

# Infrared Thermography in Marine Laminate Inspections: The Problem with Solar Loading

By Charles J. Hazouri CMI, CMS  
Offshore Marine Inspections

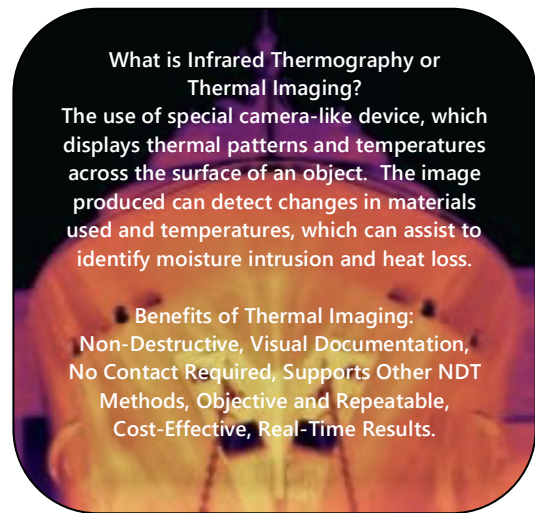
## Definitions

### Marine Survey

A marine survey is a formal, credentialed examination of a vessel conducted by a certified or accredited marine surveyor. It is performed for defined professional purposes including pre-purchase assessment, insurance underwriting, valuation, damage or casualty investigation, and warranty or legal dispute resolution. A marine survey adheres to recognized industry standards and culminates in a signed survey report presenting the surveyor's documented findings, opinions, and recommendations. In the United States, marine surveyors may hold accreditation through recognized bodies or organizations such as IAMI, IIMS, NAMS, SAMS, and Navtech.<sup>1</sup> A marine survey is distinct from a general inspection because it involves a credentialed professional, a formal methodology, and a legally and professionally defensible work product.

### Marine Inspection

A marine inspection is a broader and less formally defined term referring to any systematic examination of a vessel, its systems, or its components. Inspections may be conducted by a range of parties including shipyard personnel, flag-state surveyors, classification society surveyors, manufacturer representatives, repair technicians, or vessel owners. Unlike a marine survey, an inspection does not necessarily involve a credentialed marine surveyor, does not always produce a formal signed report, and does not carry the same uniform professional or legal standard. Thermographic examinations conducted as part of a yard condition assessment, a warranty claim investigation, or a manufacturer's quality review would typically be classified as inspections rather than surveys. The distinction is significant in legal and insurance contexts, where the qualifications of the examiner and the resulting documentation may be subject to scrutiny.



<sup>1</sup> International Association of Marine Investigators (IAM), International Institute of Marine Surveying (IIMS), National Association of Marine Surveyors (NAMS-Global), and the Society of Accredited Marine Surveyors (SAMS).

## Thermographic Survey vs. Thermographic Inspection

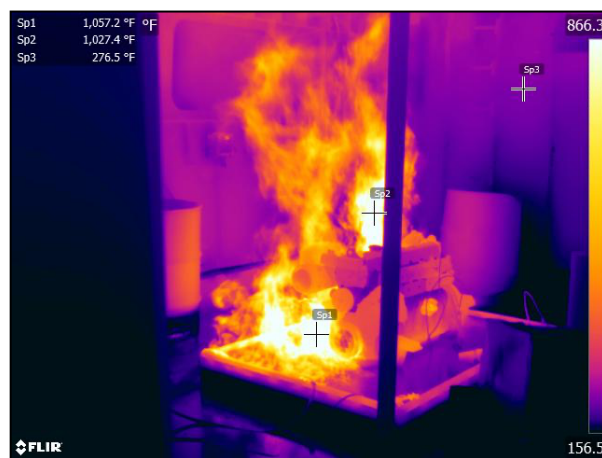
Within this document, the terms *thermographic survey* and *thermographic inspection* are used in alignment with the above definitions. A *thermographic survey* refers to a broader thermal imaging examination conducted by a credentialed marine surveyor as part of a formal survey engagement. It includes ancillary testing not limited to percussion sounding, moisture analysis, hardness testing, and a complete visual inspection, with full documentation and conclusions. A *thermographic inspection* refers to a focused thermal imaging examination of a vessel or its components whose sole purpose is to collect and evaluate thermal data, producing findings and recommendations based on that data alone. In both contexts, every individual acquiring thermographic data must personally hold the required thermographic credentials, and findings are incorporated into a signed report, rendered as professional opinions. The standards of methodology, documentation, and defensibility described in this document apply most stringently to thermographic surveys, but represent best practice for all thermographic examinations of marine Fiber-Reinforced Polymer or Plastics (FRP) and advanced composite structures.

## The Operational vs. Structural Interpretation

It is worth noting that within the marine industry, the terms survey and inspection are also commonly understood along functional rather than purely credentialing lines. Under this interpretation, a *marine survey* typically encompasses vessel condition, valuation, operational readiness, machinery, and systems — the broader assessment of a vessel's fitness for purpose, use, voyage, and market value. A *marine inspection*, by contrast, is often understood as a more focused, technical examination of a specific structural, mechanical, or material concern — including non-destructive testing, structural integrity assessment, laminate analysis, and thermographic examination.

Under this functional distinction, thermographic examination of FRP laminate and composite structure falls squarely within the inspection category — it is a specialized, technically focused, non-destructive examination of material condition rather than a broad operational assessment of the vessel as a whole.

In professional practice both interpretations have merit and are not mutually exclusive. A credentialed marine surveyor may conduct both surveys and inspections, and a formal survey report may incorporate thermographic inspection findings as supporting technical evidence. The standards described in this document apply equally to both.



Marine inspection of a controlled engine room fire. The thermogram was displayed using the Ironbow color palette, providing distinct, informative, and accurate thermal interpretation.

