CHAPTER 7

FIRE-FIGHTING TACTICS

Learning Objective: Recall the characteristics of different classes of fire, the stages of a fire, and the basic tactics and strategies to attack and extinguish different classes of fires, and the fire-fighting equipment used.

As a Damage Controlman, you will most likely encounter different types of fires aboard your ship. Although fires have certain things in common, each fire has its own unique features. Examples of some unique features of each fire are the type of material burning, the ease with which the fire can be isolated, or the location of the compartment it is in. With these factors in mind, it is easy to see that there are many things to consider when deciding what tactics to employ to attack a fire. Therefore, fire parties and repair lockers are trained to respond to a variety of situations.

FIRE-FIGHTING STRATEGIES

Learning Objective: Recall the characteristics of different classes of fire, the stages of a fire, and the basic tactics and strategies to attack and extinguish the different classes of fires.

As you become more proficient in fire fighting, combat evolutions, and dealing with engineering casualties, you develop the ability to handle more than one single casualty at a time. Your training prepares you for cascading or multiple casualties, and the opportunity to practice your training should be a learning experience. A mass conflagration is a worst-case scenario. For example, some ships have survived multiple missile hits, others mine explosions and flooding. Your ability to think clearly in the face of multiple casualties may someday save your ship. Creativity counts! For example, firemain ruptures may be jumpered around, or P-100 pumps may replace fire pumps if a casualty occurs to the ships electrical system. The ability to shore up a weak bulkhead is not learned from a book – you must practice. Do you have the skills to rig casualty power cables to return a vital system to service? There are many such scenarios; keeping your cool and remembering your training is vital to the survival of your ship. Your training prepares you to take on different positions on an attack team, or in a fire party. Should a personnel casualty require a replacement, fire party qualifications allow personnel to replace each other as needed.

Fire can spread in many different ways. Radiant heat from an intense fire may ignite materials in an adjacent compartment, or it may travel through inoperative ventilation ducts, which failed to shut. Openings between compartments, including cableways, may contribute to the spread of fire. The first sign of the fire spreading is smoke. If you are an investigator, you must constantly rove an assigned area outside the primary fire boundaries. You must also ensure that personnel assigned as boundarymen are well qualified for their job. Report any encounters with smoke outside the primary fire and smoke boundaries; then use your breathing apparatus to investigate, if possible. If the fire spreads, then the secondary boundary becomes the primary boundary, and personnel must attack this new threat to the ship.

It is the job of the damage control chain of command to make fire-fighting decisions that are based on reports from the scene, from investigators, and from boundarymen. A small fire can become a blazing inferno in a very short period of time, quickly making a compartment or area of the ship uninhabitable. When your ship is underway, you cannot use the strategies and methods used ashore. You cannot wait for the fire department – YOU ARE THE FIRE DEPARTMENT.

PROPERTIES AND DYNAMICS OF FIRE

Learning Objective: Recall the properties and dynamics that are characteristic of each of the four classifications of fire.

There are four classifications of fire and each classification has its own distinct properties and dynamics.

CLASS ALPHA FIRE

Generally speaking, a class ALPHA fire is any fire in which the burning material leaves an ash. Paper, wood, and cloth are examples of this fuel, and are located throughout your ship. These solid fuels must be heated to their ignition point before they will burn, and there must be enough oxygen to support the fire.

For a solid fuel to burn, it must be changed into a vapor state. This chemical action is known as *pyrolysis* and is defined as a chemical decomposition due to the application of heat. This decomposition creates a fuel vapor, which, mixed with oxygen, produces a fire.

Removal of any one of the three elements of the fire triangle (heat, oxygen, and fuel) will extinguish a fire. A common method of attacking class ALPHA fires is the application of water. The water cools the fuel below its ignition point, thereby removing heat from the fire triangle and thus extinguishing the fire. On larger fires of this type, aqueous film-forming foam (AFFF) will be more effective than seawater. In all such fires, other nearby combustibles (including unseen materials on the other side of that bulkhead) must either be moved or kept cool to prevent further spread of the fire.

CLASS BRAVO FIRE

A class BRAVO fire presents challenges not encountered in other types of fires. This is because they can be fueled by any of the flammable liquids stored aboard ship, including fuels, liquid lubricants, and solvents. Class BRAVO fires may be extinguished with Halon, AFFF, purple-K powder (PKP), or a combination of agents. The single most important step in combating this casualty is to secure the source of the fuel.

One of the characteristics of a flammable liquid is known as flashpoint, which is the lowest temperature at which the liquid will give off sufficient vapor to form what is known as an ignitable mixture. When mixed with air at this minimum temperature, this vapor will ignite if an ignition source is present.

WARNING

Fuels and other liquids stored aboard ship are often pressurized (to pump them to other areas of the ship), or may be stored under pressure to minimize the release of vapors. Leaks in these pressurized fuel systems will tend to spray outward, and they often atomize, increasing the possibility of coming into contact with an ignition source. As an example, the ignition source could be a heated surface in an engineering compartment or an electrical spark from a faulty electrical component.

When flammable liquids spill or leak from a pressurized source, they will cover a large area, release a great amount of vapor, and produce a great amount of heat when ignited. One of the specifications of flammable liquids is that they have a minimum flashpoint. Anytime a ship is refueled, the fuel it receives is tested for both quality and for flashpoint.

Some flammables require special storage, often in special lockers with temperature detection and sprinkler systems installed. Some of the materials stored in these lockers are paints, welding gases, flammable cleaning solvents, and other materials. An accurate inventory of hazardous materials stored in such lockers should be readily available. Fuels for portable fire-fighting pumps and special small boats may sometimes be stored on the weather decks of the ship.

Your ship's supply department can provide information about flammable materials (including safety and handling precautions, hazards, and minimum flashpoints). The Material Safety Data Sheets (MSDS) have information on each individual hazardous product carried onboard ship.

CLASS CHARLIE FIRE

A class CHARLIE fire is an energized electrical fire, and may be attacked with nonconductive agents such as carbon dioxide (CO_2) or with low-velocity water fog. Special care must be taken to maintain a safe distance from energized equipment. The most common (and safest) method of dealing with a class CHARLIE fire is to secure the electrical power, and treat it as a class ALPHA (burning insulation) fire.

WARNING

Special care must be taken to avoid contact with energized electrical equipment. CO_2 bottles must be grounded, and the horn of the portable extinguisher must not come in contact with the energized equipment. If it is necessary to use water fog as an extinguishing agent, a minimum distance of 4 feet must be maintained. A straight stream of water must never be used on a class CHARLIE fire, due to the likelihood of electrical shock.

