Plastics and Composites –

The Benefit of Industry-Accepted Testing and Modelling Goes Beyond Implementation

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Outline

SAE High Strain Rate Plastics Consortium ⇒ SAE J2749

Public Perception of "New Materials" ⇔ Litigious Aspects

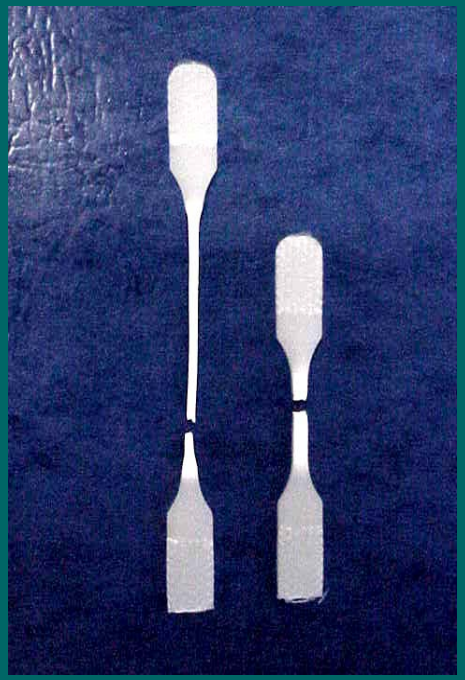
SAE High Strain Rate Consortium (HSRPC)

*Who **	⇒	**GM, Ford, Delphi, Visteon, BASF, Basell, Bayer, DOW, DSM, GE / LNP, LG Chem, Solvay**
What	⇒	**SAE Consortium : Cooperative Research Program** → SAE Subcommittee
Why	⇒	**To develop an industry standard for High Strain Rate Tensile Testing of Plastics**
When	⇒	**Formed in 2001 under impetus of UDRI (Principal Investigator)**
How	⇒	**Self-Funded by Membership Dues of $10K + $5K + $5K and In-Kind Work**

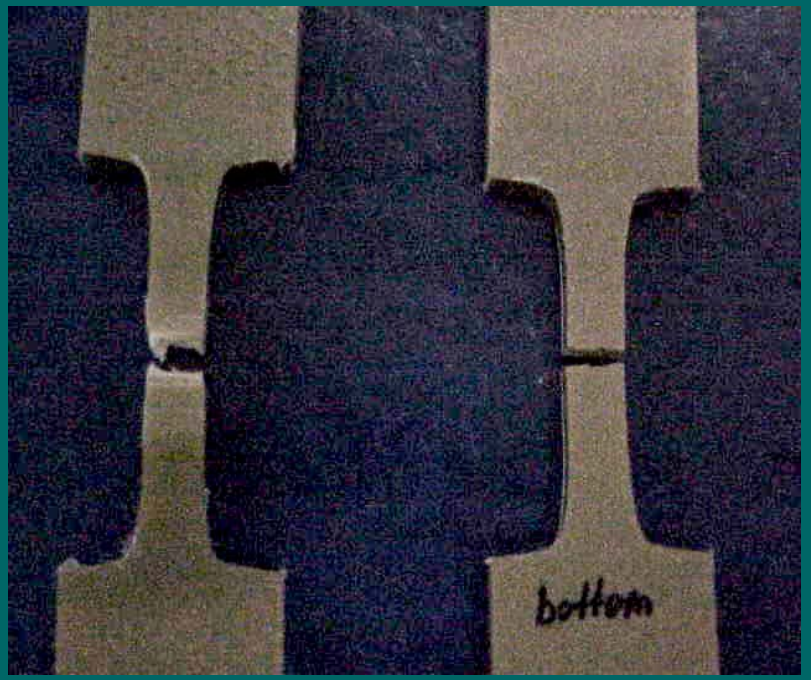
** Toyota paid initial $10K but did not participate*

Practical View of High Strain Rate Behaviour of Plastics

Energy –Absorbing TPO
left: Slow rate, *right*: High rate



Cladding TPO
left: Slow rate, *right*: High rate



High Strain Rate Tensile Testing

Why: $\sigma-\varepsilon$ behavior at rates appropriate for the application

How:
- Conditions of Quasi-Uniform Stress/Strain in Gauge Section
- High Accuracy Measurement of Load and Strain
- Strain Rates 1 s^{-1} – 500 s^{-1}
- Possible Testing Temperature Range –40°C to +120°C

For:
- Direct input for Finite Element Modeling
- Material Development (Modulus, Strength, Ductility)

HSRPC Credentials

Members are involved with:

- **ESIS** (European Society on Integrity of Structures), whose Technical Committee 5 is generating high rate standards
- **IISI** (International Iron and Steel Institute) High Strain Rate Experts Group
- **A/SP** (Automotive Steel Partnership) High Rate Characterization Team
- **USCAR ACC** (Automotive Composites Consortium) Crash Energy Management Group
- Initiatives by **DOT/Volpe** on safety of PCIV (plastics and composites intensive vehicles)
- Initiatives by the **Plastics Division of the ACC** (American Chemistry Council) on automotive safety and plastics

