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First Responders on Ships: Technological and Legislative Developments

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Abstract: The use of fuel material and different sources of ignition causes unwanted fires, producing and spreading in different spaces. Fire fighting. systems are measures taken to minimize the effects of fire. This struggle is not only on land, but also in the maritime world, through maritime security that has become a very important element for the International Maritime Organization (IMO). Therefore, maritime accidents caused by fire are one of the challenges to be taken into account, because they require immediate control and response. This article presents a historical interpretation of the concept of maritime safety through first responders on ships. It will be demonstrate how the technological advances of such equipment have been very important for their arrival on ships. In addition, the article reveals the legislative changes of International Convention for the Safety of Life at Sea (SOLAS), which reflects the IMO requirements to prevent fire risks on board, requiring a reading of the primary documents. Finally, the importance of the evolution of first intervention equipment for safety on board has been shown.

Keywords: Fire fighting; Maritime Safety; SOLAS; First Responders

1. Introduction

Since humanity discovered the fire, it has shown its two faces, its use for progress and its destructive capacity. Fire fighting. has been evolving through research into new tools and products, as well as continuous training in their correct use.

If on land this is a hard fight for the fire brigades, at sea it was always more arduous, since, despite being surrounded by water, the ships did not always have adequate means, nor did the crews have the necessary training.

Ships have gradually incorporated the extinguishing devices used on land, and crew members have been trained in their handling(Barrios and Charlo 2023) . These points remain formalized through regulations the evolution of the Convention for the Safety of Life at Sea (SOLAS).

The evolution of maritime safety and therefore fire fighting on merchant ships has been reflected in several fronts. This is the case of structural elements or passive fire protection, fixed extinguishing systems(Nguyen 2021) , even down to equipment and communication procedures for requesting a distress call(Rey Charlo 2024) and a more direct fight by the crew.

This article will look at the historical evolution of the elements used by first responders over the years. At the same time, the different updates of the SOLAS convention will be shown to see the influence of the advances in fire fighting. in the maritime sector.

This first intervention attack is concerned with three factors:

- the direct attack on the fire, that may be on a small scale by fire extinguishers or on a large scale by pumps, hoses and other elements,
- concern for the integrity of the crew, through appropriate clothing and equipment that isolates the user from the noxious atmosphere,
- Finally, training for the different situations.

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- On all fronts there has been continued research to improve the elements as the results of a fire have great personal and economic costs(McNamee et al. 2019) .

This evolution of the media has had a high dose of trial and error. Some practices remained entrenched over the years, in spite of no to be correct. An obvious example we can see in the 17th and 19th centuries, it was a requirement that firefighters have bushy beards that they wet and put between their teeth to act as a smoke filter by breathing through their mouths. After they drank a lot of steam beer because they thought it would clear their lungs(Spelce et al. 2017) . The remedies were not always correct, being discarded over the years or in more serious proving harmful materials were used for its users.

2. Methods

This article contributes to the analysis of the evolution of first intervention equipment on board by examining and seeing its evolution through technological and legislative changes. Furthermore, this research highlights the importance of training and handling of equipment for safety on board.

Data Collection and Sources

To conduct a historical analysis of first intervention equipment on ship is a crucial requirement to understand and visualize the importance of such equipment, and the training that the personnel in charge of it must have. The temporal scope of the study begins in 340 BC with fire fighting. is found in Heron's Spiritalia to the present. For this study, the documentation used by sourced from various sources. We have chosen an approach based on the review of literature, regulations and reports. Regarding the resources used, we have consulted articles, legislation, and manuals, which has allowed us to train ourselves on the subject and draw conclusions.

3. Historical Evolution

3.1. From Classical Antiquity to the 16th Century: The First Firefighters

One of the earliest references to fire fighting. is found in Heron's Spiritalia, where he describes a pump invented by his master Ctesibius (340 BC) with modifications by Heron himself. It worked through compressed air that forced the water out(De la Escosura 2012) . Although in Claudio Perrault's Compendium of the ten books of architecture by Vitruvius, it is more assimilated to an extraction pump than a fire pump(Polión 2009), it is considered the first fire pump in history.