## What Is Passive Thermal Imaging?

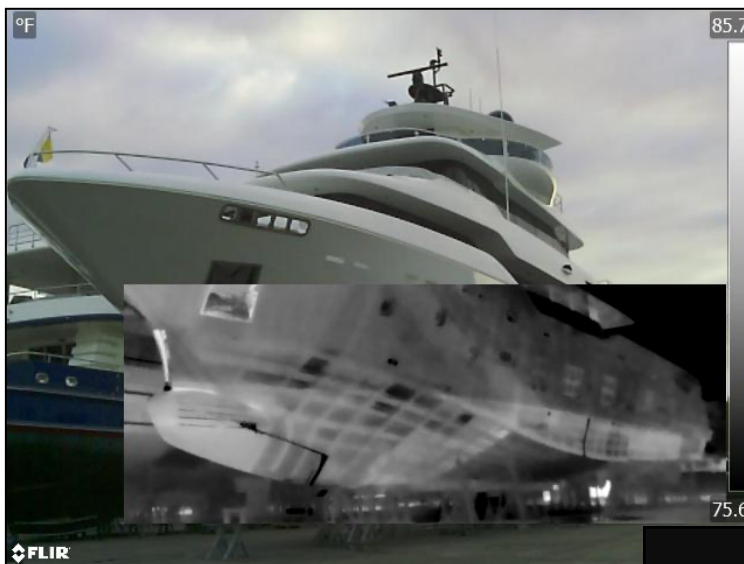
All objects above Absolute Zero (0 Kelvin) emit infrared radiation. Passive thermal imaging utilizes a thermal imager to detect and convert emitted radiation into a visible image. Typically, warmer areas appear brighter (or in false-color as red/orange), cooler areas appear darker (or blue/purple), depending on the palette used.

During passive thermal imaging, objects are inspected “as-is” without applying an external heat source. In marine surveys or inspections, passive thermography is used to detect moisture intrusion, laminate to core disbonding, interlaminar separation (delamination), and resin-starved laminates. Wet or disbonded laminate retains or releases heat at a different rate than sound laminate, creating detectable thermal differentials.

## What Is Active Thermal Imaging?

Active thermal imaging is also referred to as active infrared thermography or active thermography. It is a non-destructive testing method in which an external energy source is deliberately applied to a structure to induce a thermal response, which is then recorded using an infrared thermal imager. Unlike passive thermography, which relies on naturally occurring temperature differentials, active thermography provides the thermographer with direct control over the thermal stimulus, its intensity, duration, and timing.

The fundamental principle is heat flow: when thermal energy is applied to a surface, it diffuses inward through the material over time. Defects within the laminates such as interlaminar separation-delamination, voids, moisture inclusions, or disbonded interfaces have different thermal conductivity and diffusivity than sound material. This difference interrupts normal heat flow, causing defective or deficient areas to heat or cool at a different rate than intact material. That differential becomes visible to an infrared imager as a thermal anomaly during the heating or cool down phase.



Hull bottom inspection using a Teledyne FLIR  $f=5\text{mm}$  ( $80^\circ$ ) Field of View (FOV) wide-angle lens.

This baseline thermogram was acquired during overcast conditions at civil twilight. The subject was at thermal equilibrium. The active thermal imaging inspection was conducted after sunset with applied heat ensuring proper thermal imaging techniques.

This image is properly thermally tuned.

## Common Active Stimulation Methods

Several excitation sources are used in active thermography depending on material type, depth of the target defect, and field conditions:

- Pulsed thermography – a brief, high-intensity flash of optical or thermal energy is applied, and the surface is imaged continuously during cool down. Well-suited for relatively thin laminates and shallow defects.
- Lock-in thermography – a sinusoidal (cyclic) heat source is applied at a controlled frequency, allowing phase and amplitude images to be extracted. Effective for detecting deeper anomalies.
- Step heating – a sustained heat source is applied over a longer period and then removed with imaging continuing throughout the cool down transient. Useful for thicker laminates.
- Ultrasonic or vibration excitation – sound or mechanical energy is introduced into the structure, generating frictional heat at crack faces and disbanded interfaces. Most applicable for dry delamination detection.

In field marine survey practice, the most *commonly* used active stimulus methods involve AC-powered or propane-fired heating systems used to apply controlled warm-air loading to a surface, followed by immediate thermal imaging during the cooldown phase. They should be used to warm an area, but *not used* to heat the laminates.

## Key Advantages Over Passive Thermography

Active thermography offers several advantages that make it the preferred method for structural laminate inspection:

- The thermographer controls the thermal stimulus, making results repeatable and documentable
- The timing of heat application and image acquisition can be optimized for the specific laminate thickness and expected defect depth
- Signal-to-noise ratio is substantially higher than passive methods because the induced thermal contrast is known and calibrated against a controlled baseline
- Results are less sensitive to ambient environmental conditions, including Sun angle, surface color variation, and ambient temperature fluctuation
- Findings are more defensible in legal, insurance, and warranty contexts because the methodology can be fully documented and reproduced

Active thermography is the preferred standard in aerospace, military, and industrial composite inspection, and its application to marine FRP laminate surveying and inspections is supported by both the governing Infraspection Institute Standard and peer-reviewed field research.

## Three Distinct Thermographic Scenarios in Marine Inspection:

It is important to distinguish clearly between three separate thermographic scenarios, as they differ significantly in method, validity, and professional defensibility:

### **Scenario A: Passive Inspection (No Stimulus)**

In a passive inspection, the thermographer observes thermal patterns with no external heat stimulus applied. The structure must be at thermal equilibrium — meaning that it has not been exposed to either solar loading or artificial heating. Any external heat source, including the Sun, is a confounding variable that corrupts the baseline. This approach is most appropriate for moisture detection and early-stage delamination identification under controlled conditions such as early morning or overcast weather.

