

**Overview material characterization service
thermoplastics, SFRP/LFRP, composites, foams**

P. Reithofer, M. Rollant, H. Pothukuchi, St. Riemelmoser, Ch. Schober
20.11.2020



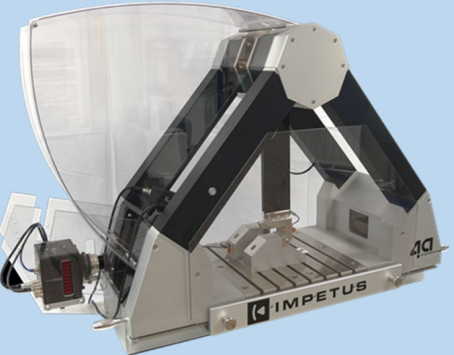


**excellence in
plastics & simulation
testing equipment
lightweight products**



intelligent reliable solutions for plastics, composites, metals, foams, ...

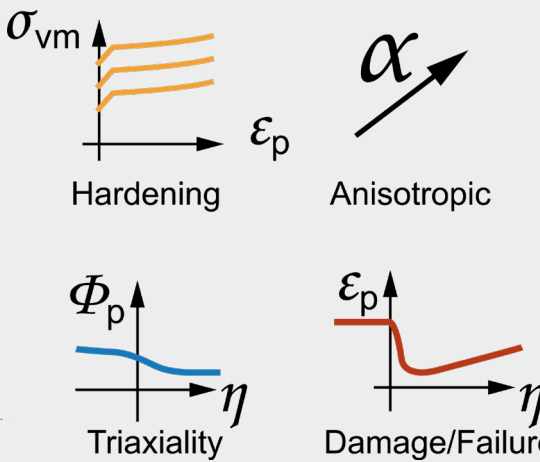
IMPETUS



efficient dynamic testing

The image shows the IMPETUS dynamic testing machine, a large industrial device with a transparent safety enclosure. Below the machine, two diagrams illustrate dynamic testing: one shows a hammer striking a plate, and the other shows a piston striking a circular sample.

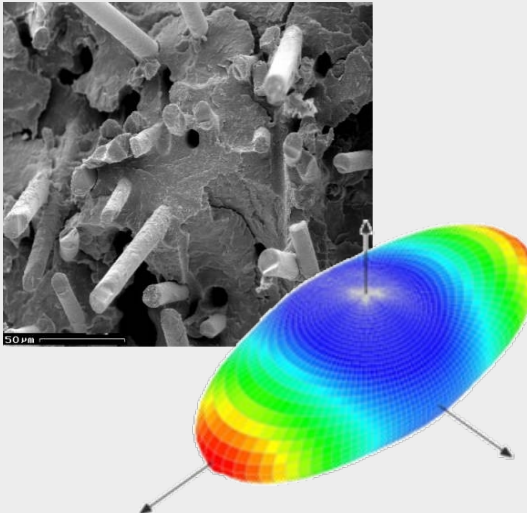
VALIMAT



from test to validated material cards

The image displays four graphs representing material cards. The top-left graph plots σ_{vm} against ϵ_p and is labeled 'Hardening'. The top-right graph shows an arrow labeled α and is labeled 'Anisotropic'. The bottom-left graph plots Φ_p against η and is labeled 'Triaxiality'. The bottom-right graph plots ϵ_p against η and is labeled 'Damage/Failure'.

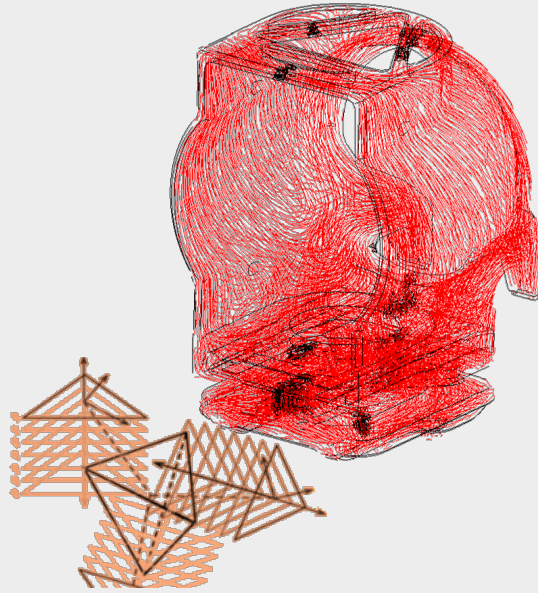
MICROMECC



3D anisotropic material cards

The image features a scanning electron microscope (SEM) image of a porous material structure on the left. On the right, a 3D visualization shows a color-coded stress or strain field over a mesh of the same structure, with a color gradient from blue to red.

FIBERMAP

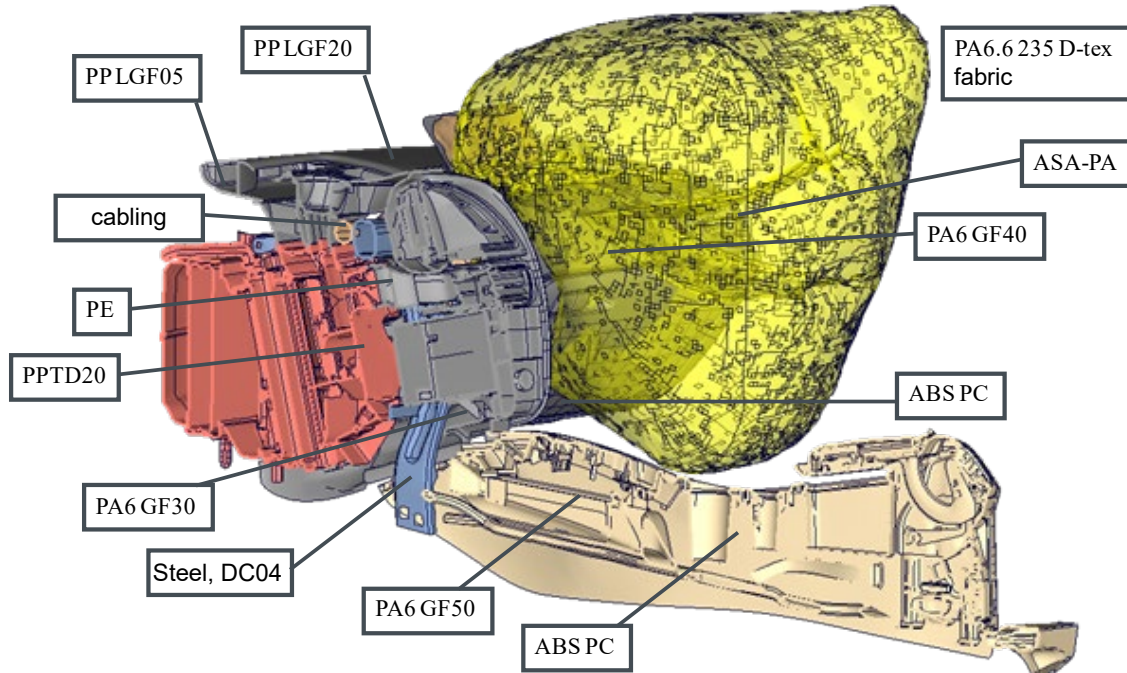


individual mapping process information

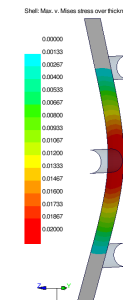
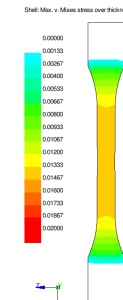
The image shows a 3D visualization of a red mesh representing a complex, curved structure. Below it, a 2D diagram illustrates a fiber-like structure with a grid pattern, representing the individual mapping process information.

