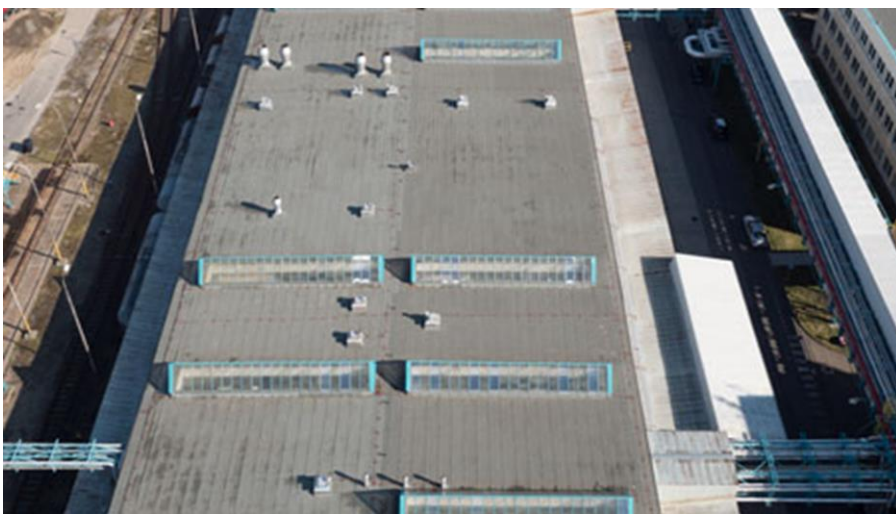


Thermodiagnostics of flat roofs

Flat roofs were originally built in areas with low rainfall. For example, they can be found in the architecture of Egypt, Babylon and Mesopotamia. They appeared in the Central Europe with the discovery of the processing of asphalt strips at the end of the 18th century. In the modern era, the quality of insulation against

atmospheric conditions increased so that flat roofs appeared on factory halls as well as highly architecturally appreciated buildings. They are a standard part of all types of buildings. The benefits of such roofs is that they save material, are less labour intensive, provide the option of variable roofing layouts and the potential use of roof areas. However, flat roofs also have disadvantages: the design of the composition of roof layers is complicated, as is the design of the thermal technical evaluation and all principles must be adhered to during implementation. Thermal imaging systems provide the perfect tool to evaluate the technical condition. The thermal imaging system located on the drone provides a fast and economical solution for surveying wide roofs on industrial sites.



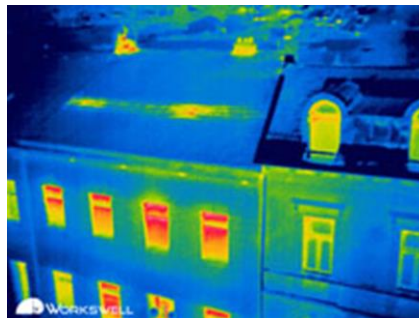
Flat roof with risk of rainfall retention and roof leaking.

Introduction to the issue



The most frequent reason for problems with flat roofs is that thermal insulation is not self-contained and between thermal insulating layers and boards are various large gaps. Therefore, during the reconstruction of roof, the exact technological procedure must be followed.

Many places on flat roofs can be the source of defects (contact of the roof with the attic, penetration through the cover, inflows, etc.). Problems with leaks can occur in the area, for example, due to unprofessional installation, neglected maintenance or degradation of the surface due to insufficient protection of the surface layers against climatic influences or the end of the service life. In most cases, flat roofs are affected by excessive loading by wind, which causes dynamic shocks, permanent oscillating movement and lifting of unsecured parts. This phenomenon is also the source of the origination of leaks. Water collected on the damaged roof construction negatively affects the durability of roof clad (degradation of multi-layers, leaks). If it flows through the gaps between the insulating parts under the non-

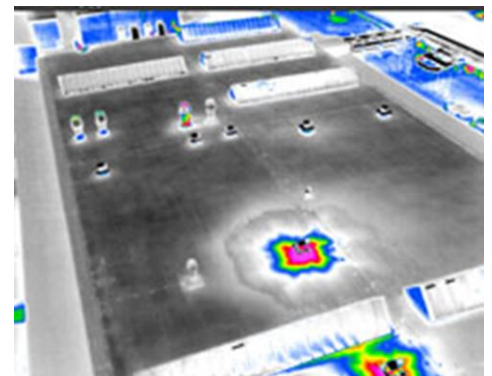


The thermal bridge on the roof of the building results in significant thermal losses.

absorptive heat insulating layer through to the waterproof insulation, it has a low temperature. This causes a decrease in the temperature of the waterproof insulation, which may cause condensation of the water steam inside the roof cladding under the waterproof insulation. In extreme cases, the leaked water may also overload the load-

bearing construction of the roof cladding.

Before removing the problem, a construction technical survey must be conducted to determine the actual cause of the problem. If the user finds a defect in the building (leaks), it is theoretically possible to approximately detect the defect. However, in most cases, the trails of leaked water are not direct and usually the upper part of the roof must be inspected in detail. Moreover, the leaks into the internal premises will cause only a very small amount of such defects. Mostly, water leaks over a long period (even several years) under the surface of the roof will destroy the foundation layers. Such widespread destruction can be prevented by timely discovery of the problem. Unfortunately, a detailed survey of the whole roof is very difficult due to the large area (for example, in factory halls), as well as due to their variability. For the inspector, it is a time consuming and physically demanding task and, therefore, in most cases, the inspector only focuses on risky areas and defects that can be overseen.