On 22 BC in Rome, the Praefectus vigilum, the first fire brigade on record, was organized. They handled the siphos, pumps that required a large number of personnel for their use. The siphonarii responsible for their manipulation and the aguarii who were responsible for filling them. Until the 1st century AD were not established these siphonarii. They used handmade tools for their performance, such as; scales, buckets, hooks, axes, mats, shovel brooms, sponges and the centons, large covers of wet wool to fight fire outbreaks(Ayuntamiento-Murcia 2005) . According to some researchers, instead of using water, they were dipped in vinegar. This was because it was a liquid that was present in some houses in containers to extinguish small fires and in others it was replaced by an aqueous solution of ammonium salts(Imamović, Agić, and Oruč 2022) . These means were used until practically the 15th century without any substantial improvement(Botía n.d.).

Advancing to 1556, an illustration of a metal workshop in book XII "De Re Metallica" shows the first description in modern history of a fire-fighting machine. It consisted of a shaft, with two handles and ending in a nozzle. In another of the illustrations in the book, we can see a huge watering can, which we can suspect as another means of extinction, but it is not appear cited by the author as such(Henry 1912) , so despite the logic it could be an artistic license.

3.2. The Beginning of Fire Hoses (17th Century)

Almost a hundred years later, in 1655, Hans Hautsch built a machine that used air pressure to throw water into the fire by means of a nozzle. It consisted of a tank on runners and a piston in the center. Because of these characteristics, it needed three men to operate the pump, plus those who filled the container(Ayuntamiento-Murcia 2005) .

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From the earliest models, fire pumps had in common that they were huge tubs filled by bucket-carrying brigades and were placed as close as possible to the fire, which they attacked with rigid cannons. Nevertheless, this changed in 1672, when Van der Heyden introduced his lightweight, transportable hand pump.

This equipment used flexible sewn leather hoses, one suction that was placed in a nearby water source and another to direct the jet to the fire. This eliminated the need to introduce the pump and avoided obstacles such as ladders.

Van der Heyden not only made technical contributions, but also contributed to the training of personnel through an illustrated book (1690) and teaching fire brigades how to use his equipment(Coleman 2020) . His collaborator, John Lofting, patented in London the "Engine for sucking worms" (1690), based on the same principle as Heyden's(Lemons and Lipscombe 2024). Thanks to the use of flexible hoses instead of rigid pipes, it could be used in all kinds of buildings, distilleries and ships(Lofting n.d.). The acceptance of this new device in London, due to the social concern about fires, as a few years earlier (1666), the city center was devastated by fire(Palau-Orta 2022) .

Between 1698 and1699, after his studies in Germany, Mr. Dumouriez-Duperrier built fire pumps that were considered an advance for their quality. This contributed to the creation of the Paris fire brigade of sappers in 1705, the first ones who started wearing helmets (Fernandez 1850) ,, these first models were made of iron and leather(Paulin 1837) .

3.3 The First Portable Fire Extinguishers (18th Century)

Richard Newsham patented two flow regulation devices for fire pumps (1721 and 1724). They consisted of an airtight chamber (The Windkessel) through which the pump introduced the water, the air trapped at the top was compressed and when it expanded the water was expelled through a hose or pipe depending on the final need. It had a narrow tank which was filled by buckets and could be easily transported to the fire site(Lemons and Lipscombe 2024).

Ambrose Godfrey Hanckwitz invented in 1723 what is considered to be the first fire extinguisher(Diaz Cortés et al. 2020) . It which could be used both in buildings and on ships(Godfrey 1890) . It was based on the studies of Zachary Greyl, who proposed methods of suffocation through an explosion to extinguish fires. Zachary's invention consisted of a machine, which was a wooden barrel filled with water. In the center was a metal box with gunpowder and a nozzle to ignite it. The machine was taken to the area of the fire, where, due to the heat and the gunpowder, it exploded, expanding the water and thus suffocating the fire. Greyl tried to sell his idea in exchange for large sums of money, but it was not possible for him.

Hanckwitz's proposal was the “Fire Annihilator”, an improvement on Zachary's model. The annihilator consisted of an internally lined barrel, the inside of which contained an extinguishing agent consisting of water and a fire-fighting agent. In the center was a pewter sphere filled with gunpowder. The advantages of the annihilator were reduced weight, greater durability, and avoidance of rusting metal parts, and efficacy by using water plus a chemical. The internal lining meant that the external receptacle could be varied in shape and size, allowing it to fit into tight spaces(Maddison 1951).

In 1756, iron and leather helmets began to be replaced by copper helmets in France(Paulin 1837). King Louis XV recommended that all firemen in France wear them, but it would be years before the normalization of this measure(Imamović, Agić, and Oruč 2022).