2004 - motivation

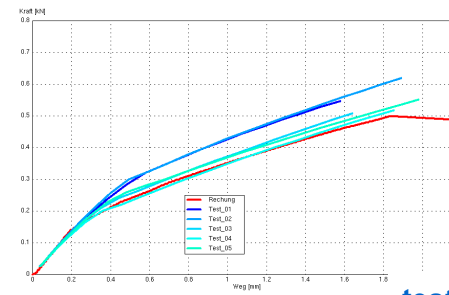
material variety



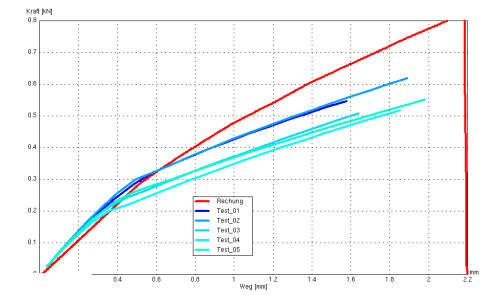
bending load case



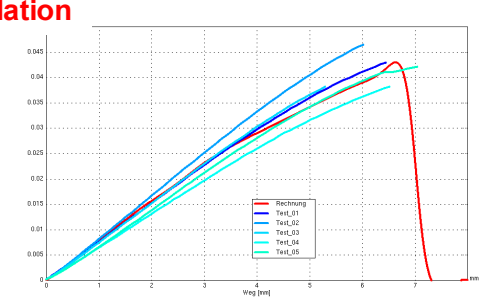
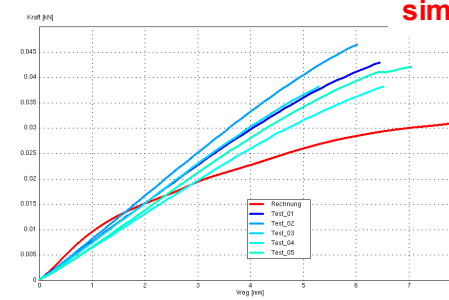
original test curve tension



scaling 1.25



test simulation



Source: R. Luijckx - *Kunststoffmaterialien in der Interieur Funktionsauslegung bei Audi AG*, 4a Technologietag 2010



IMPETUS

efficient dynamic testing



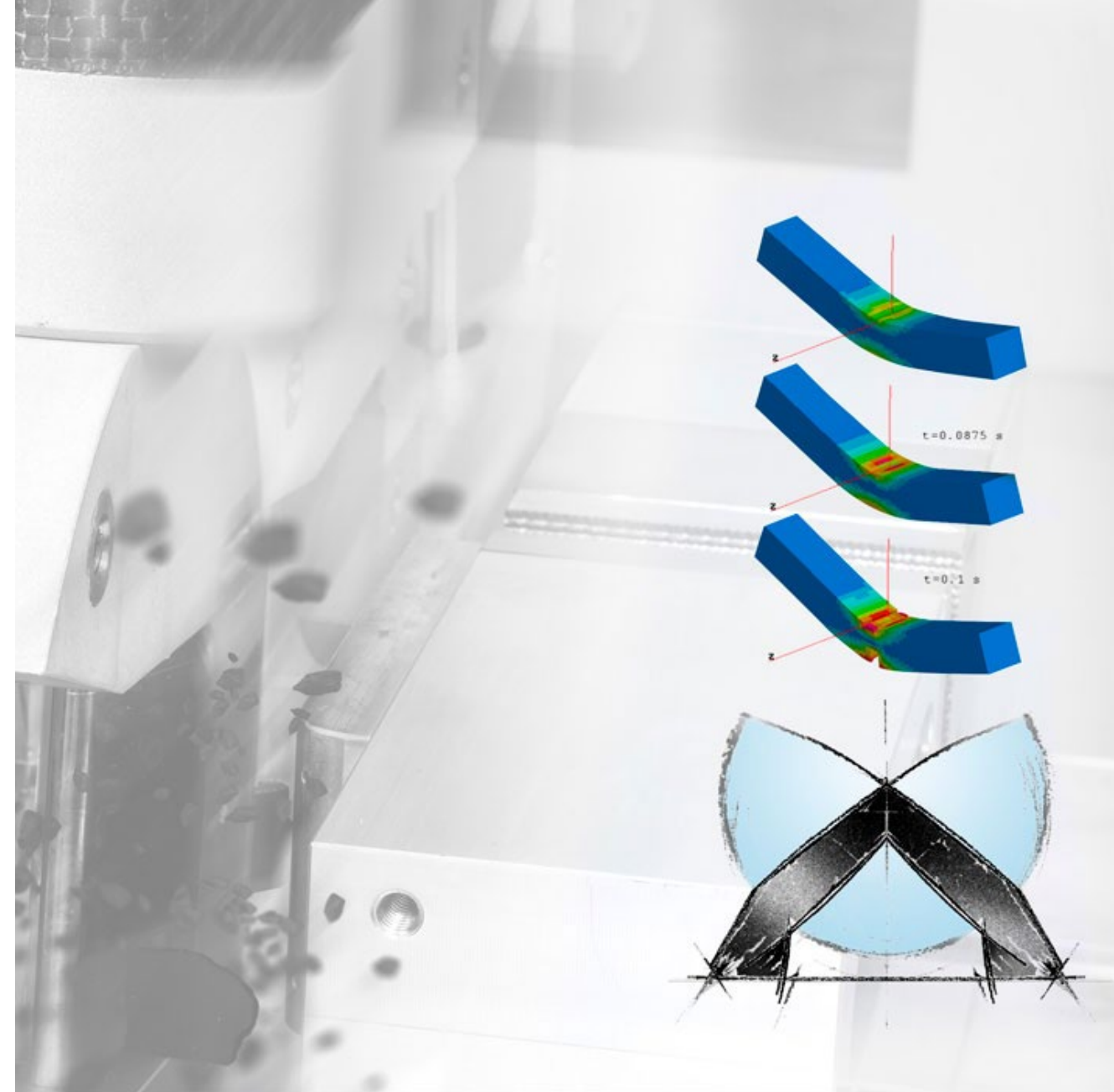
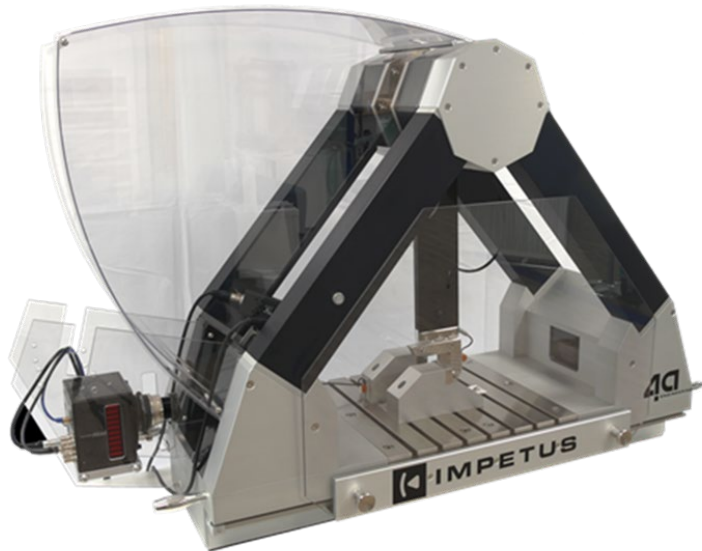
IMPETUS

plastics
production
engineering
excellence in
material science
simulation
concepts
lightweight
prototypes

