



Yacht Fire Safety

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PAR for the course...

Be Prepared

Be Alert

Be Ready

“... our first priority is to stay out of trouble, and second priority to get ourselves out of trouble, and only a very distant 3rd to call someone to come get us.” E. Starzinger

<http://www.cruisersforum.com/forums/f13/are-epirbs-dead-146136-7.html>


Hot Topics

- Statistics
- Fires
- Origin & Cause
- Prevention
- If a fire occurs... Be Prepared!

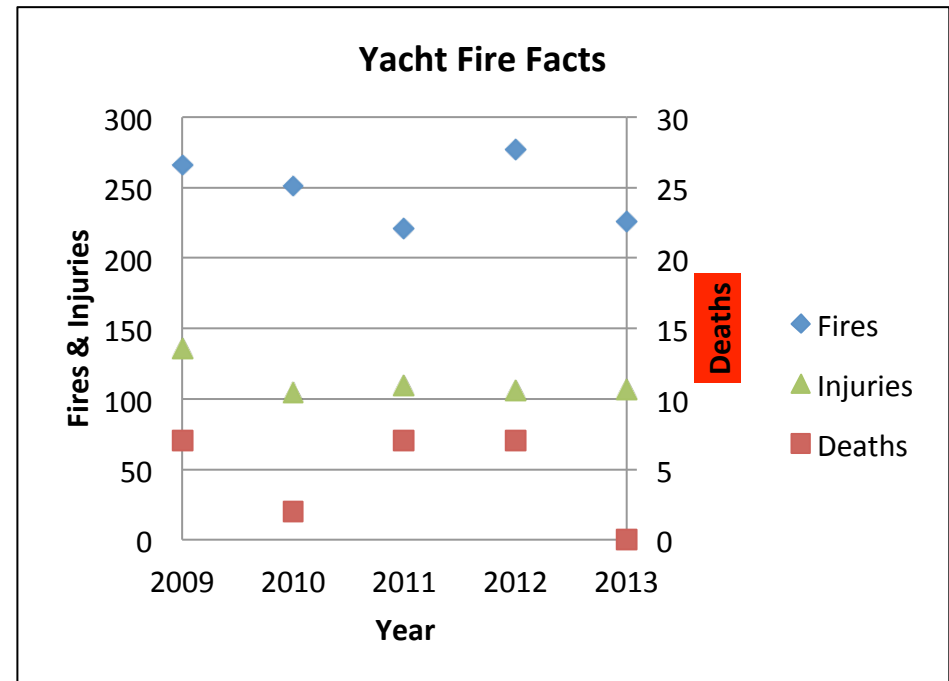


Yacht Fire Statistics

Table 17 • FREQUENCY OF EVENTS IN ACCIDENTS & CASUALTIES NATIONWIDE



2013	First Event in an Accident	Second Event in an Accident	Third Event in an Accident	Total Times Event Occurred in all Accidents	Deaths Associated with Event in all Accidents	Injuries Associated with Event in all Accidents	Damages Associated with Event in all Accidents
Capsizing	256	262	41	559	175	333	\$4,568,312
Carbon monoxide poisoning	11	0	0	11	4	31	\$0
Collision with fixed object	427	64	4	495	60	291	\$4,778,809
Collision with floating object	43	2	0	45	2	17	\$455,023
Collision with commercial vessel	19	1	0	20	5	6	\$270,470
Collision with governmental vessel	9	1	0	10	0	10	\$86,128
Collision with recreational vessel	947	52	3	1002	37	656	\$6,495,709
Collision with submerged object	145	1	0	146	10	60	\$3,022,991
Departed vessel	85	34	11	130	66	61	\$326,635
Ejected from vessel	167	541	319	1027	268	925	\$6,463,758
Electrocution	4	0	0	4	2	2	\$5,000
Fall in vessel	136	286	48	470	22	655	\$4,069,745
Falls overboard	281	31	1	313	156	158	\$89,135
Fire/explosion (fuel)	137	6	0	143	0	101	\$6,309,934
Fire/explosion (non-fuel)	73	1	0	74	0	3	\$5,905,767
Fire/explosion (unknown origin)	9	0	0	9	0	3	\$370,900
Flooding/swamping	430	228	54	712	94	249	\$12,762,290
Grounding	399	50	12	461	21	278	\$5,771,281
Person struck by boat	26	207	18	251	24	309	\$653,828
Person struck by propeller	58	85	31	174	23	162	\$160,560
Sinking	0	90	56	146	20	23	\$5,077,352
Skier mishap	332	9	0	341	12	365	\$1,110
Sudden medical condition	4	3	1	8	5	3	\$0
Other	57	9	0	66	1	59	\$436,500
Unknown	7	0	0	7	7	1	\$3,000



