Fire safety on board submarines
– Crew interventions

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Abstract
This work investigates crew opinions about manual intervention on board submarines and planned new solutions on the new submarine, the A26. The planned solutions include an unmanned aft and the installation of water mist instead of Halon 1301 as fire suppression system. Literature, survey and interviews were used to gather information. The crew routines and previous fire incidents were determined. The survey shows that many crew members have not experienced fire on board and that in many cases they start a manual intervention later than as prescribed in the regulations. Interviews and survey show that the crew is sceptical towards the planned changes but that information could change this. This work has contributed to the design and construction of the next Swedish submarine, the A26.

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PREFACE

This thesis is our last assignment at LTH before we become Fire Protection Engineers. It has been an interesting and fun time and we have learnt many things. This report has been produced in cooperation with Kockums AB with the goal to provide them with a better understanding on how the submarine crew uses their submarines in case of fire. Hopefully we have contributed to making the next generation submarine the best possible.

We want to give special thanks to following persons for the time and effort they have put into making this project as good as possible by sharing their knowledge and providing support:

Anders Håkansson
Pontus Nordberg
Johan Äqvist
Robert Jönsson
Pelle Bengtsson
Martina Ardenmark
Jörgen Wigg
Mårten Ribbing

We would also like to thank the staff and the active and former crew members at the First Submarine Flotilla who took their time to answer our questions by filling out the survey and/or taking part in the interviews. Without you this project could not have been completed.

Last but not least we would like to thank the nice people working at “12 trappor” and each other for all the fun times and a great job!

Lund 2012

Anna & Sofia
SUMMARY

This report is produced in cooperation with Kockums AB who are in the process of designing a new class of submarines, the A26 which is the first Swedish submarine where an alternative fire safety design will be incorporated. One of the changes with the A26 compared with the former submarines is that water mist is being considered as an alternative to Halon 1301 as fixed fire suppression system. This will lead to an increased amount of manual interventions and Kockums AB is therefore interested in learning more about the crew actions, routines and opinions about the planned fire safety on board. The other major change is that the aft compartment will be designed as unmanned. The objective with this project was to describe how the crew responds to a fire incident on board a submarine and what their opinions are regarding the changes in fire safety planned on the A26 compared to previous boats.

The question of issue was: How does a Swedish submarine crew act in case of fire and how do they incorporate the fire safety systems on board?

Three methods were used: literature review, survey and interviews. The literature study resulted in an overview of the regulations that regulate the fire safety on board and information regarding the fire safety on current and previous submarines. The manual interventions on board submarines can be divided into four steps: prevention, immediate action, initial attack group and fire fighters. The crew routine is described and summarised in section 7.

A survey was sent to 98 previous and current submariners (70 surveys were completed) and six people were interviewed to investigate crew opinions about fire safety. The result shows that many crew members have never experienced a fire on board but they are well familiar with the routines since they regularly have drills on board.

The crew is sceptical towards the planned changes on the A26 but more negative towards an unmanned aft than towards water mist. The crew knowledge in the planned technology is however limited. The opinion whether it will require a change in routines differs. Different routines on different submarines could lead to difficulties when changing between the boats.

During the investigation the crew has also raised suggestions of improvement for the A26 that, as far as we know, are not planned on board. The crew suggestions that we think could have a positive impact on the manual interventions are listed in section 9.
SAMMANFATTNING


Syftet med detta arbete var att beskriva hur besättningen reagerar i händelse av brand och att undersöka deras inställning till de ändringar som ska införas på A26.

Frågeställningen var: Hur agerar en svensk ubåtsbesättning i händelse av brand och hur använder de sig av de system för brandsäkerhet som finns installerade ombord?


Enkätundersökningen sändes till 98 nuvarande och före detta besättningsmedlemmar varav 70 besvarade enkäten, därtill genomfördes sex intervjuer. Resultatet visar att många ur besättningen inte har varit med om någon brand ombord på ubåt men att de är väl förtrogna med rutinerna då de övar regelbundet.


## GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation/word used in this report</th>
<th>In Swedish</th>
<th>Definition in this report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active fire safety system</td>
<td>Aktivt system</td>
<td>A system that can be activated either mechanically or electronically, for example fire alarm, sprinkler or portable fire extinguisher</td>
</tr>
<tr>
<td>AFS</td>
<td>Arbetsmiljöverkets författningssamling</td>
<td>Swedish Work Environment Authority Statutes</td>
</tr>
<tr>
<td>Aft</td>
<td>Akter</td>
<td>The stern, back part, of the boat</td>
</tr>
<tr>
<td>Airlock</td>
<td>Sluss</td>
<td>A compartment between the fore and the aft compartment. From here the individual and collective rescuing takes place</td>
</tr>
<tr>
<td>Alternative design</td>
<td>Analytisk dimensionering</td>
<td>Same as performance based design. Design that provides alternative solutions provided that the requirements are met</td>
</tr>
<tr>
<td>Assignment book</td>
<td>Fördelningsbok</td>
<td>Documentation that provides information about crew functions in different situations</td>
</tr>
<tr>
<td>BIBS</td>
<td>BIBS</td>
<td>Built In Breathing System. Oxygen used for emergency situations</td>
</tr>
<tr>
<td>Chief Engineer, CE</td>
<td>Fartygsingenjör, FI</td>
<td>Officer responsible for technical operations. Is the damage control officer, the leader of the internal battle</td>
</tr>
<tr>
<td>Collective rescuing</td>
<td>Kollektiv räddning</td>
<td>An option of evacuation from submarine. The whole crew evacuate to the URF and into pressure chamber if needed</td>
</tr>
<tr>
<td>Commanding Officer, CO</td>
<td>Fartygschef, FC</td>
<td>Officer responsible for the crew and the submarine, the captain</td>
</tr>
<tr>
<td>Conventional submarine</td>
<td>Konventionell ubåt</td>
<td>Non-nuclear submarine</td>
</tr>
<tr>
<td>Damage control party</td>
<td>Skyddet</td>
<td>Crew members that does not have a specific task in the damage control organisation and are on standby for reinforcement</td>
</tr>
<tr>
<td>Damage control organisation</td>
<td>Skyddstjänst</td>
<td>Is activated when the general alarm sounds. The crew are organised to be able to handle both external and internal battle</td>
</tr>
<tr>
<td>Duty Officer, DO</td>
<td>Vakthavande officer, VO</td>
<td>Officer in charge of the submarine operation while at sea, each watch has one duty officer</td>
</tr>
<tr>
<td>Abbreviation/word used in this report</td>
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</tr>
<tr>
<td>External battle</td>
<td>Yttre strid</td>
<td>Threats from outside the submarine, such as hostile submarines or war ships</td>
</tr>
<tr>
<td>Extinguish</td>
<td>Släcka</td>
<td>When the fire is being put out completely by either a manual intervention or by an active fire safety system</td>
</tr>
<tr>
<td>Fire cell</td>
<td>Mindre brandcell</td>
<td>Small compartment, unmanned. For example a switchboard</td>
</tr>
<tr>
<td>Fire fighter</td>
<td>Rökdykare</td>
<td>Person equipped with fire retardant clothing, breathing apparatus and air tubes</td>
</tr>
<tr>
<td>Fire fighting</td>
<td>Rökdykning</td>
<td>Manual intervention performed by fire fighter</td>
</tr>
<tr>
<td>Fire zone</td>
<td>Brandcell</td>
<td>Confined space from where smoke or extinguishing agent is prevented from spreading. Can be manned or unmanned</td>
</tr>
<tr>
<td>FMV</td>
<td>Försvarets materielverk</td>
<td>Swedish Defence Materiel Administration</td>
</tr>
<tr>
<td>Fore</td>
<td>För</td>
<td>The front part of a boat</td>
</tr>
<tr>
<td>General alarm</td>
<td>Skyddslarm</td>
<td>A general action taken in an emergency or other extreme event where the submarine has to be closed to prevent the spread of water, fire, gas or pressure</td>
</tr>
<tr>
<td>HT, main switchboard</td>
<td>Huvudtavla</td>
<td>Main switchboard</td>
</tr>
<tr>
<td>Individual rescuing</td>
<td>Fri uppstigning (FU)</td>
<td>An option of evacuation from submarine. The crew evacuate one by one through the air lock</td>
</tr>
<tr>
<td>Internal battle</td>
<td>Inre strid</td>
<td>Threats within the submarine, such as fire or leakage from torpedo</td>
</tr>
<tr>
<td>Leading fire fighter</td>
<td>Rökdykledare</td>
<td>Person in charge of the fire fighters</td>
</tr>
<tr>
<td>Passive fire safety system</td>
<td>Passiva system</td>
<td>A system that does not need to be activated, it is present all the time, for example fire zones</td>
</tr>
<tr>
<td>RMS</td>
<td>Regler för militär sjöfart</td>
<td>The Swedish regulations for military water borne traffic</td>
</tr>
<tr>
<td>Room protection</td>
<td>Rumskydd</td>
<td>System that is used to protect a bigger area, for example a whole fire zone</td>
</tr>
<tr>
<td>SJÖFS</td>
<td>Sjöfartsverkets författningssamling</td>
<td>The Swedish Maritime Administration Code of Statues</td>
</tr>
<tr>
<td>SJÖI</td>
<td>Militära sjösäkerhetsinspektionen</td>
<td>The Swedish military maritime safety inspectorate</td>
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<tr>
<td>Abbreviation/word used in this report</td>
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<td>Definition in this report</td>
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<tr>
<td>SOLAS</td>
<td>SOLAS</td>
<td>International convention for the Safety Of Life At Sea</td>
</tr>
<tr>
<td>Stirling engine</td>
<td>Stirlingmaskineri</td>
<td>One type of air independent propulsion</td>
</tr>
<tr>
<td>Suppress</td>
<td>Kontrollera, begränsa</td>
<td>When the fire is controlled but not completely extinguished, either by a manual intervention or by an active fire safety system</td>
</tr>
<tr>
<td>The Swedish Maritime Law</td>
<td>Sjölagen</td>
<td>Law that regulate for example the fire safety on board Swedish ships</td>
</tr>
<tr>
<td>The Swedish Maritime Safety Act</td>
<td>Fartygssäkerhetslagen</td>
<td>Law that regulate for example the fire safety on board Swedish ships</td>
</tr>
<tr>
<td>Trim</td>
<td>Trim, ubåtens horisontella läge i vattnet</td>
<td>The submarines horizontal level in the water</td>
</tr>
<tr>
<td>TSFS</td>
<td>Transportstyrelsens författningssamling</td>
<td>The Swedish Transport Agency Code of Statues</td>
</tr>
<tr>
<td>Ub I M: Allmän</td>
<td>Ubåtsinstruktion för marinen. Allmänna föreskrifter för tjänsten på ubåt</td>
<td>Instructions for submarine, general constitutions for working on board submarine</td>
</tr>
<tr>
<td>UKR</td>
<td>Ubåtssäkerhet: Krav och rekommendationer</td>
<td>Requirements and recommendations from FMV about submarine safety</td>
</tr>
<tr>
<td>URF</td>
<td>Ubåtsräddningsfarkost</td>
<td>The Swedish submarine rescue vehicle.</td>
</tr>
</tbody>
</table>
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INTRODUCTION

This paper is the final report for a Bachelor of Science degree in Fire Protection Engineering at the Department of Fire Safety Engineering and Systems Safety at Lund University in Sweden. The thesis has been produced in cooperation with Kockums AB who is in the process of designing a new class of submarines; the A26.

The new submarine class is being designed based on an order from FMV, the Swedish Defence Materiel Administration, who supply materiel for the Swedish Armed Forces. The A26 class will consist of two submarines that are planned to be delivered to the navy in the year of 2018-2019.

1.1 Background

Kockums AB is a company that design conventional submarines and has been building submarines since 1914 (Klintebo, 2004). The A26 is the first submarine constructed by Kockums AB where an alternative design for the fire safety will be incorporated. This results in a new and more complex approach for the fire safety on board. Since Kockums AB is responsible only for the design and construction of the Swedish submarines they have little or no knowledge in how the systems on board are used by the crew during operation.

The safety on board vessels is regulated by the International Convention for the Safety of Life At Sea, SOLAS. This is an international maritime safety agreement which in Sweden is incorporated in different laws. The fire safety on board the A26 submarines will be based on the specifications in SJÖFS 2004:31 which directly comply with the SOLAS chapter about fire safety. It is the military regulations, RMS, which states that the fire safety on board a submarine shall at least reach the level of SJÖFS 2004:31 appendix 1 and also allows performance based design on Swedish submarines. This means that alternative solutions can be considered as long as the performance specifications in SJÖFS are achieved.

Even if the construction complies with the specifications the safety on board a submarine is depending on the crew actions and their knowledge of how to act in case of emergency. One of the changes with the A26 is that water mist is being considered as an alternative to Halon 1301 as fixed fire suppression system. This will lead to an increased amount of manual interventions and Kockums AB is therefore interested in learning more about the crew actions, routines and opinions about the fire safety on board.

1.2 Objective

The objective was to describe how the crew responds to a fire incident on board a submarine. This included crew response times and when and how they use the fire safety systems installed. The objective was also to get a view of the crew’s opinion regarding the planned fire safety on board the A26.

1.3 Question at issue

The main questions to be answered during the project were:

How does a Swedish submarine crew act in case of fire and how do they incorporate the fire safety systems on board?

What is the crew opinion about the planned fire safety systems on board the A26 and what changes in crew intervention can it lead to?

To describe the first question at issue a number of sub questions were chosen:

- What are the routines in case of fire?
• What are the crew actions when they receive a fire alarm?
• How long does it take before the crew has started an initial attack (protected and unprotected) on a fire?
• What previous fire incidents have occurred on submarines?
• What is the probability of successful intervention based on previous incidents?

To validate the result the questions were answered by using three different methods: literature study, survey and interviews, refer Table 1. A study visit on board a submarine was also held to achieve better understanding for the submarine environment.

<table>
<thead>
<tr>
<th>Question of issue</th>
<th>Literature</th>
<th>Interview</th>
<th>Survey</th>
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<tbody>
<tr>
<td>What are the routines in case of fire?</td>
<td>×</td>
<td>×</td>
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</tr>
<tr>
<td>What are the crew actions when they receive a fire alarm?</td>
<td></td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>How long does it take before the crew has started an initial attack (protected and unprotected) on a fire?</td>
<td></td>
<td>×</td>
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<tr>
<td>What previous fire incidents have occurred on submarines?</td>
<td>×</td>
<td>×</td>
<td></td>
</tr>
<tr>
<td>What is the probability of successful intervention based on previous incidents?</td>
<td>×</td>
<td></td>
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</tr>
<tr>
<td>What is the crew opinion about the planned fire safety systems on board the A26 and what changes in crew intervention can it lead to?</td>
<td>×</td>
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</tr>
</tbody>
</table>

1.4 Limitations

A number of limitations had to be made throughout the process. Focus was put on the submerged mode since this is where the submarine is most vulnerable. This is also where the submarine operates most of the time and especially in war time.

Only the regulations that are valid for the A26 were chosen, some of them are old editions and some are new but they are in line with the specification from FMV. This means for example that both RMS 2007 and RMS 2010 have been used.

The survey was distributed via the Chief of Staff at the First Submarine Flotilla which made it hard to control who received the survey. The interviews were made during one day at the office at the Flotilla and the respondents were personnel on duty at the time. The number of persons interviewed was set to six.

The analysis and possible improvements of the crew reactions, routines and strategies in case of a fire was limited to the new submarine class A26, designed for the Swedish Armed Forces.
2 LAWS AND REGULATIONS

The International Convention for the Safety of Life At Sea, also known as SOLAS, is the leading agreement for ship safety in the world (International Maritime Organization, 2011). This standard is incorporated in Sjölagen, Fartygssäkerhetslagen and SJÖFS (the Maritime Law, Maritime Safety Act and Swedish Maritime Administration Code of Statues) (Carlsson & Lundmark, 2007). None of these regulations are specified for warships such as submarines. Warships are regulated by the Swedish Armed Force regulation RMS (Regulations for military water borne traffic), which has a specific part for safety and a specific chapter for submarines. However, in RMS it is expressed that the fire protection on board new submarines (read the A26) shall meet the civil regulation SJÖFS with some exceptions that is expressed in RMS part F. RMS is divided into eight parts where part F deals with safety on board and the current edition for this part is RMS 2007. For the other parts, for example RMS-P which deals with the personnel, it is the new edition RMS 2010 that is current.

An even more submarine specific regulation is the UKR which include requirements and recommendations for submarine safety. UKR is an appendix to the Submarine System Specification to design the new submarine. The specification describes how FMV want the submarine to operate. To summarise it is UKR together with RMS that specify the safety on board the A26. It is expressed in RMS-F (2007) that the fire safety shall meet the regulation SJÖFS 2004:31. The relationships between the regulations are displayed in Figure 1.

Instructions to the submarine crew, for example orders in case of fire alarm, are regulated in the Ub I M: Allmän (submarine instruction for the Swedish navy). For fire fighting the crew follows the Swedish Work Environment Authority constitution for fire fighting, AFS 2007:7. The Swedish military intend to follow civil regulations as much as possible but for warships they adjust the regulations to suit their organisation. AFS 2007:7 outlines that a risk assessment shall be performed so that the organisation and training, tests and equipment can be adapted to the identified risks and possible scenarios.
2.1 Ub I M: Allmän
Ub I M Allmän is an instruction book containing information regarding war and sea duty. It is the main safety regulation for the submarine crew. It is also the document explaining drills and orders on board and works as an instruction for the crew. Chapter 5 describes actions in case of emergency and states that fire fighting shall begin immediately by the person in the immediate vicinity of the fire. It also states that general alarm shall be announced which alerts the entire crew and fire fighters starts preparing for an intervention; the damage control organisation is activated (Försvarsmakten, 2000). For more detail of crew actions see section 3.5.

2.2 AFS 2007:7
The constitution for fire fighting, AFS 2007:7, regulates fire fighting both in training and real-life situations. The objective is to prevent injuries and maintain good health when performing fire fighting. Before a fire fighting operation starts the leading fire fighter shall evaluate the risks and should stop the intervention if the risk is too high compared to what can be achieved. The regulation also controls communication between fire fighters and the leading fire fighter as well as the physical working conditions. The fire fighting skills need to be maintained by participating in at least four exercises a year in a submarine environment. (Arbetsmiljöverket, 2009)

2.3 UKR 3.2
UKR is an appendix to the submarine specification explaining the functions of the A26. UKR handle submarine specific safety requirements and recommendations which are the base of submarine safety when FMV order or modify submarines. The objectives with the recommendations is that the safety should not be set aside for economic reasons, complex technical solutions shall be avoided if possible and the principle of double safety shall be applied throughout. Double safety means that two independent errors have to happen at the same time for intolerable risk to appear. (Försvarsmaterielverk, 2009)

The fire protection is being defined in chapter 14. UKR ranks the actions of how to minimise the risk as follows (Försvarsmaterielverk, 2009):

1. Prevention
2. Detection
3. Minimising consequences
4. Fire fighting

The requirements contain both detailed descriptions and principles to eliminate the fire and explosion risk. If incidents occur, the consequences shall be as limited as possible and a fire should not be able to spread within the submarine (Försvarsmaterielverk, 2009).

UKR together with RMS are the specific regulations for the safety on board the A26.

2.4 RMS
All Swedish warships shall comply with the requirements of RMS. Two editions have been released since the A26 project started and both will be used but for different parts of the design. For the fire safety the applicable regulation is RMS 2007. RMS consists of eight parts where RMS-F regulates the fire safety. Crew training and education is regulated in RMS-P and fire drills are regulated in RMS-S, for these parts the current edition is 2010.

Chapter 11 in RMS 2007 is specified for submarines and section 11.11 states that a submarine should be designed and equipped so that a tolerable level of safety for the crew can be maintained in an emergency situation. If nothing else is specified, the survival equipment and systems on board shall be designed for the maximum number of people that
Laws and regulations

is allowed on board and the material for surviving and rescuing shall be accessible from each pressure tight compartment of the submarine. The crew should be able to survive in submerged emergency for seven days.

