INSTRON
The difference is measurable®

Metallic Materials for Tensile Testing | ISO 6892-1:2009

Part 1: Method of Test at Ambient Temperature

Description of the Testing Requirements

The new ISO 6892-1:2009 (Metallic materials – Tensile testing – Part 1: Method of Test at Room Temperature) is a significant event for anyone performing tensile tests on metallic materials. The new standard replaces both the previous version of ISO 6892 and the widely-used EN 10002-1:2001 standard.

ISO 6892-1:2009 incorporates many detailed improvements over the older version; however, the most significant changes are in the area of test control, where the new standard introduces a new test control criteria "10.3 Testing Rate Based on Strain Rate Control (Method A)". The aim of the new test control is to reduce the variation on the mechanical properties by reducing the variability in the testing conditions. The essential feature of the new test control is the requirement to maintain the strain rate applied to the test piece within ±20% of the specified rate. This contrasts with the test control requirements of the EN10002-1:2001 and the older version ISO 6892, which specified a combination of stress and strain rate control (stress rate in the elastic region followed by strain rate) and allowed considerable variation in the rates e.g. a 1:10 variation in the strain rates when determining Lower Yield (R_{eL}) and only an upper limit on the strain rate when determining Proof Strength (R_p) (Figure 1). Since the mechanical properties of many metallic materials, including commonly used steels, depend on strain rate, reducing the variability in the strain rate will increase the precision of the measured properties (Figure 2).

In addition to reducing the allowed variation in the strain rate for all tests, the new standard also clarifies the test conditions for the two types of yield behavior displayed by metallic materials. For metals that demonstrate a smooth transition from the elastic to plastic region (Figure 3), the strain distribution in the gauge section of the material is uniform through the offset yield (R_p) and up to the maximum tensile stress (R_m). In this case, the definition of strain rate can be, unambiguously, based on the strain measured by the extensometer and the control of the strain rate can be achieved using the signal from the extensometer.

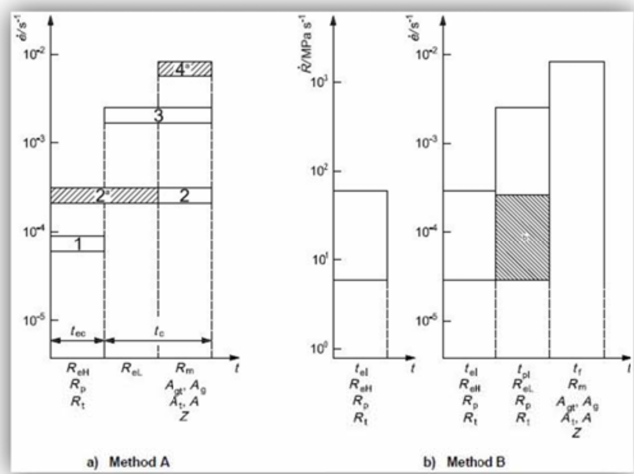

Figure 1 – Test speeds at different calculation points for ISO 6892-1 (Method A and Method B).

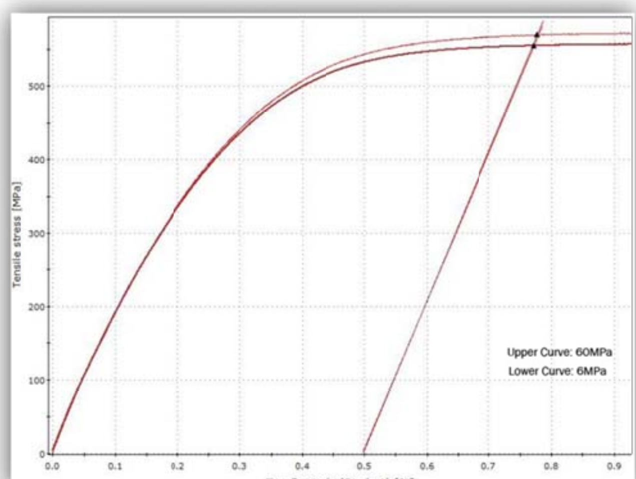

Figure 2 – Tests speeds at 6MPa and 60MPa to ISO 6892-1:2009 (Method B).

