

# Applying Infrared Imaging Techniques to Marine Surveying

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## Abstract

Marine surveyors are to the marine industry as building and home inspectors are to the commercial and residential real estate industry. A marine surveyor's opinions are relied upon to document the condition and value of the vessels (boats, ships) they inspect. A marine surveyor examining a vessel relies heavily upon experience and what can be seen, heard, and felt. Traditionally, visual anomalies seen with the unaided eye often are the sole basis for further testing. Infrared images are an effective tool in extending a marine surveyor's ability to detect anomalies. This paper will review common deficiencies found in vessels and show how infrared imaging has become an effective tool in documenting the problems found during inspections.

## Introduction

Common to all marine surveys are deliverables that provide a:

- Detailed and accurate description of the vessel
- "Condition and Value" of a vessel
- List of findings and recommendations

Typically, the "Condition" of a vessel is based upon its structural integrity and how the onboard systems function. Inherent in the "Condition" are generally accepted terms that reflect whether a boat is ready for sale or whether it requires additional work. Similar to the real estate industry, the "Value" of a vessel is based upon recent sales comparables and income earning potential of the vessel.

When vessels are inspected, they are looked at with respect to the mandatory standards promulgated by the United States Coast Guard (USCG), under the authority of Title 46 United States Code (USC); Title 33 and Title 46, Code of Federal Regulations (CFR), and the voluntary standards and recommended practices developed by the American Boat and Yacht Council (ABYC) and the National Fire Protection Association (NFPA).

Two business segments are typically served:

- Commercial – Tugboats, Passenger Vessels, Shipping, and Fisheries
- Recreational – Yachts and Small Craft

Within each business segment, types of inspections can be broken down into:

- Prepurchase – requested by buyer when purchasing a new or used vessel
- Seller – requested to help prepare for the sale of a vessel
- Insurance – required by an underwriter(s) to determine if vessel is an acceptable risk
- Appraisal – required by a lending institution, or legally for estate settlements and donations
- Damage – required to settle an insurance claim or for legal action