Section 11.14 regulates the fire protection on board a submarine. Section 11.14.2 lists eight principles for fire protection and fire extinguishing on board submarines:

- The design of the fire protection shall reflect that a fire is a great risk for the submarine and its crew
- Fire extinguishing shall not increase the total weight of the submarine while in submerged mode
- Losing control of depth or trim due to fire extinguishing is not allowed
- Forced ventilation of smoke to the outside shall be possible when in snorkel and surface position
- The submarine shall be constructed in such a way that the risk of fire is minimised
- The construction shall minimise the risk of a fire being undetected
- Minor and more severe fire incidents shall be minimised by the construction
- The construction and equipment of the submarine shall be of such kind that the crew can lead and implement a fire fighting operation

RMS-F section 11.14.1 states that the fire safety on board submarines shall at least reach the level of SJÖFS 2004:31, appendix 1, for cargo ships with the exceptions and additions that can be found in the RMS.

2.5 SJÖFS 2004:31

SJÖFS is the Swedish Maritime Administration Code of Statues. SJÖFS 2004:31 regulates the fire protection on ships covered by the SOLAS convention. Some ships are excluded from the code, for example Swedish warships and fishing boats. However, the military regulation, RMS, states that the submarines shall achieve SJÖFS 2004:31 requirements in appendix 1 and the fire safety on the A26 will therefore be based on this code of statute. SJÖFS 2004:31 was updated in 2008 but since the design of the A26 follow RMS 2007 which refers to SJÖFS 2004:31 this edition is used when designing the A26.

SJÖFS appendix 1 is divided into seven parts, A-G, and follows the structure from SOLAS convention. Rules worth noticing in this part are that a fire should be restricted and extinguished in the room where it occurs. This means that fixed fire suppression systems shall be installed and equipment shall be easy accessible and able to use instantly (Rule 10, part C); furthermore, instructions, education and exercises on board are to minimise the consequences and to secure the crew knowledge in case of emergency situations (Rule 15, part E). (SJÖFS 2004:31)

Part F (Rule 17) describe the alternative design of the fire protection on board, the full methodology are presented in SJÖFS appendix 3. The A26 will follow these directions but also the exceptions and additions that are mentioned in RMS-F. Furthermore it deals with the quantification of design values, which are necessary to ensure that the alternative design meets the requirements. (SJÖFS 2004:31)

2.6 SOLAS 74

The objective of the SOLAS Convention is to specify minimum standards for the construction, equipment and operation of ships. Each country is responsible for ensuring that ships under their flag meet the requirements (International Maritime Organization, 2011). SJÖFS 2004:31 appendix 1 is the Swedish translation of SOLAS Chapter II-2 – Fire protection, fire detection and fire extinction.
The first version of the SOLAS convention was adopted after the accident with Titanic in 1914 when more than 1500 persons lost their lives (International Maritime Organization, 2004). The current edition is number five and was adopted 1974 by the International Maritime Organization, IMO.
3 FIRE SAFETY ON BOARD SUBMARINES

The conditions in submarines give little or no room for errors. Small spaces filled with technical equipment and the fact that it most of the time operates under water makes it a special work environment. It is important to remember that a navy submarine is designed to perform missions during times of war which has to be considered when designing the fire safety on board.

The fire safety on board submarines can be divided into structural and organisational fire safety. The structural fire safety includes passive fire safety systems, active fire safety system and materials in the submarine while the organisational fire safety concerns how the crew is organised and how they act to prevent and fight fires. This separation recognise that it is as important with a trained crew and effective routines as it is with effective systems, fire zones and emergency equipment in the correct location. The fire safety on board submarines has developed through the years and will continue to develop for the A26.

3.1 History of incidents

Sweden has over hundred years of submarine history. The first Swedish submarine was launched 1904 and was named Hajen (The Shark). The first submarine fire occurred on board Hajen and was luckily extinguished by the Commanding Officer and the engineers; no one was hurt (Klintebo, 2004). The second submarine, named Hvalen (The Whale), was built in parallel with an Italian and a Danish submarine of the same class. The Italian submarine exploded when refuelling, probably due to smoking on board. Many people died and after this accident smoking was prohibited on the Swedish submarines and in the ship document it was added that everyone on board should learn the boat, its systems and restrictions on board (Klintebo, 2004). Since then the importance of crew knowledge has been essential on board submarines. Today it is added in the instructions for submarine crew, the Ub I M Allmän, that knowledge, watchfulness and endurance is needed from everyone on board to prevent devastating consequences.

Since 1904 25 classes containing approximately 80 submarines have been constructed for the Swedish Navy (Postek, n.d.). A list of all the Swedish submarines can be found in Appendix A. During these hundred years of Swedish submarines a number of incidents have happened, some due to fire but also collisions with boats and groundings (Klintebo, 2004).

Table 2 list some incidents through history that relate to fire or explosion on board (Klintebo, 2004). Most of the fires in the early years were battery explosions or fire in battery room. More recent incidents show that leaking oil and smoke development is more common. Large fires where people have been hurt or killed have only happend a couple of times on board Swedish submarines.
Table 2: Examples of fire incidents on board Swedish submarines since 1904 (Klintebo, 2004; Johansen, 2004; Skytt, 2008; Räddningstjänsten Östra Blekinge, 2010)

<table>
<thead>
<tr>
<th>Year</th>
<th>Submarine</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1907</td>
<td>Hajen</td>
<td>Fire on board, no one hurt</td>
</tr>
<tr>
<td>1911</td>
<td>Ub nr 2</td>
<td>Fire on board while in yard. No one hurt.</td>
</tr>
<tr>
<td>1948</td>
<td>U4</td>
<td>Front battery explosion. Four dead, one hurt.</td>
</tr>
<tr>
<td>1952</td>
<td>Svärdfisken</td>
<td>Fire in battery room due to short circuit. No one hurt.</td>
</tr>
<tr>
<td>1968</td>
<td>Sjölejonet</td>
<td>Diesel engine fire due to oil leakage. No one hurt, only engine damages.</td>
</tr>
<tr>
<td>1969</td>
<td>Uttern</td>
<td>Front and rear battery explosion. One dead, one hurt.</td>
</tr>
<tr>
<td>1978</td>
<td>Näcken</td>
<td>Cable fire HT7. No one hurt.</td>
</tr>
<tr>
<td>1978</td>
<td>Vargen</td>
<td>Kitchen fire. No one hurt. Leaking oxygen made fire fighting harder.</td>
</tr>
<tr>
<td>1984</td>
<td>Sjöormen</td>
<td>Diesel engine fire due to leaking oil. No one hurt.</td>
</tr>
<tr>
<td>1986</td>
<td>Sjöhunden</td>
<td>Diesel engine fire due to hydraulic leakage. No one hurt.</td>
</tr>
<tr>
<td>1989</td>
<td>Sjöhästen</td>
<td>Battery fire. No one hurt.</td>
</tr>
<tr>
<td>1993</td>
<td>Neptun</td>
<td>Short circuit fire HT7. No one hurt, rear end of submarine destroyed.</td>
</tr>
<tr>
<td>2004</td>
<td>Västergötland</td>
<td>Smoke development due to oil leakage. No one hurt.</td>
</tr>
<tr>
<td>2008</td>
<td>Södermanland</td>
<td>Smoke development in electrical equipment. No one hurt.</td>
</tr>
<tr>
<td>2009</td>
<td>Halland</td>
<td>Fire in electrical equipment while in yard. No one hurt.</td>
</tr>
</tbody>
</table>

3.2 Fire safety equipment

The fire equipment on board the submarines was in the 1950s only portable fire extinguishers and fire hoses. Later on, during the last three decades, fixed fire suppression systems have been installed and fire fighter gear has been added to the fire fighting equipment.

The Hajen III class, launched 1954-1958, had portable fire extinguishers filled with carbon dioxide and two hoses for fire fighting (Lindeman & Krokstedt, 1963). Also the submarine Draken, launched in 1960-1961, and Abborren, launched 1962-1964, was equipped with carbon dioxide portable fire extinguishers and fire hoses. The number of portable carbon dioxide fire extinguishers increased from five in the previous classes to eleven in the Sjöormen class launched in 1967-1968 (Försvarets materielverk, 1975). Portable fire extinguishers were, and still are, placed throughout the boat so that a fire could be extinguished early after detection. The fire fighting materiel was also complemented with breathing apparatus in the Sjöormen class (Försvarets materielverk, 1975).

When the Sjöormen class was modified in the beginning of the 1980s a new kind of portable fire extinguisher was added; water based foam, to better extinguish all types of fires (Försvarets materielverk, 1984). On operating submarines the foam extinguishers can be reloaded on board and a number of carbon dioxide extinguishers are also placed in the boat to provide redundancy (Försvarets materielverk, 1999).

Documentation indicates that emergency clothing for fire fighting operations was first used on the Västergötland class which was built in the late 1980s (Försvarets materielverk, 1991).
At high concentrations, carbon dioxide is lethal for human beings and unconsciousness occur after approximately one minute in a concentration of 20-30 % (Särdkvist, 2006). This is also the concentration when fire extinction is achieved in experiments. In other situations, where leakage is expected, a higher concentration is needed (Särdkvist, 2006). Restrictions regulate the number and size of carbon dioxide extinguishers on board so that the concentration of carbon dioxide remains acceptable after a fire has been extinguished.

According to RMS-F 2007 submarines shall be equipped with a Built-In Breathing System (BIBS) to be used in case of contaminated air or other emergencies. The system is only for emergency situations, for example to rapidly be able to extinguish a fire or when preparing for evacuation from the boat. The system shall be designed so that the whole crew can use the system during two hours. A document about BIBS installation has been found in the safety instruction for Hajen III (Lindeman & Krokstedt, 1963) which indicates that BIBS were a part of the emergency system in the 1960’s. Besides BIBS, a number of emergency escape hoods, so called ELSA-hood, are nowadays placed in the boat and these were shown during the visit on board Östergötland 12 September 2011. The ELSA-hoods can be used to evacuate from fire, smoke or other toxic gases but are only effective for some minutes. RMS-F (2007) also regulates that there shall be fire fighting equipment for two firemen including breathing apparatus in each pressure tight compartment of the boat. Systems for refilling the oxygen tubes shall be available in both sections of the boat.

### 3.2.1 Fire safety equipment on the A26

The equipment for fire fighting on board the A26 are the same as on the Gotland class, which is a fixed fire suppression system, portable fire extinguishers, fire hydrant, oxygen tubes with breathing apparatus and fire fighter gear (Ardenmark M., 2011a).

### 3.3 Active fire safety systems

The active fire safety systems on board current Gotland class submarines are a fire alarm system including both smoke and flame detectors, fire dampers and a fixed fire suppression system (Försvarsmaterielverk, 1999).

According to RMS-F (2007) section 11.14.7.2 areas with a high risk of fire should be equipped with a fixed fire suppression system. On board current submarines this is achieved through a gaseous system using Halon 1301 for room protection. Näcken II class was the first submarine that had Halon 1301 installed from the beginning, in 1979. Submarines manufactured earlier had not been equipped with a fixed fire suppression system. When Sjöormen was modified in the mid eighties a fixed Halon system was installed (Försvarsmaterielverk, 1984). During the following years safety awareness increased and in the 1980s Halon was also installed inside switchboards, modules and other electrical equipment as a local fixed fire suppression system (Johansson, 2011a). The valve on the Halon cylinder will automatically open and release the Halon when the cylinder has reached 67 °C or higher. When the submarine is manned the Halon system can only be activated manually by the crew to avoid activation unless necessary. Each zone in the system can be activated separately. Activation can be done either from a release box connected to the Halon cylinder, from the main switchboard HT10 in the control room or from the switchboard HT6 in the electrical equipment space (Försvarsmaterielverk, 1999). When the submarine is unmanned the Halon system is switched to automatic mode.

As of 1998 it is forbidden to install a fire safety system that uses Halon due to its negative impact on the environment (Julin & Lindvall, 1998). However, Halon systems on board operating submarines are permitted until 2040 (European Commission, 2010) but when new submarines are being constructed other methods of extinguishing is needed.
3.3.1 Active fire safety systems on the A26

For the A26 the suggestion is to install water mist as room protection in compartments except the control room and the two battery rooms and a gaseous system using Novex 1230 as local protection in switchboards and modules. Both Novex 1230 and water mist are different from Halon as extinguishing agent when it comes to suppression capacity, installation and the formation of residues. To give the reader an understanding of the differences between the three substances and how they behave on board a submarine they are presented further below. An addressable detection system with heat and smoke detectors will be installed on the A26. Aspirating systems will be installed in cabinets to allow for an early detection. (Håkansson, 2011)

3.3.2 Halon

Halon is an abbreviation of halogenated hydrocarbon which is a carbon chain with halogens; fluorine, chlorine, bromine or iodine, replacing of one or more hydrogen atoms (Särdkvist, 2006). It is this substitution of hydrogen that provides the non-flammability and fire extinguishing properties of Halon. The Halons most commonly used for fire extinction are Halon 1301 and Halon 1211 where the number indicates how many carbon, fluorine, chlorine and bromide atoms that are part of the molecule. Halon 1301 is mainly used for fixed systems and Halon 1211 for portable systems (Integrated Publishing, n.d.).

Halon and other gaseous agents extinguish the fire by lowering the flame temperature so that combustion can no longer occur (Särdkvist, 2006). In addition to this, Halon chemically interrupts the reaction in the flame (Tewarson & Khan, 1993). The extinguishing capacity of Halon 1301 occurs at 3-6% (Försvarsmaterielverket, 1999), while unconsciousness might occur at concentrations around 15-20% (Stoody Industrial and Welding Supply, 2000). However, personnel should not stay in spaces when Halon system is discharged since noticeable effects, such as dizziness and headache, start appearing when inhaling (International Program on Chemical Safety, 1998). Because of this it is important with a warning before the agent is released.

Halon has great fire suppression efficiency, is clean and need less space when stored compared to most other extinguishing agents. This is because it is being stored as a liquid and because of the low concentrations needed for extinguishing. Furthermore the installation does not require many pipes and nozzles. When Halon comes into contact with hot surfaces or flames (warmer than 482°C) it decomposes into hydrogen fluoride (HF) and hydrogen bromide (HB) (Integrated Publishing, n.d.). HF is a toxic gas that, when it reacts with water in the air, produces acid that is dangerous to humans (Ardenmark & Håkansson, 2011). In addition the acid is corrosive and could lead to malfunctioning electrical equipment. Studies show that the corrosion is highly depending on the air humidity and a high concentration HF does not lead to corrosion if the air humidity is low (Kim & Crampton, 2008).

Another disadvantage with the Halon 1301 systems on board current submarines is that once the Halon has been released it cannot be recharged until the boat is back at quay. This is not unique for Halon systems, it is a problem for all gaseous systems unless you have spare containers on board. This would however require space that is not available in a submarine. Since the system cannot be recharged at sea the crew are unwilling to activate the system unless it is completely necessary since it reduces the ability to control the next fire if it occurs.

Halon is not environmental friendly; when the bromide reacts with oxygen in the ozone layer a process starts depleting the ozone (Ujfalusi, 2011). The global warming potential is very high and the atmospheric lifetime is over 60 years, which leads to high ozone depletion potential (Särdkvist, 2006).
In 1987 an agreement was established between 196 countries with the goal to reduce the production of ozone depleting substances. The agreement resulted in a protocol named Montreal Protocol on Substances that Deplete the Ozone Layer, which entered into force 1989 (Ozone Secretariat, 2010). Since 31 December 1997 Halon is banned in commercial fire fighting in Sweden (Miljödepartementet, 1988). Due to the environmental effects of Halon FMV has decided to install water mist as total flooding agent on board the A26 (Håkansson, 2011).

3.3.3 Novec 1230
Novec 1230 is a fire suppression agent widely used as a replacement for Halon (3M, 2008). Novec 1230 is a fluoroketone with the chemical formula C₆F₁₂O and is developed by 3M. The agent is liquid at room temperature and transforms to a gas when released into the compartment at high pressure. Novec 1230 does not contribute to ozone depletion, has a low global warming potential and an atmospheric lifetime of 5 days (Gann & Reneke, 2002).

Like other gaseous extinguishers Novec 1230 physically extinguish the fire by lowering the flame temperature (Särđkvist, 2006). Novec 1230 fluid needs concentrations of between 4% and 6% to be effective in fire extinguishing while dangerous concentrations for humans is about 10% (3M, 2008).

One disadvantage with Novec 1230 is that when it comes into contact with the flames or other surfaces hotter than 570°C hydrogen fluoride (HF) is produced. The concentrations produced are up to 10 times higher for Novec than for Halon (Ardenmark & Håkansson, 2011). Experiments show that at concentrations lower than extinguishing concentration more HF is produced (Andersson & Holmstedt, 2006). It is therefore important to make sure that a high concentration is achieved early to minimise the production of HF.

On the A26 the problem with hot surfaces and the production of HF will be addressed by encapsulated hot surfaces in the engine room (Håkansson, 2011). It is also a requirement in the work environment regulations that surface temperatures on hot equipment shall not exceed 80°C, to prevent burns (Arbetsmiljöverket, 2009). A lower temperature also decreases the probability that leaking fuel is ignited when in contact with hot surfaces, like an exhaust gas pipe.

3.3.4 Water mist
Water mist is defined as a water spray where 99 % of the droplets have a diameter less than 1000 microns; 1000 millionth of a meter (Liu & Kim, 2000).

The primary extinguishing mechanism for water mist is heat extraction as the water works as thermal ballast in the reaction. Due to its thermal properties; high heat of vaporisation and a high heat capacity, water can absorb a large amount of heat from the flame and fuel and is therefore an effective extinguisher (Arvidsson & Hertzberg, 2001). Water expands about 1700 times when it vaporises which means that the water mist can work as oxygen replacement, especially in areas where the ventilation is low since it will lower the partial pressure of oxygen in the compartment (Liu & Kim, 2000). The small droplets in the water mist will vaporise, cool the hot gases and replace the oxygen so that the fire is extinguished or suppressed.

When comparing water mist to conventional sprinkler systems or gaseous agents the advantages are many. No toxic substances are produced and there is no risk for human health when activated. Water is environmental friendly and the water damage is less than of a conventional sprinkler system, water is also very efficient in suppressing certain fires (Liu & Kim, 2000).
A disadvantage with water mist is that studies show that it does not extinguish but control the fire if it is concealed and small in comparison with the compartment (Liu & Kim, 2000; Arvidsson & Hertzberg, 2001). Since the space on a submarine is limited and many systems are installed a scenario where the fire is hidden is likely. If the water mist does not extinguish a fire on board it can lead to an increased amount of manual fire fighting interventions and extra work for the submarine crew. This will be more obvious when the submarine is at quay and the system is activated automatically. Even in this case a manual intervention will be needed to ensure that the fire has been extinguished. This information is known by Kockums AB and is the main reason why this investigation of crew interventions is being undertaken.

Another disadvantage with a water system on a submarine is that nozzles, pipes and pumps need to be installed in an already crammed space. One great advantage however is that the system can be designed so that it is possible to recharge the system while the submarine is at sea (Ardenmark M., 2011b). This means that the crew can activate the system without affecting the capability to extinguish the next fire. The technical layout for this design is currently not developed and there are concerns about its feasibility. In the end there is a risk that the water mist system will not be easier to use than the halon system. A water mist system can be designed in several ways. The approach on the A26 is to design a system with strategically placed nozzles so that a fire can be suppressed or controlled within 60 seconds (Arvidsson M., 2011).

3.4 Passive fire safety systems

The submarine and its enclosed atmosphere make the structural resistance for fire very important. An enclosed compartment has impact on the pressure, oxygen levels and ventilation in case of fire. The Swedish submarines have a good basic structural protection. The submarines are constructed of a pressure tight cylinder which is separated into two main compartments, the fore and the aft. The compartments are divided by two pressure tight walls, an airlock in the middle, with pressure tight hatches allowing people to pass between the two compartments (Norrby, 2011). Refer Figure 2 for schematic picture of the submarine construction. A more detailed picture of a Gotland class submarine with the different compartments can be found in Appendix B. This construction allows one side to be used if the other takes in water or are unusable because of fire or other damage. This is also a reason why emergency material and systems should be accessible from each pressure tight compartment. The airlock is also used for individual rescue if this should become necessary, refer section 3.6.2.

