The Byford Dolphin diving accident 1983

Kåre Segadal, senior advisor, MSc Biophysics

Overview

- **The accident:** - When, where, etc
- **The investigation:** - NOU report 1984:11, Detailed explanation Swann (2007)
- **Perspective:** - Other accidents: Kahrs (2004) etc
- **The pathology:** - Giertsen et al. (1988)

The accident

Explosive decompression: 5 fatalties

- The vessel: Byford Dolphin
- The date: 1983-11-05
- Location: Frigg field,
  - Norwegian sector of the North Sea

Byford Dolphin: **an “unlucky ship”**

- semi-submersible, drilling rig operated by Dolphin Drilling, a subsidiary of Fred Olsen Energy
- Built as Deep Sea Driller (1974–1978), first Aker H-3
- registered in Hamilton, Bermuda

- drilled seasonally for various companies in the British, Danish, and Norwegian sectors of the North Sea
- scrapped 2019

Deep Sea Driller: **accident 1976**

Grounded at Fedje (north-west of Bergen) 1976-03-01
Six of the crew died
Up till then the most serious accident I Norwegian petroleum industry

Byford Dolphin: **2002-accident**

2002-04-17, a 44-year-old Swedish worker
on the rig was struck on the head and killed under work
for Statoil at the Sigyn field in the North Sea.

Statoil and the Norwegian Petroleum Directorate investigated the accident. A police investigation concluded that Statoil's and the Norwegian Petroleum Directorate's version of the incident was correct, and rejected allegations that employees were pressured to give false explanations.

The worker had worked 34 consecutive hours before the accident. This was not mentioned in the original reports.

Statoil was fined NOK 1 million for violating the safety rules, which they eventually adopted.
Statoil terminated the contract with the rig company Dolphin AS due to concerns with the safety of the rig's operating procedures.

The incident cost the company millions of US dollars in lost income

The rig was scrapped 2019

The date

5th of November

- 1605 – London gunpowder plot
  - «always remember» Guy Fawkes and his companions sententenced and hanged for treason
- 1962 – Kings Bay mining accident
  - at Svalbard – 21 workers killed
- 1983 – Byford Dolphin
  - 5 workers killed
- 1968 – Richard Nixon
  - elected US president
- 2025 – Donald Trump
  - elected US president

The investigation

Byford Dolphin diving accident

NOU 1984:11

NORWAY'S PUBLIC REPORTS

To
The Royal Ministry of Local Government and Labour
The Expert Commission on the Diving Accident on Byfjord Dolphin on 5 November 1983, appointed by the Ministry of Local Government and Labour on 7 November 1983, hereby presents its report.
The report is unanimous.

Stavanger, 22 February 1984
Reidar Godø, Chairman
Jan Haugland, Melvin Kvamme, Stein Tønjun, Hans J. Kraft Johanssen, Per Rosengren
Aksel Luhr, Secretary

2. Measures in the first period after the accident

NPD & police 5 hours after

Info from the NPD the next day, metallurgy, safety message (Appendix2)

24/11 meeting NPD – Safety Notice (Appendix 3) Improvements Equipment Procedures

Operator (Elf Aqu.), NPD & police: "*reacted quickly and correctly*"

4. Description of the diving system on Byford Dolphin

Drawings p.8 (schematic and communication lines), owned and operated by Comex Norge A/S

3 pressure chambers, Hyperbaric evacuation unit, 3-person diving bell

Chamber Control Room, Bell Control Room (the "Dive Control")

Pictures p.9-15

5. Sequence of events - cause

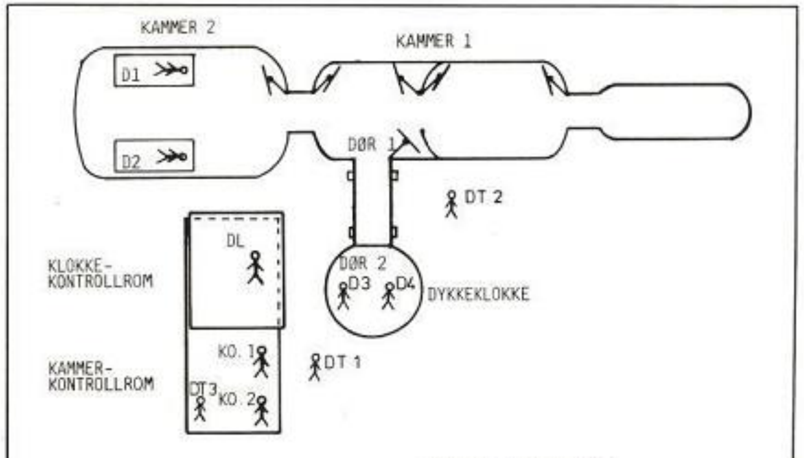
"9 approx. atmospheres of overpressure" (i.e. approx. 90 msw)