CLASS DELTA FIRE

Class DELTA fires are also known as combustible metal fires. This class of fire results when materials such as magnesium, phosphorus, sodium, or titanium are ignited. Certain types of aircraft wheels are manufactured from these materials, as well as various pyrotechnic smokes and flares. Although some ships have pyrotechnic (referred to as "pyro") magazines below decks, typically most occurrences of DELTA fires happen topside, where storage is more common.

Pyrotechnics often contain their own oxidants and therefore do not depend on atmospheric oxygen for combustion. For this reason, the exclusion of air, such as by use of PKP, foam, or other extinguishers, will typically be ineffective.

WARNING

Class DELTA fires burn with an intense heat of up to 4,500°F, and action must be taken to shield your eyes from the brilliance of the flame. High velocity fog should be used to cover and cool these fires. If possible, remove the burning material by jettisoning it over the side of the ship. To prevent the fire from spreading, you should apply large quantities of water at low pressure to cool the surrounding area. Class DELTA fires give off extreme amounts of heat and can produce explosions. Therefore, you must maintain a safe distance from the source of the fire while applying the water fog.

WARNING

During a class DELTA fire, certain chemical reactions are occurring as the water is applied to cool the surrounding area. This water reacts with the burning metal and forms hydrogen gas, which will either burn or explode, depending on the intensity of the fire and the amount of burning material. In any case, maintain a safe distance from the fire and shelter yourself and your team from any potential explosions.

DYNAMICS OF A FIRE

The fact that there is a large variety of materials aboard any ship which can burn and should be considered as fuels cannot be overemphasized. As stated before, for a solid fuel to burn, it must be changed into a vapor state. This chemical action is known as pyrolysis and is defined as a chemical decomposition due to the application of heat. This decomposition creates a fuel vapor. When this vapor is mixed with oxygen at the right temperature, a fire is produced.

A solid fuel will burn at different rates depending upon its size and configuration. For example, a pile of wood chips or wadded paper will burn faster than an equal amount of solid wood or a case of paper. This fact is true because there is a larger surface area exposed to the heat; therefore vaporization occurs faster. Because more vapor is available for ignition, the fire burns more intensely and the fuel is consumed at a faster rate.

A liquid fuel releases vapor much as a solid fuel does. However, it does so at a higher rate and over a larger temperature band. Because liquids have more loosely packed molecules, heat increases their rate of vapor release. These dynamics result in the fact that pound-for-pound liquid fuels produce about 2 1/2 times more heat than wood, and this heat is given off much more rapidly.

If a flammable liquid is spilled (or is atomized and sprayed out under pressure) it covers a very large surface area and gives off much more vapor. This is one reason flammable liquid (class BRAVO) fires burn so violently.

As mentioned earlier, the lowest temperature at which a liquid gives off sufficient vapor to form an ignitable mixture is known as the flashpoint for that liquid. An ignitable mixture is a mixture of vapor and air that is capable of being ignited by an ignition source. As an example, gasoline has a flashpoint of -45°F (-43°C). This factor makes gasoline a constant hazard because it produces flammable vapor at normal temperatures. Like gasoline, the other shipboard fuels have specified minimum flashpoints.

To ignite, a flammable gas or vapor of a liquid has to mix with air in the proper proportion. The lowest percentage of gas that will make an ignitable mixture is called its lower explosive limit (LEL). If there is less vapor or gas than this percentage, then the mixture is too lean to burn. Conversely, there is also an upper explosive limit (UEL) above which the mixture is too rich to burn.

Table 7-1. Properties of Selected Flammable Liquids and Gases

Material	Flashpoint	LEL	UEL	Ignition Temp
Acetylene	gas[1]	2.5%	100%	581° (305° C)
Carbon Monoxide	gas[1]	12.5%	74.0%	1128° (609°C)
Cooking Oil	610°F[6]	_____[3]	_____[3]	740°F-830°F[6] (393°C-443°C)
Ethyl Alcohol	55°F (13°C)	3.3%	19.0%	685°F (363°C)
Fuel, Navy Distillate (F-76) (MIL-F-16884)	140°F (60°C)	_____[2]	_____[2]	450°F (232°C)
Gasoline (100 Oct)	-45°F (-43°C)	1.4%	7.6%	853°F (456°C)
Hydraulic Fluid Mil-H-17672: 2075 TH	315°F (157°C)	_____[3]	_____[3]	_____
2110 TH	325°F (163°C)	_____[3]	_____[3]	685°F (363°C)
2135 TH	340°F (171°C)	_____[3]	_____[3]	_____
Hydrogen	gas[1]	4.0%	75.0%	932°F (500°C)
JP-4 (MIL-T-5624)	0°F (-18%C) (NSTM 542)	1.3%	8.0%	464°F ((240°C)
JP-5 (MIL-T-5624)	140°F (60°C)	0.6%	4.6%	475°F (246°C)
JP-8	100°F (38°C)	0.7%	5.0%	444°F (229°C)
Lubricating Oil: 2190 TEP (MIL-L-17331)	400°F (205°C)	0.9%	7.0%	_____[4]
9250 (MIL-L-9000)	380°F-390F (193°C-199°C)	_____[3]	_____[3]	_____
Methane[5]	gas[1]	5.0%	15.0%	999°F (537°C)
Methyl Alcohol	52°F (11°C)	6.7%	36%	725°F (385°C)
Methyl Ethyl Ketone	16°F (-9°C)	1.4%	11.4%	759°F (404°C)
Propane	gas[1]	2.1%	9.5%	842% (450°C)
Torpedo Otto Fuel II	265°F (129°C)	_____[3]	_____[3]	_____

[1] Flammable gases do not list flashpoints since they can be ignited at any temperature.
[2] Explosive limits of Fuel, Navy Distillate (F-76) are similar to those of JP-5.
[3] Data for LEL and UEL not available.
[4] Data unavailable.
[5] Methane exists in and around the CHT and VCHT systems.
[6] Cooking oil flashpoint and ignition temperatures vary with origin of oil, brand, age, and contaminants.

The range between the lower and upper explosive limits is called the explosive range of the gas (or vapor).

Table 7-1 shows the flashpoint, LEL, UEL, and ignition temperature for a few of the flammable materials carried aboard ship. As an example, a mixture of 10% gasoline vapor and 90% air will not ignite, because the mixture is too rich (above the UEL). In this case a large amount of air must mix with a small amount of vapor to form an ignitable mixture.

Fire Growth

There are four distinct stages in the growth of a fire within a compartment of a ship (fig. 7-1). These stages are known as growth, flashover, fully-developed fire, and decay.