### **Scenario B: Active Inspection with Artificial Stimulus**

In an active inspection, the thermographer applies a controlled heat source and then images the surface as heat diffuses through the laminate. Defects interrupt normal heat flow and appear as thermal anomalies during the heating or cool down phase. Solar loading is a confounding variable in this scenario and should be absent or fully accounted for, as it introduces an uncontrolled thermal gradient that reduces signal-to-noise ratio and undermines the repeatability of the applied stimulus.

Field studies and peer-reviewed research on composite laminate inspection consistently demonstrate that controlled active thermography using calibrated artificial stimulation produces superior defect detection, particularly for deeper subsurface anomalies, compared to uncontrolled environmental heating. Active thermography is the preferred approach for marine laminate inspections.

### **Scenario C: Solar Loading Thermography (Sun as Stimulus)**

Solar loading thermography uses the Sun to heat the target. The structure is allowed to absorb solar energy over a defined period, after which it is shaded and imaged during the cool down phase. This is a recognized technique in nondestructive testing of large structures where artificial stimulation is impractical.



This image exhibits poor thermal tuning and the effects of solar loading from adjacent structures.

Reflections and Shadowing.

## Why Solar Loading Is Problematic for Marine Laminate Thermography:

Solar radiation heats exposed surfaces directly and unevenly causing thermal gradients that completely mask the subsurface thermal signatures the inspector is trying to detect.

### Problems in Passive Inspection

When solar loading is present during a passive survey:

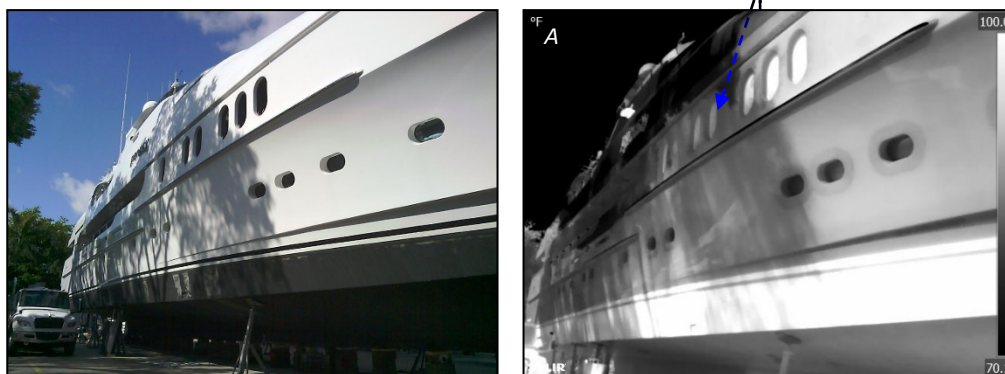
- It heats the outer surface skin rapidly, creating a strong surface-to-subsurface gradient unrelated to structural defects.
- It causes differential heating based on surface color, texture, orientation, and geometry — dark nonskid absorbs far more energy than white gelcoat, producing apparent anomalies that are purely cosmetic.
- It creates hot spots that can resemble thermal anomalies.
- It produces thermal shadows in areas shielded from direct Sun, which appear anomalously cool relative to exposed surfaces.

The result is a thermal image dominated by solar-induced surface effects rather than subsurface defects.

### Problems in Active Inspections with Artificial Stimulus

When solar loading is present alongside a controlled, artificial stimulus:

- It adds an uncontrolled, variable heat input that corrupts the established pre-stimulus baseline.
- It reduces the signal-to-noise ratio of the controlled stimulus, since the defect-related thermal contrast may be small compared to the solar-imposed surface gradient.
- It makes repeatability essentially impossible if Sun angle or cloud cover changes during the inspection window.

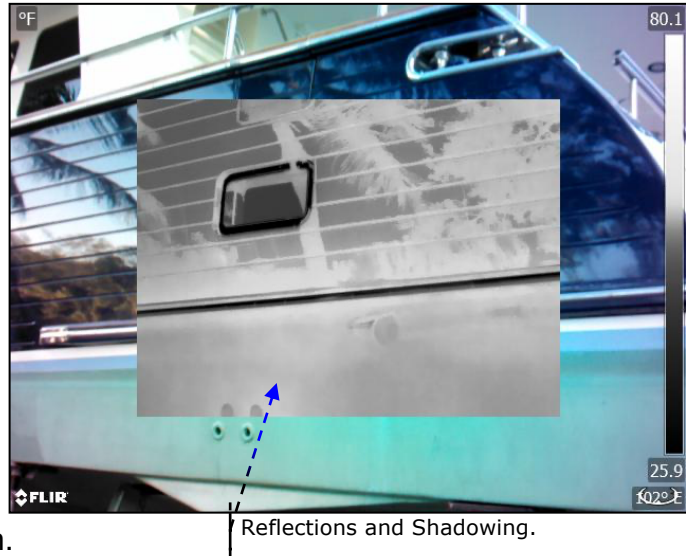


The thermal image above (A) was acquired under active solar loading conditions and exhibit characteristic artifacts including surface overheating, reflected radiation, and thermal shadowing from adjacent structures. These effects are unrelated to subsurface laminate conditions and render the thermal data invalid for professional thermographic reporting.

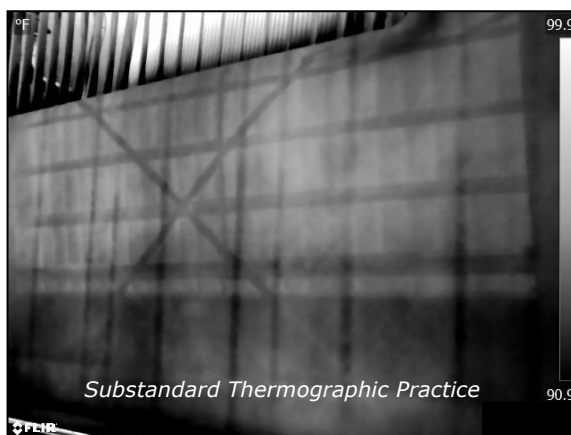
## Problems When Solar Loading Is Used as the Primary Stimulus

Even when solar loading is used deliberately as the heat stimulus (Scenario C), significant limitations apply in marine laminate inspection:

- Solar irradiance is non-uniform across complex vessel geometry — vertical topsides, curved hull sections, and overhanging structures receive uneven heating.
- Uneven heating caused by surface color and texture produces thermal patterns that are geometry-driven rather than defect-driven, complicating interpretation.
- Wind, cloud cover, and changing Sun angle introduce uncontrolled variability throughout the acquisition period.
- Thermal diffusivity of FRP laminate limits how deeply solar-induced heat penetrates before the cool down window closes, reducing sensitivity to deeper defects.
- The technique cannot be calibrated or standardized to the degree required for defensible survey documentation.