## Examples of Infrared Applications

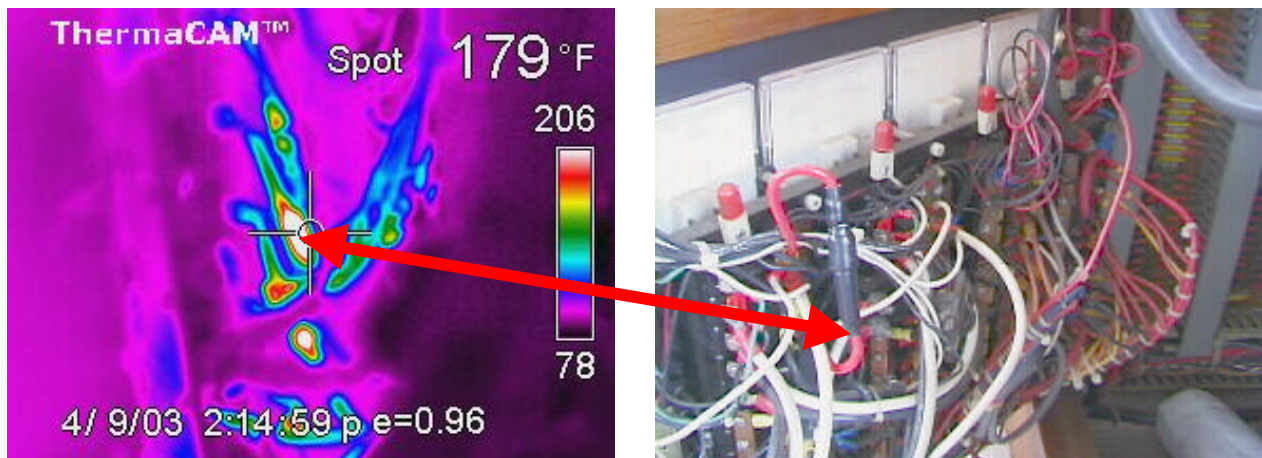
### Electrical

Direct Current (DC) systems

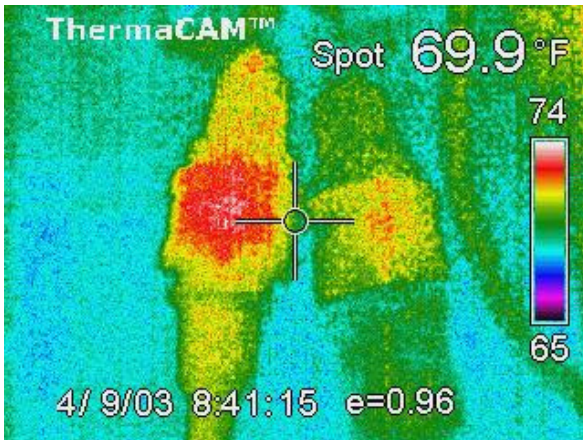
Electrical panel, batteries, and bundled wires

Alternating Current (AC) systems

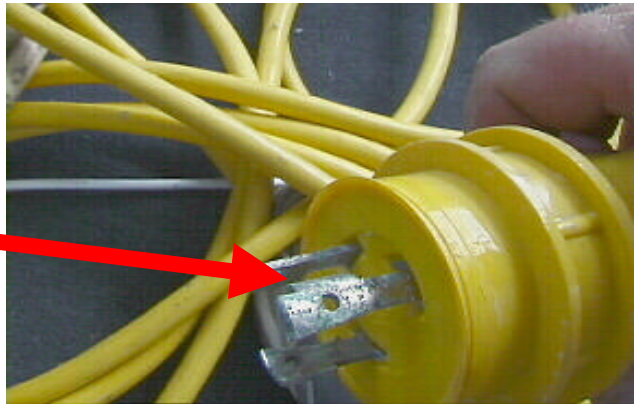
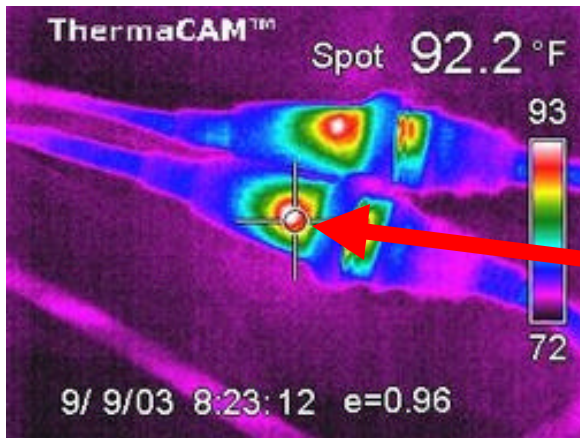
#### Case Study: Shore power, house power, electrical panel, and bundled wires



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 breaker to trip intermittently.



This is a power pedestal on a dock that supplies electric power (shore power) to a boat. A single 50 amp 220vAC shore power cord (light yellow) splits into two 30 amp 110vAC feeds. This item is known as a “Y adapter” and is commonly used for boats that have two 30 amp 120vAC inlets. There is electrical resistance building up on the left leg of the “Y adapter” and it should be scheduled to be replaced.



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.