Transfer of divers from diving bell to chamber (minute-by-minute procedure and events in Appendix 4)

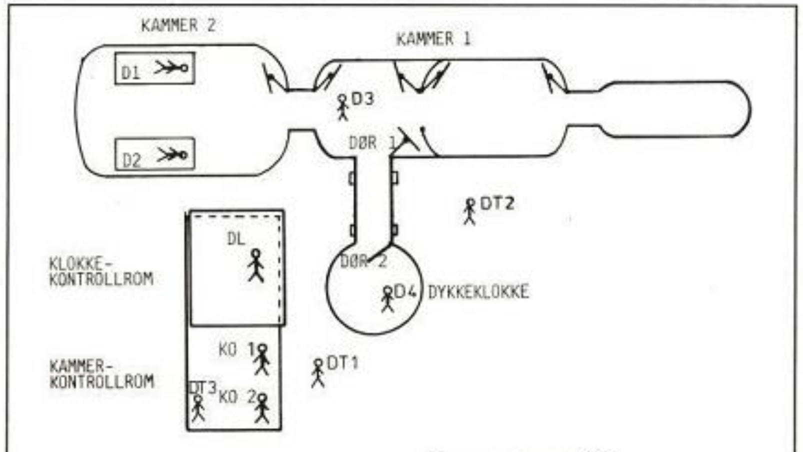
The NPD's description of the assumed course of events (Appendix 6)

"The Commission believes that the direct cause of the accident was that the coupling lock (see drawing on page 17 and pictures on pages 9—12), which connects the diving bell to the chamber system, was opened, while the system was pressurized, with all internal doors open. The divers who were in the chamber complex perished due to the sudden pressure drop that occurred.»

“Through the investigations that have been carried out, it has not been possible to prove failures in the material.»



SITUASJONEN KL. 0404
(PKT.14 I PROSEDYREN)



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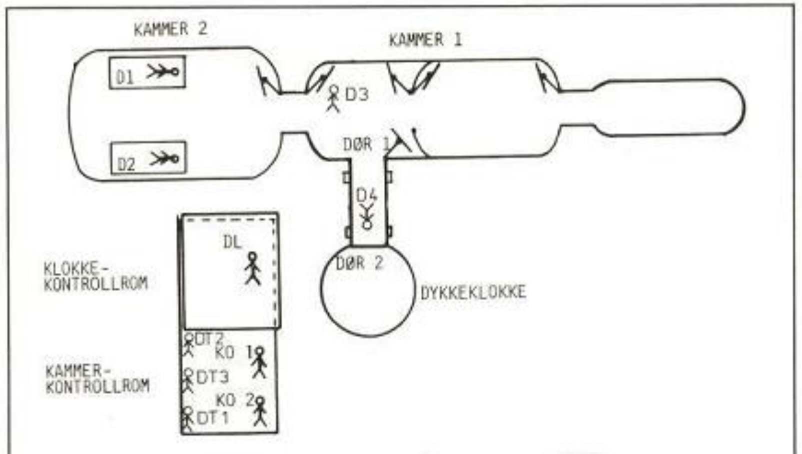
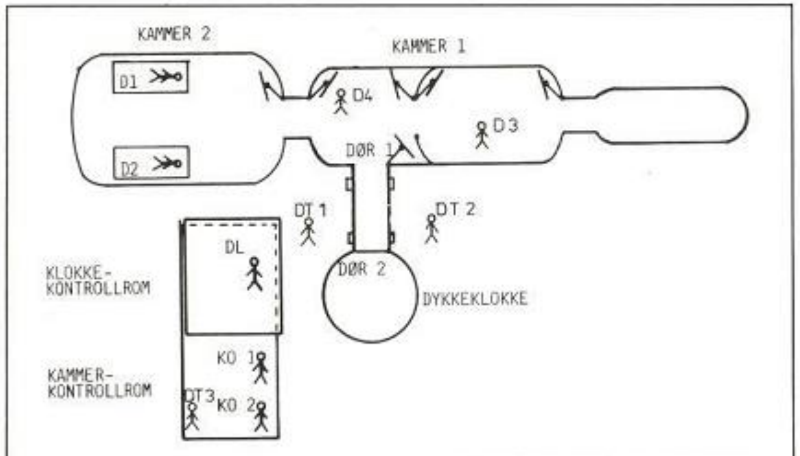


