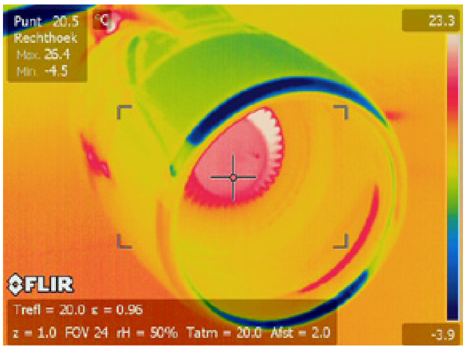

# Thermal imaging helps to detect water ingress in airplanes

The FLIR P-Series thermal imaging cameras will help you trace anomalies invisible to the human eye.

*Composite materials for modern aircraft need to be extremely sturdy and lightweight. These materials are vital to aircraft performance and airworthiness. A structure used in many parts of modern airplanes is the honeycomb. This structure has an appearance much as the honeycomb found in a beehive and is extremely light and strong. As long as they are intact, honeycomb structures offer exceptional weight to strength ratios but it is important that the structure is bonded to the outer skins, of e.g. airplane wings, in a reliable way. Often this is done with composite materials such as carbon fiber.*

*Even with the best bonding process, the bond between the honeycomb material and the sheet material is not perfect. This presents a potentially dangerous problem: water ingress in the honeycomb structure.*




*Thermal image of an engine; It takes expertise to "read" the thermal pictures of an airplane as different materials have different emmisivity, resulting in different colors in the thermal image.*

**Avoiding dangerous flight conditions**

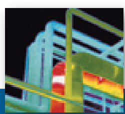
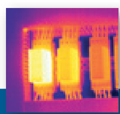
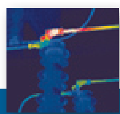
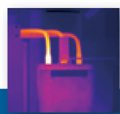
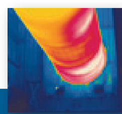
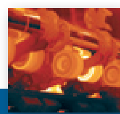
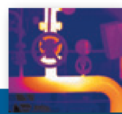
Significant pressure changes can force air into and out of honeycomb cells that are not perfectly sealed. Because airplanes experience such large pressure changes, while climbing and descending, they are particularly susceptible to this. When an airplane takes off and goes up to high altitude, where the pressure is lower, air is forced out of some honeycomb cells that are not bonded perfectly. The air at high altitude is also cooler so some water condenses out and remains in the honeycomb cells. As the airplane lands, warmer and moistured air reenters the cell. When this process repeats itself over and over again, the cell fills with water. Each time the airplane goes up to high altitude, the water in the cells freezes, and expands, and the bond is further weakened. In this manner disbanding can occur in neighboring cells and the problem will become even bigger. Water can also enter the honeycomb structure when the bonding is damaged by e.g. hail.

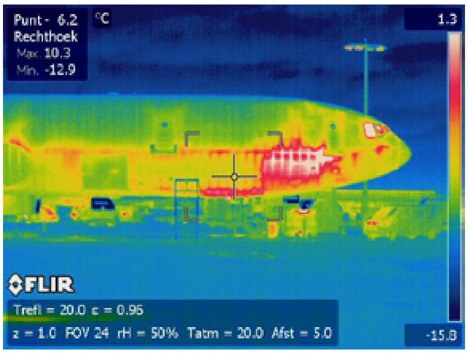
Water ingress in an airplane part can create a dangerous situation. Although the honeycomb is very strong and lightweight, it loses these characteristics when it is damaged by, in this case, ice. Furthermore, the ice will also separate the bonding from the honeycomb. Through vibration the total bonding structure can be weakened or even partly destroyed. This means that the airplane will lose its stability. The weight of the ice also influences the aircraft balance. Besides these potential dangerous consequences, the fuel consumption is rising as well. The total weight of the aircraft is increasing, so it will need more fuel to fly. It is therefore of the utmost importance that water ingress is detected in an early stage so that necessary action can be taken.

**Thermography**

Thermal imaging cameras are being used for a wide variety of applications. An enthusiastic user of FLIR Systems thermal cameras is





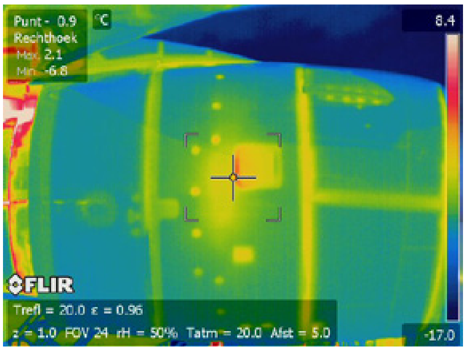

*By making a thermal image from a distance you can get a good overview of the entire airplane.*

*Mr. Ralf Grispen while inspecting an airplane with his FLIR thermal imaging camera.*

