1. Survival Principles - PST

Survival at sea is an essential factor that every seafarer, or passenger must have adequate knowledge of. No one can tell when an accident or an emergency will occur. It is only always best to know "What to do."

Proper training and familiarization will give a person the foundation of survival that will amplify his/her chances to remain alive during and after the occurrence of an accident or emergency on board.

Survival Actions

SURVIVAL - the ability of a seafarer to stay alive when life is threatened in a shipping casualty

S – Size up the situation
Think of the different aspects of the situation.

U – Use all your senses, undue haste makes waste
Consider all aspect of the situation before making an action.

R – Remember where you are
Location of lifesaving equipment
Location of survivors
Location that may present dangers that you need to stay away from

V – Vanquish fear and panic
Keep Calm Always

I – Improvise
Be resourceful

V – Value living
Do not lose your morale
A – Act wisely and with certainty
Always think about the result before acting it out
L – Learn basic skills
Review the Basics to acquire and upgrade skills

This is the main purpose of the STCW courses. By understanding the instructions and involving yourself enthusiastically in practical training and drills on board, will reduce your fear and give you self-confidence and, thus, equip you for survival.

1.1.Donning and using an immersion suit

Immersion Suits

- A protective suit that ***reduces the body heat loss*** of a person in cold water
- IMO requirement: body temperature of a person staying in 0°C cold water does not fall to less than 35 degrees after 6 hours
- Carrying requirement:
  - Shall be provided for every person assigned to crew the rescue boat or assigned to the marine evacuation system
  - All passenger and cargo ships with non-enclosed lifeboats shall carry at least three (3) immersion suits for each lifeboat

Thermal Protective Aids

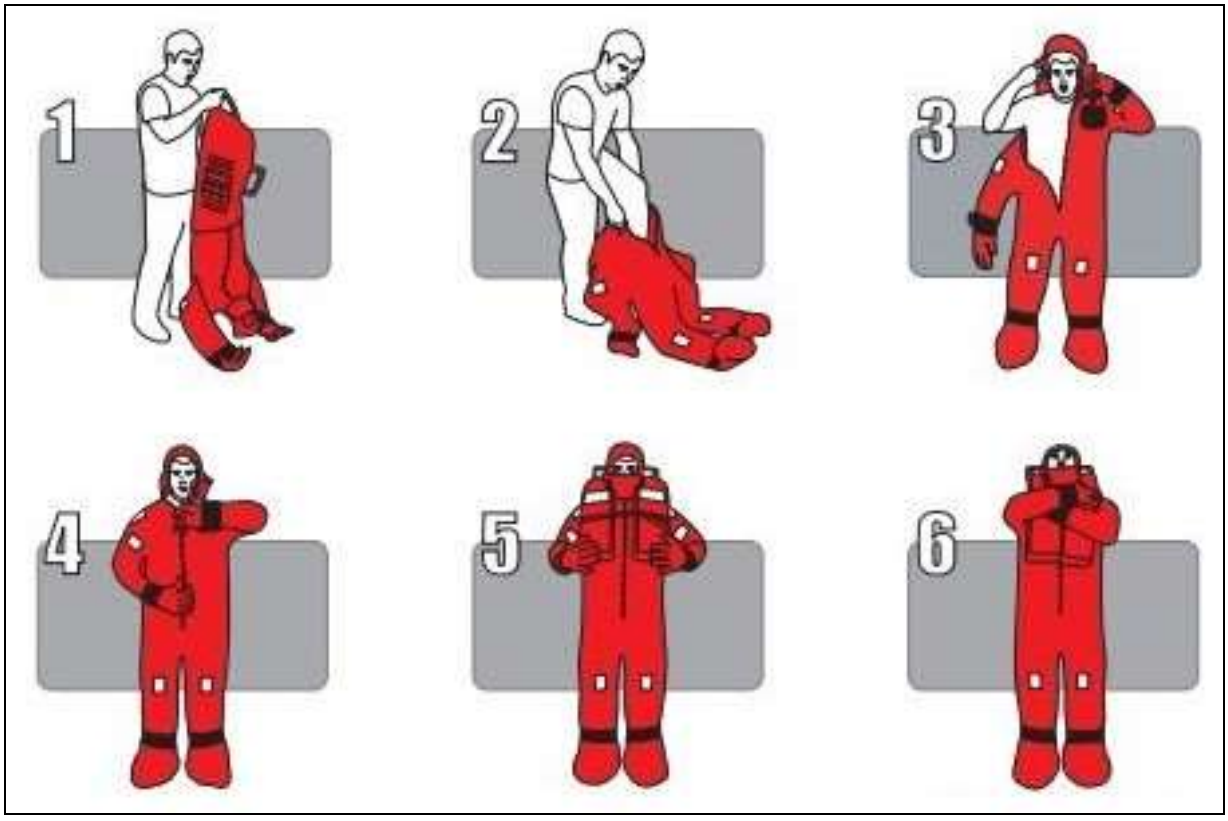
- Fully waterproof garments designed to increase the survival time of an individual in cold water
- Purpose:
  - preserve body heat in emergency or in a life raft
  - warm a hypothermic victim
- ***Does not provide flotation*** and are usually only worn once. Lifejacket must be donned after putting on the suit.
- Carrying requirement: provided for 2 persons or 10% of the persons a lifeboat is certified to accommodate and at least one in a life raft.

- Requirement for passenger and cargo ships without immersion suit:
  A thermal protective aid must be provided for persons not provided with an immersion suit.

Donning procedures of immersion suits

In an emergency there is no time to learn how equipment works. Therefore it would be sensible that the user practices beforehand, in order to become familiar with the use and features of the immersion suit.

1. Remove suit from storage bag. Open the zipper's chain.
2. Don the suit, feet first, while lying or sitting on the deck. Vessel movement or list will prevent donning the suit in a standing position.
3. Place your weaker arm into the sleeve of the immersion suit. Using your free hand, reach up and pull the hood over your head. Then place your strong arm into the sleeve of the immersion suit.
4. Holding the zipper below the slider with one hand, fully close the zipper by firmly pulling straight up on the lanyard with the other hand. Secure the flap over the face/mouth.
5. Don a lifejacket (if required).
6. Enter water feet first while protecting your airways with you hands.



1.2.Jumping safely from a height into the water

Lifejackets

Life jacket is a sleeveless jacket made up of buoyant or inflatable material used to keep human body afloat in water.

Lifejacket carrying requirements

- Passenger ships
- There must be a life jacket for every person on board ship.
- Lifejacket for each child or 10% of the total number of passenger whichever is greater.

- Cargo ships
- There must be a lifejacket for all crew and their families, if on board.
- Infant lifejackets must be provided in cargo ships.
- The number of lifejackets must be carried in excess as in case of damage to any, it can be replaced with spare one.

Life jacket buoyancy

Life buoyancy may be achieved by packing with buoyant material and can also be inflated.

- Non inflatable life jacket: These jackets are fitted with buoyant materials and they don't need to inflate.

- Inflatable life jacket: This jacket needs inflation for buoyancy and is automatically inflated when immersed in water. It normally consists of two different buoyancy compartments.

Lifejacket equipment

- Each life jacket shall be fitted with a whistle firmly secured by a lanyard.
- Life jacket lights and whistles shall be selected and secured to the lifejacket in such a way that their performance in combination is not degraded.
- Each life jacket shall be provided with a releasable buoyant line or other means to secure it to a lifejacket worn by another person in the water.
- Each life jacket shall be provided with a suitable means to allow a rescuer to lift the wearer from the water into a survival craft or rescue boat.
- Jacket must not sustain burning or melting when exposed to fire for a period of 2 seconds.
- It is clearly capable of being worn in only one way or, as far as is practicable, cannot be donned incorrectly.
- When jumped from a height of at least 4.5 m into the water no injury and dislodging or damaging the lifejacket.
- Should have buoyancy which is not reduced by more than 5% after 24 hour submersion in fresh water

Donning procedures of lifejackets

In an emergency there is no time to learn how equipment works. Therefore it would be sensible that the user practices beforehand, in order to become familiar with the use and features of the immersion suit.

1. Don lifejacket placing yoke over head. Connect velcro strips and pass belt around body.
2. Connect buckle by pushing the two parts together. Pull on loose end of webbing for a tight but comfortable fit.
3. Connect the top buckle by pushing the two parts together pull on loose end of webbing for a comfortable fit.

4. Hold nose with hand. Hold lifejacket and arm firmly with other hand when jumping in water.

Jumping safely into the water

It is important to jump into the water correctly when wearing a lifejacket to avoid injury.

1. Jump from lowest point
2. Make sure lifejacket is correctly fitted
3. Arms crossed holding lifejacket collar down and pinching nostrils shut
4. Check that the water is clear of debris and people etc. and safe to jump into
5. Look straight ahead
6. Step out, bring legs together straight
7. Once you've swam away from the sinking vessel, adopt the HELP position.

1.3. Swimming while wearing a lifejacket

Dangers to survivors

The most obvious mistake made by many persons after evacuation from ship is to assume that when they have found the relative security of a survival craft, their troubles are over. Depending on undetected circumstances, they could be, in fact, just the beginning. It should always be remembered that no one is a survivor until he/she has been rescued and brought to land. Every successful rescue will have to pass through three phases:

- The abandonment phase
- The survival phase
- The rescue phase

Description of dangers

In each separate period, there will always be dangers to survivors, both in the water and in the survival craft. These dangers can be the following:

- Immersion and drowning
- Exposure to cold and hypothermia
- Exposure as heat stroke and heat exhaustion
- Seasickness
- Drinking sea water
- Fire and oil in the water

- Failure to maintain body fluids correctly
- Hunger and Thirst
- Marine Predators/Sharks

How to clear from ship

- Obey every command.
- Wear your lifejacket and fasten it securely.
- If possible, lower yourself by ladder or lines. If you jump, jump feet first, protecting your face with your hand.
- Avoid debris in the water.
- If possible, jump to windward from the lowest part of the ship or from an overhang structure.
- If propellers are still turning, leave by the bow.
- If the water is covered with burning oil, discard your life jacket and swim under water, swim windward.
- To protect yourself from underwater explosion, swim away from the ship for at least one hundred (100) yards or swim aboard a boat raft or wreckage. If none of this are available; swim or lie flat on your back.

Heat stroke, sun stroke, exposure and hypothermia

Exposure

Exposure to the elements is your next biggest concern to surviving after abandoning ship. Heat stroke, sunstroke, dehydration, exposure to cold and hypothermia are caused by fall or rise of your body temperature with the environment.

Hypothermia –

- a condition in which core temperature drops below that required for normal metabolism and body functions which is defined as *35.0 °C (95.0 °F)*
- As body temperature decreases characteristic symptoms occur such as shivering and mental confusion

Expected Survival Time in Cold Water

Water Temperature	Exhaustion or Unconsciousness in	Expected Survival Time
70–80° F (21–27° C)	3–12 hours	3 hours – indefinitely
60–70° F (16–21° C)	2–7 hours	2–40 hours
50–60° F (10–16° C)	1–2 hours	1–6 hours
40–50° F (4–10° C)	30–60 minutes	1–3 hours
32.5–40° F (0–4° C)	15–30 minutes	30–90 minutes
<32° F (<0° C)	Under 15 minutes	Under 15–45 minutes

Hyperthermia –

- An ***elevated body temperature*** due to failed thermoregulation
- Occurs when the body produces or absorbs more heat than it can dissipate
- When the elevated body temperatures are sufficiently high, ***hyperthermia is a medical emergency and requires immediate treatment*** to prevent disability and death.
- Heat stroke

- An ***acute condition of hyperthermia*** that is caused by prolonged exposure to excessive heat and/or humidity
- Requires immediate treatment to reduce the body temperature in order to ***prevent brain damage or death***
- Most effective treatment: liquid-cooling bath

Seasickness

- Anti-seasickness pills should be issued to all persons, a medication which is part of all survival craft equipment
- Can be extremely dangerous if vomiting occurs, as vital body fluids will be lost
- Loss of moisture and distress caused by vomiting will reduce motivation, vitality, and the will to survive
- How to treat seasickness:
  - Rest in a reclined position with the eyes closed
  - Give small amounts of dry foods, crackers, bread, or the like (the absorbing qualities of these foods may help alleviate seasickness)

Prudent use of fresh water and food and the need to avoid dehydration

- Dehydration

  - *Loss of body fluids*
  - occurs with either a limited or nonexistent water supply
  - can occur in either cold or hot environments
  - if continues without fluid intake, it will result in acute dehydration and eventually death
  - NEVER, under any circumstances, ***drink urine or straight sea water.*** Urine and seawater have an extremely heavy salt content. This will considerably speed up the dehydration process.

- Hunger and Thirst

  - A person may die within a few days if he does not get water but can survive weeks without food.
  - ***Foodstuffs with high sugar content*** are best. As sugar is metabolized in the body, it yields some water helping the survivor to maintain a better water balance.
  - Survival craft rations consist of ***non-thirst provoking foods.***

Survival in case of fire or oil on the water

If you are in the area where surface oil is burning you should do the following:

- Discard your shoes and buoyant life preservers. (If you have an uninflated life preserver, keep it.)
- Cover your nose, mouth, and eyes and quickly go underwater.
- Swim underwater as far as possible before surfacing to breathe.
- Before surfacing to breathe and while still underwater, use your hands to push burning fluid away from the area where you wish to surface. Once an area is clear of burning liquid, you can surface and take a few breaths. Try to face downwind while inhaling.
- Submerge feet first and continue as above until clear of the flames.

If you are in oil-covered water that is free of fire, do the following:

- Hold your head high to keep the oil out of your eyes
- Attach your life preserver to your wrist and then use it as a raft

Survival in shark-infested areas

Castaways in survival craft commonly report the presence of sharks. However, they are often reported as more of a nuisance than an actual hazard due to their tendency to bump against the underside of a lifeboat or a life raft.

The majority of shark attacks occur in tropical water, but this may be simply because more people swim in warm waters than cold water. While it is not known what actually motivates shark attacks, a desire for food and defense of territory seem to be the strongest favors.

Here are some preventive measures in shark-infested waters:

- Avoid erratic movements that produce sound waves underwater
- Stay out of the area where fish, animal blood, offal (wastes, dumped products) – these odors attract sharks
- Avoid trailing any part of your body in the water such as dangling arms or legs from life raft.
- Discourage a shark that threatens to attack or damage the life raft by jabbing at its snout or gills with an oar

If you are in the water, kick and splash to chase the shark away. If you are in group, keep together and kick and splash. Sharks prefer easy food.

HELP (Heat Escape Lessening Position)

- A way to position oneself to reduce heat loss while immersed in cold water to lessen the effect of hypothermia
- Position knees together and hug them close to the chest using your arms

Groups of people can huddle together in this position to conserve body heat, offer moral support, and provide a larger target for rescuers

Swimming while wearing lifejacket

- Move away from fire
- Find other survivors and stay together
- Use the HELP and Group Huddle to reduce body heat loss
- Do not panic
- Look for a survival craft to board
- Use the whistle on my life jacket to attract attention
- Look for anything that is floating and hold on to it

1.4. Righting an inverted lifereft while wearing a lifejacket

Life Rafts

A raft usually made of inflatable material and used in an emergency on large bodies of water.

Types of life raft:

- Inflatable life raft
- Rigid life raft

Type description:

a. Inflatable Liferafts

- most common type
- forms the secondary appliance in the majority of ships

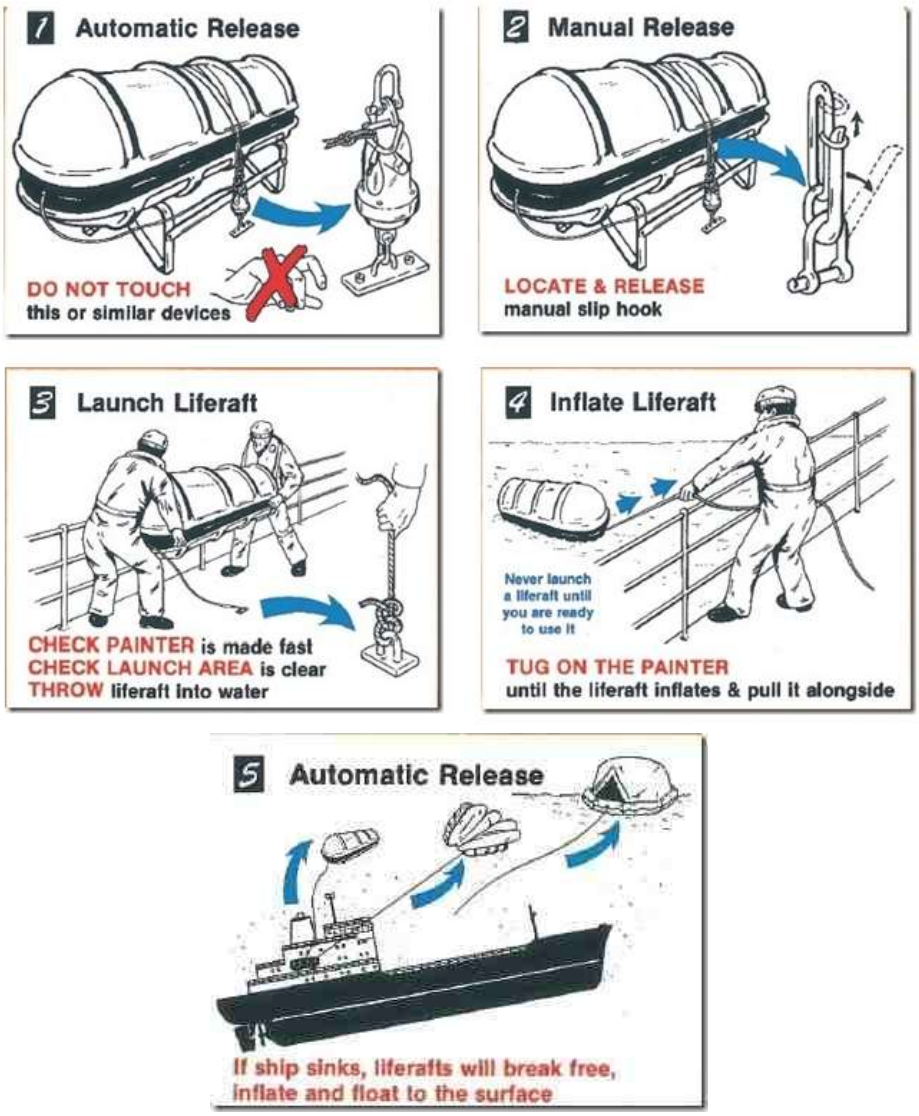
b. Rigid Liferafts

- made of rigid cork-type material
- usually have a mesh net attached and lifelines
- more common on small commercial vessels

- Requirements:
  - The life raft and its fittings shall be so constructed as to enable it to be ***towed at a speed of 3 knots in calm water*** when loaded with its full complement of persons and equipment and with one of its sea-anchors streamed.
  - The life raft ***shall have a canopy*** to protect the occupants from exposure which is automatically set in place when the life raft is launched and waterborne.
  - Carrying capacity must not be less than six (6) persons
  - Every life raft shall be so constructed as to be capable of ***withstanding exposure for 30 days*** afloat in all sea conditions.
  - The life raft shall be so constructed that when it is dropped into the water from a height of ***18 m,*** the life raft and its equipment will operate satisfactorily.
  - The floating life raft shall be capable of withstanding repeated jumps on to it from a height of at least ***4.5 m*** above its floor both with and without the canopy erected.