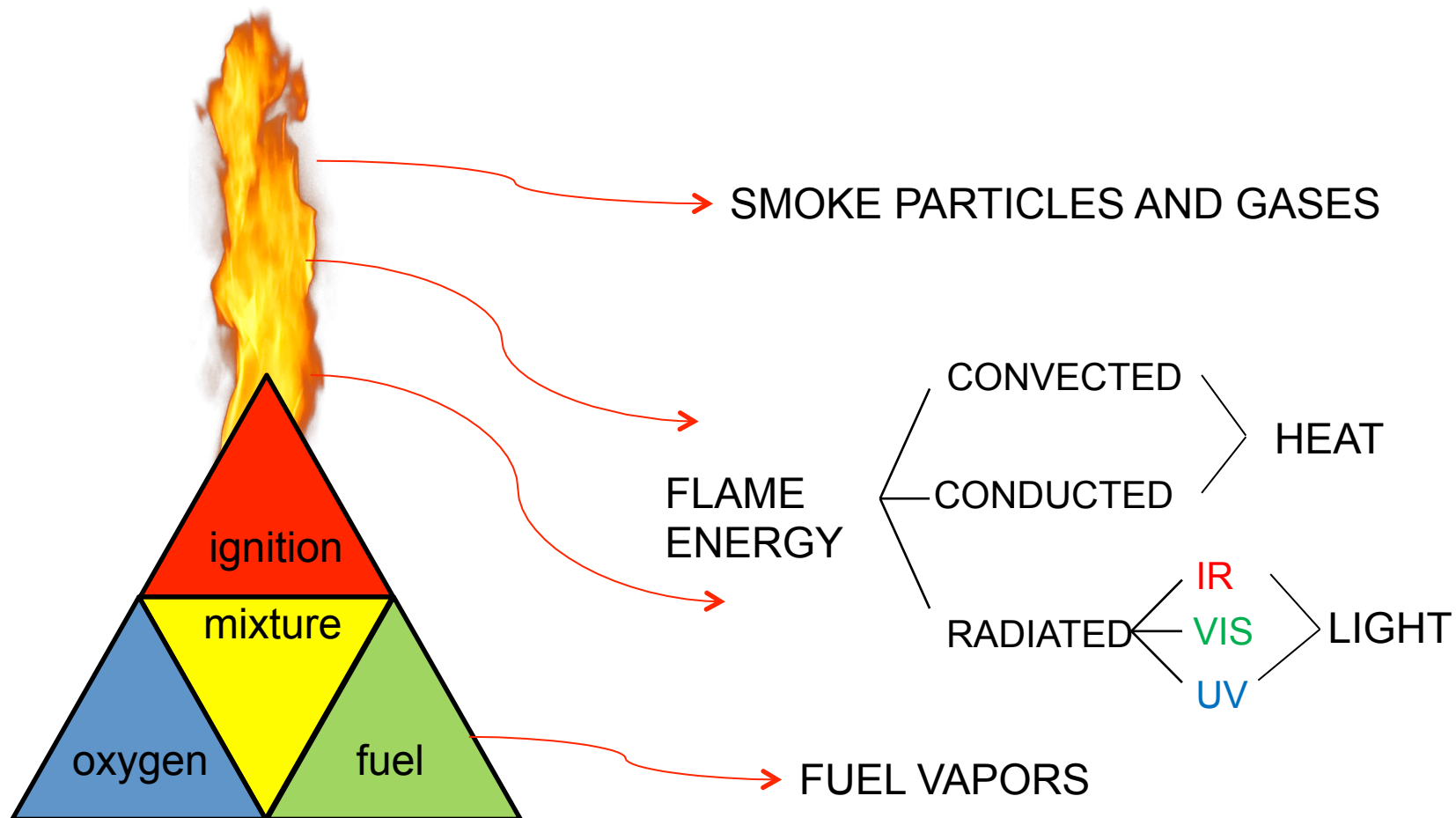
	2009	2010	2011	2012	2013
Fire/explosion - fuel	178	161	137	167	143
Fire/explosion - non-fuel	76	84	73	99	74
Fire/explosion - unknown	12	6	11	11	9
Fire/explosion - all	266	251	221	277	226
Deaths	7	2	7	7	0
Injuries	136	104	109	106	107