![Figure 2: Schematic picture of submarine compartments](image)

The submarine is also divided into fire resistant compartments called fire zones and fire cells. A fire zone is defined as a confined space from where smoke or extinguisher agent cannot spread to neighbouring space (Försvarsmaterielverk, 2009). Each pressure tight compartment consists of at least one fire zone, depending on the type of submarine. For example the Södermanland class is constructed with one fire zone in the airlock, one in the fore ship and three in the aft; the machine room, the Stirling room and the electrical central.

A fire cell is a smaller compartment such as switchboards and electrical cabinets, and is unmanned (Försvarsmaterielverk, 2009). A fire cell normally has an active fire system installed to protect it from damages caused by fire.
3.4.1 Passive fire safety systems on the A26
The goal is to design the A26 in such way that the risk of fire is minimal. On the A26 approximately nine fire zones will be designed; the airlock, five in the fore compartment and three in the aft (Johansson, 2011b). Several fire cells and encapsulated hot surfaces are also incorporated in the design to achieve this. For example the Stirling engines and diesel engines will be encapsulated in modules which are separate fire zones.

3.5 The crew
The crew are of great importance for the fire safety on board a submarine. They can prevent fires and are educated for acting in the submarine environment. According to Schager (2008) the human senses play a great role in detecting fires and other errors on board ships. Humans can also be a reason why fires occur since human errors will always be a possibility (Schager, 2008). The ship manual for the submarine Gotland specifies that all the crew members must be acquainted with the emergency procedures and emergency regulations such as Ub I M Allmän and the assignment book (Norrby, 2011).

3.5.1 Crew organisation
On operating submarines the maximum persons on board are set to 35. Normally a crew consist of 27 persons. The A26 will be designed for a maximum of 31 crew members and with a normal crew of 26 persons. The crew is divided into two watches where one watch is at rest and the other is in control of the boat. The Commanding Officer, CO, has the main responsibility for the crew, the submarine and the operations; he is the captain of the boat. Below CO in the organisation are the Chief Engineer, CE, and two duty officers, DO. CE is in charge of the technical operations and DO is in charge of the tactical operations and the active watch. Neither the CO nor the CE is part of a watch and is always available. Refer Figure 3 for the crew hierarchy. Engineers, operators and Weapon Technicians are examples of other positions on board.

![Figure 3: Crew hierarchy](image)

The crew is the organisational fire protection and this organisation is regulated in the assignment book. Every submarine class has its own assignment book but the fundamentals are the same; each member of the crew has a certain position and with the position comes a predefined assignment depending on what kind of situation it is; for example in case of fire, submerging or when preparing for war. The survival of the crew is highly dependent of that all members of the crew know their role and act instantly in case of incident (Försvarsmakten, 2000).
3.5.2 General alarm
In case of emergency when pipes, ventilation and other penetrations through different compartments in the submarine has to be closed to prevent the spread of water, fire, gas or pressure, a general alarm is activated by the duty officer which activates the damage control organisation on board (Försvarsmakten, 2000). The general alarm should always be repeated on the internal communication system with more information about the danger, for example where the fire is detected or where the water intake occurs (Norrby, 2011). The damage control organisation include that the entire crew is alerted and the Chief Engineer takes command of emergency related issues. The ship manual also describes which actions that should be performed when the damage control organisation is activated. These actions are: preparing an emergency message, count the personnel and that materiel for leaving the ship shall be initiated (Norrby, 2011).

If a fire is detected on board the undertaken actions include shutting down of diesel engine, Stirling engine and the ventilation system and the fire fighters prepare for intervention (Försvarsmakten, 2000). It is also regulated in the Ub I M: Allmän that a first intervention should start immediately by persons closest to the fire. Another routine for direct fire fighting that is not documented in Ub I M: Allmän (initial attack group) is being tested at the moment. The routine is that two crew members put on their flame retardant gloves and fire retardant hood, bring a portable fire extinguisher and an ELSA-hood for safe retreat. This result in an earlier action compared to using the totally equipped fire fighters (Ribbing, 2011).

Basically there are four routines in the organisational fire protection:

- Prevention - Patrolling, materiel maintain, training and practice.
- Immediate action - Crew member who discovers the fire try to extinguish or activate alarm.
- Initial attack - Two predetermined crew members equipped with fire retardant hood and gloves, portable fire extinguisher and ELSA-hood attempt to extinguish and enclose the fire.
- Fire fighting - Two predetermined, trained and equipped crew members try to re-entry and continue extinguishing, or if people inside save them. The equipment includes breathing apparatus, uniform, helmet, gloves, boots, communication radio, knife, light and IR-camera.

3.5.3 Education of the crew
The education of the crew is regulated in RMS-P (2010). All crew members are educated in basic safety which follows the standard in TSFS 2010:20 appendix 17. All education for the Swedish Navy is being held at the Sjöstridsskolan (the Naval Warfare Centre). An additional education must be completed to be able to act as fire fighter on board, this education follows the civil regulation AFS 2007:7 included additional provisions from the military safety instructions (Försvarsmakten, 2011).

Fire fighting is a physical demanding activity that can be dangerous and the educated crew members need to meet a high standard of mental, physical and medical requirements. In order to keep up the capacity required training and drills are carried out on board and in simulated realistic environment (Försvarsmakten, 2011). RMS-S (2010) regulates that fire drills shall be held at least one time each month and at that time, except that fire fighters shall prepare for intervention, the function of communication system and detectors shall be tested.

AFS 2007:7 regulate the manning, communication, equipment, education and medical conditions for fire fighters. The organisation for a manual fire intervention on Swedish submarines includes two fire fighters, one leading fire fighter and one person that helps the
fire fighters prepare. These roles are defined each time when the submarine operates at sea. Refer Figure 4 for the crew hierarchy on board submarines during emergency situations.

![Crew hierarchy in the damage control organisation](image)

**Figure 4: Crew hierarchy in the damage control organisation**

### 3.5.4 Exemption from regulations

The special environment on a submarine has lead to one exemption from the AFS regulations for fire fighting; the leading fire fighter is not equipped with fire fighter gear (Försvarsmakten, 2011). Since the submarine only has two sets of equipments for fire fighters in each pressure tight compartment, one of these sets of equipments cannot be used since it is located in the fire compartment. This means that the leading fire fighter cannot use the equipment and not assist the fire fighters if problems occur.

The requirement from Arbetsmiljöverket (2009) to secure access to water when fire fighting, that is to not bring the fire hydrant during intervention, cannot be fulfilled on board submarines since the pump capacity is too low and water can damage electrical equipment (Norrby, 2011). This means that the fire fighters only bring portable fire extinguishers for the intervention.

Two conditions imply that the need of safe access to water to protect the fire fighters from heat radiation is not a priority. The first is that the submarine is always surrounded by water which helps cooling down the areas around the fire. The second is limited access to oxygen when the compartment is closed which will result in a ventilation controlled fire. (Norrby, 2011)
3.5.5 Problems and possibilities
Fire fighting is a hard workwork and the submarine environment makes it even harder with its narrow spaces and hatches with ladders, which was noticed at the visit on board. Another issue is that in war time retreat might not be an option for the submarine and its crew. Retreat is not always an option in peace time either; hard weather or system errors for example can make retreat impossible. External and internal threats can result in changes in the environment on board which leads to an even more complex emergency operation.

Another aspect of an emergency on board a submarine is that the whole crew is affected by the incident which means that it might not be possible to replace the fire fighters with rested personnel. However, the crew also has the ability to detect and extinguish a fire in time; the organisation is flexible, they can react instantly and know how to use the systems on board. Another great advantage is the small space; the crew are always awake and present and can notice a fire by the smell, the noise or in another way notice error in the familiar environment. (Ribbing, 2011)

3.5.6 The crew on the A26
A change from the operating submarines is that the aft compartment, where the diesel and Stirling modules are, will most probably be unmanned in the A26. The engineers that today are working in the engine room will instead be placed in the control room together with almost all the rest of the personnel of the active watch. The aft will be supervised with a monitoring system and addressable detectors. In addition to this the submarine will be designed for less people than current submarines.

3.6 Evacuation
There are two evacuation possibilities for the crew if the submarine environment becomes dangerous while in submerged mode or if the submarine is sinking. Either the crew can wait for the Submarine Rescue Vehicle, the URF, or they can leave the submarine one by one and float to the surface. Due to the extreme environment in which the submarine operates rescuing operations could be precarious and complicated. URF is a safer method than individual rescuing and is the prime rescue option for current Gotland class (Försvarets materielverk, 1999).

The evacuation strategy inside the submarine is to escape from an unsafe zone to a safe zone. Due to the nature of a submarine it is sometimes impossible to have two emergency exits from a fire zone, as prescribed in the regulations (Kockums AB, 2011a).

3.6.1 Collective rescuing, URF
The underwater rescue vehicle of the Swedish Navy is named URF and is shown in Figure 5. It is a specially designed submarine manned with three officers and is capable of rescuing up to 35 persons in one lift. URF is based on a specially designed ship, Belos, which carries URF to the location of the submarine incident. URF can also be carried with an aircraft or on a trailer to a harbour and then towed to the emergency location. URF can operate down to 460 meters depth and connect to a sunken submarine. Docking to a submarine can be performed at angles of up to 45 degrees. The submarine crew can then enter URF through the rescue hatch and into a pressurised chamber before they are taken to the surface and Belos. Belos has special handling systems that can transfer the crew under pressure into a chamber where medical treatment can begin immediately. (Kockums AB, 2009)
3.6.2 Individual rescue

If the URF for some reason cannot be used to evacuate the submarine or if the situation is such that an immediate escape is necessary the crew has one other option; to manually exit the submarine one by one and float to the surface. This is being done through the escape trunk from the airlock in the middle of the submarine. When performing this, the crew is equipped with a special rescue suit and a life jacket (Försvarsmakten, 2000). Individual rescue is a dangerous operation and should not be performed until it is reasonable that rescue personnel have arrived at the surface. It is also preferably performed during the hours of daylight so that the individuals can be spotted by the rescue personnel (Försvarsmakten, 2000). The individual rescue takes about 2.5 hours if a number of 35 people shall leave the boat (Försvarsmakten, 1999). An advantage of individual rescue instead of collective rescue is that the crew do not have to wait until the URF can assist.
4 METHOD

A descriptive method was used to provide more knowledge of how the submarine crew act in case of fire and how they incorporate the fire safety systems on board. Data was collected with surveys in combination with six interviews and the result is both qualitative and quantitative.

4.1 Survey

The objective with the survey was to get an understanding of incidents and routines on board a submarine in case of fire. The method was chosen because it made it possible to reach a large amount of people which hopefully leads to a wide base of information. The survey was sent to both active and former crew members. The goal was also to get some personal reflections from crew members regarding certain incidents and the planned fire safety systems on board the A26.

4.1.1 Type of survey

The survey was constructed as an electronic survey that was printed and distributed in paper form to the crew by the Chief of Staff at the Flotilla.

Open and closed questions were used to gather both general information and personal reflections. Open questions allow the respondent to describe the incidents in contrary to a closed question where predefined answering alternatives are used (Höst, Regnell, & Runeson, 2006).

The questions were grouped into four sections to give structure to the survey. The sections were background information, incidents, routines and fire safety systems and the aim was that the answers would help answering the questions of issue listed in section 1.3.

It is important to formulate the questions in the right way and to use easy and correct language (Dahmström, 2011). Military accidents and incidents can be confidential or in other way sensitive, therefore effort was put into formulating the questions in such way that no responder would feel singled out by describing their experiences. Another risk was that the crew members would hesitate to answer the questions in fear of providing the “wrong” answer. To prevent this, the option to answer the survey anonymously was provided. The authorshad also gone through a safety interview and were certified to take part of classified information.

The full survey can be found in Appendix C.

4.1.2 Selection

The survey was distributed via the Chief of Staff and the Commanding Officers to three submarine crews, the maintenance group (consisting of submarine personnel with extensive experience in service at sea, often engineers) and other personnel with submarine experience that the Chief of Staff judged to be interesting to answer the survey.

In addition to this, former crew members currently working on Kockums AB were identified through personal contacts in the company and the survey was distributed to these persons via e-mail. The reason to include former crew members was to get a wider perspective on the fire safety on board.

In total 98 persons were given the survey. 90 worked at the First Submarine Flotilla and 8 worked at Kockums AB.
The total number of employees in the First Submarine Flotilla is 307. According to the Chief of Staff at the Flotilla 84 persons are currently active on board the Swedish submarines. The rest of the 307 employees either work with other submarine related tasks or with the surface ships in the Flotilla.

4.1.3 Collecting the answers
The Chief of Staff distributed the survey and they were sent back to us by mail. For persons who returned the survey by e-mail, i.e. the former crew members that today work at Kockums AB, the survey was saved digitally.

The Flotilla had approximately four weeks to distribute and send back the surveys.

4.1.4 Processing the answers
A template for processing the answers was made in Microsoft Excel and for the open questions a Microsoft Word document was created for each question. Each completed survey was manually inserted into the template and documents so that the answers could be processed and compared.

The closed questions were processed by sorting the answers based on answering options. The open questions were processed by categorising the answers based on the content; coding. The answers can be divided into two parts, the actual words said and the underlying meaning of the words; the manifest and latent content. Examples of coded answers are shown below translated to English. Correct answer in Swedish are written in italic style underneath.

The questions about the A26 were coded based on if the respondent believed that the planned changes would require a change of routines or not. Since not everybody had written “yes” or “no” to answer the question both the manifest and latent content was used when coding the answers. An example of an answer to question 21 that was coded as “yes” was:

Evacuation will not be necessary when the water mist is activated, compared to Halon. Therefore a fire can be extinguished quicker.

Utrymning kommer ej att vara nödvändig då vattendimma utlöses, till skillnad från halon. Således kan brand släckas snabbare.

This coding was made since evacuation is part of the routine when Halon is activated.

In question 6 and 15 the respondent was asked about the crew actions in case of fire. These questions were coded to see how many people that mentioned the routines in any way. Some respondents described the routine why both the manifest and latent content were used in the coding process. An example of an answer to question 6 was:

The fire was extinguished by immediate action and was then watched by a fire fighter.

Branden tillbudssläcktes och övervakades sedan av rödkykare

For question 17 where the respondent was asked to estimate the probability of successful intervention the motivating answers were coded based on what percentage the respondent had answered; only the manifest content was used. An example of motivating an answer with high percentage (90 %):

Good education about how the systems work, what actions are relevant in case of fire. High awareness of the risk of fire on board.

Bra utbildning om hur systemen fungerar, vilka åtgärder som är relevanta vid brand. En stor medvetenhet om riskerna om brand ombord.
Coding was also used when analysing the answers to question 12: what is the most common fire incident. In this case many answers said the same thing in different words and therefore the answers were combined into five categories based on the content in the answers. The same method was used for question 3: what is/was your position on board. Examples of answers in the different categories are written in section 5 Result from survey where also the result to all survey questions is presented.

4.1.5 Reliability and validity
Reliability describes the repeatability and stability of a test; in this case how accurate the survey will result in the same results if repeated (Key, 1997). To achieve high reliability we have therefore tried to describe our way of collecting and processing the data in an interesting, reliable, and understandable way. The report also describes the conditions for the task which makes it easier to understand the content, result and conclusions. This has hopefully given the reader an opportunity to evaluate the result. The survey was sent first to the former submariners working at Kockums AB and later to the Chief of Staff at the Flotilla. We had unfortunately no insight in when or how the Chief of Staff sent the survey to the respondents at the Flotilla or how much time they had to answer the survey. Another method to achieve a high reliability is by repeating the same question in different words to compare the answers and see if the answers are the same; this is called the internal consistency reliability (Thunman & Wiedersheim-Paul, 2003).

Validity defines the strength of the results and can be defined as the degree to which a test, in this case the survey, measures what it is supposed to measure (Key, 1997). To test the survey validity a test person, a former submarine crew member now working at Kockums AB, answered the questions. The goal of the test was to try the survey on someone with experience from submarines and to see if the questions were formulated correct and interpreted as intended. The test led to some changes to allow for more descriptive answers and a couple of questions were added for further clarifications. The mentor from Kockums AB was included in the process of finalising the survey. It is hard to achieve good validity when measuring attitudes and when using open questions since the result is subjective views and not facts as weight, age or likely (Dahmström, 2011). In some of the questions the respondent were asked to justify their opinion which makes it a bit easier to interpret the answers.

The answering frequency is one way of measuring the validity of a study (Bryman, 2002). With a low answering frequency no general conclusions can be made without showing that there are no differences between the persons who have answered the survey and those who did not answer. The answering frequency can be categorised as shown in Table 3 (Bryman, 2002).

<table>
<thead>
<tr>
<th>Answering frequency (%)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;85</td>
<td>Excellent</td>
</tr>
<tr>
<td>70-85</td>
<td>Good</td>
</tr>
<tr>
<td>60-70</td>
<td>Acceptable</td>
</tr>
<tr>
<td>50-60</td>
<td>Barely acceptable</td>
</tr>
<tr>
<td>&lt;50</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

To improve the answering frequency method such as several reminders or bait such as money or similar can be used (Bryman, 2002). This was judged not necessary since the survey would be distributed by the Flotilla. It would also have been hard since we had no control over who received the survey.
4.2 Interviews
To get a deeper understanding of the routines and actions on board submarines, and as a complement to the surveys, interviews were held with previous and current crew members. The objective was to get the crew members to reflect on their routines and to discuss the planned fire safety on board the A26. The interviews were held at the First Submarine Flotilla at the Swedish marine base in Karlskrona, 6 December 2011. The date was decided by the Chief of Staff based on the crew schedule.

A shorter interview was also held with some of the former crew members working on Kockums AB. This was carried out to get a better understanding of how the submarine crew are thinking and to get some clarifications from the survey answers. These interviews will not be presented in the result.

Both authors were present during the interview and one was taking notes while the other one asked questions. Notes were taken during all interviews but no recording was performed.

4.2.1 Type of questions
The interview was based on the sub questions chosen for the project, refer section 1.3. Since the goal was to allow the crew members to talk about their experiences and opinions an open interview with predefined topics was chosen. This interview type is used to get an individual's experiences in mainly qualitative terms (Höst, Regnell, & Runeson, 2006).

An interview plan was created to give structure to the interview and to make sure nothing was missed. The interview was divided into ten subjects for discussion:

- Initial questions
- Routines
- Prevention
- Initial attack
- Fire fighting
- Fires and incidents
- The A26 – unmanned aft
- The A26 – water mist
- The A26 – evacuation strategy
- Final questions

Questions were created for each subject to be used as a guide during the interview. The questions were not always asked depending on the respondent and how the discussion was proceeding. However, the A26 was discussed during all interviews since it was important to get as much opinions about the planned fire safety as possible. The interview plan can be found in Appendix D.

According to Höst, Regnell & Runesson (2006) an interview is divided into four phases; context, initial questions, main questions and summary. This is important for the outcome of the interview since it makes the respondent feel comfortable and to gives structure to the interview (Höst, Regnell, & Runeson, 2006). This was considered when designing the interview plan and during the interviews.

Before the interviews took place a meeting with mentors and a fire protection engineer involved in the A26 project was held in order to get better prepared for questions that the crew could ask us during the interviews.
To identify if some of the answers were sensitive or classified the final question during the interviews was if there were anything said that was classified based on the nature of the information.

4.2.2 Selection
The personnel on duty 6 December 2011 was the crew chosen to take part in the interviews. A contact person in Karlskrona organised the day and possible respondents were discussed with him. The goal was to get a wide perspective on the subject by talking to both officers and persons of lower rank, with engineers and operators as well as weapon and sensor technicians.

Six persons were interviewed during the day, two Chief Engineers, one former Commanding Officer, one Weapon Technician, one System Technician and the Technical Chief of the Flotilla who is a former submariner.

4.2.3 Processing the answers
Some hours after the interviews the notes were structured into more detailed text and organised so that all answers regarding the same topic were combined into a text that summarised the interview. Six documents, one for each interview was created and sent to the respondents for quality review.

After the quality review the interview notes were processed by using coding which is a content analysis that takes out the characteristic of the contents (Gillham, 2008). Both the manifest and latent content was analysed and used in the process.