3.4. Nineteenth Century: From the First Respiratory Protection Equipment to the importance of Training Through Fire-Fighting Treaties

The technological advances used to improve fire fighting. equipment led to the patenting of a portable fire extinguisher by William George Manby in 1813. This extinguisher, similar to those we know today, consisted of four metal cylinders, three filled halfway with water and a fourth with compressed air, with a valve at the top to release the water under pressure through a hose(Diaz Cortés et al. 2020).

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The appearance of the first respiratory protective equipment in 1825 by John Roberts allowed more autonomy of movement for firefighters as they were not connected to the outside. The equipment consisted of a leather hood, with a tube attached to the leg that sucked air from the ground, where fewer vapors accumulated. At the lower end of the tube was a funnel containing a cloth forming two folds and a sponge dipped in water to trap particles(Spelce et al. 2017). Aldini's research with this equipment concluded that its effectiveness was linked to the type of cloth rather than the moisture in the sponge.

For many years, the firefighters' protective uniform consisted of leather doublets and helmets or bonnets of the same material for their heads. In 1827 in Milan, Aldini introduced a new fire protection equipment. Such equipment allowed remaining for a short period in the middle of a fire, thus facilitating the possibility of rescuing both people and easily transportable goods. The suit consisted of a first layer of metallic gauze and a second layer of asbestos or woolen cloth dipped in alum, which protected from heating the first layer. A metallic gauze shield that could be used to protect itself from a flare, or serve as a screen when rescued from the heat of combustion could accompany the suit(Aldini 1830).

In 1835, Mr. Paulin, chief of the Paris firemen-sappers, designed a respiratory protective equipment. It consisted of a very wide chamois jacket and a semi-cylindrical mask made of thick glass, a whistle used for communication and a lamp kept alight by the air supplied to the equipment. The jacket acted as a bag to contain the air that was sent from the outside through a leather hose. Two qualities of this instrument stand out,

- On the one hand, the escape of air that was produced by the folds of the waist and wrists that prevent the entry of contaminated atmosphere,
- And on the other hand, the ease of breathing that prevents the wearer from fatigue(Fernandez 1850).

One of the disadvantages it presented was the need for several operators to assemble it. The fire brigades could not have several units of this suit; the respiratory protective consisted merely of moistened handkerchiefs to cover the airways.

In 1856, Antonio Rovira y Trías published his "Tratado de la extinción de Incendios". The publication sets out the importance of training exercises. These included the handling of pumps and hoses, the formation of chains to fill the barrel wagon, and the handling of other tools such as picks, axes and hoes. Rovira defended the exclusive intervention of firefighters in emergencies, and asking to eliminate the custom of involving in extinction work the neighbors of the affected area.

The manual describes techniques for extinguishing fires in different scenarios. Many of these techniques have survived, with appropriate evolutions, to the present day. The methods describe how to extinguish small outbreaks using blankets, extinguishing fires in enclosed areas by isolation from the outside, the danger of inappropriate use of water with certain substances, the importance of the distance of attack to the fire and the importance of cooling.

In the treaty, there is already a specific section on fires on ships where shore personnel are involved. The author specified that, because of the characteristics of the holds, if the fire occurs lower areas of the cargo, it is useless to throw water because the jet cannot act. The treaty offers alternatives,

- Close hermetically hatches and any openings.
- Make a hole flush with the water by means of axes or similar.
- Heel the vessel by moving shipboard weights to the side of the hole. The opening will be submerged, extinguishing the fire, saving much of the ship´s cargo and materials(Rovira y Trias 1856) .

As an evolution of breathing apparatus LaCour patented in 1863, the first autonomous breathing apparatus that contained air by itself. Beginning in 1877, the New York Fire Department and the U.S Navy used this device. The device consisted of an airtight bag of indium rubber lined with layers of canvas. Before entering the fire zone, it was necessary to inflate the bag through a bellows. A suction tube came out of the bag from the bottom and an expiration tube connected to the top of the bag. It was thought that the expelled air was revitalized for a while by the mixture. As there were no valves,

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the user himself covered the tube he was not using with his tongue while he held the two together with his mouth(Spelce et al. 2017).