Fires

- Fundamentals
- Stages
- Classifications

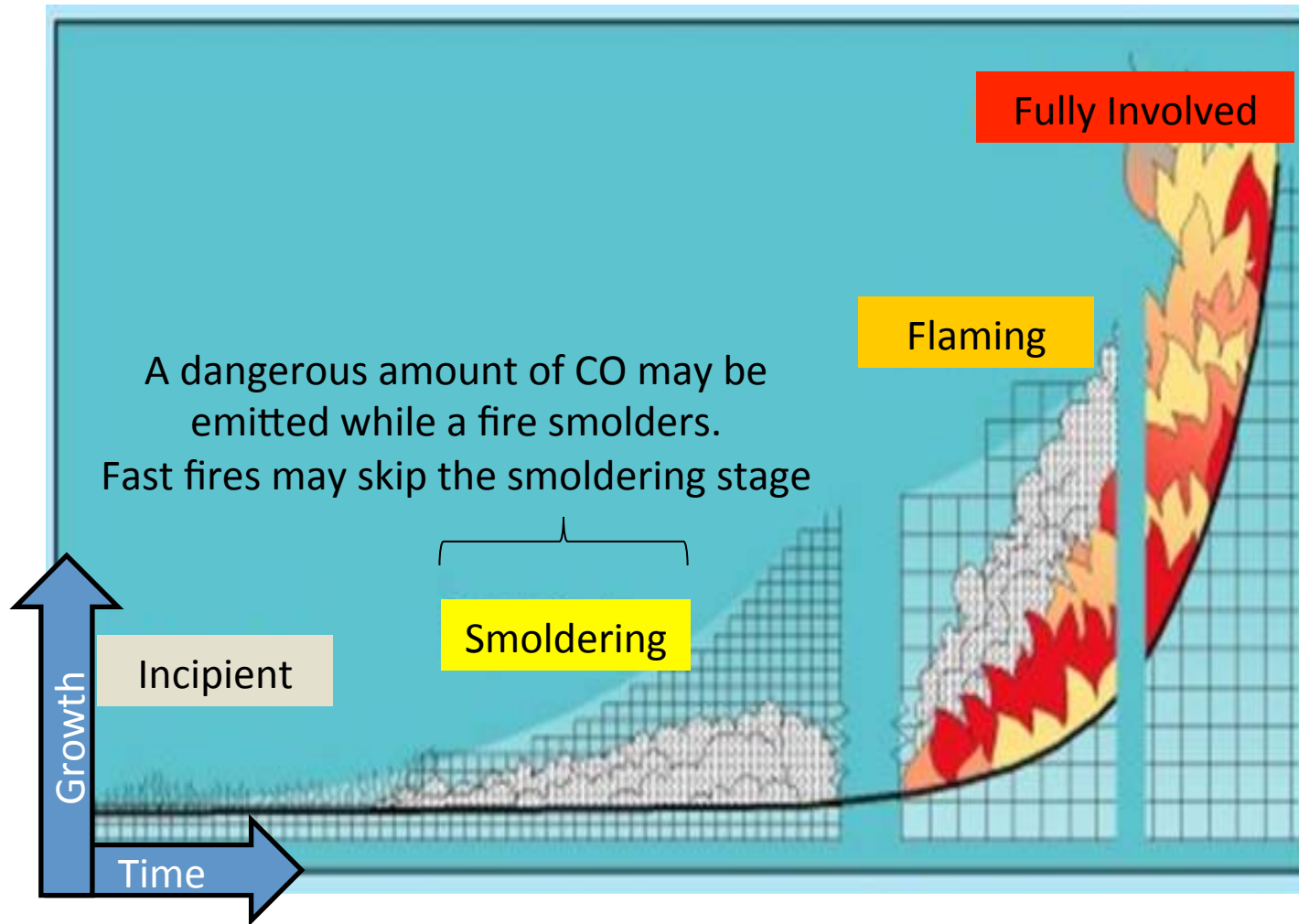


Fire Fundamentals



Conflagrations, deflagrations, detonations, explosions

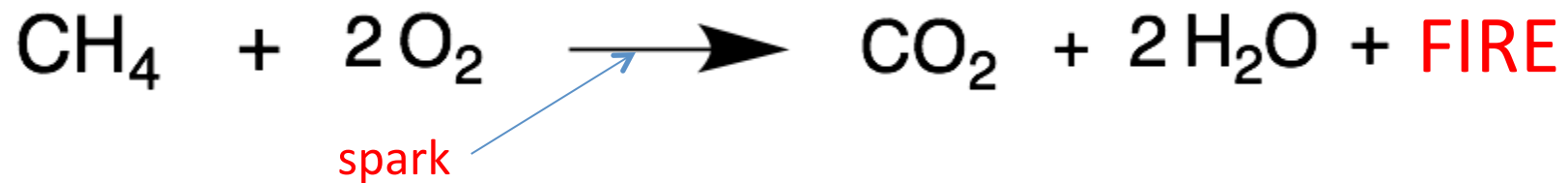
Fire Basics - Stages



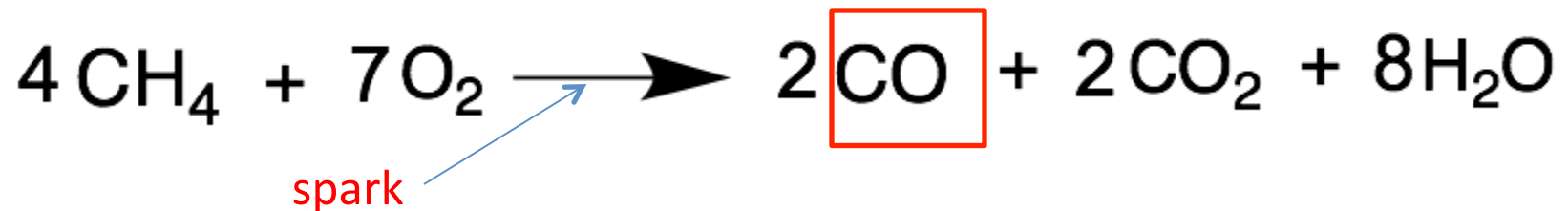
Fire Basics - Chemistry

Combustion example: methane

Complete Combustion



Incomplete Combustion, eg, smoldering



Fire Stages - Smoldering

CO Hazards

Concentration of CO	Symptoms and Time
100 ppm /.01%	Slight headache in 2-3 hours
400 ppm /04%	Frontal headache in 1-2 hours. Widespread in 2.5-3.5 hours
800 ppm/.08%	Dizziness, nausea, convulsions in 45 minutes. Insensible in 2 hours
1,600 ppm/.16%	Headache, dizziness, nausea in 5 minutes. Death within 30 minutes
3,200 ppm/.32%	Headache, dizziness, nausea in 5 minutes. Death within 30 minutes
6,400 ppm/.64%	Headache, dizziness within 1-2 minutes. Death in 15-20 minutes

DON'T MISTAKE THE EFFECTS OF CARBON MONOXIDE POISONING FOR SEASICKNESS!

Consider a CO detector in your sleep area if you have an alcohol stove or inboard engine



<http://www.boatus.com/boattech/articles/codetectors.asp>

<http://www.westmarine.com/buy/mti-adventurewear--safe-t-alert-carbon-monoxide-alarm--15544356>

Fire Classifications

Classifications – Extinguisher Markings



Class A: Ordinary solid combustibles, including wood, cloth, paper, rubber and many plastics. Often referred to as “trash” fires, most class A fires produce Ash.



Class B: Flammable liquids and gases, including gasoline, diesel and other oils, solvents, grease, some paints, hydrogen, methane. Most class B fires involve Boiling fuel.



