EFFECTIVE FIRE PROTECTION IN THE ROYAL NAVY

BY

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ABSTRACT

The article reviews the development work being undertaken by the MoD's Naval Support Command to improve fire protection on Royal Naval vessels, including submarines and Fleet Auxiliaries. It discusses the management of fire safety, development of fixed firefighting systems in the wake of the Montreal Protocol, surveillance systems, firefighting procedures and the RN's new firefighting training facilities to be provided at the *Phoenix* Nuclear, Biological, Chemical Defence and Damage Control School, H.M.S. *Excellent*, Portsmouth.

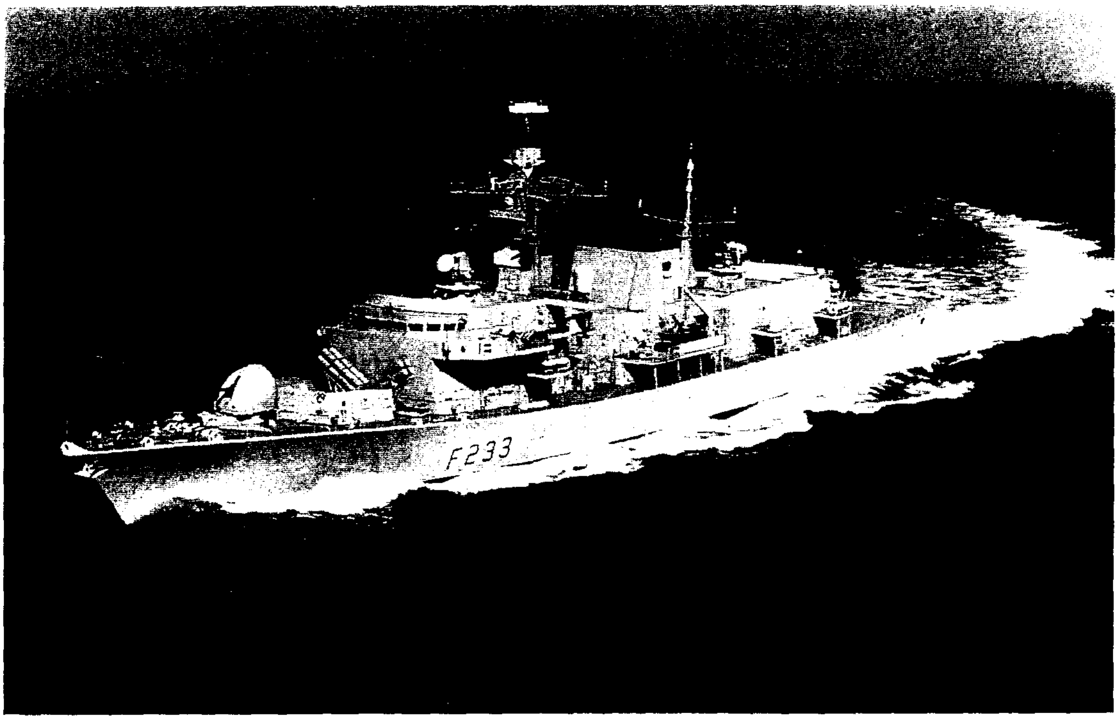

FIG. 1—H.M.S. 'MARLBOROUGH'—A TYPE 23 FRIGATE

Introduction

The Falklands Campaign concentrated the need to improve firefighting training and protection measures on Royal Naval warships (FIG. 1). It is however not only in times of conflict that our vessels need to be well protected. Statistics remind us that in peace time fire is an ever present hazard. Occasionally a major fire occurs such as those in:

- 1976 H.M.S. *Warspite.*
- 1986 H.M.S. *Illustrious.*
- 1992 H.M.S. *Turbulent.*
- 1993 H.M.S. *Broadsword.*
- 1994 R.F.A. *Argus.*

Such events, and the associated loss of life, serve to strengthen the Navy's resolve to improve fire protection arrangements and train ship's staff to save both the ship and their lives.

There are of course other considerations which have to be taken into account when equipping RN ships, such as:

- Stringent financial provision.
- The drive for leaner manning of vessels.
- The manpower and cost implications of improved technology.

In recent years increased safety and environmental awareness, including the need to take account of such edicts as the Montreal Protocol on substances that deplete the ozone layer, are also dictating the technology with which RN vessels are protected.

Against this background, the article reviews current initiatives in terms of safety management and the development of firefighting systems and equipment. The article also details measures to improve firefighting procedures and training.

Management of safety

A number of national disasters occurred during the late 1980s :

- *Piper Alpha* fire.
- King's Cross fire.
- Loss of the *Herald of Free Enterprise*.

These focused attention on the need for good safety management to be visible from the top of an organization. Whilst the existing arrangements within the RN are satisfactory, the MoD's Sea Systems Controllerate is spearheading a new initiative to further improve the management of safety by setting up a Ship Safety Management System[1]. This is intended to provide a total safety culture. It is recognized that some hazards such as fire have the potential for major loss of life. It has been decided that for these critical hazards some additional assurance of safety is warranted and this is to be provided by a process of safety certification. This safety certification will bring together and build on, where appropriate, existing standards and procedures. This will achieve a more structured and visible system which should also engender a stronger safety culture.

RN Fire statistics

The Naval Support Command (NSC) manages a fire reporting system on behalf of the RN. From these statistics some important indications can be drawn as to the types of fire, most vulnerable areas and the most likely ignition sources. On average 130 fires are reported each year. Most of these (90%) are small and are extinguished within the first few minutes. Approximately 50% originate in machinery space areas with a further 20% in electrical spaces. In approximately 30% of fires the primary ignition source is electrical.

Despite the apparent 'success' rate in ensuring that small fires do not become major conflagrations, it is important that the RN does not become complacent. The RN strives to develop and improve equipment, systems, procedures and training.

