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Metallic materials — Tensile testing at high strain rates —

Part 1:
Elastic-bar-type systems

Matériaux métalliques — Essai de traction à vitesses de déformation élevées —

Partie 1: Systèmes de type à barre élastique

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Foreword

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This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing.*

This second edition cancels and replaces the first edition (ISO 26203-1:2010), of which it constitutes a minor revision.

The main changes compared to the previous edition are as follows:

— a note above 7.1 d) has been added.

A list of all parts in the ISO 26203 series can be found on the ISO website.

Introduction

Tensile testing of metallic sheet materials at high strain rates is important to achieve a reliable analysis of vehicle crashworthiness. During a crash event, the maximum strain rate often reaches 10^3 s^{-1}, at which the strength of the material can be significantly higher than that under quasi-static loading conditions. Thus, the reliability of crash simulation depends on the accuracy of the input data specifying the strain-rate sensitivity of the materials.

Although there are several methods for high-strain rate testing, solutions for three significant problems are required.

The first problem is the noise in the force measurement signal.

— The test force is generally detected at a measurement point on the force measurement device that is located some distance away from the test piece.

— Furthermore, the elastic wave which has already passed the measurement point returns there by reflection at the end of the force measurement device. If the testing time is comparable to the time for wave propagation through the force measurement device, the stress-strain curve may have large oscillations as a result of the superposition of the direct and indirect waves. In quasi-static testing, contrarily, the testing time is sufficiently long to have multiple round-trips of the elastic wave. Thus, the force reaches a saturated state and equilibrates at any point of the force measurement device.

— There are two opposing solutions for this problem.

  — The first solution is to use a short force measurement device which will reach the saturated state quickly. This approach is often adopted in the servo-hydraulic type system.

  — The second solution is to use a very long force measurement device which allows the completion of a test before the reflected wave returns to the measurement point. The elastic-bar-type system is based on the latter approach.

The second problem is the need for rapid and accurate measurements of displacement or test piece elongation.

— Conventional extensometers are unsuitable because of their large inertia. Non-contact type methods such as optical and laser devices should be adopted. It is also acceptable to measure displacements using the theory of elastic wave propagation in a suitably-designed apparatus, examples of which are discussed in this document.

— The displacement of the bar end can be simply calculated from the same data as force measurement, i.e. the strain history at a known position on the bar. Thus, no assessment of machine stiffness is required in the elastic-bar-type system.

The last problem is the inhomogeneous section force distributed along the test piece.

— In quasi-static testing, a test piece with a long parallel section and large fillets is recommended to achieve a homogeneous uniaxial-stress state in the gauge section. In order to achieve a valid test with force equilibrium during the dynamic test, the test piece is to be designed differently from the typically designed quasi-static test piece. Dynamic test pieces are intended to be generally smaller in the dimension parallel to the loading axis than the test pieces typically used for quasi-static testing.

The elastic-bar-type system can thus provide solutions for dynamic testing problems and is widely used to obtain accurate stress-strain curves at around 10^3 s^{-1}. The International Iron and Steel Institute developed the "Recommendations for Dynamic Tensile Testing of Sheet Steel" based on the interlaboratory test conducted by various laboratories. The interlaboratory test results show the high data quality obtained by the elastic-bar-type system. The developed knowledge on the elastic-bar-type system is summarized in this document; ISO 26203-2 covers servo-hydraulic and other test systems used for high-strain-rate tensile testing.