Every part of the text from the interview notes was coded depending on its content, the codes used were based on the subjects from the interview guide, with some changes. Codes used were:

- Routines
- Prevention
- Initial attack and fire fighting
- Fires and incidents
- The A26 – general
- The A26 – unmanned aft
- The A26 – water mist
- The A26 – evacuation strategy

Some of the parts could belong to more than one of the codes and when this happened the text were placed under the code where it had the strongest connection with the topic. When all notes had been coded a summarising text was written for each code, this is the result from the interviews and is presented in section 6.

4.2.4 Reliability and validity
Reliability is about dependability (Thunman & Wiedersheim-Paul, 2003). In an interview the words are the measuring device and the goal is to formulate questions that measure what they are intended to measure (Dahmström, 2011). During an interview the respondent’s answers depend on how the questions were asked, how the questions were interpreted and if the right formulations were used, in our case submarine language. But they will also depend on how the interviewers act, what position the respondents had, how the respondent think they should answer etcetera (Dahmström, 2011). To achieve high reliability non-leading questions were formulated, the background of the questions were explained and the same question was asked to more than one respondent. The authors were also familiar with the discussed subject and the interviews were held late in the project process. Before the
interviews a meeting was held with the mentor at Kockums AB to receive the latest information about the A26 and the fire safety on board. Open questions were used to get the respondents view of the subject and closed questions were used for background information about the respondent.

Validity is basically about being able to handle and discuss the errors in the study (Thunman & Wiedersheim-Paul, 2003). In the report we have therefore tried to provide as transparent picture as possible when describing our approach. This is to give the reader an opportunity to evaluate the results and if we measured what we intended to measure.

It is hard to achieve good validity when measuring attitudes and personal values (Dahmström, 2011). The asked question can be interpreted different by different respondents and the questions were not asked in the same context in all the interviews. The interview questions were based on the questions of issue with the objective to answer our main question of the thesis. To see the questions and answers in different ways triangulation was used. Respondents with different positions on board and on land were chosen and to validate the answers the structured notes taken during the interviews were sent to the respondents as control. Our interpretation of the answers was then made from the notes controlled by the respondents.

The reliability and validity for the interviews is discussed qualitatively in section 8.
5 RESULT FROM SURVEY

The completed survey was returned either by mail, from the respondents from the Submarine Flotilla, or by email, from the employees at Kockums AB. The answers were transferred to a Microsoft Excel spreadsheet and Microsoft Word documents and processed. The results are presented in this section both in a qualitative and a quantitative way.

5.1 Answering frequency

The total answering frequency of the survey was 71 % which is considered good (Bryman, 2002).

- 98 persons received the survey
- 70 responded
  - 8 from Kockums AB
  - 62 from the First Submarine Flotilla
- 63 % of the crew members that are active today have answered the survey

Answering frequencies for all questions are shown in Table 4.

Table 4: Answering frequency (%) for all questions in the survey

<table>
<thead>
<tr>
<th>Question number</th>
<th>Answering frequency (%)</th>
<th>Question number</th>
<th>Answering frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>93</td>
<td>11</td>
<td>71</td>
</tr>
<tr>
<td>2</td>
<td>100</td>
<td>12</td>
<td>71</td>
</tr>
<tr>
<td>3</td>
<td>99</td>
<td>13</td>
<td>97</td>
</tr>
<tr>
<td>4a</td>
<td>100</td>
<td>14</td>
<td>94</td>
</tr>
<tr>
<td>4b*</td>
<td>63 (93)</td>
<td>15</td>
<td>74</td>
</tr>
<tr>
<td>5</td>
<td>87</td>
<td>16</td>
<td>93</td>
</tr>
<tr>
<td>6a</td>
<td>93</td>
<td>17</td>
<td>87</td>
</tr>
<tr>
<td>6b*</td>
<td>63 (92)</td>
<td>18a</td>
<td>97</td>
</tr>
<tr>
<td>6c*</td>
<td>61 (90)</td>
<td>18b*</td>
<td>14 (59)</td>
</tr>
<tr>
<td>7a*</td>
<td>64 (94)</td>
<td>18c*</td>
<td>24 (100)</td>
</tr>
<tr>
<td>7b*</td>
<td>30 (44)</td>
<td>19</td>
<td>56</td>
</tr>
<tr>
<td>7c*</td>
<td>36 (52)</td>
<td>20</td>
<td>84</td>
</tr>
<tr>
<td>8</td>
<td>99</td>
<td>21</td>
<td>77</td>
</tr>
<tr>
<td>9*</td>
<td>69 (97)</td>
<td>22</td>
<td>31</td>
</tr>
<tr>
<td>10*</td>
<td>71 (94)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Follow-up question, number in brackets shows the answering frequency when answers to previous questions have been considered.
5.2 Questions
The results from all questions in the survey are presented in this section. Some of the questions are presented together for easy comparasion.

5.2.1 Question 1, 2, 3, 4, 5, 6, 7, 9, 11 and 18
The first questions were constructed to receive background information about the respondents. The result from these questions and other questions that were constructed with pre-defined answers are displayed in Table 5.

Table 5: Answers from the background questions in the survey

<table>
<thead>
<tr>
<th>Question number</th>
<th>Explanation</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Time on board</td>
<td>From 2 weeks to 35 years (average = 10,5 years)</td>
</tr>
<tr>
<td>2</td>
<td>Still in duty</td>
<td>76 %</td>
</tr>
<tr>
<td>3*</td>
<td>Position</td>
<td>51 % Operator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>27 % Engine</td>
</tr>
<tr>
<td></td>
<td></td>
<td>9 % Weapon</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7 % Electric</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 % Chef</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 % Belos crew members</td>
</tr>
<tr>
<td>4a</td>
<td>Have fire fighting education</td>
<td>66 %</td>
</tr>
<tr>
<td>5</td>
<td>Have/ have had fire fighting as assignment</td>
<td>47 %</td>
</tr>
<tr>
<td>6a and 9</td>
<td>Have experienced fire on board</td>
<td>64 %</td>
</tr>
<tr>
<td>7a, b and 11</td>
<td>Have taken part in a manual intervention</td>
<td>11 %**</td>
</tr>
<tr>
<td>18a</td>
<td>Have experienced an activation of the Halon system</td>
<td>24 %</td>
</tr>
</tbody>
</table>

* Question 3 was an open question and the answers have been categorised by us into different groups of positions that are present on board Swedish submarines or Belos
** Includes on board submarine, surface ships and at home

5.2.2 Question 2
Question 2: Are you still in duty? For result see section 5.2.1.

5.2.3 Question 3
Question 3: What is/was your position on board? For result see section 5.2.1.

5.2.4 Question 4
Question 4a: Do you have fire fighting education for submarine personnel?
Question 4b: If you do, for how long have you had it?

46 (69%) responded that they had fire fighting education, see section 5.2.1. 14 of these have had it for 10 years or more. 26 persons have had it for less than 10 years. Remaining 6 respondents have not provided an answer to question 4b or answered in such way that we cannot understand how long they have had the education.

5.2.5 Question 5
Question 5: What is/was your assignment if a fire occurs? For result see section 5.2.1.
5.2.6 Question 6
Question 6a: What is the most severe fire incident you have experienced on board a submarine? Describe what happened. In the two following questions, 6b and 6c, the respondent were asked to describe the crew and his/her actions respectively.

- 31 % had never experienced fire on board
- 48 % mentioned general alarm or the routines
- Initial attack group has extinguished several fires

Due to similarities in the answers between question 6 and 15 see section 5.2.1 for further results from question 6.

5.2.7 Question 7
Question 7a: Did you do an intervention to extinguish the fire? In the two following questions, 7b and 7c, the respondent were asked if the intervention were manual or with fire suppression system and if the manual intervention was with or without fire fighting gear. Question 7 was a follow-up question to question 6.

Five respondents (7 %) answered yes to this question. How these respondents answered question 7b and 7c are shown in Table 6 and answers to 7a and 7b are also shown in section 5.2.1.

Table 6: Answers to questions 7b and 7c for those who answered yes on question 7a

<table>
<thead>
<tr>
<th>7b</th>
<th>7c</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>Without</td>
</tr>
<tr>
<td>Manual</td>
<td>With</td>
</tr>
<tr>
<td>Manual</td>
<td>Without</td>
</tr>
<tr>
<td>Manual</td>
<td>Without</td>
</tr>
<tr>
<td>Both</td>
<td>With</td>
</tr>
</tbody>
</table>

5.2.8 Question 8
Question 8: Have you experienced additional fire incidents on board a submarine? This question was a follow-up question to number 6.

28 respondents (40%) have answered yes. Hence these have experienced at least two fire incidents on board.

5.2.9 Question 9
Question 9: Approximately how many fires? This question was a follow-up question to number 8.

Seven respondents (10%) have experienced five or more fires. 38 (54 %) have experienced 1-5 fires.

5.2.10 Question 10
Question 10: Approximately how many of these required extinguishing in some way? This question was a follow-up question to number 9.

11 (16 %) answered they have experienced an additional fire that needed extinguishing.

5.2.11 Question 11
Question 11: Have you ever performed a manual intervention with the goal to extinguish a fire? For result see section 5.2.1.
5.2.12 Question 12
Question 12: According to your experience, what is the most common fire incident?

This question was open and the answers were grouped into the following types of fire: electrical fire, engine room fire, kitchen fire, false alarm and other. Electrical fires included answers such as fire in cabinet and fire in electrical equipment. The engine room fires included everything between oil leakages and diesel fire to fire in the engine room.

Figure 6 show the result of question 12. Some surveys had more than one answer why the total percentage is higher than 100%.

Figure 6: Result from question 12. The answers were grouped in six categories including no response
5.2.13 Question 13
Question 13: For what purpose would you consider doing an intervention in a burning compartment?

This question was designed with four pre-defined answers and one option to enter additional reasons. More than one answer could be chosen why the total percentage is higher than 100%.

Figure 7 shows the result from question 13.

![Figure 7: Result from question 13. The answers were pre-defined and more than one answer could be chosen](image)

Examples of answers in the category “other” are to prevent spread of fire, on command, depend on the situation and whatever is needed.

5.2.14 Question 14
Question 14: How often do/did you have fire drills?

This question was an open question and many of these answers were described with words and some with a number.

69%, 48 persons, state that they have drills one or more times per week when they are on a mission.
5.2.15 Question 15
Question 15: Describe the crew actions when the fire alarm sounds.

34 persons (49 %) stated that the crew act according to the routines or described how their routines are. The descriptions varied in detail but some things that were mentioned in the answers were:

- General alarm is activated
- Person closest to fire start extinguishing (immediate action)
- Initial attack group is sent to the fire
- Fire fighters getting dressed with fire fighting gear and start intervention
- The crew members are counted to check if someone is missing
- Medical equipment is prepared
- Emergency message is prepared
- Ventilation is turned off
- Preparation for evacuating the submarine starts

No answer included all of the actions and the order varies among the answers.

5.2.16 Question 16
Question 16: Approximately how long do you think it will take before a manual intervention is started? The question was divided into two parts, one for the initial attack and one for fire fighting.

73 % answered this question with an interval and for a conservative result the longer time period in these answers has been used in the diagram. <60 seconds includes six answers of 30 seconds, two of 15 seconds, one of 5 seconds and one of 20 seconds, in total ten answers. 120 seconds includes one answer of 90 seconds. The result is shown in Figure 8.

Figure 8: Result from question 16
The majority of the respondents answered that an intervention can be initiated within 60 seconds and that fire fighting will start within 300 seconds. No respondent answered with a longer time period than 12 minutes.

For this question the answers from persons who have experienced fire incidents on board were compared with the answers from persons who have not experienced any fires. The result from this comparison is shown in Figure 9.

![Figure 9: Difference in answered time depending on fire experience](image)

**5.2.17 Question 17**

Question 17: Estimate the probability of a successful intervention and that the fire is extinguished. This question was not presented in the same way for all the respondents, refer section 8.2.2. 14 of the returned surveys was an older version and had a line to mark the probability on while the other 56 had pre-defined boxes with specified percentage.

All the respondents of this question made an estimation of a successful intervention of 50% or higher. The result is presented in Figure 9.
40% estimated the probability to 90% or higher. 41% estimate the probability to 50-85%. 4 persons answered that they do not know or that it depends on the situation.

Question 17 also included a part where the respondent was asked to motivate the indicated probability. The respondents estimating 100% probability explain this with an early detection and early intervention in combination with a trained crew and fixed fire suppression system. One person mentioned that he/she has only experienced successful interventions. Persons who have given lower probability also give similar arguments.

Eight persons (11%) answered that the probability is 60% or lower. Examples of given explanations are that there will be panic due to smoke and that the probability of extinguishing will decrease as the fire grows. Many respondents also wrote that it will depend on the situation and the size of the fire. All comments to this question are listed in Appendix E.

5.2.18 Question 18

Question 18a: Have you experienced activation of the fixed fire suppression system (Halon 1301)? In the two following questions, 18b and 18c, the respondent were asked if the activation was before or after the manual intervention and what type of fire it was.

17 of the respondents (24%) had experience from Halon 1301 activation. How these respondents answered question 18b and 18c are shown in Table 7.

<table>
<thead>
<tr>
<th>18 b)</th>
<th>18 c)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before</td>
<td>Diesel fire</td>
</tr>
<tr>
<td>Before</td>
<td>Engine room fire</td>
</tr>
<tr>
<td>Before</td>
<td>False alarm</td>
</tr>
<tr>
<td>Before</td>
<td>Fire in electrical equipment, HT7</td>
</tr>
<tr>
<td>Before</td>
<td>Fire in electrical equipment</td>
</tr>
<tr>
<td>Before</td>
<td>False alarm, no fire</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Before</td>
<td>Malfunctioning, not on board submarine</td>
</tr>
<tr>
<td>Before</td>
<td>Oil inside exhaust cooler</td>
</tr>
<tr>
<td>Before</td>
<td>Oil leakage in engine room</td>
</tr>
<tr>
<td>After</td>
<td>Malfunctioning system during maintenance</td>
</tr>
<tr>
<td>No answer</td>
<td>System wrongly connected</td>
</tr>
<tr>
<td>No answer</td>
<td>High temperature, no fire</td>
</tr>
<tr>
<td>No answer</td>
<td>Accidental release</td>
</tr>
<tr>
<td>No answer</td>
<td>Accidental release</td>
</tr>
<tr>
<td>No answer</td>
<td>Smoke/fire in engine room</td>
</tr>
<tr>
<td>No answer</td>
<td>Accidental release</td>
</tr>
<tr>
<td>No answer</td>
<td>Malfunctioning, no fire</td>
</tr>
</tbody>
</table>

**5.2.19 Question 19**

Question 19: Do you have any suggestions of improvement in the fire safety systems or the routines related to fire on board?

39 respondents answered this question with a variety of long and short answers. Areas that several answers included were:

- More space is needed for the fire fighting equipment
- More space is needed for the fire fighters to get dressed
- A BIBS system that last longer
- More portable fire extinguishers are needed
- More fire zones and fire cells

All the answers to this question can be found in Appendix F.
5.2.20 Question 20

Question 20: The aft compartment on the A26 will be unmanned. Do you think that the crew actions in case of fire will change due to this? Describe how.

26 respondents (37 %) answered that they think the crew actions will change and 8 (14 %) answered that the crew actions will not change. Not all of these persons answered a plain yes or no and in those cases the answers were coded by us depending on the content. All answers and how they were coded are shown in Appendix G.

19 respondents (32 %) mentioned that the equipment need improvements if an unmanned aft will work properly. Examples of the answers:

- Additional alarm is needed
- Additional detection is needed
- Monitoring is needed
- More/other equipment for fire fighting is needed

A majority of the persons who mentioned the manual intervention state that the immediate action will be delayed since there will be no person in close vicinity to the fire. Some answers also include the importance of humans to be present, in the aft with the explanation that human senses are better than technical equipment.

Some of the respondents also mentioned the Näcken class submarines that were constructed with an unmanned aft in the 1970s but since the crew did not trust the technical equipment and the sensors the crew did not want to leave it unmanned. The thoughts expressed in the answers are that since an unmanned aft did not work then it will not work on the A26 either, even though someone also mentions that the technology is better today.

5.2.21 Question 21

This question first introduced water mist and that the crew need to extinguish the fire since water mist only suppresses the fire if it is obstructed.

Question 21: Will this lead to a change in routines? In what way and what do you think of this potential change?

16 respondents (23 %) answered they think the crew actions will change and 11 (17 %) answered they think the crew actions will not change. Not all of these persons answered a plain yes or no and in those cases the answers were coded by us depending on the content. The answers coded as yes included for example:

- Sanitation of water will need a routine
- Evacuation will not be needed before activating the water mist
- Some changes to the fire fighting might be needed

The answers coded as no included for example:

- We already send fire fighters to check the fire
- Cannot see any purpose of changing the routines

Some of the answers could not be coded. All answers and how they were coded are shown in Appendix H.
12 respondents (17 %) included comments of what is needed to make the water mist work on board the submarine, for example:

- More and better equipment (portable extinguishers, air tubes etc.)
- Higher level of monitoring
- More personnel
- More drills

Problems like materiel damage, unmanned submarine (for example at quay) and limited visibility due to the mist was mentioned, as well as comments about a fixed suppression system that not extinguish the fire is not ideal on board a submarine.

5.2.22 Question 22
Question 22: Do you have other reflections about the fire protection? Please explain.

Many of the reflections were repeated from question 20 and 21 (good monitoring, new routines and human presence).

Additional reflections or questions about the fire protection were:

- It is important with more than one indication of fire, for example both visual (camera) and audible
- It is good with many fire zones
- How much does it costs to refill the water mist system?
- What about a fire in the kitchen when almost all the crew are in the fore compartment and need to evacuate to the aft?

All the reflections and answers to this question can be found in Appendix I.
6  RESULT FROM INTERVIEWS

Six persons were interviewed during one day at the First Submarine Flotilla in Karlskrona. All the respondents have six or more years of experience on board Swedish submarines and are well familiar with the special environment on board. Many of them have also had role as fire fighter at some point in their submarine career. Table 8 shows background information about the respondents.

Table 8: General information about the respondents in the interview

<table>
<thead>
<tr>
<th>Position on board</th>
<th>Years on board</th>
<th>Fire fighter education</th>
<th>Role in the damage control organisation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>System Technician</td>
<td>6</td>
<td>Yes</td>
<td>Damage control party</td>
<td>-</td>
</tr>
<tr>
<td>Chief Engineer</td>
<td>22</td>
<td>Yes</td>
<td>Damage control officer – Leader of the internal battle</td>
<td>-</td>
</tr>
<tr>
<td>Chief Engineer</td>
<td>18</td>
<td>Yes</td>
<td>Damage control officer – Leader of the internal battle</td>
<td>-</td>
</tr>
<tr>
<td>Weapon Technician</td>
<td>6</td>
<td>Yes</td>
<td>Stays in torpedo room, responsible for the submarine being prepared for external battle</td>
<td>-</td>
</tr>
<tr>
<td>Technical Chief</td>
<td>13</td>
<td>Yes</td>
<td>-</td>
<td>Used to work on board, now works in the office</td>
</tr>
<tr>
<td>Commanding Officer</td>
<td>16</td>
<td>Yes</td>
<td>Captain of the submarine</td>
<td>-</td>
</tr>
</tbody>
</table>

The interview result is a complement to the results from the survey and the qualitative data from the interviews are compiled based on the topics in the interview plan. The material has been processed and is presented primarily in linear form. Each topic contains an arranged structure of the answers that act as support to the reader and answers that were important or summarises the subject has been highlighted by indentation. Each topic and its subheadings are presented in Table 9.
### Table 9: Interview topics and sub headings

<table>
<thead>
<tr>
<th>Topic</th>
<th>Subheadings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Routines</strong></td>
<td>Initial attack group</td>
</tr>
<tr>
<td></td>
<td>ROVER</td>
</tr>
<tr>
<td></td>
<td>Same routines on all submarines</td>
</tr>
<tr>
<td></td>
<td>Issues</td>
</tr>
<tr>
<td><strong>Prevention</strong></td>
<td>“Safety thinking”</td>
</tr>
<tr>
<td></td>
<td>Drills on board</td>
</tr>
<tr>
<td></td>
<td>Issues</td>
</tr>
<tr>
<td><strong>Initial attack group and fire fighting</strong></td>
<td>Initial attack group</td>
</tr>
<tr>
<td></td>
<td>Issues with initial attack group</td>
</tr>
<tr>
<td></td>
<td>After the initial attack</td>
</tr>
<tr>
<td></td>
<td>Fire fighting</td>
</tr>
<tr>
<td></td>
<td>Issues with fire fighting</td>
</tr>
<tr>
<td><strong>Fires and incidents</strong></td>
<td>Different fire scenarios</td>
</tr>
<tr>
<td></td>
<td>Ventilation</td>
</tr>
<tr>
<td><strong>A26 – General</strong></td>
<td>Holistic view</td>
</tr>
<tr>
<td><strong>A26 – Unmanned aft</strong></td>
<td>Human senses vs. modern technology</td>
</tr>
<tr>
<td></td>
<td>Delayed immediate action</td>
</tr>
<tr>
<td></td>
<td>Positive and negative reflections</td>
</tr>
<tr>
<td><strong>A26 – Water mist</strong></td>
<td>A new system</td>
</tr>
<tr>
<td></td>
<td>Positive reflections</td>
</tr>
<tr>
<td></td>
<td>Negative reflections</td>
</tr>
<tr>
<td><strong>A26 – Evacuation strategy</strong></td>
<td>Hatches</td>
</tr>
<tr>
<td></td>
<td>Issues</td>
</tr>
</tbody>
</table>

### 6.1 Routines

Routines were discussed to some degree with all the respondents except the Technical Chief who is no longer active on board. With this section of the interview we wanted to discuss if the crew follows the routines and what special routines that they have on board submarines.