Shipboard firefighting arrangements

Major RN surface vessels have a High Pressure Sea Water (HPSW) system supplying large volumes of sea water throughout at a pressure of 710 kPa (7 bar). This serves waterspray/Aqueous Film Forming Foam (AFFF) systems in high risk compartments and first aid firefighting equipment such as centre feed hose reels. In main and auxiliary machinery spaces it has been policy to provide a primary gas drench (normally Halon) system, backed up by the waterspray/AFFF system. The implications of the Montreal Protocol and the desire to fight fires with the minimum amount of water to preserve ship stability, mean that a radical re-think of existing policy has had to be undertaken.

Probably the most significant factor to affect firefighting policy over recent years has been the Montreal Protocol. The rapidity with which environmental pressure has resulted in the advancing of phase-out dates for Halons was not foreseen. As the long term atmospheric damage caused by Halons has become more apparent, pressure has mounted to phase-out their production even though for many critical uses suitable alternatives do not exist. The MoD has stated that it will comply with the spirit of the Montreal Protocol and considerable progress has been made in:

(*a*) Identifying essential and non-essential uses.

(*b*) Banking sufficient halon to support essential uses through to the end of the equipments in-service life or until an acceptable alternative can be identified and retrofitted.

The designation of essential uses has been carefully monitored against an agreed definition by the signatories to the Montreal Protocol. This recognizes the need for Halon to be used where there is an unacceptable threat to human life or national security and there is no acceptable alternative. Within the RN most fixed Halon systems are in main and auxiliary machinery spaces and have been accepted as essential uses. It is policy to support from the MoD Halon bank, existing vessel designs whilst requiring future vessel designs to adopt alternative agents/systems. From the MoD's point of view there is only one other approved extinguishing gas and that is carbon dioxide (CO_2). This in itself has major disadvantages as between four to five times the storage capacity required for halon is necessary for CO_2 to provide an effective extinguishing concentration. Of even greater concern is the potential for fatalities if there are lapses in maintenance procedures or personnel training. Exposure of casualties or trapped personnel to CO_2 in an action damage situation may also prove fatal.

A great deal of research is being undertaken by industry to identify suitable replacement agents for Halon 1301/1211. For occupied spaces on naval vessels it is considered there are only 2 available contenders. These are Great Lakes FM200 (heptafluoropropane) and Duponts FE13 (trifluoromethane). All other claimed replacements can be ruled out on the grounds of toxicity, effectiveness or global warming potential. Even FE13 and FM200 have significant drawbacks when compared with the halons. For instance they require significantly more storage capacity than Halon 1301 (FM200: approximately twice the relative volume and FE13: four times the relative volume). They are also known to produce significant amounts of Hydrogen Fluoride (HF). If this is allowed to combine with water it can form highly corrosive hydrofluoric acid.

The amount of these agents which can be expected to decompose in extinguishing a fire depends on the size of the fire, the concentration of the agent and the length of time the agent is in contact with the flame or heated surface. If there is a very rapid build up of concentration to the critical value, then the fire will be extinguished quickly and the amount of HF and other decomposition products that are produced will be limited to the minimum possible. Longer exposure of these agents to high temperatures will produce greater concentrations of HF. It is therefore important that systems with such agents should incorporate high rate detection and automatic discharge following predischarge alarms. For naval applications this is a departure from current practice whereby such systems are activated manually following authority from the Commanding Officer or his nominated deputy. This is because the Command are in a position to take decisions in full knowledge of all due considerations.

As regards the acceptability of these decomposition products for personnel and material compatibility on naval vessels, studies are in hand with the Institute of Naval Medicine (INM). To determine the effectiveness of these agents much work has been done by SHEINSON *et al*[2] on behalf of the US Naval Research Laboratory (NRL) and tests in a full scale machinery space on the US Navy's Fire and Damage Control Test Ship, the ex-USS *Shadwell*, are planned to take place during 1994 (FIG. 2).

For the longer term, interest is now developing in a potential second generation substance termed CF_3I (trifluoroiodomethane) which is basically Halon (CF_3Br) with the bromine replaced by iodine. Early testing has demonstrated the effectiveness of this product in that the equivalent firefighting capability can be stored in approximately the same volume as that required for Halon 1301. It is:

- A clean extinguishant that leaves no residue.
- Non conductive.
- Has a virtually zero ozone depletion potential.
- An estimated lifetime in the atmosphere of 1.15 days.

