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Infrared Thermography and Void Detection in GRP laminates

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Abstract:

This paper will demonstrate how the use of Infrared (IR) Thermography can be used as part of a Quality Control program to quickly and effectively locate and document voids in Fiberglass Reinforced Plastic laminates. The process of using IR Thermography combined with corrective measures to eliminate and/or repair the voids detected is offered as a means of "IR certifying" at the yacht construction factory that the GRP laminates are free of voids. Many yacht manufacturers' offer a limited five (5) year warranty that the hull(s), deck(s) and other fiberglass parts they manufacture will be free of gel coat voids. It is proposed that the net effect of "IR certifying" these items will instill a greater confidence in how customers perceive a need for this warranty while significantly reducing and/or eliminating warranty claims against the manufacturer and increase the buyer demand for their product.

Keywords: Marine Surveyor, Certified Infrared Thermographer, Percussion Testing, Cored FRP Composite, Fiberglass Reinforced Plastic (GRP), Thermal Mass, Destructive and Non Destructive Testing.

Background:

Yachts constructed of Fiberglass Reinforced Plastic (GRP) typically are composed of an exterior gel coat, followed by layers of fiberglass cloth, a core material, and more layers of fiberglass cloth. The layers and types of fiberglass cloth and coring material used in the build up are referred to as a "laminate schedule". Successive layers of the fiberglass cloth are wetted out with a catalyzed resin and hand rolled with metal bubble rollers that have air relief properties and/or hand rolled and vacuum bagged to ensure that all the materials are fully wetted out, while removing excess resin and reducing the number of air bubbles or pockets. When air bubbles or pockets remain, voids form when the laminate cures. Voids may lead to a structural failure of the GRP of GRP/Core laminate (large air pockets may result in disbonds from the incomplete wetting out of adjoining layers in the laminate), or may simply be a cosmetic nuisance (air bubbles in Gel Coat) when they break open on high traffic areas such as walkways or coach roofs. Often the pigmented Gel Coat that is applied as the outer layer in the lay-up of the laminate hides voids. To counter this, some yacht hull manufacturers will eliminate applying a pigmented Gel Coat on the exterior hull surface below the waterline so that it is easier for them to visually inspect the laminate to detect and repair voids.

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Besides the visual inspection to locate suspected voids, a process known as "percussion sounding" is commonly used. Under ideal conditions the entire surface of the GRP laminate is tapped or "sounded" with a phenolic plastic hammer. When sounding the laminate, a void is identified by a different acoustical sound. Besides being time consuming, tedious, and difficult to document the different acoustical sounds in a factory full of background noises, "percussion sounding" is a potentially Destructive Testing (DT) process. Care must be taken to strike the GRP surface forcefully … yet so hard as to mar or dimple the surface of the Gel coat, the GRP laminate, or unnecessarily stress the interface between a composite core and the next layer of GRP laminate. When a yacht has a sales price of millions of RAND, randomly beating a GRP laminate with a hammer to find voids does not demonstrate a level of professionalism concomitant with the perceived quality and value of the yacht.

There is a better way … and it involves using Infrared (IR) Thermography. Compared to percussion sounding, scanning a GRP laminate with Infrared (IR) Thermography is a quick and definitive Non Destructive Testing (NDT) procedure. It is a tool that offers a concise methodology to locate and document voids in Gel Coat and GRP laminate as well as to confirm that those voids were properly repaired.

Process:

Once pulled from the mould and after the hull and deck have been assembled, the surface temperature of the GRP is artificially raised in discrete sections with a gentle stream of warm air (approximately 45°C) supplied by an electric hot air heat gun, while the surface is simultaneously scanned with an infrared camera that is capable of capturing radiometric images either as single images or in burst recording mode. As each section of the hull surface is "painted" with a gentle, rhythmic sweeping motion of warm air, the "real time" differences in the surface temperature of the laminate is visually observed on the infrared camera's LCD screen. Areas where voids are present in the FRP laminate warm quickly while the homogeneous and "void free" laminate surrounding the void remain cooler due to its ability to act as a more effective heat sink. Voids in the Gel Coat are quickly discovered and effectively repaired at the factory, without a buyer having to invoke the terms of the warranty that promised a void free Gel Coat. The sections of the hull that were IR scanned are now "IR Certified" and provide additional level of Quality Control comfort to the buyer.

Conclusion:

Proper and procedural IR Thermal scanning of FRP laminates by factory Quality Assurance and Quality Control personnel under the direction of a Certified Infrared Thermographer who is familiar with yacht construction and best yacht building practices offers a quick and effective way to find voids in Gel coat and laminates. This process is Non Destructive; the findings can be visually captured and the supporting documentation of discovery and repair easily understood.