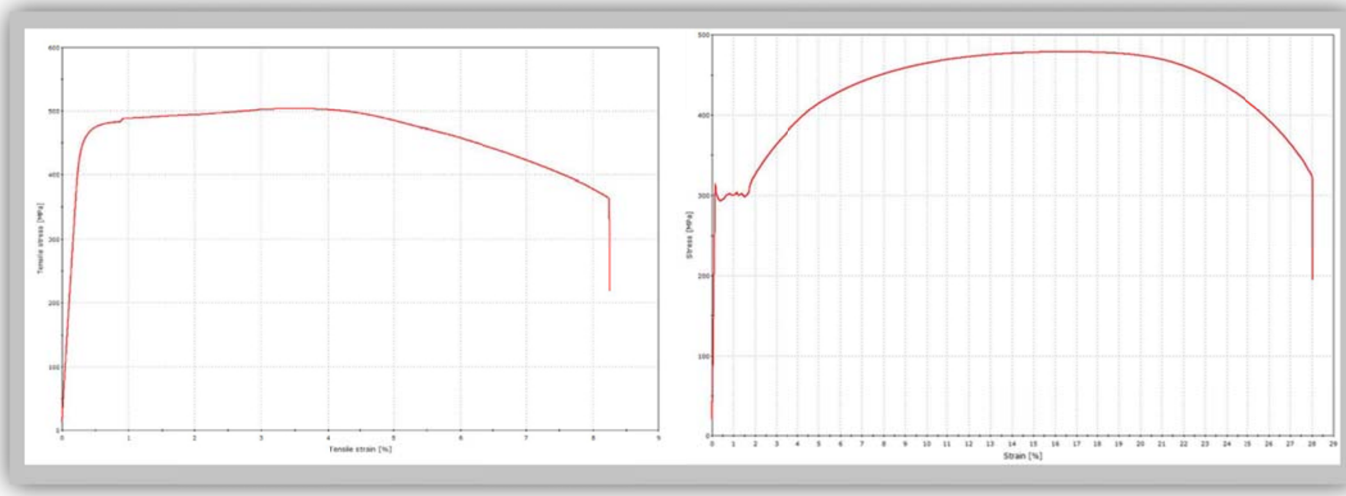

Figure 3 – Without and with yield points graphs.

Many metals, however, display a "yield point". In this case, the stress increases in proportion to the strain (the elastic region) and then at the upper yield point (R_{eH}) there is a sudden decrease in the stress. Furthermore, when a metal yields in this way the strain distribution along the parallel length is no longer uniform and instead it is localized in narrow regions known as Luders bands. These Luders bands often form outside the extensometer gauge length and under these conditions the strain measured by an extensometer can actually decrease despite the fact that the strain over the entire parallel section of the specimen is increasing. In this region it is impossible to control the strain rate using the signal from the extensometer. In the latest version of ISO 6892-1, it is made clear that the strain rate after a yield is to be based on the extension rate applied divided by the parallel length of the specimen.

ISO 6892-1:2009 outlines two distinctly different methods of strain rate control, e_{Le} (strain rate) and e_{Lc} (estimated strain rate over the parallel length). e_{Le} is based on direct feedback from the extensometer or closed-loop strain control, whereas e_{Lc} is based on a calculated rate and is in closed-loop crosshead position control.

The crosshead separation rate is calculated using $v_c = L_c \cdot e_{Lc}$ where L_c is the parallel length.

In both types of yielding behavior after yield the control mode is specified as extension and the strain rate can be increased – the recommended rate being 0.0067/s. The new standard introduces the requirement that the rate change should be gradual in order to avoid introducing a steep change in the stress–strain curve, which could possibly be misinterpreted as a material characteristic. Figure 4 shows how an abrupt strain rate increase could result in a false R_m result.

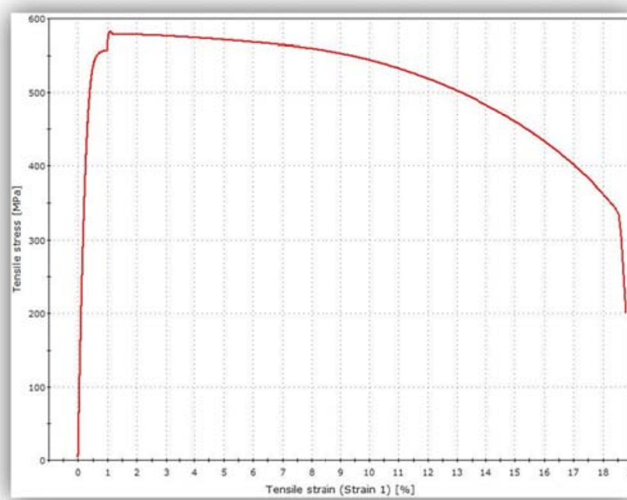

Figure 4 – Fast speed change showing false Rm.

Instron Solution

Instron testing machines are able to meet the demanding requirements of ISO 6892-1:2009, both Method A, based on strain rate control, and Method B, based on stress rate.

Materials Testing Machines

Our electromechanical or static-hydraulic machines can be equipped with a range of clip-on or high-resolution automatic extensometers for strain rate control. With many gripping solutions available, Instron® has a suitable gripping mechanism for almost all material types.

Method A

Materials with No Yield Point

Figure 5 shows a typical curve of a specimen that exhibits no yield point or continuously yielding behavior. Construction lines show points where typical calculations for ISO 6892-1 have been determined, including $R_{p0.2}$ and R_m. Construction lines or markers are available for almost all calculations in BlueHill® 2 and BlueHill 3 for a quick and easy visual indication of the correct result being calculated.