#### 6.1.1 Initial attack group

The routine with an initial attack group is fairly new according to the respondents but they can already see that the routine is working well on board all the submarines.

Comments about the initial attack group include:

- Initial attack group is brilliant
- The initial attack group will most likely be the cause of fire extinguishing
6.1.2 ROVER
Answers from the survey indicated that one part of the routines, the ROVER, in the damage control organisation is new. Information from the respondents during the interviews:

The ROVER is the DO that is off duty at the moment of alarm.

The Chief Engineer and Commanding Officer answered that the ROVER acts as an extra resource in the damage control organisation and organises the damage control party. The DO is in charge of the external battle while the CE is in charge of the internal battle. It is important that the submarine can handle both at the same time and the CO will give the priority and instructions for this. The ROVER ensures that the Commanders intent is followed at the Damage control station and will distribute personnel to where they are needed. How the ROVER fits in the emergency organisation is shown in Figure 10.

![Figure 10: Schematic picture of the damage control organisation including ROVER](image)

6.1.3 Same routines on all submarines
Both the initial attack group and the ROVER are routines that are being used on all submarines according to the respondents. One respondent mentioned that a new military tactical regulation, TRM AF:FS, March 2009, for the Navy is being used which regulates these routines. This regulation is however only partly used since it is written for surface ships and the submarines can choose what parts suits their organisation, the respondent continues.

6.1.4 Issues
An issue that came up during almost all the interviews was that the number of crew members limits the performance on board. The crew members have more than one assignment and the organisation during a fire is highly dependent on what personnel are on board. If they only have one System Technician on board this person cannot also be a fire fighter. This has to be taken into consideration whenever changes are made in the crew organisation mentioned the respondents.
6.2 Prevention
Prevention was discussed in some degree with all the respondents. They mentioned that prevention and other work with damage control have received a higher priority in the Flotilla during the last 3-4 years. The respondents thought that this was a positive change.

6.2.1 Safety thinking
When it comes to risks, one of the respondents thinks the level of awareness is high among submariners. One reason to this could be the fact that the submarine spends much time under water and a water leak always is a possibility. The Commanding Officer mentioned that:

It is a part of the higher positions (CO, DO and CE) to think of different scenarios and to be prepared. This is something that I am trying to implement for the whole crew.

The System Technician was mainly thinking about different scenarios in the beginning said that with experience came knowledge about how to handle different situations. Safety thinking is part of all submarine education, the technician added.

An important part of preventing fires is to keep everything clean and tidy one of the respondents mentioned. The engineers told us that they regularly have garbage rounds and that it is important to keep the keel tidy.

6.2.2 Drills on board
One of the respondents said that they have drills several times per week when they are out at sea. One respondent also said that:

As much as 75 % of the drills on board are fire drills.

One of the interviewed Chief Engineers has created a database with different scenarios that are used to create drills. Some of the scenarios are based on real accidents and some are fiction. All drills are followed by a discussion where the drill is evaluated and experiences are shared, said the Chief Engineer.

6.2.3 Issues
One respondent mentioned that a problem with the drills on board is that they rarely have an independent person supervising and controlling the drills. This means that someone on board knows the scenario and is not being tested in the same way as the rest of the crew. According to one respondent the goal is to have an independent person on board who runs a drill two times each year but this is hard to achieve.

6.3 Initial attack group and fire fighting
This part of the interview focused on the manual interventions on board and the assignment for the initial attack group and the fire fighters. Initial attack was also mentioned in section 6.1 Routines.

The difference between the fire fighters and the initial attack group is mainly their safety equipment; they all use the portable fire extinguishers to fight the fire according to the respondents.
6.3.1 Initial attack group
The respondents informed us that the two crew members assigned as initial attack group are part of the off duty watch. One respondent should prefer to have the initial attack group in the on duty watch but stated this cannot be achieved due to the personnel resources.

According to the respondents the initial attack group shall:

Start intervention after order from the CO, quickly be at the origin of fire and start extinguishing.

6.3.2 Issues with initial attack
According to one of the respondents the initial attack group has no communication with the control room which makes them vulnerable. One of the respondents also mentioned the problem that:

There is no assigned equipment for the initial attack group. At the moment they grab two ELSA-hoods in their vicinity which means that these are missing for the other crew members if something further happens.

The same problem can occur when grabbing a portable fire extinguisher which then will be used and empty when the fire fighters arrive.

6.3.3 After the initial attack
The initial attack can be followed by the fire fighters or an activation of the Halon 1301 system the respondents told us. There are different opinions in which alternative that are used first. According to one of the respondents the fixed system is often the first choice if the fire is in a module or similar place where persons are not present but before using the Halon in larger compartment he/she would want additional information to ensure that they are making the right decision.

One respondent said that using the fixed system is the natural choice to extinguish any fire, despite the equipped fire fighters being available. Another respondent said they are restrictive in when they use the Halon 1301 system since they know that they do not have any backup system if anything else should happen. Figure 12 shows the different alternatives of action after the initial attack group.

![Figure 12: It depends on the situation what happens after the initial attack](image)

According to one of the respondents the fire fighters will normally be sent in when they are ready but their task can differ. Normally the primary task is to save lives but it could also be to continue fire fighting or to secure the fire for re-ignition.
6.3.4 Fire fighting
The respondents stated that fire fighters on board submarines do not work in the same way as on surface ships or as written in the regulation AFS. Two main exceptions were mentioned.

- Not using the fire hydrant for fire fighting, i.e. “safe water” is not brought when doing the intervention
  - According to the respondents the water hydrant could be used for this purpose but are mostly used for cooling the torpedoes or when the place of fire is watched over to prevent re-ignition
- The leading fire fighter is not equipped according to the regulations
  - Because of the number of fire fighting equipment on board

Problems with water on board:

- The crew always need to consider what can happen with the surrounding equipment
- A lot of water can be troublesome for the stability of the submarine

Problems with a leading fire fighter who is not equipped:

- If something happens with the fire fighters there are no third person that are dressed and can assist them.

One good thing that was mentioned about the fire fighter equipment was the IR-camera. The camera is being used by the fire fighters and one of the respondents told they recently had a drill where they tried having the IR-camera connected to a screen so that the leading fire fighter could follow the fire fighters in the fire compartment. The respondent thought this was a good idea for the future since it made it easier for the CE in the control room to know what was happening in the fire compartment.

6.3.5 Issues with fire fighting
One major problem with fire fighting on board submarines is the narrow spaces according to the respondents. One of the respondents told us that:

Some of the fire fighters have to take off their air tubes to be able to pass through some of the hatches and passages.

Another thing that was discussed during most of the interviews was that only two pairs of fire fighting gear are stored on board, one of them will be in the fire compartment and not useful since the air lock will be kept closed, the respondent explained.

Additional gear was wanted by some of the respondents but it was also questioned if they really need all the equipment for fire fighting.

Maybe breathing apparatus would be enough since the fire fighters do not perform fire fighting as per definition and since they are not protected as required argued one of the respondents. This is a problem when it comes to giving the order fire fighting said one of the Chief Engineers. The respondent continued by saying that extinguishing the fire is not the main task; the fire fighter intervention is to save life. The other Chief Engineer argued that more communication equipment is needed if the leading fire fighter will take part in the intervention, otherwise they will lose the connection between the fire fighters and CE/CO in the control room.
6.4 Fires and incidents
The latest submarine fire was two years ago on board Halland, while the boat was in yard and one of the respondents informed us that the local fire brigade could extinguish the fire with one of the portable fire extinguishers on board. One of the respondents explained:

There are always portable fire extinguishers on board

6.4.1 Different fire scenarios
The fires scenarios that can occur on board are very different. According to one respondent it does not often burn with flame; it is more common with electrical fires and oil leakages. The respondent also mentioned that it is important to be able to improvise which actions that are undertaken since a fire will most likely be followed by other problems such as malfunctioning equipment or contaminated air.

Another respondent said that it has been quite many false alarms from the detectors located in ducts and cabinets probably due to dust. This is more common after the boat has been in yard and has resulted in a routine to check the detectors. The respondent also said that:

The crew always act as if it is a fire but there is also a risk with too many false alarms, the crew can become less alert.

One respondent said that all fires are reported with incident reports and while at sea everyone on board will be updated of the situation.

Some of the respondents were asked about fires in the front compartment and what this could lead to. The Commanding Officer and the System Technician answered that there are many back-up systems for the propulsion system and if a fire occur in the front the crew that have crucial positions stay and breathe through the BIBS and continue to operate the boat. The rest of the crew will evacuate to the aft compartment, which hopefully is uncontaminated.

6.4.2 Ventilation
Some of the respondents mentioned the ventilation on board when discussing fires. The local Halon 1301 system inside modules and cabinets is linked to the ventilation and fire dampers that close when the Halon is activated. However, one of the respondents explained:

No confirmation whether the dampers are closed properly or not is received, which would be good to know.

Mechanical parts have a tendency to malfunction and it might be better with a closed system with direct cooling for modules and cabinets the respondent continues.

All the respondents mentioned the human senses in some way. The System Technician mentioned that overheated electronics smell much, and the ventilation spreads the smell in the boat which possibly makes it harder to find the origin of the smell (and the possible fire). The respondent also said that:

The crew will notice the smell and everyone will check their equipment for errors. Normally the origin of a smell is quickly identified.
One respondent think that the argument for maximum number of carbon dioxide extinguishers is weak. The fire itself will make the environment unsuitable and the crew must therefore use the BIBS to breathe. The argument that carbon dioxide contaminates the air is not enough to justify a limitation in the ability to extinguish the fire. In addition to this, the boat is always ventilated after a fire if possible, the respondent explained.

6.5 A26 – general
Before discussing the A26 and its changes the respondents were asked how much they knew about the A26 and how they had received the information.

Generally the information about the A26 has reached the crew members as rumours, news or from an information meeting with FMV which took place a long time ago. The only person having contact with FMV in conjunction with A26 was the Technical Chief since he is responsible for all the materiel on board and that it follows the regulations.

6.5.1 Holistic view
On board a submarine everything is interrelated and a comprehensive view is needed to see how everything is connected. Kockums AB has to see the whole picture when designing the A26 many of the respondents said. The number of personnel will affect the routines, the water mist will affect the personnel, the room location will affect the communication etcetera.

6.6 A26 - unmanned aft
When discussing the A26 and the unmanned aft, which is a major change compared to the boats today, the majority of the respondents did not see advantages with an unmanned aft.

6.6.1 Human senses vs. modern technology
Some of the respondents refer to the Näcken type submarines that were designed with an unmanned aft but were not used this way. This because they did not trust the sensors, they were too slow according to the Technical Chief that was in the Näcken crew. Since the aft was not designed as work space they ended up sitting on cardboard boxes the Technical Chief told us. The Technical Chief continued to say that it is difficult to compare the A26 and Näcken since the technology is much better today; an unmanned aft is not impossible on a modern submarine. The Technical Chief said:

Modern sampling systems are faster than the human nose in detecting gases one of the respondents thought.

However, a majority of the respondents think the olfactory sense is important on board, which they use as an argument for the aft not to be unmanned. One of the Chief Engineers explained:

The crew uses their senses to detect if something is wrong; this has prevented many fires on board

One of the respondents mentioned that the monitoring system on the A26 has to be addressable. Some of the respondents however think that even if the system is advanced they will probably still end up having people in the aft. One of the respondents cannot see any advantages with an unmanned aft, not from a security point of view. The respondent believes that initial attack and the ability to smell is important; humans are the best detectors. In the end monitoring by technological means should be a complementary to the human senses and not replace them, one of the respondents think.
6.6.2 Delayed immediate action
The immediate action will be delayed and the fire has more time to increase before extinguishing starts if the aft is unmanned argued one respondent. Something that was mentioned by almost all of the respondents was:

The immediate action is very important to control fires on board.

6.6.3 Positive and negative reflections
A remark made by one of the Chief Engineers about the unmanned aft was that it might be a problem if a fire starts in the fore compartment, which requires the damage control organisation to be organised in the aft. This requires equipment and space to be able to operate from.

One benefit with an unmanned aft that was mentioned during the interviews was that all the competences are gathered in the control room and facilitate the contact with the CO and CE. The engineer in the control room can on the other hand be less focused since he has to share the focus between the damage control organisations and operating the boat mentioned one of the respondents.

Another possible change that could follow an unmanned aft is that the number of crew members is reduced. This is however very complex and as one of the respondents explained: if an engineer is always positioned in the control room and something that requires two persons needs to be done in the aft the personnel resources might even have to be expanded. They will at least have to be maintained at the same level as today the respondent said.
6.7 A26 - water mist
To investigate the respondents’ thoughts about the plan to install water mist instead of Halon 1301 as room protection on the A26 water mist was discussed during the interviews.

6.7.1 A new system
The Commanding Officer stated that the crew is definitely not used to water mist but the routines will probably not change. The CO mentioned that fire fighters today are used to check if the fire is extinguished and to prevent re-ignition, which seems to be the routine even if water mist will be installed. One respondent said:

The main task for the submarine is to continue the operation, even after a fire

One of the respondents expressed concerns for the equipment functionality after using the water mist. Will there be water damage and can the systems be used as normal after releasing the water mist?

With a new system there will be new routines the Weapon Technician mentioned. Routine checkups need to be established to ensure that systems not are damaged by the water mist was an example and the System Technician mentioned that cables needs to be checked so they are not damaged when releasing water mist.

Another question that arose was how to use the water mist when the fire fighters enter the compartment. Will both water mist and fire fighters be used at the same time?

6.7.2 Positive reflections
The Weapon Technician mentioned that it would be good to install water mist in the torpedo room since it would make it easier to cool the torpedoes and to dilute a potential hydrogen peroxide leakage. At current submarines this is done by using the fire hydrant and one person has to be set aside to do this. The Weapon Technician also mentioned that it would be good if the system could be started directly from the torpedo room and suggested that it is connected to the system that detects a leakage of hydrogen peroxide.

Another positive reflection was that the containers holding the water will be refillable. But the Commanding Officer wondered whether the system will be used more because of this and asked how long the refilling takes. Another thing that was questioned was wheater water mist is effective in extinguishing electrical and oil fires which are the most common fires on board.

A third positive aspect mentioned by the respondents was that it is harmless to humans and to the environment. One of the Chief Engineers said:

Water mist is environmental friendly which make it easier to practice with. It is also positive that the temperature decreases in the fire compartment.

The other Chief Engineer mentioned that water mist should be an alternative between the portable fire extinguishers and the Halon 1301. The engineer believed that there is a need to fill the gap between these two systems, which is too large today.

6.7.3 Negative reflections
The Technical Chief would prefer continue having Halon 1301 installed on board, or at least a gaseous fixed suppression system. The Chief continued to say that water mist would be good if it extinguished the fire and argued that Halon is the most effective system. The crew
performance will decrease with many manual interventions. There is also a question on how the strategy with a decreased number of crew members will work together with more manual interventions which is a result of the water mist. One respondent said:

The crew safety is more important than meeting environmental goals.

The respondent said that it is important to consider the environment but a gaseous system will create an inert environment which is important when protecting against re-ignition which is an important argument to keep Halon on board.

6.8 A26 - evacuation strategy
Some of the respondents were asked questions about the emergency strategy and especially about hatches and the placement of these. This section was added to the interview because Kockums AB was working on the evacuation strategy for A26 at the time of the interviews. This section will not be analysed.

6.8.1 Hatches
One of the respondents informed us that the hatches today are mostly left open, but added that they do not have any fire resistant function and that they are placed so they are not obstructing the passage. Hatches placed in the middle of the path will be kept closed according to the Chief Engineer. Again it was mentioned that the hatches need to be large enough for fire fighters to pass with their equipment.

6.8.2 Issues
There will be a hatch in the control room with a ladder down to the torpedo room and the question is if the hatch is needed for daily passage or if it should be used only as an emergency hatch. The hatch to the control room is needed, but not necessary for everyday use the CO and the Weapon Technician said.

The Weapon Technician said the hatch can be an emergency hatch as long as the alternative way down to the torpedo room is big enough. The normal path will be by hatch from the mess and a passage over the battery to reach the torpedo room. The Weapon Technician also adds:

The normal path shall be easy to use since the crew go back and forth to the torpedo room, it should not be possible to get stuck in the torpedoes when passing.

Both the CO and the Weapon Technician also commented that a hatch between the control room and the torpedo room is good since it facilitates the communication between the officers in each room.
7 ANALYSIS

In this section of the report the result from the survey and interviews are analysed together with information found during the literature review, i.e. chapter 2-4.

Prevention is important to minimise fires on board a submarine, this was mentioned both in the interviews, surveys and is written in the regulations. The level of awareness among the submarine crew is high according to the respondents and at least some of the crew members think of different scenarios while out on mission, to be prepared to act accordingly. Schager (2008) states that “we use our experience and knowledge, i.e. our memory, as an aid to understand the present” which indicates that thinking of scenarios hopefully speed up the reaction. Drills are a part of prevention and according to the survey result drills are performed several times a week when the boat is at sea. The better trained a person is the shorter time he/she needs to structure the information when something happens and this will result in a the faster reaction time and a safer action.

When asking about the routines on board many of the respondents referred to the regulations and that the crew act as written in the regulation. However, interviews, surveys and literature also show that it is important that all crew members know their task in case of emergency. In case of fire many actions are undertaken parallel to each other and the respondents lifted different actions that are a part of the routine. Our interpretation of the routine (order depends on situation) is as follows:

Immediate action
Persons closest to the fire will try to extinguish.

General alarm
The general alarm is activated if the CE, CO or DO thinks that the situation requires it. General alarm is also activated to alert the crew in case of water leakage or other extreme situation where the submarine has to be closed to prevent the spread of water, fire, gas or pressure.

Initial attack group
The initial attack group are two persons that should be ready within 60 seconds and replace the immediate action. The group is sent into the fire compartment upon order from the CE that has a dialogue with the CO and DO. Each watch has an initial attack group and the one used is part of the off duty watch.

Fire fighters
The fire fighters are two designated persons that are getting dressed upon alarm and are sent into the fire compartment upon order from CE or CO. Their task is to extinguish the fire, to save lives or to do something else that is necessary. The fire fighters are often used to secure that everything is safe and the submarine can continue its mission.

Crew members
Each crew member has a designated role in case of fire. This could for example be fire fighter, medical officer or damage control party. The role is connected to the position the person have and is documented in the assignment book. The crew is counted to make sure that no one is missing.

Medical equipment
The medical equipment is prepared by the medical officer assisted by other crew members. Mostly this is done in the mess but if a fire occurs in the fore compartment this is done somewhere in the aft where there is enough space.
ROVER
The ROVER is the off duty DO and is in charge of the crew members that are part of the damage control party.