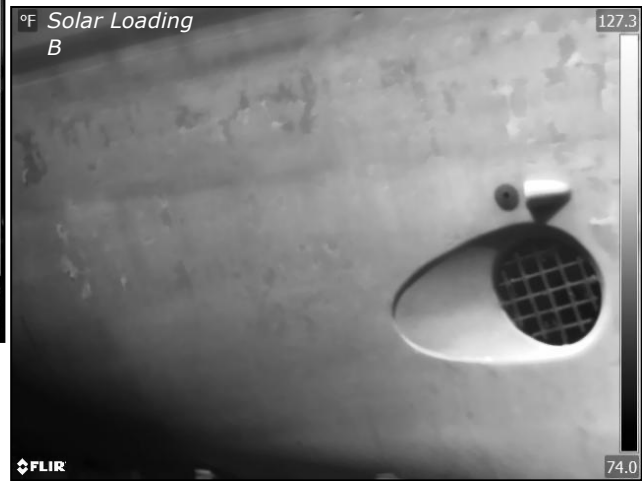
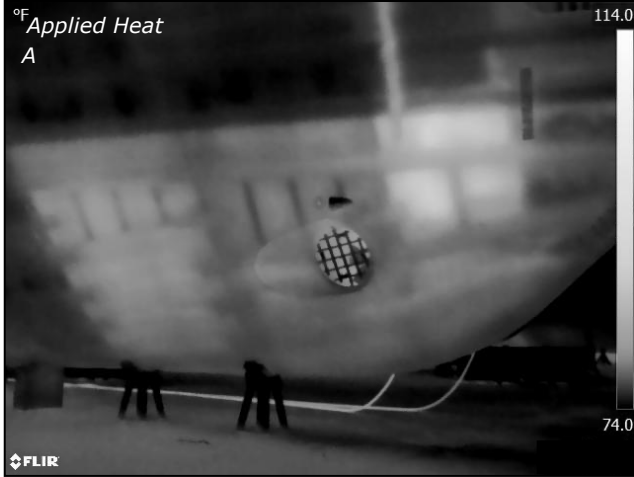


Infraspection Institute, the body that publishes the Standard for Infrared Inspection of Recreational Yachts & Small Craft Constructed of Fiberglass Reinforced Plastic and Composite Materials, states explicitly that solar loading should be avoided in thermographic inspections, as there is no reliable means to compensate or correct for its effects. The standard advises thermographers to image on heavily overcast days (obscured), at night, or early morning, or to shade exposed targets and wait for temperatures to normalize before imaging.

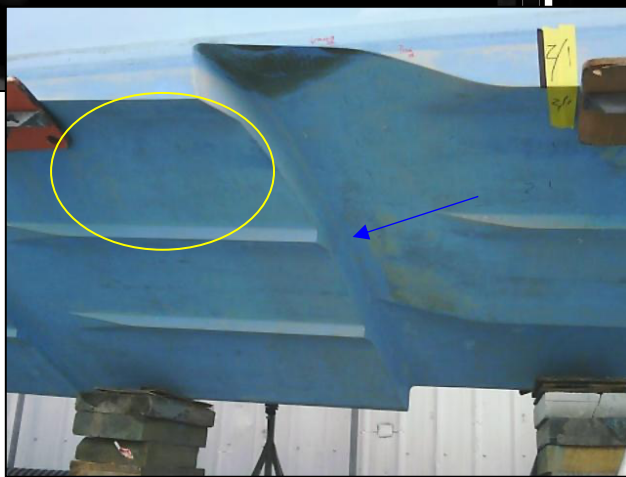
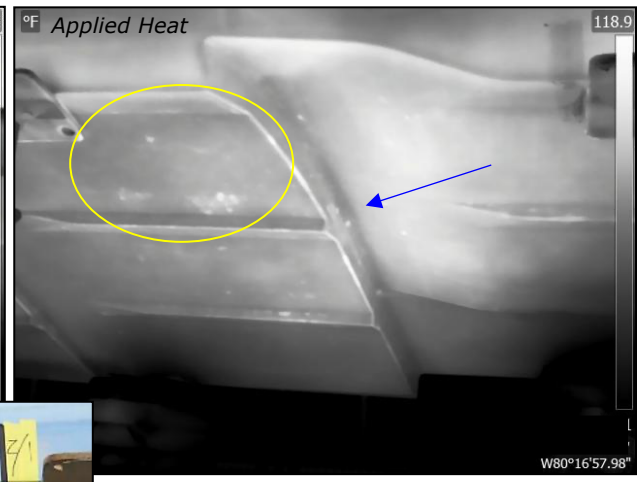
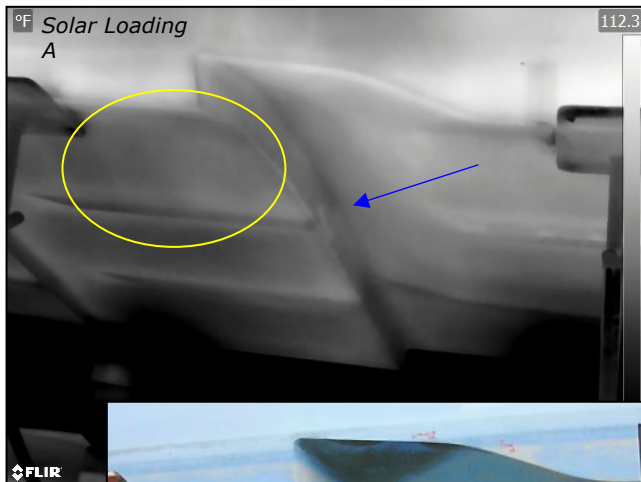


