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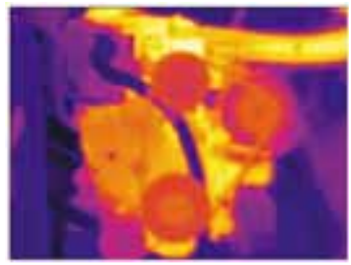
Applying Infrared Thermal Imaging Techniques to Marine Surveying

Part II: Mechanical Systems

By John (Jack) N. Allinson, II SAMS® Accredited Marine Surveyor AMS®
Level I Certified Infrared Thermographer
J.N. Allinson Associates, Inc.

The Winter 2008 issue of *the Reference Point* presented how infrared thermal imaging can be applied for the documentation and presentation of findings during an electrical inspection. Part II of this series will concentrate on targeting prime candidate areas for loss prevention and preventative maintenance on "mechanical systems," and an introduction to the differences between "qualitative" and "quantitative" analysis of infrared thermal images.

Mechanical systems

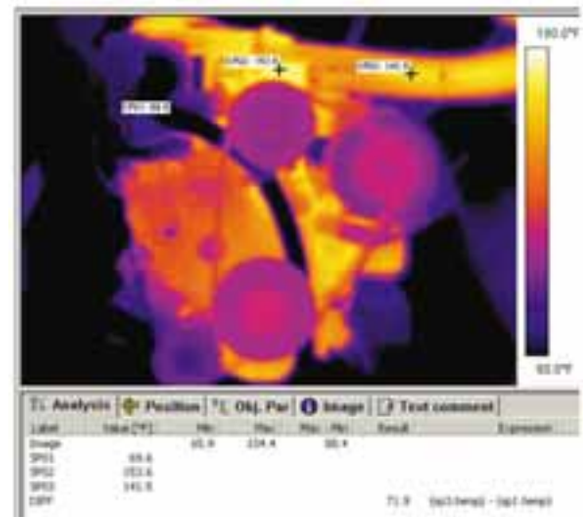


Infrared thermal image of the front of an actively running YANMAR diesel engine. This image is considered "qualitative" because a surface pattern is shown with no indication of what temperatures the different colors represent.

For the context of this article, "mechanical systems" will include systems and their associated components whose longevity and performance are affected by heat transfer, lubrication and friction.

Infrared thermal images are displayed when the small rectangular photo detectors in the camera's focal plane array are energized. In the Winter 2008 issue of *the Reference Point,* mention was made that J.N. Allinson Associates, Inc. captures individual stills and burst series of images in radiometric format. An image saved in "radiometric" format saves the energy information associated with these energized photo detectors (displayed as pixels in the image) while an image saved in "non-radiometric" format does not. Post processing of radiometric images sets the stage for "quantitative," reproducible analysis on saved images.

J.N. Allinson Associates, Inc. also studies "mechanical systems" while they are actively running under normal operating conditions. The infrared thermal images saved in radiometric format during the field observations are further analyzed back at the office using ThermaCAM™ Researcher Pro post processing software.

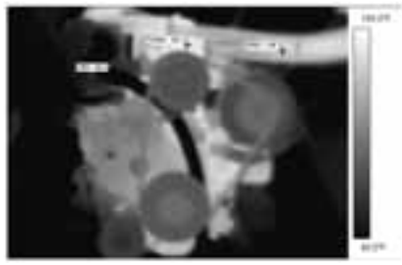


"Quantitative" analyses … same image as on the left, but now shows temperature scale and select spot measurements. Three (3) spot temperature measurements (SP01-SP03). Image taken on January 5, 2005.
SP01 – (69.6º F) rubber hose supplying raw-water for cooling system.
SP02 – (153.6º F) cast metal housing engine exhaust gases and raw water cooling water (wet exhaust).
SP03 – (141.5º F) rubber hose discharging wet exhaust.
DIFF – (ΔT 71.9º F) calculated temperature difference between SP03-SP01.
Note: Temperature analysis does not take the different emissivities of rubber hose (SP01 & SP03) versus metal housing (SP02) into consideration.

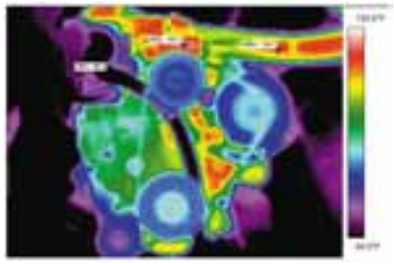
Internal combustion (IC) engines

A typical IC engine is designed to be the most efficient when it operates just below a temperature threshold that causes it to catastrophically fail. In support of the importance of temperature, you will often see gauges at the helm station (or mounted near the engine) which show the temperature of the engine block, exhaust gases and cooling water. When a marine surveyor conducts a "sea trial," these temperature measurements are key components presented in the findings. This leaves little doubt of the suitability of using infrared thermal imaging equipment that provides both visual and quantitative information in support of the instrument gauges and thermal signature of an IC engine.

