# Shipboard Fire-Fighting on Museum Submarines

Draft version

# I. Purpose

The purpose of this document is to advise submarine museums on issues surrounding fires on board museum ships, fire prevention and fire fighting onboard museum submarines. The emphasis is on prevention and safety.

This document should be construed as advisory only and is intended to generate thought and discussion; this document may be incomplete and may be inaccurate in places. The author recommends that you consult with professional fire safety officials in your local area before placing any part of this plan into effect. **Your use of this document constitutes release of the author from any liability resulting from your use.**

# II. Shipboard Environment

Submarines are obviously a confined environment. In addition to tight quarters, access to compartments is restricted to water tight doors or possibly a hatch. Modification of access is not desirable.

Because of the restrictive nature of the compartments, several elements which are not normally considered become more important. There are six ways that fire can be dangerous to humans: Oxygen Depletion, Flames, Heat, Fire Gasses, Smoke and Structural Reduction.

## A. Oxygen Depletion

As fires burn, they consume oxygen. Oxygen levels below 10% are considered deadly to humans; below about 14% is dangerous. During and immediately after a fire, oxygen levels in the affected compartment may not be able to sustain life. During the fire, oxygen depletion will assist with fire fighting, so once technique is to ensure that no new air is introduced to the compartment and that the compartment isolated.

## B. Flames

Contact with flames can result in burns. If severe enough, such burns can be fatal.

## C. Heat

Similar to direct exposure, heat can also cause burns. However it can additionally heat the air and cause dangerous breathing conditions, even with a clean air supply. With excessive heat, firefighters may not even be able to enter a compartment or may need to use a fog shield.

## D. Fire Gasses

The toxicity of gasses from fires can be normal off gasses such as carbon monoxide or gasses resulting from the combustion of the fuel. Regardless of the type and potential effect of the gasses, the compartment must be ventilated prior to reentry.

## E. Smoke

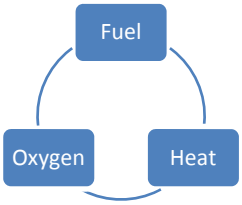
Smoke is generally considered the most dangerous part of a fire, producing more fatalities that other hazards. In a submarine, smoke will build quickly and will prevent escape.

### F. Structural Reduction

Structural reduction is not a large threat on board submarines due to the steel construction of the ship. Any fire producing enough heat to compromise the steel construction would very likely result in the complete loss of the ship.

## III. Nature of Fire

Fire is chemical reaction produced by sufficient heat causing the consumption of a fuel in the presence of oxygen. What we call fire is the self-sustaining combustion where the heat created by the combustion is sufficient to cause further combustion. The three components of fire are the fuel, oxygen and heat.




Removal of any one of these components will stop the fire. As most people think of fires being put out with water, the water is primarily removing heat, not smothering the fire. Once the heat goes below the threshold to sustain the fire, the fire goes out.

If the conditions are right, it is possible for a fire to restart once the removed element is restored. The classic example of this is a CO2 extinguisher. When used, it removes the oxygen from the area of the fire and extinguishes it. However, it does not remove the fuel or the heat. Shortly after the CO2 extinguisher is removed, natural air circulation reintroduces oxygen to the site and the fire restarts. Removal of the oxygen can also reduce the severity of the fire. With less oxygen in the air, a fire will not burn as vigorously.

### A. Types of Fires

#### 1. Alpha

The burning of solids through combustion. Examples of fuels are wood, paper, cloths or upholstery.

#### 2. Bravo

The burning of liquids through combustion. A Bravo fire is liquid based, such as gasoline, paint, diesel or oil.

#### 3. Charlie

Charlie fires are electrical in nature. The most effective means of controlling a class-C fire is to remove the power; 90%+ of class-C powers go out once the power is removed.

#### 4. Delta

Class-D or Delta fires are special fires which cannot be expected to be controlled through normal means. The classic example is a magnesium fire, where the metal starts combustion at room temperature. Class D fires are not expected on board a submarine.

## IV. Shipboard Systems

For the purpose of emergency response in the event of a fire, certain shipboard systems should be installed in the museum.

## A. Emergency Lighting

Emergency lights are critical. If lights are lost, the submarine will become extremely dark; this has happened in non-emergency situations. Evacuation will be very difficult in dark conditions.

Emergency lighting should be….