SITUASJONEN KL.0408
(PKT.23 I PROSEDYREN)



SITUASJONEN KL.0413 UTBLÅSNING

6. Technical Arrangement and Security

Communication, TV surveillance

Extra pressure control of the tunnel (i.e. both in dive control and chamber control) – procedure violations:

("All control devices for transmission under pressure shall be located on one panel only and not distributed in several locations").

According to Veritas' rules of 1975, there are no specific requirements that affect the locking arrangement used on the diving system on Byford Dolphin, while in the rules of

"1982 requires that the coupling mechanisms between the clock and the chamber must be designed in such a way that they cannot be opened while the connecting tunnel is under pressure. However, this modification had not been carried out on the diving system on the Byford Dolphin. The Commission will return to this later in the report.»

7. Regulatory-control-security

7.1.1 Diving from Norwegian-registered diving vessels in general

The Norwegian Maritime Authority is the primary control body of diving systems

"The Norwegian Petroleum Directorate, on behalf of the Norwegian Maritime Authority, carries out inspections of the diving system with regard to ensuring the safety of divers, in accordance with the Norwegian Maritime Authority's regulations.»

agreements with Det norske Veritas and the American Bureau of Shipping.

"The control scheme is discussed in more detail in the Regulations with comments, and in a letter from the NMA to the Norwegian Petroleum Directorate on 24.3.83 (see Appendix 5).»

7.1.2 Diving on the Norwegian continental shelf

The Norwegian Petroleum Directorate is the primary control body

pursuant to temporary regulations for diving on the Norwegian continental shelf, laid down by the Norwegian Petroleum Directorate on 1.7.78, pursuant to Act no. 12 of 21.6.63 on exploration and exploitation of subsea petroleum deposits.

For mobile facilities, any diving regulations of the flag state will also apply. On Norwegian diving vessels, both the Norwegian Petroleum Directorate's and the Norwegian Maritime Authority's regulations will therefore apply.

7.1.3 Working time rules

7.1.4 Safety delegates and working environment committees

7.2 STATUS IN RELATION TO CURRENT REGULATIONS

7.2.1 The diving system

The diving system was classified in Det Norske Veritas according to the rules of 1975 and was approved by both the Norwegian Maritime Authority and the Norwegian Petroleum Directorate. There were no outstanding orders.

7.2.2 Personnel qualifications

Two minor non-conformities (basic safety training) assessed as insignificant

7.2.3 Working hours

Missing shift schedule, working time journal
Overtime used
Bell Run Time Limit Exceeded (Appendix 6): 38% > 8 hours

7.2.4 Procedures

The procedures for "transfer under pressure" in the COMEX SERVICES DIVING PROCEDURES AND SAFETY MANUAL were not followed and the accident was result of this. This will be subject to its own consideration (7.7)

7.3 RESPONSIBILITIES

7.4 THE ROLE OF THE INSPECTION INSTITUTIONS

7.5 FOLLOW-UP BY THE AUTHORITIES

7.6 THE NORWEGIAN PETROLEUM DIRECTORATE'S REGULATIONS FOR DIVING

7.7 DIVING SYSTEM MANUAL (MANUAL)

7.8 INSTRUCTIONAL RESPONSIBILITIES

7.8.1 Risk factors during transfer operations

7.8.2 Diving/organization/responsibility

7.8.3 Measures that could have reduced the scope of the accident this.

8. Should the accident have been avoided?

8.1 BACKGROUND

It is also mentioned in 7.4 that in the new rules for certification of diving systems, which were introduced in 1982, Det Norske Veritas required that locking systems for connecting the diving watch to the chamber should be designed in such a way that the lock could not be opened as long as the tunnel was under pressure. Such a locking device would, in the Commission's opinion, have averted the accident on the Byford Dolphin. In other words, at the time of the accident, there were strong indications that the locking system was not considered to be good enough in terms of safety: Firstly, the very strong and detailed warnings mentioned in the manual. In reality, the manual largely describes what happened on the Byford Dolphin as a significant danger related to the system itself and its use. Second, the introduction of the new requirements included in Veritas' 1982 rules must be understood as a direct recognition of the need to procure more secure locking devices. These new requirements were adopted by Veritas' board of directors on 1 January 1982, i.e. about two years before the accident occurred (the rules came into force on 1 July 1982)

8. Should the accident have been avoided?

8.2 THE COMMISSION'S ASSESSMENT

A rule that can provide an indication is: where strong warnings about the hazard of improper use of the material are necessary, the question should be asked whether it is not possible to reduce the hazards by structural changes. Such a question would have been highly relevant with regard to the accident on the Byford Dolphin.

