

7 Things

You need to know

about IR-NDT!

Starter's Guide

Infrared NDT

Learn how to inspect 8 x faster!



What's in this NDT Guide?



*"Welcome to our NDT Guide for **Infrared Non-Destructive Testing!**
I have collected answers and explanations to the most frequently asked questions.
I hope you find the information provided useful!
If you have any questions, please do not hesitate to contact me!"*

Markus Tarin, President & CEO, MoviTHERM
m.tarin@movitherm.com

Inside this Guide:

How does Infrared or Thermal Non-Destructive Testing work?	3 & 4
How long does a measurement take?	5
How large of an area can I measure?	6
How small of a defect can I detect, using this method?	7
What type of defects can I detect?	8 & 9
Will this work for my application? How can I find out?	10
Who uses this technology?	10

How does Infrared or Thermal Non-Destructive Testing work?

Infrared Non-Destructive Testing ('NDT') has been around for more than 30 years but has recently gained more momentum.



The momentum is primarily driven by the need for faster inspection times on large aerospace structures. The most widely spread NDT method to date is still ultrasound ('UT'), but it has its limitations with respect to rapid, large area inspection capabilities.

Thermal NDT is based on the principle of thermal wave imaging. It is considered an active thermography method, as opposed to a passive method.

The active part comes from using an external heat source to warm up the part. Whereas in standard thermography, the camera is usually capturing heat, inherent to the process. For example, when using a thermal camera to check for the temperature of an electrical motor that is in operation.

A passive method does not lend itself very

well to an NDT inspection, since the part is typically at room temperature. We call that also being in state of thermal equilibrium. A workpiece in that state would not create any useful information or thermal contrast when imaged. Hence, the need for an active excitation.

The most used methods of excitation for thermal NDT applications are either a Xenon Flash Lamp or a Halogen Lamp. The flash method is used for "Flash Thermography".

A large amount of energy is being stored in a flash generator, on average 6 kilo Joules or above. Upon start of the measurement, that stored energy is being discharged in the Xenon flash bulb.

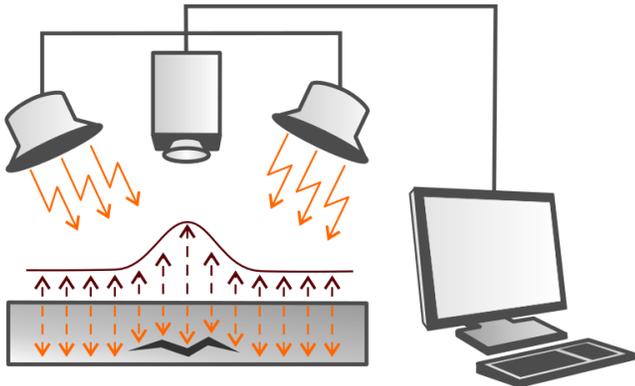
The discharge happens in a flash in only about 2 milliseconds. This creates a rapid increase of temperature on the surface of the workpiece, which also starts to dissipate immediately.

A thermal camera pointed at the part is being used to record a thermal image sequence, thus monitoring the temperature decay on the surface of the part.

What happens during this time is that the energy on the surface starts to penetrate the material via a thermal wave. The thermal wave propagates back to the surface and creates a temporal pattern of heat conduction (or the lack thereof).

How does Infrared or Thermal Non-Destructive Testing work?

For example, if the thermal wave encounters a void, the heat flow is being slowed down. This manifests itself on the surface during



the image recording sequence. Although, this technology can not technically “look into” the part, it indirectly can.