**Boat Fires at Dockside**





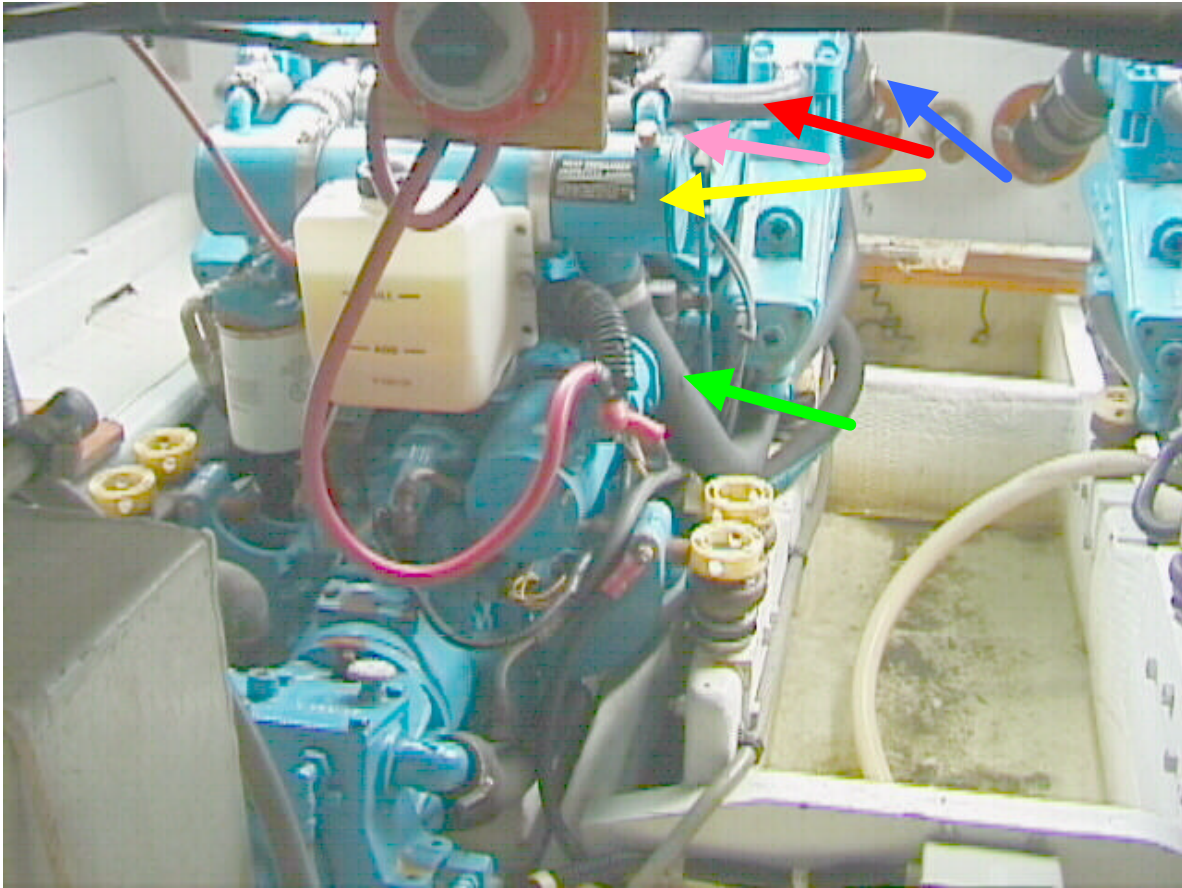
## Mechanical

Motors, both electric and internal combustion  
Bearings  
Gears  
Refrigeration

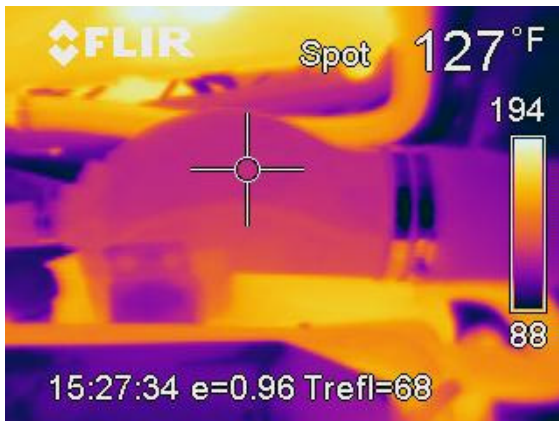
### Case Study: Engine overheating problem