In 1866 the physician Francois Carlier patented an extinguishing product based on sodium bicarbonate and tartaric acid, the mixture produced CO2 that propelled water to the outside(Diaz Cortés et al. 2020) . In that same year, James Braidwood published a study on fire prevention and extinguishing. His study was characterized by;

- the need to design smaller, lighter and more powerful fire pumps,
- Importance of hose connections in order to work more efficiently, and the need to study nozzles and hydrant nozzles.
- In addition, the need to study lances and hydrants.
- He also questioned the true efficiency of “Fire Annihilators”.

Braidwood use to choose seamen for his brigades, because he thought they were accustomed to receiving orders, long hours and hard work. To facilitate the fire-fighting work, he pressured the Admiralty to place fire pumps in dockyards and dock warehouses. Finally, floating fire pumps were installed for continuous availability(Braidwood 1866) .

As a result of the great Chicago fire of 1871(Ortega-Mateos 2016) , there was a proliferation of devices to assist firefighters in the area. An example of this is the Loeb smoke breather (1875). It was characterized by;

- It was equipped with glycerin-soaked charcoal and wool filters at the front of the mask.
- It had a protective grille and a windscreen wiper for fogging the glass.
- A rubber bulb on the head which, when squeezed, provided "essences to strengthen the nerves",
- The ensemble was complemented by a guideline and a pearl connected to a whistle at the waist to alert colleagues.

Just two years later, Nealy (1877) patented a filtering breathing apparatus. Composed of a cap with a mask. In the eye area, it had mica or glass to allow vision. A conical mouthpiece fitted with a hinged lid that allowed speech when open and protected the wearer when closed. The filtered air was inhaled through two rubber tubes connected to several sponge filters moistened by means of a water bag carried by the user on the chest(Spelce et al. 2017) .

That same year, the first historical antecedent of fire-fighting froths appeared, whose composition towards floating on the surface of the oil, extinguishing fires and preventing their reignition (Botta 2021) .

In 1880, Almon M. Granger of New Orleans patented an extinguisher called “bottle-breaking fire-extinguisher”, based on acids. It contained a glass receptacle that was broken before use, the contents being poured into the body of the extinguisher and exiting to the outside through a conduit that allowed it to be directed. Once used, the bottle was replaced and the device was available again(Granger 1880) . Two years later, it it would be improved by a screw system that allowed the bottle to break more easily and quickly(Granger 1882) .

3.5. Beginning of the 20th Century: The Disaster of Courrières

However, in 1902 Louis M.A. Muntz patented a respirator with a water and carbon sponge filter box. It incorporated an exhalation valve to the side and an inhalation valve to the front, both would be controlled by the user by breathing(Spelce et al. 2017) .

Almost 30 years later, Alexander Laurent (1905) used fire-fighting froths based on mixtures of: Aluminum sulfate, sodium bicarbonate and stabilizing agents. They smothered inflamed liquids by creating a layer of CO2 bubbles that floated to the surface(Diaz Cortés et al. 2020) .

A date to remember is 10 March 1906, when a massive explosion occurred at the coal mine in Courrières (France), whre 1000 workers lost thir lives. Bernhard Dräger brought his new breathing apparatus to the scene of the emergency. His 1904/09 model achieved an airflow of 50/60 litres per minute, up from 20 litres per minute for its predecessors, making it safer for rescuers(Dräger 1889) . The equipment consisted of a bag with two bottles, worn on the chest and connected by tubes to a scuba diving suit similar to those worn by divers.

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In 1910, Edwar M. Davidson patented a chemical procedure of extinction based in the carbon tetrachloride, composed synthetic expelled to the intervening exterior CO2 under pressure. This substance, in contact with air, formed a heavy gas that extinguished the fire(Diaz Cortés et al. 2020) . During its use it was very useful in fires involving oily materials and for electrical fires where water could cause great damage and safety risks, in which case mirbana oil (nitrobenzene), a non-conductive material, was added to the mixture(Davidson 1911). Davidson's procedure is considered the first extinguishing agent based on vaporizable liquid halogens. Its effectiveness was acceptable, but subsequent studies on the toxicity of the products led to its disappearance from 1959(Ayuntamiento-Murcia 2005).

Until now we have mentioned the technological changes suffered in the intervention teams, however, as will be analyzed below, it is through technological and legislative changes.

