DMAC and IMCA guidance, such as:

- ♦ Have suitable extra lighting for the area of the casualty
- ♦ 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 an onshore DDC is used, the divers will require treatment for omitted decompression. Therefore consideration needs to be given to the DDC for treating omitted decompression (for the maximum personnel identified in a 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.
4. The onshore DDC should be fitted with (or available) medical equipment that is capable of measuring: blood pressure, temperature, heart rhythm, and SPO₂, 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.

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-man 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 July 2015
DMAC 15	Medical Equipment to be Held at the Site of an Offshore Diving Operation Rev 5
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
USN	Diving Manual Rev 7
Photographs	
	Screen grabs from IMCA D36 DVD
	Wikipedia
	https://www.flickr.com/photos/navcent/