Solar loading combined with reflected radiation creates competing thermal effects that make accurate identification of laminate defects impossible. Under these conditions, emissivity and reflected temperature parameters cannot be correctly established, rendering any apparent thermal anomaly in the image unreliable as evidence of a genuine subsurface laminate failure. Presenting thermal images acquired under these conditions as professional thermographic findings is inconsistent with the standards of a certified infrared thermographer.

The thermogram on the left (A) was acquired prior to sunrise using controlled thermal excitation. The thermogram on the right (B) was acquired during moderate morning solar loading without controlled thermal excitation. The active image on the left reveals clear structural detail and subsurface definition consistent with professional thermographic standards.



The solar loaded image on the right (B) exhibits significantly reduced structural resolution, demonstrating how even moderate solar loading suppresses thermal contrast and obscures subsurface laminate detail. This direct comparison illustrates why solar loading, even at low to moderate intensity, is insufficient as a primary stimulus for professional marine laminate thermographic inspection and why findings generated under these conditions cannot be considered reliable evidence of laminate condition.



These thermograms were acquired during low to moderate solar loading under overcast conditions without controlled thermal excitation. The solar loaded image (A) exhibits significantly reduced structural resolution, demonstrating how even low to moderate solar loading suppresses thermal contrast and obscures subsurface laminate detail.

Without applied controlled thermal excitation, the voids present within the laminate would have gone undetected, findings that would have been absent from any thermographic report generated under these conditions.

## The Measurement Physics: Emissivity and Reflected Temperature Under Solar Loading

Accurate non-contact temperature measurement depends on two critical measurement parameters being correctly established before any thermal data can be trusted: Emissivity and Reflected Temperature (T-Reflect). Solar loading introduces compounding errors into both, undermining the validity of temperature measurements at a fundamental level.

### Emissivity( $\epsilon$ )

Emissivity is the ratio of thermal radiation emitted by a surface compared to that of a perfect blackbody at the same wavelength and temperature. It is treated in thermographic practice as a fixed material property, assigned by the thermographer in the thermal imager. In marine FRP and composite surfaces, emissivity values typically range from 0.75 to 0.95 depending on material, surface condition, and viewing angle.

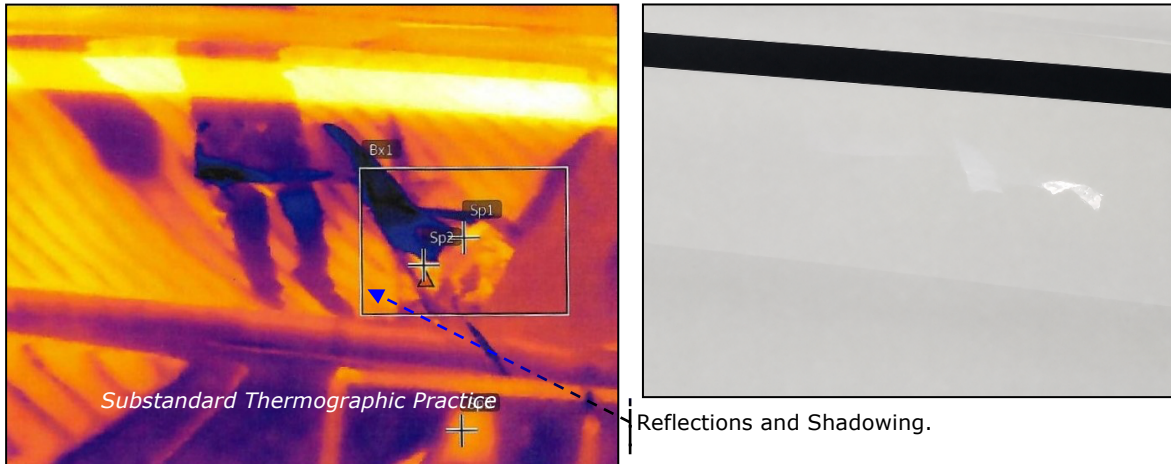
Solar loading destabilizes emissivity-based measurements in several ways. Uneven solar heating across a vessel surface causes adjacent zones with different emissivity values — nonskid versus gelcoat, dark antifouling versus white topsides — to produce temperature differentials that are driven entirely by surface absorption characteristics rather than subsurface conditions. Additionally, solar-induced surface effects including moisture evaporation, thermal expansion, and oxidation can temporarily alter the emissive behavior of the surface in ways that cannot be properly adjusted by fixed emissivity correction.

A thermographer who sets a single emissivity value for a hull or deck surface under solar loading is applying one correction to a surface that is behaving as multiple different emitters simultaneously.

It should also be noted that emissivity values for marine surfaces are rarely verified in the field through direct measurement. Most thermographers apply a generalized value based on material type alone, without accounting for weathering, fouling, surface contamination, or coating condition. Solar loading compounds this shortcut.