Conducting Valid High Rate Tests
Aspects to Address

- Initial loading
- "Constant" velocity
- System frequency
- Measurement System
- Time lag
- Filtering
- Specimen Geometry

Summary of HSRPC Work

- **UDRI developed Recommended Practice based on tests done by them and member labs**
- **Round Robin conducted on 5 materials:**
  HDPE, PC/ABS, TPO, LGFR-PP, GFR-Nylon
- **Testing split in two phases:**
  - Load Measurement (12 labs) *completed 2005*
  - Strain Measurement (4 labs) *completed 2006-2007*

Final Product

SAE J-2749 Recommended Practice
"High Strain Rate Tensile Testing of Polymers"

- load measurement protocol and strain measurement discussion

- **Formal Ballot by SAE Plastics Committee** — **May 2008**
- **Comments Addressed** — **May 2008**
- **2nd Phase Ballot by SAE** — ***expected*** — **Aug. 2008**

- **Potential Adaption to a Global Standard**
  - Discussions with ASTM D20 Plastics Committee

Differences Between SAE J-2749 and ISO 18872

SAE J-2749 High Strain Rate Tensile Testing of Polymers

- For testing at strain rates between **0.001** s^{-1} **– 1,000** s^{-1}
- Use ASTM D638 or ISO 527-2 for rates ≤ 0.01 s^{-1}
- Detailed guidance on **conducting good tests** – speed variation tolerance, specimen gauge, grips, damping, time shift, measurement requirements, "quasi-homogeneous" stress and strain field, acceptable failure
- Use same specimen geometry and test procedures across all tested rates
- Precision Statistics

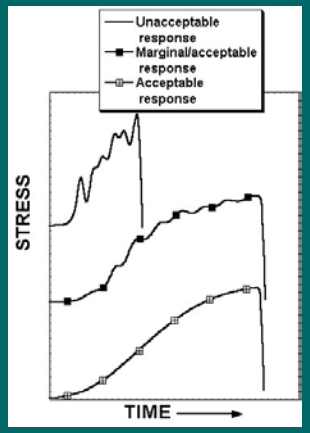
ISO 18872 Plastics – Determination of tensile properties at high strain rates

- Use ISO 527-2 to determine tensile stress-strain curves at speeds 0.1-100 mm/s
- Measure variation of Poisson's ratio with strain
- Recommend long specimen gauge for strains below yield, short gauge for strains above yield
- **Calculate** true stress and true plastic strain at each rate
- Mathematically **model** stress-plastic strain curve
- Model / **Extrapolate to higher strain rates** – 2 decades faster than measurement rate
- Precision is mentioned but not addressed

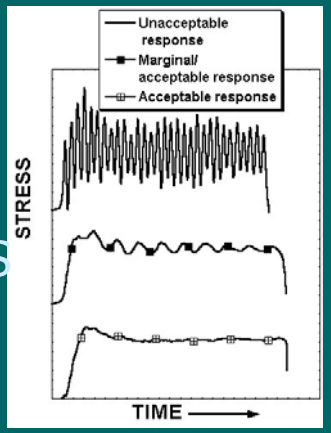
Current Issues for Standard

- **Load measurement**

LGFR-PP

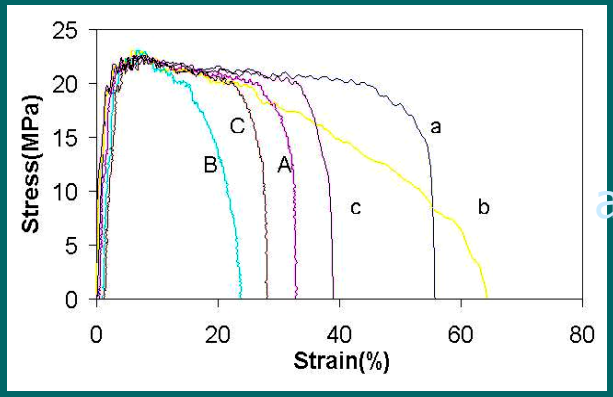


PC/ABS



- **Strain Measurement**

A,B,C from LVDT



a,b,c from LDE (lasers)

- **Specimen Geometry**

Need for Standards / Industry-Accepted Methods

Implementation of Plastics/Composites

- Appropriate Material Selection
- Robust Product Design

Beyond Implementation & Towards Failure Analysis

- Public Perception of Material Integrity
- Litigious Aspects

Beyond Implementation & Towards Failure Analysis Examples

Coextruded 6-Layer Plastic Fuel Tank vs Traditional Steel Tank

- New 6m, -40C drop test added for plastic tanks

Beyond Implementation & Towards Failure Analysis Examples

Laminated Glass -Saflex ®

2007 Ford Focus
Carbon Fibre Decklid

2007 Opel Zafira
Composite Roof

2008 Nissan Murano
Composite Liftgate

Beyond Implementation & Towards Failure Analysis Examples