Emergency message
An emergency message is prepared to be ready to send if needed.

Services
Services that run between pressure tight compartments are turned off. This is so that one half of the submarine still can be used if the other is damaged.

Engines
Stirling and diesel engines are turned off when general alarm sounds.

Evacuation
The crew evacuates the fire compartment and evacuation of the submarine is prepared.

The respondents think that an initial attack will start immediately to five minutes from alarm and a majority has answered that it will take maximum 60 seconds which is also the time it shall take according to the regulation. Comparing this with the 90 seconds fire fighters in land based rescue service have to get dressed and roll out of the station it seems like 60 seconds should be achievable on board a submarine. The submarine crew acting as initial attack group does not have to change clothes nor run/walk long distances.

However, almost a third of the respondents have answered that they think it will take more than 60 seconds. Why? Is the regulation too tight? Are the crew too slow? Why does the crew think it takes longer time to start the initial attack? The initial attack group are off duty when they receive the alarm, perhaps sleeping or in the bathroom. This should however been taken into consideration in the regulations since it is always two crew members off duty that have the function of initial attack group. Some respondents said it takes five minutes for the initial attack group to get ready and if this is the case the crew might have to practise this routine to achieve an early intervention. The initial attack group is quite new in the damage control organisation and it might take time for the crew to find the routines. However, according to the respondents in the interviews the initial attack group has made a big difference and is showing good results.

According to the regulations fire fighters shall be ready for intervention within six minutes from alarm and the majority think this is achieved. However, twelve persons think it will take as long as 10-12 minutes. Literature and interviews state that fast action is crucial. Crew survival is largely dependent on rapid and correct actions and starting an intervention after 12 minutes seems late. On the other hand fire extinguishing could already have been started by the initial attack group and a delay of the fire fighters might not be crucial in this case. Regardless of this, 12 minutes is twice as long as the time stated by the regulations, which can only be considered as not acceptable. If the initial attack and fire fighters are delayed as the fire is allowed to grow significantly and the probability of a successful intervention is decreased. One reason for waiting with the fire fighter intervention is that the CO might decide to use the fixed suppression systems instead. In this case the fire fighters can be sent in afterwards to ensure the fire does not reignite.

Literature, interviews and survey all show that a fire on board a submarine is most likely to occur in electrical equipment or in the machinery in the aft compartment. This is also the “best” scenario since the submarine is operated from the fore compartment and this is where people are sleeping. However, the engines and many systems are placed in the aft and a fire
could result in lots of damaged equipment. Despite a fire in the aft being the most likely, a fire in the fore compartment is not neglected when the crew practice. It is important that they are prepared of all possible scenarios since it is impossible to predict where and if a fire will start.

More than a third of the respondents thinks the probability to extinguish a fire on board is 90% or higher. In Sweden fire accidents on board submarines are rare. During the last years only one large fire has been reported and this was while the boat was in yard. Incident reports show that minor incidents such as smoke developments are more common than open flame fires. The most recent large fire before this occurred in 1992 on board a submarine class that is not operating today. So, if fires do not happen on board, what do the respondents base their answers on? The crew have drills regularly and also minor incidents result in an activation of the emergency situation. This means that even though many crew members have not experienced fires they are well familiar with the routines and actions to be undertaken should a fire occur. The crew seem to be confident that they and their crew members, the organisation and the fixed fire safety system on board can handle an upcoming situation. This is important as they cannot evacuate the submarine and wait for the fire department to show up.

All respondents agree that the crew has the same routines on board all submarines that are operating today. This simplifies when crew members switch between boats. The opinions differ weather the A26 will require new routines or not but this is likely since new systems with different properties will be installed. Having different routines on board different boats might make it harder for the crew to switch between the boats. By changing crew members on board knowledge are shared between the boats which is good. With different routines on different submarines it might take longer before the crew is confident on board all boats and the risk of mistakes might increase. Different boats can also be a problem for the fire fighters since it will make it harder to remember for example where the important valves are located in each boat.

Both interviews and survey result indicates that the crew know very little about the A26. The opinions are different but the feeling is primarily negative, both when it comes to water mist and an unmanned aft. Why is this? Are these changes so large that it is hard to understand how it will function and therefore the crew becomes reserved? It is possible that the crew is so used to how it “should” be that any major changes are bad? It is easy to understand the crew arguments, especially about water mist since water mist is not as effective as Halon 1301 and that the crew will have to work harder because of this. An unmanned aft seems easier to understand for the crew and the negative reaction is more extreme. But the aft will be equipped with a fire detection system that is more advanced than on operating boats and the reactions to having the engineer in the control room are positive. The crew opinion might change when they get to practice with the systems and learn how the detectors function. Some answers referred to the unmanned aft on previous boats and the fact that it did not work then. The technology has improved and we do not think a comparison can be made between then and now. However, an unmanned aft will most probably affect the immediate action, which, according to both survey and literature, is one of the most important tools for fire fighting on board a submarine today.
8 DISCUSSION

The discussion has been divided into three parts. First the result is discussed, then the method and last we discuss areas where further investigations might be interesting.

8.1 Result

The same tendencies can be found in the results from both interviews and survey which is good since the interviews was suppose to work as a complement to the survey and to validate the result. If the results had differed from each other there might have been issues with either the construction of the survey or the interview. The interview respondents were chosen from the same population as the survey which means that these persons might also have answered the survey. We know that this is the case with at least one of the interviewed persons. We however see no problem with this since the main objective for the interviews were to get a deeper understanding of the life on board a submarine.

A third of the persons who responded to the survey had not experienced any fires on board a submarine. What impact does this have on the result? Since the objective was to identify the crew actions and routines and they regularly practice this we do not think that this has a great impact on the overall result. It is possible that the crew acts differently if it is a real situation but they normally do not know that it is a drill, at least not in the beginning. The persons who had not experienced any fires on board might have had problems with estimating the probability of a successful intervention.

Only one of us has experience from the world of submarines, and this was several years ago, it was hard to know what to expect from the survey and the interviews. One thing that surprised us was that there had been so few incidents connected to fire. The impression we got from talking to former submariners was that it happened something quite often. It is likely that incidents were more common before and that this is why current crew members have not experienced many fires.

Another thing that was surprising was the wide range of answers when it came to estimating the time for initial attack group and fire fighters to get ready. We had expected more answers around the prescribed times. The fact that we used the longer time, when the respondent had answered with an interval, have also had an impact on the result. It is interesting that so many respondents think it takes longer than 60 seconds and 6 minutes respectively. However, the result also shows that crew members that have experienced fire on board think it takes shorter time than crew members that have not experienced fire. This could mean that it would not take that long as it seems. It is also important to remember that the respondents were asked to estimate the time and this is not easy to do. Estimations of time does not always correlate with the actual time passed. It would have been interesting to compare the estimated times with times from an observation which was planned but not carried out. A comparison might have shown whether the crews’ estimations are correct or not. Without this information it is hard to draw any final conclusions regarding the time to start an intervention.

8.2 Chosen method

We chose to make an interview study and a survey study. These two studies complemented each other and only a survey would have been too little. The interviews gave us a deeper understanding and we had the opportunity to ask follow-up questions that were relevant to understand the answers. This leads to a higher validity since the probability that we interpreted the answer as intended increased and it also made it easier to analyse the result. With the survey we reached a majority of the active crew members which was good to achieve a reliable study. The survey and interviews show the same result why the validity of the study increased. A literature research of regulations, laws and and other documents
regarding submarine construction and history was performed as a complement and gave us a better understanding of the submarine environment. This made it easier to create survey questions and to interview and increase the reliability of the study. However, our knowledge of how to interview and construct a survey was limited before this project and our research on how to perform such studies could have been better.

We chose not to record the interviews and think this made the respondent more open and talkative which also was our intention with the interviews. The interviews worked as a complement to the survey and we wanted to have a discussion with the respondent more than a question-answer based dialogue. We were two persons that interviewed which made it easier to follow the discussion and take extended notes at the same time.

8.2.1 Answering frequency

The survey reached an answering frequency of 71 % which is good according to Bryman (2002). We had expectations of a higher frequency based on the survey being distributed by the Flotilla and maybe as an order from the Commanding Officers to each crew but are satisfied with the frequency. We wanted to send the survey electronically to the respondents but the Flotilla decided that it was easiest to print and return them by post. During the day in Karlskrona one of the crew members said that they would have preferred to receive the survey electronically. It is hard to say whether this affected the answering frequency but it is possible.

Some of the questions have a low answering frequency, one question as low as 14 %. This might seem extremely low but these questions were follow-up questions of the type that did not require an answer depending on how the previous question was answered. Therefore we see no reason that there should be anything wrong with the wording in these questions. When we calculated the answering frequency based on the answer of the previous question the frequency is similar to the other questions. Other questions had high frequency, some as high as 100 %. The questions with highest answering frequency were mainly background questions and questions with pre-defined answers. This seems naturally but since we also wanted to measure attitudes and opinions we created the survey with a mix of open and closed questions.

8.2.2 Error in survey

Our insight in the distribution process was very limited which lead to some errors. Also the formulations of some questions could have lead to some errors. It is hard to know what differences in the result this has lead to.

Some persons had received an earlier version of the survey which meant that question 17 was slightly different and question number 10 was missing. This earlier version was sent to the Flotilla when we made the formal question whether we could contact the crew members and for reasons we do not know ended up with some of the crew members. We do not know how many crew members that received the older version but judged the changes to be small and decided to include the 14 surveys of the older version that were returned in the analysis. Question number 17 was distributed in two versions; one as a multi choice question with pre-defined answers and another where the respondent marked his/her answer with a cross on a line. For the later we calculated the probability by measuring where the cross was situated on the line and the percentage was rounded off to closest fifth percentage to keep as good accuracy as possible. Due to this the result was both in fifth and tenth percentage and the answer might not been that unambiguous as we thought. One can argue that we should have rounded to the closest ten percentage but since one person had written what percentage the cross represented and one respondent had marked between the boxes and written another percentage it would still have resulted in a degree of unambiguousness.
Despite great efforts being put into making the survey questions easily understandable and clear some of them might have been misinterpreted by the respondent. One example of this is question number 17 where the respondent was asked to estimate the possibility for a successful intervention. The goal was to get a probability of a successful manual intervention but since the question was formulated without a specification on manual intervention the answers might include both manual and Halon intervention. The results show the probability that any fire intervention on board will be successful and not that the manual intervention will be successful. One question that could have been misinterpreted is question number 16. We asked about the time needed to start initial intervention and this could be interpreted as both immediate action and initial attack. We were interested in the time to start an initial attack and when looking at the answers it seems like most respondents have interpreted it this way. However, some respondents have answered very short times; immediately and 5 seconds. These persons might have been thinking about the immediate action.

8.2.3 Processing error
When analysing the answers we noticed that some errors had occurred when transferring the answers manually to the Excel spreadsheet. These were of course corrected but there is a possibility that some errors were not discovered and affect the result. Using an electronically distributed survey would have reduced the processing errors since it eliminates the transferring step since this can be done automatically.

Another issue when analysing the answers was the interpretation of the open questions. Coding was used as a method to systematically categorise the answers and the analysis is based on this. The result is therefore our interpretation of the answers.

8.2.4 Error in interviews
Both the interviewer and the respondent can be sources of error. Even if we tried to ask non-leading questions the respondent might have been led in some way. The fact that we were two persons increases the possibility that we remembered the answers and the context correct. To minimise the misinterpretation of the interview answers a summary of the interview was sent to each respondent where they were given the opportunity to correct any misinterpretations. It is important to have knowledge in the discussed topics and we think we were prepared for the interviews; however, it was also a balance to discuss the topics in an objective way.

The questions we asked were not always strictly used as in the interview guide. If we noticed the respondent did not understand we asked the question with different words but mainly we tried to have a discussion with the respondent so that he/she could describe the topic in their own way.

8.3 Way forward
One thing that could have brought an extra dimension to the investigation was to study the crew during a real incident or during one of their drills. Such a study was planned but due to the schedule of the submarines it was not possible to carry out during the time of this investigation. With the drill we had hoped to be able to compare the result from survey and interviews with how the crew act in a real situation. Do they actually do the things they say that they do? Do they follow the routines? Do their estimations correlate with the drill? This is therefore an area where further investigations can be performed if additional information about the crew action is wanted.

Another possibility for further investigation is to compare the Swedish submarine crew with the crew of another country. Do submarines from another country act differently compared to Swedish? This might not be of highest priority but since Kockums AB is interested in
selling the A26 to other countries as well it could be interesting to know what routines they have and how they fight fires on board.
CONCLUSIONS

This project has shown how a Swedish submarine crew acts in case of emergency on board based on their routines. The crew opinions about the planned fire safety on board the A26 is also shown in this report. Therefore we believe that we have provided Kockums AB with a view of how the crew uses the submarines constructed and designed by the company. Therefore the objectives with this project are considered met. The general conclusions drawn are listed below.

Fire fighting on board Swedish submarines follows routines described in regulations and implemented by the crew. Actions that are a part of these routines are listed and summarised in section 7.

More information would be necessary in order to draw any conclusion regarding the probability for successful intervention. The respondents have not experienced many fires on board and because of this their estimation of the probability in the survey is not considered reliable. More information would also be necessary regarding time to intervention. The crew members estimated times are not considered reliable enough to draw any conclusions without comparison with actual times, for example from drills.

At the moment of this investigation the crew knew very little about the A26 and were sceptical towards the planned changes in the fire safety strategy. Providing the crew with more information could result in a more positive attitude and would be recommended. We however do not think there will be any major problems with developing a suitable routine if needed when the crew receives the submarine. It will be easier for the crew to understand the systems when they can start making themselves familiar with the construction.

The crew members raised suggestions of improvement for the A26 that, as far as we know, are not planned. We think that many of these suggestions are good and recommend Kockums AB to consider these during the design and construction of the A26. Suggestions that we think would have a positive impact on the manual interventions on board are:

- Hatches and passageways that are large enough for fire fighters to pass without having to take off their equipment
- Larger space where the fire fighters get dressed
- Thermal imaging camera connected to a fixed screen in the control room so the leading fire fighter and others in the control room can follow the fire fighters during an intervention
- Equipment designated for the initial attack group
- Confirmation when fire dampers in ventilation have closed
10 REFERENCES


## APPENDIX A – Swedish Submarines

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A.1 References


APPENDIX B – Gotland Class Submarine
APPENDIX C – Survey

Introduktion

Syfte
Syftet med enkäten är att vi ska få en bild av vilka incidenter som kan ske ombord, hur ubåtsbesättningen agerar i dessa fall, samt vilka tidsspann det rör sig om.

Varför du valts ut
Du har valts ut för att du är eller har varit i ubåtstjänst. Vi vill gärna ta del av dina erfarenheter av incidenter ombord och hoppas du vill delge dessa. Vår uppgift är att sammanställa svaren och ge Kockums en ökad förståelse för de manuella insatserna ombord.

Information om att enkäten är frivillig
Vi är mycket tacksamma att du vill ställa upp och svara på enkäten men vill här också poängtera att ditt deltagande är frivilligt.

Konfidentialitet
Vill du vara anonym i dina svar går detta givetvis bra. Det är frivilligt att ange namn och kontaktuppgifter nedan, dessa kommer endast att användas vid en eventuell återkoppling. Enkäten kommer att behandlas konfidiintiellt, namn och svar kommer inte att kopplas ihop i analysarbetet.

Ev. namn och kontaktuppgift________________________________________________________

Resultaten

Våra kontaktuppgifter:
anna.olofsson@kockums.se eller
sofia.bohlin@kockums.se

Telefon: 0734-34 11 49
alt. 0702- 81 76 86

Enkäten insändes via brev till:
Kockums AB
Att: Anders Håkansson
205 55 Malmö

För att vi ska kunna sammanställa materialet behöver vi få in dina svar senast 5 december.

Tack för att du medverkar! /Anna och Sofia
**Bakgrundsinformation**

1. Hur länge har du varit i ubåtstjänst?

2. Är du fortfarande i tjänst?   Ja □   Nej □

3. Vad har du/har du haft för befattning?

4. a) Har du rökdykarutbildning för ubåtspersonal?   Ja □   Nej □

   b) Om ja, hur länge har du haft den?

5. Vad har/hade du för uppgifter vid brandlarm?

**Incidenter**


   b) Beskriv besättningens agerande.

   c) Beskriv ditt agerande vid samma tillfälle.

7. a) Gjorde du en insats att släcka branden?   Ja □   Nej □

   b) Om ja, var insatsen manuell eller startades släcksystemet ombord?

   c) Om insatsen var manuell, var den skyddad (med rökdykarutrustning) eller oskyddad (endast uniform)?
8. Har du varit med om ytterligare brandincidenter ombord på ubåt? Ja □ Nej □

9. Ungefär hur många?

☐ □ □ □ □ □
<5 5-10 10-15 15-20 >20

10. Ungefär hur många av dessa krävde släckning av något slag?

11. Har du gjort manuell insats för att försöka släcka brand vid något tillfälle? Berätta!

12. Vilken är den vanligaste brandincidenten enligt dina erfarenheter?

13. Vid vilka tillfällen kan du tänka dig att göra en insats i ett utrymme som brinner?

☐ För livräddning

☐ För att rädda viktig utrustning

☐ För att säkra framdriften

☐ För att kontrollera om branden är släckt

☐ Annat, beskriv vad
Rutiner

14. Hur ofta har/hade ni brandövning?

15. Beskriv besättningens agerande vid brandlarm.

16. Ungefär hur lång tid tar det innan ni startar en manuell insats tror du?

   Initial insats:
   Rökdykning:

17. Bedöm sannolikheten att en insats lyckas och att branden släcks. Motivera gärna

   □  □  □  □  □  □  □  □  □  □  □
   0 %  10%  20%  30%  40%  50%  60%  70%  80%  90%  100 %

Släcksystem

18. a) Har du varit med om att det fasta släcksystemet (Halon) har aktiverats?  Ja □  Nej □

   b) Skedde aktiveringen före eller efter manuell insats?  Före □  Efter □

   c) Vilken typ av brand var det? Beskriv
19. Har du förslag på förbättringar i brandskyddssystemen och rutinerna för brand ombord? Berätta!


Innebär detta en förändring i rutiner? På vilket sätt och hur ser du i så fall på denna förändring?

22. Har du andra funderingar kring brandskyddet? Utveckla gärna!

Tack för dina svar!
APPENDIX D – Interview Plan

Introduktion

Syfte med intervjun

Varför du valts ut
Valet av besättning som finns till förfogande för intervju har skett i samråd med stabschef, Per Edling, på Första ubåtsflottiljen, utifrån ubåtarnas körschema och tillgänglighet. Vi vill intervjua besättningspersonal i olika befattningar och hoppas att du vill dela med dig av din erfarenhet.

Information om att enkäten är frivillig
Vi är mycket tacksamma att du vill ställa upp på intervjun men vill här också poängtera att ditt deltagande är frivilligt.

Konfidentialitet
Intervjun behandlas konfidentiellt, namn och svar kommer inte att kopplas ihop.

Känsliga uppgifter
Vi är säkerhetsgodkända och får därmed ta del av hemlig information. För att underlättta för oss får du gärna påpeka om något du säger är känsligt och ska behandlas med försiktighet.

Resultaten

Tack för att du medverkar!

/Anna och Sofia

Våra kontaktuppgifter
E-post: anna.olofsson@kockums.se
sofia.bohlin@kockums.se
Telefon: 040-34 11 49 Alt. 0701-762 495
Intervju – Karlskrona 6 december, 2011
How does a Swedish submarine crew act in case of fire and how do they incorporate the fire safety systems on board?

- What are the routines in case of fire?
- What are the crew actions when they receive a fire alarm?
- How long does it take before the crew has started an initial attack (protected and unprotected) on a fire?
- How much time is necessary for evacuation before the activation of active fire suppression systems?
- What previous fire incidents have occurred on submarines?
- What is the probability of successful intervention based on previous incidents?
- What does the crew think about the planned fire safety systems on board A26 and what changes in crew intervention can it lead to?

Vi inleder med att sammanfatta det som står på första sidan. Tryck på att vi är säkerhetsgodkända och får ta del av hemlig information. Fråga om det går bra att vi spelar in intervjun på diktafon och om vi får ta kontaktuppgifter för eventuell uppföljning.

