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Survival in cold waters - learnings from participation in cold water exercises - a regulatory perspective related to the Norwegian offshore industry

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Abstract: Participation in exercises lead by the University of Stavanger, the SARex 1 in 2016 and SARex 2 in 2017, provided valuable lessons related to survival in a cold maritime environment. The scenario of the exercises was a mass evacuation from a stranded cruise ship in Arctic waters but provided experiences relevant beyond the cruise industry. This article focuses on the relevance for the oil and gas industry in the Norwegian sector. SARex 1 and 2 were rescue exercises carried out north of Spitzbergen by industry, regulators and academia during the spring of 2016 and 2017. The Norwegian Coast Guard, the University of Stavanger and GMC, Stavanger, organized the exercises. The Petroleum Safety Authority found it important to participate in SARex 1 and 2, to better understand the factors enabling success in a cold climate survival situation. The survival tests in lifeboats and life rafts during SARex 1 and 2 showed the necessity of having trained and competent leadership on board. This issue has perhaps been neglected, compared to the development of equipment to ensure successful evacuation and avoid hypothermia. Some key factors for survival success were (1) Functioning of emergency equipment (2) Organising and teaching the function of various items of safety equipment (3) Operating evacuation means at sea, e.g. watch routines, operating hatches/venting routines and (4) Activities and maintaining mental awareness and motivation. The overall learning from SARex 1 and 2 is that survival is dependent on active participation from the survivors. There is a need for sufficient competence amongst personnel to micro-manage all the details required for survival. The mental factors following fatigue and seasickness, in addition to hypothermia, make leadership and competence in a cold maritime climate essential for survival.

1. Introduction

There has been a renewed interest in exploration in the Barents Sea, since the opening of licensing blocks further north and east more than a decade ago. These areas are further from the coast than existing discoveries in this region, thus creating new challenges compared to the more mature areas developed for oil and gas in the Norwegian sector. Today, resources for handling emergency situations are considerably scarcer in the Barents region.

The basis for SARex 1 [1] and 2 [2] was the International Maritime Organization's (IMO) new Polar Code [7] with a five-day survival requirement in the Arctic. There is no similar regulatory requirement in the oil and gas industry, as most of the requirements are functional. However, the industry has set its requirements through analyses of the different major accident scenarios. These requirements are intended for areas with emergency response cooperation but have been regarded as industry standard throughout.

The survival requirement is established by IMO, based on the time of rescue in remote polar areas. These are applicable to all maritime activities under the flag regime, but not oil and gas activities. The criticality, difficulties working with arrangements to be used on demand, and state of the art regarding equipment is different from marine activities regulated by IMO-Polar code due to the urgency of acting quickly to escape in case of an incident onboard an oil and gas platform. The focus of the regulations and the oil and gas industry has been on technical inventions to ensure success in handling escape and evacuation during emergency scenario and not on the survival phase.

In an emergency, where evacuation is necessary, one is exposed to the following phases:

Escape – Evacuation – **Survival** – Rescue

Specifically, experiences from Norwegian Safety Authority Norway also shows that education of emergency personnel on board ships and oil installations focus mostly on the escape and evacuation but much less on the survival and rescue.

SARex 1 and 2 have shown the importance of validating technical requirements versus towards functional requirements. This article will show some of the challenges experienced in these two expeditions, in the frigid waters around Svalbard, held in spring 2016 and 2017.

One of the worst-case scenarios to put the search and rescue resources to the test is assumed to be the sinking of a cruise liner in polar waters. The *TS Maxim Gorkiy* incident, in which a cruise ship with nearly 1000 passengers hit drift ice on the evening of 19 June 1989 outside Svalbard, was such a scenario.

There are many heroic accounts of sealers and fishermen being stranded in their rescue craft for prolonged periods. Knowledge and equipment have been key factors in their survival. This article looks into the regulations, competence and equipment that are in place today, relevant for a survival situation in the northernmost areas of the Norwegian sector. It also includes experiences made during SARex 1 and 2, and recommendations based on these experiences.

2. Background

Most of the requirements in today's offshore regulations, guidelines and the progress in technology have been done in relation to the evacuation processes, for example with the introduction of free-fall lifeboats and marine escape chutes. With the prolonged survival phase being most likely to occur in northern waters compared to the more southern regions of the Norwegian continental shelf, it would be most relevant to look further into the evacuation means' ability to sustain survival, and to verify whether regulatory requirements are sufficient. Survival suits, and particularly helicopter transport suits, have also improved significantly over the last decade.