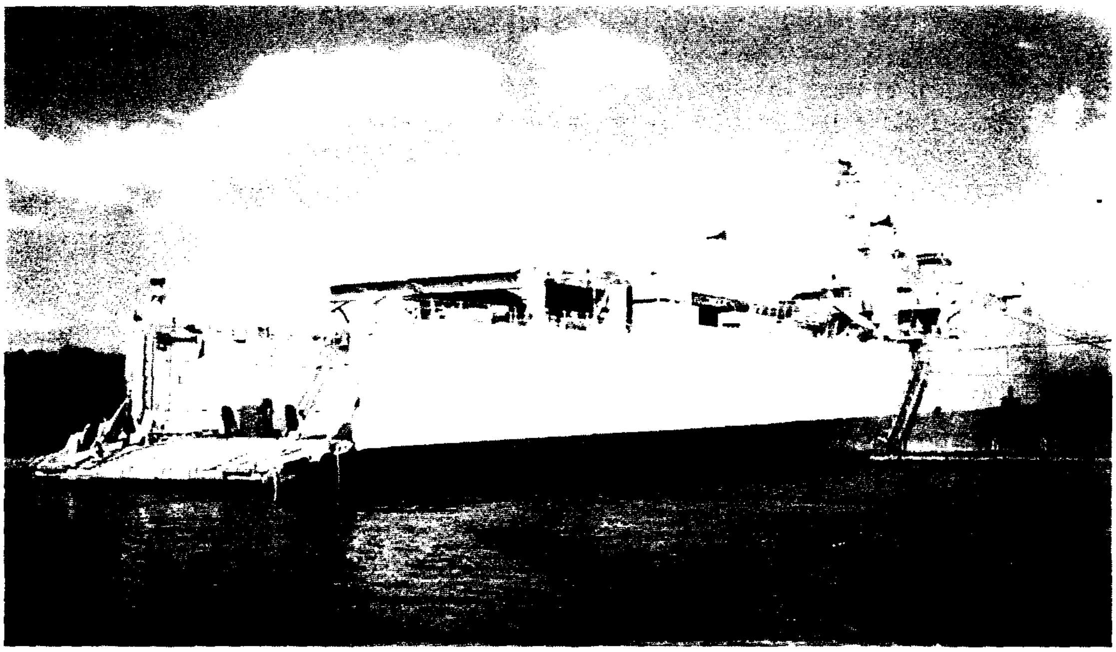

FIG. 2—THE US NAVY'S FIRE AND DAMAGE CONTROL TEST SHIP THE EX-USS 'SHADWELL' MOORED AT MOBILE BAY, ALABAMA

Further work is required to assess the toxicological acceptability and long term stability of the gas. The development of CF_3I is being managed by a working group led by the New Mexico Engineering Research Institute of the University of New Mexico. The working group includes representation from industry, the US Department of Defense and the Royal Navy. It is anticipated that CF_3I will be approved for use in occupied spaces in the next 18 months. For applications that require the agent to have a boiling point below −22.5°C, such as in aircraft engine nacelles, azeotropic blends of CF_3I are being investigated. CF_3I is also seen to have potential as a refrigerant and for foam blowing. Table 1 lists the chemical/physical properties of the main alternatives to Halon 1301.†

TABLE 1—*Chemical/physical properties of the main alternatives to Halon 1301*

	Halon 1301	**FM200**	**FE13**	**CF_3I**
Chemical Formula	$CBrF_3$	C_3HF_7	CHF_3	CF_3I
Normal boiling point (°C)	−57.8	−16.4	-82.0	-22.5
Molecular weight (G/Mole)	149	170.03	70.01	195.91
Vapour pressure (MPa)	1.47 at 21°C	0.405 at 21°C	4.59 at 25°C	0.625 at 20°C
Ozone depletion potential	16	0	0	0.011
Cup burner concentration with 20% safety factor (%)	3.7	7.9	14.4	3.6
Atmospheric lifetime (approx)	75 years	30 years	300 years	1–2 days

† Subsequent to this article being written, CF_3I has be shown to be toxicologically unacceptable for occupied spaces. This was contrary to expectations. It is understood that the working group will continue to function and explore other possible agents.

It has been the MoD's policy not to adopt interim replacements. Selected agents should reasonably be seen as having an availability to support new vessels for the duration of their in service lives which may be 20–30 years. It may be that realism may dictate that an interim agent will have to be accepted recognizing that a second generation substance will be available in 5–10 years time. It may of course then be necessary to bank the interim replacement to support transitional vessels.

Alternative fixed firefighting systems

As regards alternative systems, the Montreal Protocol has generated much interest in watermist systems, otherwise known as fine water spray/fog for applications in industry, merchant and naval shipping. Water mist relies on the generation of very fine (20–400 micron) droplets to extinguish fires. Compared with conventional water sprinkler systems, water mist has been shown to use relatively small quantities of water to produce an extremely effective cooling and fire suppression mechanism. Such systems are non-toxic and do not cause environmental problems. From a naval operational point of view, the virtually instant cooling effect and suppression capability will potentially allow early re-entry to a compartment by a firefighting team to fight a major conflagration and/or rescue casualties whilst saving valuable time in resuming naval operations. With the drive for leaner manning of warships there is an implicit need to employ more automatic systems. Water mist could be activated automatically which would enable earlier control of a fire lessening the potential damage and causing no significant collateral damage.

The US, Canadian and UK navies have a co-operative programme for the development of water mist as a fixed firefighting system in naval ships Main Machinery Spaces (MMSs). The main contributions by each nation are:

(*a*) *UK*

Undertaking a comprehensive literature survey and research into the fundamental principles and mechanisms of water mist. Characterizing nozzles for further development.

(*b*) *Canada*

Investigating the fire suppression capability of water mist, and establishing engineering guidelines for the design and evaluation of watermist fire suppression systems as applied to naval ships MMSs.

(*c*) *US*

Progressing a series of small scale trials and based on these and the output from UK and Canadian studies undertaking a full scale trial on the ex-USS *Shadwell* in 1994. The test space will model the proposed machinery space arrangement on the future US LPD 17 amphibious carrier.

The intention of this joint venture is to gain an understanding through research and development of the mechanisms of water mist and produce a design standard for such systems in naval vessels MMSs. There are a number of commercial systems available, but experience in the merchant marine area has been one of mixed success with these systems and gives little confidence that these can be effectively applied in the naval environment. It is widely recognized that suitable design standards are urgently required with a rigorous testing/certification regime.

Much valuable work in support of this naval co-operative programme has been done by J R Mawhinney[3] of Canada. This suggests that the original concept of a MMS total flooding system, based on watermist acting as a gaseous agent, was perhaps too optimistic. For a gaseous type agent it is necessary to achieve very fine water droplets. However to penetrate the flame zone from a significant distance, the droplets also require momentum. This can be achieved by high nozzle exit velocities or larger droplet size. Also the effect of obstructions and turbulence in a large space tend to lead to agglomeration of droplets, so that what starts out as fine spray develops into a coarser spray and the gaseous penetration of congested areas is lost (FIG. 3).