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Moving Forward:

Other applications of IR Thermal scanning during the build out process in the yacht construction factory may significantly reduce or eliminate voids when IR is used to:

- See and measure the uniformity of heat released by laminates as they cure in their moulds (see and measure how the use of different core materials effects the exothermic heat released, avoid having brittle areas),
- Monitor the exothermic reaction between different batches of resin and catalyst (avoid using an over catalyzed or "hot batch" of resin),
- Monitor work from afar without disturbing workers inside the yacht as they assemble internal bulkheads and tabbing,
- Monitor and measure the uniformity of resin wet out in materials during the wet lay-up and/or vacuum bag process in the moulds,
- Monitor and measure the uniformity of resin impregnation as it flows into the kerfs of composite core materials,
- Monitor and measure, workers effective use of metal bubble rollers to ensure see that they fully wet out the laminate and release trapped air prior to applying the vacuum bagging,
- Finally … in the case of resin infusion technology where catalyzed resin is injected into dry reinforcement fabrics and then wetted out using a vacuum to pull the resin through the laminate, monitor the inflow and spread of the catalyzed resin as it migrates through the fabric.

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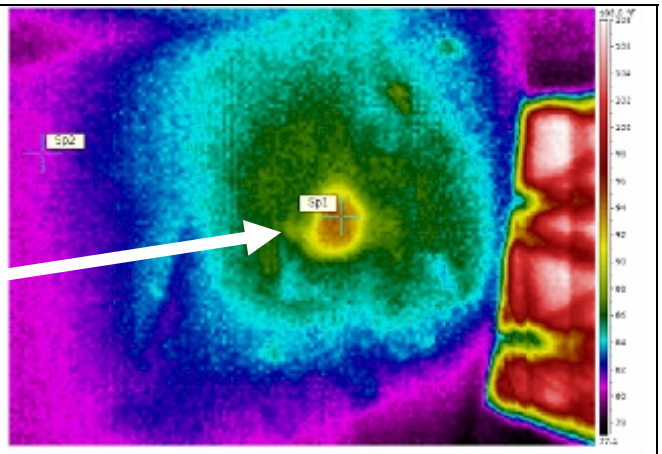
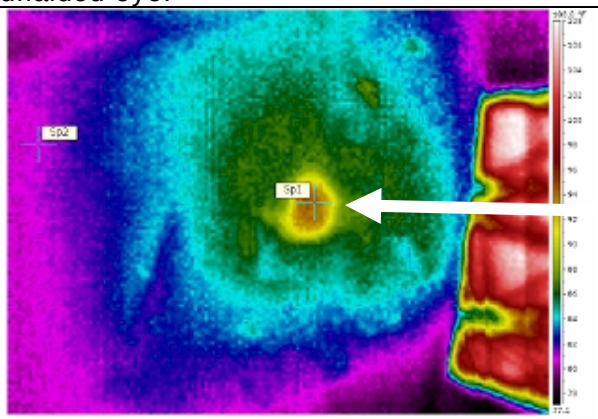
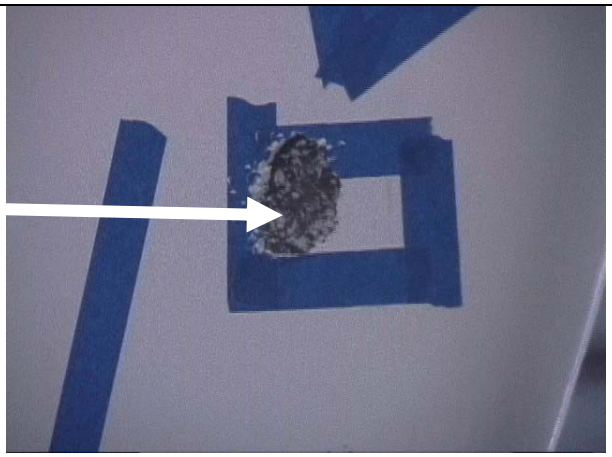
Photographs:

	 Void in Gel Coat
Exterior surface of the Gel Coat is shiny and uniform. No suspicious signs of deformity or voids in the Gel Coat as seen with the unaided eye.	Thermal pattern as displayed by the Infrared Camera while the hull is being gently warmed by the electric hot air gun.
 Void in Gel Coat	
	Void in Gel Coat confirmed by percussion sounding followed by grinding it out for repair.