Image Display Pallets Infrared Thermal Images



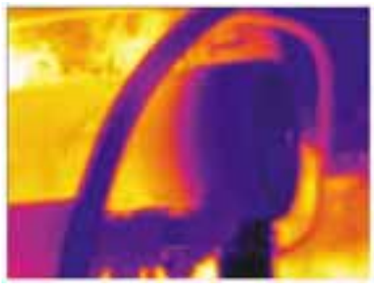
Infrared image displayed using "grey" palette with 120 shades of color representing different temperatures in the temperature scale (80.0ºF – 180.0ºF).



Infrared image displayed using "infra" palette with 233 shades of color representing different temperatures in the displayed temperature scale (80.0ºF – 180.0ºF).

The images above show the importance of selecting a palette for an Infrared Thermal image. The only difference in the images is the selection of palettes ("grey" versus "infra"). The image displayed using the "infra" palette reveals more visual information about the heat signature of the YANMAR diesel engine, the raw-water cooling and wet exhaust system.

Heat exchangers (IC) engines

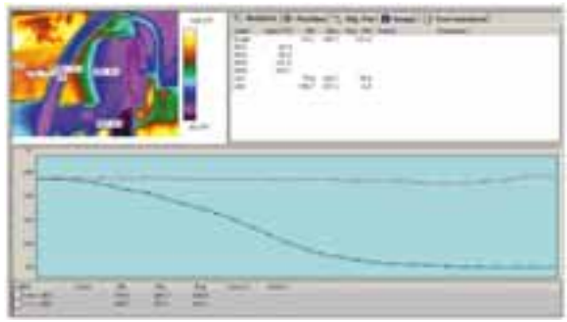


Heat exchangers are designed to remove heat away from an IC engine. The thermal image is of a horizontally installed cylindrical heat exchanger using raw-water supply.

A common style of heat exchanger is cylindrical in shape with a bundle of tubes running longitudinally through it. The bundle of tubes is covered by the flowing hot engine coolant, while a cooler liquid flows through the tubes. The heat from the engine coolant is transferred (or exchanged) to the cooler liquid flowing through the tubes. The cooler liquid can either reticulate to an external closed water cooling system as in the case of a "dry stack" exhaust system coupled to a keel cooler, or is discharged to an external raw-water discharge system as in the case of a "wet" exhaust system. A common method to determine whether there is a need for replacement or preventative maintenance on a heat exchanger is to measure the difference in surface temperature along the length of heat exchanger while the IC engine is running. If there is no temperature difference, the heat exchanger is not working properly. The cause for its malfunction will need to be determined and corrected.

The following infrared thermal images illustrate the importance of saving infrared thermal images in radiometric format.

"Qualitative" analysis in the field shows negative findings for a blocked heat exchanger.



"Quantitative" post processing shows spot temperature measurements and a line graph analysis that characterize the ΔT 75.0º F for line LI01 and ΔT 6.4º F for line LI02.

Additional mechanical systems that benefit from inspection using infrared thermal imaging include:

1.1.	Exhaust systems	3.2.	Hydraulic
1.1.1.	Wet	4.	Drive Shafts
1.1.2.	Dry	4.1.	Transmission Coupler
2.	Pulleys And Fan Belts	4.2.	Shaft Logs
2.1.	Alternators	5.	Steerage Assemblies
2.2.	Raw Water Pumps	5.1.	Rudder Post Shaft Logs
2.3.	Fan Belt Alignment	5.2.	Power Steering
3.	Transmissions	6.	Refrigeration
3.1.	Mechanical	6.1.	Compressors

The average in-the-field infrared thermal image scan of mechanical systems on vessels up to 65 feet in length represents about 2.5 hours of work effort.

In a future article, we will look at applying infrared thermography to marine surveying, and cover the inspection of hull structure systems such as wood, metal and fiberglass composites along with a look at energy audits (e.g. thermal barriers, water leaks and energy loss in conditioned air spaces). ■

John (Jack) N. Allinson II is a SAMS Accredited Marine Surveyor, Accredited Claims Adjuster in Florida, and a Level I Certified Thermographer. He is the president of J.N. Allinson Associates, Inc., a firm that provides Marine Surveying Consulting Services based out of Jacksonville, Fla., and is a long-time ABYC member. For more information about Mr. Allinson's services and credentials, please visit www.allinson.com.