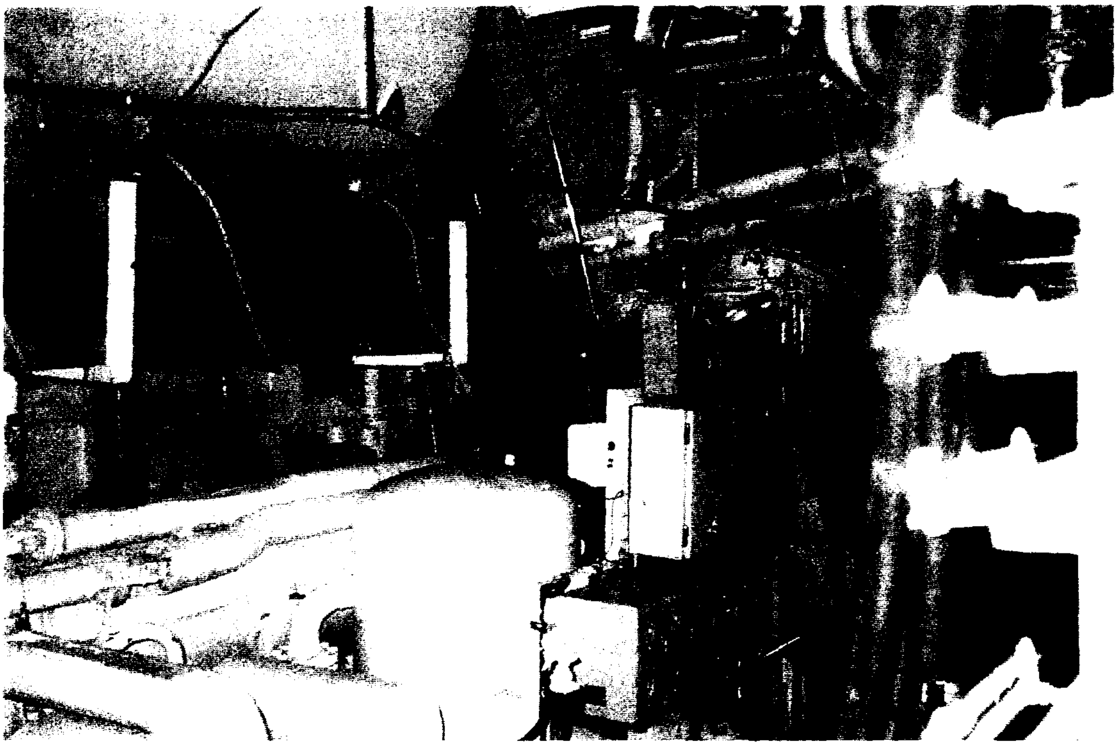

FIG. 3—TYPICAL CONGESTION OF A NAVAL MACHINERY SPACE

For reasons of system cleanliness and minimal collateral damage, it is necessary for water mist systems to rely on the use of fresh water rather than the ships installed HPSW system. Fire testing has demonstrated that the total water demand for a total flooding system could be high in order to support effective discharge for any significant length of time. With limited fresh water reservoirs it is also inefficient to total flood a large compartment to extinguish a localized small fire.

Mawhinney has concluded that the most practical approach is to limit the size of the protected zones to a maximum of $200m^3$. Each zone would be suitably engineered to protect the defined area or object. Such an approach will require sophisticated detection/actuation equipment to discriminate on the location of the fire and ensure appropriate actuation of the zonal systems. Pursuing a zonal approach is likely to require:

- More equipment/pipework.
- Greater cost/weight.
- Possible increased vulnerability to action damage.

For highly congested areas such as the bilge it may be more effective to use water spray/AFFF.

Water mist also has potential for application in other areas such as:

- High risk/high value compartments.
- Accommodation spaces.
- Gas turbine enclosures.
- Electrical cabinets.

A considerable amount of directed research and development is underway as well as the development of dedicated design standards.

In the world of fire protection, water mist is a fast developing technology and it is reasonable to assume that the range of credible alternatives to Halon will include water mist in some applications.

For the much longer term it is believed that the need to reduce manning, improve speed of response and minimize water usage, will lead to the development of intelligent automatic systems. A feasible system could employ infra-red sensors/cameras to survey the machinery space and detect prohibitively high temperatures. This data could be compared with that contained in a software model describing the relevant geometry of the protected space in relation to sensor viewing locations. The model could also identify zones of prohibitive temperatures and also the particular hot spots against which a strategy could be selected to fight the fire in the most effective and efficient manner. This information would then be used to define trajectories for water mist nozzles. The nozzles being controlled to ensure the trajectory of the spray matches strategy determined in the software model. This concept has parallels with existing intelligent automatic systems and enabling technologies to perform a variety of tasks.

Foam

The benefits of non-aspirated foams such as Aqueous Film Forming Foam (AFFF) have been recognized for many years. AFFF has gained wide acceptance within the fire industry due to its fast knockdown capability with the minimum amount of agent. Since the adoption of AFFF by the RN there have been a number of significant developments in film forming foams. One of the newer contenders is a substance called Film Forming Fluoro Protein (FFFP), which is claimed to have better heat burn-back resistance and fuel tolerance properties. Heat burn-back resistance is the ability of the foam to resist heat and burn-back prior to extinguishment. Fuel tolerance is the resistance of the foam to mixing with the fuel and hence preserving its effectiveness. The changeover by the RN to this later generation of foam has to be considered carefully as the logistics will be complicated, however the MoD is considering a thorough review of non-aspirated foams.

Another aspect of film forming foams that is worthy of investigation is the level of concentration to be employed. Existing fixed spray systems utilize 6% concentration, whilst flight deck monitors use 1% which is quite sufficient in the large quantities of water used by these devices. It is proposed to undertake trials to evaluate the reliability of induction and fixed systems with just 1% AFFF. If successful this would reduce operating costs, aid clean up and standardize all non-aspirated foam systems at 1%.

Over recent years a lot of interest has been generated in the use of High Expansion (Hi-Ex) foam to smother fires in ship's machinery and other spaces. A solution is mixed with water and air through a foam generator and produces an expansion of approximately 500:1. This foam is then injected directly into the compartment and can continue until the compartment is completely filled with foam, thus smothering the fire.