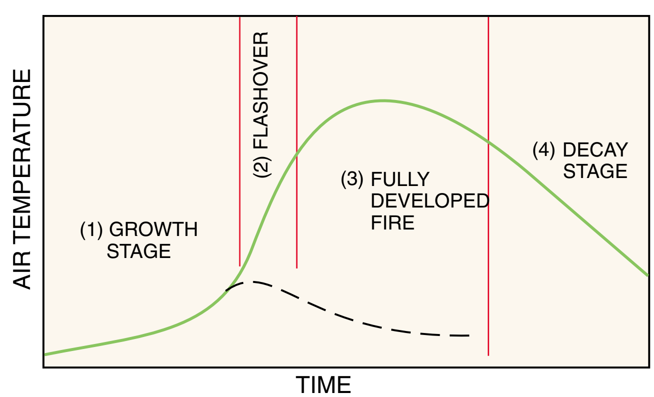


Figure 7-1. Stages of compartment fire growth.

During the growth stage of a fire (fig. 7-2), the average space temperature is low and the fire is localized near the area where it started. It is hot in the immediate vicinity of the fire, and rising heat and smoke create a hot upper level in the compartment.

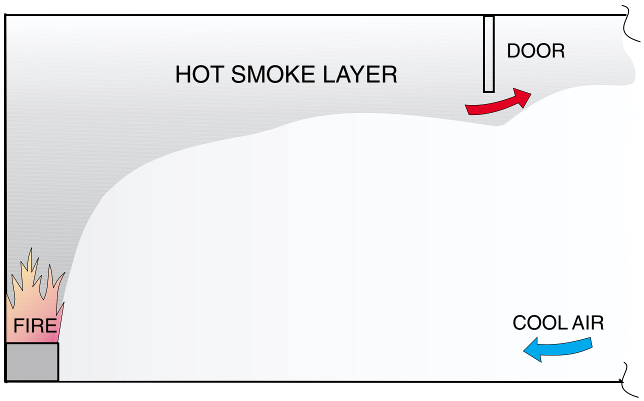


Figure 7-2. Growth stage of a compartment fire.

In what is called the "rollover" of a compartment fire, a flame front of burning gases is formed across the overhead of the space. Rollover takes place in the growth stage when unburned combustible gases from the fire mix with fresh air in the overhead and begin burning at some distance from the fire. Rollover differs from flashover in that only gases are burning in the space.

The flashover stage is the period of transition from the growth stage to the fully-developed fire stage. It occurs in a short period of time and may be considered an event, much as ignition is an event in a fire. It normally occurs at the time the temperature of the upper smoke layer reaches 1100°F (600°C). The most obvious characteristic of flashover is the sudden spreading of flame to all remaining combustibles in the space. Personnel still in the compartment when flashover occurs are not likely to survive.

In the fully-developed fire stage all flammable materials in the compartment have reached their ignition temperature and are burning. The rate of combustion will normally be limited by the amount of oxygen available in the air to provide combustion. Flames may emerge from any opening; hatches, open ventilation ducting, etc. Unburned fuel vapor in the smoke may flash when it meets fresh air in adjacent compartments. There may be structural damage to bulkheads or decks when exposed to these extreme temperatures. A compartment may reach the fully-developed fire stage very quickly during machinery space flammable-liquid fires or during enemy weapon-induced fires.

As the available fuels and combustibles in the space are consumed the fire begins to decay. In the decay stage, combustion slows down (decays) and finally the fire goes out.

There are significant exposure thresholds for human tolerance to heat as shown in table 7-2, along with other temperature characteristics that may help you put them in perspective.

If a fire goes out quickly due to a lack of oxygen, such as in a tightly sealed compartment, fuel vapors may still be formed from any flammable liquid that is heated above its flashpoint. If fresh air is allowed into the space before this fuel vapor cools below its flashpoint, this mixture can ignite explosively. This is known as backdraft, and fortunately, is an unusual occurrence.

Fire Spread

If space personnel attack a fire early and efficiently, it can be confined to the area in which it started. If the fire continues to burn unchecked, it can generate great amounts of heat that will travel away from the fire area, starting more fires wherever fuel and oxygen are available. Steel bulkheads and decks and other fire barriers can delay but not prevent heat transfer.

When a fully-developed fire exists in a compartment, the fire is most quickly spread to other compartments through openings such as doorways, vent ducts, and unsealed cableways. It will also spread to adjacent compartments by heat conduction through the bulkheads. Fires normally spread faster upward to the space above than to adjacent horizontal spaces simply because heat rises.

Tests have been developed to provide typical temperatures, radiant heat flux, and length of time for material ignition by conduction through steel bulkheads from a fully-developed fire. The compartments tested were 8-foot x 8-foot x 8-foot steel cubes with bare metal surfaces. These typical values shown will differ based on the space that the fire is in, due to factors such as bulkhead insulation, compartment dimensions, ventilation, specific material characteristics, and water application and cooling. These figures, as shown in table 7-2, are provided to show you the characteristics of conduction, and should be of particular interest to your boundarymen.

Table 7-2. Significant Exposure Thresholds

IGNITION THRESHOLDS (PILOTLESS IGNITION WITHIN 30 SECONDS)			
Material	**Hot Air (Oven Effect)**	**Hot Metal Contact (Frying Pan Effect)**	**Radiant Heat Flux**
Paper	450°F (230°C)	480°F (250°C)	20 kW/m^2
Cloth	480°F (250°C)	570°F (300°C)	35 kW/m^2
Wood	570°F (300°C)	660°F (350°C)	40 kW/m^2
Cables	700°F (370°C)	840°F (450°C)	60 kW/m^2

IGNITION OF PAPER VIA RADIANT HEAT	
Radiant Heat Flux	**Time to Ignition**
20 kW/m^2	25 seconds
25 kW/m^2	14 seconds
35 kW/m^2	8 seconds
50 kW/m^2	3.5 seconds
75 kW/m^2	2.5 seconds

HUMAN TOLERANCE TO HEAT	
Hot Air Exposure	
200°F (90°C)	Incapacitation 35 minutes, death 60 minutes
300°F (150°C)	Incapacitation 5 minutes, death 30 minutes
380°F (190°C)	Immediate Incapacitation, death 15 minutes
400°F (200°C)	Irreversible respiratory tract damage
650°F (340°C)	Death
Radiant Heat Exposure	
1 kW/m^2	Noon sun radiation on clear sunny day
5 kW/m^2	Pain Threshold for exposed skin
10 kW/m^2	Immediate blistering

ELECTRONICS HEAT THRESHOLDS	
Thermal Effects on Electronics	
120°F (50°C)	Computers develop faults
300°F (150°C)	Permanent computer damage
480°F (250°C)	Data transmission cables fail

Fire may spread through bulkhead penetrations such as electrical cableway openings. Although these openings are sealed, experience has shown that even armored cables will burn from extreme heat. Cableway fires may be hard to extinguish because they are difficult to cool because the grouping of multiple cables traps and contains heat. Also, cableways are often run through the overhead of compartments, and heavy smoke hinders finding the source of the fire. Older-style electrical cables will generate toxic black smoke from their insulation. Newer cables in use aboard ship are designed to reduce the amount of smoke generated.