*A surface that has been absorbing direct solar radiation for several hours becomes significantly overheated, obscuring subsurface anomalies. No camera correction applied at the start of an inspection can remain valid across a hull that is actively changing temperature under solar influence. The result is not a minor calibration concern — it is a systematic source of false data embedded in every image captured under those conditions.*

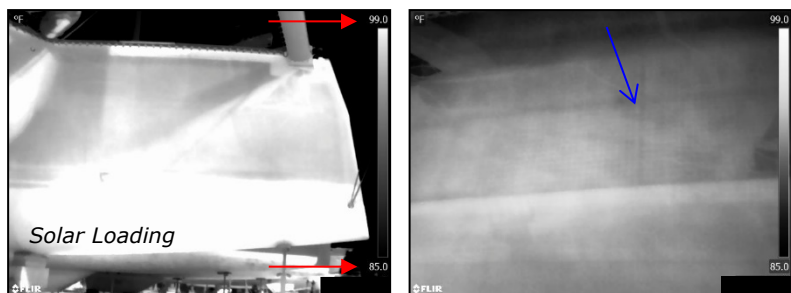
## Reflected Temperature (T-Reflect or $T_{ref}$ )



Reflected temperature compensation accounts for infrared energy that is reflected off the target surface rather than emitted by it. Under solar loading, T-Reflect error becomes severe. The Sun is an extraordinarily powerful broadband radiation source, producing shortwave and longwave infrared energy at intensities far beyond what the camera's T-Reflect compensation is designed to handle under normal ambient conditions. Reflected solar energy adds directly to the apparent temperature reading, causing systematic overestimation of surface temperature across the inspection area. This error is not constant. It varies continuously with Sun angle, cloud cover, and the geometry of the surface being imaged, meaning that a T-Reflect value entered at the start of an inspection becomes increasingly incorrect as conditions change throughout the inspection. On curved hull surfaces, specular reflections can produce localized apparent temperatures substantially above actual surface temperature, generating false anomalies indistinguishable from genuine defect signatures.



The solar loading thermograms were acquired during moderate solar loading under partly cloudy conditions. The applied heat thermograms were acquired after sunset under partly cloudy conditions using controlled thermal excitation. The solar loading images exhibit extreme reflected radiation and could not be thermally tuned to produce comparable image quality. The kerfs and termination lines of the coring material are clearly visible in the applied heat images, subsurface detail that solar loading failed to reveal.



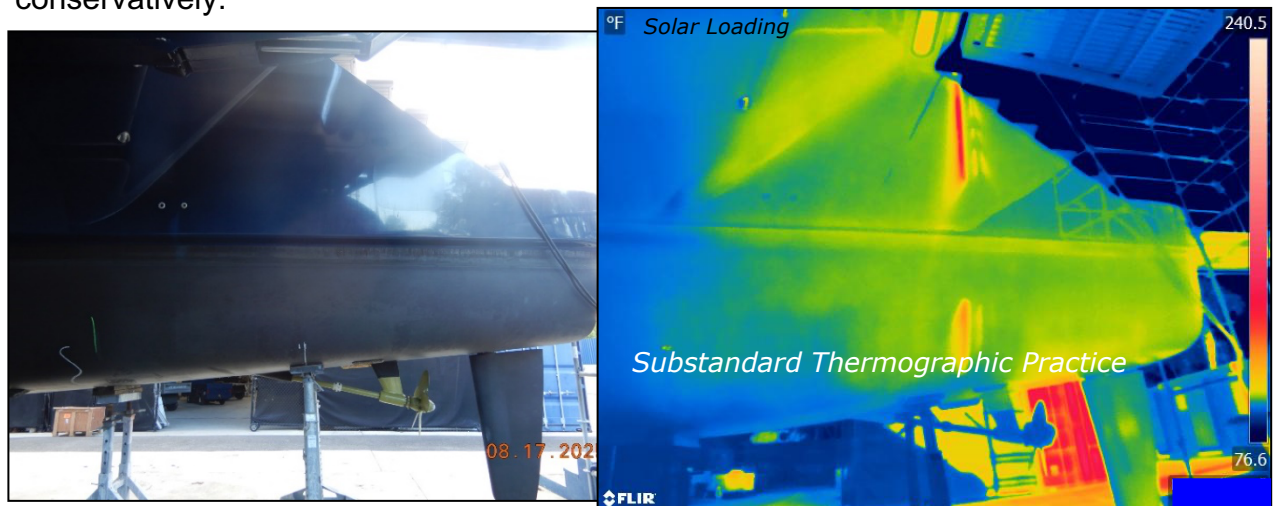
Deficient coring non-conformities of direct structural significance would have gone *undetected* and *unreported* under solar loading conditions alone. Subsurface detail is lost entirely under solar loading.

## Solar Loading Is Not the Preferred Method for Marine Laminate Inspection:

Based on both published standards and field research, solar loading thermography should not be the preferred or primary method for marine FRP and composite laminate inspection. The following professional position is supported by field studies and the governing industry standard:

- Controlled active thermography with calibrated artificial stimulation consistently demonstrates superior defect detection sensitivity for composite laminate defects, including delamination, moisture intrusion, voids, and disbanded tabbing.
- Solar loading introduces variables that cannot be fully controlled, compensated for, or documented to the standard required for survey reports submitted to vessel owners, insurers, or legal proceedings.
- Peer-reviewed research on FRP laminate inspection confirms that active thermography with controlled excitation sources outperforms passive or environmentally stimulated techniques in signal-to-noise ratio and defect characterization accuracy.
- The Infrasppection Institute Standard, the only published industry-specific standard for FRP marine vessel thermography, addresses both active and passive techniques but does not endorse solar loading as a primary inspection methodology.

Solar loading thermography may serve a supplementary role in field conditions where no artificial stimulus is available, but findings generated under such conditions should be clearly documented as such, corroborated by other non-destructive methods (percussion sounding, moisture meter readings, core sampling), and interpreted conservatively.



The thermogram above is poorly tuned and displayed using a Rainbow palette. Due to the effects of solar loading and the inappropriate choice of color palette, the resulting image is considered unreliable for accurate forensic evaluation of the laminate structure. Any level of active solar loading — low, moderate, or high — introduces uncontrolled thermal variables that suppress subsurface thermal contrast, corrupt measurement parameters, and compromise the validity and defensibility of thermographic findings. There is no threshold which solar loading becomes acceptable for professional marine thermographic inspections.