4. Historical and Legislative Developments

4.1. International Convention for the Safety of Life at Sea (SOLAS), 1974

As a result of the numerous maritime accidents and behind the outcome of one of them, the Titanic, cause that States be convenient some standards that they guaranteed more safety. Following this accident, the ineffectiveness of existing safety regulations was highlighted, leading to the United Kingdom convening maritime nations for the First International Maritime Safety Conference. Representatives of maritime nations participated in the Conference held in London. This conference resulted in the Convention for the Safety of Life at Sea (SOLAS) adopted on 20 January 1914(Piniella 2012) . In this first version, measures to actively prevent and combat fire are drafted in Article XLIX "detection and extinguishing of fires". Where it can be observed that;

- It required the establishment of on-board patrols to detect outbreaks, the need to have powerful steam fire pumps or other means. All this had to be prepared before leaving port, with the aim of providing two jets anywhere on the ship by means of hydrants and hoses.
- Fire extinguishers, without specifying the type or quantity, shall be available, approved by each government and located in machinery spaces.
- The collaborative spirit of the standard was emphasized, since if a government accepted a new type of extinguishing agent, a description and the tests carried out had to be sent to the other signatory parties.
- Protective equipment for the intervention was discussed: two smoke hoods and a safety lamp, located at different points on the ship.
- And as a fundamental point for the handling of emergency situations, Article LI obliged the crew members to carry out a fire drill every fortnight, to be recorded in the ship's logbook(IMO 1914).

At the end of 1917, the United States Bureau of Mines (USBM) developed a method that eliminated CO from the atmosphere by means of a catalytic reaction within the filter. This discovery, initially for military use, was a major breakthrough in many industrial sectors(Spelce et al. 2017). This discovery comes during the First World War, in the same year that the United States joined the war. The development of respiratory protection equipment was fundamental in a war in which attacks with gaseous chemicals such as chlorine had been recorded since 1915(Sadurní 2024).

In 1924, Dräger took a new model to market, an autonomous breathing equipment, which was a revolution in comfort. The helmet was replaced with a mask that could regulate the air flow between demand or constant supply(Dräger 1889).

In 1927, Lodias J. Dugas of Chicago patented a method that eliminated fire by applying a solid powder. Based on sodium bicarbonate propelled by a non-combustible gas, giving preference to nitrogen that decreased the risk of caking. It proved very suitable in hydrocarbon fires where water is dangerous. The heat decomposed the bicarbonate and released CO2, which suffocated the fire and at the same time formed a non-combustible film of sodium carbonate on the surface. For greater effectiveness, he mixed the bicarbonate with other products such as diatomaceous earth, asbestos powder, silicate or ashes. This mixture was inserted into in the body of a fire extinguisher with a hose, which allowed it to be directed to the source(Dugas 1927). A few months later (1928), a chemist from

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the same company, David Julian Block, solved the problem of compacting. By mixing a small quantity of tricalcium phosphate inside the body of the extinguisher(Block 1931).

4.2. SOLAS 1929

The second revision of SOLAS took place in 1929 where as active fire fighting. are added;

- Automatic fire detection and alarm systems, placed in parts of the ship not accessible to patrols.
- It takes into account fuel oil as a fuel for ships and its particularities in the event of a fire. A spray effect of the means of extinction is sought, to avoid splashes that spread the fire. As well as the requirement that the portable fire extinguishers in the engine, room must be approved for fossil fuels.
- Sawdust treated with soda (or similar products), 283dm ^{3} of sand and shovels for handling and distribution are brought on board.
- Mention for the first time fire fighting. froths for fuel areas(IMO 1929).

4.3. SOLAS 1948

The third update of the SOLAS Convention took place in 1948 and left new actions for the intervention of fire fighting. equipment such as:

- A central control system that closes the fans to prevent the entry of air.
- Specifications on hoses: sufficient length for the water jet to reach any space to protect. They will be easily connected to hydrants, which will always be accessible. If you need any tools, they should be ready and close. The fittings must be fixed and must not come loose while the fire pumps are in operation.
- Extinguishers are regulated between 9-13 litres. If they are permanently pressurised, they shall not be located in the accommodation. They will be located near the spaces to be protected and shall have spare charges.
- Breathing equipment consists of a smoke helmet with an air hose long enough to reach a safe space. It will have a safety lamp with a duration of 3 hours. And the axe is added to the fire fighting. equipment. And in the case of passenger vessels, a portable electric drill for access through decks or bulkheads in case of fire.
- The watchkeeping patrol is linked to passenger ships. Manual alarms are installed in passenger areas and accommodation. They are required to have foam fire extinguishers of not less than 45 litres capacity or 16 kg CO2 fire extinguishers.
- Fire drills: for passenger ships to be carried out weekly where possible, if the voyage exceeds one week they shall be carried out before leaving the final port. In the case of cargo ships they shall be carried out in periods not exceeding one month(IMO 1948).

