INFRAMATION
THE THERMOGRAPHER'S CONFERENCE

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. Marine surveyors' opinions are relied upon to document the "Condition and Value" of the vessels (boats, ships) they inspect. When marine surveyors examine a vessel, they rely 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 visual ability to detect anomalies. This paper illustrates the use of the FirstMate™ infrared camera from FLIR. Presented are examples of what can be found when inspecting structural, mechanical, and electrical systems on boats. It will refer to common deficiencies found in vessels and show how infrared imaging has become an effective tool in documenting problems found during inspections.

Keywords: marine surveyor, "Condition and Value", ABYC, NFPA, USCG, USC, CFR, NFPA, underwriter, fiberglass reinforced plastic composite, FRP

INTRODUCTION

Common to all marine surveys are deliverables that provide a "Condition and Value" of a vessel. Typically the "Condition" of a vessel is based upon its structural integrity and how the systems onboard function. Inherent in the "Condition" are generally accepted terms that reflect whether a boat is ready for sale and required no 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 inspections can be broken down into the following types:
- 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 (Figures 1 and 2)

- Direct Current (DC) systems
- Electrical panel, batteries, and bundled wires
- Alternating Current (AC) systems
- Shore power, house power, electrical panel, and bundled wires.

Mechanical (Figures 3 and 4)

- Motors, electric and internal combustion
- Bearings
- Gears
- Refrigeration

Vessel Construction Materials and Common Problems

- Fiberglass Reinforced Plastic (FRP) hulls (Figures 5 and 6)
  - Moisture accumulation
  - Osmotic blisters
  - Delamination
- Wooden boat hulls (Figures 7 and 8)
  - Open seams between wooden planks
  - Moisture accumulation
  - Wood rot
  - Mechanical fasteners

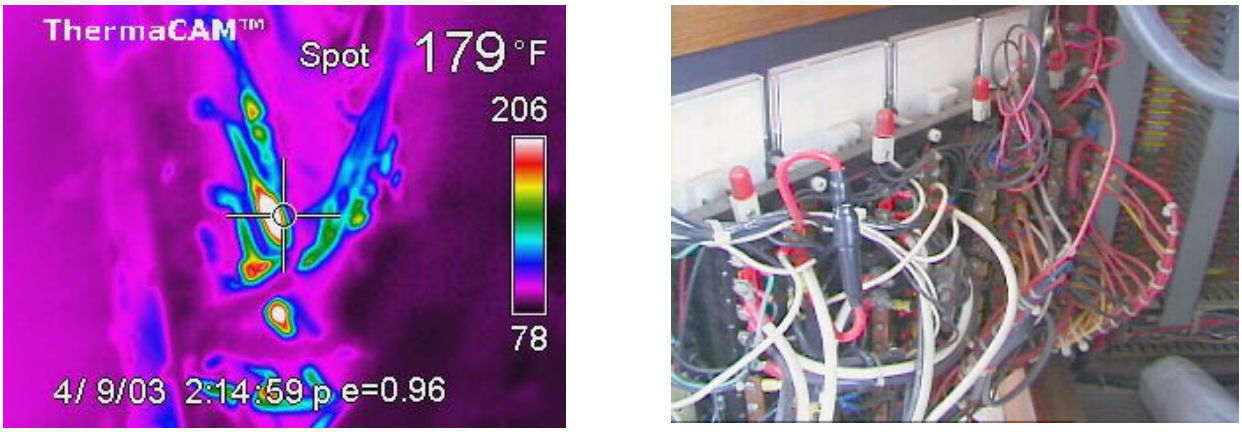

Figure 1. *This is the back of an electric distribution panel in a 40-foot boat. Visual inspection shows that the wires are intact, wire insulation and terminals were free of burn or scorch marks. Infrared view shows that one of the wires in the bundle of wires is much hotter than the others. The heat and resistance in this wire caused its magnetic circuit breaker to trip intermittently*.