## Best Practice in Marine Thermography Inspections or Surveys:

***“If an object absorbs enough heat from the Sun, significant thermal anomalies may be hidden and go undetected. As there is no way to compensate or correct for solar loading, the most prudent course of action is avoidance. Solar loading can be avoided by imaging on cloudy days, at night, or early in the morning. Solar loading can also be overcome by shading an exposed target and waiting for the object’s temperature to return to normal.”***

— Infraspection Institute, “The Problem with Solar Loading,” IRINFO.org, Tip of the Week, July 13, 2025

The following practices represent the professionally defensible standard for thermographic inspection of marine FRP and composite laminates:

- Conduct inspections at dawn, dusk, nightfall, or under extreme overcast conditions, ensuring the structure has had sufficient time to thermally equilibrate and residual solar heating has fully dissipated prior to initiating a thermal imaging inspection.
- For active inspections, use controlled, calibrated artificial heat sources and document the heat source type, intensity, duration, and distance.
- Document conditions, ambient temperature, surface temperature, relative humidity, and Sun angle at the time of inspection for all sessions.
- Corroborate thermographic findings with percussion sounding, calibrated moisture metering, and where appropriate, physical sampling or destructive testing.
- Do not rely on solar loading as the primary heat source in any inspection where results will be used to support survey opinions in legal, insurance, or warranty contexts.
- The certified thermographer who personally conducted the thermographic survey or inspection must be the sole signatory of the final report — findings may not be signed, certified, verified, or reviewed by any party who was not present during the examination.
- Follow the Infraspection Institute Standard for Infrared Inspection of Recreational Yachts & Small Craft Constructed of Fiberglass Reinforced Plastic and Composite Materials as the governing procedural framework.

The professional standard is not merely to be aware of solar loading, but to actively control for it and to select inspection methods that produce repeatable, calibrated, and defensible results.

## Thermal Palette Selection

The selection of an appropriate thermal imaging palette is a critical and often overlooked component of professional thermographic practice. The palette determines how thermal data is visually represented and directly affects both the thermographer's ability to detect anomalies in the field and the clarity and credibility of findings presented in a formal report.

**Ironbow** (Iron) is the recommended palette for active detection and field examination of marine FRP and composite laminates. It provides a broad, distinguishable color gradient across the thermal range, making subtle subsurface temperature differentials more visually identifiable than other palettes. It is widely referenced in structural, building, and composite inspection literature as the preferred detection palette.

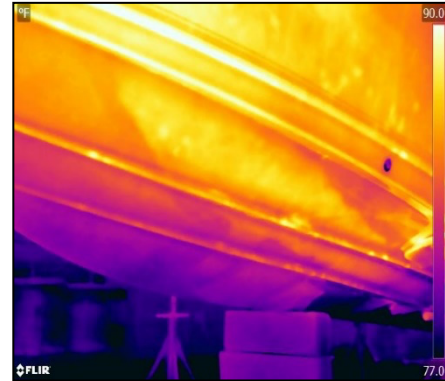
Ironbow is best suited for the following marine thermographic applications:

- Moisture detection and moisture mapping across hull and deck surfaces, where subtle variations in thermal retention across a broad area need to be visually distinguishable.
- General temperature variation surveys where the thermographer is scanning for the presence and extent of thermal anomalies across large surface areas.
- Active thermography detection phases where the full thermal gradient needs to be visible across the cooldown sequence.

**Grayscale** (White Hot or Black and White) is recommended for formal reporting. It reproduces accurately in both color and black and white print, is not subject to visual misinterpretation based on color bias, and is the palette most consistently referenced in ASTM standards and peer-reviewed thermographic research. Best practice is to capture images in Ironbow for detection purposes and present final report images in Grayscale for documentation purposes.

Grayscale is best suited for:

- Formal report documentation where images must reproduce accurately in print.
- Laminate discontinuities and structural imperfections where high contrast between sound and defective material is more important than color differentiation.
- Legal and insurance submissions where palette neutrality and print reproducibility are required.

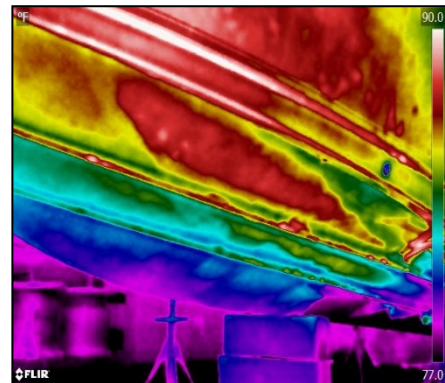


**Inverted Grayscale (Black Hot)** is best suited for:

- Laminate discontinuities, voids, and disbanded interfaces where the inversion reverses the contrast, making cooler anomalies appear as dark features against a light background — often making subtle imperfections more visually apparent than standard Grayscale.
- Situations where the defect signature is a thermal depression rather than a thermal elevation. Inversion can make these easier to identify and document in formal reporting.



**Rain, Rainbow, and Spectrum** are *not* recommended for thermographic reporting in technical, legal, or insurance contexts. These palettes compress subtle thermal differentials, introduce visual artifacts at palette transition boundaries, and can present thermal data in a visually misleading manner that does not accurately represent actual temperature gradients across the inspection surface. The use of Rainbow or Spectrum palette images in a formal survey report or inspection document is inconsistent with the standards of professional thermographic practice and may undermine the credibility of the findings presented.



It should be noted that Rainbow and Spectrum palettes have legitimate and well-established applications in other thermographic disciplines, most notably medical and clinical thermography, where controlled environments, uniform surface emissivity, and physiological pattern recognition make them appropriate and effective. Their unsuitability is specific to technical, structural, and professional marine inspection and survey reporting.



This solar loaded image in Rainbow Palette exhibits poor thermal tuning.