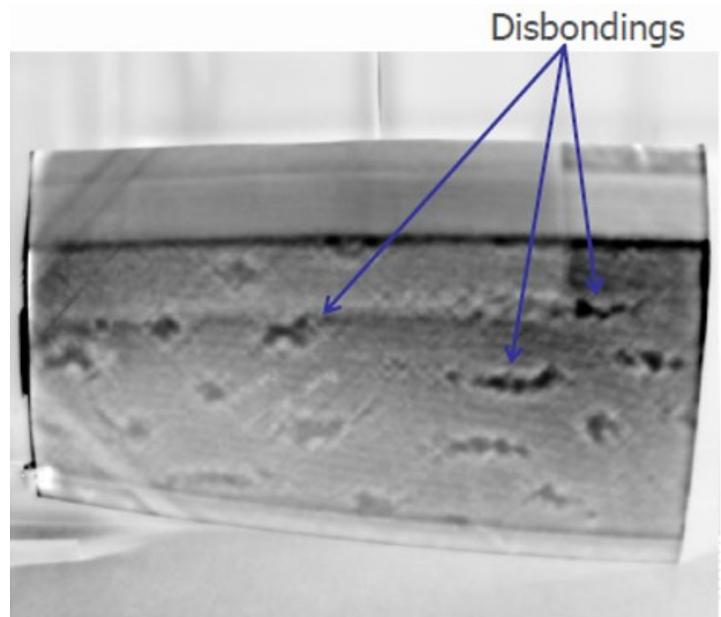
Flash thermography is limited with respect to how deep it can find defects. This is due to the rapid heat discharge. There is another active excitation method that helps overcome this limitation. That method is referred to as “Transient Thermography”. The concept is very similar. The difference is the way the heat is being induced into the part.

The excitation source of choice for a transient thermography NDT measurement is a halogen lamp or lamp array for larger areas. Using a halogen lamp has the advantage that the heat can be induced as long as needed. There are practical limits, of course. But rather than relying on a 2-millisecond pulse, the part can now be warmed up for several seconds.

Neither the flash method nor the transient method will ever heat up the part surface to any temperatures of concern.

Remember, we are talking about a “Non-“ Destructive Method.

A thermal NDT measurement only requires a temperature increase of about 8 to 10 degrees Celsius above ambient. This increase is enough for creating enough thermal contrast in the result images.



More importantly the excitation source needs to create a uniform heat flux on the surface of the part that is being inspected. The more uniform, the better the measurement result. That’s why it is necessary to use multiple halogen lamps in an array to inspect larger area in one measurement.

How long does a measurement take?

The length of the measurement is in direct relationship to the type of material that is being measured. It also depends on the desired penetration depth.

The type of material, specifically its thermo-physical property (Thermal Conductivity) impacts how fast the thermal wave travels through the material and back up to the surface. Carbon composites tend to be a good thermal insulator. Therefore, it takes longer to measure a carbon composite sample than it would take to measure a piece of metal of the same thickness.

Thermal Conductivity is the ability of a material to conduct heat. It is part of the thermodynamics law, in particular the Fourier's law, which states:

“When there exists a temperature gradient within a body, heat energy will flow from the region of high temperature to the region of low temperature.”

This is also known as heat transfer by conduction. The heat transfer by conduction occurs faster in materials with a higher thermal conductivity, compared to materials with a lower thermal conductivity.

Materials with a very low thermal conductivity are often used as thermal insulators.

To put this understanding in a practical sense, let's look at a thermal NDT measurement of carbon composite coupon.



The coupon has face sheet thickness of 1mm and the face sheet is bonded to a foam core. The objective is to determine if the face sheet is properly bonded to the core. Of interest are any voids.

A good choice for the measurement method would be to use flash thermography. This is because the face sheet is only 1mm thick and still within the penetration limits of that method. The entire measurement would take about 8 to 10 seconds from the time the flash fires.

How large of an area can I measure?

The size of the area that you can measure in one shot depends on several things. First, the available camera pixel resolution. Second, the smallest defect size you wish to detect and third, the available excitation source.

Okay, let's unpack those statements. In order for the camera to detect the smallest defect size, there need to be a sufficient number of pixels projected over the defect. A standard rule of thumb in thermography for this minimum pixel resolution is 3x3 pixels. However, in practical terms we need more. A good number is about 10 x 10 pixels. With that in mind and the given camera resolution, of let's say 640 x 512 pixels, we can now calculate the max area we can inspect.

For this we will assume the smallest pixel size to be 0.25" in diameter. Then based on our 6 x 6-pixel resolution criterion, we can state that 6 pixels = 0.25" (in one direction). Or, one pixel = 0.042". We have 640 pixels in the horizontal. That provides us with a horizontal field of view size of 640 pixels x 0.042" = 26.8". In the vertical, we have 512 pixels. That provides us with a vertical field of view size of 512 pixels x 0.042" = 21.5".

Therefore, the recommended maximum inspection area should not exceed 26.8" x 21.5" by much. This is true for the minimum defect size of concern of 0.25".

If the area of inspection is of great value, for

instance when inspecting large aerospace structures, then using a camera with a higher spatial resolution might be a good option.

In comparison, a camera with 1280 x 720 pixels will allow an inspection are of 1280 pixels x 0.042" = ~ 54". In the vertical the size is 720 x 0.042" = ~30".