REVIEW QUESTIONS

Q1. What chemical action is defined as a chemical decomposition due to the application of heat?

1. Oxidation
2. Reduction
3. Pyrolysis
4. Combustion

Q2. The lowest temperature at which a liquid gives off sufficient vapor to form an ignitable mixture is known by what term?

1. Pyrolysis
2. Upper explosive limit
3. Lower explosive limit
4. Flashpoint

Q3. The formation of burning gases in the overhead of a compartment is known by what term?

1. Flashover
2. Rollover
3. Backdraft
4. Decay

Q4. The lower explosive limit (LEL) for a gas is the lowest percentage of that particular gas in an air-gas mixture that forms an ignitable mixture.

1. True
2. False

Q5. There are a total of how many distinct stages in the growth of a fire within a compartment?

1. One
2. Two
3. Three
4. Four

ATTACK TEAM CONSIDERATIONS

Learning Objectives: Recall the duties and responsibilities of an attack team while responding to a fire and the use of specific fire-fighting equipment.

During the initial stages of a fire, the fire marshal proceeds directly to the scene to direct efforts of the rapid response team. If a fire is beyond the capabilities of the rapid response team, the fire marshal shall turn his duties over to the scene leader of the at-sea fire party in order to coordinate this larger threat. These duties may include the following:

- Overall command of the at-sea fire party
- Supervising the establishment and maintenance of communications
- Setting boundaries

Providing necessary support to the at-sea fire party. The fire marshal assumes a "big picture" role, paying particular attention to the possibility of fire spread. He will also make recommendations for additional personnel or for the setting of general quarters (GQ) as required by the size of the fire.

GENERAL QUARTERS (GQ)

During general quarters (GQ), the ship has its maximum capability to withstand and recover from damage. Many ships routinely set GQ upon notification of a fire; others wait until after an initial estimation of the fire size and severity is received.

During GQ the crew dons battle dress. This action consists of fully buttoning up all worn clothing, tucking trouser legs into socks, and wearing anti-flash hood and gloves. The anti-flash hood simply pulls over your head and hangs down over the outside of your shirt. If your ship provides the older beige-colored style anti-flash hoods, you may wear two of them for additional protection. A new, single thickness fire-fighter's hood is being supplied to replace the older hoods. You will recognize it by its gold color, similar to that of the fire-fighter's ensemble. It is more durable, longer in length, offers more protection, and has a larger face opening to accommodate the oxygen breathing apparatus (OBA) or self-contained breathing apparatus (SCBA).

While manning GQ, personnel should have their MCU-2P mask and a life preserver with them. They are carried ready for use, using the waist straps provided. While individual workcenters are responsible for the repair, maintenance, and testing of these devices, Damage Controlman personnel are responsible for life preservers stowed in repair lockers.

IN-PORT ACTIVITIES

In-port duty sections are set up not only to man the required watchstanders needed while pierside, but also to ensure that an in-port fire party can be properly manned. Depending upon the number of personnel assigned, some people may be required to perform multiple functions. When at sea, during GQ Condition 1, a particular fire party may request assistance from a different repair locker if needed. In port however, this option may not be available. However, the repair party may request assistance from other members of the duty section, other ships pierside, or the base fire department.

REPAIR PARTIES

A repair party is a part of the damage control organization as specified in NWP 3-20.31. A damage control repair station is an area designated as a locker. It contains damage control equipment, including fire-fighting equipment, and serves as the control location for a particular repair party. When at GQ, respective repair party members will man all damage control repair stations, and each repair party will be organized to provide one fire party. During conditions other than GQ, the fire party will typically go to the damage control repair station nearest the fire and use the equipment located there. The number of repair parties aboard a ship depends on the size and configuration of the ship. Some ships will split a repair party into multiple locations to better respond to the ship's configuration.

TYPE OF ATTACK

Many factors go into the decision-making process to size up a fire, and information is vital. The location, type, and size of the fire, available resources (including personnel), and fire growth all determine the overall plan of attack. Reports from the scene will include (1) location of fire, (2) class of fire, (3) action taken to isolate and combat the fire, (4) fire contained, (5) fire out, (6) reflash watch set, (7) fire overhauled, (8) compartment ventilated (9) compartment tested for oxygen, (10) compartment tested for flammable gases, and (11) compartment tested for toxic gases. If a chemical, biological, and radiological (CBR) threat exists, reports should include any CBR contamination and condition of CBR boundaries.

Much of the initial information about a fire will come from evacuating watchstanders. Space personnel will evacuate when they are endangered, or the fire goes out of control. Every attempt must be made to account for all space personnel, since they may not all evacuate through the same exit. All evacuees will muster at a pre-arranged location outside of designated smoke and fire boundaries. Missing personnel must be reported to damage control central (DCC). Use of bilge sprinkling and Halon activation (if installed) is documented, including time of activation.

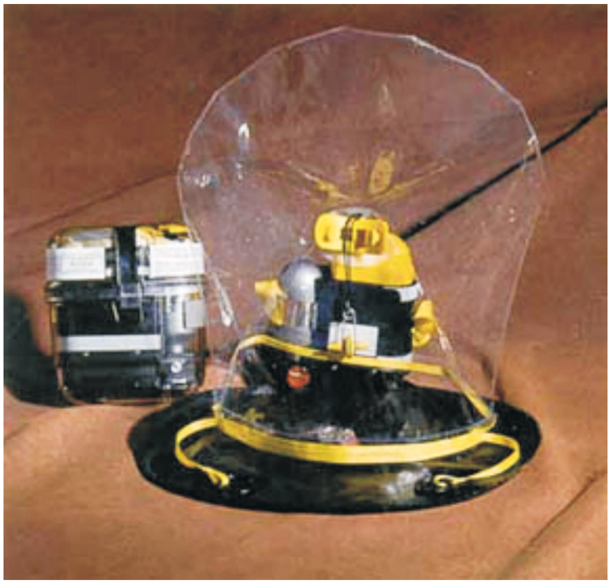
Other information may come from boundarymen or investigators. A boundaryman is responsible for observing a particular bulkhead or deck for signs of heat, such as smoldering or blistering paint, or smoke (particularly through bulkhead or deck penetrations). The boundaryman will attempt to cool the bulkhead to prevent spread of the fire as necessary. The investigators travel prearranged routes ensuring that fire and smoke boundaries are set, checking for Halon effectiveness, and making ongoing reports to their associated repair locker. When smoke is encountered, the investigators will immediately report it and don their OBAs prior to further investigation. Various circuits are available for the investigators to use to make reports, and many ships have hand-held radios for damage control use.

