Background  Historical dam failures and incidents show that internal erosion caused by seeping water constitutes a significant threat to the safety of embankment dams and other hydraulic structures. Internal erosion is particularly dangerous since it can occur suddenly, causing catastrophic failure of a full reservoir.

Seepage zones within embankments are always potential zones where internal erosion might occur. The detection and location of seepage zones at an early stage of development is therefore essential for the safety of water retaining structures. This can be achieved through continuous inspection and monitoring with reliable and sensitive seepage detection methods.

Temperature measurements have been used since the 1950’s to detect leakage in earthfill dams. The temperature of the reservoir water acts as a natural tracer when it percolates through the dam, and causes ground temperature anomalies which can be detected and located using a ground temperature measurement technique developed by GTC (Pat. No. DE 41 27 646). This method is easy to apply, and substantial lengths of dam can be covered within a short time at low cost. Throughout Europe, more than 500 km of embankment dams and other hydraulic structures have been investigated successfully with this method.

Case Study 1  As an example, the ground temperature measurements within a 6 m high earthfill dam are presented in the figures below. The scope of this survey was to determine whether water was percolating through either the core, or the foundation of the dam. The temperature plot (left hand figure) shows clearly that both cases are relevant. Between chainages 40.570 km and 40.630 km, water is seeping through the dam foundation, and at 40.680 km water from the reservoir is seeping through the core, potentially causing internal erosion. The endangered zones can be emphasized by subtracting the average temperature / depth curve of an intact section of the dam from the data containing the observed temperature anomalies. The resulting image (right hand figure)

is the temperature disturbance caused by the seepage. The flow underneath the dam is the result of the natural geology of the foundation, and is not critical to the safety of the dam, whereas the leak in the core of the dam requires further investigation by repeated temperature measurements.
Case Study 2  As a further example, data is presented in the figure below from a 9 m high dam along a river, incorporating an impervious facing. The surface sealing system of the dam has been penetrated by water at several points. Temperature measurements were made to locate seepage zones and determine the depth where the maximum flow velocity is reached. The temperature contour plot clearly indicates seepage zones between chainages 2.45 km and 2.54 km. The strongest anomaly was found near 2.5 km, at around 3 m depth, with a temperature value of 3° C.

Since the temperature of the river was 2.8° C at the time of survey, it is clear that the anomaly indicates the area with the greatest flow velocity. In order to prevent erosion, it was recommended that the leaks in the impervious facing of the dam should be repaired.

Case Study 3  A further example of seepage underneath a dam embankment is provided in the figure below. Measurements were taken in late autumn, when water temperatures were already decreasing. The figure shows a contour plot of the measured ground temperatures; a clear underflow was detected along the entire stretch investigated. The abnormally high temperature values of the dam embankment are due to the underflow of warm water during summer, when the water temperature was over 20° C.

Clearly there is no significant leak in the sealing system of the dam; only the lack of a cut-off wall results in the underflow. This would only endanger the safety of the dam if the filter system is not stable enough to prevent internal erosion, or if external loads were applied (for example earthquakes). It was concluded that careful monitoring of the dam, together with an evaluation of the above risks, was required.