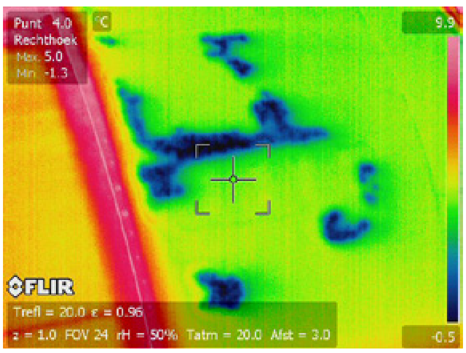
the Dutch 'Thermografisch & Adviesbureau Uden BV'. It is an experienced agency which is specialized in independent inspections and supplies subsequent recommendations to industry and construction. "A major part of our work is doing electrical and mechanical inspections", says Mr. Ralf Grispen, commercial manager at Thermografisch & Adviesbureau Uden BV. Thermal cameras are proving their worth during fast inspections of airplanes as well. Although thermal imaging cameras are being used for periodic maintenance inspections of engines and other parts of an airplane too, the cameras are being used at a large scale to look for water ingress in airplane wings and in the airplane body." At the moment we have a wide experience within a number of 75 aircrafts for several MRO's (Maintenance, Repair and Overhaul) and airlines". "When you are being contacted by these kinds of clients, it tells a lot about the delivered quality. I dare to say that we are pioneers if we are talking about this sort of industry segment."

## Detecting "cold-spots" with the thermal imaging camera

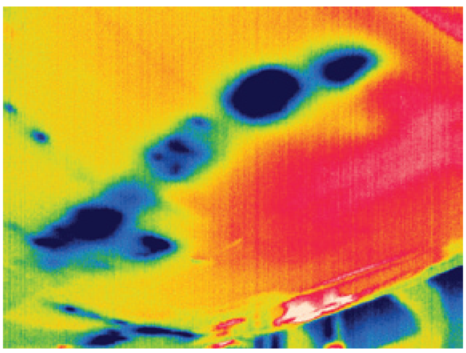
"Thermal imaging is a great technology to inspect water ingress", explains Mr. Paul Kennedy, Composite/Painting and Supervisor/Inspector at Air Atlanta Aero Engineering. "At high altitude, at temperatures of -40°C or lower, the water in the honeycomb cells freezes. The airplane descents relatively fast so when it lands, the water is still frozen. The thermal imaging camera can clearly distinguish these cold-spots. Thermal imaging also gives us the opportunity to check large surfaces within very short timeframe. This is necessary because when the ice melted we cannot see the damaged parts anymore. Depending on the temperature on the ground, in general we can say that we have only one hour to inspect a plane. With thermal imaging this is perfectly possible. "The FLIR P660 thermal imaging camera is a great tool to perform these types of inspections", says Mr. Grispen. The FLIR P660 produces crisp thermal images of 640x480 pixels on which the smallest of details can be seen. The camera allows seeing temperature differences as small as 0.03°C. Not only does the FLIR P660 has a super size 5.6" foldable high-quality LCD screen, it also has a viewfinder which can be extremely easy to do inspections in summertime and the sun is shining on the LCD display. "Once the inspection is done, we produce a report in Reporter. This easy-to-use software allows us to deliver a perfectly documented and detailed report of our findings to the crew that will do the actual repairs. The FLIR P660's possibility to take a visual image as a reference against the thermal image, allows us to show these people the exact location on the airplane that needs to be fixed. If the camera finds any parts with severe water ingress, the skin is opened up, and the water removal program will run."




*An overview (inboard) of an engine, taken from a Boeing 767-300ER.*




*The thermal image shows lots of damages on top of an inlet cowl.*



*Also a lot of damage on the bottom of this inlet cowl can be seen on this thermal image.*

## Thermal imaging cameras help to have safe flights

There are of course other ways to detect water ingress in airplane parts but compared to thermal imaging they present great disadvantages. You can work with liquid crystal sheets that are put, under vacuum, on the parts to be inspected. This is however a very slow method and it works only for small parts. X-ray has the disadvantage that it is expensive in time, equipment and manpower.

Although not too many people realize that these inspections are being done, the FLIR P660 ensures that passengers have a safe flight. Mr. Kennedy says that removing the water in an early stage is very important. "If we should leave the water for a substantial period of time, it can lead to complete failure of the particular parts. And an airplane is much heavier with a lot of water, this will give unnecessary costs. Removing water not only saves money, more important it will save lives."

*Source: Investigation of an accelerated moisture removal approach of a composite aircraft control surface (Chun Li, Rick, Ueno, Vivier Lefebvre, National Research Council Canada, The university of Ottawa, Department of National Defence Canada).*

*Credits: Mr. Paul Kennedy, Air Atlanta Aero Engineering (www.airatlanta.ie), Mr. Ralf Grispen, Thermografisch & Adviesbureau Uden BV (www.thermografie.nl), Martinair Holland*

*Pictures: Thermografisch & Adviesbureau Uden BV*

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