- ***Substitution of lifeboat by life raft*** may be permitted, provided that there shall never be less than sufficient lifeboats on each side of the ship to accommodate 37.5% of the total number of persons on board

Steps to launch a liferaft:

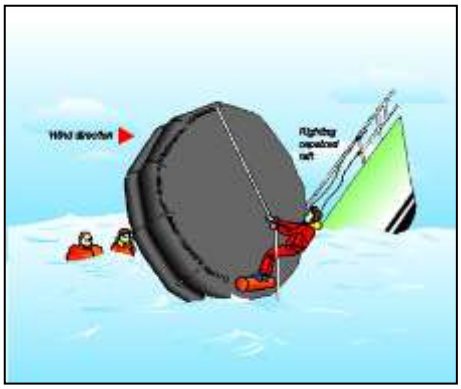


Float-free arrangement for life rafts:

Life rafts shall be installed with a hydrostatic release unit (HRU), whereby the craft is automatically release in case the ship sinks and the raft is ready for use.

Righting an inverted liferaft

- Both feet on gas bottle
- Grab righting strop
- Stand up & lean back
- Use wind to help
- Board liferaft

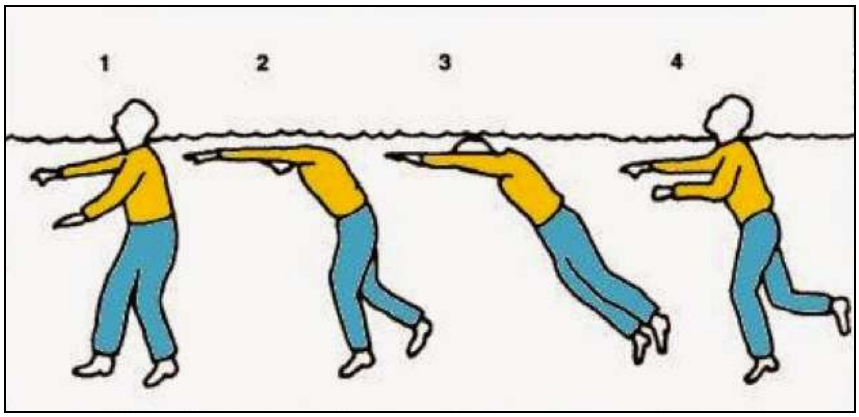


Boarding liferaft

- Survivors spread out holding external lifeline of survival craft
- This improves stability if my survival craft is a liferaft
- Board one at a time and assist others

1.5.Keeping afloat without a lifejacket

When one is not with a life jacket then floating horizontally with the head above water is the best option to stay afloat. One can also float in a vertical position and swim to short distances using buoyancy from trapped air underneath the clothes and also by expansion and contraction of air in the lungs. See below for further explanation:



1. Float upright in the water and take a deep breath.
2. Lower your face into the water (Keeping your mouth closed) and bring your arms formard to rest at water level
3. Relax in this position until you need to take in more air
4. Raise your head above the surface, treading water, and exhale. Tke another breath and return to the relaxed position.

Survivor can also make floating aid using trousers:

1. Prepare the trousers by tying a bottom of the legs tightly
2. Enter the water to waist depth and hold the trousers behind the shoulders, with the waist open
3. Bring the trousers quickly over the head and bang them onto the water in front. This action fills them with air.
4. Squeeze and hold the waist together, lie over the trousers, and float as if on water wings.

2. Fire Fighting Elements – FPFF

Seafarers have gone to sea in all types of watercraft, and, more often than not, with very limited protection against the threat of shipboard fires. In the event of fire, persons ashore often have available the immediate assistance of well-trained firefighting professionals. Seafarers are alone aboard ship, and when fires occur at sea they must remain onboard and cope with these incidents to the best of their own abilities. These efforts, often because of lack of knowledge, training, and experience, have produced less than satisfactory results and at times have resulted in tragedy. Because of the many technological advances in ship design and operation, seafarers must possess more knowledge in many special areas. Fire prevention, control, and extinguishment are one of these areas.

What is fire?

Fire is the rapid oxidation of a material in the exothermic chemical process of combustion, releasing heat, light, and various reaction products. The flame is the visible portion of the fire. If hot enough, the gases may become ionized to produce plasma. Depending on the substances alight, and any impurities outside, the color of the flame and the fire's intensity will be different.

2.1. Elements of fire and explosion (the fire triangle)

Conditions of fires

Conditions for fire to occur

- The presence of material which acts as fuel
- A source of ignition, e.g. chemical, biological and physical
- The presence of oxygen

The fire triangle

- is used as a model for conveying the components of a fire.
- The fire triangle's three sides illustrate the three elements of fire, which are heat, fuel, and oxidization.
- The three elements must be combined in the right proportions for a fire to occur.
- If any of the three elements is removed, the fire is extinguished.

For a fire to thrive and spread it requires three things:

• Fuel for the fire to burn

• Air for the fire to breathe

• Heat for the fire to continue burning

Removal of any one of the sides of this Fire Triangle will extinguish the fire.

Fuel

- If fuel is removed, the fire will starve and be extinguished. With bushfires this can be done through a number of pre-emptive methods, including prescribed burning or physical removal of the fuel.
- The removal of fuel can also be done through the lighting of small controlled fires to remove the fuel ahead of the fire.
- These fires, called burn-out fires, are lit from control lines and must only be done by experienced firefighters and well-supervised crews.

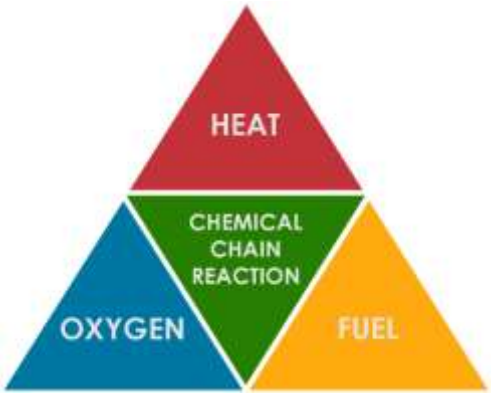
Air

- If air is removed, the fire will suffocate—because of a lack of oxygen—and go out. The removal of air from a bushfire is quite difficult as fires are normally quite big and encompass considerable area.
- Water-based foam sprayed on to the fire will act as a blanket between the fire and the air. Similarly, a layer of dirt shovelled onto the fire will act as a blanket.

Heat

- The removal of heat or the cooling of a fire is the most common form of suppression.
- In most cases water is used to essentially soak up the heat generated by the fire. This heat turns the water in to steam, thereby robbing the fire of the heat used.

- Without energy in the form of heat the fire cannot heat unburnt fuels to ignition temperature and the fire will eventually go out. In addition, the water can act to smother the flames and suffocate the fire.



Extinguishing the fire by the following methods will break the “fire triangle” and “fire tetrahedron” and prevent the spread or continuation of the fire.

Starvation – the fire will not sustain combustion if the source of the fuel is removed. Eliminate any inflammable materials from the fire area; turn the valves off.

Smothering – reduce the oxygen around the fire boundaries. The extinguishing agent used here is CO2, foam, sand, steam, or fire blankets.

Cooling – the fire must be cooled down to a temperature below the ignition point. The most common agent here is water fog and foam is also used for this purpose.

Chain Breaking – using dry powder can interrupt the chain reaction.

2.2.Using various types of portable fire extinguishers

Fighting fire on ships is done in several ways and can involve automatic systems releasing water or fire suppressant gases or by manual means using fire hoses and hand-held extinguishers, buckets and sand.

A fire extinguisher is an active fire protection device used to extinguish or control small fires, often in emergency situations. Typically, a fire extinguisher consists of a hand-held cylindrical pressure vessel containing an agent which can be discharged to extinguish a fire.

Main types of fire extinguishers:

1. Stored pressure type – In stored pressure units, the expellant is stored in the same chamber as the firefighting agent itself. Depending on the agent used, different propellants are utilized. With dry chemical extinguishers, nitrogen is typically used; water and foam extinguishers typically use air. Stored pressure fire extinguishers are the most common type.

2. Cartridge-operated type – contain the expellant gas in a separate cartridge that is punctured prior to discharge, exposing the propellant to the extinguishing agent. Unlike stored pressure types, these extinguishers utilize compressed carbon dioxide instead of nitrogen.

Parts of Portable Fire Extinguisher

- The cylinder: The body of the stored pressure extinguisher holds some combination of extinguishing agent and expellant gas.
- The handle: The handle is nothing more than a grip for carrying and for holding the extinguisher when you use it.
- The trigger: This is usually a short lever mounted above the handle at the top of the extinguisher, although some models may differ. Squeezing the trigger releases the extinguishing agent through the nozzle.
- The nozzle or horn: Depending on the type and model, the extinguishing agent is expelled from the top of the extinguisher through a fixed nozzle, or a nozzle or cone attaches to the extinguisher by a short hose.
- The pressure gauge or pressure indicator: Stored-pressure extinguishers are designed with a built-in pressure gauge or pressure indicator so you can check the extinguisher's operating pressure. (A pressure check should be done at least once a month.)
- The locking mechanism or pin: To prevent accidental discharge, all portable extinguishers come with some sort of locking mechanism that must be removed or released before the extinguisher will work.

Types of Fire Extinguishers

It is essential that the type of extinguisher you use is appropriate for the type of fire you are fighting. If, for example, you spray water on a grease fire, the water will cause the grease to splatter and the fire may spread. Similarly, if you dowse live electrical equipment with water, you are putting yourself in danger of electrical shock.

There are many types of portable fire extinguishers on board ships. Depending on their intended use, fire extinguishers use a variety of "fire extinguishing agents"– the water or the chemical(s) that put out the fire.

- Water extinguishers – contain water and compressed gas and should only be used on Class A (ordinary combustibles) fires.
- Carbon Dioxide (CO2) extinguishers – are most effective on Class B and C (liquids and electrical) fires. Since the gas disperses quickly, these extinguishers are only effective from 3 to 8 feet. The carbon dioxide is stored as a compressed liquid in the extinguisher; as it expands, it cools the surrounding air. The cooling will often cause ice to form around the "horn" where the gas is expelled from the extinguisher. Since the fire could re-ignite, continue to apply the agent even after the fire appears to be out.
- Dry Chemical extinguishers – are usually rated for multiple purpose use. They contain an extinguishing agent and use a compressed, non-flammable gas as a propellant.
- Halon extinguishers – contain a gas that interrupts the chemical reaction that takes place when fuels burn. These types of extinguishers are often used to protect valuable electrical equipment since they leave no residue to clean up. Halon extinguishers have a limited range, usually 4 to 6 feet. The application of Halon should be made at the base of the fire, even after the flames have been extinguished.
- Foam Fire Extinguisher – when sprayed onto a fire, foam extinguishes and smothers the flames, then seals in any harmful vapors under the outer film of foam. The foam also penetrates absorbent materials, and cools the fire as the water in the foam evaporates. Foam is extremely effective on Class A fires and Class B (flammable liquids such as petrol, spirits, and diesel).

2.3.Extinguishing smaller fires, e.g., electrical fires, oil fires, propane fires

How to Operate a Portable Fire Extinguisher:

There are four basic steps to operating a portable fire extinguisher. An easy way to remember the procedure is to think of the word "PASS."

Pull the Pin: Holding the extinguisher with the nozzle pointing away from you, release the locking mechanism. In most cases, this means pulling out the pin located below the trigger.

Aim low: Standing 6 to 8 feet away from the fire, point the extinguisher nozzle at the base of the fire – the lowest point of the fire nearest you. Extinguishers are designed to be operated in an upright position. Always hold the extinguisher vertically. Never cradle it horizontally or at an angle in your arms.

Squeeze the trigger: Squeeze the trigger slowly and evenly. This will release the extinguishing agent and expel it through the nozzle.

Sweep side to side: As the extinguishing agent is expelled, sweep the nozzle from side to side. As the fire closest to you goes out, you may move closer to the fire and continue the sweeping motion until the fire is extinguished.

2.4.Extinguishing extensive fire with water with the use of jet and spray nozzles

In most cases involving a large vessel fire, you will initially proceed to a defensive posture. This is a long-standing procedure to contain the fire and to stop it from spreading into other compartments. To accomplish this, set up primary fire boundaries (also known as the hot zone). Primary fire boundaries are set up in the compartments directly surrounding the fire compartment. This is known as the “box method”.

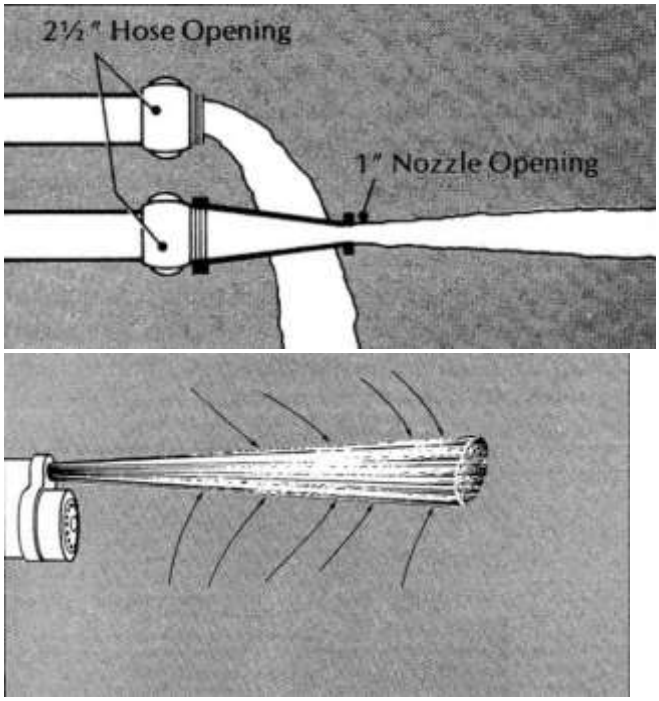
Aboard ship, water is moved to the fire in two ways: 1) via the firemain system, through hoselines that are manipulated by the ship’s personnel and 2) through piping that supplies a manual or automatic sprinkler or spray system. Both are reliable methods for bringing water to bear on a fire, provided the pumps, piping and all components of the system are maintained.

The mobility of a hoseline is an important asset in most firefighting operations. The hose and nozzle complete the job of moving water to the fire in the proper form. Moreover, hoseline operations represent a much greater involvement of crew members in combating the fire.

This human involvement – and the possibility of human error – make drills of paramount importance. Through periodic drilling, crewmen should become proficient in the use and maintenance of water-moving equipment. The hose must be situated at its proper location and maintained in good working order. More than one small fire has become a major fire owing to poor maintenance practices.

Straight Streams (Jet Streams)

The straight stream is formed by a nozzle that is specially designed for that purpose. The end from which the water is thrown is tapered to less than one half the diameter of the entry or hose end. The tapering increases both the velocity of the water at the discharge end and the reach.



(The taper greatly increases the velocity of the water coming from the nozzle.)

Efficiency of Straight Streams

The distance that a straight stream travels before breaking up or dropping is called its reach. Reach is important when it is difficult to approach close to a fire. Actually, despite its name, a straight stream is not really straight. Like any projectile, it has two forces acting upon it. The velocity imparted by the nozzle gives it reach, either horizontally or at an upward angle, depending on how the nozzleman aims the nozzle. The other force, gravity tends to pull the stream down, so the reach ends where the stream encounters the deck.

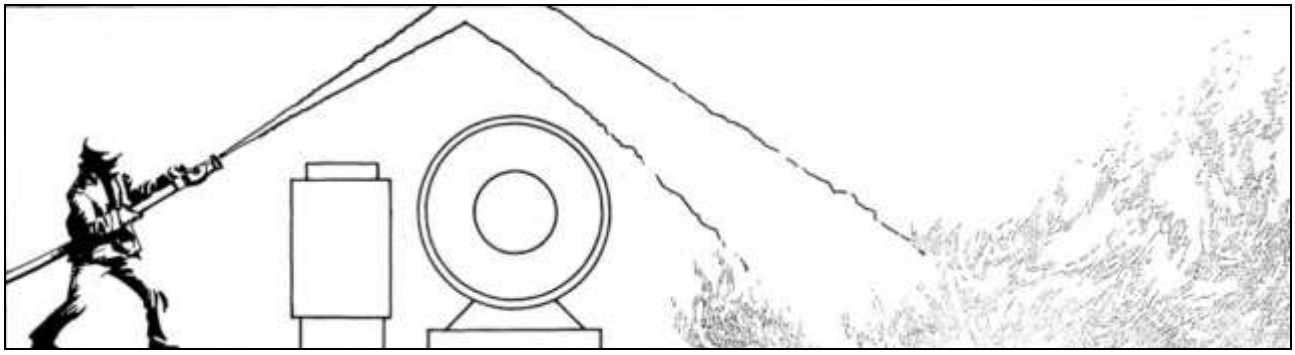
Using Straight Streams

A straight stream should be directed into the seat of the fire. This is important: For maximum cooling the water must contact the material that is actually burning. A straight stream that is aimed at the flames is ineffective. In fact, the main use of straight streams is to break up the burning material and penetrate to the seat of a class A fire.

It is often difficult to hit the seat of a fire, even with the reach of a straight stream. Aboard ship, bulkheads with small openings can keep firefighters from getting into proper position to aim the stream into the fire. If the stream is used before the nozzle is properly positioned, the water may hit a bulkhead and cascade onto the deck without reaching the fire. The nozzleman must not open the nozzle until he is sure it is positioned so that the stream will reach into the fire.