Use of EEBD

During a fire, smoke and a variety of toxic gases will be produced, and personnel responding to initial reports of the fire must also be aware of any hazardous materials stored within the compartment. Throughout the ship, emergency escape breathing devices (EEBDs) are stored in marked locations in most compartments. These are used to provide a limited amount of breathable oxygen to evacuating personnel, and are not used to combat a fire. In manned engineering spaces, the watchstanders there will initially combat the fire. As more personnel arrive to assist, EEBDs should be passed out to all personnel within the space. The EEBD should be carried over the shoulder by the strap attached to the carrying case. Some newer-style EEBDs are worn on your belt, and have different donning procedures. These will be maintained by the damage control petty officer, and should be inspected in accordance with the planned maintenance system (PMS). EEBDs are one-time use devices, and are disposed of after they have been used. If a CBR threat exists, personnel evacuating the compartment will exchange their EEBD for the MCU-2P once they have reached a smoke-free area.

In engineering spaces, the watchstanders carry Supplementary Emergency Egress Devices, known as SEEDs. These pressurized cylinders are much more limited in their air supply, and provide breathable air long enough to reach an EEBD. Because smoke and toxic gases may have filled the passageways along your escape route, the EEBD is preferred for evacuation purposes. Many ships are now receiving recharging equipment for the SEEDs; in the past, the SEEDs had to be sent off the ship for recharging.

The newer-style compressed-oxygen EEBDs (Ocenco M-20.2), shown in figure 7-3, are currently replacing the Scott EEBDs. These can be worn on your belt and also can be mounted in a stationary bracket in any space, as shown in figure 7-4. The new EEBDs have a service life of 15 years.



Courtesy of Ocenco, Inc.

Figure 7-3. The Ocenco M-20.2 EEBD has been selected for exclusive use by the U.S. Navy, U.S. Coast Guard and the Hellenic Navy.

Courtesy of Ocenco, Inc.

Figure 7-4. The Ocenco M20.2 shown donned and ready for escape.

The new compressed-oxygen EEBD has different donning procedures because of their new design. The new EEBD provides 10 minutes of oxygen for escape, although it is rated up to 32 minutes. It uses an automatic on, compressed oxygen, demand regulated system. The new EEBD can be donned in seconds; simply unlatch the case, pull out the unit, and insert the mouthpiece and don the nose clip. The attached hood can be donned at anytime needed during emergency egress. The hood protects the user from hazardous environments, while allowing a full range of view. The Teflon hood and breathing bag provide excellent heat and chemical resistance. The compressed oxygen and mouthpiece combination allows the Ocenco M-20.2 EEBD to be donned in a smoke-filled environment. The actual EEBD can be identified by its orange storage case. The training EEBD comes with two extra mouthpieces and is stored in a light blue secondary container. It provides training in both the worn and stored positions.

Affected/Damaged Systems

The information necessary to effectively combat a large fire must include an assessment of any damage to fire-fighting systems, as well as any major systems within the compartment that are not isolated and electrical isolation. The decision to secure compartment lighting rests with the on-scene leader.

Fire and Smoke Boundaries

Fire and smoke boundaries are determined for each of the large engineering spaces aboard your ship. The ship's fire doctrine lists both primary and secondary boundaries. The boundaries are designed to effectively contain a fire to prevent its spread.

Primary fire and smoke boundaries are set at all bulkheads immediately adjacent to the fire. Boundarymen will man these primary boundaries with a fire hose, and may have to cool the bulkhead to prevent spread of the fire. Fire could spread through any penetration, including ventilation, electrical cableways, piping conduits, or defective welds in cases of extreme heat.

A secondary set of boundaries is set at the next immediate watertight bulkhead from the scene. If a boundary fails, and the fire cannot be contained at the first boundary, the boundaryman will attempt to secure the space and evacuate. What were previously secondary boundaries now become the primary boundaries. Boundary information is plotted by DCC and all repair lockers.

Reports (Halon, Bilge Sprinkling, etc.)

Reports by evacuating personnel will include whether bilge sprinkling was used, whether the source of the fire (such as leaking or spraying fuel) was secured, and whether Halon was activated.

Investigators will attempt to determine whether Halon was effective by observing the color of smoke inside the space through the battle ports at the escape trunk. Smoke color may also be observed from topside, if the space is not completely air-tight, and reported to DCC. These reports help make the determination whether to immediately re-enter to combat the fire, or if it is already out, to allow the space to cool prior to entry.

PREPARING TO ENTER THE SPACE

If you are a scene leader, your primary source of information is your locker leader. The locker leader maintains plots of all damage control information throughout the ship, and will pass along all pertinent information to the scene leader. You are responsible for briefing your personnel and giving them the necessary information, so they will be better prepared to deal with conditions inside the compartment. Figure 7-5 shows an attack team preparing to enter a compartment.

Briefing Hose Teams

Some of the information that hose teams must be briefed on are as follows: (1) status of the fire to include location, type of fire (and is it still burning), was Halon effective; (2) status of the compartment: extent of major damage, equipment status, mechanical isolation, electrical isolation, boundaries); (3) watchstanders not accounted for; (4) activation of bilge sprinkling; and (5) planned method of attack.

The ship's main space fire doctrine provides a basic checklist for various personnel actions (including the damage control assistant, locker and scene leaders, and team leader), and is tailored to your ship. Other information may be important as well, depending upon your ship's configuration or additional casualties to the ship or systems.

Figure 7-5. Attack team lighting off OBA and preparing for compartment reentry.

Dressing Out

You and other attack team personnel will assist each other as necessary while donning personal protective equipment. You must ensure that your shipmate is properly dressed out. Personal protective equipment is intended to fit slightly loosely, especially gloves. This ensures that your skin has room to move somewhat inside this clothing. It also helps to keep hotter areas of the clothing from remaining in constant contact with your skin. This practice also reduces the likelihood of heat stress by allowing some air movement within the confines of the fire-fighter's ensemble (FFE).

Checking Equipment

When donning an OBA or SCBA, you should examine it and ensure it has not been damaged while in storage. Your OBA canister should not show any sign of damage, which may prevent you from properly inserting or removing it. The copper foil seal must be in place. If the canister is not in good shape, replace it with a new one before entering the space.

NFTI.—If the naval fire-fighter's thermal imager (NFTI) will be used, it must be warmed up in accordance with the manufacturer's technical manual. Because it is very fragile, only qualified personnel will handle the NFTI. Most team leaders carry a spare battery for the NFTI. Helmet lights, handheld radios, voice amplifiers, and handheld firefinders are among the equipment that should be checked prior to re-entry. Damage Controlmen maintain and test this equipment in accordance with PMS or with the manufacturer's instruction.