During NSC trials, performance of Hi-Ex foam was found to be disappointing. One of the major problems encountered was that it was difficult to get the foam to drop down through hatches into the machinery space where the fire raged. It is believed that this was due to the thermal updraft which resisted entry by the foam. To get the foam to enter a compartment, a second opening needs to be provided to allow for a 'through flow'; this is contrary to current RN firefighting doctrine. Other problems identified with Hi-Ex foam are:

- It is easily diverted by equipment/machinery/structure and will run down drains and openings. Users cannot, therefore, be certain that the foam has reached the seat of the fire and completely extinguished it.
- Disorientation of the firefighter can occur due to the foams opacity which can result in a 'whiteout' effect and claustrophobia. Hearing can also be impaired, restricting the effectiveness of distress signals and warning whistles from breathing apparatus.
- It provides an efficient thermal barrier which resists penetration by thermal imaging cameras. Personnel could also be close to a fire without feeling radiated heat. This could result in them stumbling into a fire.
- It is difficult to remove from the space once injected.

Trials by the Norwegian Navy *et al*[4] at the Swedish National Testing Institute concluded that Hi Ex foam is not suited for use against machinery space fires. This was due to the foam burning off at high temperatures and the difficulty injecting the foam against the pressure generated by a sizeable fire. These extensive trials found that low expansion foam discharged through high velocity non aspirating nozzles gave superior extinguishing results against high pressure oil spray fires as well as against oil surface fires.

Although it is not proposed by the MoD to sponsor further dedicated Hi-Ex foam trials, developments by others will be monitored. Hi-Ex foam may have applications in accommodation spaces and large uncongested spaces with relatively low fire burdens such as may be found on Royal Fleet Auxiliaries.

Passive fire protection

The MoD commissioned a study in 1992 to look critically at the fire protection arrangements on the RN's latest class of frigates, the Type 23, review new technologies and based on these studies propose an improved fire protection package for the next generation of frigates. One of the areas which was highlighted for improvement was the use of A60 fire barrier material. This is a generic term for a fire barrier material having an endurance of 60 minutes in accordance with time/ temperature requirements stipulated under the International Maritime Organisation's (IMO) Safety of Life at Sea (SOLAS) regulations. In current warships the practice is to boundary cool compartments where a major fire is raging. This is achieved by using ship's staff to monitor and cool as necessary hot boundaries including decks, bulkheads and deckheads adjacent to the fire. This technique protects high value/risk compartments and avoids the spread of the fire by spontaneous combustion. These activities are extremely labour intensive and could be significantly reduced by the use of A60 barrier material for inter-compartment boundaries of all high value/risk compartments, for all zone boundaries and the damage control deck (the lowest through deck). Design investigations are being undertaken to ensure that the fire resistance of A60 boundaries will not be compromised by penetrations from cable runs, vent trunking etc.

Surveillance systems

An information display and distribution system is necessary to pass damage control information between a number of operating positions throughout a ship and to ensure it may be displayed when and where required. Present systems are largely dependant on voice links, which are manpower intensive, become easily saturated, and are liable to induce confusion. Modern technologies for information display and distribution now offer the possibility of substantially eliminating these problems. The MoD is progressing the development of a Damage Control Information Displays (DaCoIDs). This system will provide a full shipwide electronic incident board and information display network.

Sensors will be linked into DaCoIDs. Present ship-wide damage surveillance sensors are restricted to smoke, fire and flood detection. These sensors do not provide sufficient detail to determine the extent of an incident. Current fire detection systems are based predominantly upon smoke detection and can give misleading information on the extent of a fire. Consequently, personnel have to attempt to inspect compartments to gain more information of the circumstances triggering the sensor. Such action is manpower intensive and greatly increases reaction times. It also has the potential for loss of life should personnel entering a space cause flashover or backdraught. It is considered that sensors should be used in groups to detect heat, smoke or flame and information should be presented to the ship's Command in a manner which permits rapid discrimination between compartments on fire and those which are simply smoke logged.

In addition to the above systems it is believed that greater use of Closed Circuit Television (CCTV) should be made. This will enable the ship's Command to evaluate the situation first hand and prioritize their approach. The value of CCTV was demonstrated during a recent major machinery space fire on the RFA *Argus*.

Naval firefighters equipment

In the event of a fire on a naval vessel the priority for the firefighting team is to fight the fire with a continuous aggressive attack in order to save the ship and hence the lives of those onboard. It is therefore the role of the MoD to ensure that firefighters are well equipped and trained to cope with such situations. In this regard there is continuing development to improve equipment for the firefighter. A whole series of minor development items are currently in progress including:

- Smoke curtains.
- Escape lighting.
- Hatch/door water wall devices.
- Improvements to centre feed hose reels etc.

Current major items under development include a firefighter's wire free communications helmet and enhanced endurance breathing apparatus (FIG. 4).

Firefighters wire free communications helmet

The development of a new firefighters helmet has stemmed from the need to improve communications between members of a firefighting team, the team's leader and the person in charge at the fire boundary. Reports of ship incidents and training exercises have highlighted the ineffectiveness of the current firefighters' communications during firefighting operations. It is therefore essential that a system that enables the firefighting team and its support group to communicate, be developed. The helmet is in one piece, similar to a motorcycle crash helmet and contains within it the communication set and the breathing apparatus face mask. The communication set comprises the radio, microphone and earpiece. Considerable development has been undertaken in conjunction with industry. Lessons have been learnt from production helmets issued to ships operating in the Gulf region in 1991/1992. Industry is being invited to tender against a procurement specification. Some development work has also been undertaken to incorporate a small thermal imaging camera in the top of the helmet. This will be a major improvement from the current hand-held version now in service.