In 1950, the Dupont corporation developed halon as an extinguishing agent, present until 2003, when it was completely banned by the Montreal Protocol.

In the same decade, sodium bicarbonate-based chemical powder extinguishers were marketed, activated by an attached pressure canister of CO2. At the end of the decade, in 1959, it began to be replaced by potassium bicarbonate, resulting in smaller equipment suitable for more types of fire(Diaz Cortés et al. 2020).

4.4. SOLAS 1960

The fourth SOLAS update also brought new developments in active fire fighting. on board:

- It specified the capacity of fire pumps, compared to bilge pumps, to avoid problems of water accumulation. Other pumps were allowed to supplement fire pumps as long as they do not operate with fuel. And the resistance of the lines is established, having a diameter sufficient to discharge 140 tons/hour, with two pumps operating at the same time. Pressure is required that varies depending on the tonnage of the vessel and whether it is intended for cargo or passenger use (between 2.6 kg per cm² to 3.2 kg per cm²).

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- The two jets to combat the fire continue to be the normal thing. However, it was added that they will not come from the same hydrant. They will be distributed in such a way that a single hose section of one of them can be the second of two connected hoses
- For hoses, their specifications are increased. They will have only one type of coupling, unless each hydrant is fitted with a hose. They will be 12, 16 or 20 mm in diameter or as close as possible.
- International shore connection, a metal part that allows hoses to be coupled with the different fittings used in each country, was introduced.
- Portable fire extinguishers could not contain agents harmful to people. In areas with an electrical presence, they could contain tetrachloride charcoal or similar.
- To firemen's team, a line of fireproof life is added, attached by a carabiner to the harness or belt of the breathing equipment. The hose of the breathing equipment should not exceed 36 metres, in which case the equipment will be replaced by self-contained breathing apparatus. The number of fire fighting. teams is increased according to the tonnage of the passenger ship, up to four in some cases.
- With regard to drills, on cargo ships they will also be carried out when more than 25% of the crew has been replaced(IMO 1960).

It would be in 1969, when Dräger Corporate changed the filling pressure of self-contained breathing apparatus to 300 bar, in 6-litre cylinders. This quickly replaced the four-litre cylinder pair of 200 bar cylinders and became the European standard for self-contained breathing apparatus(Dräger 1889). It is still in force today

4.5. SOLAS 1974 to Present Day

The IMO published its most modern version of SOLAS in 1974. This SOLAS has undergone changes through amendment procedures up to the present day.

Currently, SOLAS requires for the fighting of first responders on ships is:

- Detection of any fire in the area of origin. This may be automatic, by easily accessible push buttons or by mandatory fire patrols on vessels with more than 36 passengers.
- Immediate availability of fire extinguishing equipment, following the precepts of maintenance, signaling, location and handling.
- Water supply systems, such as manifolds and hydrants, made of materials not easily rendered unusable by heat and well protected from heat and impact with cargo. Piping and hydrants so constructed as to prevent freezing. On passenger ships, at least one fire pump is required to be self-acting.
- Specific froths for ships containing liquid cargoes with flash point below 60°C and resistant to alcohol.
- Emphasizes the importance of communications, and their procedural training, each patrol member and intervention team leaders will have a portable two-way radiotelephone, in some cases intrinsically safe or explosion-proof is required.
- Hoses of non-perishable materials, with a length between 10 metres and 25 metres. On ships carrying more than 36 passengers they shall be permanently attached. Nozzles shall have dual spray and jet effect and locking device. Placed in visible near the connections. Couplings shall be fully interchangeable.
- Portable fire extinguishers, which will be ready for use, near the entrance to the spaces to be protected. CO2 extinguishers are prohibited in accommodation. In areas with electrical equipment, they shall not conduct electricity or damage equipment. Spare charges or spare equipment shall be available.
- Firefighter's equipment shall consist of compressed air breathing apparatus. Minimum 2 pieces of equipment increasing according to the type of vessel. Spare charges or equipment shall be available to fill to at least 1200 litres.
- Helicopter area shall have 45 kg dry powder extinguishers, 18 kg CO2 extinguishers, foam cannon and a flame resistant blanket.
- Chemical resistant clothing will be provided.