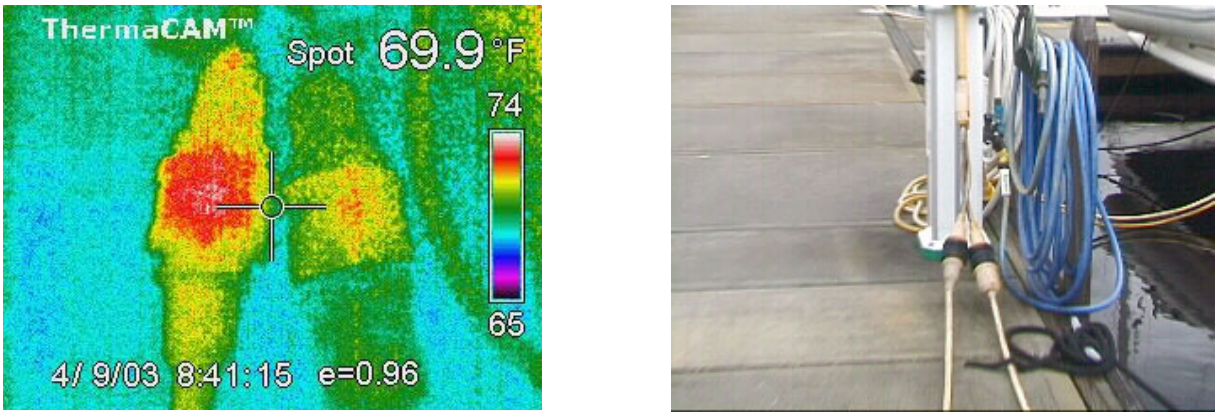

Figure 2. *This is a power pedestal on a dock that supplies electric power (shore power) to a boat. A single 50 amp 220vAC shore power cord (light yellow) splits into two (2) 30 amp 110 VAC feeds. This item is known as a "Y adapter" and commonly used for boats that have two (2) 30 amp 120 VAC inlets. There is electrical resistance is building up on the left leg of the "Y adapter" and it should be scheduled to be replaced.*

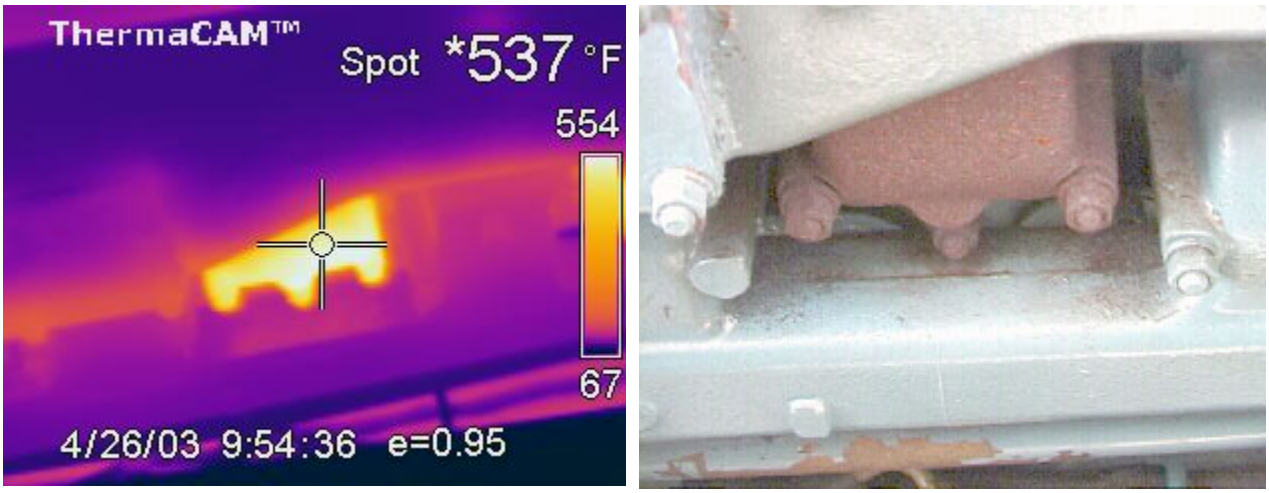

Figure 3. *Views of a portion of an exhaust manifold for a 160 hp 6 cylinder turbocharged diesel engine. During the sea trial, the engine overheated. A thermal image of one of the exhaust ports on the manifold showed excessive temperature. Buyer advised to have a marine mechanic examine the turbocharger system.*