The Polar Code was implemented in January 2017 and is applicable to all vessels covered by the IMO in Arctic and Antarctic waters. These requirements are not applicable for offshore installations in the oil and gas industry, but they may be in the future (pers. com. Å. Waage, Norwegian Maritime Authority (resigned June 2019)). There have been exploration activities to date in the Polar Code area (Korpfjell- prospect), but only outside the harshest winter season.

3. Methods and materials

This article is based on review of regulations applicable as of August 2019 related to the competence in survival in the oil and gas industry in the Norwegian sector. The course content in safety courses required for work in the offshore industry in Norway will be compared to regulatory requirements and lessons learned from SARex 1 and 2. The author of this article was an active participant in tests during these exercises.

4. Limitations and assumptions

This article highlights the most relevant regulations for a survival scenario relevant for the offshore petroleum activities on the Norwegian continental shelf and compares how these requirements will support survival and rescue in a cold climate survival situation. Not all requirements related to emergency response are covered in this report.

The exercises were conducted with the leadership of naval officers with special training in leadership in emergency situations, in both the lifeboat and -raft. This competence would not be available in the case of civil vessels or oil and gas installations. The exercise participants also had personnel with special competence in the equipment used, with vendors' representatives on board. The privates onboard K/V Svalbard, civil servants and academics also had relevant knowledge to some extent.

There was also the continual presence of medical personnel on board during SARex 1 and partial presence during SARex 2. This can be assumed to produce less stress for the participants, compared to a real case, where it is unlikely that there would be medical personnel on board. The exercises were held in sheltered waters. The evacuations where dry evacuations.

5. Relevant regulations

The key regulations governing offshore petroleum activities are provided in the health, safety and environment regulations [3] that consist of the the Framework -, Management -, Facilities – and Activity regulations.

The regulations covering requirements for escape -, evacuation - and rescue means, and competence and training can be divided into different groups of barriers, which are all covered by the Norwegian offshore industry HSE-regulations; cf. the Management Regulations Section 5 about the different types of barrier elements:

- Technical
- Operational
- Organizational

"WHO is doing WHAT with what EQUIPMENT" illustrates the organizational, operational and technical barrier elements, respectively. All these types of barrier elements need to be in place, to ensure safe operations and a robust emergency preparedness in the offshore industry's operations. The Norwegian Petroleum Authority has written guidelines on how to interpret these requirements [4].

The offshore petroleum regulations in the Norwegian sector consists of mainly functional requirements. This is not the case for the maritime regulations. However, there is an exception with the recently introduced IMO Polar Code. Most of these requirements are of a functional nature, e.g. the five-day survival requirement mentioned in the introduction. It should, however, be noted that actors operating within the regulations are responsible for risk analyses and risk management in which design scenarios need to be developed; therefore, it is expected that the five-day requirement will be challenged by operators documenting safe survival when closer to rescue means.

5.1. Maritime regulations

On the Norwegian continental shelf, offshore mobile units can follow the maritime technical requirements in the design and equipment of maritime systems on board; cf. the Framework regulations Section 3. This includes the design of escape ways and all emergency response equipment on board. The maritime regulations related to petroleum activities offshore are stipulated through the Norwegian Maritime Authority (NMA) regulations or other flag state regulations to a similar or higher safety level. Where the other flag state requirements are below the NMA's regulations, then the NMA's regulations are to be followed. The NMA normally refers to the IMO requirements but, in some cases, has additional requirements. So, in practical terms, the NMA regulations form the basis for the design of mobile offshore units, including the evacuation equipment. As of today, most mobile units include semi-submersible and jack-up installations used for drilling or purely accommodation services (often referred to as "floatels").

The relevant regulations for the mobile offshore units are in the “red book”, issued by the NMA [5]. In this collection of different regulations are the NMA regulations of 2 February 2016 No. 90 on evacuation and life-saving appliances on mobile offshore units (Rescue regulation), which gives the requirements for the design, placement and numbers of necessary life-saving equipment on board. In particular, the NMA Rescue regulations Chapter 4 (numbers and placement of evacuation and life-saving equipment) and Chapter 5 (design requirements) state the requirements for mobile units in terms of evacuation equipment. These regulations refer, to a large extent, to the IMO Life Saving Appliances Code (LSA-Code) [6].

Regarding life rafts, the LSA Code has some requirements that are seemingly useful features. However, the experience from SARex 1 and 2 has shown that the requirements have not been sufficient. For instance, there is not an absolute requirement of a double bottom in life rafts:

LSA Code, chapter 4.2.2.2 - *The floor of the life raft shall be waterproof and shall be capable of being sufficiently insulated against cold either:*

1. *By means of one or more compartments that the occupants can inflate, or which inflate automatically and can be deflated and re-inflated by the occupants; or*
2. *By other equally efficient means not dependent on inflation.*

The latter has in practice become a thin neoprene layer with silver foil/ heat reflective material on the top. The first requirement could be a double bottom, which in SARex 2 proved a lot better than the solution chosen by following item 2 above. However, the most common life raft type used on offshore installations today is the single bottom with a thin insulating layer.