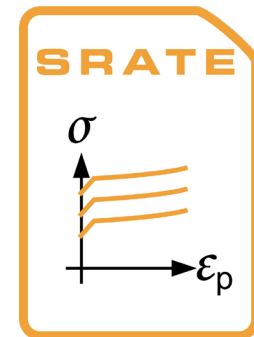
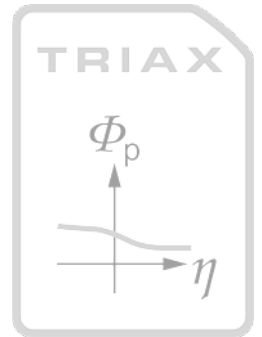
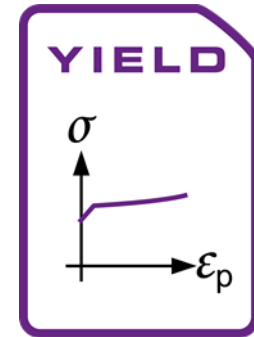
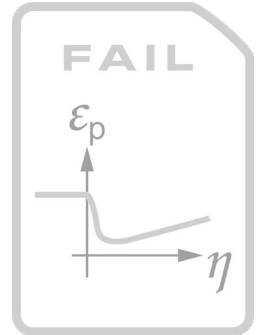
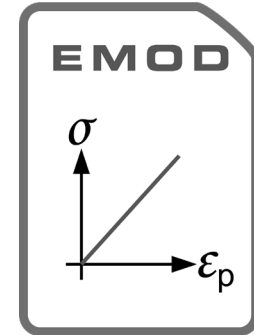
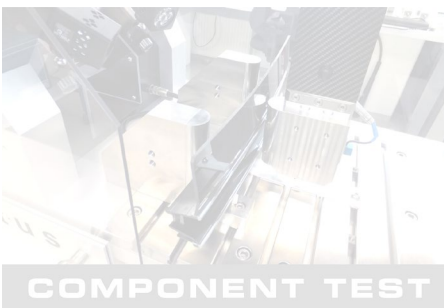
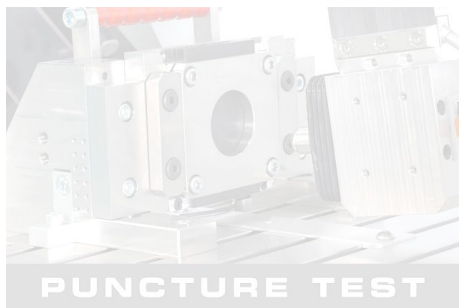
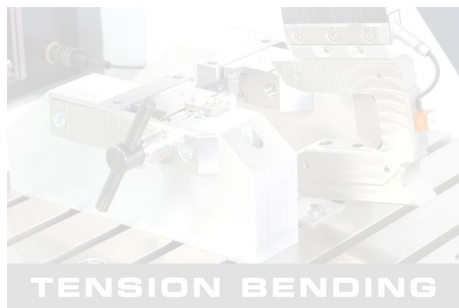
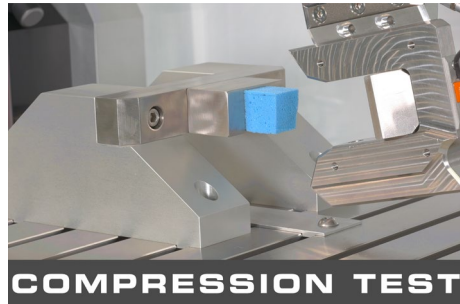
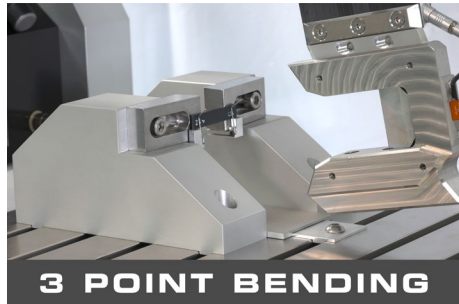
efficient dynamic testing

- desktop testing device
- instrumented high-speed testing
 - acceleration \rightarrow force / displacement
- impact velocity 0.5 – 4.5 m/s

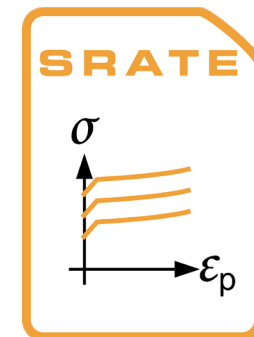
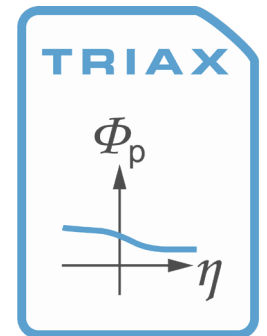
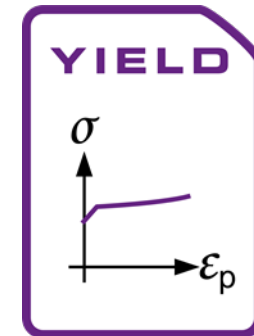
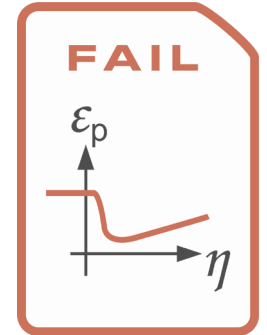
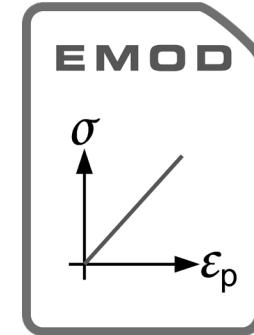
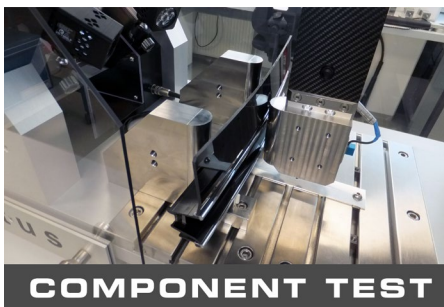
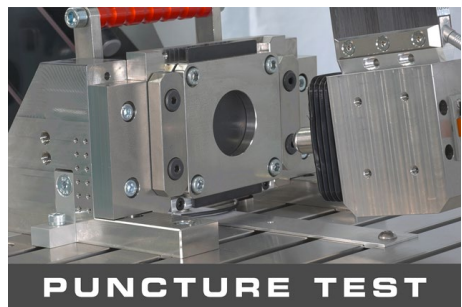
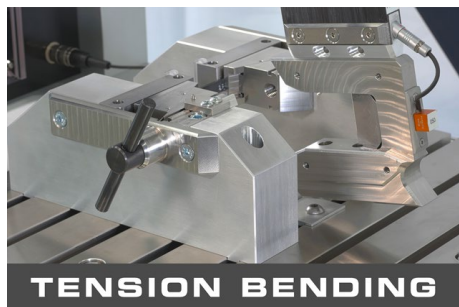
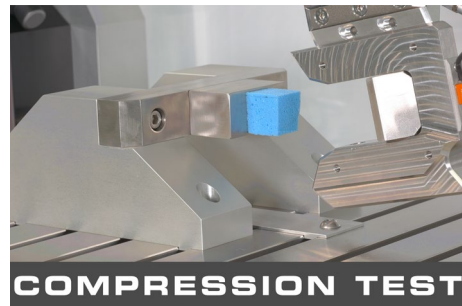
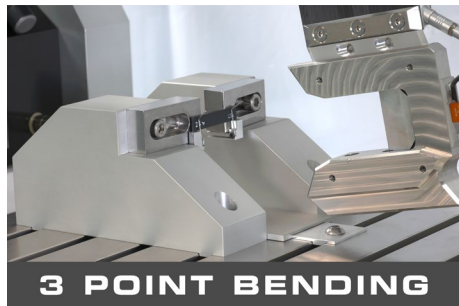
 **IMPETUS**