Inledande frågor

Vi tänkte vi skulle börja med lite inledande frågor.

Namn och kontaktuppgift om det går bra, om vi vill fråga något i efterhand.

Vilken befattning har du?

Hur länge har du åkt ubåt?

Hur kom det sig att du började åka ubåt? Vad var det som lockade? Berätta!

Vilken båt åker du på i dagsläget?

Hur länge har du åkt på den?

Vad innebär din befattning? Vad har du för uppgifter när ni är ute på uppdrag?

Om vi istället går in på nödsituationer, har du speciella uppgifter då?

Har du rödkykarutbildning?

Hur ofta övar du som rödkykar på ubåt?

Kan du uppskatta hur lång tid det tar att dra ut någon från maskinrummet/torpedrummet/propellern/cc?

Om skyddslarmet går, vad är det första du gör? Varför? Är det rutin eller sunt förnuft? Hur lång tid tar det ungefär?

Hur många sjödagar har ubåten per år?

Hur många sjödagar har besättningen per år? (antal kör)
Rutiner

Tänkte att vi skulle prata lite om vad ni har för rutiner om det händer något oplanerat.

Vi har förstått att ett skyddslarm sätts igång om det händer något. Har ni fastställda rutiner när skyddslarmet går? Hur ser dessa ut?

Hur ser rutinerna ut om skyddslarmet följs av förklaringen brand i…?

Tror du att alla känner till rutinerna? Varför/varför inte? Hur lång tid tar det innan det mesta sitter i ryggmärgen?

Har man samma rutiner i olika besättningar på olika båtar?

Förebyggande

Vi förstår att man helst inte vill att det ska brinna ombord, det är kompex.

Hur arbetar ni för att förebygga bränder? Finns det rutiner angående var oljiga trasor ska slängas osv?

(På A26 kommer det att finnas avsedda stuvningsutrymmen)

Vad gör ni för något annat för att förebygga bränder, utbildning eller liknande?

Hur mycket tänker ni på olika scenarier när ni är ute och kör? Går igenom själva i huvudet?

Första insats

Om något ändå händer, är det den som sitter närmast som reagerar? Hur lång tid?

Om den personen inte lyckas, vad är nästa steg i brandbekämpningen? Använder ni er av första insats, vi har förstått att det är något relativt nytt?

Om den första insatsen inte lyckas, vad är nästa åtgärd?

Sedan har ni rökdykare också, i vilket läge används de?

Vad är sannolikheten att handbrandsläckare respektive släcksystem släcker branden? Ungefär hur lång tid tar det?

Rökdykning

Vi har förstått att rökdykarnas främsta uppgift är att dra ut folk om det är några kvar, betyder det att man inte går in som rökdykare om det inte finns någon att hämta?

Är det då man aktiverar Halonet?

Anses de manuella insatserna vara uttröttande för besättningen? Vill ni helst undvika det?

Om rökdykarna inte heller släcker branden, vad gör ni då? (Halon?)
När börjar ni planera en evakuering? I vilket läge evakuerar ni? Hur illa måste det vara?

I första hand evakuering till annan del av ubåten? Vilket läge URF/FU?


Fler scenarier?

Hur ofta övar ni att det brinner?

När ni övar, är det viktigt att rutinerna följa? Varför/varför inte?

Bränder/incidenter

Så om det händer på riktigt…

Har du varit med om några riktiga bränder? Berätta!

Har du varit med om någon brand som inte släckts? (Bara stängts in? Eller väntat på assistans?)

Anmäls brandincidenter? (Det finns reglerat att de ska anmälas) Hur/till vem?

Tror du att alla incidenter anmäls?

Hur görs uppföljningar till incidenterna?

A26

Antar att du känner till att Kockums håller på att designa en ny ubåt?

Vilken information får ni om projektet?

Vad känner du till om A26?

Är det något som Kockums speciellt ska beakta då de designar A26?

Brandskydd


Tryckknappar för manuell aktivering.

Akustiskt och visuellt larm kopplat till systemet. Brandskyddstablåer som kan kommunicera med varandra, en i förskeppet och en i akter.

Runt torpeder blir det förtätat släcksystem.

Brandposter, handbrandsläckare och rökdykarutrustning kommer följa kraven.

BIBS kommer dimensioneras som kraven, inget slutet ”oändligt” system

**Obemannat akterskepp**

I dagsläget planeras två större förändringar när det gäller brandsäkerheten på A26 jämfört med tidigare ubåtar. En av dessa förändringar är att akterskeppet kommer att vara obemannat.


Vad är din spontana tanke kring detta?

Behöver era rutiner vid brand förändras om akterskeppet är obemannat?

Ser du några fördelar med att ha ett obemannat akterskepp? Vilka?

Ser du några problem med att ha ett obemannat akterskepp? Vilka?

**Vattendimma**

Den andra förändringen i A26 är att Halon 1301 byts ut mot vattendimma i de fasta släcksystemen.

INFO: Det kommer inte vara högtryck utan snarare vattendimma med mellanstora droppar, så små droppar som möjligt med det tryck som går att få på ubåt. Vattendimma kommer bland annat leda till att man kommer att behöva komplettera med en manuell insats för att säkerställa att branden släcks. Detta eftersom studier har visat att vattendimma främst begränsar en brand, speciellt om den är dold. Systemet kommer ha en egen tank med vatten, troligtvis placerad i mittsektionen

Vad är din spontana tanke kring detta?

Behöver era rutiner vid brand förändras på grund av detta? Hur? Är det lätt att byta rutiner för ubåtspersonal?

Ser du några fördelar med att använda vattendimma istället för Halon (eller annat gassläckssystem)?

Ser du några problem med att använda vattendimma istället för Halon (eller annat gassläckssystem)?

Tänk scenario att det brinner, vattendimman går igång, det blir dålig sikt, brandgaser blandas i rummet.

Vad tänker du kring en manuell insats i detta läge?
Det går att starta insats snabbare eftersom man kan vara kvar i utrymmet när systemet startar.

**Utrymningsfilosofi**

Visa ritningar för rumsplaceringen, brandzonsindelning och utrymningsritning.


Manöverrum längst förut kan leda till blockerad utrymningsväg? Vad tror du om det?

Om alla är i fören och det börjar brinna där, vad händer då?

Luckan i manöverrum ner till torped, ska den vara genomgångslucka eller användas mer som nödutgång?

Övriga luckor i durken ner till våningen under, vilka finns idag? Hur används dessa och stör de när man vill passera? Är det problem med utrymning om de står öppna?

Luckan i akter upp till däck, är den svår att använda i ytläge? Den är en av de utrymningsvägar till öppet däck som finns. Kan den göras säkrare?

Har du några andra synpunkter på A26?

**Avslutande frågor:**

Är det någonting du vill tillägga kring det vi har pratat om idag?

Är det något av det du har berättat som är hemligt och ska behandlas med försiktighet?

Ge personen en kopia av försättsbladet så att han/hon har våra kontaktuppgifter och kan höra av sig om det är något.

Question 17: Estimate the probability of a successful intervention and that the fire is extinguished. All motivations and related probabilities are listed in this appendix grouped based on the estimated probability. The answers were no probability was estimated can be found at the bottom of the list.

(100%) Första insatsen brukar vara på plats väldigt snabbt. Vid mer omfattande brand kan man ju på många ställen skärma av och utlösa halon.

(100%) Branden släcks eller innesluts pga snabbt agerande och återkommande övningar plus brandsensorer och HiFog.

(100%) Bemanning i ubåtens alla avdelningar underlättar övervakning och initial insats. Fasta släcksystem i utsatta sektioner.

(100%) 1. snabb insats. 2. Compartement escape. Compartement flooding (gas). 3. 2 av varandra tryckfasta avdelningar.

(100%) Såvida inte batteriet brinner/kortslutning.

(100%) Då många sensorer kan upptäcka en tidig brand så är chanserna stora att man kan släcka den i ett tidigt skede. Att nivån på syrehalten ombord är lägre än normalt är också en faktor. En väl tränamn besättning är ett vinnande koncept.

(100%) Hittills har det alltid lyckats.

(95%) Fasta släcksystem och lägre syrehalt i luften i samband med begränsad luftmängd gör att brand sällan uppstår. Snabba insatser.

(90%) Är branden en ljusbåge nära kraftkällan(batteri) så socknar ljusbågen först när energikällan är tömd.

(90%) ”Mindre” incidenter såsom brand på t.ex. ett stekbord bör vara närmast 100%. Vid allvarligare incidenter är troligen siffran något lägre.

(90%) Bra utbildning om hur systemen fungerar, vilka åtgärder som är relevanta vid brand. En stor medvetenhet om riskerna om brand ombord.

(90%) Beror på var men i maskin med hjälp av fasta släcksystem mycket goda möjligheter. Finns ett flertal handbrandsläckare i övrigt så elden kan snabbt bekämpas av insatsgrupp.

(90%) Bra släckningssystem, materiel och välutbildad personal.

(90%) Ett tacksamt system att använda sig av med släcksystem, begränsad luftmängd och relativt goda resurser för att stänga av berört system.
(90%) Tror att vår organisation och släckmedel (samt vårt eviga övande) kommer innebära att bränderna släcks. Det är efterbörden som brukar vara det komplexa.

(90%) Bra träning. Bra struktur.

(90%) Upptäcks sannolikt tidigt då övervakning och personal ständigt närvarande. Fasta släcksystem finns på "utsatta" ställen.

(90%) Pga att vi ofta övar ombord.

(90%) Det finns många fasta släcksystem som är väldigt effektiva. Finns folk överallt i fartyget så vid brand är nästan alltid första insatsen på plats väldigt snabbt.

(85%) Mkt stor sannolikhet då en brand detekteras snabbt och folk finns tillgängliga i omedelbar närhet.

(85%) Tidig upptäckt (brandlarmssystem- automatiska brandsläckningssystem. HALON samt spridning hindras med att ventilation slås igen) Tillbudssläckning inom 30s. Första insatsgrupp inom 1 min. rökdykare klar inom 5 min för insats.

(80%) Tiden är dybar.

(80%) (initial insats) Sannolikheten att rökdykarna kan släcka t.ex. en dieselbrand är obevisslig. Detta p.g.a. dålig sikt, värme och svåra komliga skrymslen och vrår som t.ex. i kölar under durk. Ett ordentligt fast släcksystem krävs. Rökdykarna är på plats för sent för att kunna genomföra en vettig insats. Deras uppgift blir att rädda liv och att övervaka en redan släckt brand.

(80%) Chansen att lyckas beror på första insatsen och eftersom att hela båten är bemannad till sjöss finns det alltid någon nära till hands för att genomföra insats.

(80%) Jag tror att brand upptäcks snabbt och insats görs snabbt innan läget är okontrollerbart.

(80%) Lyckad insats, starkt beroende på vad som brinner.

(80%) Insats kan avbrytas och förskippet eller akterskeppet kan utrymmas och släckning med fast släcksystem kan igångsättas, läs halon.

(70%) Det är självlärt helt beroende på situation. Men med den övning och den materiel vi har anser jag att vi faktiskt har en chans.

(70%) Om initial insats sker inom en minut.

(70%) Helt beroende på brandens omfattning.

(70%) Liten luftvolym, hög syrekoncentration. Fasta släcksystem. Bemanning i hela fartyget.

(70%) Jag tror att brandfarligt ämne samt syre är begränsat, så branden kommer antagligen att dämpas efter ett tag. Därmed borde branden gå att bekämpa med rökdykarpersonal ombord.
(60%) Väldigt mycket beroende på vad som hänt. Ju större brand desto mindre sannolikhet att insatsen lyckas.

(60%) Beroende på allvarligheten och släckningsmöjligheterna (halonskyddat utrymme etc.). Branden kommer nog att släckas tillslut oavsett omfattning då syret tar slut.

(50%) Jag tror som sagt att röken kommer att göra besättningen panikslagen. Jag jobbade på Sjöormen och där bodde halva besättningen i akterskeppet där både byssa och maskinrum finns.

(50%)Är brasan tillräckligt stor eller aggressiv kan det bli svårt att få kontroll över förloppet.

(50%) Beror helt på vad som brinner och om elden sprider sig till något illa.

(-) Jag har svårt för att bedöma sannolikheten pga. komplexiteten i systemen ombord och omgivande faktorer (uppträder taktiskt, läge, ytläge, hård sjö, etc.).

(-) Beror på omfattning och placering.

(-) Har aldrig haft brand till sjöss, våra övningar resulterar i att minska tiden mellan larm och åtgärd. Så jag vet inte, vet bara att jag inte vill ha brand ombord, såklart.

(-) Beror helt på typ och ställe. Explosionsartad brand i maskin: 10-20%. Brand i pudas: 100%.

(-) Det beror helt på vad som brinner och hur omfattande branden är.

(-) Går ej att bedöma med anledning av att inget tillbud är det andra likt.

(-) Beroende på var branden inträffar kan det inträffa att branden ej går att släcka, t.ex. batteriet.
Fråga 19: Har du förslag på förbättringar i brandskyddssystemen och rutinerna för brand ombord? Berätta!

Question 19: Do you have any suggestions of improvement in the fire safety systems or the routines related to fire on board? All the comments to this question are listed here.

- Jag var som sagt rökdykare när jag var frivakt, då jag mestadels ligger och sover. Det innebär att jag måste vakna upp innan jag kan fungera på ett bra sätt. Eftersom jag som TeleB inte har några viktiga arbetsuppgifter när jag går vakt, tror jag det hade varit betydligt bättre att jag varit rökdykare på min vakt, istället för på min frivakt. Jag fungerar nämligen bättre i vaket tillstånd än 5 sekunder efter att jag vaknat efter att jag sovit tungt.

- Önskemål om ett brandlarmssystem som har väldigt få oönskade/falsklarm.

- Större yta för rökdykare att klä sig (Gtd MR ej bra...) Larntabla som visar var branden äger rum.

- Ett helhetstänk, d.v.s. titta både på enskilda system och/eller sektioner/delar av ubåten. Kanske inte fler vattentäta avdelningar men åtminstone fler brandklassade dörrar/skott. Tänk även lodrätt, går det att avgränsa ett våningsplan istället för en hel sektion?

- Halon i fler utrymmen.

- Enkla handhavande för brandövervakningen.

- Kontinuerlig övning.

- År ej längre aktiv på ubåt.

- Akterskeppet skall vara så tomt som möjligt. BIBS-luft måste finnas till alla så att det räcker i flera timmar.

- Bra med fasta kameror som kan se i rök (IR eller annan bildbehandling). Detta för att ifrån förskottet se var branden startat och var personalen befinner sig.

- Ja. Längre tid med andningsluft, BIBS. Ett slutet system med möjlighet att stanna i ubåten.

- Små ”hametriskt” tillslutna utrymmen. Möjlighet till lokal släckning (punktinsats). Var inte rädd för CO2 i små doser.

- Fler/mer fasta system in i konsoller och datorer.

- Förespråkar taktiken som Roger Bengtsson tagit fram (FI Hms Halland). D.v.s. initial insats omedelbart även med andningsgas (insatsgrupp) man tar då inte på sig hela stället utan endast SSD93 samt rökdykaragg (vid behov). Under tiden klär sig rökdykare i andra avdelningen för att kunna göra insats om ”insatsgruppen” måste retirera p.g.a. värme eller flammor. Larntabla som är lättjämförliga, underhållsvänliga, detektorer som är säkra (få falsklarm), montering som gör det möjligt att demontera/byta enheter utan problem.

- Nej.

- Fortsatt utveckling av den nya typen av detektorer som är betydligt känsligare.
• Vid ett dieselläckage liknande det jag har varit med om hade ett fast system för skumfyllning av kölar varit mycket värdefult. Personalen kan då koncentrera sig på att släcka branden ovanför däkrönivå. Ett lättöverskådligt mimiksystem (ej datorskärm) där man ser vilken detektor som löst ut, var denna är placerad och det ska vara lätt att lista ut vilka knappar man ska trycka på (eller vippor) för att sektionera bort och släcka just det området där detektorn sitter.

• Rutinerna i stort är bra, dock bör möjligheten att sektionera fler delar av fartyget beaktas och ett större antal detektorer med ett TYDLIGT HMI där man grafiskt får presenterat vad som är utlöst och var!

• Förbättra möjligheterna för en snabb första insats. Att kunna ha större möjligheter för "kabinettsläckning".

• De nya rutinerna som används på vissa båtar är bra. Insatsgrupp gör inledande insats, rökyrkare gör sig klara på kommande, är i övrigt behjälpliga vid förbandsplatsen.

• Fler brandsläckare kanske. En brandsläckare tar fort slut.

• Så många fasta släcksystem som möjligt. Automatisk släckning med gas inne i elektronikskåp, slutna rum mm.

• Videoövervakning över känsliga obemannade områden. Fasta släcksystem. Trycknedtagningsfläkt som kan användas för rökgasvakuerings och eller trycknedtagning vid t.ex. tvingat bottenlage. Någon lättare utrustning (flamskydd/andning under begränsad tid/radiokommunikation) för insatsgruppen.

• Som rökyrkare på ubåt har vi ju främst handbrandsläckare som "hjälpmedel" för släckning. Första insatsen brukar ju ta "första bästa" när de kommer på plats. Om den då är slut när rökyrkarna kommer så kan det bli krångligt och tar extra tid att få dit släckare om det behövs. Summan av kardemummman…ev. fler handbrandsläckare.

• Tydligare och uttalade rollfördelningar.

• Fast vattensystem för att vid behov kunna späda och släcka utläckande väteperoxid i torpedrum. 

• Andringsapparatsutbildning för samtliga ombord. Släckutrustning en skärfärgkorttyp. Dock bör man väl vara restriktiv med nyttjandet av själva skärfunktionen. 

• Tror att övningar och noggrannhet (regelbunden rengöring etc.) är av största vikt.

• Nuvarande rutiner bygger på över 100 år av ubåtserfarenhet inom organisationen. Vidare har jag svårt att föra att se om jag ska kunna komma med synpunkter än, då jag i dagsläget har endast 1 år av erfarenhet av ubåtar.

• Trädlos videoöverföring från rökyrkakamera till monitor hos rökyrkarledaren. Bättre och smidigare slangar.

• Bra och rymligt ställe att byta om till rökyrkare på. Bra ställe att kunna leda rökyrkare ifrån. Handbrandsläckare lätt tillgängliga.

• Främst för mig som rökyrkare hade tiden till insats minskat om det fanns bättre plats att klä mig och lättare komma åt utrustningen. Vad gäller de fasta systemen har jag ingen åsikt. Mitt förtraende för dessa är ganska hög.
• Tycker det fungerar bra.

• Ja, fast pappret räcker inte.


• Jag har lämnat in förslag på att utöka övervakningssystemet ombord för att undvika överhettning och kortslutning av vissa komponenter… så i långa loppet så har jag förslag.

• Idag saknar vi ett släcksystem på nivån mellan handbrandsläckare och fast släcksystem (halon). Ett fast vattendimsläcksystem skulle kunna vara ett alternativ, om detta är påfyllnadsbart och kan användas flera gånger i samma utrymme.

• Bättre kommunikationsmöjligheter mellan rökdykare och rökdykledaren.

• Nej.

• För lång tid har gått sedan aktiv tjänst – rutiner är ej likadana idag som för 10 år sedan.
APPENDIX G – Answers to Survey Question 20


Question 20: The aft compartment on A26 will probably be unmanned. Do you think that the crew actions in case of fire will change due to this? Describe how. All received answers to this question are listed below in accordance with their classification as yes or no answer.

Svar som kodades till JA. Answers coded as YES

- Ja, inga livräddningsresurser äga rum i akterskepp. Dock blir 1a insats betydligt långsammare.

- Risk finns att en "enkel" släckning med handbrandsläckare inte kan ske då detta troligen kräver en tidig upptäckt. Det medför att det fast installerade släcksystemet kanske behöver användas i större utsträckning.

- Förmoderligen. Mer övning kommer krävas för att få samma kännedom om den aktra sektionen. Följfrågan blir ju också vad som kommer hända med bemanningen? Om det blir färre individer ombord blir beroendet av släcksystemen större enligt min mening. Dessutom högre krav på övervakningssystemen.