IMO Polar Code: The IMO Polar Code [7] is a set of functional requirements that are adapted to the specific challenges of operating and handling emergency situations in polar regions. It covers the complete aspect of operating in these regions, but the most relevant sections related to emergency response are:

- Chapter 1 Definitions:
  - 1.2.4 *Habitable environment* means a ventilated environment that will protect against hypothermia.
  - 1.2.7 *Maximum time of rescue* means the time adopted for the design of equipment and systems that provide survival support. It shall never be less than 5 days.
- Chapter 8 Life-saving appliances and manning: That evacuation equipment shall function in the adverse conditions during maximum time of rescue. There is also Chapter 8.2.3 covering *survival*. Amongst several requirements, then the means of escape shall provide a habitable environment.
- Chapter 12 Manning and training: This chapter has the goal of ensuring that ships operating in polar waters are appropriately manned by adequately qualified, trained and experienced personnel.

5.2. Offshore Petroleum Industry

Within the petroleum industry, the most relevant regulations governing the design and operation of evacuation means are stipulated in Table 1 below. None of these regulations (Table 1) are specific about requirements for the survival phase of an emergency situation. However, as stated in the Activity regulations Section 77, item c): “*Measures shall be taken so that personnel can be rescued during accident situations*”. “Rescued” in this context means that survivors shall be brought to a safe area either on board an installation, vessel or on land where necessary medical attention can be given.

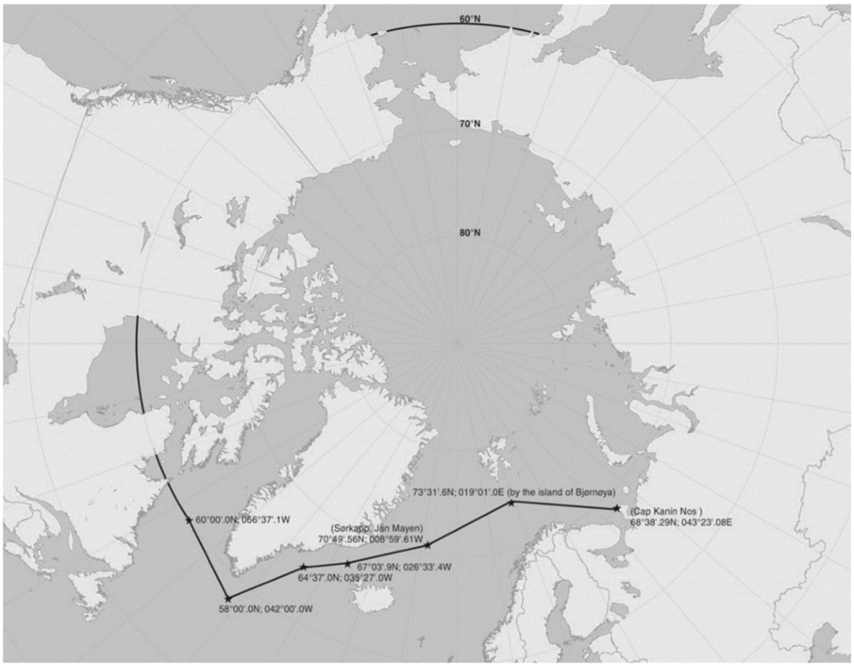

Figure 1. The maximum extent of the IMO Polar Code in the northern hemisphere (source: www.imo.org).

Table 1 Regulations governing emergency preparedness in Norway offshore oil and gas industry.

Regulation	*Description*
Framework reg. Section 20	Coordination of emergency preparedness resources, which state the operator's responsibility to establish and coordinate the emergency preparedness.
Management reg. Section 5	Barrier regulation.
Management reg. Section 14	Manning and competence, which, for instance, are relevant for ensuring that offshore personnel are competent to work in an Arctic environment (including emergency situations).
Management reg. Section 17	Risk analysis and emergency preparedness assessments.
Facility reg. Section 44	Means of evacuation, which refer to the requirements in NORSOK S-001 [8] Chapter 21 and for the design of free-fall lifeboats DNVGL-ST-E406.
Facility reg. Section 45	Survival suits and life jackets, etc.
Activity reg. Section 17	Transport to and from the offshore installations.
Activity reg. Section 21	Competence of offshore personnel, including the handling of situations of hazard and accident
Activity reg. Section 23	Training and drills, which require that personnel are trained and equipped to handle situations of hazard and accident in an efficient manner.
Activity reg. Section 73	Establishment of emergency preparedness, which state that there shall be a strategy for emergency preparedness in hazardous and accident situations based on analyses.
Activity reg. Section 75	Emergency preparedness organization, which state that this organization shall be robust, so that it is able to handle hazard and accident situations in an efficient manner.
Activity reg. Section 76	Emergency preparedness plans.
Activity reg. Section 77	Handling hazard and accident situations. Sub section c) here states that measures shall be taken so that personnel can be rescued during accident situations.