Class C: Electrical equipment, especially energized. Class C fires involve electrical Current.
















Class D: Flammable metals and self-oxidizing materials. Class D fires are Darn hard to put out.



Class K: Cooking oils and fats, as those used in Kitchens. Similar to some class B fires.

Fire Classifications

Beware: Countries use different classification schemes!

Fire Classification  Know How To Handle It				Fire Classification  Know How To Handle It			
Classes Of Fires	Types Of Fires	Picture Symbol	Extinguisher	Classes Of Fires	Types Of Fires	Picture Symbol	Extinguisher
A	Wood, paper, cloth, trash and other ordinary materials.		<ul style="list-style-type: none"> Water Foam Spray ABC Powder Wet Chemical 	A	Wood, paper, textiles, etc		<ul style="list-style-type: none"> Water Foam Spray ABC Dry Powder Class F Wet Chemical
B	Gasoline, oil, paint and other flammable liquids		<ul style="list-style-type: none"> Foam Spray ABC Powder Carbon Dioxide 	B	Flammable Liquids		<ul style="list-style-type: none"> Foam Spray ABC Dry Powder
C	May be used on fires involving live electrical equipment without danger to the operator		<ul style="list-style-type: none"> ABC Powder 	C	Flammable Gases		<ul style="list-style-type: none"> ABC Dry Powder
D	Combustible metals and combustible metal alloys		<ul style="list-style-type: none"> ABC Powder Carbon Dioxide 	D	Metal		<ul style="list-style-type: none"> Class D Powder
K	Cooking media (Vegetable or Animal Oils and Fats)		<ul style="list-style-type: none"> Wet Chemical 	F	Cooking Oil and Fat fires		<ul style="list-style-type: none"> Class F Wet Chemical
					Electrical		<ul style="list-style-type: none"> ABC Dry Powder Carbon Dioxide