Enhanced endurance breathing apparatus

A common set of Breathing Apparatus (BA) is currently used on surface ships and submarines. This is a positive pressure single bottle set with a maximum breathing time of 27 minutes. However, for safety a whistle blows when there is 7 minutes of air left. As soon as the BA whistle blows for one member of the team,

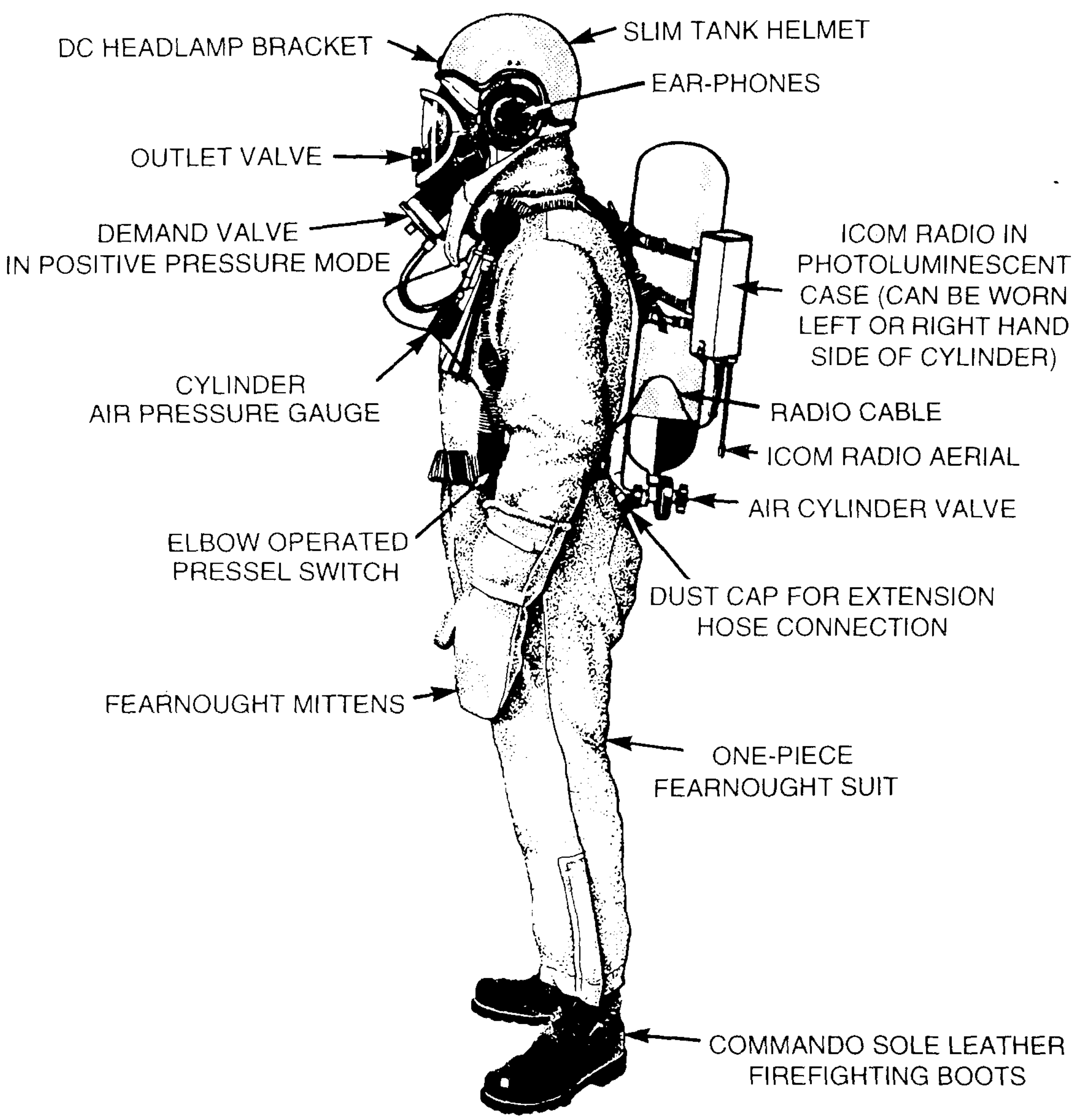

FIG. 4—EXISTING RN FIREFIGHTING RIG

the complete team must leave the scene and be replaced by a backup team. On submarines particularly, this limited endurance can provide insufficient time on the task. Trials have shown that as a result of congestion and space restrictions within submarines, firefighters use a large percentage of the cylinder air transitting to and from the scene of a fire. Investigations have identified that the weight of the steel BA cylinders can be markedly reduced by the use of aluminium and kevlar in their construction, thus reducing the physical demands on the individual. Action is also in hand to increase the endurance of BA sets to at least 40 minutes, giving a significant increase in time on task for the firefighters. For surface vessels similar sets are likely to be phased in and could make a significant contribution to reducing the number of firefighters required to fight a fire and therefore aid the drive for leaner manning.

Firefighting procedures

In the event that first aid measures are inadequate to fight a ship fire, firefighting parties equipped in fearnought suits, helmets, BA, thermal imaging cameras and hoses are required to form up. The RN has a rigorous procedure for sending a four-man team into a compartment to fight a fire. Basically team member:

Number one (Water wall).

Kneels outside the compartment access and uses a water wall nozzle to create a vertical sheet of water to protect the team on re-entry to the compartment from the heat, steam, and any possible fire balls.

Number two (Firefighter).

Kneels alongside number one and using a jet nozzle, possibly with a Chubb FB5X foam inductor, sprays through the water wall in the direction of the fire on entry.

Number three (Team leader).

Leads the group and carries a thermal imaging camera to identify the source of the fire.

Number four (Hose tender).

Tends the hoses, connecting to hydrants and turning the water supply on and off as required.

It is acknowledged that this method does use a lot of firefighting water which could adversely affect ships stability if not properly managed.