## B. Ventilation

Ventilation on board is limited in capabilities. Compartment bulkhead flappers can be isolated, hatches can be open or shut and ventilation fans can be secured. Consideration should be developed as to how to control the ventilation flow for each compartment on board the submarine. Portable fans can be used at hatch access points to create air flow without providing the affected compartment with fresh air. As an example, with a fire in the control room of a Tench class, the amidships hatch in crews mess could be opened. With the control room WTD and bulkhead flapper shut, a high volume fan exhausting from the hatch would draw fresh air from aft, providing clear air nearly up to the control room.

## C. Extinguishers

There are three primary types of fire extinguishers exist

### 1. AFFF

An AFFF (Aqueous Film Forming Foam) extinguisher works by smothering an area, removing oxygen and providing fair cooling. AFFF extinguishers are water based and should not be used on energized electrical fires. AFFF should not be mixed with other types of fire suppression since they will remove or dampen the foam which provides the primary protection of the extinguisher.

### 2. CO2

CO2 extinguishers work by displacing oxygen with carbon dioxide and provide very slight cooling capability. Because the extinguisher is gas based, it is commonly used on class-C electrical fires. Care should be taken to ensure that the horn does not touch the electrical system since frost formed on the horn can conduct electricity even if the horn itself is non-conductive. Although present on submarines, CO2 extinguishers should be not be relied upon for non-electrical fires because they are simply not very effective.

### 3. PKP

Purple K Powder (potassium bicarbonate) interrupts the fire by suspending fine particles of dust in the air and preventing the interaction of oxygen and fuel. They do not provide cooling or smothering of the fire. PKP extinguishers can be used on class Bravo and Charlie fires. They are generally not preferred due to the corrosive nature of the powder and the fact that the suppression effect dissipates over time.

### 4. Other

Fire suppression systems targeting oxygen such as Halon or oxygen depletion systems are not recommended for installation onboard museum submarines. Although effective in extinguishing fires, these systems represent a danger to humans that cannot be justified in a limited access environment.

If a permanently installed system is required, a modern sprinkler system with a manual start should be used. The heads can be covered with a light paper to avoid disrupting the interpretation of the

submarine; if the sprinkler system is engaged, the paper will quickly be dissolved and blasted out of the way. The sprinkler system should be fed to an outside control location and preferably controlled so it can turn on sprinklers individual compartments. Although it seems strange to have a water dispersion system in a museum, submarines were built for marine environments and most components can withstand water. Prior to using an installed sprinkler system the power to the entire ship, including and DC electrical, should be isolated.

### D. Smoke Hoods

The value of smoke hoods cannot be under estimated. At a minimum, a smoke hood should be provided for the docent's use in the event of a fire. The smoke hood should be able to last some multiple over the time it takes to walk through the boat and ensure all visitors have evacuated.

### E. Emergency Lights

All submarines should have emergency lights installed on board.

### F. Electronic Detectors

Smoke, Fire, CO2, etc.

### G. Fire Hoses

Most museums do not supply on site fire hoses. If a fire is large enough to require a fire host, it represents a serious danger and most volunteers should not attempt to fight. Fire hoses should not be provided on board museum submarines except as historic displays UNLESS the volunteer crew is well staffed and well trained in their use.

### H. Fire Sprinkler System

A good alternative to fire hoses is a sprinkler system. In particular, they should be considered for bilge areas, especially in the engine rooms.

## V. Preparation – What to do before a fire.

### A. Local Fireman orientation

Prior to a fire occurring, the local fire department should be shown and escorted through the boat. If possible, this should be done twice, the second time with only emergency lights on. This should reoccur annually as new personnel rotating into the fire department.

If any local volunteers have professional firefighting experience, they should be considered as potential adjuncts to the local fire crew. Coordinate with your local fire department so they can understand and trust your abilities. The time to build this bridge is before the fire happens. Having an individual who knows both the state of the boat and how to coordinate with a professional fire crew could be the difference between saving the boat and or not.

### B. Diagrams

Diagrams of the ship and compartments should be available in hard copy topside for reference. When the fire crew arrives, it is very simple to use these to point to where the fire is.

### C. Qualifications

Personnel working on the museum, either as volunteers or paid staff members should be fully qualified on how to operate and reset equipment on board.

- Location of Topside Electrical isolation
- Location of alarm isolation, including bilge alarm.
- Phone numbers for fire, police and museum staff

### D. Documentation

No matter how well you think you know your boat, it is inevitable that you will not remember everything. There is no substitution for documentation of the material state of the ship. After a fire, this documentation will be invaluable in restoring the damaged compartment to its original state. At the very least, walk through each compartment with a video camera and document what it looks like. This way, even if the entire ship is lost, a video documentation can be preserved.