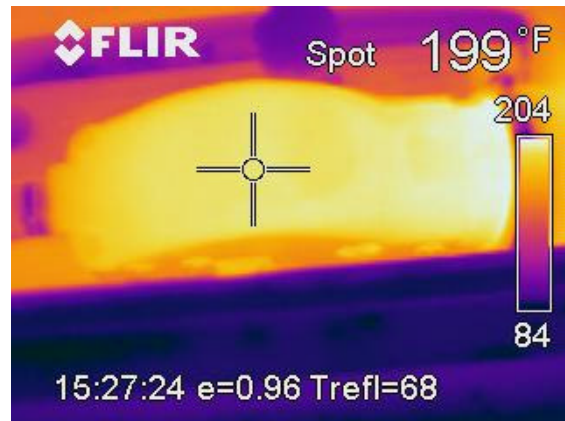
**Figure 1.** Looking down from above into the engine compartment. Here are two gasoline powered engines. Each engine has an open (raw water) and closed water cooling system. The raw water system takes the water that the boat is floating in, passes it through a heat exchanger (yellow arrow) for the closed water cooling system. Then, raw water mixes with combustion exhaust gases at the exhaust manifold (red arrows) and routes the cooled exhaust gases and raw water mixture overboard (green arrow) through an exhaust hose.



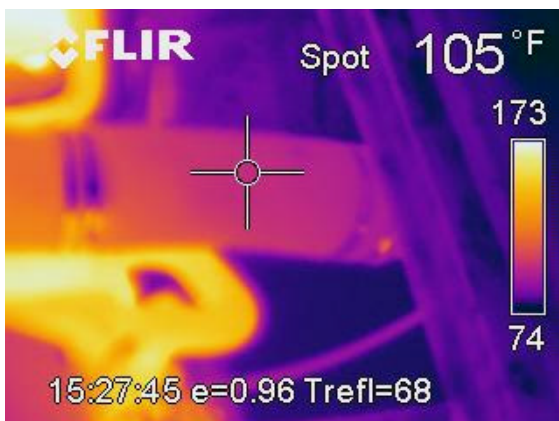
**Figure 2.** Anterior view from inside the engine compartment of a gasoline powered engine's cooling system. Green arrow points to raw water intake hose. Yellow arrow points to heat exchanger. Pink arrow points to a sacrificial "pencil zinc" fitting in raw water. The pencil zinc is a maintenance item and is periodically inspected and replaced when it becomes wasted. Raw water feeds to exhaust manifold (red arrow) where it mixes and is ejected as a wet exhaust (blue arrow).



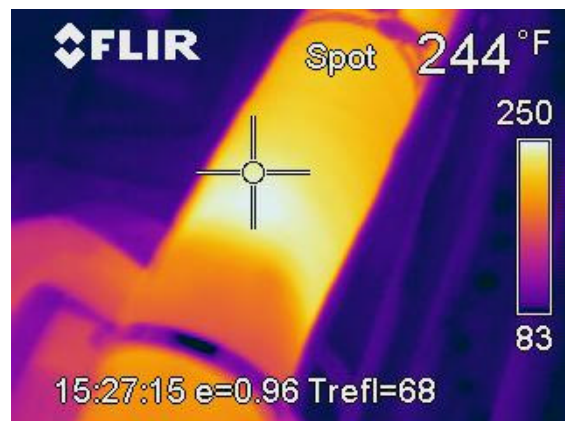
**Figure 3.** Uniform temperature pattern on wet exhaust riser. Everything appears to be normal.