9. Measures to prevent similar accidents

1. A locking system should be provided to prevent the connection between the chamber and the bell from being opened as long as the connecting tunnel is pressurized.

2. An arrangement requiring the doors in the chambers to be kept closed, or that they automatically close in the event of sudden pressure drops, should be implemented. The structural modifications required to arrange this in a way that increases overall safety should be implemented as an immediate order and incorporated into the regulations.

3. Clear and firm operating procedures laid down in the form of instructions and strict discipline in their implementation are of great importance for safety. Standardization of procedures should be pursued as a goal.

9. Measures to prevent similar accidents (cont)

4. The requirement to record conversations between the dive supervisor and divers on tape should be extended to also apply to the actual transfer of divers between watch and chamber, including the actual coupling operation

5. A boundary increase with a view to simplifying both the organisation and function of the public control apparatus is required

6. Protection and environmental work on the platforms should be made more functional, so that it also includes diving personnel in practice

7. Information to personnel, in particular with regard to instructions, safety regulations, protection and environmental measures, etc., should be readily available at the workplaces themselves, in an appropriate form (presentation). Checklists should be used in all routines where appropriate. Measures for systematic training and maintenance of knowledge and skills should be intensified.

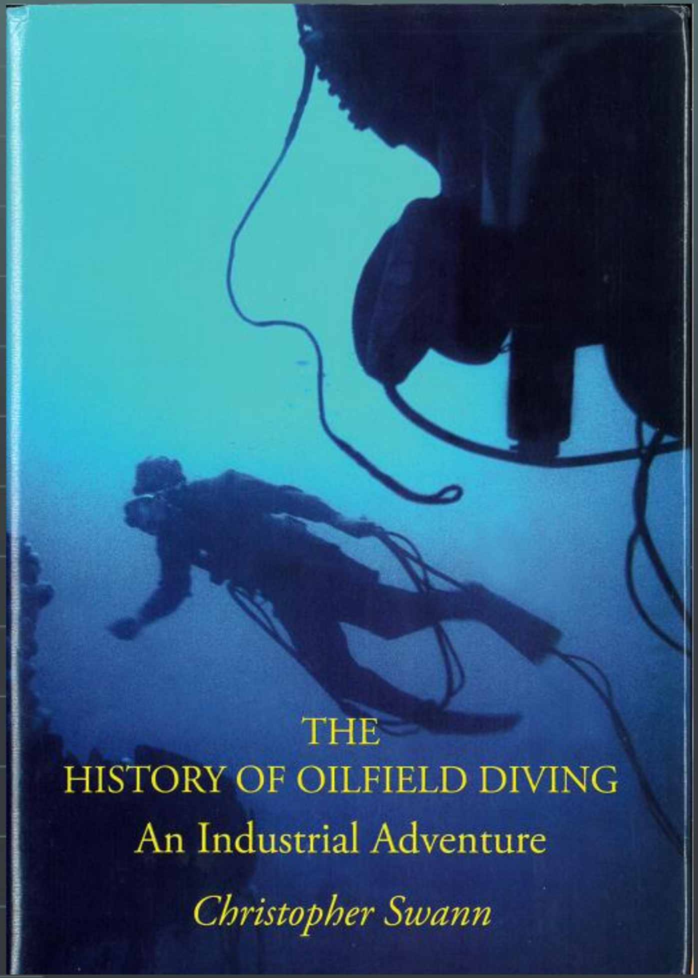
9. Measures to prevent similar accidents (cont)

8. A forum of designers, users, inspection bodies, research institutions and inspection authorities should be established for the identification, cataloguing and evaluation of potential hazards, with a view to measures that can help prevent accidents from occurring

9. When changing the rules for classification/certification of equipment that must be assumed to be of great importance for safety, narrow time margins should be set for implementation. Veritas decided, shortly after the accident on the Byford Dolphin, that the 1982 rule, which requires that the lock connecting the diving bell to the chamber system must be designed in such a way that the lock cannot be opened while the tunnel is under pressure, should be given retroactive effect and also apply to diving systems that have already been classified. The Norwegian Petroleum Directorate has also issued a corresponding order to this effect, so that this requirement will apply to all systems used on the Norwegian shelf. The NMA should also follow up with a similar provision, so that the rule will also be made applicable to Norwegian vessels/systems operating outside the Norwegian continental shelf.