Standards and guidelines: The industry has developed standards and guidelines for the design of evacuation and safety equipment. NORSOK S-001 [8] states requirements related to lifeboats and life rafts in Chapter 21.4.3. However, there is no specific mention of requirements related to a prolonged cold-water survival phase. Survival suits are also covered here in NORSOK S-001. When it comes to the design of lifeboats, reference is made to the standard, DNVGL-OS-E406 [9]. For life rafts, SOLAS and flag state requirements are referred to. Chapter 21.4.4 covers requirements for survival suits. It also refers to SOLAS requirements.

The Norwegian Oil and Gas Producers Association (NOG) has also developed guidelines for both helicopter transport suits (A) and survival suits available at lifeboat stations (B) in their NOG guideline GL094. This guideline refers to the standard:

- NS-EN ISO 15027-1:2002 Immersion suits; Part 1, Constant wear suits, requirements including safety.
- NS-EN ISO 15027-2:2002 Immersion suits; Part 2 Abandonment suits, requirements including safety.

According to NOG GL094, both types of suits shall fulfill the requirements in the LSA Code (except item 2.3.2.1, where special Norwegian requirements apply). The suits shall be able to sustain a survivor's body heat and prevent drowning and near drowning for a period of at least 120 minutes. It is given in NOG GL064 [9] about area emergency preparedness. In Chapter 3.9, the guideline pays special attention to activities in the Barents Sea region. Other than recommending that special consideration be given to the performance criteria in this region, it does not find any reason to establish individual requirements for this region on a scientific basis. This statement can be understood based on the capacities of today's helicopter transport suits and specifications for the alternative IMO suits, but it does not mention anything about a most likely longer survival time during winter operations in the most distant parts of this region. The lack of daylight, the polar lows and significantly colder waters in the north-eastern part are not considered. *The industry has not yet established a common performance criterion for the survival time!* However, BaSEC group (BaSEC = Barents Sea Exploration Collaboration - established by Statoil, Eni Norge, Engie (GDF Suez), Lundin and OMV, in April 2015) has suggested a criterion for rescue in the Barents Sea of 24 hours [13] (pers. com. S. R. Jakobsen, Petroleum Safety Authority Norway).

6. Competence requirements for emergency response in the offshore petroleum industry

6.1. Onshore competence training

The onshore training centers in Norway provide a Basic Safety Training (GSK = nor. "Grunnleggende Sikkerhetskurs", English: "Basic Safety Training course") course for all personnel traveling to offshore petroleum installations in the Norwegian sector. On this course, there are only some basics on survival and rescue from lifeboats and life rafts, which are repeated in the refresher courses held at regular intervals (every fourth year).

The participants on these courses have:

- An equipment demonstration at an inflated life raft, exercises in the sea involving the turning of a capsized life raft.
- Demonstration of launching mechanisms, either by davit-operated rafts or by using the marine escape chute system.
- Evacuation exercise through the escape chute.
- Lifeboats, performing entering, lowering and evacuation
- Helicopter underwater evacuation training (HUET) in swimming pools (non-mandatory).

The lifeboat coxswain courses are mostly concerned with the functionality of the lifeboats, from mustering at the lifeboat stations to preparing for launching, launching techniques and moving away from the offshore installations, avoiding collision and re-entry. A minor part of the course focuses on operational/ organizational factors after entering the sea in a lifeboat:

- Get an overview on board, take care of passengers

- Keep the command and initiative, get an overview – provide information
- Delegate tasks to passengers (equipment, first aid, emergency systems)

However, these subjects are not elaborated to a large extent and, as from the lessons from SARex 1 and SARex 2, they are an important contributor towards increasing survival chances. These lessons are presented in a later chapter in this report. At the end of the lifeboat coxswain courses, this is the expected learning (source: A.-E. Sævareid at Falck-NUTEC, Norway):

- Recognize 10 items from the lifeboat equipment package
- Highlight position using available equipment
- Know the lifeboat's six emergency systems and be able to use these
- Manoeuvre, also by means of emergency tiller
    - Using compass heading
    - Towards objects in the sea
- Launching of marine escape chute
- Prepare davit-operated life rafts for launching
- Recognize the most common stress reactions in an evacuation situation

As a conclusion, there is very little or no focus, in either the Basic Safety Training courses or the Lifeboat Coxswain Training courses, on the knowledge needed for survival of a prolonged survival time in cold waters in lifeboats or life rafts.