In some instances, there may be an obstruction between the fire and the nozzleman. Then the stream can be bounced off a bulkhead or the overhead to get around the obstacle. This method

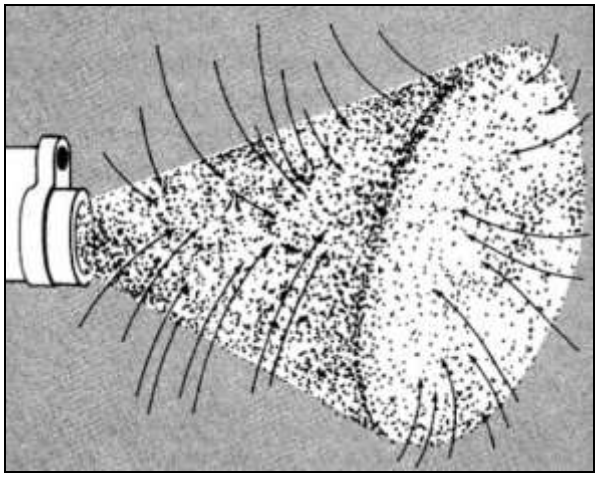
can also be used to break a straight stream into a spray-type stream, which will absorb more heat. It is useful in cooling an extremely hot passageway that is keeping firefighters from advancing toward fire. (A combination fog-jet nozzle could be opened to the fog position



(A straight stream can be bounced off the overhead to hit a fire located behind an obstruction.)

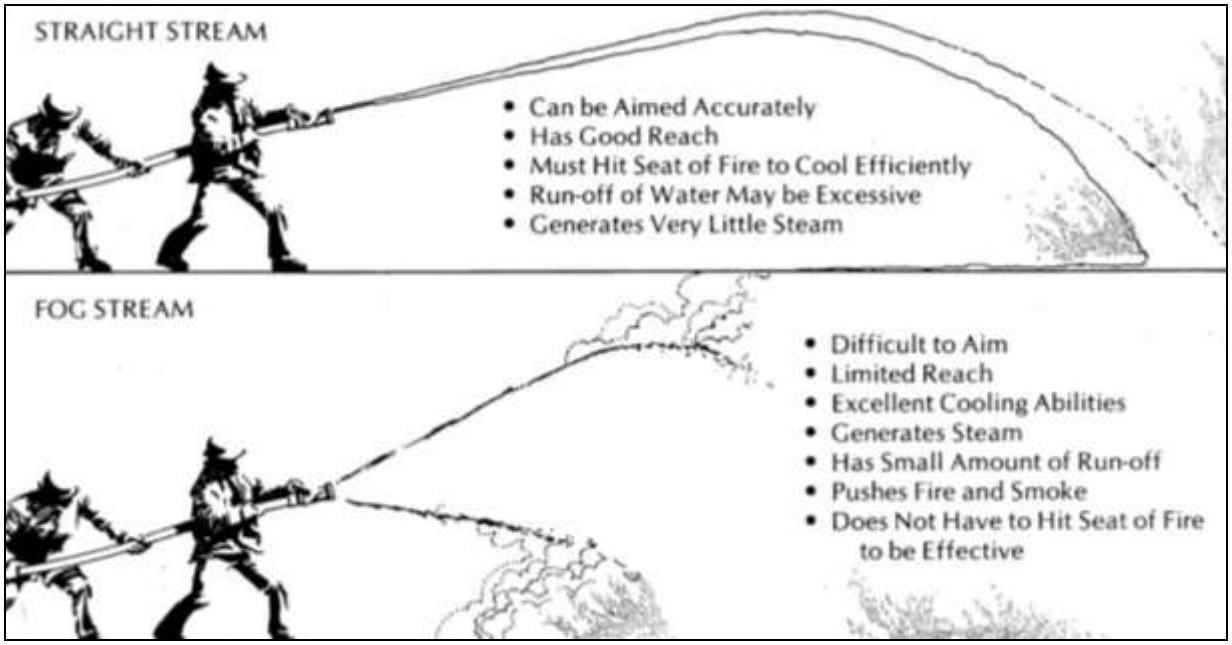
Fog Streams (Jet Streams)

The fog nozzle breaks the water stream into small droplets. These droplets have a much larger total surface area than a solid stream. Thus, a given volume of water in fog form will absorb much more heat than the same volume of water in a straight stream.



(Fog stream droplets present a greater water surface area to the fire and can absorb more heat.)

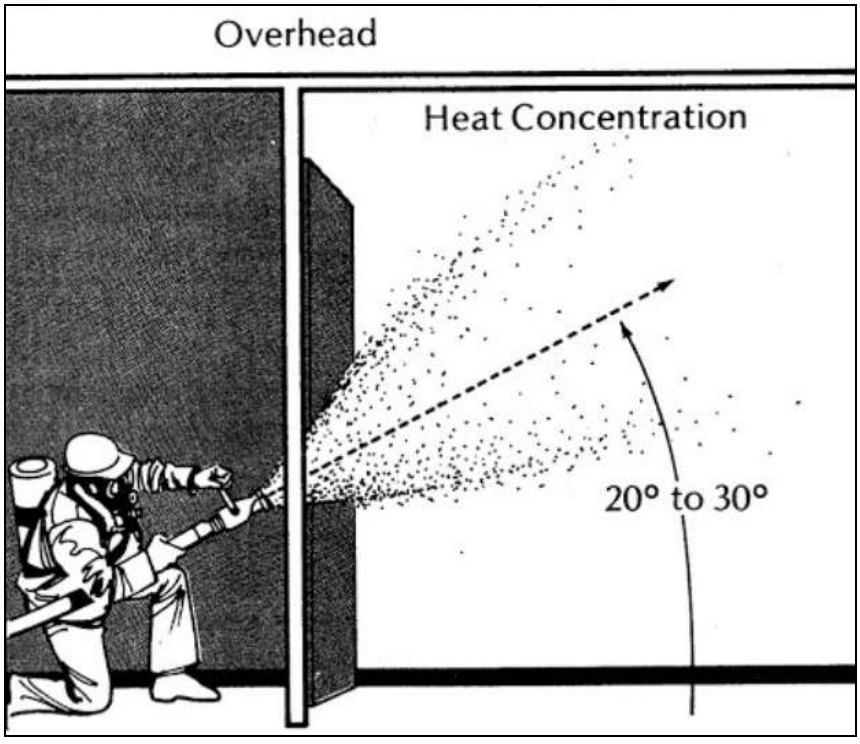
The greater heat absorption of fog streams is important where the use of water should be limited. Less water need to be applied to remove the same amount of heat from a fire. In addition, more of the fog stream turns to steam when it hits the fire. Consequently, there is less runoff, less free surface water and less of a stability problem for the ship.



(Advantages and disadvantages of straight and fog streams.)

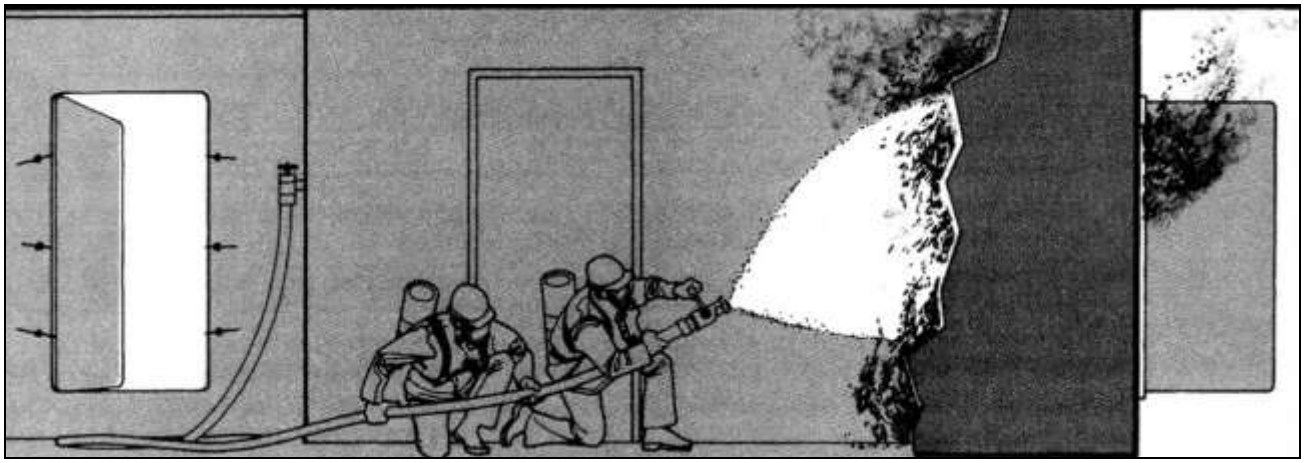
High-Velocity Fog Streams

The high-velocity fog stream can be used effectively to reduce heat in compartments, cabins and cargo spaces. In spaces where there is an overhead, the nozzle should be directed upward at an angle of 20° - 30° from the plane of the deck. This directs the fog toward the overhead, where the most heat is concentrated. The foglike spray quickly absorbs heat, allowing firefighters to enter or advance to the fire.

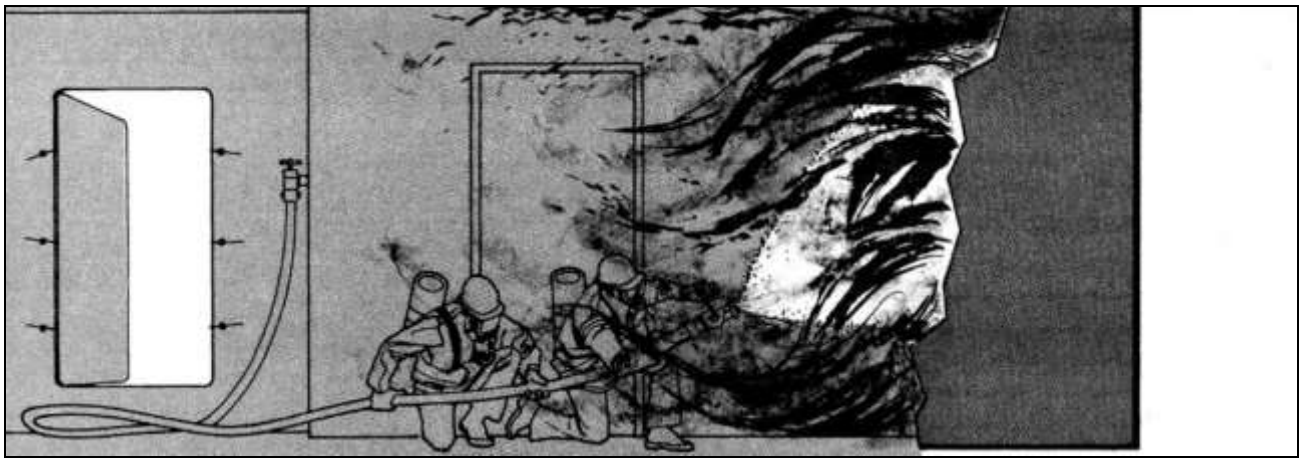


(The fog nozzle should be directed upward at an angle of 20° - 30° to hit heat concentrations at the overhead.)

The high-velocity fog stream can also be used to move air in passageways and to drive heat and smoke away from advancing firefighters. This operation can be used to facilitate the rescue of persons who are trapped in staterooms, cabins or other spaces. If at all possible, the far side of the passageway should be opened and kept clear of people. However if there is no opening in a passageway other than the one from which the nozzle is being advanced, the heat and smoke will have no place to go and may burst through or around the fog stream (blow back) and endanger those advancing the nozzle. Therefore, in such a passageway, short bursts of fog should be aimed at the overhead to knock down the flame while minimizing the chance of blowback or it may be better to use a solid stream.



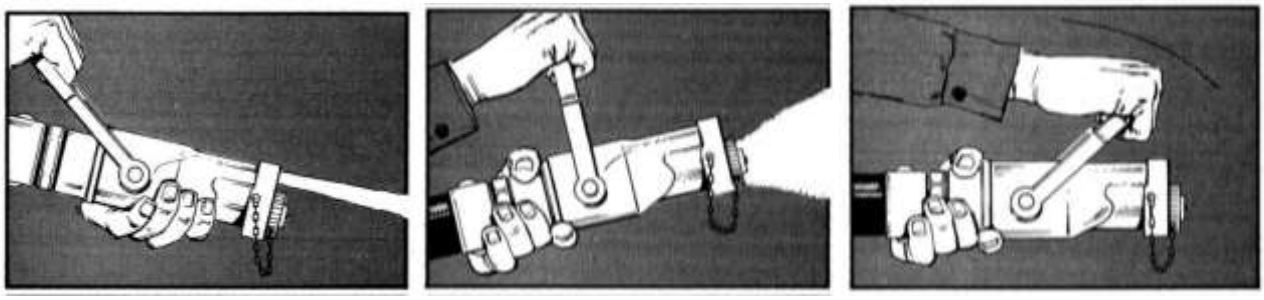
(A high velocity fog stream can be used to drive heat and smoke ahead of firefighters when there is an outlet for these combustion products.)



(If there is no outlet for combustion products that are being pushed ahead, they may blow back and engulf advancing firefighters.)

Combination Nozzle Operation

The combination nozzle will produce a straight stream or high-velocity fog, depending on the position of its handle.



When any nozzle is to be used, the handle should be in closed position until the water reaches the nozzle. The hose will bulge out, and the nozzleman will feel the weight of the water. Before pushing the handle to an open position, he should let the entrained air out of the nozzle. This is done by turning a bit sideways with the nozzle and slowly opening it until a spatter of water comes out. Now the nozzle is directed at the target. The backup man closes up to the nozzleman and takes some of the weight of the hose and the back pressure from the nozzle. The nozzle is opened to the desired position, and the fire is attacked.

Straight and fog streams can be very effective against class A fires in the hands of skilled operators. Fog streams can also be used effectively against class B fires. However, it is important that crewman have actual experience in directing these steams during drills. Applicators should also be broken out at drills so crewmen can get the feel of these devices.

Hose Team

One of the most important units within the fire party is the hose team (fire fighters). The key member of the hose team is the nozzleman, who controls the nozzle and directs the stream onto the fire. In many instances, the nozzleman must make decisions before an officer arrives on the scene. The nozzleman must have the training and discipline to advance the team close to the fire to ensure that the water is directed into the seat of the fire. This is a responsible position, and it should be assigned to a crew member who has received training in firefighting. The nozzleman should also be thoroughly familiar with the ship's design and construction features.

The backup man is positioned directly behind the nozzleman. He takes up the weight of the hose and absorbs some of the nozzle reaction, so that the nozzle can be manipulated without undue strain. To be able to maintain his position, he must work in unison with the nozzleman. The other hose team members are positioned along the hose to assist in maneuvering and advancing the nozzle.

Advancing the Hoseline

When an emergency occurs, the hose should be run out before the fire station hydrant is opened. Without water, the hose is light and easy to handle; it can be advanced quickly. Once the hose is charged with water, it becomes heavy and difficult to advance. Firefighters become tired from moving the additional weight of the water, especially if the hose must be manhandled up or down ladders and along narrow passageways. If they are wearing breathing apparatus, their labored breathing depletes the oxygen supply more rapidly than normally.

The hose should be run out as follows: The nozzleman and backup man pick up the first section of the hose and advance toward the fire. The third team member picks up the center section and advances it. The fourth team member remains at the fire station to open the hydrant. When the nozzleman is in position, he asks for water. As the water fills the hose, the third and fourth team members should straighten out any kinks and check hose couplings for leaks. Leaky couplings should be tightened with a spanner. Upon calling for water, the nozzleman should open the nozzle slightly to allow trapped air to escape. The nozzle should be closed when water begins to flow. The hoseline is then ready for use.

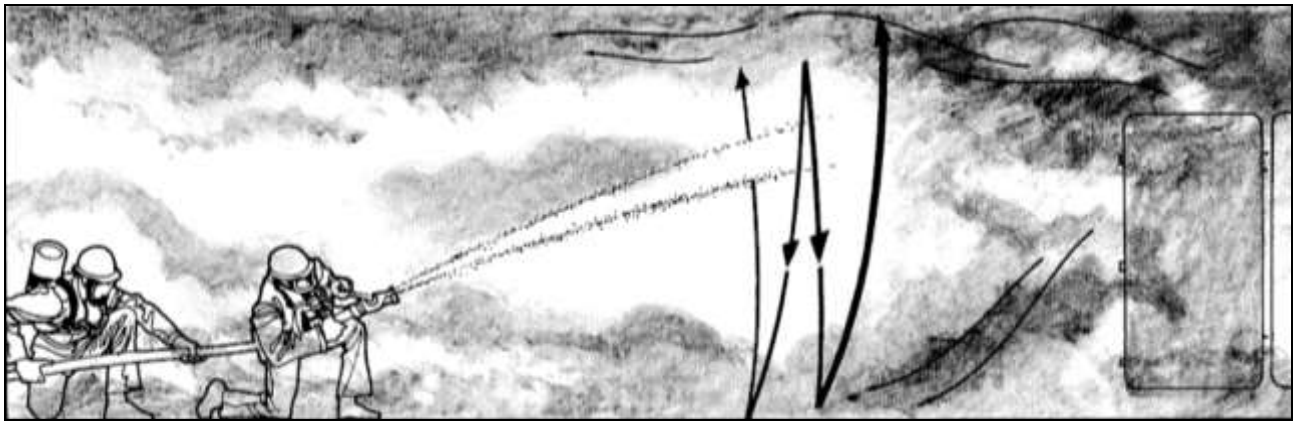
During drills, hose should be run out, and the nozzle should be positioned to attack a simulated fire. The training should be as realistic as possible. Hose teams should practice maneuvering the hose below decks, through passageways, and up and down accommodation ladders and narrow hatches.

Using the Hose Stream

The manner in which hose streams are applied depends on the fire situation. The nozzleman must know what type of stream to use, and how to use it, under different fire conditions.

Passageway Compartment Fire

When flames have traveled out of a compartment and into a passageway, it is essential that the compartment be reached. The hose stream must be directed into the seat of the fire. The flames in the passage way must be knocked down before the nozzle can be positioned properly. This is best accomplished by advancing as close to the flames as possible keeping low to the deck. Then the nozzle should be opened to the fog position. The stream should be moved up and down so that the water bounces off the bulkhead and the overhead, and into the flames. This will push the heat, and flames ahead of the nozzleman, who should continue to advance until he reaches his objective.