The NFTI is a device that allows the user to see through dense smoke and light steam by sensing the difference in infrared radiation given off by objects with a temperature difference of at least 4 degrees Fahrenheit. A small television-type monitor is built into the back of the NFTI, and displays these variations in temperature as a black and white image. Hotter objects will appear lighter on the screen than cooler objects. The NFTI has multiple uses, including locating the seat of a fire, locating injured personnel, and searching for hangfires and hotspots.

The NFTI is battery-operated and displays five light emitting diodes (LEDs) when fully charged. A good practice is to change the battery when more than one light goes out during use. To conserve battery power, turn the NFTI off when not in use, and allow 1 minute for warmup prior to use.

The NTFI has two modes of operation; pan and chop. The pan mode provides the greater sensitivity; however, the NFTI must be kept in motion or the image will fade out. The chop mode is best for fire fighting, allowing the user to focus on one area while holding the NFTI still. A blue button on the front of the NFTI allows you to change modes. Prior to compartment entry, you must ensure the NFTI is in the chop mode.

When using the NFTI, it has been proven that slow, steady advancement, along with periodic scanning of the scene during an approach, helps the operator judge distances better. A side-to-side scan also provides important information on hazards in the area and the best direction in which to proceed. An occasional vertical scan will detect hazards above deck level, i.e. cableway or overhead fires.

FIRE-FIGHTERS ENSEMBLE (FFE).—The fire-fighter's ensemble (FFE) consists of fire-fighter's coveralls, fire-fighter's hood, damage control/fire-fighter's helmet, fire-fighter's gloves, and fireman's boots, all designed to protect the fire fighter from the heat generated by a growing (pre-flashover) fire. For a flashover or fully-developed fire, the FFE provides only a few seconds of protection for escape. The fire-fighter's glove size should be selected for a loose hand and finger fit to reduce heat transfer from continuous material contact and allow glove adjustment at hot points. Additional hand protection can be gained by wearing a flash glove as an extra inner liner to an over-sized fire-fighter's glove. While waiting to enter the fire area, the FFE coveralls should only be donned to the waist, tying the coverall arms around the waist.

Accessing the Space

Proper fire boundaries must be set prior to accessing the affected compartment, to provide a safe area from which fire fighters can attack the fire. Electrical isolation must be complete prior to re-entry; the only exception is lighting. The on-scene leader will decide whether to secure compartment lighting. Complete electrical isolation helps to decrease the number of ignition sources inside the compartment. Mechanical isolation does not have to be complete prior to re-entry; however, it does provide greater safety for firefighters.

Prior to space re-entry, there may be evidence that Halon and bilge sprinkling was not effective. If secondary Halon is available it should be used, and observed for effectiveness. Activate AFFF bilge sprinkling for 2 minutes prior to entry. If Halon was effective, allow at least 15 minutes prior to space entry. If Halon was not effective, re-entry should be attempted as soon as evacuation and mechanical isolation are completed.

Direct Attack

The type of attack is determined from all information received. A direct attack upon a fire involves entering the compartment, proceeding to the seat of the fire, and attacking it "directly." Other direct attacks involve a fog attack into the overhead gases, or a direct attack upon the base of the fire from the compartment entrance. The accessman opens the hatch or door so that fire fighters can enter the compartment. If a fire has burned for a considerable time, the access hatch to the compartment may be jammed. It may be necessary to use forcible entry equipment, including bolt cutters, sledge hammers, pry bars, PHARS, and PECU.

Indirect Attack

An indirect attack is used when conditions do not allow fire fighters to enter the space. A fog spray is introduced from a cracked doorway or any available penetration. Upon completion, fire fighters will then enter the compartment and attack the fire directly. Compartment venting is another means of cooling the space so fire fighters may enter safely. An opening leading directly to an open weather deck area (or a large open compartment leading directly outside) allows the hot gases overhead to vent. It may be desirable to cut a hole in the overhead leading outside. This hole should be at least 1 square foot in diameter to allow proper venting. Prior to entry, bilge sprinkling (if installed) will be activated for 2 minutes.

Loss of Personnel

Your training prepares you to take on different positions on an attack team, or in the fire party. A personnel casualty requires you to find a replacement for that person. Battle damage may prevent a member of the fire party from reaching his or her GQ station. The key element is training, enabling personnel to perform a variety of functions in the fire party.

REVIEW QUESTIONS

Q6. During the initial stages of a fire, what person proceeds directly to the scene to direct efforts of the rapid response team?

1. Officer of the deck
2. Damage control assistant
3. Fire marshal
4. Repair party leader

Q7. During general quarters (GQ), a ship has its maximum capability to withstand damage. For this reason, many ships routinely set GQ upon notification of a fire.

1. True
2. False

Q8. EEBDs should be cleaned and stored immediately after they are used.

1. True
2. False

Q9. The new EEBD provides a maximum of how many minutes of oxygen for escape purposes?

1. 18
2. 15
3. 12
4. 10

Q10. The locker leader maintains plots of all damage control information throughout the ship, and will pass along all pertinent information to the scene leader.

1. True
2. False

Q11. Personal protective equipment is intended to fit slightly loosely, especially gloves.

1. True
2. False

Q12. What device allows the user to see through dense smoke and light steam by sensing the difference in infrared radiation given off by objects?

1. EEBD
2. PHARS
3. NFTI
4. PECU

Q13. Proper fire boundaries must be set prior to accessing the affected compartment, to provide a safe area from which fire fighters can attack the fire.

1. True
2. Fa1se

FIRE ATTACK AND HOSE HANDLING

Learning Objective: Recall various methods available to coordinate movements of hose teams to combat a fire effectively.

When inside a compartment that is on fire, the attack team leader coordinates the movements of the attack team. The leader passes and receives information by means of the personnel manning the hose, who relay the message to the next person on the hose.

HOSE TEAM MOVEMENTS

The first obstacle for a hose team member is often a ladder leading downward. For safety, only one person should be on the ladder at a time. As the nozzleman advances, the hose team members pass the hose down to him while he descends the ladder. After he reaches the deck, the first hoseman will descend the ladder, followed by another hoseman, as needed to handle the hose. As the hose progresses further into the space, more hose is needed, as well as hosemen.

The attack team leader usually operates the NFTI, looking for hotspots and hangfires. Although the team leader already knows the location of the seat of the fire, he must be alert to the likelihood that other parts of the compartment are on fire. The leader must also look for obstructions that prevent advancing to the seat of the fire. The team leader will also issue orders for hose advancement, and instructs the nozzleman to attack the fire with the necessary spray pattern.

Hosemen follow the direction of the team leader, moving forward on the hose, advancing or backing up with the hose, and handling the weight of the hose. Whenever the nozzle is opened, a recoil effect pushes the hose backwards, and hosemen will push forward to compensate for this.