ISO 6892-1 details test speeds that must be adhered to within a tolerance of ±20% while certain material properties are calculated. There are four speed ranges in total, with recommendations as to which should be used at each point of the test. Figure 6 focuses on the yield region of the test curve. The red lines show the strain rate being maintained well within the ±20% allowable limits.

Materials with Yield Point

The diagram (Figure 7) shows a typical curve of a specimen that exhibits yield point behavior or discontinuously yielding behavior. Construction lines show points where typical calculations for ISO 6892-1 have been determined, including R_{eH} and R_{eL}.

A discontinuously yielding material elastically deforms up until R_{eH}. Following R_{eH} the force typically drops dramatically as the strain continues to increase. If the machine was left in strain control the testing speed would increase dramatically to counter this yielding characteristic resulting in an incorrect strain rate and non-compliance with the standard. Using an intelligent algorithm, the Instron® machine swaps to position control, as detailed in the standard, allowing it to maintain the standard defined estimated strain rate through the discontinuous yielding region. At the end of this yielding region with the onset of strain hardening the machine then moves to a final rate that it maintains until the conclusion of the test.

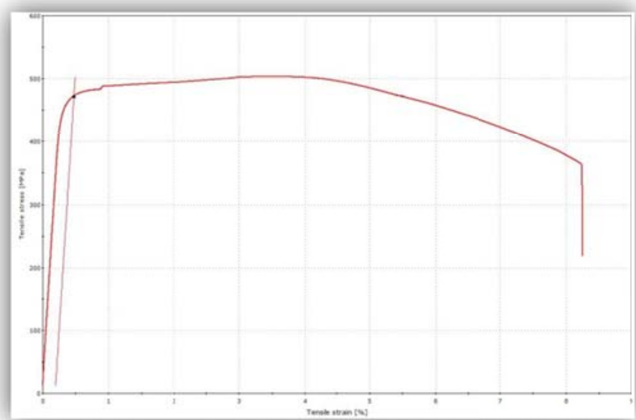

Figure 5 – BH3 screen shot of continuously yielding material.

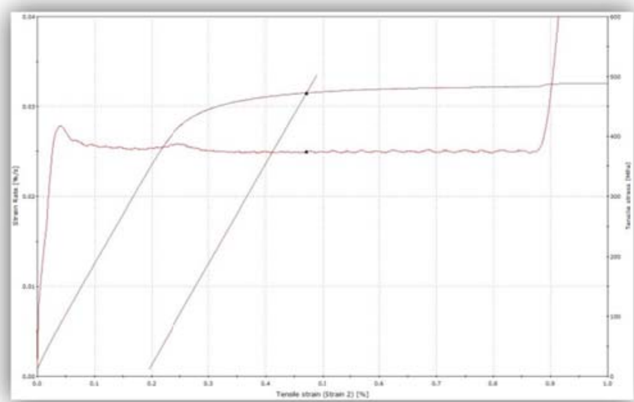

Figure 6 – BH3 screen shot of yield region with strain rate and ± 20% error band.

Method B

This stress-controlled method has far wider allowable speed ranges than Method A. From the start of the test up until 50% of the specified yield strength of the material under test the machine can be run at any convenient speed. From this 50% point the system should be run at a stress rate between 2MPa/s and 60MPa/s, depending on the modulus of elasticity of the material. Through yield and as calculations such as R_{eH}, R_{eL}, R_p and R_t are performed the rate of separation of the crosshead must be kept constant within set strain rate limits. Following these yield/proof strength based calculations the test speed can be increased to a strain rate not greater than 0.008/s.

Unless otherwise agreed, the choice of method (A or B) and the test rates within them are at the discretion of the producer running the tests provided they comply with the requirements of the relevant section of ISO 6892-1:2009.

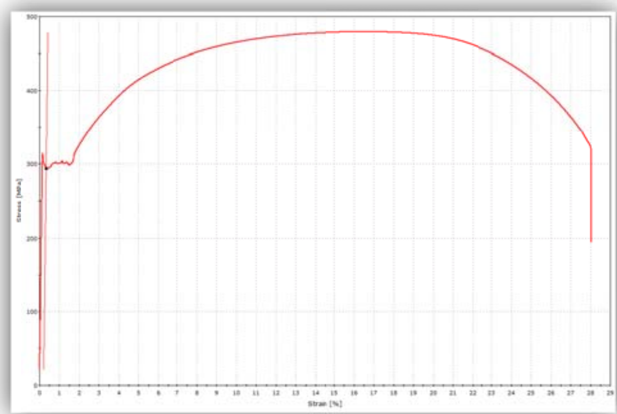

Figure 7 – BH3 screen shot of discontinuously yielding material.

References

International Organization for Standardization, Metallic materials -- Tensile testing -- Part 1: Method of test at room temperature, ISO 6892-1:2009, International Organization for Standardization, Geneva.

Disclaimer