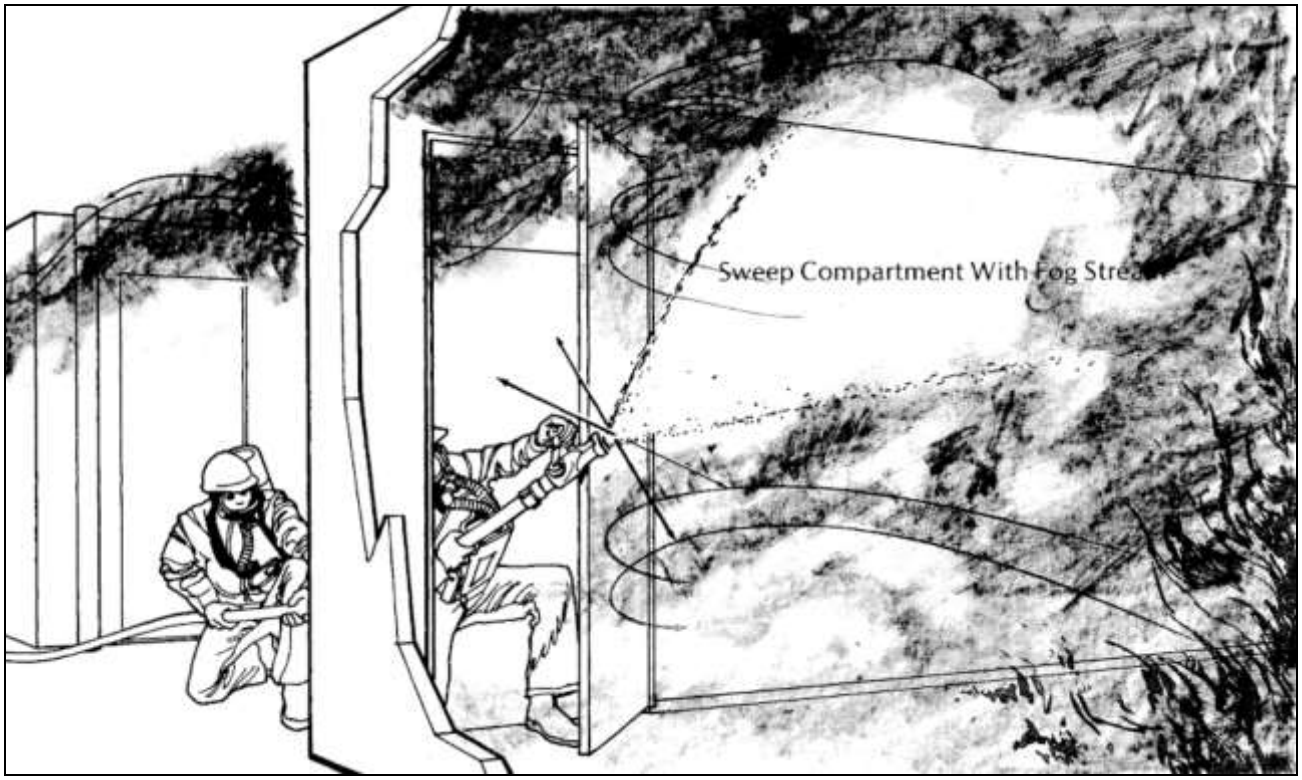


(A fog stream is used to push flames, heat and smoke ahead of an advancing hose team. Firefighters must keep low to allow the heat to pass above their bodies.)

Stream will be produced when the stream hits the flames and hot gases. This and the smoke will make visibility very poor. A backup hoseline should be brought into position behind the first attack line as quickly as possible. The backup line can be used to protect the advancing hose team, or it can be directed onto the fire if a larger volume of water is required to gain control of the situation.

Hidden Compartment Fire

When attacking a substantial fire behind a closed door, the charged hoseline should first be positioned outside the door. Then the door should be opened only enough to insert the nozzle. Using the door to protect his body, the nozzleman should sweep a fog stream around the compartment. Both the nozzleman and the backup man should crouch as low as possible, to allow the heat and steam to pass overhead. After a few seconds, the door may be opened a bit more. If conditions permit, the team should enter the compartment and advance until they can hit the seat of the fire with a straight stream (jet stream).



(Fighting a fire in a closed compartment. The door is opened slightly and used as a shield. The fog stream is swept back and forth across the compartment. The hose team crouches low.)

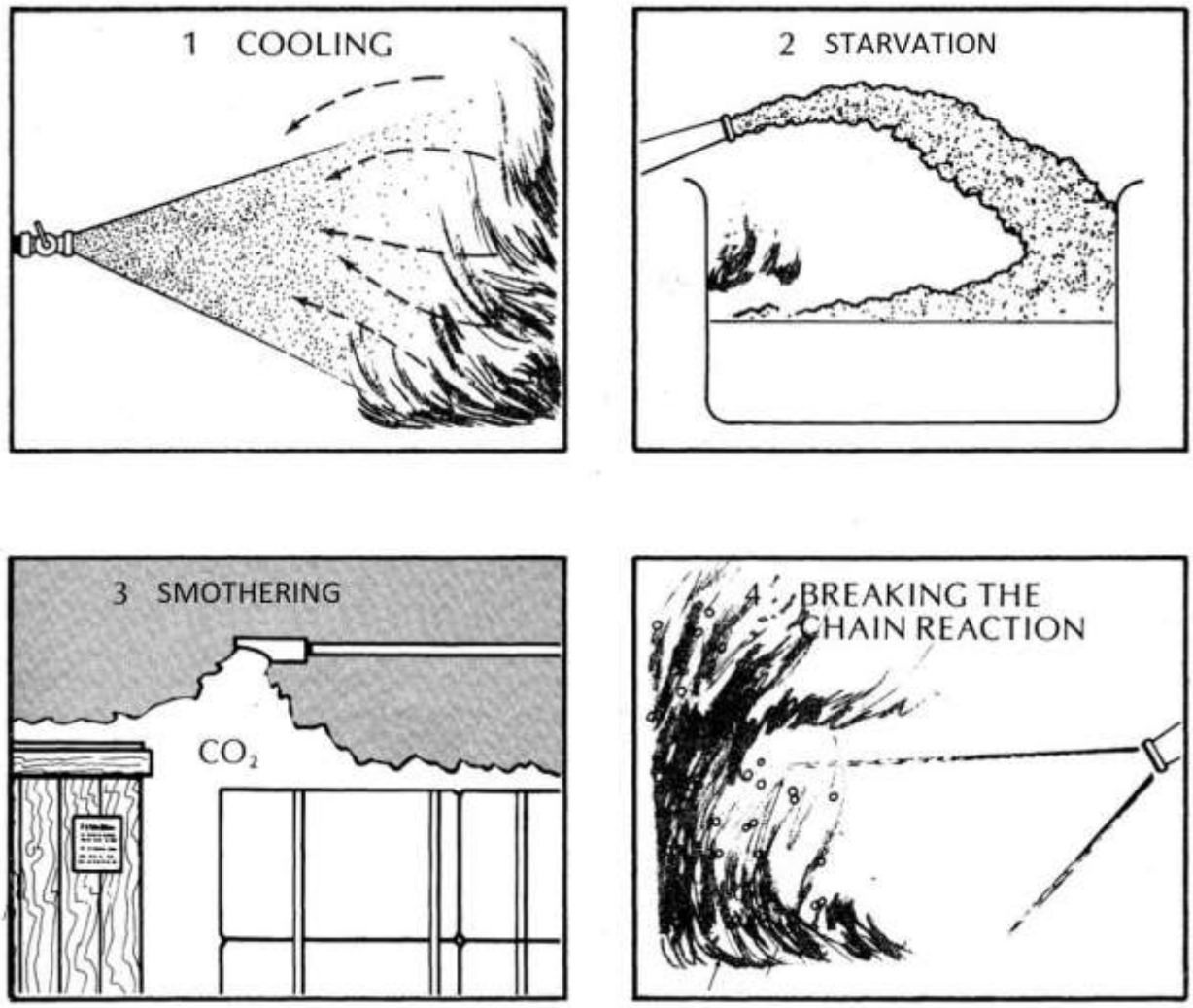
2.5.Extinguishing fire with foam, powder or any other suitable chemical agent

To extinguish a fire successfully, it is necessary to use the most suitable type of extinguishing agent – one that will accomplish the task in the least amount of time, cause the least damage and result in the least danger to crew members. The job of selecting the proper extinguishing agent has been made easier by the classification of fires into four classes. Within each class are all fires involving materials with similar burning properties and requiring similar extinguishing agents. Thus, knowledge of these classes is essential to efficient firefighting operation, as well as familiarity with the burning characteristics of materials that may be found aboard ship.

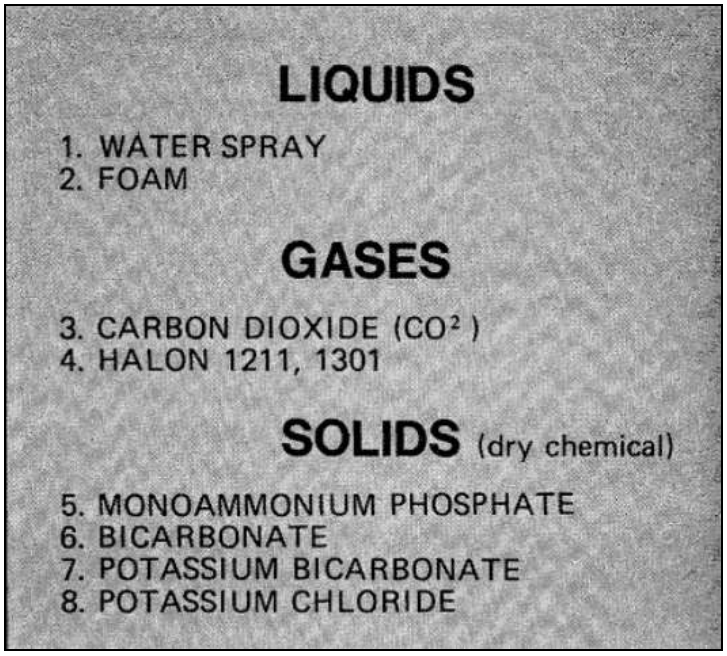
An extinguishing agent is a substance that will put out a fire. Every extinguishing agent operates by attacking one or more sides of a fire tetrahedron. The specific actions involved are the following:

- Cooling: to reduce the temperature of the fuel below its ignition temperature. This is a direct attack on the heat side of the fire tetrahedron.
- Starvation (Blanketing): to separate the fuel from the oxygen. This can be considered as an attack on the edge of the fire tetrahedron where the fuel and oxygen sides meet.
- Smothering: to reduce the amount of available oxygen below that needed to sustain combustion. This is an attack on the oxygen side of the tetrahedron.

- Chain breaking: To disrupt the chemical process that sustains the fire (the chain reaction side of the tetrahedron).



Each fire extinguishing agents are applied to the fire as a liquid, gas or solid depending on its extinguishing action and physical properties. Some may be used on several types of fires, whereas others are more limited in use.

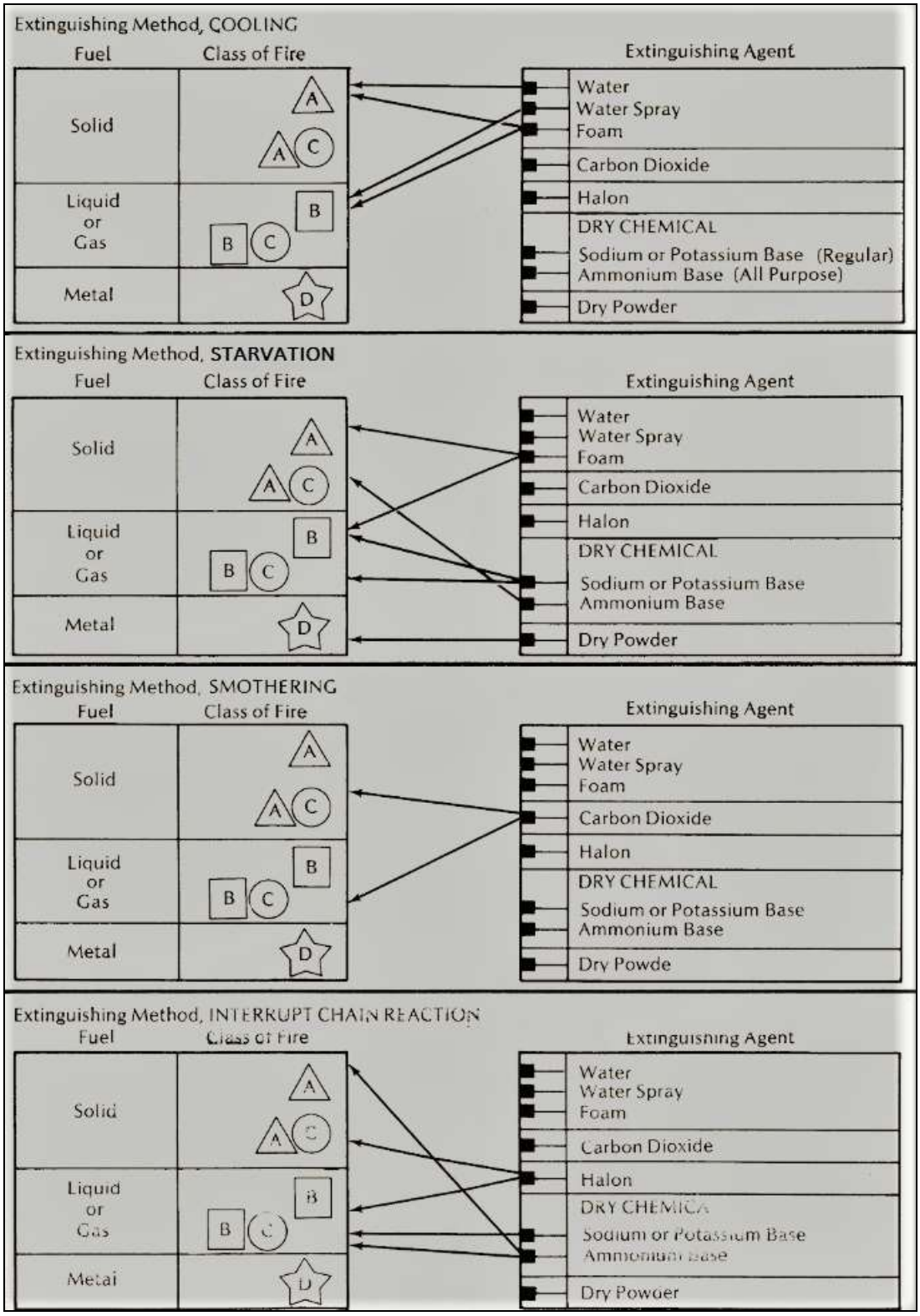


Classes (and combinations) of fires

Fires are grouped into four classes labeled A through D, according to their fuels. However, some fuels are found in combinations, and electrical fires always involve some solid fuel. Thus, for firefighting purposes, there are actually six possible combinations of fire classes:

- Class A fires (common flammable solid fuel)
- Class B fires (flammable liquid or gaseous fuel)
- Combined class A and B fires (solid fuel combined with liquid or gaseous fuel)
- Combined class A and C fires (solid fuel combined with electrical equipment)
- Combined class B and C fires (liquid or gaseous fuel combined with electrical equipment)
- Class D fires (combustible-metal fuel)

The choice of extinguishing agent depends on the class of fire, the hazards involved and the agents available.



(The actions of extinguishing agents on the different classes of fires.)

Class A Fires

Fires involving common combustible solids such as wood, paper, cloth and plastics are most effectively extinguished by water, a cooling agent. Foam and dry chemical may also be used; they act mainly as smothering agents.

Class B Fires

For fires involving oils, greases, gases and other substances that give off large amounts of flammable vapors a starvation agent is most effective. Water fog, dry chemical, foam and carbon dioxide (CO_2) may be used. However, if the fire is being supplied with fuel by an open valve or a broken pipe, a valve on the supply side should be shut down. This may extinguish the fire or, at least, make extinguishment less difficult and allow the use of much less extinguishing agent.

In a gas fire, it is imperative to shut down the control valve before you extinguish the fire. If the fire were extinguished without shutting down the valve, flammable gas would continue to escape. The potential for an explosion, more dangerous than the fire, would then exist. It might be necessary to extinguish a gas fire before shutting down the fuel supply in order to save a life or to reach the control valve; however, these are the only exceptions.

Combined Class A and B Fires

Water spray and foam may be used for starvation of fires involving both solid fuels and flammable liquids or gases. These agents also have some cooling effect on the fire. Carbon dioxide has also been used to extinguish such fires in closed spaces.

Combined Class A and C Fires

Because energized electrical equipment is involved in these fires, a nonconducting extinguishing agent must be used. Carbon dioxide, halon and dry chemical are the most efficient agents. Carbon dioxide dilutes the oxygen supply (smothering), while the others are chain breaking agents.

Combined Class B and C Fires

Here again, a nonconducting agent is required. Tires involving flammable liquids or gases and electrical equipment may be extinguished with halon or dry chemical acting as a chain breaker. They may also, in closed spaces, be extinguished with CO_2

Class D Fires

These fires involve combustible metals such as potassium, sodium and their alloys and magnesium, zinc, zirconium, titanium and powdered aluminum. They burn on the metal surface at a very high temperature and often with a brilliant flame. Water should not be used on class D fires, as it may add to the intensity or cause the molten metal to spatter. This, in turn, can extend the fire and inflict painful and serious burns on those in the vicinity.

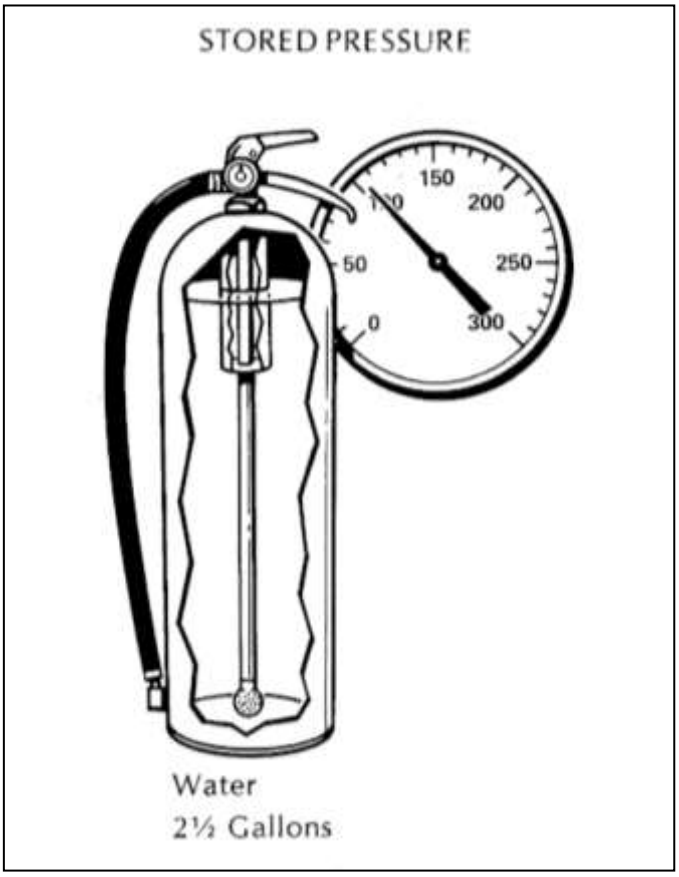
Fires in combustible metals are generally controlled with specialized agents known as dry powders for starvation. Dry powders are not the same as dry chemicals, although many people use the terms interchangeably. The agents are used entirely for different types of fires: Dry powders are used only to extinguish combustible-metals fires. Dry chemicals may be used on other fires, but not on class D fires.