**Figure 4.** Non-uniform as well as elevated temperature pattern on wet exhaust riser. Something is not right!



**Figure 5.** Uniform temperature on wet exhaust rubber hose. Everything appears to be normal.

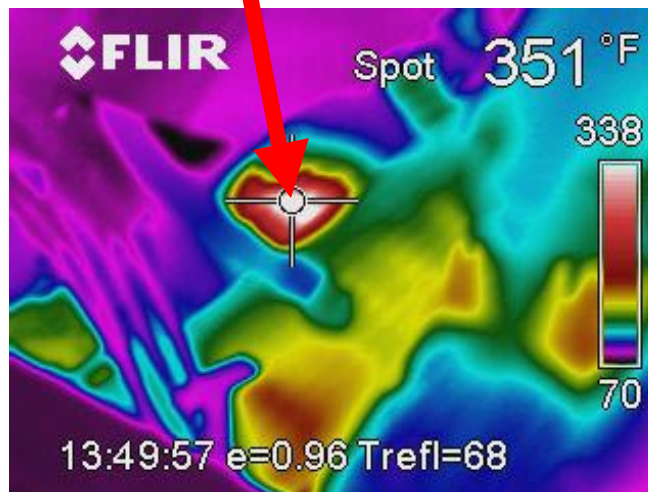
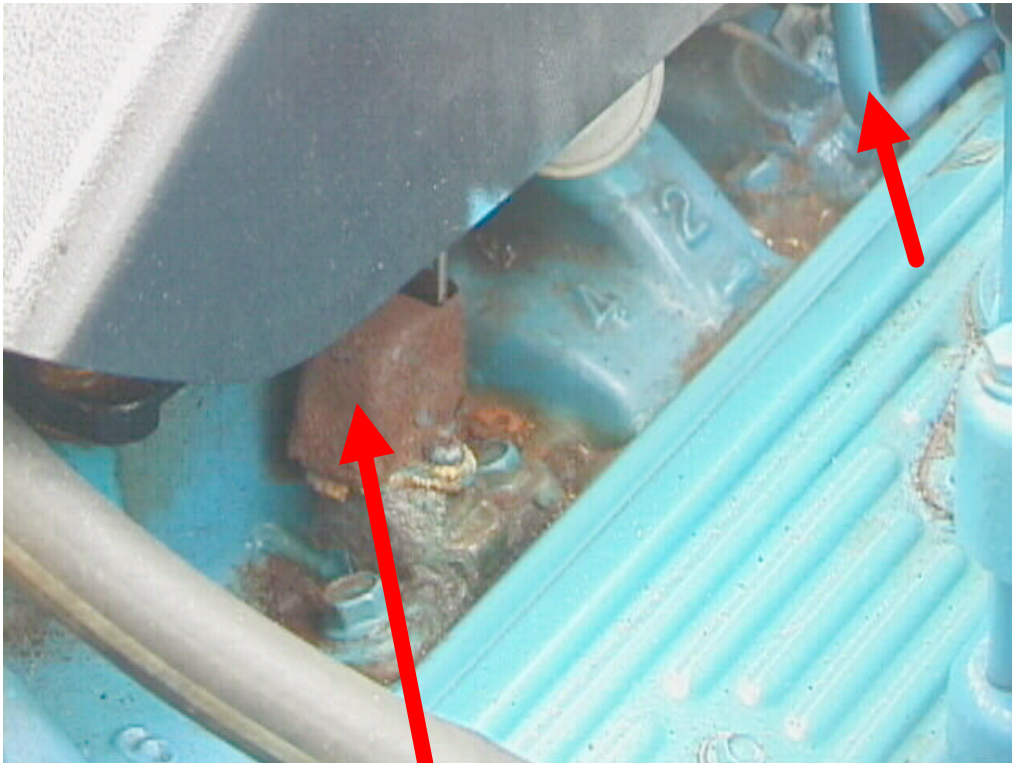


**Figure 6.** Non-uniform overheated wet exhaust rubber hose. Something is not right! Engine was shut down and the exhaust hose was removed for inspection. Interior wall of rubber hose was found to be charred and separated.

**Cause of overheating:** Blockage in the raw water coming from the heat exchanger. A loose pencil zinc worked itself free and lodged in the heat exchanger (pink arrow, figure 2), thus preventing the correct amount of water from mixing with engine exhaust gases, which caused the exhaust hose to start to fail.



**Case Study: Thermal image reinforces why ABYC recommends approved gasoline fuel supply lines do not come in contact with an engine block.**



Red arrow in photograph above points to the “cook stove” that visually appeared as a simple rusted part mounted on the engine block. Why is this part rusty and the paint discolored? **Answer:** The “cook stove” is part of a mechanical choke assembly for the carburetor installed on this engine. The assembly reacts to the temperature of exhaust gases that pass by it.

