



**ISO 14577-6**

**Metallic materials — Instrumented indentation test for hardness and materials parameters —**

**Part 6:  
Instrumented indentation test at elevated temperature**

*Matériaux métalliques — Essai d'indentation instrumenté pour les paramètres de dureté et de matériaux —*

*Partie 6: Essai d'indentation instrumenté à température élevée*

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Hardness has typically been defined as the resistance of a material to permanent penetration by another harder material. The results obtained when performing Rockwell, Vickers, and Brinell tests are determined after the test force has been removed. Therefore, the effect of elastic deformation under the indenter has been ignored.

ISO 14577 (all parts) has been prepared to enable the user to evaluate the indentation of materials by considering both the force and displacement during plastic and elastic deformation. By monitoring the complete cycle of increase and removal of the test force, hardness values equivalent to traditional hardness values can be determined. More significantly, additional properties of the material, such as its indentation modulus and elasto-plastic hardness, can also be determined. All these values can be calculated without the requirement to measure the indent optically. Furthermore, by a variety of techniques, the instrumented indentation test is able to generate hardness and modulus values at different indentation depths within the indentation cycle.

This document has been prepared to enable the user to obtain hardness and other materials parameters using instrumented indentation testing at elevated temperature. The elastic and plastic properties of material components at elevated temperature are critical for determining the performance representative of in-service condition above ambient temperature. Typical applications include hard coatings, nuclear materials, welded materials, fuel cell materials, aerospace materials, etc. In-service properties of wear surfaces, cutting tool, high friction contacts are also significant applications.

This document covers the instrumented indentation testing systems with independent heating of both the indenter and test piece with feedback control and equipped with temperature sensing. This type of instrumented indentation testing system is suitable for testing materials of high or low thermal conductivity in air, in inert or reducing gaseous environment, and also in vacuum, which offers the potential for higher testing temperature. Active heating of the indenter tip allows independent adjustment of energy flow into the tip and test piece so that a condition of iso-thermal contact is achieved rather than just thermal equilibrium with constant (but unknown) thermal gradients. A temperature sensor mounted in an indenter body with a low heat capacity is sensitive to small heat flows and, therefore, can detect small temperature differences between test piece and tip.

The method described in this document can achieve low uncertainty in the temperature assigned to the indentation contact when testing materials with high thermal conductivity (uncertainty increases when testing low thermal conductivity materials). This is achieved by traceable calibration of the indenter tip temperature for a reproducible temperature offset between the contact temperature and indenter temperature sensor reading. A reproducible temperature offset is obtained by using a procedure to minimise (optimally to zero) the heat flow between the test piece and the indenter. This not only makes the temperature offset from indenter temperature sensor to indenter tip a reproducible amount, but also minimises the temperature gradient in the test piece (from the contact to the bulk of the test piece) that occurs when there is a heat flow through the contact. The minimum detectable heat flow of a system depends upon the heat capacity of the indenter and the resolution of the indenter temperature sensor. Any amount of heat flow causes a higher uncertainty in assigned contact temperature that is higher the lower the thermal conductivity of the test material is.