Stored-Pressure Water Extinguisher

The stored-pressure water extinguisher is the most commonly used portable firefighting appliance. It weighs about 13.6 kg (30 lb) and has horizontal range of 10.7 – 12.2 m (35 – 40 ft). In continuous operation, it will expand its water in about 55 seconds. However, it may be used intermittently, to extend its operational time.

The container is filled with water or an anti-freeze solution, within about 15 cm (6 in.) of the top. The screw-on cap holds a lever-operated discharge valve, a pressure gauge and an automobile tire-type valve. The extinguisher is pressurized through the air valve, with either air or an inert gas such as nitrogen. The normal charging pressure is about 690 kilopascals (100 psi). The gauge allows the pressure within the extinguisher to be checked at any time. Most gauges are color coded to indicate normal and abnormal pressures.

Operation



(Stored-pressure water extinguisher used for class A fires only.)

The extinguisher is carried to the fire, and the ring pin or other safety device is removed. The operator aims the nozzle with one hand and squeezes the discharge lever with the other hand. The stream should be directed at the seat of the fire. It should be moved back and forth to ensure complete coverage of the burning material. Short bursts can be used to conserve the limited supply of water.

As the flames are knocked down, the operator may move closer to the fire. Then, by placing the tip of one finger over the nozzle the operator can obtain a spray pattern that will cover a wider area.

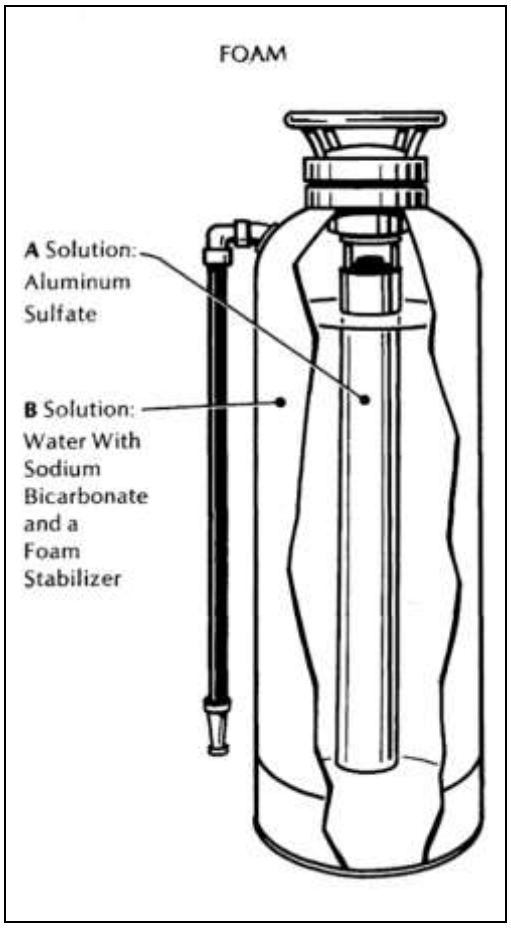
Maintenance

Inspect gauge for loss of pressure, check for leaks and check condition of hose and overall condition of the tank.

Foam Extinguisher

Foam extinguishers have a great extinguishing capability. It may be used on both class A and class B fires. It has a range of about 9.2 – 12.2 m (30 – 40 ft) and a discharge duration of slightly less than a minute.

The extinguisher is charged by filling it with two solutions that are kept separated (in the extinguisher) until it is to be used. These solutions are commonly called the A and B solutions; their designations have nothing to do with fire classifications.



(Cutaway of foam extinguisher used for class A and class B fires)

Operation

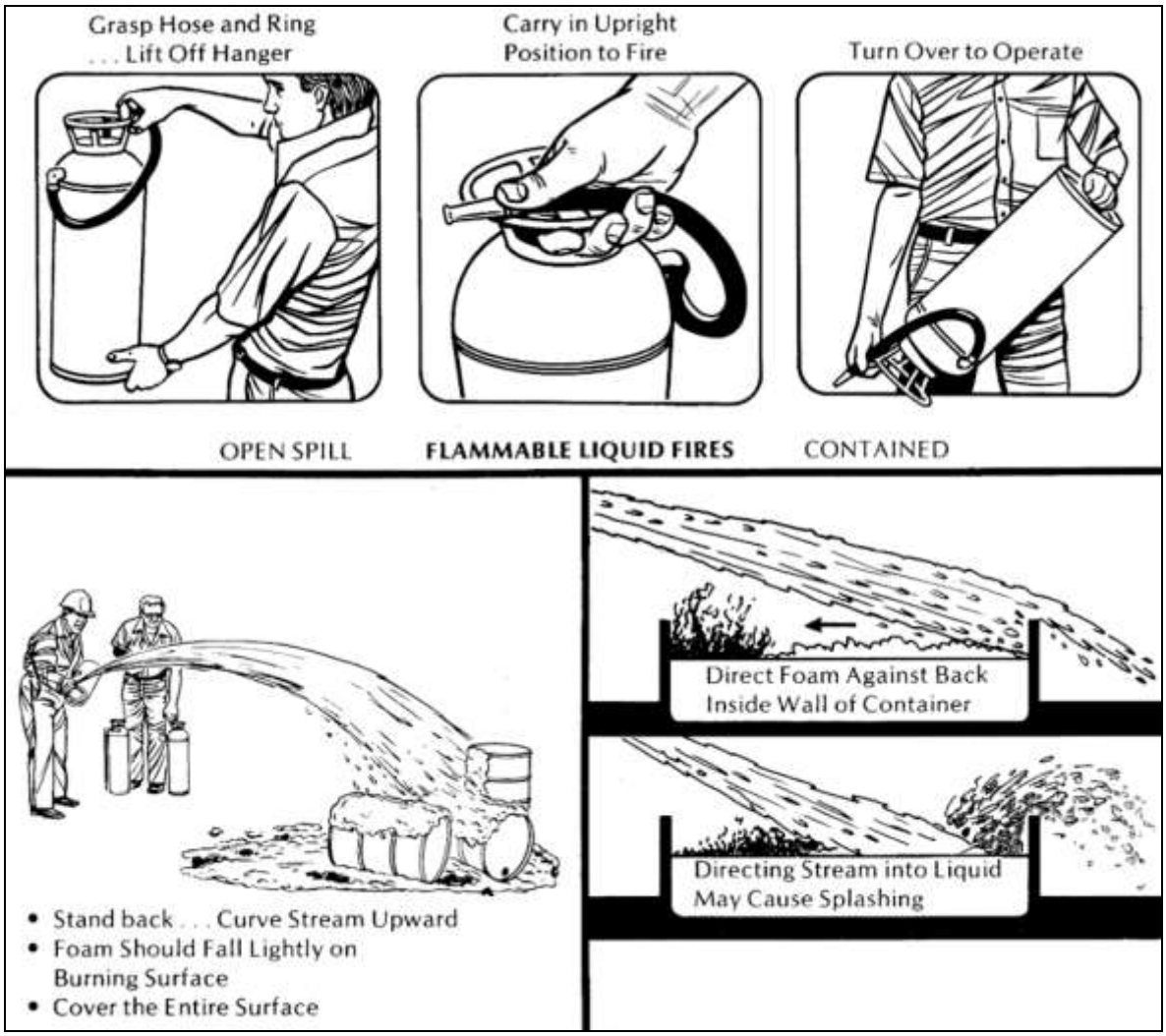
The foam extinguisher is carried to the fire right side up and then inverted. This mixes the two solutions, producing a liquid foam and CO_2 gas. The CO_2 acts as the propellant and fills the foam

bubbles. The liquid foam expands to about 8 times its original volume; this means the 9.5 liter (2 ½-gal) extinguisher will produce 68-76 liters (18-20 gal) foam.

The foam should be applied gently on burning liquids. This can be done by directing the stream in front of the fire, to bounce the foam onto the fire. The stream also may be directed against the back wall of the tank or a structural member to allow the foam to run down and flow over the fire. Chemical foam is stiff and flows slowly. For this reason, the stream must be directed to the fire from several angles, for complete coverage of the burning materials.

For fires involving ordinary combustible materials, the foam may be applied in the same way, as a blanket. Or, the force of the stream may be used to get the foam into the seat of the fire.

Foam extinguishers are subject to freezing and cannot be stowed in low temperatures below 4.4°C (40°F). Once activated, these extinguishers will expel their entire foam content; it should all be directed onto the fire. As with other pressurized extinguishers, the containers are subject to rupture when their contents are mixed, and are a possible cause of injury to the operator. Maintenance consists mainly of annual discharging, inspection, cleaning and recharging.



(Steps in operating a foam extinguisher on flammable liquid fires.)

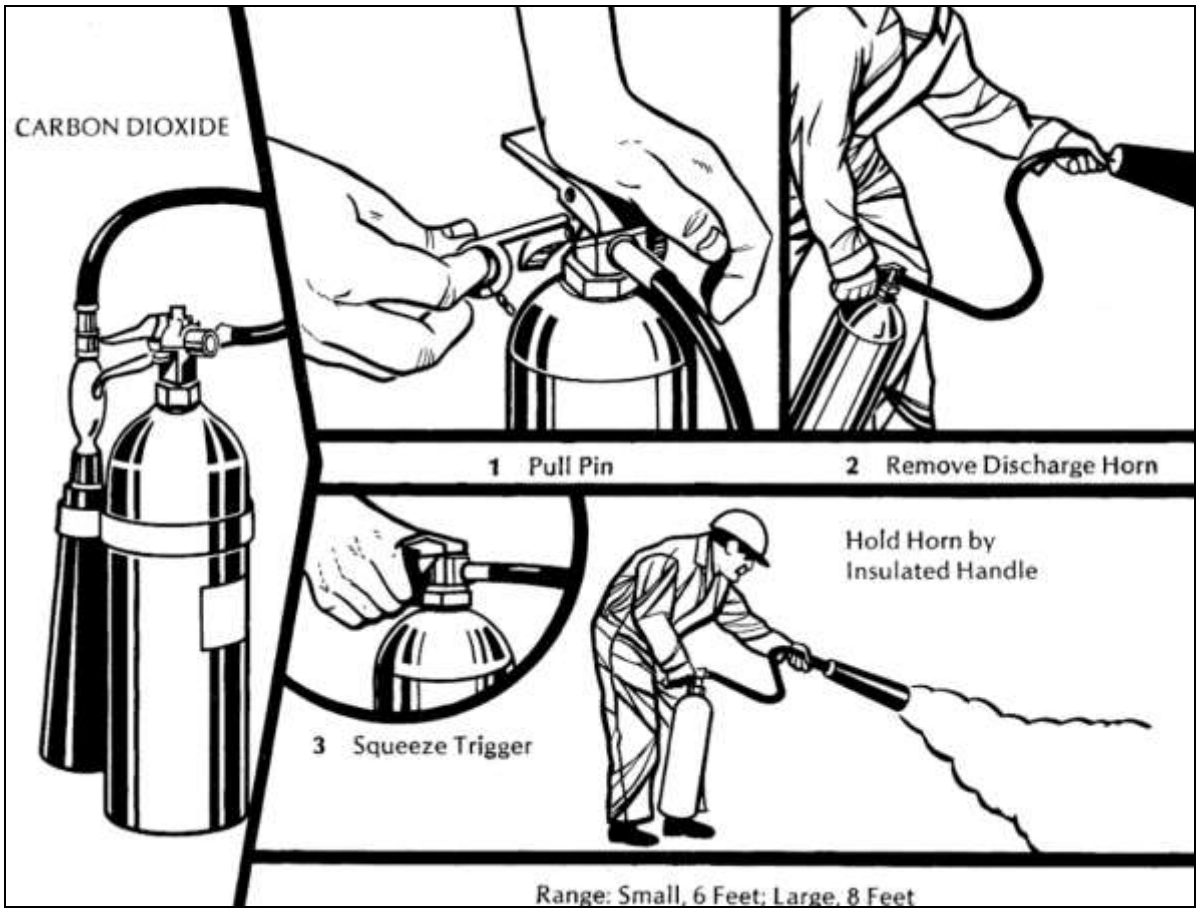
Carbon Dioxide (CO_2) Extinguisher

Carbon dioxide extinguishers are used primarily on class B and class C fires. The most common sizes of portable extinguishers contain from 2.3 – 9.1 kg (5 – 20 lb) of CO_2 not including the weight of the relatively heavy shell. The CO_2 is mostly in the liquid state, at a pressure of 5.86 x 10^6 pascals (850 psi) at 21°C (70°F). The range varies between 8-30 seconds depending on the size.

Operation

The extinguisher is carried to the fire in an upright position. (The short range of the CO_2 extinguisher means the operator must get fairly close to the fire.) The extinguisher is placed on the deck, and the locking pin is removed. The discharge is controlled either by opening a valve or by squeezing two handles together.

The operator must grasp the hose handle, and not the discharge horn. The CO_2 expands and cools very quickly as it leaves the extinguisher. The horn gets cold enough to frost over and cause severe frostbite. When a CO_2 extinguisher is used in a confined space, the operator should guard against suffocation by wearing breathing apparatus.



(Steps in operating the CO_2 extinguisher used for class B and class C fires)

Class B Fires Extinguishment Using CO_2 Fire Extinguisher

The horn should be aimed first at the base of the fire nearest the operator. The discharge should be moved slowly back and forth across the fire. At the same time, the operator should move forward slowly. The result should be a "sweeping" of the flames off the burning surface, with some carbon dioxide "snow" left on the surface.

Whenever possible, a fire on a weather deck should be attacked from the windward side. This will allow the wind to blow the heat away from the operator and to carry the CO_2 to the fire. Generally, CO_2 extinguishers do not perform well in a wind. The blanket of CO_2 gas does not remain on the fire long enough to permit the fuel to cool down.

Class C Fires Extinguishment Using CO_2 Fire Extinguisher

The discharge should be aimed at the source of a fire that involves electrical equipment. The equipment should be de-energized as soon as possible to eliminate the shock and the source of ignition.

Maintenance

CO_2 extinguishers need not be protected against freezing. However, they should be stowed at below 54°C (130°F) to keep their internal pressure at a safe level. (At about 57°C (135°F), the safety valves built into CO_2 extinguishers are activated at approximately 18.62×10^6 pascals (2700 psi), to release excess pressure.)

Several times each year, CO_2 extinguishers should be examined for damage and to ensure that they are not empty. At annual inspection, these extinguishers should be weighed. Any extinguisher that has lost more than 10% of its CO_2 weight should be recharged by the manufacturer. A CO_2 extinguisher should also be recharged after each use, even if it was only partly discharged.

<u>Dry Chemical Extinguisher</u>

Dry chemical extinguishers are available in several sizes, with any of five different extinguishing agents. The different dry chemical agents have different extinguishing capabilities. If sodium bicarbonate is arbitrarily given an extinguishing capability of 1, then the relative capabilities of the other dry chemical agents are as follows:

Monoammonium phosphate (ABC)	1.5
Potassium chloride (BC)	1.8
Potassium bicarbonate (BC)	2.0
Urea potassium bicarbonate (BC)	2.5

*When sodium bicarbonate is classified as 1.

(Relative Extinguishing Capabilities of Dry Chemical Agents)

Thus, for example, potassium bicarbonate is twice as effective as sodium bicarbonate.

Cartridge-Operated Dry Chemical Extinguisher

Portable cartridge-operated, dry chemical extinguishers range in size from 0.91 – 13.6 kg (2 – 30 lb); semiportable models contain up to 22.7 kg (50 lb) of agent. An extinguisher may be filled with any of five agents, and its rating will be based on the particular agent used. A small cylinder of inert gas is used as the propellant. Cartridge-operated, dry chemical extinguishers have a range of from 3 – 9.1 m (10 – 30 ft). Units under 4.5 kg (10 lb) have a discharge duration of 8 -10 seconds, while the larger extinguishers provide up to 30 seconds of discharge time.

Operation

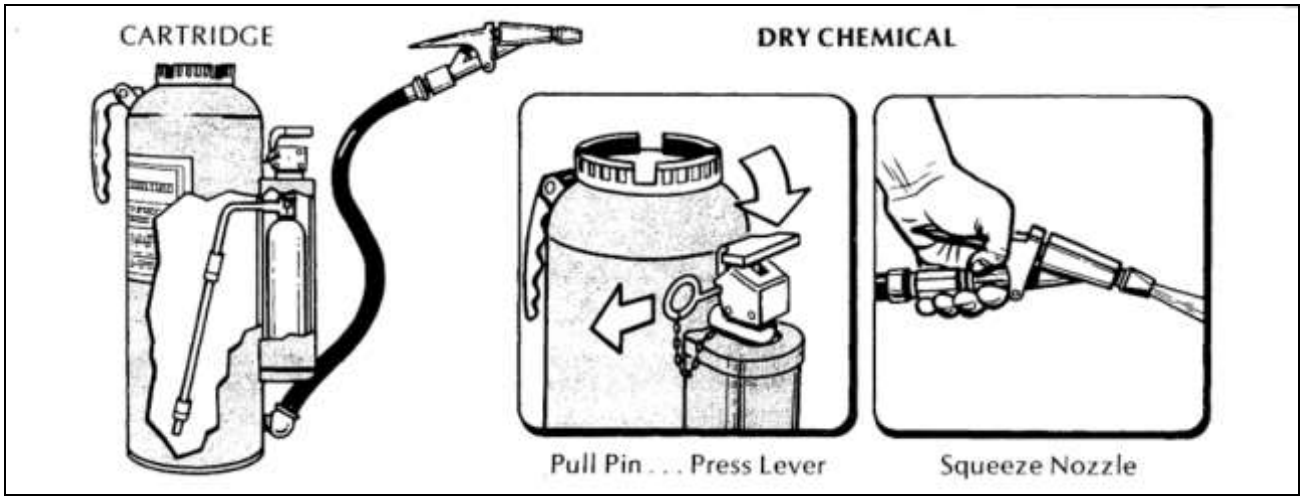
The extinguisher is carried and used upright. The ring pin is removed, and the puncturing lever is depressed. This releases the propellant gas, which forces the extinguishing agent up to the nozzle. The flow of dry chemical is controlled with the squeeze-grip On–Off nozzle at the end of the hose. The discharge is directed at the seat of the fire, starting at the near edge. The stream should be moved from side to side with rapid motions, to sweep the fire off the fuel. On a weather deck, the fire should be approached from the windward side if possible.

The initial discharge should not be directed onto the burning material from close range (0.91 – 2.4 m (3 – 8 ft)). The velocity of the stream may scatter the burning material.

If the propellant gas cylinder is punctured but the extinguisher is not put into use or is only partially discharged, the remaining gas may leak away in a few hours. Thus, the extinguisher must be recharged after each use or activation. However, the agent may be applied in short bursts by opening and closing the nozzle with the squeeze grips.