10. The Commission's concluding remarks

The diving profession is often described as a dangerous profession. Normally, the hazards are related to the work underwater. However, the accident discussed in this report occurred during the divers' stay overwater. In that respect, it is special. Some of the dangers that divers encounter underwater can be difficult to eliminate completely. It is all the more important to facilitate conditions so that the divers can feel safe during their stay overwater. They are in their situation at work, as well as at rest, especially dependent on the safe functioning of the diving system and its operation. The accident should therefore call for extra efforts in this respect.



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During their tour offshore, the crew had discovered that under Norwegian law anyone who worked more than 12 hours a day could claim overtime. This was quite new. It was different from what prevailed in other North Sea jurisdictions, and for days they had talked of little else. They talked about it before the dive and they talked about it during the dive; the only time they stopped talking about it was when the bell was being recovered.

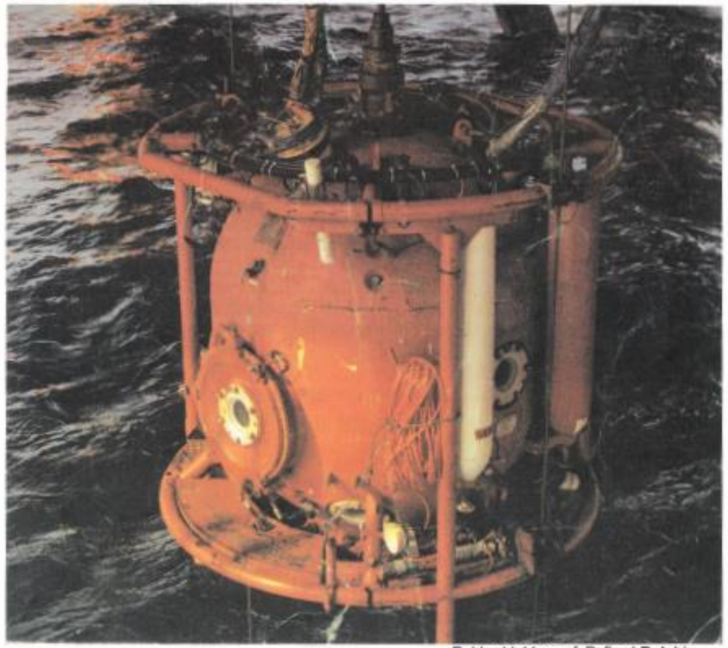
After the bell came on board two of the crew put on the clamp. One then went to watch a flare being ignited; the other returned to the chamber control van to resume the discussion of overtime with three of his mates. Meanwhile in the bell van, the diving supervisor was waiting for the okay from the chamber to depressurise the transfer trunk. Over the intercom between the two vans, he heard the crewmen going on and on about overtime, as they had been doing for hour after hour, which led him to say more or less: 'Never mind about your bloody overtime! You can talk about that after you've taken off the clamp.'

To three of the men in the chamber van, it was nothing more than a bantering remark, but to the fourth, whose turn it was to take off the clamp, it was a rebuff: Stop talking about overtime; you should already have taken off the clamp. Thinking the supervisor was repeating the order - which engrossed in the conversation he had missed - he left the chamber van muttering about being kept in the dark, walked over to the trunking and began to undo the clamp.

KåSE
NUI

Døde nordsjødykkerne forgjeves?

Regelverksendringer med bakgrunn i erfaringer
etter dødsfallene.



Dykkerklokken på Byfjord Dolphin

Bjørn Wilhelm Kahrs
Hovedfagsoppgave i historie
Høsten 2004
Historisk institutt
Universitet i Bergen.