6.2. Offshore competence training

The requirements related to training on site at each individual installation are stated in the Activity regulations Section 23 about training and drills. They require that each individual team member in an emergency team on board trains a minimum of once per offshore trip for each role he or she has in an emergency response team. The Norwegian Oil and Gas Producers organization (NOG) has focused on making the onshore training more efficient and reducing the time spent on these courses, while emphasizing the importance of local training on each installation. NOG has developed a set of modules (https://www.norskoljeoggass.no/drift/opplaring/treningsmateriell-for-beredskapslag/) to ensure that important aspects of handling different hazard and accident situations are covered in the training sessions offshore. These modules for coxswains do not focus much on survival phase.

7. Lessons learned in relation to survival in SARex 1 (2016) and SARex 2 (2017)

This section is based, to a large extent, on the author's contribution to the SARex reports [1] and [2]. Note that this paper does not provide a full list of experiences from SARex 1 and 2 but, rather, highlights those that are identified as particularly relevant for Norwegian offshore petroleum activities, as well as personal experiences.

7.1. SARex 1 and 2 in brief

SARex 1 and 2 considered evacuation and survival for maritime emergencies in Arctic waters. The scenario on both expeditions was an emergency on a cruise ship, involving evacuation. This section will look into lessons learned from SARex 1 and 2, which could be relevant for the oil and gas industry on the Norwegian continental shelf.

The author of this article was an active participant in the tests. Participation in the survival tests in both SARex 1 and 2 took place in the life raft. Of course, the best learning came from direct participation, which were the raft survival tests, the evacuation of the lifeboat by KV Svalbard personnel, helicopter evacuation from the lifeboat with the SAR-rescue helicopter and the use and testing of emergency equipment for maritime casualties in the Arctic.

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Figure 2 Circles indicate areas for SARex 1 and 2 activities.

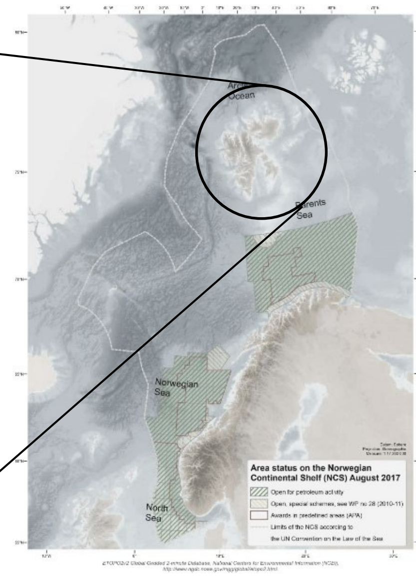

Figure 3 Illustration of the areas open for petroleum activity. Source: www.npd.no.

7.2. Climatic relevance

The sea temperatures were about 4-5 °C lower at SARex venues compared to normal winter temperatures at the northern part of the Norwegian continental shelf. However, in the far north and north east of the licensed area, there are occasionally sea temperatures close to 0 °C. The air temperatures where comparable. The wind conditions where for most of the time calm, with an exception towards the end of the SARex 2. The fetches were very limited at the venue of the trials.

7.3. Relevance of technical, operational and organizational barriers

7.3.1. Technical barriers

The equipment put to test for both SARex 1 and 2 was, for the most part, relevant for the offshore oil and gas industry, i.e. lifeboats, life rafts, survival equipment, survival suits and life vests, personal Protective Equipment (PPE), clothing underneath suits and life vests, hoods and gloves, as well as EPIRB and SART – detection equipment.

7.3.2. Operational and organisational barriers

Several operational and organisational barriers were tested during both SARex 1 and 2 relating to:

- Leadership in survival exercise on board life raft and lifeboat.
- Rescue of people from lifeboat to KV Svalbard with the use of a MOB boat (SARex 1).
- Rescue of people from lifeboat to shore with the use of a helicopter (SARex 2).

7.4. Differences and similarities in the exercise scenario of SARex 1 and 2, compared to potential oil and gas-related accident scenarios

There are some key **differences** between the scenario of SARex 1 and 2 (a large-scale mass evacuation scenario in the northern part of Svalbard) and the accident scenarios possible in the petroleum industry:

- Time to rescue: Oil and gas industry in Norway has suggested a criterion of maximum 24 hrs from launch of lifeboats to rescue [13] vs. 5 days IMO Polar Code requirement [7].
- Distance from marine resources: Offshore oil and gas activities offshore have a dedicated stand-by vessel with hospital with trained first aiders and man-over-board systems. Their rescue capability is of course influenced by the weather.