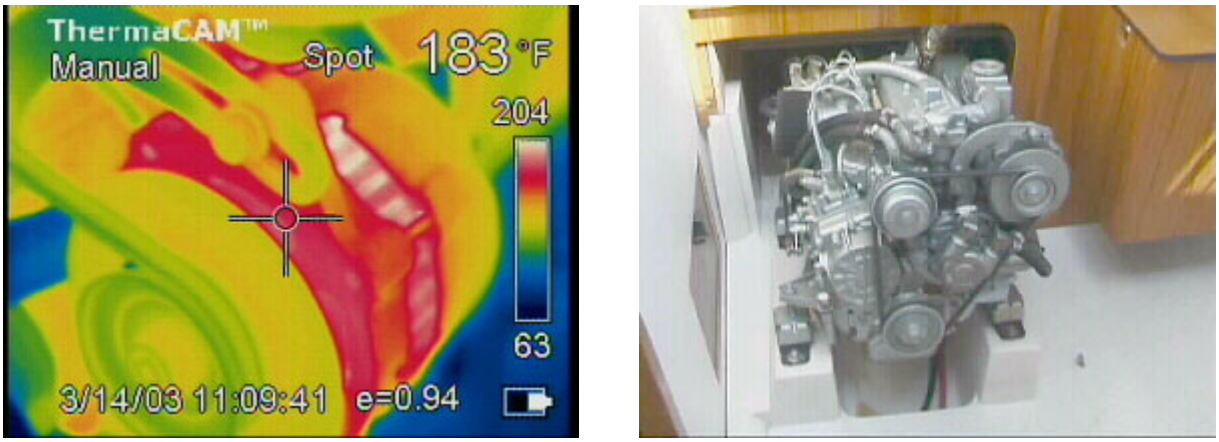

Figure 4. *Views of a 3-cylinder naturally aspirating diesel engine. Visual photograph (right) shows the engine with a factory installed low amperage output 12VDC alternator. Owner replaced original "wet cell" battery bank to one with a larger capacity. The new battery bank was much too large to be effectively charged by the factory installed alternator. There were no visual signs that the alternator was being overworked, however the battery bank would never get fully charged and batteries suffered from sulfation. Infrared showed windings in alternator were hotter than expected. This visual evidence coupled with measuring low input voltage at the battery terminals solidified the recommendation why the buyer should upgrade to a higher amperage output alternator.*

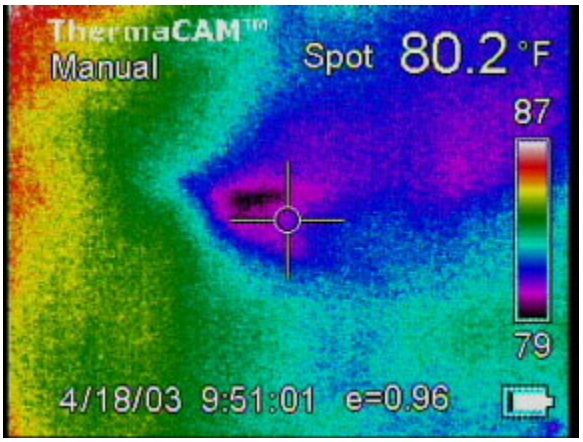

Figure 5. *The area circled in yellow shows an unusual indentation in the hull of a boat constructed with FRP. Area visually appears dry. Infrared image shows cooler temperature, revealing moisture intrusion in this portion of the hull.*