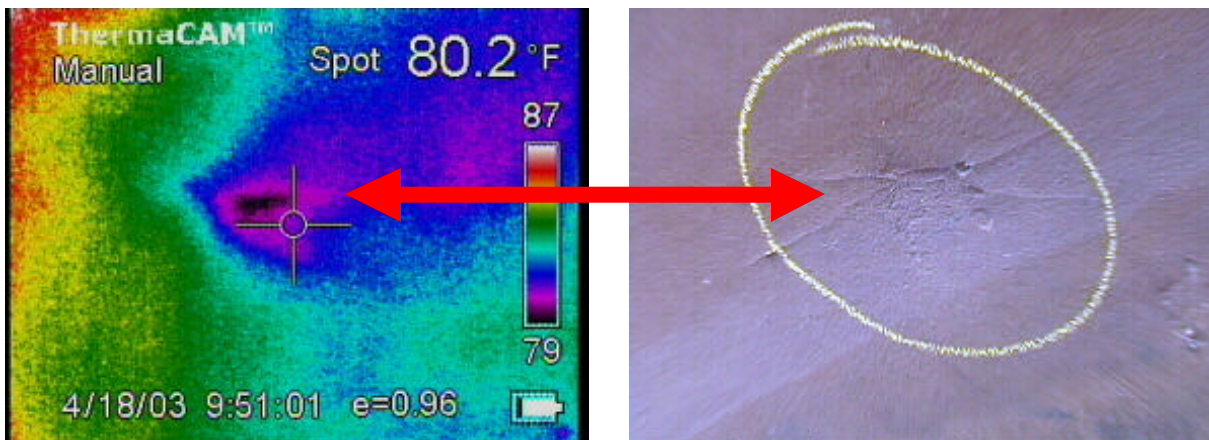
The thermal image illustrates why this part is commonly called a “cook stove” by some mechanics. The measured temperature reinforces that sections of fuel supply lines should not come in contact with the engine surface.



## Vessel Construction and Materials

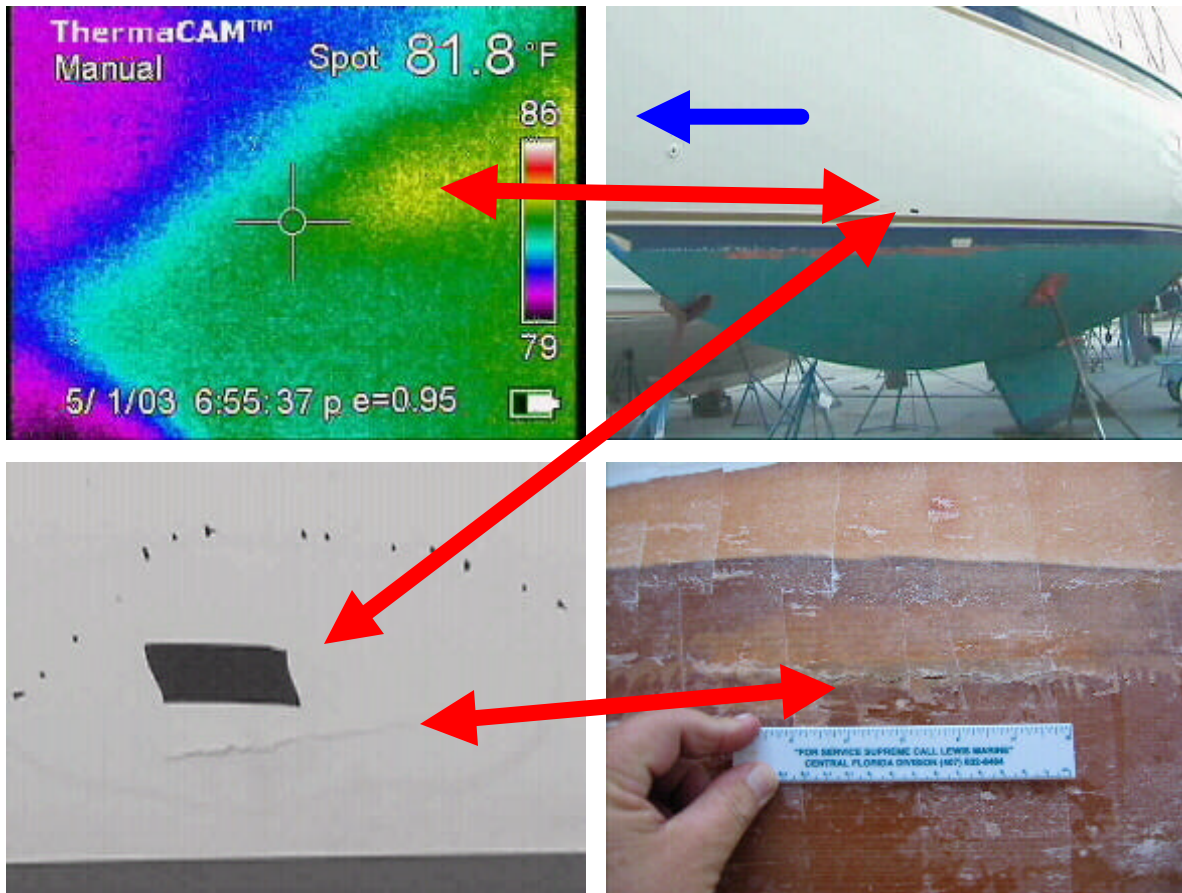
Fiberglass Reinforced Plastic (FRP) Hulls  
Moisture Accumulation, Osmotic Blisters and Delamination