- Distance from shore-based resources: Today's distances from shore-based rescue resources to the offshore facilities, even in the furthest exploration areas, are considerably less than that of a potential cruise ship evacuation north of Svalbard (except exploration well Korpfjell in block 7435, where there was exploration drilling in 2017).
- Number of persons to be rescued: Less on oil rigs vs. cruise ships. Typical manning of mobile semi-submersible drilling rig is about 120 persons.
- Threat of solid ice: No areas on the Norwegian continental shelf with exploration drilling (or production) suffer an imminent threat of either sea- or glacial ice.

Other environmental differences: The areas chosen for SARex 1 and 2 were in an area with:

- Limited fetch, i.e. well protected, as opposed to the offshore oil and gas industry.
- Low average precipitation compared to areas of the offshore oil and gas industry.
- Lower sea water temperature compared to offshore industry (except far north east licenses).
- Wildlife threats (polar bears and walruses).
- Presence of daylight: Cruises have 24 hours light vs. offshore industry in dark winter months.
- Availability of emergency preparedness resources: Dedicated resources for offshore industry.
- Emergency preparedness training: The offshore industry provides more extensive emergency response training compared to cruise passengers.
- Average health of cruise passengers vs. offshore workers: Stricter health requirements offshore vs. cruise industry.

There are also some key **similarities** between the scenarios and equipment used in SARex 1 and 2 and what is relevant for the offshore oil and gas industry on the Norwegian continental shelf:

- Means of evacuation: Use of enclosed lifeboats and life rafts although free fall lifeboats are more common on semi-submersible rigs.
- Emergency preparedness organization: Trained dedicated emergency response personnel
- Survival suits and life vests: Similar insulation capacities although latest generation of helicopter transport suits for offshore industry are better.
- Air and sea temperatures: In the case of sea temperatures it is on relevant during winter in north eastern part of Norwegian part of continental shelf.

7.5. Learning and recommendations from SARex 1 and 2

7.5.1. Technical barriers

Lifeboats: See also SARex Spitzbergen Report April 2016 [1], Chapter 2.2.4 "The lifeboat's capabilities and capacity during the Phase 1 exercise" and similar chapter from SARex 2 [2].

1. Ice formation in vents in SARex 1. The low-pressure release valve that activates when the engine is running (using air inside) clogged up with ice. DNVGL-ST-E406 Chapter 3.6.1.2 states that ice formation shall be taken into account when designing a lifeboat. It also refers to DNVGL-OS-A101.
2. Ventilation – an issue related to condensation and also low O_2 plus high CO_2 levels. Part of DNVGL-ST-E406 Chapter 8.3.3. There was a CO_2 meter that indicated the need for ventilation. This, in turn, caused the lowering of temperatures inside and condensation.
3. Diesel heater provided temperatures too warm for wearing survival suits. Use of diesel heater needs to be such that survival suits could be worn in the case of need for quick evacuations. There is not enough room to store survival suits in a secure and proper manner. Part of DNVGL-ST-E406 Chapter 8.3.3.

4. Ability for lifeboat captain to communicate with passengers at the opposite/ far end of the vessel. The captain is often located at the helm, which was a raised seat in the aft of the lifeboat. There was additional noise from engine, wind, wave motion, etc., which made it difficult to make direct commands. A speaker system inside the lifeboat would be of great help. This subject is not covered by DNVGL-ST-E406.
5. Evacuation to helicopter from lifeboat rooftop not realistic in open seas, due to wave motion and risk of hooking into deluge system. Some sort of removable railing, together with anti-skid cover, would be a great asset to aid standing on lifeboat roof.
6. Toilet facility useful. Covered by DNVGL-ST-E406 Chapter 8.3.5.

SARex 1 and 2 utilized the same conventional lifeboat. The lifeboat used in 2017 was an improved version of the one used in the previous exercise, e.g. insulation on seats (styrofoam), toilet (type "Porta Potti") and diesel heater. These two improvements alone provided a huge impact on comfort and estimated survival rate on board.

Life rafts: See also SARex Spitzbergen Report April 2016 [1], Chapter 2.2.6 "The life raft's capabilities and capacity during the Phase 1 exercise" and similar chapter from SARex 2 [2].