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VEDLEGG 1. (written in English so that old colleagues in the UK can read it)
Appendix 1
SUMMARY (of 58 fatalities)
38 fatalities after accidents in British waters.
17 fatalities after accidents in Norwegian waters.
2 fatalities after accidents in Dutch waters.
1 fatality after an accident in Irish waters
Nationalities:
39 British,
8 United States (USA)
5 Norwegian
3 French
1 Italian
+ 2 of unknown nationality but with British, US sounding names.

In table under Possible cause of death and other factors/Key words
For the Byford Dolphin accident: Misunderstanding leading to wrong procedure?
For the four divers at depth:
Explosive decompression
HSE database: Explosive decompression. Bell became
detached from complex whilst system was pressurised with
all internal doors open.
For the diver at surface:
Killed by clamp
Of the 53 other fatalities:
Decompression, gas embolism, blow up, pulmonary barotrauma: 9
None of these. 44

Other accidents

- From NUI-report 2018-52 for Havtil

https://www.havtil.no/utforsk-fagstoff/fagstoff/prosjektrapporter/2020/rapport-nod-dekompresjon-fra-heliox-metningsdykk/

nui	Title of report: **Emergency decompression from heliox saturation dives**			
NUI AS Gravdalsveien 245, 5165 Laksevåg Norway www.nui.no	Report no.: **2018-52**	Rev. no.: **4**	Project no.: **502803**	Date: 2020-03-06
Client / sponsor of project: **Petroleum Safety Authority Norway (PSA)**	Client's / sponsor's ref: **John Arne Ask, Olav Hauso, Bjarne Sandvik**		Approved by: **Rolf Røssland**	
Work carried out by: **Kåre Segadal, Andreas Møllerløkken**	NUI's contact: **Kåre Segadal** kse@nui.no		Checked by: **Jan Risberg**	

Summary:

This study was done on initiative from PSA. The objective was to investigate emergency decompression as an alternative, in cases where the evacuation from a saturation facility of divers at increased pressure, is not available for whatever reason. It is stressed that it will not be the purpose of such procedures to prevent pain or discomfort, but to prevent serious injury and death.

Historical survey shows that need for hyperbaric evacuation / emergency decompression is not a very rare situation as a "probability-weighted" sum of such incidents was found to be 32.

So it is important that plans including accelerated emergency decompression, are available as a supplement to hyperbaric evacuation of divers. The recommendations in DMAC 31, with a few additions/modifications (possible gas switch to air) is a good start for making practical procedures. The risk of injury will be high, but if the decompression speed is not too high the chance of survival may be good. Probability for injury decrease with shallower saturation depth.

The risk by using emergency decompression by itself, and up against the risk, which hyperbaric evacuation may represent is discussed. A workshop with relevant people from the industry was organized, and documentation related to emergency and accelerated decompression was identified and distributed to participants of the workshop, involving medical and operational expertise. Based on the feedback from workshop participants further documentation was collected and included in this report.

Key Words in English:	Key Words in Norwegian:
Saturation Diving Decompression Emergency procedures	Metningsdykk Dekompresjon Nødprosedyrer

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	"Valid."	Start of Incident						Country /ocean	Depth msw	Number of divers		Comments
		Date	Year	Company	Vessel	Reason	Location			Tot.	dead	
1	1.0	15/2	1982	Hydrosp.(Fraser?)	Ocean Ranger	sunk in storm	Hibernia field, Newfoundland	CA		5	5	No HRU, semirig sank, 84 died
2	1.0	15/12	1985	Protexa	HuicholII (ex Kattenturm)	sunk in storm	off Carmen del Cuidad	GOM		4	4	Not possible to use HRU
3	0.2	Feb.	1986		Semi drilling rig	sunk in storm		XX		4	4	No HRU
4	1.0	4/11	1989	Oceaneering	Seacrest (ex Scan Queen)	sunk by Typhoon Gay	Gulf of Siam, South China sea	TH		*5*	*3*	No HRU, drillship capsized, 91 (incl. diveteam?) perish
4	1.0	15/8	1991	McDermott	DB29	sunk by Typhoon Fred	South China sea	TH		4	4	No HRU. Emergency decomp. with high PO_2 to 60'. 22 (incl. 4 drowned divers) died
5	1.0		1995	McDermott	DLB269	Hurricane Roxanne	Bay of Campeche	GOM	48	4	4	Emergency DC to surface, no DCS. Barge sunk afterwards, 6 died
6	1.0	20/10	2011	Adsun ODC	DSV Koosha 1	Weather	South Pars, off Lavan island	IR	64	6	6	Total 13 lost, 4-man HRC
7	1.0	25/2	2022	Paria Fuel Trading Company		sucked into pipe	near Pointe-à-Pierre	TT	16	5	4	
	7.2									37	34	