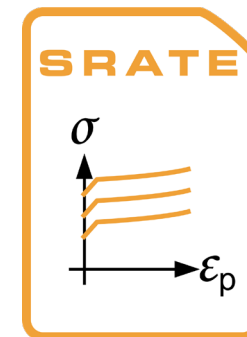
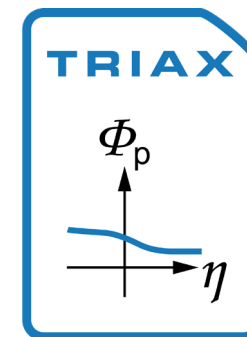
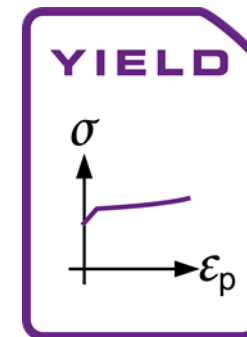
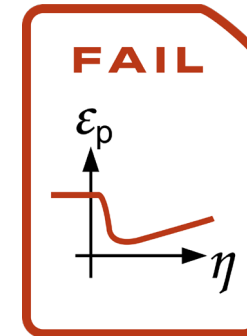
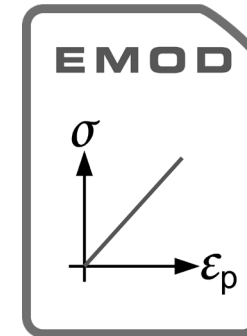
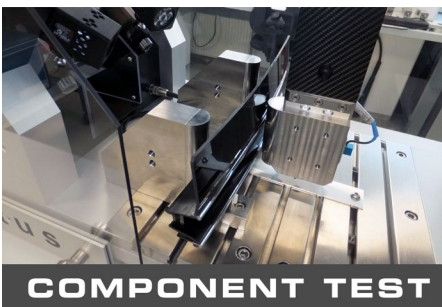
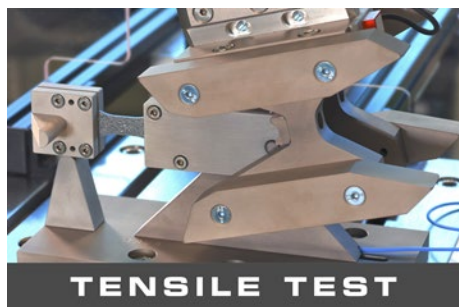
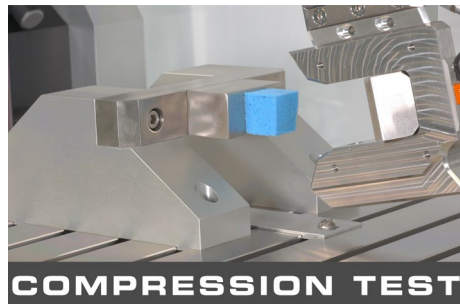
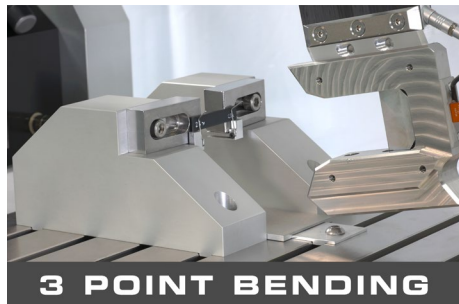
- 3-point bending for thermoplastics and compression testing for foam materials



- research on different load cases
uniaxial and biaxial behavior



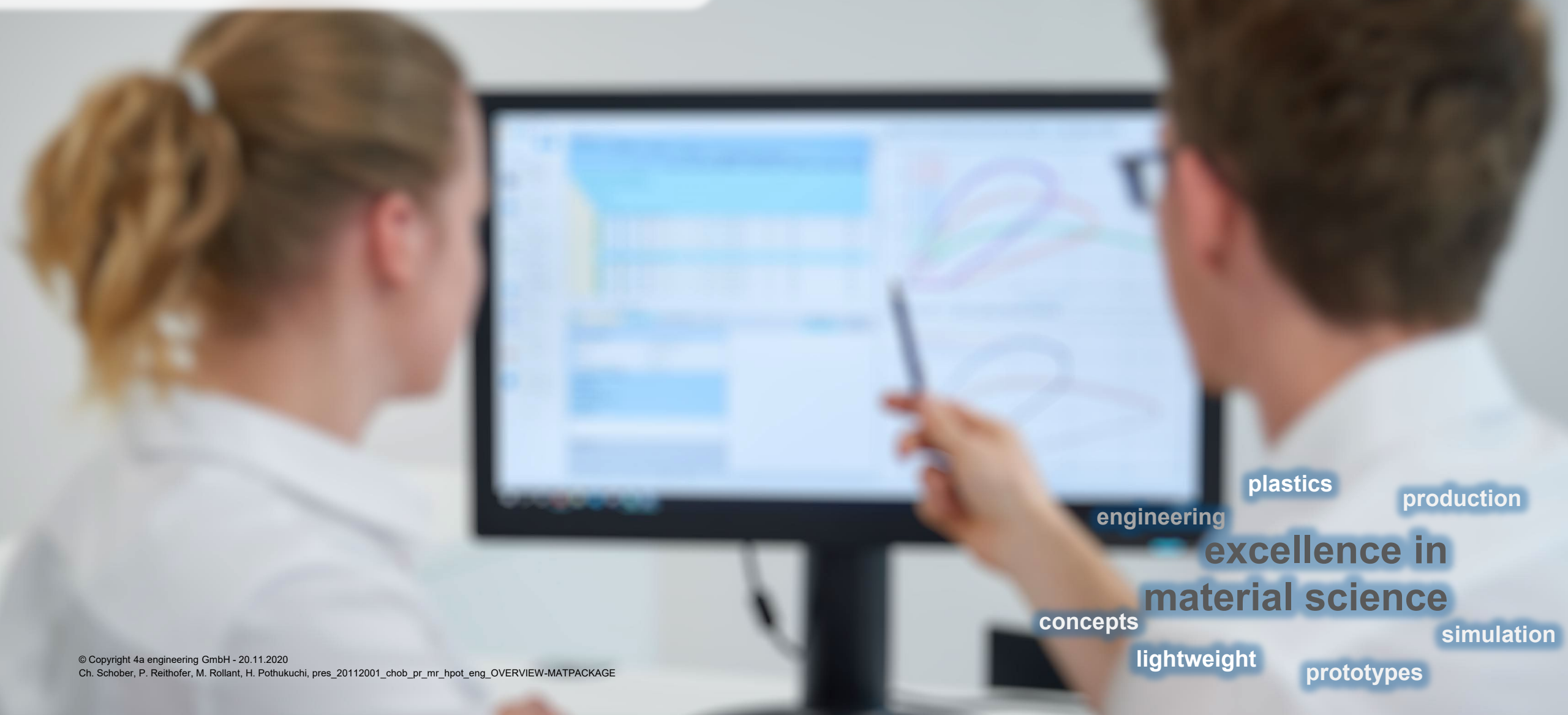
- everything for your dynamic material card (i.e. *MAT_187) with general yield surface





