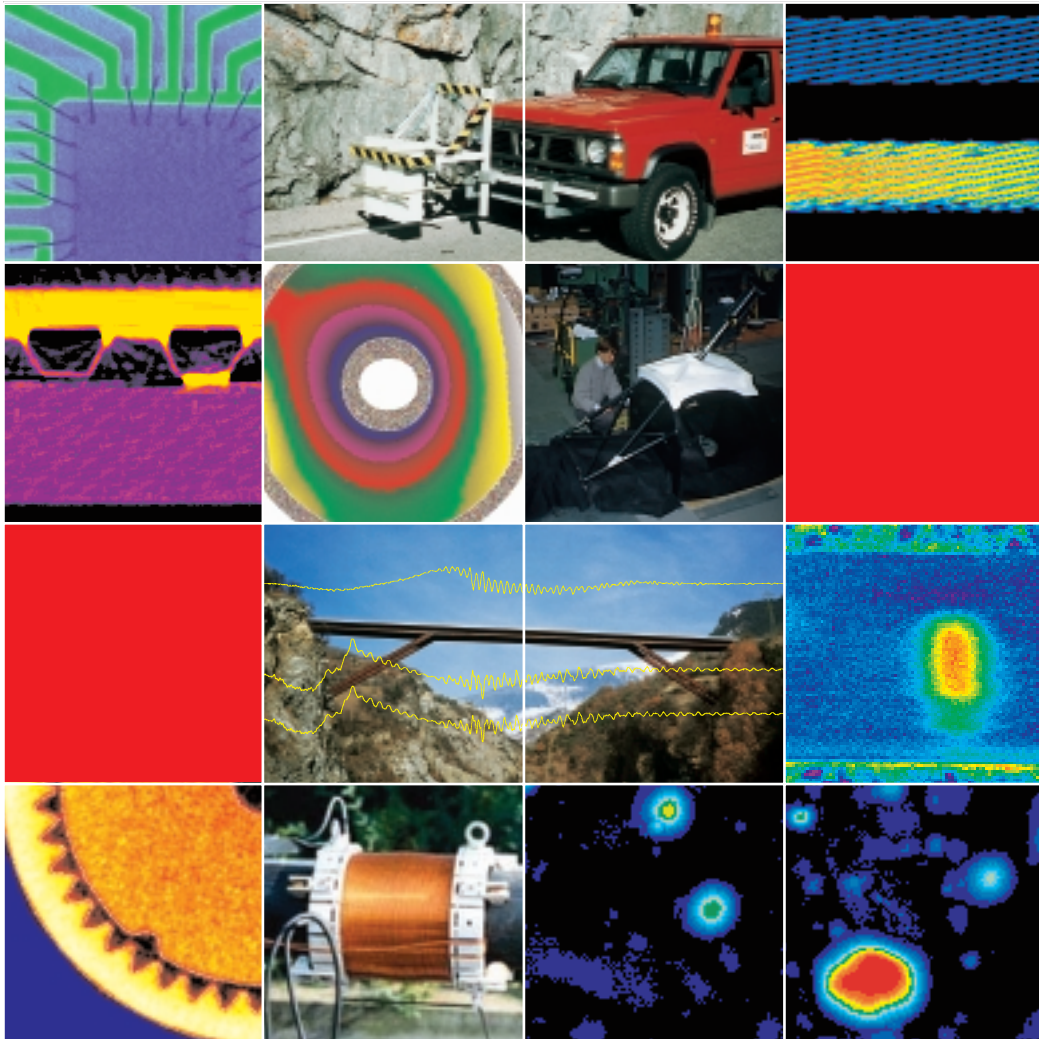


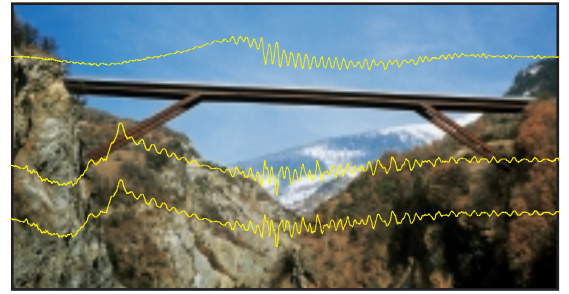
# ***Non-destructive testing methods***



*Vibration analysis, infrared thermography,  
acoustic emission analysis, ultrasonic imaging,  
x-ray computer tomography, ground penetrating radar,  
digital radiography, optical testing methods,  
eddy current imaging, magneto-inductive cable testing*

## Vibration analysis

Vibration analyses can be carried out on a wide range of structures such as bridges, dams, buildings, etc. The tests are designed to determine the dynamic characteristics of the structures such as natural frequency, modes of vibration and damping. The results are used to gain basic information for the evaluation of earthquake safety, long-term monitoring, short-term condition tests and optimising of analytic models. The two methods available are «ambient vibration analysis» and «forced vibration analysis».

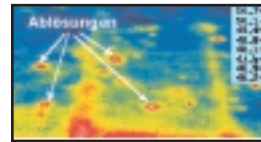


Impulse excitation for large structures

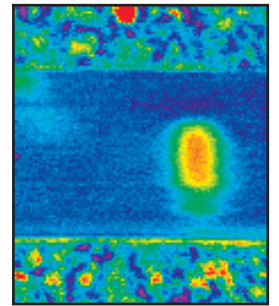
## Infrared thermography

IR thermography is a method for measuring the temperature distribution of a surface. It permits to detect regions of heat production (e.g. due to a crack under cyclic loading or a hot spot in a defective IC) or regions of inhomogeneous cooling (e.g. due to blisters or air voids in a pavement or under waterproof membranes).