Giertsen et. Al. (1988)

Four divers in a compression chamber system were suddenly decompressed from 9 atm to l atm. One of the divers was about to close the door between the chamber system and the trunk when the accident happened. He was shot out through the door and severely mutilated. The three others died on the spot. The autopsy results are described. The most conspicuous finding was large amounts of fat in the large arteries and veins and in the cardiac chambers, as well as intravascular fat in the organs, especially the liver. This fat can hardly have been embolic, but must have "dropped out" of the blood in situ. It is suggested that the boiling of the blood denatured the lipoprotein complexes, rendering the lipids insoluble. Key Words: Decompression. explosive-Decompression, accident.

KSE-29-88-9

The American Journal of Forensic Medicine and Pathology 9(2): 94–101, 1988.

An Explosive Decompression Accident

J. C. Giertsen, M.D., E. Sandstad, M.D., I. Morild, M.D., G. Bang, M.D., A. J. Bjersand, M.D., and S. Eidsvik, M.D.

Four divers in a compression chamber system were suddenly decompressed from 9 atm to 1 atm. One of the divers was about to close the door between the chamber system and the trunk when the accident happened. He was shot out through the door and severely mutilated. The three others died on the spot. The autopsy results are described. The most conspicuous finding was large amounts of fat in the large arteries and veins and in the cardiac chambers, as well as intravascular fat in the organs, especially the liver. This fat can hardly have been embolic, but must have "dropped out" of the blood in situ. It is suggested that the boiling of the blood denatured the lipoprotein complexes, rendering the lipids insoluble.
Key Words: Decompression, explosive—Decompression, accident.

On 5 November 1983, an accident resulting in the sudden decompression of four divers from a pressure of 9 atm to 1 atm occurred on board the Norwegian oil rig Byford Dolphin in the North Sea.

THE ACCIDENT

The situation just before this accident occurred was as follows (Fig. 1). Compression chambers 1 and 2 were connected via a trunk to a diving bell. This connection was sealed by a clamp operated by two tenders (Dt 1 and Dt 2), who themselves were experienced divers. A third chamber was in fact connected to this system, but was not involved. On this day, divers 1 (35 years old) and 2 (38 years old) were resting in chamber 2 at a pressure of 9 atm. The diving bell with divers 3 (29 years old) and 4 (34 years old) had just been winched up after a dive and joined to the trunk. Leaving their wet gear in the trunk, the divers had then crept through the trunk into chamber 1. The normal procedure would have been to (a) close the bell door, (b) slightly increase the bell pressure to seal this door tightly, (c) close the door between the trunk and chamber 1, (d) depressurize the trunk to 1 atm, and (e) open the clamp to separate the bell from the chamber system.

Operations a and b had been completed and diver 4 was about to carry out operation c when, for some inexplicable reason, one of the tenders opened the clamp. The result was a free communication between the chamber system with a pressure of 9 atm and the surroundings with a pressure of 1 atm. A tremendous blast shot from the chambers through the trunk, pushing the bell away and hitting the two tenders. The one who had opened the clamp died, and the other was severely injured. Unfortunately, the dead tender was not sent to us for autopsy.

Figure 2 shows how diver 4 probably was about to close the chamber door when the accident occurred. The chamber opening was 60 cm in diameter. Unfortunately, the door jammed (Fig. 3) so firmly that it later had to be cut loose with an acetylene burner. Diver

From the University of Bergen, The Gade Institute, Bergen, Norway. Professor of Forensic Medicine (J.C.G.); Acting Head, The Gade Institute, Section of Neuropathy (I.M.); Professor of Oral Pathology (G.B.); Assisting Head, Haukeland University Hospital, Department of Radiology (A.J.B.); Captain of the Royal Norwegian Navy, Senior Diving Medical Officer (S.E.).

A preliminary version of this paper was given by Giertsen at the 10th Meeting of the International Association of Forensic Sciences, Oxford, England, 19 September 1984.

Address correspondence and reprint requests to J. Chr. Giertsen, M.D., University of Bergen, The Gade Institute, Department of Forensic Medicine, 5021 Bergen, Norway.

Thank you for the attention

- With memory and in respect for all divers who have lost their lives at work