VALIMAT

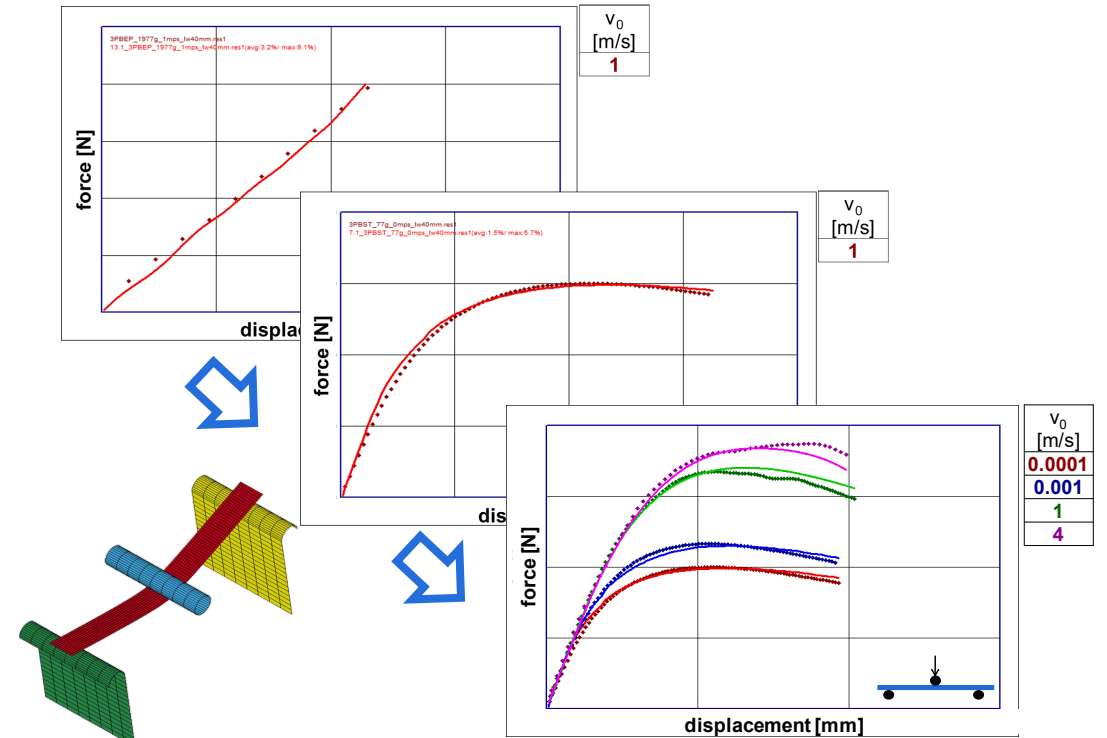
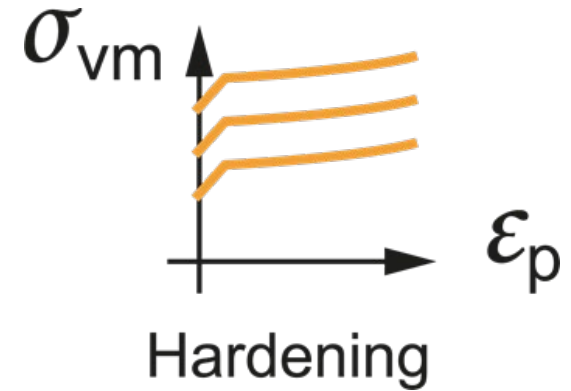
from test to material card



plastics production
engineering excellence in material science
simulation
concepts lightweight prototypes

from test to material card

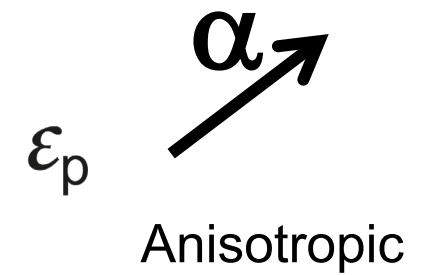
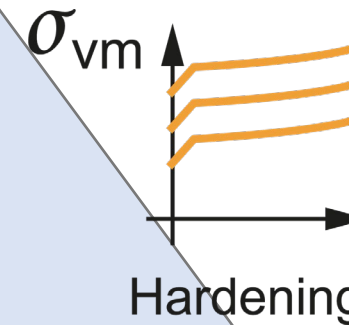
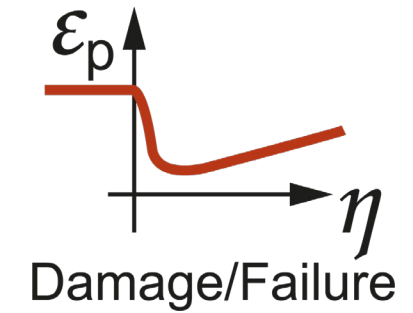
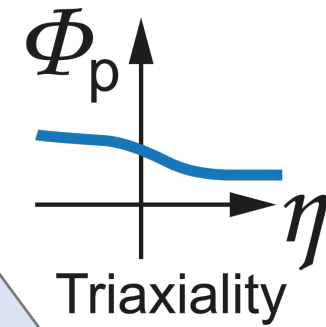
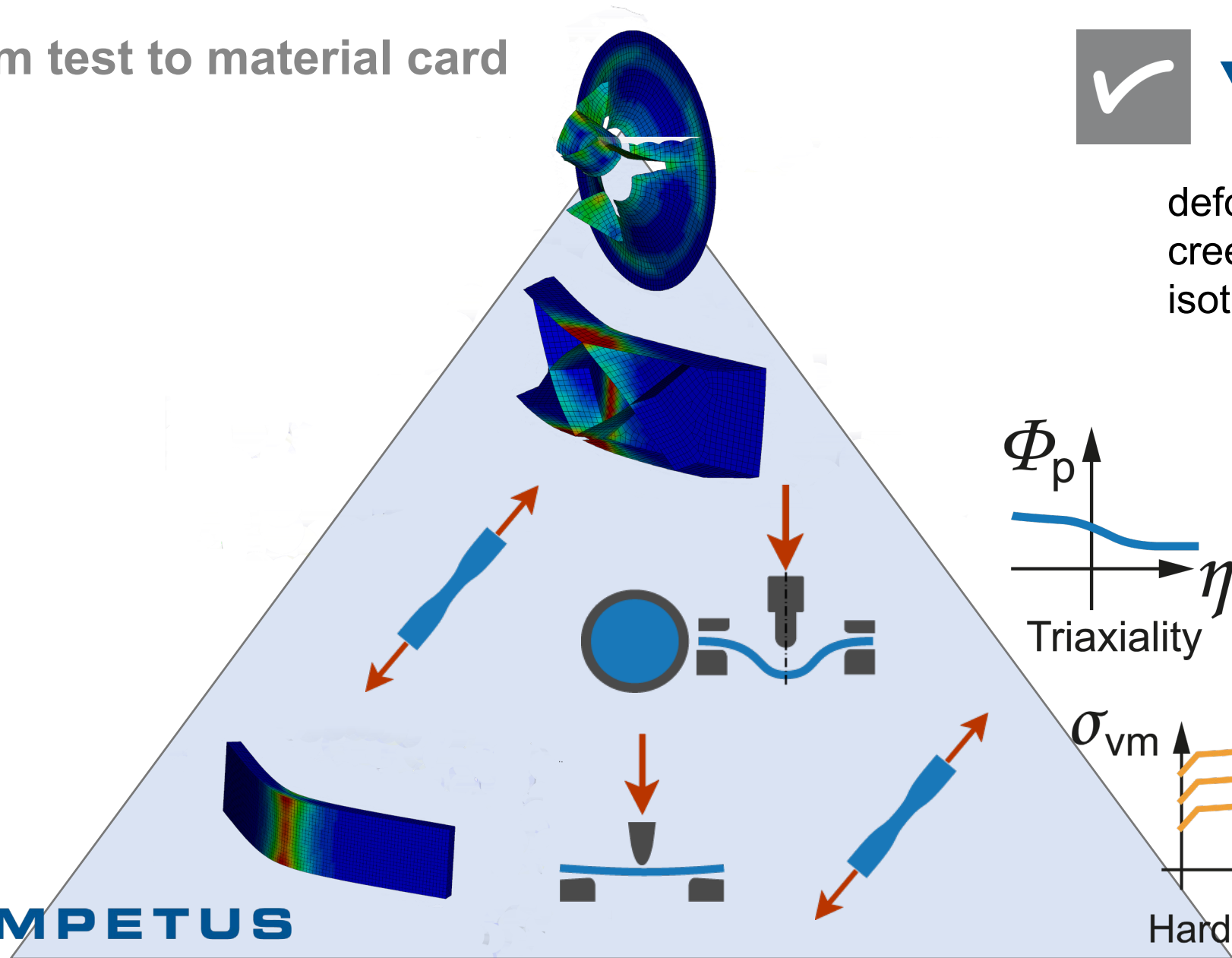
- desktop testing device
- instrumented high speed testing
 - acceleration → force / displacement
- impact velocity 0.5 – 4.5 m/s
- maximum energy 50 J
- easy approach - deformation
 - plastics → bending → **MATERIAL_CARD*
 - foams → compression → **MATERIAL_CARD*



from test to material card



deformation → failure
 creep → static → crash
 isotropic → anisotropic



intelligent reliable solutions for plastics, composites, metals, foams, ...