Heat Stress

Extreme compartment heat, weight of the FFE, carrying heavy equipment, and handling a fire hose are contributing factors to heat stress. As fire fighters rotate out of the compartment, the team leader and scene leader will coordinate relief personnel. Under harsh conditions, personnel working hard (such as the nozzleman) will need to leave the compartment sooner than others. A complete relief team should be standing by, ready to enter as needed, to relieve personnel in the space.

Heat stress training is conducted as part of "all hands" training, and you must be aware of its symptoms and required treatment. The symptoms of heat stress are as follows:

- The skin appears ashy gray; the skin is moist and clammy
- The pupils of the eyes may be dilated (enlarged)
- Vital signs are normal; but the victim may have a weak pulse and rapid shallow breathing
- Heavy sweating

You may observe these symptoms in one of your shipmates after leaving the compartment. The treatment for heat stress is as follows:

- Loosen clothing; apply cool wet cloths
- Move the victim to a cool or air-conditioned space, and fan the victim
- Do not allow the victim to become chilled
- If the victim is conscious, provide a solution of 1 teaspoon of salt dissolved in a quart of water.
- If vomiting occurs, do not give any more fluids

Transport the victim to sickbay (if manned) or the nearest battle dressing station for treatment by corpsmen

Heat Stroke

The sympthoms of heat stroke are as follows:

- High body temperature

- No sweating—skin is hot and dry
- Pupils of the eyes may become constricted
- Strong rapid pulse
- Possible unconsciousness

During heatstroke, the body is no longer able to sweat, preventing removal of excess heat. If the internal temperature of the body rises above 105°, the brain, kidneys, and liver may all suffer permanent damage. In its earlier stages, the victim may have shown symptoms of heat exhaustion, as detailed above. The treatment of heat stroke may include:

- Immediately informing medical personnel, moving the victim to the coolest possible area, and removing clothing.
- Reduce body temperature immediately by dousing the body with cold water or by applying cold, wet towels to the body.
- Ensure the victim has an open airway.
- Place victim on his or her back, head and shoulders slightly raised.
- If cold packs are available, place them under the arms, around the neck, at the ankles, and on the groin. This helps lower internal body temperature.
- Give the victim cool water to drink. Do not give any hot drinks or stimulants.

ATTACKING A FIRE

There are different methods for attacking a fire; however, no single tactic or strategy is applicable to every situation. For example, in a multiple hose attack, it is possible to drive smoke and flames away from one hose team onto another team. Therefore, all attacks must be coordinated.

One of the dangers of opening an access to a compartment is that fresh oxygen is introduced into the space. If space temperatures are above the auto-ignition point of any combustible materials, they may start burning again once fresh air reaches them. This is the reason for allowing a cooldown period, assuming that Halon was used and was effective.

Direct Attack

The ideal method of attacking a fire is a direct attack. This technique involves short bursts with a narrow fog or direct stream, as directed by the team leader. Fire fighters advance into the immediate fire area and apply AFFF directly onto the fire.

Locating the Seat of a Fire

All members of the fire party have been briefed regarding the location of the fire from information received from space evacuees. Finding the seat of the fire probably will not be too difficult; reaching it may be another matter. In extreme temperature conditions, deckplates may warp, or ladders may fail. Move throughout the compartment with extreme caution.

Extinguishment

Once the team leader and nozzleman have successfully reached the seat of the fire, the team leader directs the nozzleman in foam application to extinguish any remaining fire. Different spray patterns from the hose nozzle are used as needed, either to break up any combustible material, or to cover a certain area with AFFF.

Prevention of Reflash

AFFF is particularly effective against class BRAVO fires, because it serves three distinct functions. As foam it floats on top of flammable liquids, preventing vapors from being released to the atmosphere. This foam also prevents oxygen from reaching the flammable liquid. The AFFF foam, being a mixture of concentrate and water, also provides a cooling effect. Therefore, covering hot spots with AFFF is highly effective in preventing reflash. Allowing the compartment to cool down prior to reentry (with Halon effective) also helps to prevent reflash.

Reflash Watch

Once satisfied that the original fire is extinguished, the team leader stations a reflash watch. The person assigned as reflash watch remains near the seat of the fire with a charged hose, and observes the area to ensure that no new fire breaks out. Normally at least one other hoseman remains on scene with the nozzleman to tend the hose in case a reflash occurs.

Hangfires and Overhaul

Once the reflash watch is set, the team leader and a second hose team search for hangfires. All areas of the compartment are examined with the NFTI, ensuring that no areas are missed. All cableways, areas beneath deckplates, and overheads are examined to ensure no hangfires are missed. At various times, the team leader will make reports detailing percentage of overhaul. If hangfires are found, they are extinguished. It is sometimes necessary to use overhaul equipment to pull smoldering or burning material (such as lagging) from an overhead or bulkhead in order to extinguish it.

REVIEW QUESTIONS

Q14. Which member of the attack team controls the movement of hose teams while inside a space that is on fire?

1. On-scene leader
2. Fire marshal
3. Nozzleman
4. Attack team leader

Q15. Which of the following conditions is NOT a symptom of heat stroke?

1. No sweating with skin hot and dry
2. A weak pulse
3. Constriction of the pupils of the eyes
4. Victim is unconscious

Q16. What is the purpose of a reflash watch?

1. To overhaul the compartment
2. To ensure that no new fire breaks out
3. To extinguish hangfires
4. To maintain primary boundaries

DESMOKING AND ATMOSPHERIC TESTING

Learning Objective: Recall the procedures used once a fire is extinguished to prepare the compartment for remanning.

Once a fire is extinguished, specific actions must be taken to return the compartment or space damaged by the fire to a condition suitable for remanning. These actions include the following: desmoking, atmospheric testing, dewatering, and a thorough follow-up inspection.

DESMOKING

Active desmoking is the process of removing smoke and heat from the buffer zone prior to extinguishing a fire. This action aids fire-fighting efforts, and helps prevent the spread of smoke throughout the ship. Desmoking may be accomplished using ventilation fans in adjacent compartments or with portable fans. There will be some smoke in surrounding areas; smoke boundaries will help slow the spread of smoke. This type of desmoking should not be confused with the desmoking process of the affected compartment after the fire has been overhauled.

When a class BRAVO fire has been extinguished, combustible gases may be present. Operating electric controllers to start ventilation fans may ignite these gases. Desmoking with installed ventilation can proceed with minimal risk once specific conditions are met. These conditions include the following:

- The fire is extinguished and overhauled.
- The AFFF bilge sprinkling has been operated.
- The source of the fuel for the fire is secured.
- The space has been allowed to cool.
- All fuel has been washed to the bilges.
- No damage has been sustained to the electrical distribution system.