<http://www.safetypostershop.com/category/fire-safety-posters/>

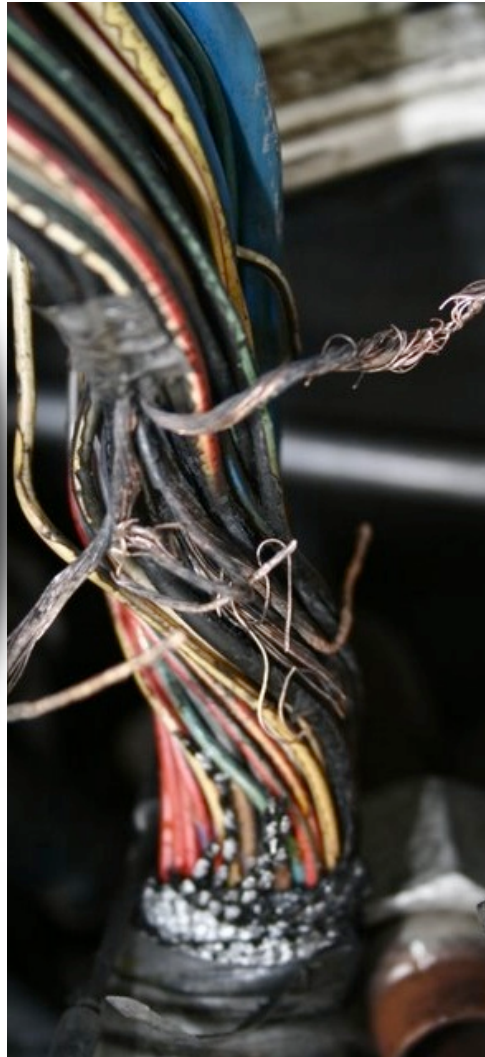
Fire Classifications

- Extinguisher fire classification
 - Guide for the use of agents with fire fighter safety in mind
 - Not specific to any particular application fires
- Operational classification example: Fires in machinery
 - Fuel leak
 - Electrical fault
 - Mechanical fault
 - Debris buildup
 - Human error

Yacht Fires - Origin & Cause

- Fuel leak: Engine or cooking fuel or lubricating oil component failures can lead to leakage of flammable materials that are ignited by contact with hot surfaces and/or sparks
- Electrical fault: Electrical component failures or corrosion can lead to overheated circuits that ignite wire insulation, nearby materials or contamination
- Mechanical fault: Overheated engine, transmission, or hydraulic components can cause fires
- Debris: Trapped debris may be ignited by an otherwise benign fault – maintenance should include cleaning
- Human error: A fire may be caused by human operating error or inadequate maintenance

Electrical Faults



Never disconnect AC while it's hot!

Case Study – Frolic 2013



During the sail home from HI in summer 2013, I smelled 'smoke'....

Origin: The junction box of one of two 75W solar panels was afire! Easily extinguished by disconnecting panel.
Probable cause: seawater ingress



Case Study - All boats can burn



FRIDAY THE 14TH (June 2013) is a date that no doubt will live infamously in the memories of the owner of this 80-foot Jongert 2400M that was utterly and completely destroyed by fire at Prickly Bay in Grenada late last week. (Unless, of course, this is an insure-and-burn situation...) According to a bluewater cruiser named Mark, who took this series of photos from aboard his Beneteau 393 Sea Life, the fire is believed to have started behind an electrical panel and raged for over eight hours. Grenadian authorities responded promptly, but weren't able to do much, as their boats carried no working pumps.

<http://archive.constantcontact.com/fs171/1108231808762/archive/1115401794201.html>

Case Study - All boats can burn



<http://archive.constantcontact.com/fs171/1108231808762/archive/1115401794201.html>

Prevention

- Situational Awareness
- Compartmentalization
- Interlocks & Venting
- Fuel Leak Detection