◀ **IMPETUS**

✓ **VALIMAT**

◻ **MICROMECH**

↗ **FIBERMAP**

foams

thermoplastics

fiber reinforced plastics (SFRT & LFRT)

composites (carbon)

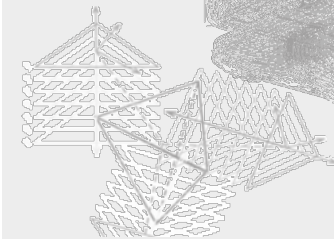
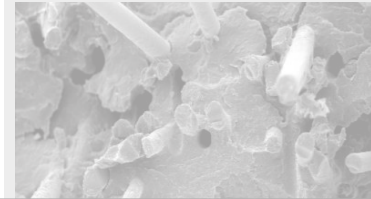
metals

efficient
dynamic testing

from test to validated
material cards

3D anisotropic
material cards

individual mapping
process information



intelligent reliable solutions for plastics, composites, metals, foams, ...



- manage test results
(import, export, filter, evaluation)
- statistical analysis
- automated report and workflows
- material card generation and validation
for LS-DYNA, PAM-CRASH, ABAQUS

for all material types

from test to validated material cards



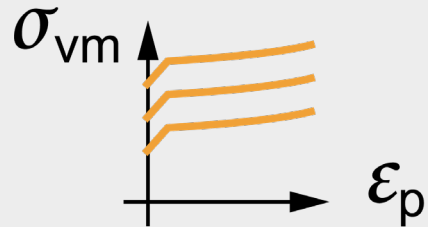
- single pendulum up to 4.5 m/s
- double pendulum up to 8 m/s
- standard test methods
- specialized test methods
- component testing
- advanced measurement

plastics and composites

efficient dynamic testing

intelligent reliable solutions for plastics, composites, metals, foams, ...

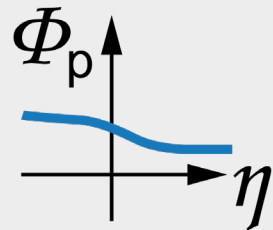
✓ VALIMAT



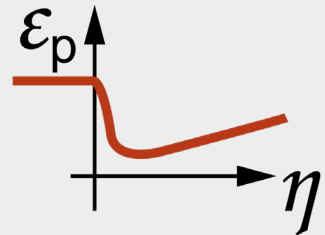
Hardening



Anisotropic



Triaxiality



Damage/Failure

for all material types

from test to validated material cards

◀ IMPETUS



plastics and composites

efficient dynamic testing

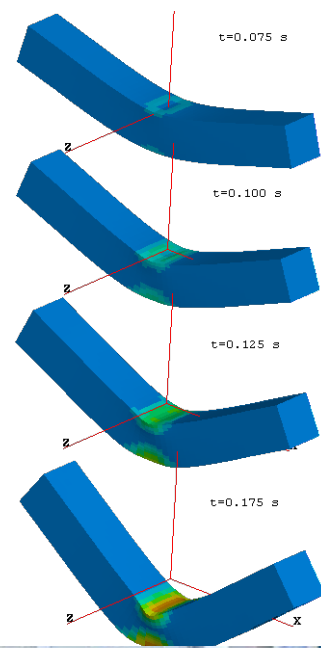
material characterization service



plastics
production
engineering
**excellence in
material science**
concepts
lightweight
simulation
prototypes

material characterization service

- efficient high-dynamic testing
- dynamic material behaviour
- plastics, foams, composites, ...
- **validated material cards ready to use for your crash-simulation**



PACKAGES

validated material cards
for LS-DYNA®, PamCrash®, Simulia ABAQUS®

isoP

isotropic PLASTIC

isotropic elastic visco plastic

frP

fiber reinforced PLASTIC

orthotropic elastic visco plastic

comP

composite PLASTIC

orthotropic elastic damage

foam

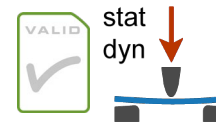
foamed PLASTIC

isotropic hyper-elastic
based on static and dynamic compression tests

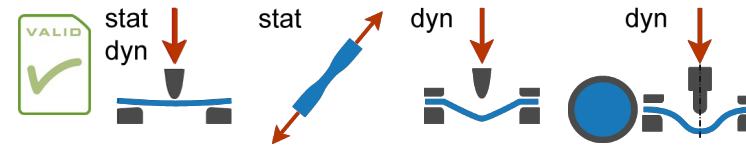
UPGRADES

PLUS – dynamic tensile
TEMP – low and high

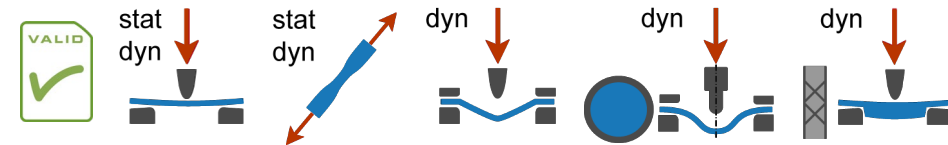
BASIC



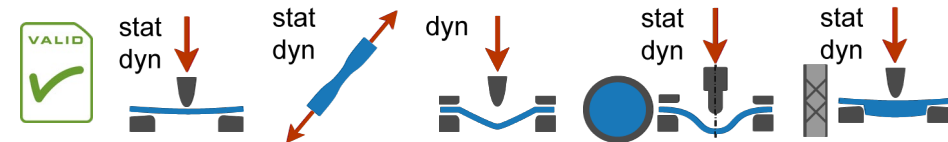
STD

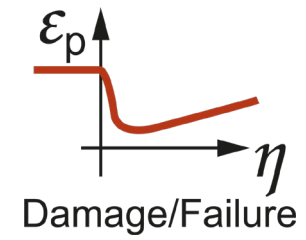
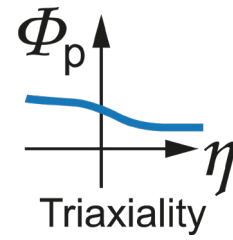
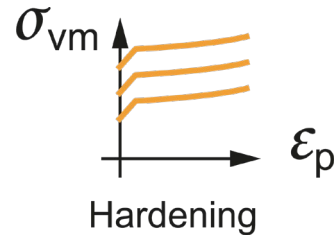


PRO L



PRO





BASIC

2* 3*

STD

2* 3*

1 1

1

PRO L

2* 3*

1 1 1

1

1

PRO

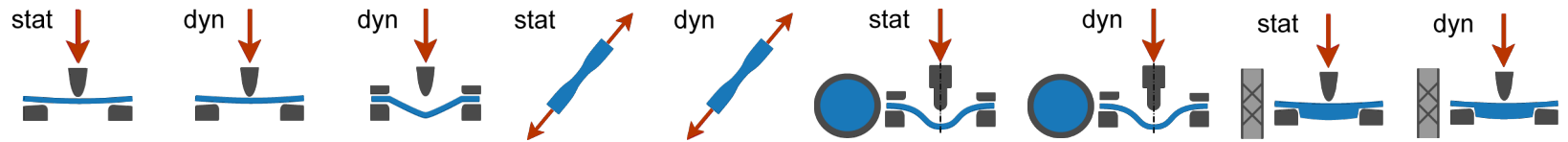
2* 3*

1 1 1

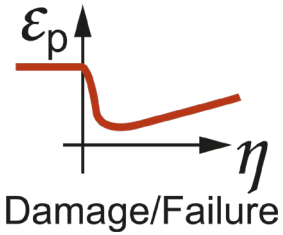
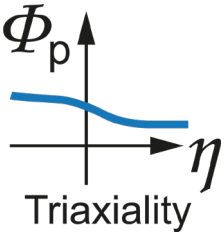
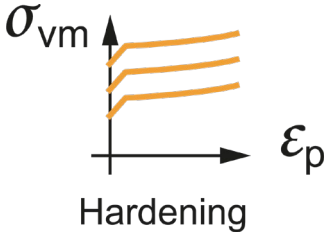
1 1