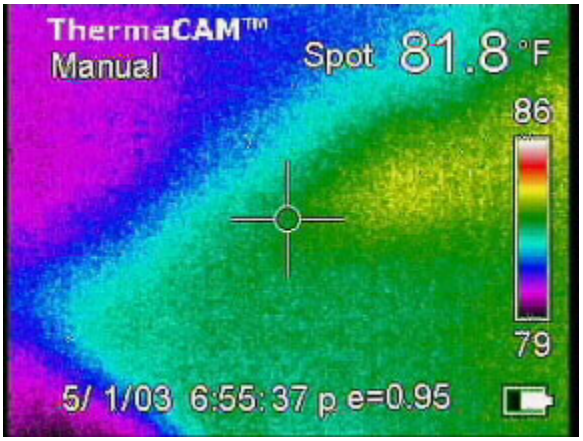

Figure 6. *This is the side of a sailboat constructed with FRP. The sailboat sustained impact damage and there was a faint visual sign of delamination. The infrared image shows warmer temperatures, revealing the extent and pattern of delamination in the FRP.*

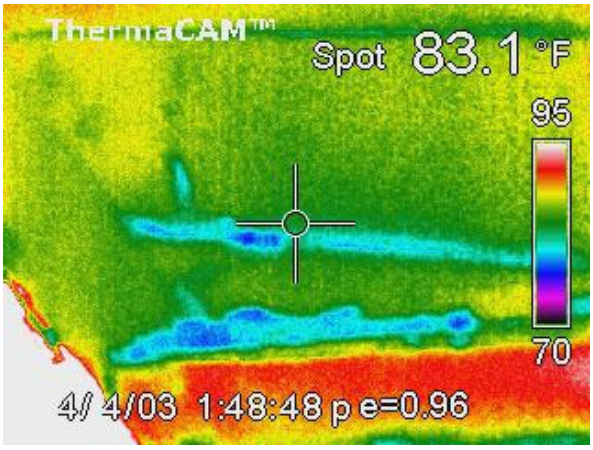

Figure 7. *Views of the bow of a boat hull constructed of wooden planks. Routine maintenance involves caulking the seams between the wooden planks to prevent moisture intrusion. The infrared image confirms that caulking is needed as it shows cooler areas where moisture has entered into seams.*

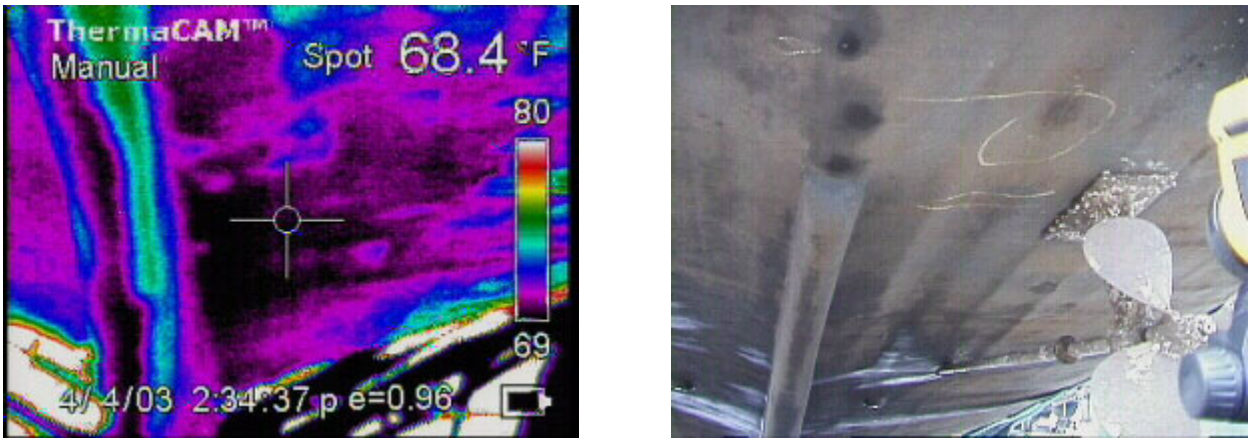

Figure 8. *A common practice to extend the life of the bottom of a wooden boat is to sheath it in FRP. It is used to reduce maintenance and prevent marine organisms (e.g., Terado worms) from boring into the wood. Sometimes the physical bond between the wood and FRP breaks down, and water gets trapped in the interstitial space. The wood continues to decay and the FRP disbonds from the wood. Coolness in the infrared image shows the extent of water entrapment and disbonding that can be heard when sounding the hull with a percussion hammer.*