This is a **64% increase** in **inspection area** and leads to **significant time savings** for inspection of large structures.



To assure a very uniform heating of the inspection surface, the excitation source needs to be dimensioned properly for such large area.

How small of a defect can I detect, using this method?

We hear that question all the time during our initial conversation with our clients.

However, the question to ask is not “What is the smallest defect you can detect?”, it is “What is the smallest defect of concern?”.

In other words, at what point does a certain size defect lead to issue, such as jeopardizing the structural integrity of the component?



The most common answer we hear is about $\frac{1}{4}$ " inch. Using that as our smallest defect size of concern, we at least have a common starting point for this discussion.

There are a couple of parameters that will determine whether a defect of $\frac{1}{4}$ " in diameter can be detected. These are depth of defect and camera resolution.

Due to the thermal diffusion effects, the defect must have a certain size (diameter) in order to be detected reliably.

As a rule of thumb, the defect cannot be deeper than its diameter. So, for a $\frac{1}{4}$ " diameter defect, it has to be located within the first

$\frac{1}{4}$ " measured from the surface it is being looked at.



There is also an upper practical limit for each of the excitation methods.

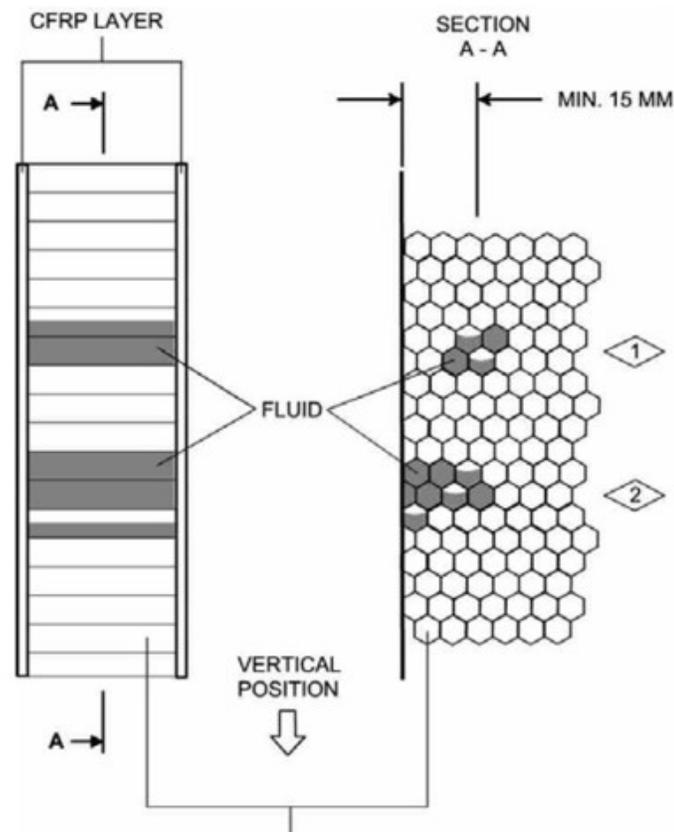
For example, using flash thermography may not find any defects deeper than about 1.5mm to 2.0mm in carbon composites. Using transient thermography, the practical limit is about 7 to 8mm.



What type of defects can I detect?

Thermal non-destructive testing is based on the concept of converting the difference in relative (temporal) heat flow into contrast.

This in and off itself does not indicate defects. It only expresses the difference in heat flow in a pixel by pixel contrast change.



With that said, the inspector needs to have an intimate understanding of the structural makeup of the part he or she is inspecting.

This knowledge is necessary to differentiate between a known and intended structural change in the part and an area with a potential defect.

This can be compared to a medical doctor looking at an X-ray image. Detecting a fracture in a bone requires an understanding of the skeletal structure of the human body and what a fracture could look like.

The type of defects that can be detected with a thermal NDT system with respect to carbon composites are:

- ✓ Delaminations
- ✓ Voids
- ✓ Cracks
- ✓ Bonding issues
- ✓ Water ingress
- ✓ Foreign objects and debris
- ✓ Resin rich and resin poor areas
- ✓ Fiber layup orientation and related issues
- ✓ Porosity
- ✓ Foam core issues
- ✓ Honeycomb cell resin fills
- ✓ Honeycomb cell crushes
- ✓ Impact damages
- ✓ Other fiber breaks

What type of defects can I detect?