1 1

* reduced setup available



frP



BASIC*

2 6

STD*

2 6

2

1

PRO L

3 5

1 1

1

1

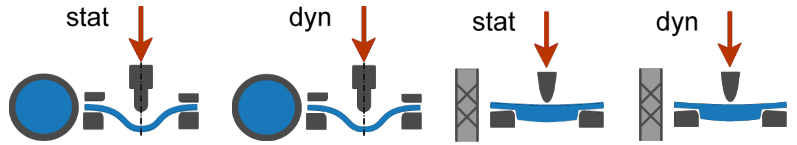
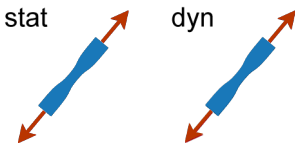
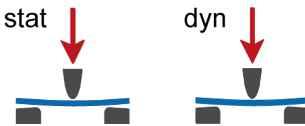
PRO

3 7

3 1

1 1

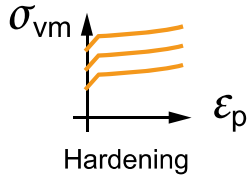
1 1



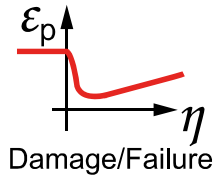
* card per orientation and averaged provided



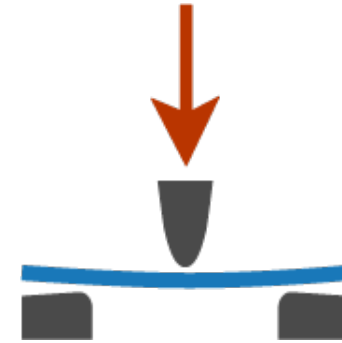
Isotropic-elastic, visco-plastic material model
vonMises yield surface with associated flow rule



based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s



failure is not considered



Typical exemplary material card:

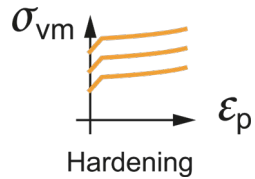
LS-DYNA **MAT_024*

Pam-Crash *MATER103*

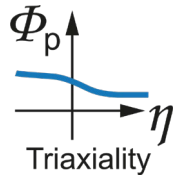
Abaqus **PLASTIC*



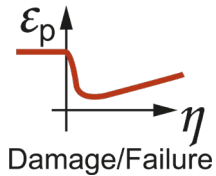
Isotropic-elastic, visco-plastic material model
vonMises yield surface with associated flow rule



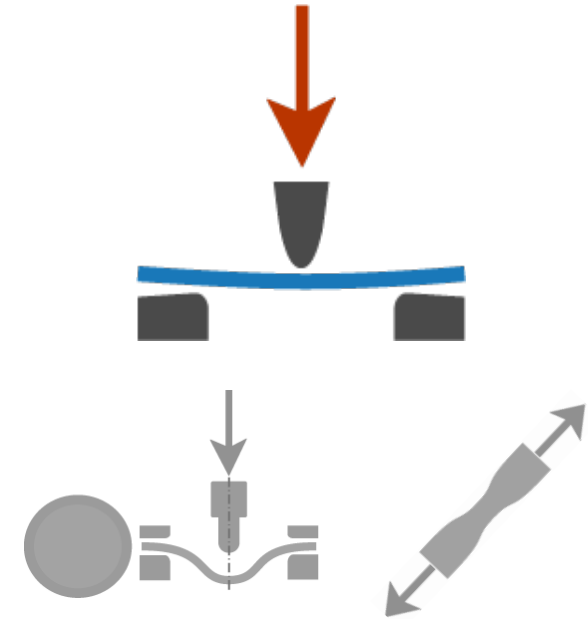
based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s



tension/compression assymetry depicted



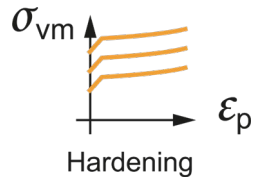
failure set to mean max. principal strain of
conducted tests



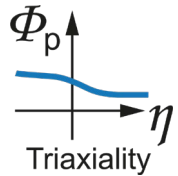
Typical exemplary material card:
LS-DYNA **MAT_024*
Pam-Crash *MATER103*
Abaqus **PLASTIC*



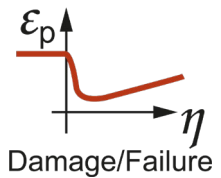
Isotropic-elastic, visco-plastic material model
Drucker-Prager yield surface with a non associated flow rule



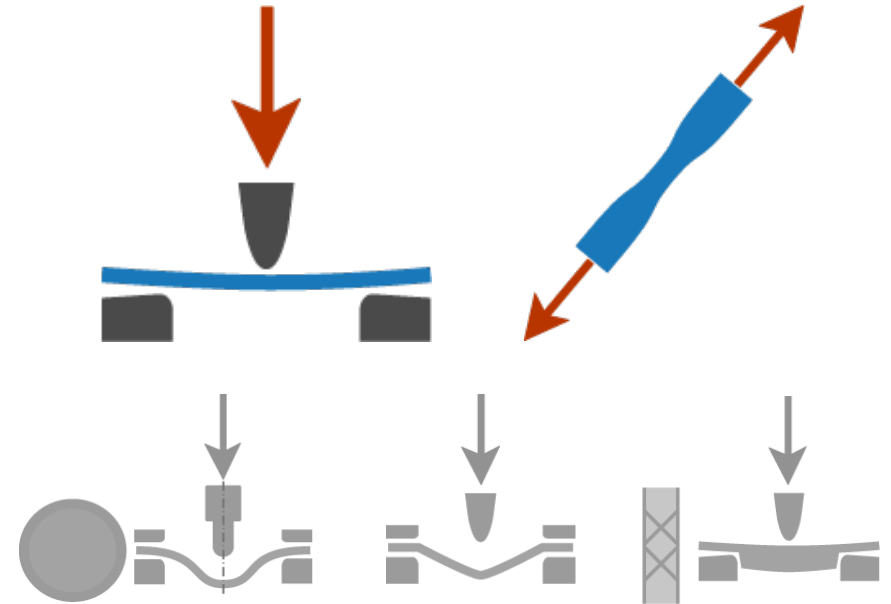
based on 3-point bending test setups conducted at 2 static and 3 dynamic velocities up to 4.4 m/s



based on tensile testing
tension/compression asymmetry



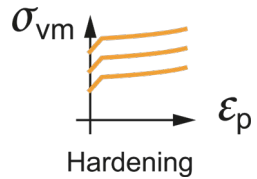
failure set to mean max. principal strain with strain rate dependency of conducted tests



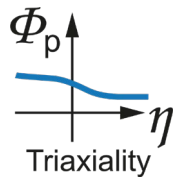
Typical exemplary material card:
LS-DYNA **MAT_187L*
Pam-Crash *MMATER*



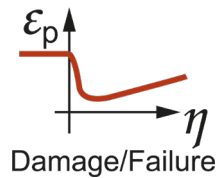
Isotropic-elastic, visco-plastic material model
Drucker-Prager/complex yield surface with a non associated flow rule