Desmoking should begin once the compartment has cooled sufficiently so there is no danger from reignition. Circuit breakers that have tripped should not be reset until qualified personnel can make a damage assessment. Examine the electrical distribution system, and if possible, reestablish power to the installed ventilation fans. If the fans are fully operational, run them on high speed for a minimum of 15 minutes to remove smoke and toxic gases. If the installed system is partially operational or inoperative, desmoking will take longer, but can be accomplished by using portable blowers, or by providing a positive ventilation from adjacent spaces. On ships without Halon or AFFF bilge sprinkling, the safest method of desmoking is to exhaust the compartment with portable fans, or to provide a positive ventilation pressure from adjacent compartments.

ATMOSPHERIC TESTING

Atmospheric tests are always conducted after desmoking is complete, because combustible gas indicators will not operate reliably in a Halon atmosphere, and an oxygen analyzer is unreliable when its sensor is exposed to excess moisture or comes in contact with particulates found in a post-fire atmosphere.

When the space is clear of smoke, test the atmosphere for oxygen, combustible gases, and toxic gases. The level of oxygen must be between 19.5 and 22 percent. Combustible gases must be less than 10 percent of the lower explosive limit, and all toxic gases must be below their threshold limits before the space is certified safe for personnel without breathing devices. After a class BRAVO fire, the compartment should be tested for the following gases:

- Hydrocarbons
- Carbon dioxide
- Carbon monoxide
- Hydrogen chloride
- Hydrogen cyanide

If Halon 1301 was discharged into the compartment, a test for hydrogen fluoride must also be conducted. Shipboard personnel authorized to conduct these tests aboard ship are the gas free engineer and gas free petty officers. Required tests shall be conducted near the center and at all four corners, on each level of the compartment. At least one satisfactory reading at each location must be obtained.

Specific information regarding testing procedures and equipment is found in *Naval Ships' Technical Manual* (*NSTM*), chapter 074,volume 3, "Gas Free Engineering." If the compartment has been exposed to a CBR environment, decontamination procedures detailed in *NSTM*, chapter 470, "Shipboard BW/CW Defense and Countermeasures" must be followed.

DEWATERING

Dewater the compartment with the commanding officer's permission, and in accordance with operating procedures. Dewatering a class BRAVO pool fire will not commence until the space is completely overhauled, except in extreme conditions where ship stability is threatened. Dewatering will affect the vapor barrier on top of pooled flammable liquid, an extreme caution must be exercised to ensure the AFFF blanket is maintained until completion of overhaul. Following overhaul, normal dewatering may be conducted or completed at the same time as desmoking or post-fire gas free testing.

COMPARTMENT REMANNING

Once the space is certified safe, remanning can begin. A careful damage assessment is conducted, and once individual equipment or systems are verified operational and safe, then may be placed in service.

INVESTIGATION

After overhaul, the fire should be investigated to determine the point of origin, types of combustibles involved, path of fire spread, ignition source, and significant events in the growth and eventual extinguishment of the fire. Starting from the point of farthest fire spread, burn patterns will usually extend back to the area of origin. Efforts should be directed toward recreating the conditions that caused the fire, and identifying any changes in design or procedures that could have prevented the fire or lessened its spread and intensity. These changes are very helpful to ship designers and operators. Photographs, material samples, metallurgical samples, and failed equipment assist in reconstructing a fire history. If there is a major fire which involves significant damage or loss of life, a NAVSEA technical expertise team is available to investigate such fires, and to develop lessons learned from a ship design and a material standpoint.

REVIEW QUESTIONS

Q17. What percentage(s) of oxygen must be present when conducting post-fire atmospheric testing of a compartment?

1. Less than 10 percent
2. 19.5 to 22 percent
3. 30 to 33 percent
4. 40 to 42.5 percent

Q18. Halon 1301 was discharged into the compartment to extinguish a fire. This requires a test be conducted for which of the following types of gas?

1. Hydrogen sulfide
2. Carbon monoxide
3. Hydrogen flouride
4. Hydrogen bromide

SUMMARY

This chapter provides information pertaining to the tactics and strategies involved in fire fighting. Although every fire is different, certain practices apply to all fires. More detailed information on combating different types of fires is found in *NSTM*, chapter 555, volume 1, and *NATOPS U.S. Navy Aircraft and Rescue Manual*, NAVAIR 00-80R-14. While the information is located in these volumes, there is no substitute for actual hands-on training. As you become proficient as a Damage Controlman, you will train your shipmates in fire fighting, as well as other aspects of damage control. A properly trained in-port fire party or attack team may make the difference between dealing with a small easily controlled fire, and one that threatens the entire ship.

REVIEW ANSWERS

A1. What chemical action is defined as a chemical decomposition due to the application of heat? **(3) Pyrolysis**

A2. The lowest temperature at which a liquid gives off sufficient vapor to form an ignitable mixture is known by what term? **(4) Flashpoint**

A3. The formation of burning gases in the overhead of a compartment is known by what term? **(2) Rollover**

A4. The lower explosive limit (LEL) for a gas is the lowest percentage of that particular gas in an air-gas mixture that forms an ignitable mixture. **(1) True**

A5. There are a total of how many distinct stages in the growth of a fire within a compartment? **(4) Four**

A6. During the initial stages of a fire, what person proceeds directly to the scene to direct efforts of the rapid response team. **(3) Fire marshal**

A7. During general quarters (GQ), a ship has its maximum capability to withstand damage. For this reason, many ships routinely set GQ upon notification of a fire. **(1) True**

A8. EEBDs should be cleaned and stored after use. **(2) False. EEBDs are a one-time use device, and are disposed of after they have been used.**

A9. The new EEBD provides a maximum of how many minutes of oxygen for escape purposes? **(4) 10**

A10. The locker leader maintains plots of all damage control information throughout the ship, and will pass along all pertinent information to the scene leader. **(1) True**

A11. Personal protective equipment is intended to fit slightly loosely, especially gloves. **(1) True**

A12. What device allows the user to see through dense smoke and light steam by sensing the difference in infrared radiation given off by objects? **(3) NFTI**

A13. Proper fire boundaries must be set prior to accessing the affected compartment to provide a safe area from which fire fighters can attack the fire. **(1) True**

A14. Which member of the attack team controls the movement of hose teams while inside a space that is on fire? **(4) Attack team leader**

A15. Which of the following conditions is NOT a symptom of heat stroke? **(2) A weak pulse. A strong rapid pulse is symptomatic of a heat stroke.**

A16. What is the purpose of a reflash watch? **(2) To ensure no new fire breaks out.**

A17. What percentage of oxygen must be present when conducting post-fire atmospheric testing of a compartment? **(2) Between 19.5 to 22 percent**

A18. Halon 1301 was discharged into the compartment to extinguish a fire. This requires a test be conducted for which of the following types of gas? **(3) Hydrogen fluoride**