Situational Awareness

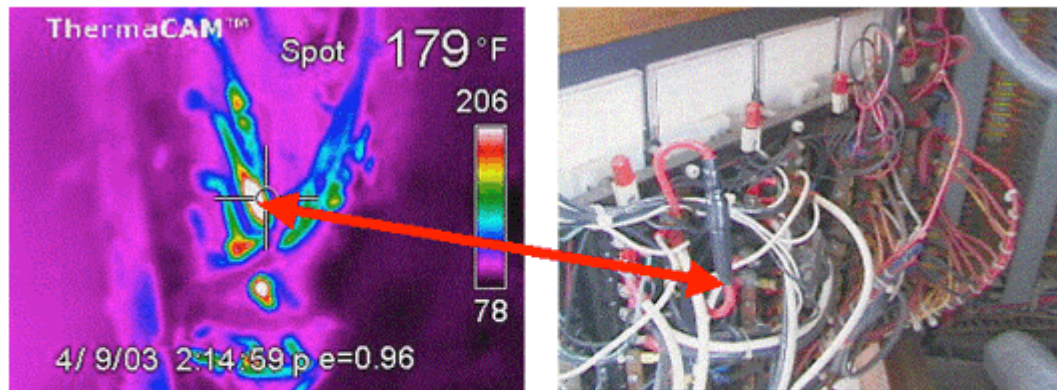
- Keep fuels and ignition sources separated as much as practical
- Pay attention and be familiar with normal sounds and smells on your boat and understand changes
 - Monitor the inboard engine with an IR thermometer
- Understand the most likely fire scenarios on your boat and how you would deal with them
 - Is your handheld extinguisher mounted near where a fire is most likely to start, eg, near a stove? If so, move it!
 - Do you have a fire port on your engine box?



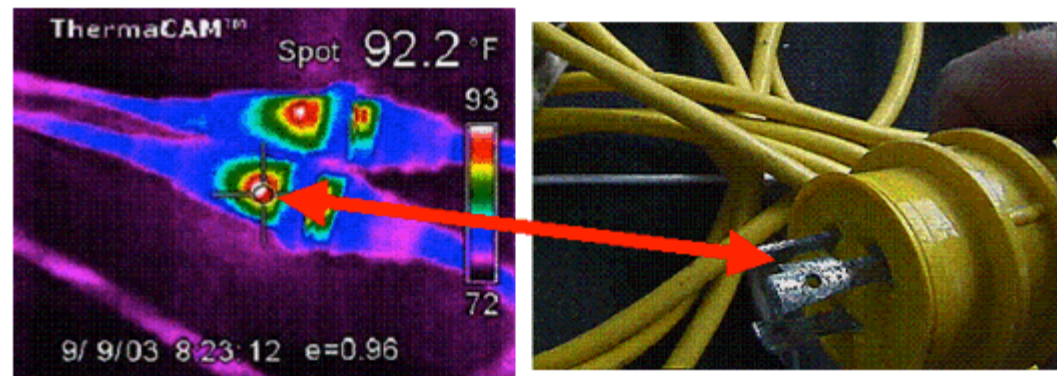
**Increased technology doesn't
increase situational awareness.**

Situational Awareness - IR imaging

Case Study: Shore power, house power, electrical panel, and bundled wires



This is the back of an electric distribution panel in a 40-foot boat. Visual inspection shows that the wires are intact, wire insulation and terminals were free of burn or scorch marks. Infrared view shows that one of the wires in the bundle of wires is much hotter than the others. The heat and resistance in this wire caused its magnetic circuit



Two assembled two 30 amp 110vAC feeds. Infrared shows warm spots. Checking plug confirms surface corrosion (red arrow) on the pins. Infrared image reinforces to owner why the pins need to be free of corrosion.

<http://www.irinfo.org/03-01-2006-allinson/>

Compartmentalization - Fuel Storage

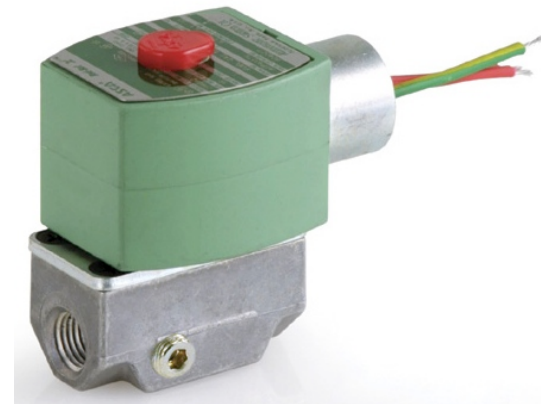
- Low flashpoint ($<70^{\circ}\text{F}$) fuels, eg, gasoline, alcohol and propane, are easy to ignite thus dangerous
 - Leaking gasoline, alcohol or propane pose significant fire hazards
 - These fuels should be stored outside the cabin, and their storage area should be vented overboard
- Diesel, with a flashpoint of about 125°F , is relatively safe because, at normal temperatures, it is hard to ignite
 - Leaked diesel is a mess but not a significant fire hazard unless it is hot
 - Of course, diesel tanks should be vented overboard