Dry chemical extinguishers extinguish class B fires by chain breaking, with little or no cooling. Thus, a reflash is possible if the surrounding surfaces are hot. Additional dry chemical or another appropriate extinguishing agent must be available as backup, until all sources of ignition are eliminated.

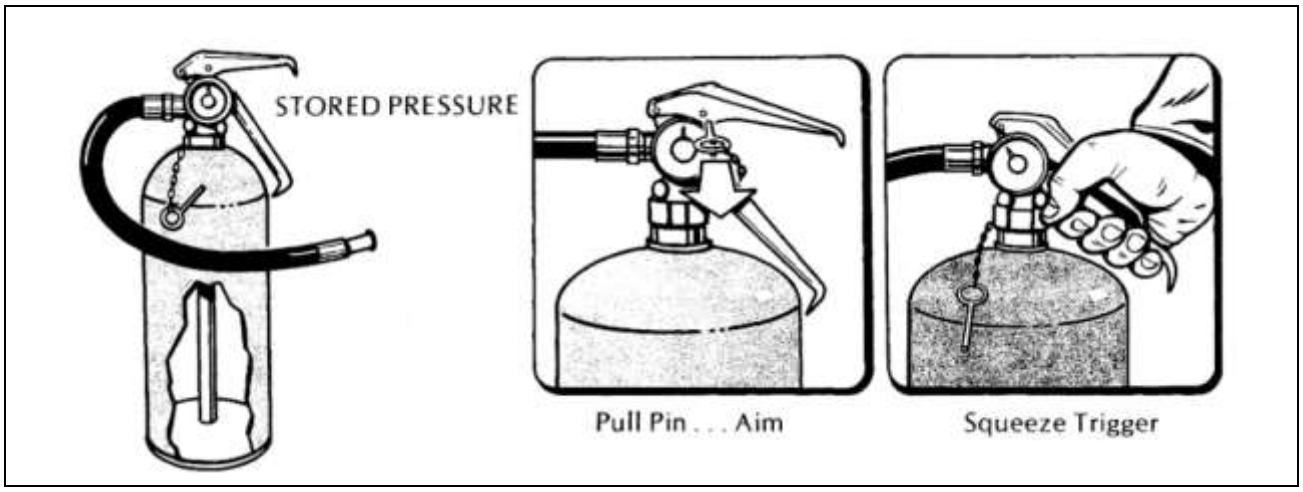
Dry chemical extinguishing agents may be used along with water. Some dry chemical extinguishers are filled with an extinguishing agent that is compatible with foam.



(Operating the cartridge-operated dry-chemical extinguisher.)

Stored-Pressure Dry Chemical Extinguishers

Stored-pressure dry chemical extinguishers are available in the same sizes as cartridge-operated types. They have the same ranges and durations of discharge and are used in the same way. The only difference is that the propellant gas is mixed in with the dry chemical in the stored-pressure type; and the extinguisher is controlled with a squeeze-grip trigger on the top of the container. A pressure gauge indicates the condition of the charge.



(Operating the stored-pressure dry-chemical extinguisher.)

Class A Extinguishment Using ABC Dry Chemical

Only one dry chemical extinguishing agent, monoammonium phosphate (ABC, multipurpose) approved for use on class A fires. This agent extinguishes fire by chain breaking, as do the other dry chemical agents. In addition, it softens and clings to the surfaces of burning materials to form a coating that deprives the fuel of air. As with the other agents, this dry chemical should be directed at the seat of the fire and swept from side to side to knock down, the operator should move close

to the burning debris. Then all fuel surfaces should be thoroughly coated with the chemical agent. For this, the operator should use short, intermittent bursts.

Class B Extinguishment Using BC or ABC Dry Chemical

A flammable-liquid fire should be attacked as noted above. The agent should first be directed at the edge nearest the operator. The nozzle should be moved from side to side, with a wrist action, to cover the width of the fire. The operator should maintain the maximum continuous discharge rate, remembering that the extinguisher has a range of from 3 – 9.1 m (10 – 30 ft). The operator must be very cautious, moving in toward the fire very slowly. A liquid fire can flank an operator who moves in too rapidly, or reflash around an operator who is too close.

When all the flames are out, the operator should back away from the fire very slowly, being alert for possible reignition. Many types of flammable liquids will reflash under normal atmospheric conditions. A hot spot that the operator has missed could cause reignition, resulting in a duplicate of the original fire. For this reason it is always a good idea to have reserve units or additional extinguishers ready to move in to assist in the extinguishment of the fire.

In using dry chemical to approach a pressure gas fire close off the fuel flow, the heat shield afforded by the dry chemical should be maintained constantly in front of the operator's face. When extinguishment is desired, the dry chemical stream must be directed into the gas stream nearly parallel to the gas flow, with approximately 10 degrees to the right or left side entry. If dry chemical is directed into the stream at too great an angle, the dry chemical will not penetrate the full stream and will be unsuccessful. Conversely, if the chemical stream does not have a slight right or left angle, the dry chemical will be deflected by the gas pipe.

Once the gas is shut off or extinguished, the operator should slowly back away. Remember, never extinguish a pressure gas fire unless by so doing the fuel flow can be controlled.

Class C Extinguishment Using BC or ABC Dry Chemical

When electrical equipment is involved in a fire, the stream of dry chemical should be aimed at the source of the flames. In small spaces, the smoke and the cloud produced by the dry chemical will limit visibility (and may cause choking). The chance of electrical shock is also increased. For this reason, electrical equipment that may be involved in a fire should be deenergized at its source, if at all possible, before any attempt is made to extinguish the fire.

Dry chemical extinguishing agents leave a coating on materials involved in the fire. This coating must be cleaned off electrical equipment before it can be used. Monoammonium phosphate (ABC) dry chemical leaves a sticky coating that is very difficult to remove. This coating also penetrates and sticks to circuit breakers and switching components making them virtually useless. For that reason, ABC dry chemical is not recommended for use on electrical fires.

Dry chemical agents that contain sodium can contaminate or corrode brass and copper electrical fittings. Electric fires are best extinguished with carbon dioxide or Halon, which are "clean" extinguishing agents.

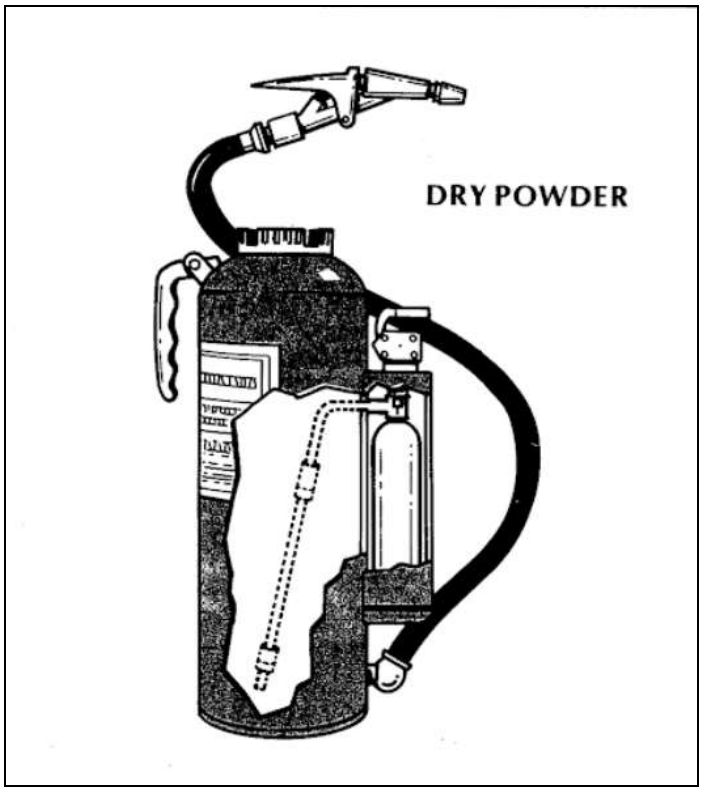
Maintenance of Dry Chemical Extinguishers

Dry chemicals and their propellants are unaffected by temperature extremes and may be stowed anywhere aboard ship. They do not deteriorate or evaporate, so periodic recharging is not necessary. However, the cartridge in cartridge-operated extinguishers could be inspected and weighed every 6 months. Cartridge that are punctured or weigh 14.2 gm (¼ oz) less than the indicated weight should be replaced. At the same time, the hose and nozzle should be checked to ensure that they are not clogged.

Dry Powder Extinguisher

Dry powder (not dry chemical) is the only extinguishing agent that may be used on combustible metal (class D) fires. The available class D extinguisher is a 13.6 kg (30 – lb) cartridge-operated model that looks very much like the cartridge-operated dry chemical extinguisher.

One difference is that the class D extinguisher has a range of only 1.8 – 2.4 m (6 – 8 ft). The extinguishing agent is sodium chloride, which forms a crust on the burning metal.



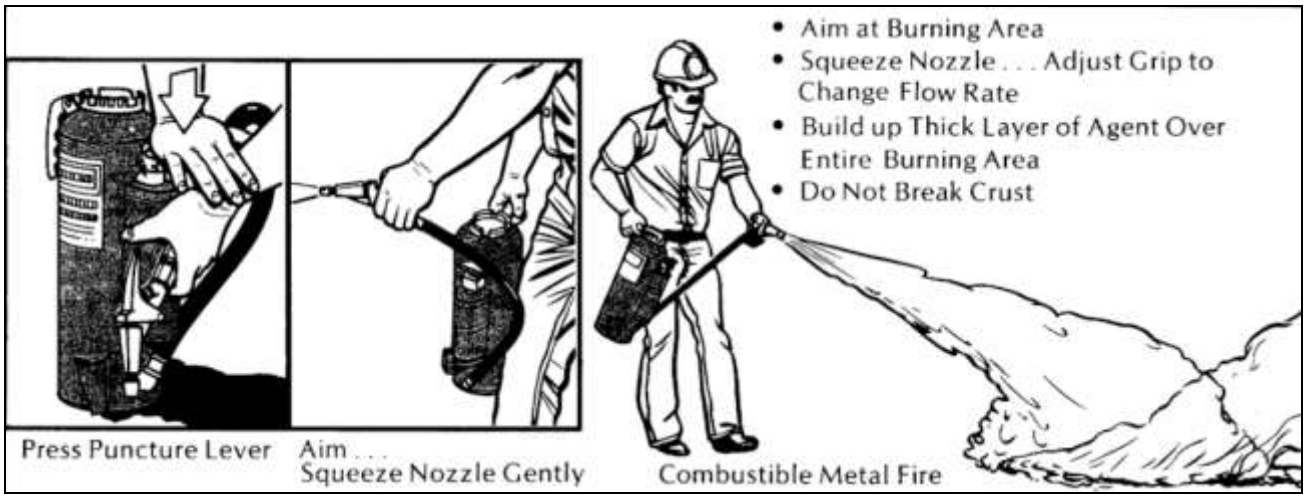
(Dry-powder extinguisher used for class D fires only.)

Operation

The nozzle is removed from its retainer, and the puncture lever is pressed. This allows the propellant gas (CO_2 or nitrogen) to activate the extinguisher. The operator then aims the nozzle and squeezes the grips to apply the powder to the surface of the burning metal.

The operator should begin the application of dry powder from the maximum range 1.8 – 2.4 m (6 – 8 ft). The squeeze grips may be adjusted for the desired rate of flow, to build a thick layer of powder over the entire involved area. The operator must be careful not to break the crust that forms when the powder hits the fire.

A large amount of dry powder is sometimes needed to extinguish a very small amount of burning metal. A brown discoloration indicates a hot spot, where the layer of dry powder is too thin. Additional agent should be applied to the discolored areas. When the fire involves small metal chips, the agent should be applied as gently as possible, so the force of the discharge does not scatter burning chips.



(The dry-powder extinguisher is operated in an upright position. The agent must be applied gently, to maintain a crust on the burning metal.)

Class D dry powder also comes in a container for application with a scoop or shovel. Here, too, the agent should be applied very gently. A thick layer of powder should be built up and the operator should be careful not to break the crust that forms.

(Application of dry powder with a shovel or scoop.)

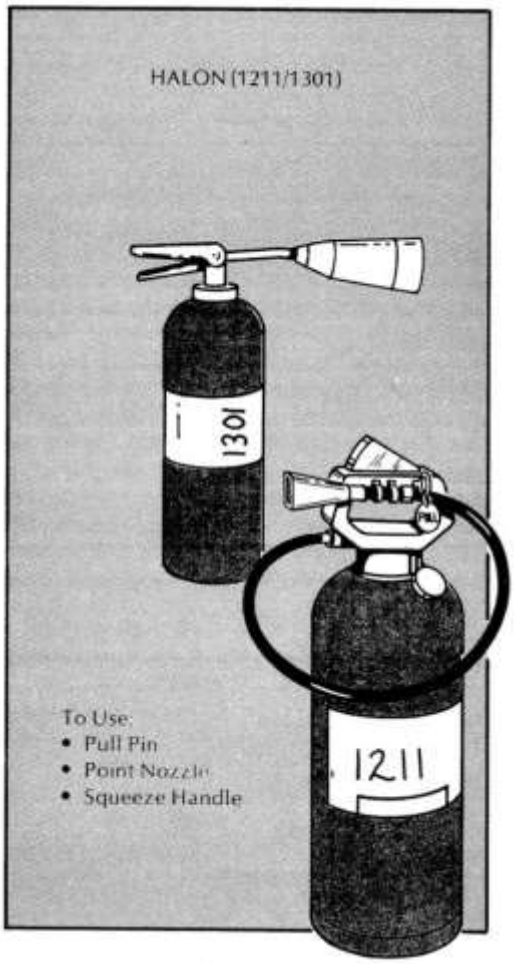
Halon Extinguishers

Halon 1211 extinguishers are available in several sizes; Halon 1301 in only one size. All the Halon extinguishers look alike and are used in the same way.

Bromochlorodifluoromethane (Halon 1211) extinguishers contain from 0.91 – 5.44 kg (2 – 12 lb) of extinguishing agent. Their horizontal range is from 2.7 – 4.6 m (9 – 15 ft), and they discharge their contents in 9 – 15 seconds. Halon 1211 is more effective than CO_2, leaves no residue and is virtually noncorrosive. However, it can be toxic, and its vapors should not be inhaled.

Bromotrifluoromethane (Halon 1301) is available only in a 1.1 kg (2 ½ lb) portable extinguisher. Its horizontal range is from 1.2 – 1.8 m (4 – 6 ft), and its discharge time is 8 – 10 seconds.

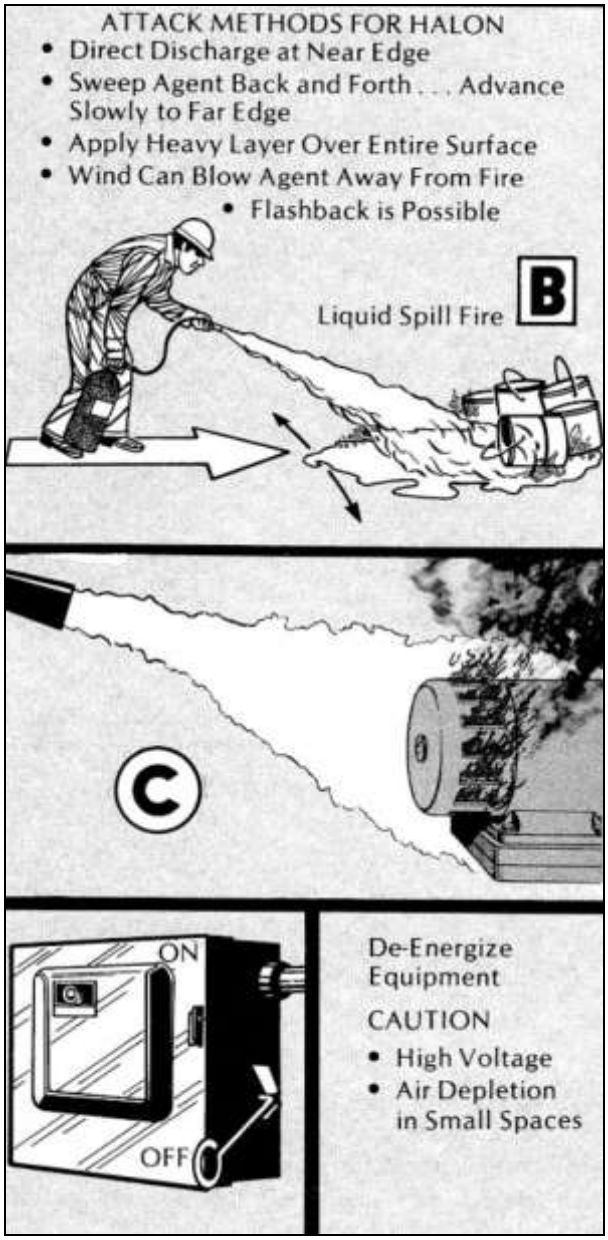
Both extinguishing agents are pressurized in a light weight steel or aluminum alloy shell. The cap contains the discharge control valve and discharge nozzle.



(Halon extinguisher for use on class B and class C fires.)

Operation

The extinguisher is carried to the fire, and the locking pin is removed. The discharge is controlled by squeezing the control valve-carrying handle. The Halon should be directed at the seat of a class B fire, and applied with a slow, side-to-side sweeping motion. It should be directed at the source of a class C fire.



(Operation of Halon extinguishers.)

2.6. Entering and passing through, with lifeline but without breathing apparatus, a compartment into which high-expansion foam has been injected

Lifeline

For each breathing apparatus a fireproof lifeline of at least 30 m in length shall be provided. The lifeline shall successfully pass an approval test by statistical load of 3.5 kN for 5 min without failure. The lifeline shall be capable of being attached by means of a snap-hook to the harness of the apparatus or to a separate belt in order to prevent the breathing apparatus from becoming detached when the lifeline is operated.

Lifeline Signals between Wearer and Tender

Tender to Wearer	
Pulls on line	*Meaning*
1	Are you all right?
2	Advance.
3	Back out.
4	Come out immediately.
Wearer to Tender	
Pulls on line	*Meaning*
1	I am all right.
2	I am going ahead.
3	Take up my slack.
4	Send help.