- Ja. Initialt agerande förseknad. Tidig upptäckt och tidigt agerande minskar brandens utveckling.

- Jag tror att det blir alldeles utmärkt, men det kräver någon typ av övervakningssystem så att man vet vad som väntar rökdykarna när de öppnar luckan och går in i aktra avdelningen. Nu kan man ta det lite lugnare och planera insatsen.

- Ja! Då personal inte finns i akterskeppet kommer upptäckstiden samt insatsstiderna bli längre i denna avdelning.

- Ja, manuella insatser i akterskeppet kommer att begränsas i fredstid då vi inte har någon livräddning.

- Jag tror att besättningarna kommer att vara noggrannare vid rondering etc av akterskeppet och att man kommer att vara ”nojigare” och kanske inte helt lita på övervakningssystemet.

- Ja.


- I händelse av brand i akterskeppet tror jag att alla kommer att undvika att gå in i brandhärjat utrymme såvida det är inte är personal där.
• Längre tid till första insatsen kan agera. Kanske tar det längre tid att identifiera vart det börjat brinna etc. Men å andra sidan kanske man kan utlösa halon snabbare om det inte finns personal där bak.

• Enligt min erfarenhet sker de flesta incidenter/tillbud i aktra avdelningen. Ett obemannat dito kan få till följd att tid för insats förlängs och situationen inte blir enklare att överblicka. Besättningen kanske avvakta och väntar på rökdykare i större män än tidigare.

• Ja troligen, första insats i aktern kommer att försenas då ingen personal är på plats. Vid brand i förskottet finns kanske ingen rökfri plats där rökdykare kan göras klar för insats. Personlignen tror jag ett obemannat akterskepp är en dålig idé.

• Ja, vi kommer vara mycket mer beroende på fasta släcksystem. Förmodligen kommer det dröja innan larm detekteras, då vi oftast idag upptäcker elektronikfel på lukten långt innan rökutveckling skett. Detta gör att problemet kan åtgärdas långt innan det orsakat ett brandlarm.

• Ja, de förutsätter jag då rökdykare i aktern inte kommer befinna sig i aktern.

• Ja, se 19 (Pappret räcker inte).

• Ja. Man drar på halonet och lämnar fartygets akter.

• Självklart kommer den ändras eftersom delar av besättningen idag arbetar i akterskeppet. Man kommer nog troligtvis skicka bak personal i alla fall.

• Initial insats är ej genomförbar, ursäkting av brinnande elmateriel är ej genomförbar inom rimlig tid. All släckning kommer ske med det fasta släcksystemet p.g.a. den långa tid som går innan manuell släckning kan påbörjas. Tveksamt om FC vågar skicka en oskyddad grupp för att kontrollera ett brandlarm. Eftersom ingen personal finns på plats från början vet man ju inte hur miljön i akterskeppet är. Man blir nog tvingad att skicka rökdykare för att kontrollera akterskeppet men dessa är för klumpiga för att snabbt kunna genomföra tekniska åtgärder. Dessutom tar det lång tid för dem att komma på plats.

• Jag tror att man kommer att lita på det automatiska systemet i större utsträckning. Eftersom det inte finns någon personal i akterskeppet finns det heller ingen att rädda och därmed ett större incitament att ha ett tätt bra automatiskt släcksystem i aktern. Jag tror också att det är viktigt med både indikering och släckning i elektronikskåp. De kommer att bli helt inkapslade och därmed kommer det både ta längre tid att upptäcka branden och det kommer bli svårare att lokalisera den.

• Insatsen är nog mycket beroende på om personal finns i utrymmet. Jag antar att om brandlarmet utlöses kommer personalen invänta brandbekämpning. Därefter kommer man eventuellt kontrollera med rökdykare i efterhand hur stor skada som är skedd.

• Det är viktigt att få till bra kameraövervakning, där alla möjliga finesser från kameror bör tas omhand. Eftersom det är obemannat, bör det vara väldigt lite som rör sig där, och man borde kunna få indikationer på när något börjar hända. När en brand brutit ut, och akterskeppet snabbt rökfylls, bör man även kunda spela tillbaka video för att se var rökutbildningen utbrutit. En rökdykledare bör kunna leda en insats betydligt bättre än nu hva. kameror; framförallt om IR-kameror tas fram för att matcha rökdykarinsatsers behov.
Svar som kodades till NEJ. *Answers coded as NO*

- Nej.
- Nej, ögon på plats kommer att behövas.
- Nej. Näcken hade också obemannat akterskepp.
- Besättningens agerande kommer nog i start vara detsamma, dock kommer tiden till första insats tveklöst bli mycket längre vid en eventuell manuell insats. Fartygskännedomen i akterskeppet kommer gradvis att minska vilket på sikt kan få konsekvenser för hur snabbt och hur väl man kan hantera alla typer av haverier.
- Nej.
- Nej, jag tror inte akterskeppet blir obemannat om inte insats kan ske omedelbart från förskottet.
- Nej.

Svar som kodades till varken JA eller NEJ. *Answers coded as neither YES or NO*

- Ovissheten om vad som sker och har skett i det obemannade utrymmet kommer att kräva ett väldigt effektivt larm och släcksystem. Jag tror stor ovilja kommer att råda för att skicka in personal till ett okänt scenario.
- Jag tror inte på obemannat akterskepp då det har varit meningen på andra ubåtstyper. Det har blivit bemannat då vissa saker behöver mänsklig övervakning. Blir det obemannat på A26 så kommer det att innebära högre tillgänglighet och säkerhet på släckningsmateriel och en ökad tillgänglighet/närhet av personal.
- Hoppas inte det, vi är fortfarande beroende av den delen av fartyget...
- Mycket viktigt med personal på plats. Initial insats extremt viktig! Om obemannat tror jag på fasta släcksystem.
- Bör vara bemannat med tanke på säkerheten.
- Inte så benägna att gå in i ett obemannat utrymme för att släcka.
- Tiden till första insats blir längre. Detta kan göra att branden kan utvecklas.
- Första insats blir rimligen försenad.

G3
• Vid obemannat akterskepp blir det en ökad risk för att en brand oupptäckt kan brinna. Jag tycker annars att röd-detektorer etc har visat på en god eller mycket god förmåga att upptäcka bränder. Faran är om man får brandlarm i aktern så vet man inte om det är en liten avgasläcka eller en ”eldstorm”

• Första insatsen kan bli fördröjd då ingen personal finns i akter. Detta kan innebära utmaningar för fasta system.

• ”Öron, näsa och ögon försvinner”. Vidare försenas den första insatsen.

• Tror inte att obemannat akterskepp är en bra idé!! Även om tekniken har gått framåt sen sist detta var aktuellt och det är tekniskt möjligt så tror jag att det är svårt att ersätta bemanningen på ett tillfredsställande sätt. Både vid normal-drift och vid någon form av tillbud.

• Obemannade delar av fartyget är säkerhetsmässig katastrof! De incidenter som inträffar visar att de mänskliga sinnena overstiger sensorer. Vi mörker att något är fel långt innan något system larmar. I händelse av larm är det bara att hoppas att vi haft folk på plats för att ta hand om problemet tidigt innan det har eskalerat. På 70-talet provade obemannat akterskepp – gå inte i samma fälla igen.


• Jag tror att det tar längre tid att få en bra överblick av läget om aktern är obemannad och en första insats kan göras snabbare. Syn och lukt är, ger bra förklaring. Kameraövervakning och sensorer kan kanske ersätta mycket?

• Det finns ingen nära initial insats och övervakningen som människor göra kan ofta konkurrera maskiner och larm.

• Detta beror på vilka automatiska system som byggs in. Personal på plats kommer nog alltid att behövas för att kunna kontrollera och lösa problem.

• Det kommer nog ta längre tid innan första åtgärderna görs, vilket kan göra bränder större innan släckinsats.

• Jag tror inte det kommer vara obemannat i slutändan.

• Vid brand i akterskeppet där en manuell insats behövs kommer kanske branden hinna ta sig mer innan första insats kommer dit vilket kanske leder till mer oro om brandens utbredning. Men kan man bara utlösa det fasta systemet (vilket man borde kunna om det inte är någon i akterskeppet) i akterskeppet så borde det inte förvärra något, tvärtom skulle det känns säkrare.

• Vet ej.

• Längre tid till initial insats.

• Om det inte finns några kamera-övervakning så blir det svårt att avgöra om det är fallarm eller en riktig brand.

• Se ovan (För lång tid har gått sedan aktiv tjänst – rutiner är ej likadana idag som för 10 år sedan).
APPENDIX H – Answers to Survey Question 21


The A26 will probably be designed with water mist instead of Halon. The question in the survey introduced the water mist philosophy and that the extinguishing process will need a complementary intervention from the crew to extinguish the fire. The question was: Will this lead to a change in routines? In what way and what do you think of this change? All answers are listed in this appendix.

Svar som kodades till JA. Answers coded as YES

• Har svårt att bedömma då det är 15år sedan jag seglade ubåt. Men troligtvis behöver vissa rutiner ändras då en, om jag uppfattat saken rätt, manuell insats även behöver sättas in.

• Med vattendimma kan personalen stanna kvar/ej ha så bråttom att lämna utrymmet som man har med halon. Jag tror att med vattendimma så kommer mer materiel (maskiner m.m.) att förstöras.

• Troligtvis – nytt system.

• Antagligen. Bra med tanke på miljön om halonet kan ersättas.


• Mindre skadligt för individerna, mer skadligt för materielen. Sanering av vatten kommer kräva en rutin. Har inte jobbat med vattendimma i fasta system. Känner en oro för att det kan skada så pass mycket att vi inte kan fortsätta striden.

• Ja om det endast är begränsande av branden kommer det krävas att personal går in och släcker och inte som nu att man kan släcka med halonet. D.v.s. mera personal kommer att krävas.


• Ja, självklart ett begränsande system låter betydligt sämre än ett släckande eftersom man i så fall måste skicka in personal till brandhärden innan den är släckt.

• Utrymning kommer ej att vara nödvändig då vattendimma utlöses, till skillnad från halon. Således kan brand släckas snabbare.

• Ja. Manuell insats på ubåt är oerhört farlig.

• Njae, lite ändring i hur man göra och tanken bakom bara.
Jag måste lita på att SP gör ett bra jobb och att våra nya rutiner (vilket det bör bli) kommer vara helt ok. Jag har inte tänkt på detta men nya rutiner medför alltid en risk att ngt glöms bort eller att man helt enkelt får situationer som man ej är beredda på. Å andra sidan kan det medföra att rutinerna blir bättre!

Utrustningsmässigt i form av fler brandmannautrustningar för en andra insatsgrupp. D.v.s. 4 andningsapparater/avd.

Viss ändring kanske det blir i hur rökdykarna agerar för att kontrollera att branden är släckt.

Högst sannolikt, kan vara till det bättre, även om obemannat akterskepp anses personligen vara av ondo.

Svar som kodades till NEJ. Answers coded as NO

- Ser inte någon direkt anledning att ändra rutinerna.

- Nej.

- Nej, inte någon större eftersom vi alltid skickar rökdykare för efterkontroll av branden.

- Inte mycket.

- Nej. Vi skickar alltid folk för att kontrollera ev. brand och sedan kyla med t.ex. CO2.


- Inte så som det beskrivs här. De flesta tillbud följs upp av manuell insats idag. Möjligt att en högre säkerhetsnivå kan uppnås om ”inerteringsnivån” är högre innan en manuell insats pga ovan nämnda utr.

- Det tror jag inte.

- Ingen större förändring då man ändå alltid skickar personal med släckkapacitet för kontroll.

- Nej.

- Inga förändringar men man tillför hjälp att klara situationen.

Svar som kodades till varken JA eller NEJ. Answers coded as neither YES or NO

- Om ubåten är obemannad (till kaj) kommer det att bli ett problem om personal måste ta sig ner för att släcka. Idag ska det mycket till om personal ska ta sig ner ombord vid brand om man vet att det inte finns folk i ubåten. Man resonerar att det är för farligt med tanke på vapen, LOX, tryckkärl och annat smått och gott ombord.
• Är man medveten om detta så kommer man agera uteftör förutsättningarna om att en manuell insats behövs genomföras. Jag tror inte det skulle bli ett problem eller skapa oro.

• Mitt antagande är att manuell insats måste ske i nära anslutning till att vattendimman utlössts för att branden inte skall flamma upp igen. Sikten kommer troligen vara begränsad inte bara av rök utan även vattenånga.

• Om större utsträckning sker med manuell släckning måste antalet handsläckare och luftpaket tillhandahållas.

• Jag tror att det blir viktigare att övervaknings- eller indikeringsystemet kan ge ett bättre stöd till vart insatsen trots behövas, om inte annat så för att köpa tid. Dessutom så blir det då också viktigare att det är relativt enkelt att med rökdykarutrustning på röra sig från en nivå till en annan.

• Sorgligt, vill gärna kunna lita på att det fasta systemet gör sitt jobb, efter-kontroller i ubåtens konstiga trånga utrymmen kan vara tämligen lurigt.

• Använd halon istället för vattendimma. Annars krävs fler släckare och ett bemannat akterskepp.

• Brandsläckningen blir likvärdig. Eftersanering kommer att behövas. Återfyllning av släcksystemet kan ske till sjöss.

• Detta kan innebära att man behöver kraftfulla handbrandsläckare eller liknande.

• Det är drygt 15 år sedan jag åkte ubåt och jag åkte en gammal ubåtstyp. Dagens rutiner är säkert annorlunda jämfört med de vi hade. Allt kan bli bättre än vad vi hade...

• Detta ställer högre krav på rökdykarinsatsen om man måste – de facto – släcka branden och inte bara kontrollera att halonet "bet".

• Detta omöjliggör ett obemannat akterskepp. Löser man ut ett fast släckssystem ska detta släcka branden. Något annat är inte acceptabelt.


• Inget att erinra.

• Det är att föredra att ha gas så att man kan lita på att branden är släckt. Kontroll av att branden är släckt görs i vilket fall som helst men i dagsläget finns inte riktiga släckmöjligheter med skyddsdimma för rökdykare. Eftersläckning blir svårare om inget nytt system tillkommer.

• Rutinerna förändras kanske inte då det fasta systemet dras igång relativt sent. Det kanske igångsätts tidigare i och för sig. Frågan är dock hur kommer båtens vattenläge att påverkas av en ökad vattenmängd?

• Viktförändring/fria vätskeytor vid dåliga släcksystem (stor volym), tryckökning. Utrustning måste täla det. Brandskyddsdräkterna måste vara effektiva även blöta. Trycksättning av systemet måste gå fort/klara haverier. Om detta funkar kan vattendimma vara något man tom övar med och får förtsökte för.

• Man slipper bry sig om farorna med halon.
• Tror sikten kommer bli riktigt dålig om det är vattendimma så det kommer nog ytterligare försvåra identifieringen av källan. Jag tror att halon är bättre (snabbare) på en ubåt är just ett snabbt agerande livsviktigt.

• Alla till buds stående hjälpmedel som underlättar insats vid tillbud är bra. Eftersom brand kan uppstå av flera olika anledningar är det inte bra att belasta organisationen med fler uppgifter.

• Vet ej hur det skulle förändra rutiner. Dock kan man ju med vattenbaserade system kanske montera fasta system i fler rum än i de vi har idag.

• Låter inte bra.

• Vi måste börja öva varmt på återtagande av utrymme.

• Pga vattendimman kommer nog rökdykargruppen att få vänta tills att den lagt sig. De blir genomblöt vilket minskar skyddet på dem.

• Kräver bättre utrustning, framförallt brandposter så att det går att göra på ett smidigt sätt, brandinsats mellan avdelningarna.

• Vatten i eltavlor! Är det så smart?

• Inget att erinra.
APPENDIX I – Answers to Survey Question 22


Question 22: Do you have other reflections about the fire protection? All answers to this question are listed in this appendix.

- Jag tror det är väsentligt att få ytterligare en bekräftelse på brand, förutom brandindikat/larm, genom att man tex. kan se rökutveckling på en kamerabild alt. temperaturförhöjning i utrymmet som bekräftar.

- En stor skillnad på A26 jämfört med nuvarande ubåtar är att man förflyttat manöverrum till längst förut i båten. Detta gör att en stor del av besättningen är längst fram, istället för strax för om mitten, vilket tidigare varit fallet. Innan har luckan till akterskeppet suttit i manöverrum. Om en eld utbryter i byssan eller i hytterna, kommer denna brand att delvis blockera utrymningsvägen till akterskeppet. Det finns en nödtrappa ner genom torpedrum, men det kommer ej bli lika effektivt som på dagens ubåtar.

- Inför dessa manuella insatser (A26) är behovet av övervakning av utrymmet stort, då med optiska och IR utrustning. Rutiner för återstart av elektriskasystem efter insats med vattendimma, då kanske hög luftfuktighet råder och lokala vattenansamlingar kan uppträda, stor risk att detta vatten är elektriskt ledande efter släckning.

- Systemintegration och redundans är två saker att särskilt beakta i detta.

- RD-utrustningens mängd och placering har förbättringspotential om man ser till dagens båtar, att kunna klä sig ostört och ur vägen vore bra, samt att kunna ha sina personliga prylar. Längre och högre bingar för att fullvuxna snabbare ska kunna ta sig ut vid larm.

- Ubåten har en fördel att branden ofta slocknar av sig själv beroende på att syret i avdelningen tar slut om det stängs till. Bra med många brandzoner på A 26.

- Det som ställde till det extra för oss var att vi hade halva besättningen i akterskeppet och att det bara fanns en (1) lucka mellan avdelningarna (ingen sluss). Det innebar, i händelse av brand i maskin, att halva besättningen skulle evakueras fram till förskepet. I och med att luckan då behövde vara öppen en längre stund skulle sannolikt även förskepet bli rökfyllt.

- Nej. Jag har jobbat i A26 projektet och tycker att som gjordes var bra. Särskilt viktigt tycker jag att det ”oändliga nödandningsskyddet” BIBS är bra.

- Batterimaximalers placering. Mittbrytare i batteri. Ellbränder (batteri) är svårsläckta och genererar en grym atmosfär. → Nödandningssystem… Fartygets övergivande…

- Är mycket nyfiken på hur tanken är med det totala brandskyddet ombord A26. Brandarm, ”halon”larm (vattendimma), brandsläckare, brandposter, fasta installationer i taylor, ELSA etc..

- Skaffa en riktig dyr försäkring. Då kommer det ALDRIG att börja brinna…

- Ska akterskeppet vara obemannat måste man ha ett släcksystem om fungerar, dessutom får man vara beredd på att detta kommer att utlöses vid varje allvarligt brandlarm (miljöaspekter, ekonomi för omfyllning m.m. måste tas i beaktande).

- I enlighet med det jag redan skrivit, främst m.h.t. obemannat akterskepp.
• Vad för gas skall utnyttjas i gassläckssystemet? Kan ett alternativ för fasta släcksystem som ej enbart begränsas brand tas fram?

• Som information, vi försöker hålla ned O2 halten till mellan 18-19 % för att minska tändvilligheten. Om möjligt. Jag har ett förslag om vi hur skall sänka tändvilligheten i elskäpen. Detta genom att sänka trycket i elskäpen till t.ex. 0,5 bar. Detta renderar i att om det är luft i utrymmet så motsvarar det en syrehalt på 10,5 %. Då brinner inte många grejer. Sedan ha N2 (kvävgas) som fast släckmedel i modulen. Om man då fyller på N2 till 1,0 bar så behåller man den låga koncentrationen av syre sam att man sprider inte ut varken rök eller andra gaser i båten. Detta medför bättre miljö i båten efter insats.


• Jag tror att medvetenheten rörande säkerhet är hög i ubåtsflottiljen/på båtarna. Jag tror att vid tillbud uppstår flera problem än brand.

• Bättre brandpump än i dagsläget behövs.

• Idag har vi endast rök begränsning mellan för- och akterskepp. Samt i aktern mellan MAR/EC samt EC/SR. Skulle ge mycket att kunna rökavgränsa mer i förskepet ex.vis övre/undre plan samt MR/HI.

• Massor.

• Nej.

• Det finns 2 slags vattendimma, HiFog och DryFog där det senare redan idag används i utrymmen såsom elrum, datarum och SLC.