In the building phase of road constructions, IR thermography can be used to control the temperature of the single components. When flashes or a sine-modulated radiator heat an object, voids and debondings buried below the surface hinder the heat transfer. The resulting transient thermal contrast on the surface is made visible with pulse or lock-in thermography.



IR photograph



Phase display of a CFRP plate with defective bonding to concrete

## Acoustic emission analysis

Acoustic emission analysis uses sensors mounted on the surface of parts or structures to record elastic waves caused inside by microscopic processes such as, e.g., crack growth. In principle, the analysis allows a qualitative and, under certain conditions, quantitative assessment of the integrity of the part or structure.

Acoustic emission analysis is also suited for other industrial applications, e.g., process monitoring.

Acoustic emission analysis is also used for load tests carried out during investigations on a car chassis made of carbon fibre reinforced plastic.



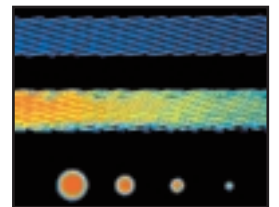
During filling with silage, selected locations (in this case the hatches) of an agricultural silo (height approx. 10 m,  $\phi$  approx. 4 m) are monitored using acoustic emission analysis.

## Ultrasonic imaging

Ultrasonic waves permit non-destructive testing of materials for the detection of component defects. Using this test procedure the precise location of cracks, pores, inclusions and fusion flaws can be determined. This method is used for testing metal, ceramic and plastic materials together with their bonding system (adhesion, welding, soldering). Images are generated either with a high-precision mechanical scanner or a phased array system.

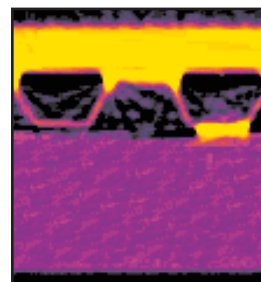
Images are generated either with a high-precision mechanical scanner or a phased array system.

20 MHz ultrasonic images of aluminium-stabilised super conducting cables. Top: good bonding Middle: faulty bonding Bottom: as comparison a test block with flat-bottom holes ( $\phi = 1-6$  mm).



## X-ray computer tomography

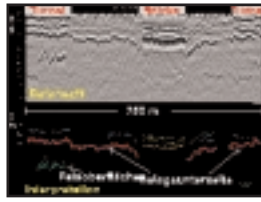
Computer tomography is a well-known test method used for medical diagnostics. Using industrial scanners, cross-sectional pictures of the object being investigated are taken in any selected plane, recorded and processed. Three-dimensional views, surface point clouds and first-article inspections can be produced by stacking contiguous tomograms.



The tomogram shows a section through a metal-ceramic joint. The metal and ceramic plates are soldered with a mattress-shaped interlayer. The aim of the investigation was non-destructive testing of the solder joints. The tomogram shows that one joint has no solder.



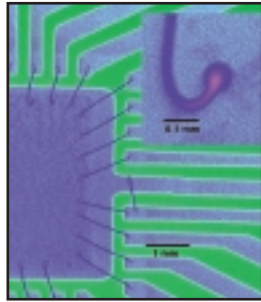
Mobile radar test system



Example of pavement inspection

GPR is used for investigations on roads, bridges and other elements of infrastructure. The test method is based on an electromagnetic signal which is emitted by an antenna into the object. Energy from this signal is reflected by inhomogeneity and recorded for later analysis. The mobile system permits efficient investigations of roads while causing minimum obstruction to the flow of traffic. After suitable data processing and interpretation the results of a radar investigation provide a vertical profile of the object.

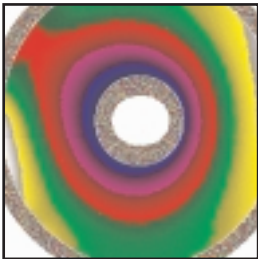
## Ground penetrating radar (GPR)



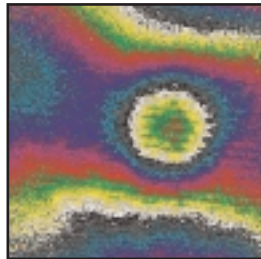
Radioscopy of a faulty bonded integrated circuit chip

Welding, solder and joint bonds must be tested without the need to remove the casing or the casting compound. The X-ray microscope is an ideal tool for this task. This test unit is equipped with an X-ray tube that has a very small focal spot, a highly sensitive image intensifier and a manipulation jig for the sample under test. Faulty locations with extensions measuring from 10 to 100  $\mu\text{m}$  can be detected dependent on the contrast to the background material or to the influence of the total attenuation of the radiation. Digital radiographs can also be made using imaging plates.

## Digital radiography



Measurement of deformation on a synthetic resin model under tensile load



Delamination in a rolled CFRP tube

Laser light scattered back from an object is compared with a reference field by an interferometer. The interference pattern is recorded by a CCD camera so that the deformation field can be measured simultaneously over the complete surface of the object in multiples of the laser wavelength. As deformations can be detected in the nanometer range, this test method is suitable for proving the smallest inhomogeneity caused by faults, weaknesses or cracks. Related methods: shearography, holography.

## Optical methods



Eddy current amplitude image of drilled holes in a coated turbine blade

The application of eddy currents permits the registration of surface inhomogeneities in metallic objects. The position and extension of e.g. cracks or holes, also under non-conducting layers, can be imaged by a high-precision mechanical scanner in conjunction with an eddy current equipment.

## Eddy current imaging



Testing device for magneto-inductive cable testing

Magneto-inductive testing allows for the detection of flaws such as wire fractures or severe corrosion in the free length of large diameter cables. The comparison of the results of measurements performed at regular intervals offers a useful tool for the assessment of the condition of stay cables.

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