1. The SARex 2 life raft also had near standing height and an air-filled beam to keep the tent in position, which provided support to hold on to during times of wave motion and when it was necessary to move around the raft.
2. The SARex 2 life raft, with features such as a double bottom and double tent, provides a major improvement, in terms of insulation from the single bottom and tent version used in SARex 1.
3. The SARex 2 life raft had a welded double bottom; the welds themselves created cold bridges.
4. The SARex 2 life raft also had some leaks in the seams that created a small but constant flow of sea water into the raft. This was removed by using sponges throughout the exercise.
5. Although the raft was not filled to maximum certified capacity, there was very little room to move. It was a similar experience in both SARex 1 and 2. However, personnel pulled out of the experiment at a far faster rate in SARex 1, leaving much more room to move. This room was used effectively last year to perform exercises, in order to produce heat. This was not possible to the same extent in SARex 2, where almost all participants lasted the whole duration of the experiment.
6. The zipper on the outside of the tent froze when waves hit the raft's tent. Over a prolonged stay in a raft, this could be an issue with oncoming hypothermia.
7. The radar reflector was not easily mounted on the raft ceiling outside. The reflector was also lost when the wind reached gale force.
8. There were too few waterproof torches on board for a winter situation with complete darkness. Then, it would be essential to have sufficient lighting to ensure all necessary activities and operations.

Survival suits & life vests: See also SARex Spitzbergen Report April 2016 [1], Chapter 2.2.7 "The capabilities of personal protection equipment the Phase 1 exercise" and similar chapter from SARex 2 [2].

1. Compared to SARex 1, all participants in SARex 2 wore full suits. Three participants in the survival test wore uninsulated suits, the rest fully insulated suits. Some of the insulated suits also had extra insulation/ padding in areas that had contact with the raft floor, when in sitting or lying positions. The insulated suits were comparable to the commonly used helicopter transport suits used on the Norwegian continental shelf. The expected time of rescue in the case of an oil and gas-related incident on the Norwegian continental shelf is about 24 hrs, although this is not an established dimensioning criterion. Together with wool clothing, these suits would most

likely provide enough insulation, in a dry environment inside a double-bottomed/ double tent type raft, to sustain body temperature in an Arctic environment.

2. The “one size fits all” suits that were used in SARex 1 and 2 do not have pockets, which could be useful for storing safety equipment and food rations.
3. The personnel on board used suits differently. It was obvious that some basic competence related to routines for opening the zipper to let moisture out would have been useful. The suits are water- and airtight. There is a build-up of moist inside the suits. How long time the suit was unzipped and how far down the zipper was seemed essential for the ability to maintain heat and stay dry. In addition, the use of the hood influenced the cold experienced. Those persons without an integrated hood noticed cooling at an earlier stage than those with integrated hoods.
4. The Velcro around the ankles and the waist strap was an essential feature for smaller persons using the “one size fits all suits”.
5. Those participants with uninsulated survival suits without integrated hood, but separate hood, noticed a distinct cooling of the neck area.
6. All suits had separate gloves or mittens. The types provided were either three-fingered type crab-claw neoprene mittens or five-fingered thin (2 mm) neoprene gloves. The crab-claw mittens are far warmer but impossible to wear while performing the simplest tasks.
7. It is a requirement of the NMA to have life vests with a light, which automatically starts in contact with water. Lights on life vests might not be sufficient to detect personnel in the sea in snow or fog. See section below about detection equipment. There were no lights either on the “one size fits all” type survival suits used in this experiment.
8. The pontoons around the raft in SARex 2 provided a good bench, removing the need to sit on the cold – and at times wet – raft bottom.
9. The ballast tanks underneath the raft bottom provided a lot of stability, together with the very strong winds and short period wind-waves (chop) towards the end of the experiment. Nevertheless, there was sincere concern, when the winds reached more than 20 m/s, that the wind could have toppled the raft. At this time, the personnel on board the raft were taken on board KV Svalbard. The situation at least showed the importance of stability measures in place, particular for an open ocean situation.
10. When performing the helicopter pick-up, the inflatable life vest popped, as it should. However, it was not possible for the rescuer to thread the sling either from above or below. The blown-up floatation device on the life vest had to be cut open by the rescuer, using a knife.

Personnel Protection Equipment (PPE) according to trials done by Norwegian Maritime Authority and Memorial University of Newfoundland, St. John’s.

1. There are no protective gloves with insulation for Arctic conditions that enable the operation of valves or small items in either a normal work or emergency situation: operating VHF-radio, zippers, fastening and mounting radar reflector, emergency flare, etc. The personnel on KV Svalbard used conventional Arctic clothing; however, this equipment did not provide protection against crush injuries.
2. The personnel on KV Svalbard used balaclavas combined with googles to provide adequate protection in e.g. operating the MOB boat in a considerable wind chill. They also used Gore-Tex waterproof working suits with neck seal.

7.5.2. Organizational and operational barriers

Leadership: See also SARex Spitzbergen Report April 2016 [1], Chapter 2.2.8 “Leadership on board life raft during Phase 1 exercise”, Chapter 2.2.9 “Leadership on board lifeboats during Phase 1 exercise” for lifeboats and similar chapter from SARex 2 [2].