- Composites – foam and wood coring materials (Figures 9 and 10)
  - Delamination
  - Moisture accumulation
  - Disbonding

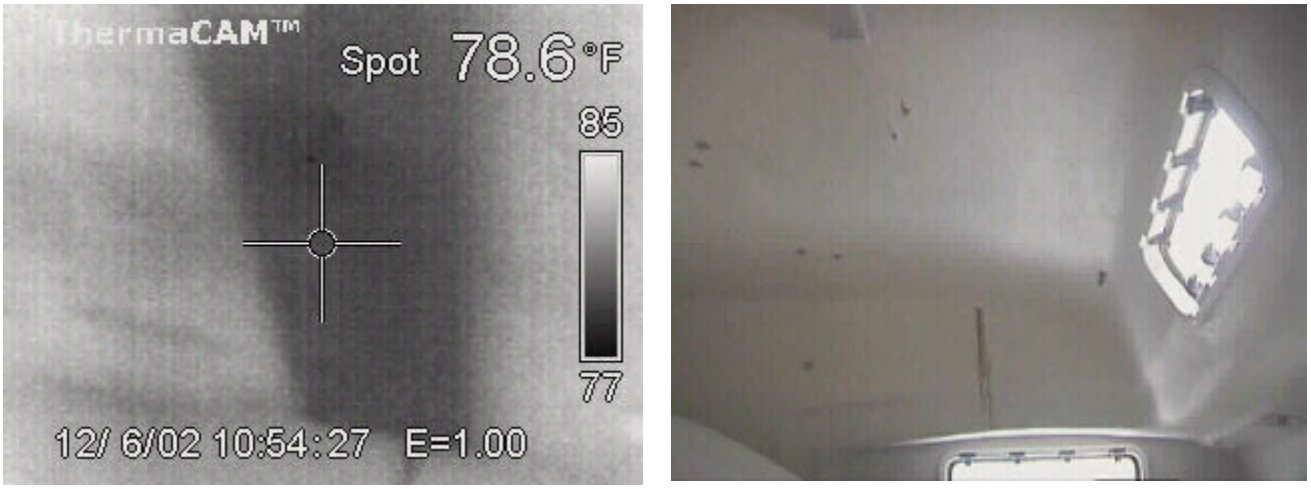

Figure 9. *This is the interior ceiling of a FRP constructed catamaran sailboat. Brown fluid observed running out down the ceiling wall visually shows there is a problem with water intrusion. The ceiling is a sandwich construction composite of an outer skin of FRP, an intermediate core of wood, and an inner skin of FRP. The black and white pallet infrared image (left)shows the extent of moisture intrusion.*

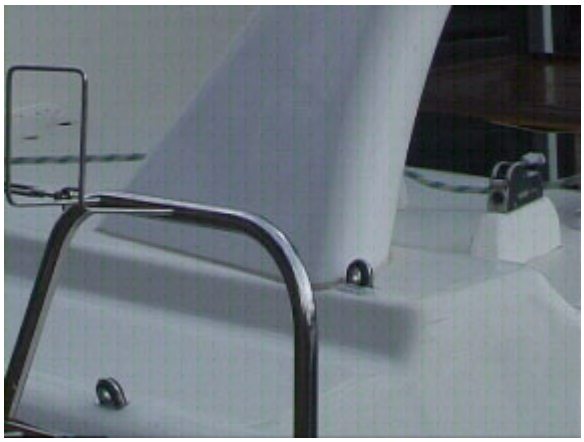

Figure 10. *On deck photos of the sailing catamaran shows the exterior side corresponding to the interior ceiling. Note the raised deck in the FRP construction. It is common practice to use a composite construction to reduce the weight of the boat. In this case the composite is FRP/wood/FRP. If the raised deck area were constructed with a solid FRP laminate, it would be much heavier and cost more to construct. A lighter boat sails faster than a heavier boat.*

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 clearly is a valuable tool for a marine surveyor. Like other investigative tools, it should not be used as the sole source for identifying a problem. A surveyor's experience, knowledge of how the boats systems function, the construction methods used, and use of other supporting investigative tools are key to the accurate interpretation of what the infrared images show.