The US Navy's approach is somewhat different and relies on using as little water as possible. In order to examine the fundamental difference of philosophy, a RN firefighting team was invited to participate in a firefighting and damage control workshop on the *USS Shadwell*, in September 1993. This was an extremely successful co-operative event and a greater understanding of each navy's approach now exists. From the RN's point of view, it confirmed the wisdom of using a waterwall nozzle as protection for the team. It also enabled the RN to handle some new equipment and evaluate this for RN application. One of the most useful pieces of equipment trialled was a cool vest for wearing under a firefighter's suit. The vest has horizontal pockets across front and back panels into which are placed gel sachets straight from a freezer. The vest was shown to be highly effective in delaying the onset of heat stress by keeping the wearer's torso cool. A number of other equipments are being evaluated as a result of these successful trials.

Training facilities

The RN places great importance on the need for effective and realistic training. The Falklands campaign clearly demonstrated the need for more stressful and realistic training in the skills of firefighting, damage control and Command, Control and Communications (C^3)[5]. In September 1993 the RN opened its new NBCD (Nuclear Biological Chemical Defence and Damage Control) School at H.M.S. *Excellent*, Whale Island, Portsmouth.

The NSC is making a major contribution to this School by managing the development and production of a number of training facilities including computer controlled propane fired Firefighting Training Units (FFTUs), an NBCD and Ship Stability Computer Based Training System (NSCBTS) and an NBCDC^3 Ship Control Centre Simulator[6].

For firefighting training, the RN currently uses basic three deck multi compartment steel boxes which represent a ship configuration at its most simplistic. These have a number of fireplaces in which timber and diesel are lit. The resulting fires are not truly representative of ship fires and produce thick acrid black smoke which is environmentally unacceptable. The new FFTUs, which are due to enter service in 1997/1998, incorporate gas burners which are highly controllable and will allow a variety of ship fires to be simulated, ranging from a waste sack fire to a major bilge fire. The layout of the units is such thay they will be representative of a ship and the environmental conditions will create realistic hot zones at the point of entry and within the compartment. The trainee will also experience smoke obscuration. The burners will be controlled by a programmable logic controller, which will set up the required training scenario and then control the environment in response to the trainee's actions. The burners have extinguishant sensors which are capable of differentiating between water and foam and provide suitable input to the control system. (FIG. 5) represents a layout of a firefighting training unit, showing arrangements at Decks 2 and 3.

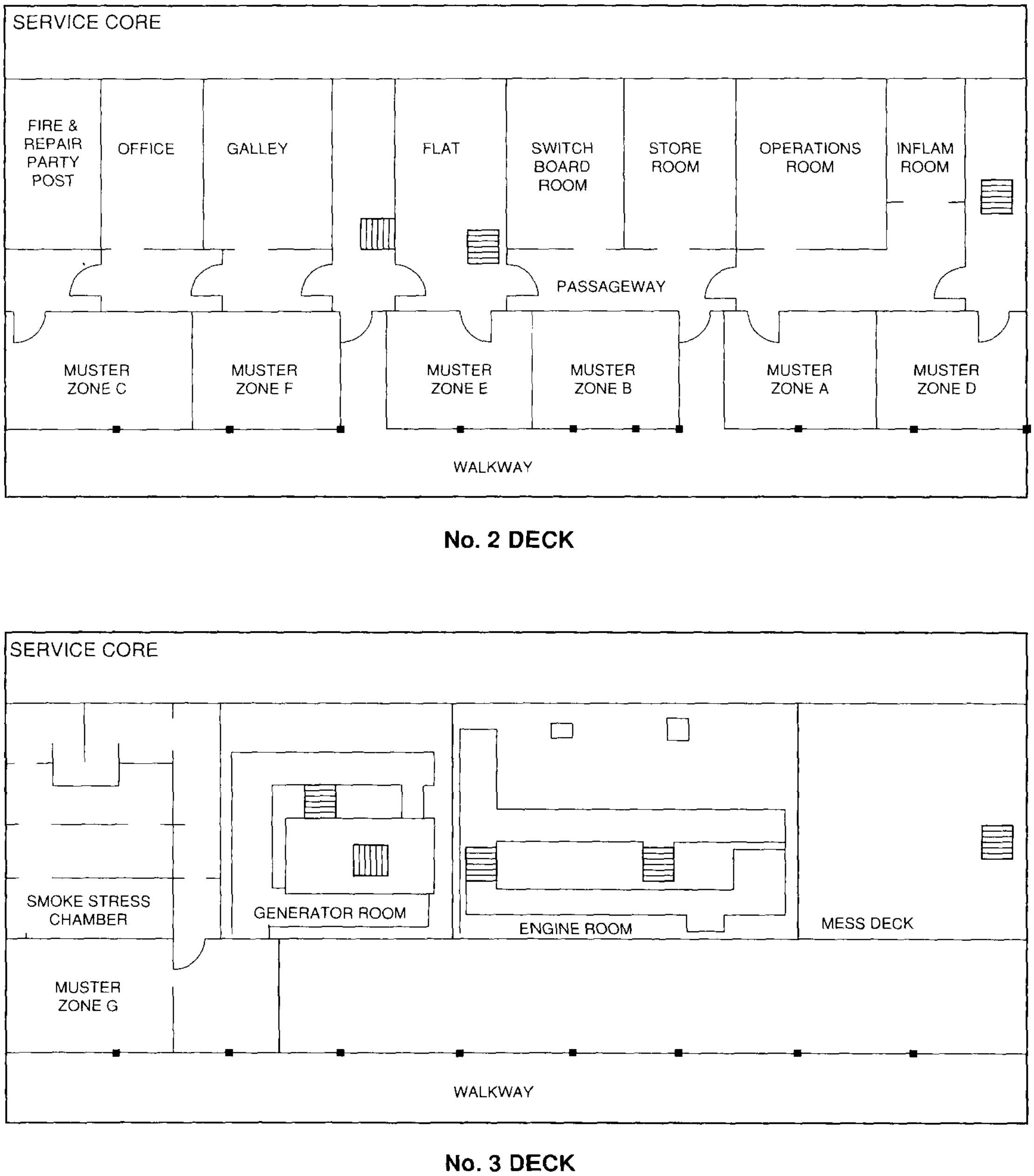

FIG. 5—FIREFIGHTING TRAINING UNIT MODULE LAYOUT SHOWING ARRANGEMENTS AT DECKS 2 & 3

The NSCBTS is a classroom trainer which consists of twenty trainee stations and two instructor stations all linked to a central data base. The trainees will be able to run a number of software packages which will teach them NBCD ship knowledge specific to the class of ship they are to join, generic NBCD procedural and C^3 skills in networked exercises as well as learning to preserve ship stability by taking countermeasures following fire and flooding incidents.