Post-propane explosion

Valve Interlocks and Ventilation

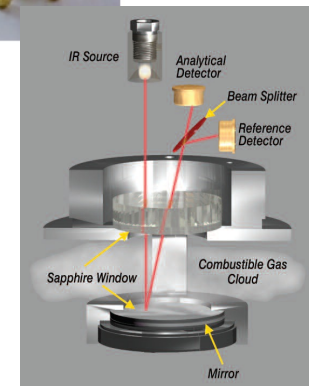
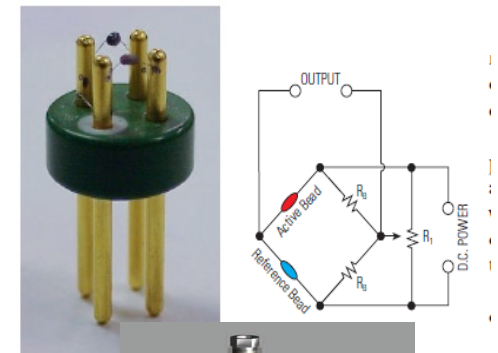
- Propane storage areas should vent overboard and delivery to an inboard galley should be via two valves
 - Cylinder valve (manual)
 - In galley: remotely activated valve (electric)
- Gasoline inboard engines should only be started after the bilge has been actively vented



USCG Requirements, <http://www.boatus.com/boattech/casey/propane-systems.asp>

Fuel Leak Detection

- Propane and other fuels can be detected before they reach flammable levels, or at least before they ignite. Available detectors:
 - Metal-oxide semiconductor (MOS) sensors use a heated, evaporated catalytic layer to detect combustible gases. They are the most common type on boats, low cost and sensitive but prone to drift and poisoning and have limited life
 - Catalytic coated beads suspended on thin wires detect combustible vapors when heated. The catalytic bead sensor is relatively stable and can be calibrated but it is somewhat expensive, prone to poisoning and has limited life
 - Infrared (point and path) sensors rely on specific absorption characteristics of target flammable gases. They do not require routine calibration, have unlimited life but are expensive



<http://search.defender.com/?expression=propane%20detector&s=1&Trigger=ac>

<http://www.amazon.com/Marine-Technologies-30-442-P-BR-Brown-Detector/dp/B003D32OK0>

If a fire occurs... Be Prepared!

- 1st Response
- Fire blankets
- Extinguishers
 - Handheld
 - Automatic
- After a fire



1st Response to a Fire

- Determine fire location and gauge rate of growth
- Get the crew to a safe place with life jackets on
- Turn boat into the wind so smoke blows away from crew
- Formulate and execute a plan
 - Throw burning material overboard?
 - Shut-off electrical, fuel, engine?
 - Fight Fire?
 - Mayday?
 - Abandon Ship?



Sometimes you have to be creative



<https://youtu.be/esxpEoDENsk>

Fire Fighting - Fire Blankets

- Fire blankets are often made of wool (sometimes treated with a flame retardant fluid)
- These blankets are usually mounted in vertical quick-release container so that they can be easily pulled out and thrown over a fire, or wrapped round a person whose clothes are on fire



<http://www.amazon.com/MICHIGAN-FIRST-AID-Emergency-Blanket/dp/B001B9RNMC>

Fire Fighting - Hand Held Extinguishers

- Know how to use your extinguisher(s)! The primary method of fighting small fires with a portable fire extinguisher is called the PASS method (Point, Aim, Squeeze, and Sweep)
- Meeting Coast Guard requirements equips your boat to extinguish only the smallest of onboard fires
- For better fire protection, take aboard B-II extinguishers, or the larger B-I, rated 2-A:10-BC
- All but the smallest watercraft should have at least two extinguishers aboard, mounted in opposite ends of the boat
- Also, replace the cheap plastic brackets with USCG approved metal ones! (read the label)
- Consider a fire port to make attacking an inboard engine fire possible without opening the box
- Maintain extinguishers per manufacturer instructions and check pressure gauge regularly



<http://www.boatus.org/findings/46/>

Acme Fire Extinguisher Co. 1305 Fruitvale Ave., Oakland, CA 510-532-4040

<http://www.westmarine.com/buy/marine-east--fire-port--3734464>

Fire Fighting - Hand Held Extinguishers

Any vessel with any of the following conditions will be require to carry fire extinguishers regardless of length:

- Closed compartments under thwarts and seats where portable fuel tanks may be stored
- Double bottoms not sealed to the hull or which are not completely filled with flotation material
- Closed living spaces
- Closed stowage compartments in which combustible or flammable materials are stowed.
- Permanently installed fuel tanks
- Specific requirements at