Areas affected by moisture are discovered via thermal differences identified by the WIRIS thermal imaging system located on the drone.

Use of thermal cameras for the resolution of the problem

A fast and simple way to resolve the problem of the inspecting various flat roofs exists. This method is a thermal imaging system (thermal camera), which

due to the thermal difference between a dry place and a place with penetrating moisture, fully identifies discovers where moisture has penetrated.

Depending on the construction of the roof, it is possible to see how large an area is affected by moisture, i.e. to

localize and state the scope of the problem.

The physics behind the issue of thermal image inspection of problems related to the moisture is based on the fact that the dry part of the roof (not affected by moisture) is cooled and heated slower than the wet part of the roof insulation.

Thermal image inspection using a thermal camera during or after sunset (where the roof has been heated throughout the whole time) identifies the moist areas because the dry parts of the roof cool slower than the wet places, which have a higher thermal capacity.

During the heating season, the thermal camera can also identify areas that are poorly insulated (where what are known as thermal bridges have occurred) and where there are thermal escapes. These areas show as warmer than the surrounding parts of the roof.

Checking the air



Workswell WIRIS thermal imaging system located on the drone. The system combines a thermal imaging camera and a camera in a visible spectrum.

Even when using a thermal camera, which is an excellent diagnostic tool, the question remains how fast and easily it can check the large area of a roof.

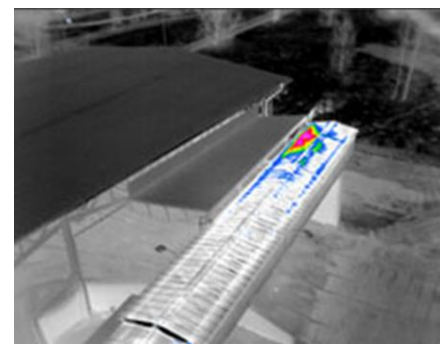
The way round this problem is to use a pilotless aircraft on which the thermal camera is attached. Such an aircraft can fly above roofs and is not restricted by the number of ladders, elevations or unstable surfaces. The operator controls the drone from a safe place, has an immediate overview of the condition of the roof and if they spot a defect, can focus in detail and personally check the area.

Why choose a Workswell WIRIS system?

The company **Workswell** developed the **Workswell WIRIS system**, which combines two camera systems - a visible spectrum camera (for inspection of visible defects found by thermal camera) and a thermal camera for detecting the problems mentioned above. **The servicing software enables to remotely switch camera regimes, to record radiometric videos or to make static images in both the visible and infra-red spectrum.** The operator sees the objects under the drone in real time or can analyse records and identify damaged areas.

Moreover, Workswell WIRIS, unlike similar systems, enables to manually set the range of temperatures, e.g. in the

interval of 15 °C to 25 °C. Even this range of temperatures can be changed during the flight. Without the need to land, the system actual situation can be set for the system and to easily achieve the required thermal sensitivity setting, **which is required for the localization of minor moisture defects** or the most precise localization of large defects. Traditional photo documentation is required to localise a defect, therefore, the Workswell AIRvision video camera is of sufficient quality to produce a traditional photo. Moreover, the system can be fitted with a **GPS sensor** for storing information about the position of the drone when creating a record.



Checking the roof using a manual thermal camera would be very complicated, the roof is difficult to walk on. When using Workswell WIRIS, monitoring is fast and safe and it is possible to obtain an excellent overview of any problems.

The system can measure temperature at the central point, as well as in the local minimum and maximum.

Minimum and maximum are localized using a blue (minimum) and red (maximum) cross. This function can also be used to navigate drones because the system automatically shows where the largest potential problem is located.

Produced records are fully radiometric, including videos. After termination of the flight, the records can be evaluated using the Workswell CorePlayer software to produce a measurement report on measurement with the exact localization of the problems. For this reason, a photo is available of all produced thermal images (thermogram).

Individual photos from the radiometric video can be taken and used as separate thermal images (thermogram) to analyse a problem.



View on the operator's screen. When in use, the Workswell WIRIS system provides the same comfort as existing manual thermal cameras. All parameters can be set for measuring, including emissivity and the reflected temperature. The high sensitivity of the system is achieved by manually setting the range of temperatures. A whole series of pallets are available and the option to measure either in the point, as well as in the local maximum and minimum. Minimum and maximum are localized by a blue (minimum) and red (maximum) cross.

Summary

The combination of a visual and thermographed inspection using drones can discover a series of problems that unless resolved will become hazardous and/or financially demanding. Small leaks into the roof can be seen on the thermogram so the roof can be repaired at a fraction of the required cost, e.g. in the case of the destruction of load-

bearing layers and the roof fall. Moreover, the whole system is universal and can be used in other industrial applications when checking leaks from a construction or when inspecting the quality of piping and identifying defects. We found that in most cases, the heat insulation was incorrectly fitted and such were the thermal bridges that its

efficiency was reduced by one third. The most frequent reason for these problems is that the heat insulation is not self-contained and between the thermal insulating layers or boards are a series of large gaps.