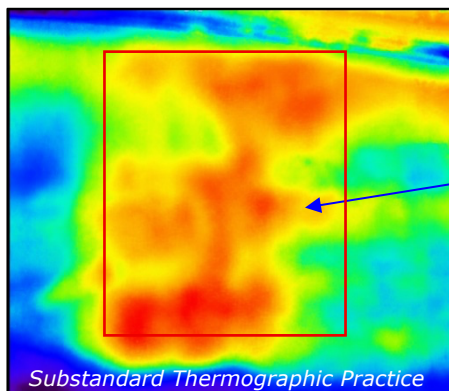
Moisture mapping using Iron Palette.

## Conclusion:

Field studies and peer-reviewed research on composite laminate inspection consistently demonstrates that solar loading produces inferior thermographic results compared to controlled active thermography using calibrated thermal excitation. The evidence is clear. Solar loading is not, and should not be, the preferred method of thermographic examination in professional marine FRP and composite laminate inspection. It is uncontrolled, uncalibrated, and incapable of producing the defensible thermographic data required for professional marine inspection and/or survey reporting.

The integrity of thermographic examination in the marine survey field depends not on the sophistication of the equipment employed, but on the discipline, methodology, and professional accountability of the thermographer behind it. Solar loading is uncontrolled, uncalibrated, and incapable of producing defensible thermographic data. It represents the antithesis of that standard. The client deserves an accurate report with accurate findings, and the vessel deserves a thorough and methodologically sound examination. When the integrity of the vessel, the accuracy of the findings, and the credibility of the thermographer are all at stake, solar loading has no place as a primary method in professional marine thermographic inspection.

*Every credentialed marine surveyor, inspector, investigator, and thermographer is bound by the codes of ethics of each organization under which they hold certification. Those codes universally require that professionals accept only assignments they can complete with competence and professionalism, that findings be honest, accurate, and defensible, and that no false, misleading, deceptive, or unfair statements be made against others in the field outside of formal legal proceedings. Submitting thermographic findings acquired under substandard conditions — including solar loading — as professional survey or inspection evidence is not merely a methodological failure. It is a potential violation of the professional code of ethics governing every credential the maritime professional holds. This document does not seek to impugn any individual practitioner. It seeks to elevate the standard of the practice in the interest of the clients, the vessels, and the profession we serve.*



This thermogram is poorly tuned and inadequately optimized.



Reflected infrared energy from the thermographer or adjacent personal can become visible within thermograms during solar loading.

Such reflections will create misleading thermal signatures and reduce reliability of forensic interpretation.

**Reflections move. Structural anomalies do not.**

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## **Charles J. Hazouri** **Offshore Marine Inspections**

Certified Level I – Infrared Training Center (ITC)

Certified Level II-III and Master Thermographer® – Infrasppection Institute

Infrared (IR) Technician IR-TechIIMS – International Institute of Marine Surveying

Certified Marine Investigator CMI – International Association of Marine Investigators

Certified Marine Surveyor CMS – National Association of Marine Surveyors



### **About the Author**

*Charles J. Hazouri has spent his life in the marine industry, serving as a Captain, Project Manager, Marine Surveyor, Investigator, Inspector, Auditor, Published Author, and Thermographer. Holding certifications as a Master Thermographer® through the Infrasppection Institute alongside four independent marine-specific credentials, he is one of the most credentialed thermographers currently practicing across the marine survey, inspection, and investigation fields. His work spans engagements with vessel owners, insurance professionals, legal counsel, and law enforcement — bringing the same standard of methodological rigor and professional accountability to every assignment regardless of context or audience. He has a passion for thermal imaging, non-destructive testing, and marine surveys and inspections, and is always on the lookout for new technologies, proper techniques, and improved reporting standards that advance the effectiveness and integrity of the profession.*

*A prominent Infrasppection Institute Master Thermographer/Colleague has expressed to me over and over again; “**Magic comes from the Thermographer, not the Imager.**”<sup>2</sup>*

*Special thanks and professional recognition to the following individuals for their insight and contributions:*

**Mr. James Seffrin**, Director of Infrasppection Institute,  
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**Mr. John Banister** SAMS-AMS©, Level III Master Thermographer,  
Suenos Azules Marine Surveying and Consulting,  
**Ms. Lynda H. Cobb**, Editor, and **Dr. Lisa K. Hawk**, Spousal Support.

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<sup>2</sup> Mr. James Seffrin, Infrasppection Institute— Certified Level III Infrared Thermographer, Master of Thermography, and Director of Infrasppection Institute.

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## References

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The professional codes of ethics governing the maritime and thermographic credentials referenced throughout this document are published by their respective organizations and are available for review. These include the Society of Accredited Marine Surveyors (SAMS) Code of Ethics, the National Association of Marine Surveyors (NAMS-Global) Code of Ethics, the International Association of Marine Investigators (IAMI) Code of Ethics, the International Institute of Marine Surveying (IIMS) Code of Professional Conduct, and the Infraspection Institute Code of Ethics for Certified Infrared Thermographers.

The thermograms presented in this document were acquired using the *currently calibrated* Teledyne FLIR T865, 640 x 480 U-Max@ 30 Hz, 7.5 - 14.0  $\mu\text{m}$ , Digital HP Thermal Infrared Camera. The spectral range ( $\mu\text{m}$ ) and 30 Hz frame rate meet the minimum instrumentation requirement specified in the Infraspection Institute Standard for Infrared Inspection of Recreational Yachts and Small Craft Constructed of Fiberglass Reinforced Plastic and Composite Materials. Controlled thermal excitation was applied using the Ripack 3000-70 Propane Fired Heat Tool, a professional-grade propane heat source delivering consistent, adjustable, and documentable thermal excitation, as distinguished from uncontrolled environmental solar loading. All thermographic data was acquired, post processed, thermally tuned, and interpreted in accordance with the Infraspection Institute Standard.

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