2.7. Fight fire in smoke-filled enclosed spaces wearing self-contained breathing apparatus

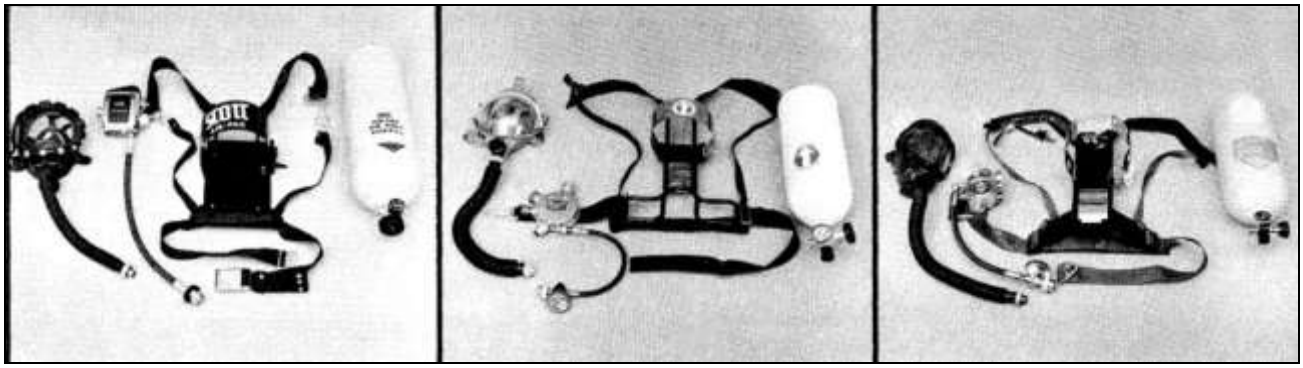
Although the air encountered at a fire is hot, contaminated by smoke and toxic gases, and deficient in oxygen, crewmen must enter this hostile environment to fight the fire. Their problem is simple, direct and urgent – they must breathe.

Breathing apparatus is available in several types. Each type is effective if used properly, and each has certain advantages and disadvantages. However, no breathing apparatus provides complete protection against poisonous gases that are absorbed through the skin. Crewmen operating in atmospheres containing such poisons must wear special protective clothing.

Self-Contained, Demand-Type Breathing Apparatus

Demand-type breathing apparatus is being used increasingly aboard merchant ships. Its popularity stems from its convenience, the fact that it supplies the user with cool fresh air, the speed with which it can be put into service and its versatility.

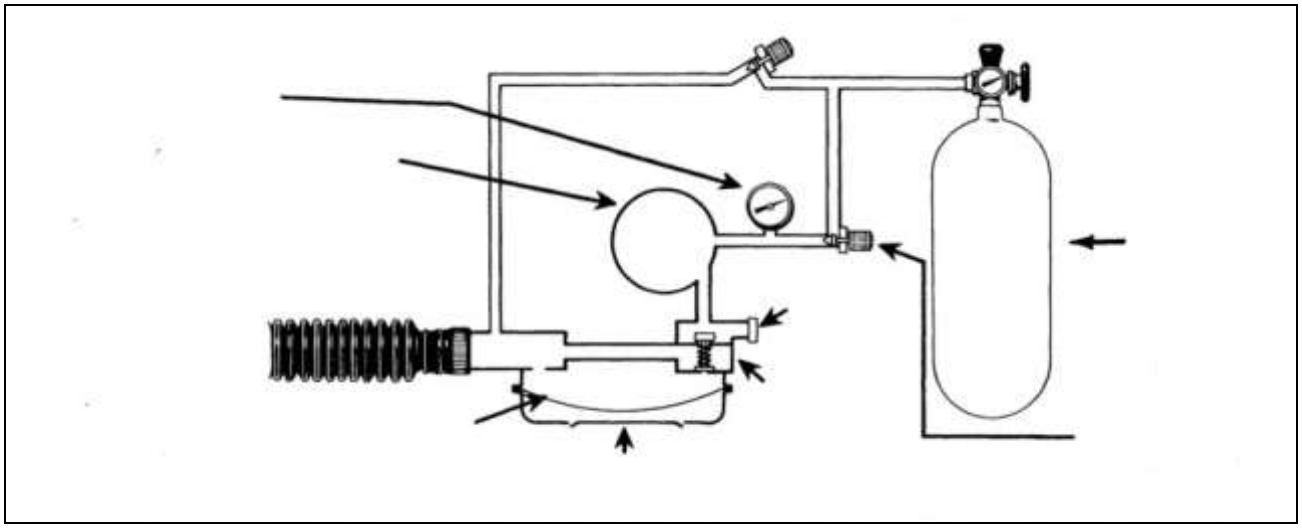
The demand-type apparatus gets its name from the functioning of the regulator, which controls the flow of air to the facepiece. The regulator supplies air "on demand"; i.e., it supplies the user with air when he needs it and in the amount his respiratory system requires. It thus supplies different users with air at different rates, depending on their "demand".



(Three self-contained, demand-type breathing units.)

Construction

The self-contained, demand-type apparatus consists of four assemblies: the facepiece with inhalation tube, exhalation valve, head harness and wide-vision lens; the regulator with pressure gauge, valves, high-pressure hose and alarm bell; the air cylinder with valve and pressure gauge; and the back pack or sling pack with adjustable harness.



(Schematic diagram of the self-contained, demand-type breathing apparatus.)

Donning

When a backpack unit has been properly stowed in its carrying case, it can be donned by the user without assistance. The unit should be stowed with the tank down, backpack up and harness straps fully extended. The high-pressure air hose should be lying along the front of the case, with the regulator at the front right-hand corner. The harness take-up straps must be attached to the chest straps. One should be to the left of the regulator, and the other should be attached to the metal buckle on the right chest strap. The waist straps should be rolled or folded neatly between the backpack and the cylinder valve. The facepiece should be placed between the air cylinder and the high-pressure air hose.

When the unit has been stowed as described, it is donned in this way:

1. Take a crouched position at the right end of the open case. With one hand, grasp the cylinder valve handle, and stand the cylinder and backpack on end. Check that the main-line valve (usually a yellow knob) is opened and locked in the open position. Check that the bypass valve (a red knob) is closed.
2. Check the cylinder gauge to be sure the cylinder is full. Then open the cylinder valve three turns. Now check the regulator gauge. At the first opportunity, check the gauges for accuracy and make any necessary repairs.
3. Grasp the backpack with one hand on either side, making certain that the harness straps are resting on the backs of your hands or arms. Now, from the crouched position, lift the unit over your head. Allow the harness to drop into position over your arms.
4. After the harness has cleared your arms, lean forward, still in the crouched position. Lower the unit to your back. While still in this position, fasten the chest buckle.
5. Stand, but lean slightly forward to balance the cylinder on your back. Then grasp the two underarm adjusting strap tabs. Pull the tabs downward to adjust the straps. To get the equipment as high on your back as possible, bounce the cylinder by moving your back and legs; at the same time, pull the tabs to position the cylinder.
6. Locate both ends of the waist harness, hook the buckle, and tighten the strap. Once this is done the equipment is secure, and you may stand erect.
7. Remove the facepiece from the case, and don it as described earlier. The donning of the facepiece should be practiced and mastered before this equipment is used.
8. Insert the quick connect coupling of the inhalation tube at the regulator and tighten it down. To conserve air, this step should be performed just before you enter the contaminated area.

The user's breathing should now feel and remain normal. If the unit does not supply sufficient air automatically, the main-line valve (yellow knob) should again be checked to ensure that it is fully opened and locked. The bypass valve (red knob) must be closed at all times; it is opened only if the regulator malfunctions. Then the air flows directly to the facepiece, bypassing the regulator. When the bypass valve must be opened, the main-line valve should be closed.

Removal and Re-stowing

The backpack unit should be removed as follows:

1. Disconnect the inhalation tube from the regulator.
2. With the tips of your fingers, release the self-locking buckles on the facepiece harness.
3. Make sure the face piece harness straps are fully extended. Pull the harness over the front of the facepiece, and place the facepiece in the carrying case.
4. Unbuckle the backpack waist belt, and extend the belt fully.
5. With your thumb and index finger, release and extend them fully.
6. Disconnect the chest buckle.
7. Get a firm grip on the body harness as if you were removing a vest.
8. Grasp the harness with your right hand above and as close to the regulator as possible. Then remove the equipment from your left shoulder and arm. By removing the equipment this way, you will keep the regulator from striking nearby objects, which could damage it.
9. Close the valve on the air cylinder. Remove the air pressure from the regulator by cracking the bypass valve open momentarily.

The unit should be thoroughly cleaned, and the air cylinder should be replaced immediately with a full cylinder. However, it may be necessary to re-stow the equipment before it is cleaned, and its cylinder is replaced.


Step 1

Step 1. Taking a position at the right end of the open case, grasp the cylinder valve handle with one hand and stand the cylinder and backpack on end.

Step 2. Check the cylinder gauge, open the valve, and compare the regulator gauge with the cylinder gauge (it should be within 200 psi).

Step 3. Lift the unit over your head, allowing the harness to drop down over your arms.

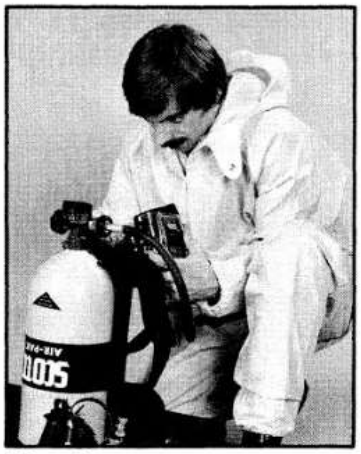
Step 4. Lower the unit onto your back and fasten the chest buckle.

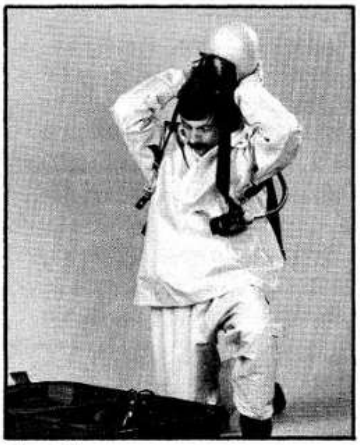
Step 5. Bounce the cylinder into position on your back and pull the underarm strap tabs to secure its position.

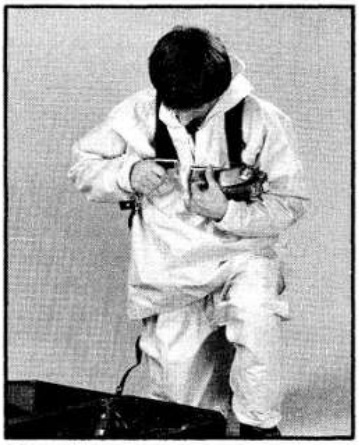
Step 6. Hook the waist harness buckle and tighten the strap.

Step 7. Don the facepiece.

Step 8. Tighten down the quick connect coupling of the inhalation tube at the regulator.


Step 2


Step 3


Step 4


Step 5


Step 8

(Proper stowage of the backpack unit allows one crewman to don the unit without assistance.)

Step 2

Step 2

Step 7

Step 8

Step 1. Disconnect the inhalation tube from the regulator.

Step 2. Release the self-locking buckles on the facepiece harness. Remove the facepiece.

Step 3. Pull the harness over the front of the facepiece and place the facepiece in the carrying case.

Step 4. Unbuckle the waist belt.

Step 5. Release and hold the underarm strap buckles.

Step 6. Disconnect the chest buckle.

Step 7. Hold the body harness and regulator in your left hand and slip your right arm out of the harness.

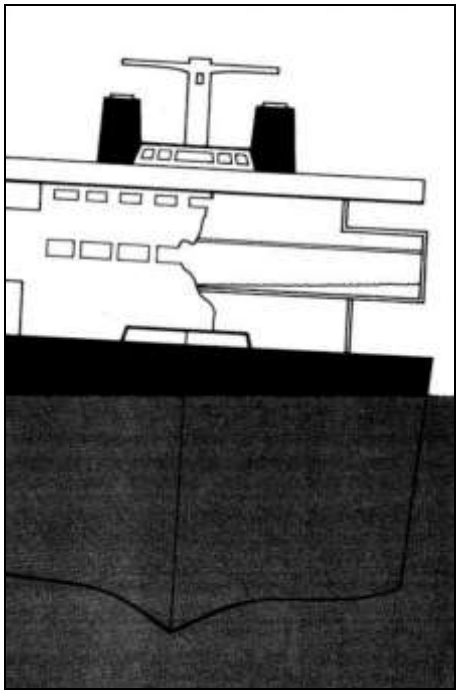
Step 8. Grasp the harness and regulator in your right hand and remove the unit from your left arm.

Step 9. Close the valve on the air cylinder and stow the equipment in the carrying case as detailed in the text.

(Removing the backpack unit.)

2.8. Extinguishing fire with water fog or any other suitable fire-fighting agent in an accommodation room or simulated engine-room with fire and heavy smoke

At sea the supply of water is limitless; however, moving the water is another matter. But even when water is available in huge quantities, it still must be used economically and wisely. If it isn't, its weight can affect the equilibrium of the ship. This is especially true if large amounts of water are introduced into, and remain at, a high point in the ship: The weight of the water raises the center of gravity of the vessel, impairing its stability. In many cases the vessel will list or even capsize. Water that is not confined but can run to lower portions of the ship may affect the buoyancy of the ship. Ships have capsized and sunk because excessive amounts of water were used during firefighting efforts.



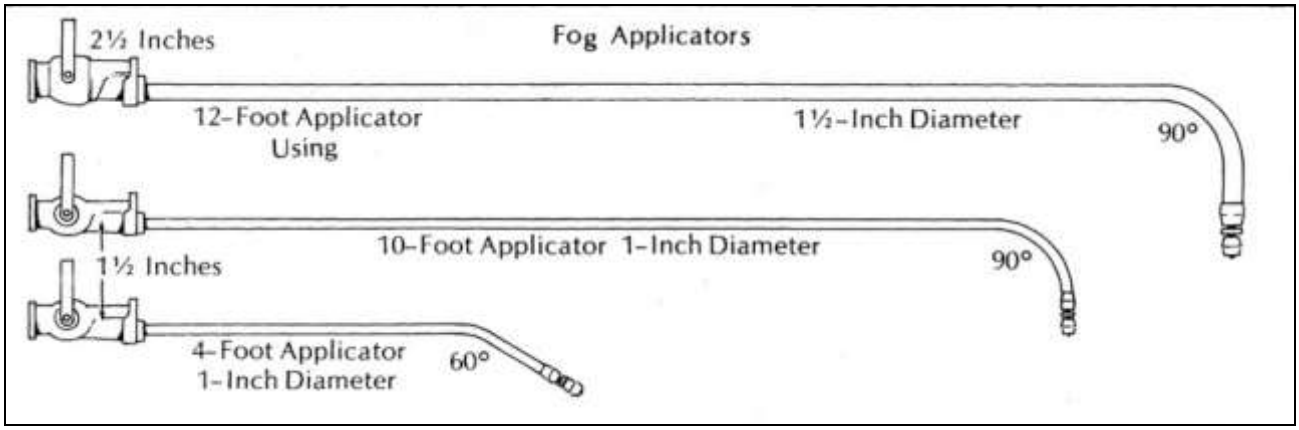
(Water confined high on the ship has a detrimental effect on the ship's stability.)

Low-Velocity Fog Streams

Low-velocity fog is obtained by using an applicator along with a combination nozzle. Applicators are tubes, or pipes, that are angled at 60° or 90° at the water outlet end. They are stowed for use with the low-velocity head already in place on the pipe. Some heads are shaped somewhat like a pineapple, with tiny holes angled to cause minute streams to bounce off one another and create a mist. Some heads resemble a cage with a fluted arrow inside. The point of the arrow faces the opening in the applicator tubing. Water strikes the fluted arrow and then bounces in all direction, creating mist.

For 3.8 cm (1 ½ - in.) nozzles, 1.2 m (4-ft) 60° angle and 3 m (10-ft) 90° angle applicators are approved for shipboard use. For 6.4 cm (2 ½ - in.) nozzles, 3.7 m (12-ft) 90° angle applicators are approved. Other lengths with different angles are sometimes found. The 1.2 m (4-ftt) applicator is

intended for the 3.8 cm (1 ½ - in.) combination nozzles fitted in propulsion machinery spaces containing oil-fired boilers, internal combustion machinery or fuel units.



(Low-velocity fog applicators approved for shipboard use.)

Low-velocity fog is effective in combating class B fires in spaces where entry is difficult or impossible. Applicators can be poked into areas that cannot be reached with other types of nozzles. They are also used to provide a heat shield for firefighters advancing with foam or high-velocity fog. Low velocity fog can be used to extinguish small tank fires, especially where the mist from the applicator can cover the entire surface of the tank. However, other extinguishing agents, such as foam and carbon dioxide, are usually more effective.

Limitation of Fog Streams

Fog steams do not have the accuracy or reach of straight streams. Improperly used, they can cause injury to personnel, as in a blowback situation. While they can be effectively used on the surface of a deep-seated fire, they are not as effective as straight streams in soaking through and reaching the heart of the fire.

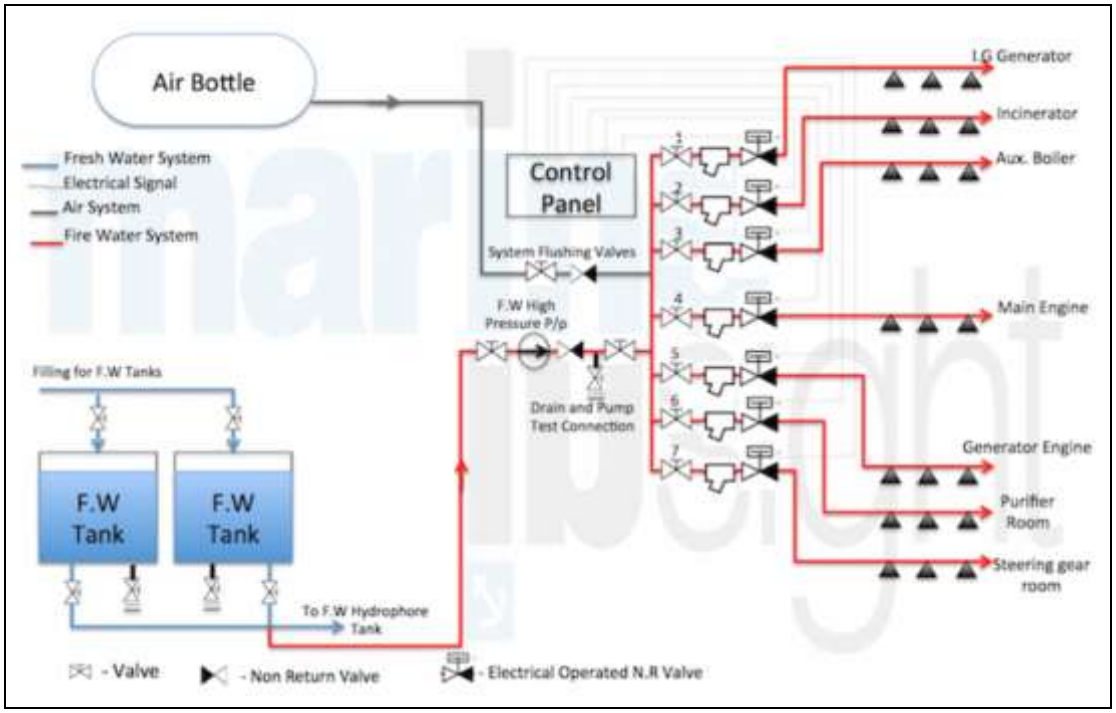
Hyper Mist System

The hyper mist or high pressure fog fire fighting system is installed for all important ship's machinery systems in the engine room (ME. AE, Purifier, Boiler etc.). The high-pressure water mist/fog system provides water mist protection during emergencies to engine room areas and machinery spaces. This system is independent of any other fixed fire fighting system such as foam or CO2 system.