Following training in the classroom in the NSCBTS the trainees will then progress to the NBCDC^3 Ship Control Centre Simulator (FIG. 6) which will be a full scale representation of a Ship's Control Centre (SCC) with outstations. The SCC will incorporate software driven glass touch screen displays representative of the control consoles in Type 22/23 frigates. The software will incorporate models of all the major ship propulsion and support systems such as the HPSW system, electrical distribution system etc., and will allow appropriate interaction between them. Instructors will be able to inject damage, flood and fire scenarios based on which the software will be able to model the reactions of real ships systems and trainee team inputs. Trainees will then practise their C^3 skills and NBCD knowledge to save their ship.

Conclusions

The RN fully recognizes that fire at sea is an ever present hazard that demands effective firefighting equipment and systems and inherent fire resistance in ships and submarines. The sailor has also to be continually vigilant and well trained in firefighting procedures and C^3 skills. It is considered that the foregoing clearly illustrates the RN's commitment to the improvement of equipment, systems, procedures and training to achieve effective fire protection at sea.

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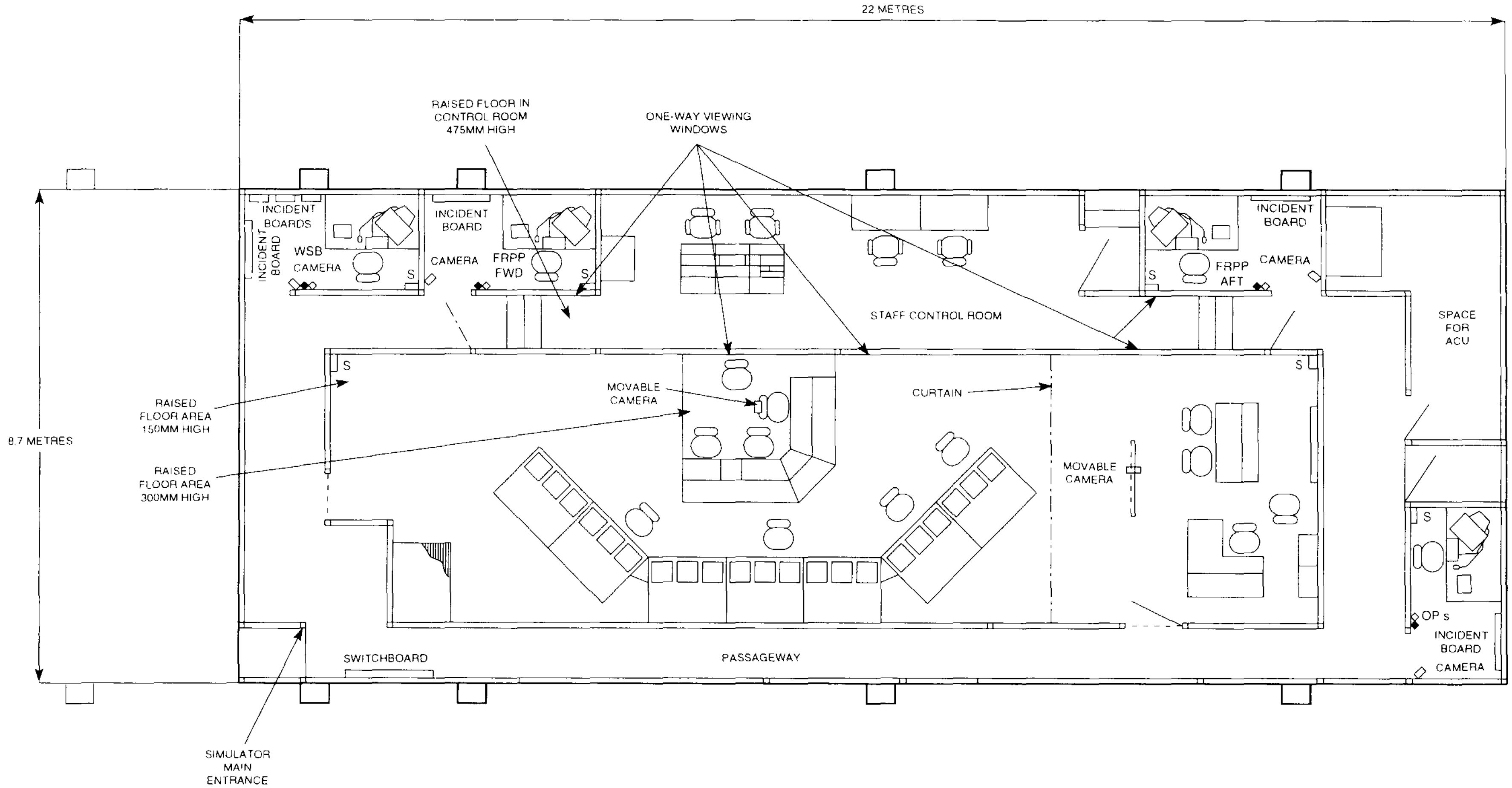

FIG. 6—PLAN VIEW OF NBCD[3] SHIP CONTROL CENTRE SIMULATOR