ISO/FDIS 26203-1:2025(E)

ISO/TC 164/SC 1/WG 7

Secretariat: AFNOR

Date: 2025-0708-04

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

FDIS stage

Contents

Foreword

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This document was prepared by Technical Committee ISO/TC 164, *Mechanical testing of metals*, Subcommittee SC 1, *Uniaxial testing,* in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 459/SC 1, *Test methods for steel (other than chemical analysis),* in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 26203-1:2018), which has been technically revised.

The main changes are as follows:

— ~~—~~modification of note in 7.1~~subclause 7.1;~~;

— ~~—~~ ~~Note~~note in A.6~~A.6~~ changed to be part of main body.

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

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Introduction

Tensile testing of metallic sheet materials at high strain rates is important in order to achieve a reliable analysis of vehicle crashworthiness. The strain-rate range between 10^{-3} and 10^{3} s^{-1} is considered to be the most relevant to vehicle crash events based on experimental and numerical calculations such as the finite element analysis (FEA) work for crashworthiness. In order to evaluate the crashworthiness of a vehicle with accuracy, reliable stress-strain characterization of metallic materials at strain rates higher than 10^{-3} s^{-1} is typically used. 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, there are three significant problems to be solved.

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 often has 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 different 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 is 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 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 thus provides 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” [0[1]] 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, while ISO 26203-2[0[2]] covers servo-hydraulic and other test systems used for high-strain-rate tensile testing.