As with any other NDT inspection method, it is recommended to create a test coupon. The test coupon needs to be fabricated to match future parts that need to be inspected. Expected defects need to be built into the test coupon.

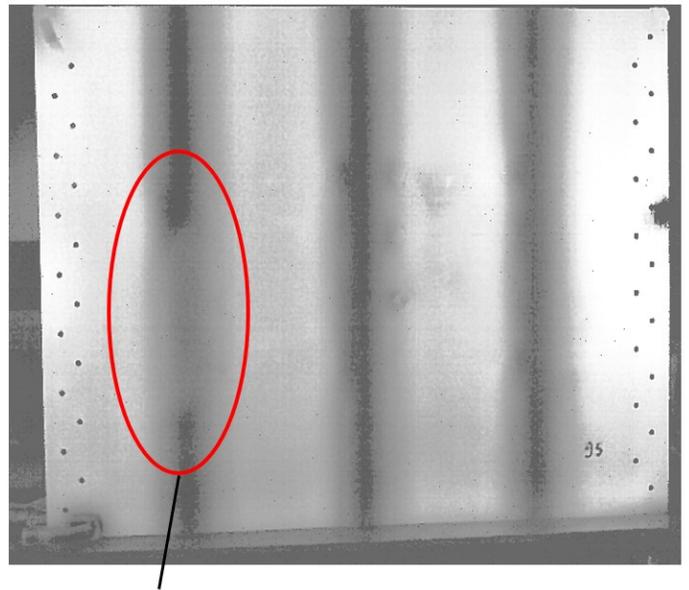
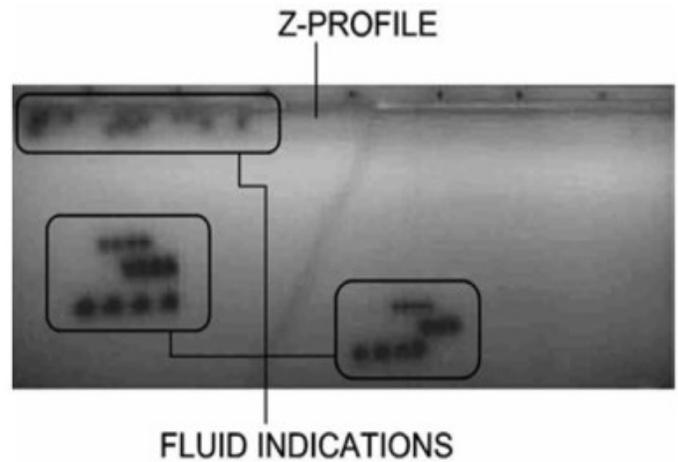
The test coupon should be imaged with the thermal non-destructive test system, prior to starting daily testing.

This is to assure and validate that the system and thermal camera are working as expected.

 One word of advice is to not use Teflon inserts for simulation of a delamination.

Teflon is wonderful for attenuating ultrasound signals, but terrible in creating thermal contrast.

This is due to the fact that the thermo-physical properties of Teflon are near equal that of resin used in carbon composite manufacturing. Instead, create a true delamination using pull tabs or baby powder.



Stringer partially detached

Will this work for my application? How can I find out?

This is a good question. Although we have seen hundreds of applications, it is always a great idea to test things out to make sure.

Especially before investing in a new technology. For this reason, we offer a **cost-effective**, low risk **feasibility study** service.

You can send us one or more samples and we perform a test evaluation on them. We then provide you with a detailed finding report.

We credit the cost of the study back towards the purchase of the system, if the order is received within 60 days of the study.

FEASIBILITY STUDY

NDT Feasibility Studies

are a great way to

take this technology

for a test drive.

The insight gained is invaluable!

For more information, please visit our website:

<https://movitherm.com/services/non-destructive-testing-feasibility-studies/>

Who uses this technology?

Our non-destructive testing systems are being used by many major aerospace companies around the world as well as tier one carbon composite structure suppliers, as well as NASA and the US Army.



“MoviTHERM’s NDT System has enabled me to inspect my composite structures much faster compared to my ultrasound method. My aircraft parts have many part lines, which were difficult and time consuming to inspect before. I was able to improve my NDT inspection time by a factor of 8 to 10 times!”

- Don N., NDT Professional, Quatro Composites

Do you have an NDT application you would like to discuss?

>> Call us today! 949.699.6600 Extension 111