## VI. What to do in a Fire

What actions should be taken in a fire are governed first by safety of personnel, then by the safety of the ship and finally to preserve the historic fabric. Some levels of minimum risk are acceptable, but personnel should never place themselves at risk

### A. Actions

#### 1. Pass the word

In the event of a fire, the first action should be to pass the word and begin evacuation.

#### 2. Evacuate

The first action of all individuals should be to evacuate. One person should be designated to walk through the boat (safety permitting) and ensure all visitors are evacuated.

#### 3. Muster

A topside muster location should be clearly designated. All museum personnel should muster there. Since boats will probably not require volunteers and employees to check on and off the boat, people mustered will have to manually check that all personnel known to be on board are accounted for. Do no reenter the boat to search for a suspected missing crew member.

#### 4. Coordinate with Fire crew

Stand by with the map of the boat and indicate to the fire officer in charge where the fire is. Offer advice on the best avenue of approach and stand out of the way.

#### 5. Fight ONLY if Safe and Possible.

If the fire is small, it may be possible to fight the fire and extinguish it before it becomes large. The decision is in the hands of the individual seeing the fire and the local conditions.

### B. Atmosphere

#### 1. Oxygen

The atmosphere inside the submarine must be kept in mind. A key point is always to avoid introducing a flow of air to the fire; fires will burn less vigorously with lower oxygen levels. As fires consume oxygen, the air will become less able to support life. A fire will continue burning at oxygen levels that do not support human life.

#### 2. Smoke

Smoke is a primary concern; a compartment will fill VERY quickly; in less than a minute depending on the source of the fire. To control smoke, the compartment should be isolated and a ventilation plan be already in place for each compartment.

### C. Veterans

Submarine and Navy veterans may require special training for a fire situation. They must suppress their training and instincts to fight the fire and evacuate instead; for many veterans, this can be difficult. To help them understand this, remind them they are not backed up by a crew; there will not be a fire hose team at the scene in 30 seconds to relieve them. If a fire cannot be put out with two extinguishers or is not being contained, the veteran must evacuate to avoid becoming a casualty of the fire. Their life is worth more than the entire ship.

## VII. After a Fire

### A. Atmosphere

A critical concern immediately after the fire is the atmosphere inside the boat and specifically inside the compartment. Do not re-enter the compartment until you are sure the gas levels are in the range to support human life; oxygen is not primarily a concern because if there was enough oxygen for a fire to burn, there is enough to sustain human life. Of a greater concern are carbon dioxide and carbon monoxide as well as side effect gasses from the combustion process. Portable atmosphere sampling kits are available.

### B. Dewatering

Water used to extinguish a fire will wind up in the bilge. In order to continue fighting a fire, it could become necessary to dewater the compartment at the same time the fire casualty is being fought. Sufficient power is probably not available for the ship's drain pump and power may not even be available on board. An externally power drain pump, such as a Navy P-250, should be available if needed.

Consideration should be given to where the water will be pumped. Waterborne ships cannot discharge overboard except in extreme emergencies.

### C. Flooded Equipment

After a fire, equipment in the affected compartment should be allowed to completely dry prior to re-energizing. An understanding of how to control the electrical system to isolate compartments should be developed prior to a casualty.

### D. Restoration

## VIII. Fire Prevention

Fire prevention starts with recognition of fire hazards. With most museum ships being static displays with few operational systems, recognition of most fire hazards should be relatively simple.

### A. Hotwork

If it is necessary to perform hot work, complete attention must be paid to the conditions surrounding the work site. Any combustible material must be removed, including material on the far side of any affected bulkheads. A fire watch must be stationed with an appropriate (water based) fire extinguisher.

### B. Oily Rags

Oily rags must never be left on board. If left in a pile, the heat produced by decomposition can cause spontaneous combustion.

### C. Causes of Electrical Fires

Why do electrical fires happen and what can be done to prevent them? Good electrical house keeping, professional evaluation prior to using period circuits, minimize use of equipment on board.

## Checklist

Smoke alarms
Emergency lights
    Power
Electrical power isolation
Ventilation lineup
Smoke hoods
Fire extinguishers
    Type
    Expiration, charged
Fire department orientation
    annual
Post work inspections

Bibliography

Flammability Handbook for Plastics, By Carlos J. Hilado,
http://books.google.com/books?id=fKnNdVdjFOsC&pg=PA37&lpg=PA37

Escape from Fire: Once you're out, stay out, FEMA.
http://www.usfa.dhs.gov/downloads/pdf/publications/fa-246-508.pdf

Fire Fighting Fundamentals,
http://www.globalsecurity.org/military/library/policy/navy/nrtc/14057_ppr_ch4.pdf