### Case Study: Short Haul Bottom Inspection



The area circled in yellow shows an unusual indentation in the hull of a boat constructed with FRP. Area visually appears to be dry. Infrared image shows cooler temperature, revealing moisture intrusion in this portion of the hull.

## Case Study: Damage Inspection



This is the side of a sailboat constructed with a FRP composite of balsa wood and fiberglass laminate. The sailboat sustained impact damage on the bow (blue arrow). An R thermal scan of the hull sides showed an anomaly, and there was a faint visual sign of delamination. The infrared image shows warmer temperatures, revealing the extent and pattern of delamination in the FRP.

### Wooden Boat Hulls

- Open Seams between Wooden Planks
- Moisture Accumulation
- Wood Rot
- Mechanical Fasteners

### Composites

- Foam and Wood Coring Materials
  - Delamination
  - Moisture Accumulation
  - Disbonding

### **Other materials that lend themselves to IR imaging**

Carbon fiber used to construct sailboat masts, booms, arches, and hulls

- Delamination
- Shows fractures from point source loading

Metal, Aluminum and Steel

- Surface leaks on fuel, holding, or water tanks
- Moisture accumulation in select areas in the hull interior

Concrete (ferro cement)

- Identify fractures and cracks
- Moisture accumulation
- Disbonding between cement and wire reinforcement
- Locate metal reinforcement

### **Summary**

Infrared imaging is clearly a valuable tool for a Marine Surveyor. Like other investigative tools, it should not be used as the “sole source” for confirming a problem. A surveyor’s experience and knowledge of how a boat’s systems function, the construction methods used, and use of other supporting investigative tools are essential to the accurate interpretation of what the infrared images show.



## References

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ABYC - American Boat & Yacht Council, July 2005, "Standards for and Technical Information Reports for Small Craft", 3069 Solomon's Island Road, Edgewater, MD 21037-1416

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CFR - Code of Federal Regulations and other government publications. Obtain from the Superintendent of Documents, United States Government Information, POB 371954, Pittsburgh, PA 15250-7954

NFPA - National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269

USCG - United States Coast Guard, USCG Headquarters, Washington, DC, 25093

Various IR papers <http://www.flirthermography.com/industries/industry/1027/>

**Keywords:** Marine Surveyor, "Condition and Value", ABYC, USCG, USC, CFR, NFPA, Underwriter, Fiberglass Reinforced Plastic (FRP), composite, vessel, watercraft