The participation in the life raft survival tests showed the necessity of having good leadership on board: for both physical and mental aspects. The life raft leader on both SARex 1 and 2 was one of the Navy's own officers, with the ability to organize the evacuated personnel to ensure:

1. Activities to sustain heat/warmth.
2. Operating the life raft at sea, watch routines.
3. Organizing water and food rations.
4. Organizing various safety equipment on board the raft.
5. Activities to maintain awareness, encouraging people to take responsibility, to come forward with good ideas and provide entertainment.

The life raft leader ensured that:

1. All survivors on board had responsibility for at least one or two pieces of equipment, making all persons on board explain the function and usage of the designated equipment.
2. Other tasks were distributed amongst the survivors, e.g. distribution of food rations, control of timing, taking turns on watch.
3. Bonding and engaging activities took place on board: introduction of each individual survivor onboard, games, etc.

Competence and fitness: Based on the operation of the life raft and the function of various pieces of equipment, it proved important to have either a competent life raft leader or competence amongst the evacuated passengers to operate the life raft and associated equipment. Knowledge on cold climate survival would also be an important asset in terms of increasing survival chances: activities for keeping warm, how to minimize exposure to cold surfaces (e.g. raft floor).

7.6. Other lessons and recommendations for the offshore oil and gas industry in cold and remote waters

7.6.1. Technical measures

- Wearing thin neoprene gloves in emergency situations during helicopter flights and before embarking, and underneath the mittens permanently attached on most helicopter transportation suits. Stricter guidance on wearing correct size suits to ensure too large suits are not given to passengers.
- Wearing hood zipped up during flights in cold waters, not only during take-off and landing as seen practiced in the Norwegian sector. It is common practice to not wear the hood during take-off and landing, only zipping up the neck seal. However, it is usual to see passengers not zipping up, even when instructed to do so by the pilot before take-off and landing.
- The industry should develop performance criteria and efficient patents to ensure better ventilation in lifeboats and life rafts, without affecting the watertight integrity. This is also to meet the functional requirement in the IMO Polar Code Section 8.2.3.3, sub-item .1: "*…resources shall be provided to support survival following abandoning ship, whether to water, to ice or to land, for the maximum expected time of rescue. These resources shall provide a habitable environment*". "*Habitable environment*" is defined in Section 1.2.4 "*…a ventilated environment that will protect you against hypothermia*".

7.6.2. Operational/ organizational measures

- Consider removing the N-notation on the GSK certificates in the Norwegian sector for offshore travel, which is given when personnel are exempted from HUET (see chapter 6.1).

- Ensure cold water acclimation before offshore helicopter transport in cold waters, e.g. introduce real scenario temperatures in HUET training or add an additional module for acclimation.
- Establish performance criteria for the Norwegian offshore oil and gas industry, in relation to maximum time until rescue by either helicopter or vessel, where necessary first aid treatment can be given; cf. BaSEC recommendations [13].
- Introduce specialized courses for oil and gas operations within the Polar Code area that educate participants in all aspects of emergency preparedness, especially in the survival and rescue phase, which is not part of the other safety courses available. This should include the management of a lifeboat/ life raft, trauma handling, survival techniques, etc.

8. Conclusion

The offshore regulations through Activity regulations Section 77 about handling hazard and accident situations, sub section c) states that measures shall be taken so that personnel can be rescued during accident situations. "Rescued" in this context means that survivors shall be brought to a safe area either on board an installation, vessel or on land where necessary medical attention can be given. The lack of regulatory requirements and focus from the industry to date, in relation to cold water survival, can mainly be attributed to the relatively short length of rescue times expected for the more established and developed areas of the Norwegian continental shelf. At least in theory. However, considering the exploration activities and possible new field developments in the more remote northern parts of the Norwegian sector and the lessons learned from SARex 1 and SARex 2, one must consider the extraordinary challenges that these marine environments impose on a marine survival situation.

Given the complexity of extended survival in cold waters, the petroleum activities taking place in the areas of the IMO Polar Code needs to have compensatory measures in place *to obtain a similar safety level to that of petroleum activities in the more southerly parts of the Norwegian continental shelf*. For example, if not considering the five-day survival requirement for the polar regions, then additional rescue resources should be in place to considerably reduce rescue time. To achieve a similar rescue time to that in the more southern parts of the Norwegian sector will be a difficult task, considering the limited infrastructure; therefore, effort needs to be put into developing individual requirements and equipment for operating in these areas. Due consideration needs to be given to technical, operational and organizational measures in this aspect, to maximize survival chances during petroleum activities within the area applicable for the IMO Polar Code.

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