<http://www.boatingmag.com/boatingsafety/fire-board-0>



Fire Suppression Agents

Agent	Comments	Suppression Effect
Dry Chemicals (ABC, BC)	The only all-around agent is ABC powder (ammonium phosphate-based) but it is messy and the residue is corrosive; Dry chemicals based on sodium and potassium bicarbonate are BC, less corrosive and very effective against hydrocarbon fuel fires but not recommended for 'trash' fires; dry chemicals are safe in confined spaces but are minor irritants and will reduce visibility	Quench and chemical to varying degrees
Aqueous (A, AB)	Water-based agents (including seawater) are best on 'trash' fires but are messy and may be dangerous when used on live electrical systems; Foaming agents are also effective on hydrocarbon fuel fires	Quench and smother to varying degrees
Carbon Dioxide (BC)	CO ₂ is clean and effective against hydrocarbon fuel fires but can be dangerous in confined spaces and is not recommended for 'trash' fires	Smother (O ₂ displacement)
Fluorinated (BC)	Clean, fluorinated agents like FM-200, Halon 1301, and others, are effective fire fighters but beware: in some cases dangerous levels of toxic gases can result (combustion byproducts include acid gases) and they are not recommended for 'trash' fires	Quench and chemical to varying degrees

Beware the internet...

Responses to "BOAT FIRE: Gorgeous Yacht Destroyed in Grenada"

1. *Mike says:*

June 27, 2013 at 9:03 PM

And on vessels, a fire can double in size in under 30 seconds and quickly overwhelm the boat, fire suppression system or not.

2. *Mike says:*

June 27, 2013 at 9:01 PM

Even if it did have halon, I imagine it would primarily be used in the engine compartment, as its designed to smother the fire by displacing oxygen. I work on commercial ships, and I know it a different ball game, but those type systems are only used in engine compartments.

Another thing...why halon? It's been banned in the US and many other countries for years now as a fire suppression system...mostly due to its lethality. At least on ships, CO2 is used world wide now. It gives a you bit more time to clear the space and is just as effective.

But back on topic. Even if there was a halon system that was set throughout the boat, I don't think it would be very effective. The only way it works is to have the ventilation shut down and space sealed before releasing it. If they had their AC on, a hatch open, vents open, etc...the affect of the halon would have been minimal, if anything by the time the sensors were triggered. Having an automatic halon system sounds like a risk to me though., sounds like a good way to get trapped or accidentally have it go off when you burn dinner.

Sounds like a pretty big design flaw. You would think for a boat of that size and caliber, there would be better fire fighting measures. But unless someone was on the boat at the time of the fire, even a fixed water system wouldn't if worked because you would need manual activation and start a fire pump.



Mike sounds reasonable but...

...his comment is not accurate:

- Halon suppression is 70% chemical and 30% thermal quenching (not O₂ displacement)
- Halon 1301 is non-toxic; its production was banned because it's an ozone depleter
- Common replacement: FM200
- CO₂ works by smothering and is dangerous in confined spaces

Fire Fighting - Automatic Extinguishers

- An option to protect machinery space(s)
- Automatic extinguishers include some sort of fire detection that, when a fire is present, releases the extinguisher
- Most common detection is thermal, but high-end applications use optical devices
- The simplest thermal detection is the sprinkler head but there are others, eg, pneumatic linear (which allows better coverage)
- Options include automatic engine shut down and alarms



Automatic Fire Protection of Engine



After a fire

- Once the fire is out, watch for re-ignition – it can happen
 - Consider using water to cool the fire site once the flames are extinguished
- If you called a May Day, cancel it if assistance is no longer needed, but....
- ...Monitor all who were exposed to fumes – breathing problems may occur hours after exposure and can become serious
- Once ashore
 - Replenish used gear (blankets, extinguishers, etc)
 - deal with accident reporting (per state, federal and insurance requirements)
 - Repairs?



Summary *Be Prepared, Alert, & Ready*

- Beware the internet! Be sure of your sources
- Any boat can burn – be prepared mentally and with thought-out equipment (at least with what is required in your situation)
- Do what you can to prevent a fire
- Be cognizant of changes in your environment
- Consider fuel leak and CO detectors
- Mount up-to-date extinguishers away from likely fire hazards
- Consider having a fire blanket handy
- Do the maintenance
- If you have an inboard
 - have a method to discharge the extinguisher into the engine box without opening the lid
 - consider an automatic fire extinguishing system
- If a fire starts the 1st priority is getting the crew to a safe location – then understand the fire, consider your options, and execute a plan