Following are the most common areas covered by water mist system:

- Incinerator room
- Auxiliary boiler room
- Auxiliary generators
- Main engine cylinder head platform

- Purifier room
- Inert gas generator room
- Steering gear room



A fresh water pump takes suction from fresh water tank to supply high-pressure water to the sprinkler system. Each area is isolated by valves, which can be opened during emergency situations involving fire. The system is kept at constant stage of readiness.

The MICROFOG Fire Extinguishing System has the following effects:

- Cooling effect (quick cooling by evaporation latent heat)
- Oxygen replacement effect (replacement of air with water vapor generated in a large quantity, and absorption of radiation heat)
- Shut-off effect (the floating fog forming walls of water)
- Smoke eliminating effect (the floating smoke particles being adsorbed and settled by the fog)

High-pressure water is injected through a special nozzle working within pressure range of 4 to 10 MPa (depending upon the design of the system), which breaks the water droplets into fine mist. The diameter of the water mist particle range from 50 to 200 µm which improves the fire extinguishing effect and efficiency of the system. The distance between any two nozzles is very critical as area covered by one nozzle must be such that no space is left unsprayed in the fire affected area.

Operating Procedure:

The system start select switch on the main control panel must always be set to AUTO & MANUAL position for automatic start. (The automatic activation with the fire alarm system is possible only in this mode.)

Starting:

Automatic Start: Water mist system will be automatically released into the protected area where fire is detected by the fire alarm system (both smoke and flame detectors), and an audible and visible alarm is activated in that protected area.

Manual Start: Water mist system can be started manually from the control panel and from the local points whenever needed, independent of the fire alarm system.

The following conditions must be maintained at all times to ensure hyper mist system is on stand by for operation:

1. Sufficient water level must be retained in the fresh water tank
2. Make sure the power supply is available.
3. The fire alarm system must be in operation.
4. Drain and test valves must be closed.
5. The area around the hyper mist water pump must be clear of any obstructions.

Stopping:

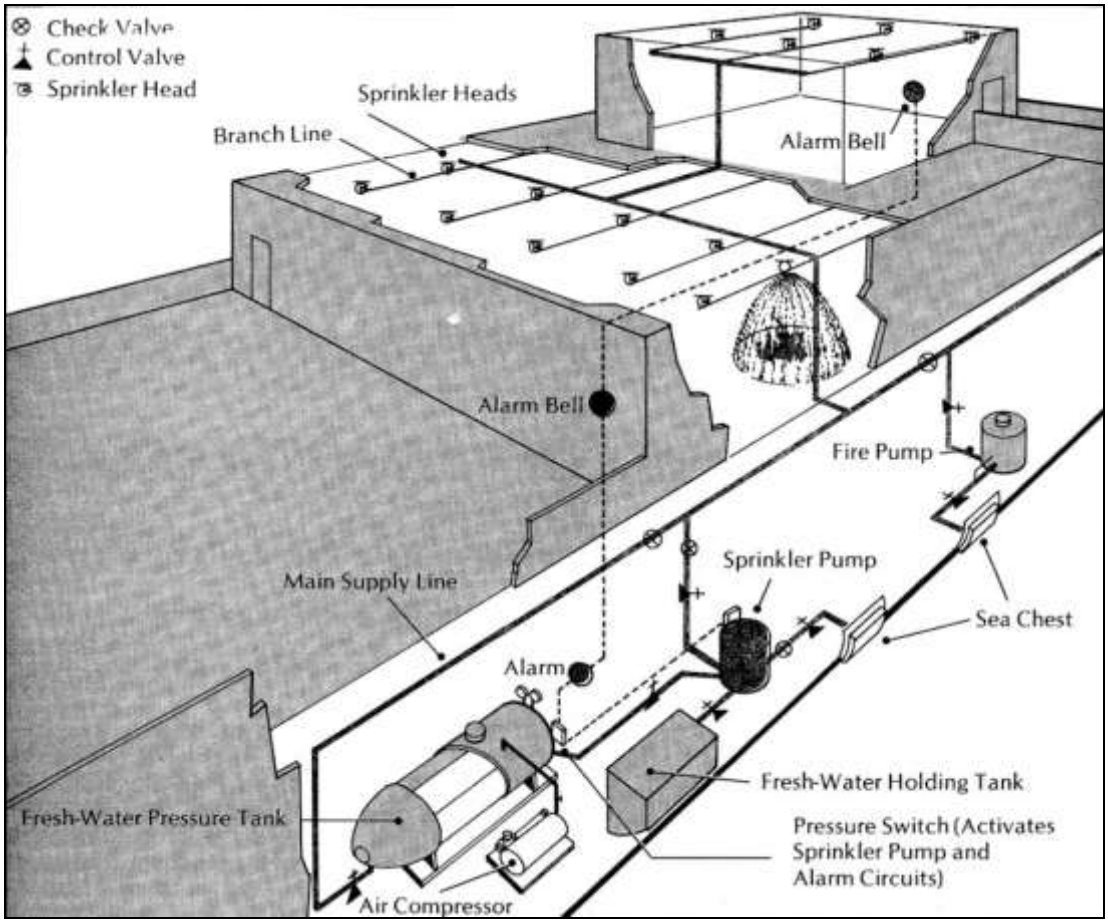
After confirming extinction of a fire, the water mist system can be stopped manually by cancelling the signal from the fire alarm system and pressing the STOP button on the control panel or local point.

Water Sprinkler System

Sprinkler systems may extinguish fire in various spaces. However, their primary function is to protect the vessel's structure, limit the spread of fire and control the amount of heat produced. They also protect people in these areas and maintain escape routes.

Automatic Sprinkler System

The sprinkler system is an automatic fire detecting, alarm and extinguishing system which is constantly on guard to deal quickly & effectively with the outbreak of fire that may occur in accommodations and other spaces.



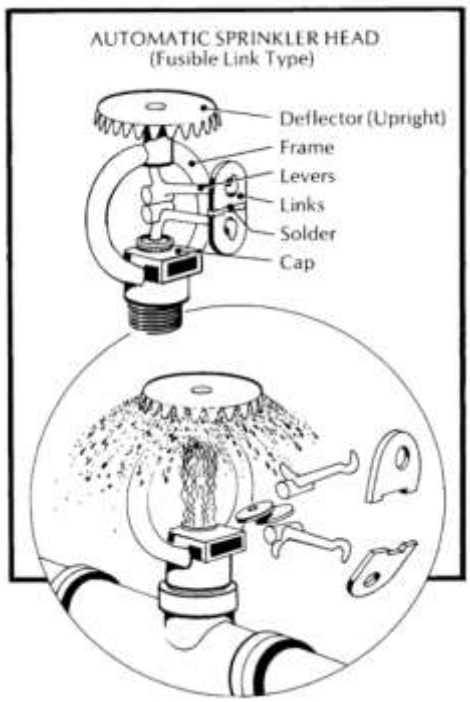
(Shipboard automatic sprinkler system. The sprinkler pump is started automatically by a switch in the pressure tank.)

This system consists of a pressure water tank with water pipes leading to various places in the compartments. These water pipes consist of sprinkler head which comes in operation when there is an outbreak of fire.

The pressurized water tank is half filled with fresh water through fresh water supply connection. Compressed air is delivered from the electrically operated compressor or from the air bottle which raises the pressure to predetermined level.

The pressure in the tank is such that it would be able to deliver pressure at highest sprinkler head in the system and is not less than 4.8 bars.

The sprinkler heads are grouped into different sections with not more than 200 sprinkler head in each section. Moreover, each section has its own alarm system which gives alarm on operation.



*(**A.** Heat from fire melts solder, allowing links to separate. **B.** The lever come apart and **C.** water pressure pushes the valve cap off the sprinkler outlet. **D.** Water flows up against the deflector, forming a spray that falls onto the fire.)*

The sprinkler head consists of a quartzoid bulb which bursts when the temperature increases beyond the limit and the water starts flowing from the sprinkler head. These quartzoid bulbs are color coded in red, yellow and green. The rating of red bulb is 68° C, yellow is 80°C and green is 93°C.

Each sprinkler head covers a deck area of 16 m^2 and the flow of water in each one of them should be at least 5 liters/minute as per the regulation of SOLAS.

When the sprinkler head bursts and comes into operation, the non-return valve in the line opens and water starts flowing. Due to this flow there is a drop of pressure in the line and the alarm activates for the particular section, indicating fire in the section.

This system is also connected to sea water pump which can supply water to the system in case the water in the pressure tank is used up.

Various alarms and pressure switches are provided in the system for maintenance and check of alarms and activation of sea water pump by isolating the system.

The sprinkler system is generally used in accommodation, paint room and other places on the ship.

Manual Sprinkler Systems

The manual sprinkler system differs from automatic systems in two respects: 1) the sprinkler heads are normally open and 2) the piping does not normally contain water. Water is supplied to the manual system by the ship's fire pumps; no pressure tank is required.

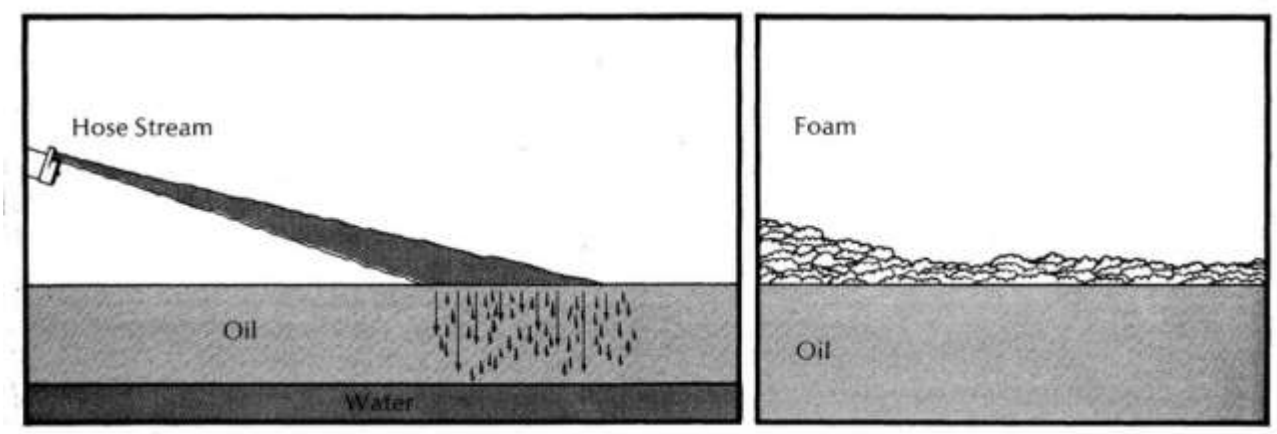
The system is composed of the piping, open sprinkler heads, control valves, fire pumps and water supply. It may be used along with a fire detection system. However, the fire detectors do not activate the system automatically; they sound alarms so that the system can be put into action manually.

When fire is discovered or the alarm is sounded, the fire pumps are started. A control valve is manually opened to allow water to flow into the system. The control valve is located either at the fire-pump manifold or near (but not in) the protected area. Water is discharged out of all the sprinkler heads, so the entire area is covered with a large volume of water capable of knocking down a sizable fire.

2.9. Extinguishing oil fire with fog applicator and spray nozzles, dry chemical powder or foam applicators

Foam

Foam is a blanket of bubbles that extinguishes fire mainly by starvation. The bubbles are formed by mixing water and foam-making agent (foam concentrate). The result is called a foam solution. The various foam solutions are lighter than the lightest of flammable oils. Consequently, when applied to burning oils, they flat on the surface of the oil.



*(**A.** Water is heavier than oil and sinks below its surface. **B.** Foam is lighter than oil and floats on its surface)*

Firefighting foam is used to form a blanker on the surface of flaming liquids, including oils. The blanket prevents flammable vapors from leaving the surface and prevents oxygen from reaching the fuel. Fire cannot exist when the fuel and oxygen are separated. The water in the foam also has a cooling effect, which also gives foam its class A extinguishing capability.

The ideal foam solution should flow freely enough to cover a surface rapidly, yet stick together enough to provide and maintain a vapor-tight blanket. The solution must retain enough water to provide a long-lasting seal. Rapid loss of water would cause the foam to dry out and break down (wither) from the high temperatures associated with fire. The foam should be light enough to float on flammable liquids, yet heavy enough to resist winds.

The quality of a foam is generally defined in terms of its 25% drainage time, its expansion ratio and its ability to withstand heat (burnback resistance). These qualities are influenced by

- The chemical nature of the foam concentrate
- The temperature and pressure of the water
- The efficiency of the foam-making device

Foams that lose their water rapidly are the most fluid. They flow around obstructions freely and spread quickly. Such foams would be of use in engine room or machinery space fires; they would be able to flow under and around machinery, floorplates and other obstructions.

There are two basic types of foam -- chemical and mechanical.

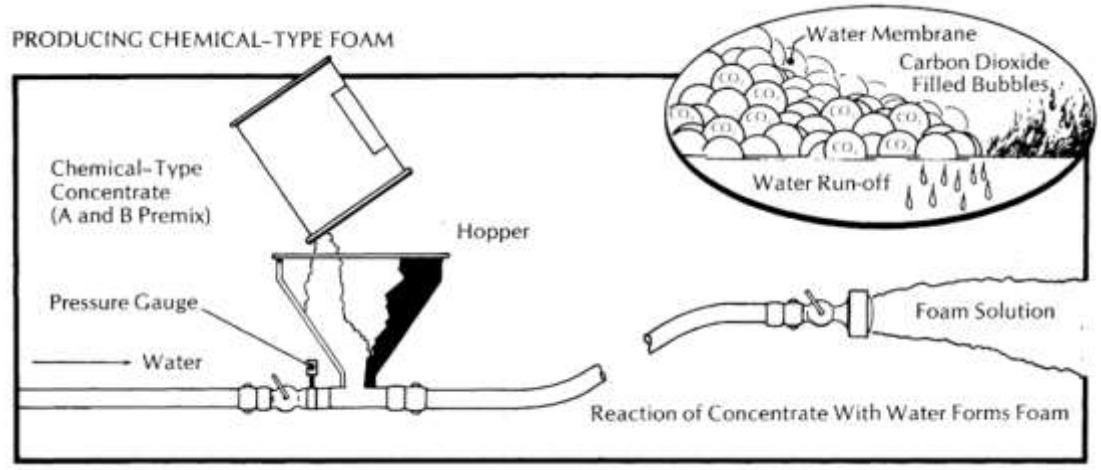
Chemical Foam

Chemical foam is formed by mixing an alkali (usually sodium bicarbonate) with an acid (usually aluminum sulfate) in water. When chemical foam was first introduced, these substances were stored in separate containers; they are now combined in a sealed, airtight container. A stabilizer is added to make the foam tenacious and long lived.

When these chemicals react, they form a foam or froth of bubbles filled with carbon dioxide gas. The carbon dioxide in the bubbles has little or no extinguishing value. Its only purpose is to inflate the bubbles.

The premixed foam power may be stored in cans and introduced into the water during firefighting operations. For this, a device called a foam hopper is used. Or, the two chemicals may be premixed with water to form an aluminum sulfate solution and a sodium bicarbonate solution. The solutions are then stored in separate tanks until the foam is needed. At that time, the solutions are mixed to form the foam.

Many chemical foam systems are still in use, both aboard ship and in shore installations. However, they are being phased out in favor of the newer mechanical foam or as it is sometimes called, air foam.

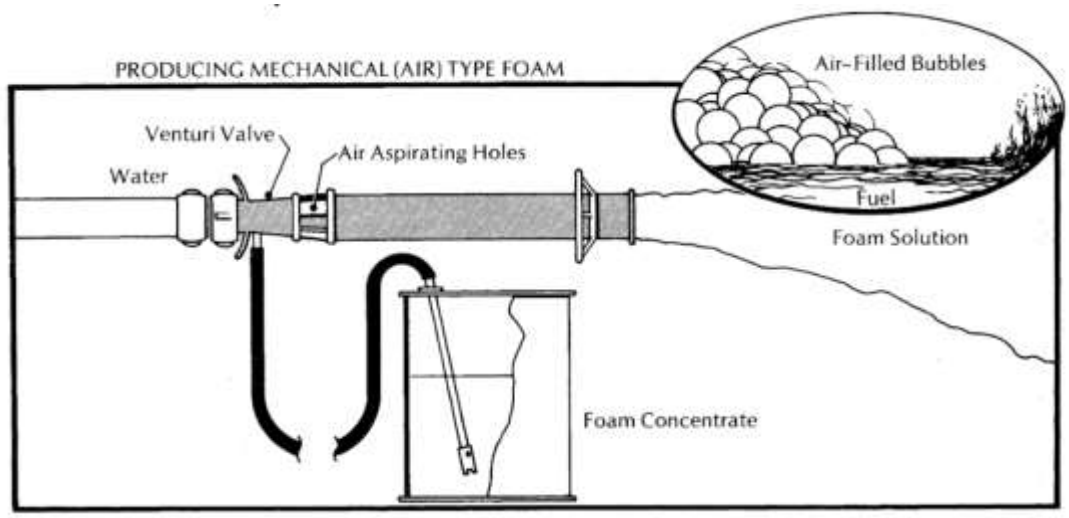


(Production of chemical foam with a foam hopper.)

Mechanical (Air) Foam

Mechanical foam is produced by mixing a foam concentrate with water to produce a foam solution. The bubbles are formed by the turbulent mixing of air and the foam solution. As the name air and foam implies, the bubbles are filled with air. Aside from the workmanship and efficiency of the equipment, the degree of mixing determines the quality of the foam. The design of the equipment determines the quantity of foam produced.

There are several types of mechanical foams. They are similar in nature, but each has its own special firefighting capabilities. They are produced from proteins, detergents (which are synthetics) and surfactants. The surfactants are a large group of compounds that include detergents, wetting agents and liquid soaps. Surfactants are used to produce aqueous film-forming foam commonly referred to as AFFF.



(Production of mechanical (air) foam by mixing foam concentrate with water and air.)