

Characterization of Dynamic Material Response

KEYWORDS

High Strain Rate

Dynamic Mechanical Behavior

Dynamic Fracture Toughness

Split Hopkinson Pressure Bar

Confining Pressure

High-Speed Imaging

Materials Characterization

Deformation Response

Failure Mechanisms and Shear Banding

Constitutive Model Development

The performance of materials at high strain rates is of interest for various applications (e.g., structural, military and sports). Southwest Research Institute® (SwRI®) has a long history in characterizing the high strain rate response of materials, and has the capability to perform high rate tests in tension, compression, torsion and three-point bend. The SwRI High Rate Test Facility is equipped with instrumentation for measuring, recording and analyzing test data for strain rates approaching 5000 s^{-1} . High-speed imaging systems are also available to record the high rate response. Microstructural characterization of tested material can be accomplished to determine deformation and failure mechanisms. The facility is staffed with experienced personnel who can adapt test conditions to meet unique requirements.

Dynamic Test Capability

- Tension ($\dot{\epsilon} \leq 2 \times 10^3 \text{ s}^{-1}$)
- Compression ($\dot{\epsilon} \leq 5 \times 10^3 \text{ s}^{-1}$)
- Torsion ($\dot{\epsilon} \leq 2 \times 10^2 \text{ s}^{-1}$)
- Fracture toughness

Materials Testing Experience

- Metals
- Porous materials
- Ceramics
- Concretes
- Polymers
- Rocks and soils
- Composites
- Powders

Dynamic Test Equipment

- Split Hopkinson pressure bar systems
 - Environments: vacuum, air, Ar, N
 - High temperature ($T \leq 1000^\circ\text{C}$)
- High-speed torsion actuator
- Nicolet high-speed data acquisition system
- High-speed strain gage amplifiers (10 MHz)
- High-speed imaging systems
 - IMACON ultra high-speed digital camera (up to 10^8 frames/second)
 - Kodak high-speed video system
- Displacement mapping system (DISMAP)
- Confining pressure apparatus (pressures $\leq 300 \text{ MPa}$)

Materials Characterization

- Deformation response: stress-strain curves
- Strain rate sensitivity
- Failure mechanism determination
- Shear band identification
- Deformation measurements (DISMAP) – measures post-test deformation in strained material
- Constitutive model development

Support Facilities

- Metallurgical laboratory
 - Scanning electron microscopy
 - Energy dispersive spectroscopy
 - Auger spectroscopy
 - Optical microscopy
 - X-ray diffraction
- Ballistics and explosives range
- Mechanical test laboratory
 - Low strain rate material characterization
 - High-temperature testing
 - Testing in extreme environments
- Full-service machine shop



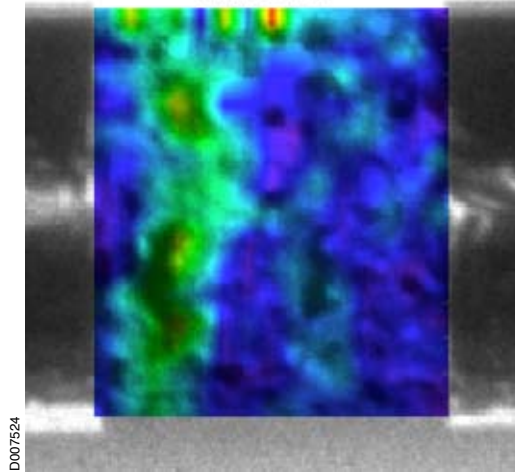
SwRI High Rate Test facility



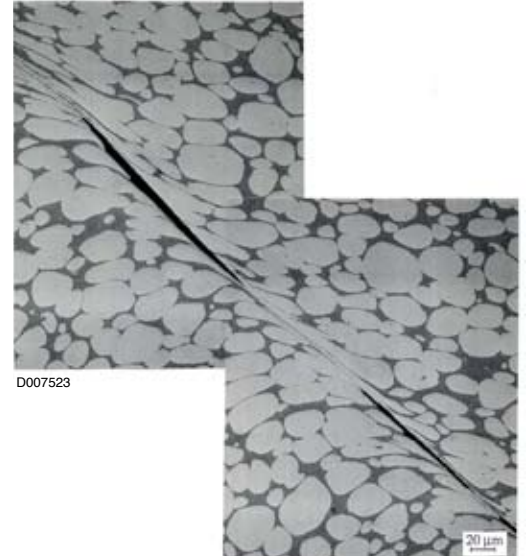
Dynamic mechanical test specimens



Effective Strain



Strain field image showing damage in a metal foam following high strain rate compression testing



Compressive shear band and associated local microcracking in a tungsten alloy tested at a high strain rate



Southwest Research Institute® is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies 1,200 acres in San Antonio, Texas, and provides more than 2 million square feet of laboratories, test facilities, workshops and offices for more than 3,300 employees who perform contract work for industry and government clients.

We welcome your inquiries.

For additional information, please contact:

K. A. Dannemann, Ph.D.
Senior Research Engineer

(210) 522-2523
kdannemann@swri.org

J. D. Walker, Ph.D.
Principal Scientist

(210) 522-2051
jwalker@swri.org

Engineering Dynamics Department
Mechanical and Materials Engineering Division
Southwest Research Institute
6220 Culebra Road • P.O. Drawer 28510
San Antonio, Texas 78228-0510

Southwest Research Institute Website: www.swri.org