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- Water foggers and portable foam lances on roll-on/roll-off vessels(IMO 2009).

In 1978, the IMO adopted the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW), which has undergone several amendments from 1991 to 2016. It specifies, among many other skills, the fire-fighting training that workers in the maritime sector must have(IMO 1978).

Between 1980 and 1990, work was done to improve self-contained breathing apparatus, with the incorporation of panoramic visors that allowed greater visibility and positive pressure in the mask that prevents the entry of gaseous contaminants in the event of a leak.

In 1995, there were great advances in the materials of breathing apparatus, incorporating them,

- Anti-allergenic materials for masks.
- More resistant plastics in their construction, resulting in greater thermal resistance and ease of decontamination after use.
- Lighter bottles, both made of steel and with the incorporation of the first bottles made of composite materials that achieved a reduction of almost 30% in weight(Torra Piqué 2019).

Considering the importance of fire fighting. on ships, in December 2000, the IMO Maritime Safety Committee adopted the International Fire Safety Systems Code (ISSC), linked to Chapter II of SOLAS. It deals with various aspects of first response fire-fighting equipment.

- The use of toxic extinguishing agents is prohibited.
- It specifies the firefighter's equipment on board. It shall consist of individual equipment and breathing apparatus. The individual equipment shall consist of;
- protective clothing of impervious surface material protecting the skin from heat and steam burns;
- boots of rubber or other non-electrically conductive material;
- rigid helmet providing protection against impact;
- electric safety torch with a 3-hour service life, being explosion-proof in tankers or hazardous areas;
- An axe with a voltage-insulated handle. The breathing apparatus shall be self-contained compressed air breathing apparatus with a minimum capacity of 1200 litres or other apparatus capable of operating for 30 minutes; plus a 30-metre fireproof safety cable with attachment hook.
- Approved fire extinguishers, dry powder and CO2 extinguishers shall be at least 5 kg, foam extinguishers shall be at least 9 litres. To be considered portable, their weight shall not exceed 23 kg.
- Portable foam lance devices, with lance compatible with on-board hoses, 20-litre foam concentrate container suitable for fuels(IMO. 2004).
- In the early 2000s, there were some improvements in breathing apparatus, which were increasingly linked to electronics:
- Masks that attach directly to the helmet are adopted.
- Incorporation of electronics into SCBA through Integral Control Units (ICU).
- Thermal Imaging Cameras (TIC) to facilitate movement in smoke-filled areas(Torra Piqué 2019).

Once we have considered both the technological advances and the legislation binding on the intervention teams on board, to improve maritime safety on board, we can reach the following conclusions

5. Conclusions

As we have seen in the historical overview, fire fighting. has evolved slowly in many cases. For this evolution, the bases and criteria of previous inventions were used, but making small modifications. It can be affirmed that the precepts that are sought in each improvement respond to the needs for greater efficiency of the products and machinery, as well as the reduction of the weight and size of the various equipment.

The years have shown that methods or products that seemed good at first have turned out to be merely popular legends, such as the use of the beard or the regeneration of air. Others have fallen into oblivion as shields, or those that were harmful to health as was the use of asbestos fibres.

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Nowadays, fire fighting. suits offer protection against various elements such as humidity, temperature, abrasion, blood and some chemical projections. On ships, the fire fighting. model is used for structural activities, whose the characteristics are included in the UNE en 469 standard in Europe(UNE 2020) and in the United States by the NFPA 1971.For this purpose, they are made up of several layers that offer insulation against extreme temperatures by creating air spaces between the layers. The special fabrics that make it offer resistance to heat and flames that are shrouded instead of melting or burning, as well as to different liquids(Lion-Group 2021) .

Despite these advances in protective clothing for firefighters, today they still have limitations that are reflected in complaints by users. These include the low sensitivity of the gloves to handle objects and the weight of the suit itself(Briones Orellana 2016). Current improvement research is aimed at finding more advanced protective materials and integrating electronic components that provide information on the conditions of the operation and the wearer's condition. Other fields where fire fighting. equipment is advancing include improvements in communication equipment in indoor areas with high noise levels and body cooling mechanisms attached to the clothing(Berger, Crouse, and Pieper 2016). There is certainly one way to go in some teams that have been stuck for years.

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