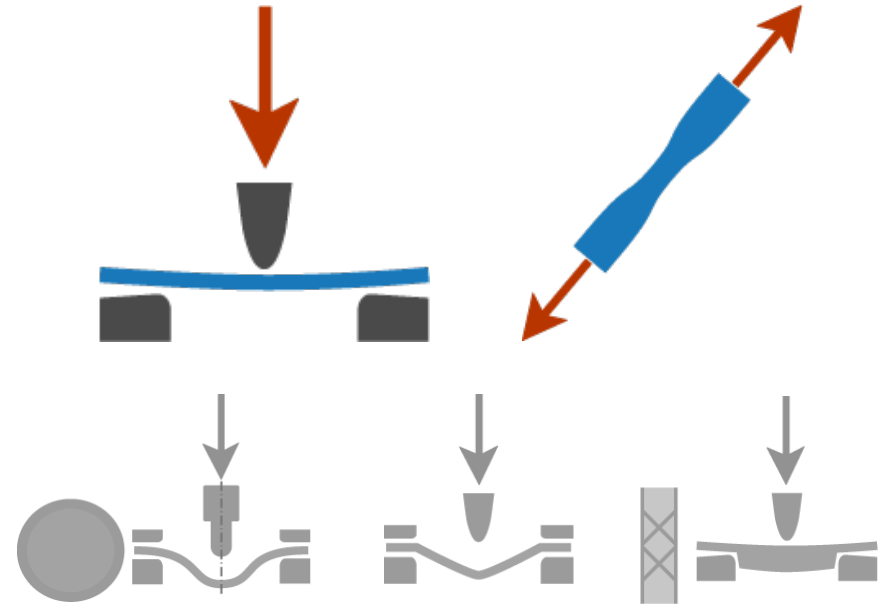
based on 3-point bending test setups conducted at 2 static and 3 dynamic velocities up to 4.4 m/s



based on tensile testing
tension/compression asymmetry



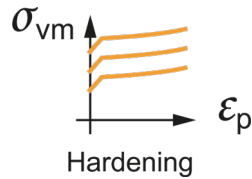
Fully adjusted triaxiality curve with strain rate dependency and validation on all conducted tests



Typical exemplary material card:
LS-DYNA **MAT_187*
Pam-Crash *MMATER, MMM*



0° & 90° card defined as:
isotropic-elastic, visco-plastic material model
vonMises yield surface with associated flow rule

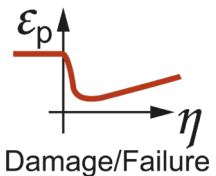


based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s

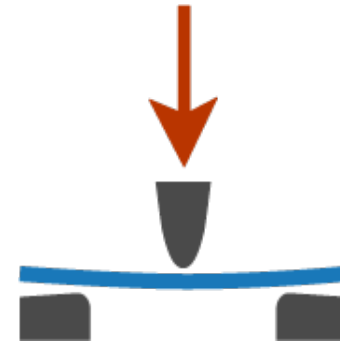


Anisotropic

longitudinal and transversal card provided



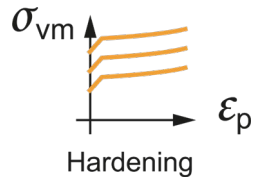
failure is not considered



Typical exemplary material card:
LS-DYNA **MAT_024*
Pam-Crash *MATER103*
Abaqus **PLASTIC*



0° & 90° card defined as:
isotropic-elastic, visco-plastic material model
vonMises yield surface with associated flow rule

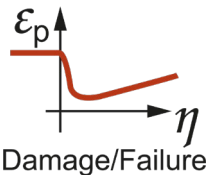


based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s

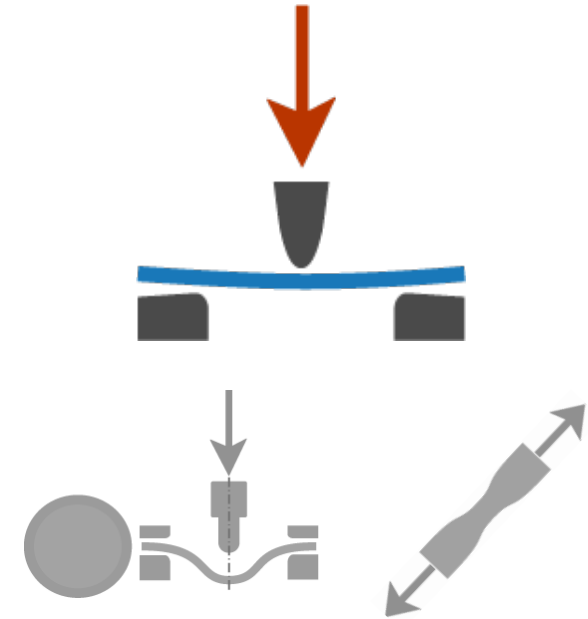


Anisotropic

longitudinal and transversal card provided



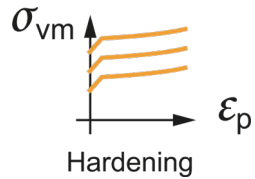
failure set to mean max. principal strain of
conducted tests



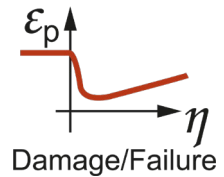
Typical exemplary material card:
LS-DYNA **MAT_024*
Pam-Crash *MATER103*
Abaqus **PLASTIC*



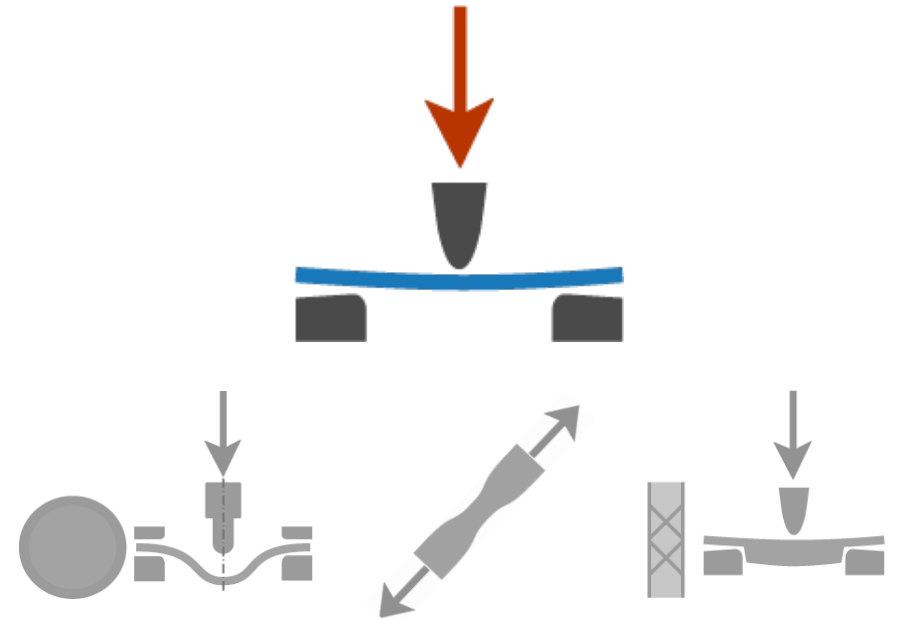
anisotropic-elastic, visco-plastic material model
composite/micro-mechanics based approach



based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s



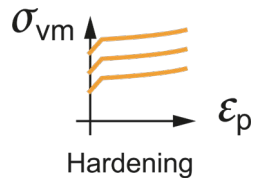
failure set to mean max. principal strain of
conducted tests



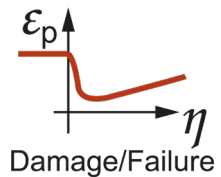
Typical exemplary material card:
LS-DYNA **MAT_157*, **MAT_215*
Pam-Crash *MMATER*



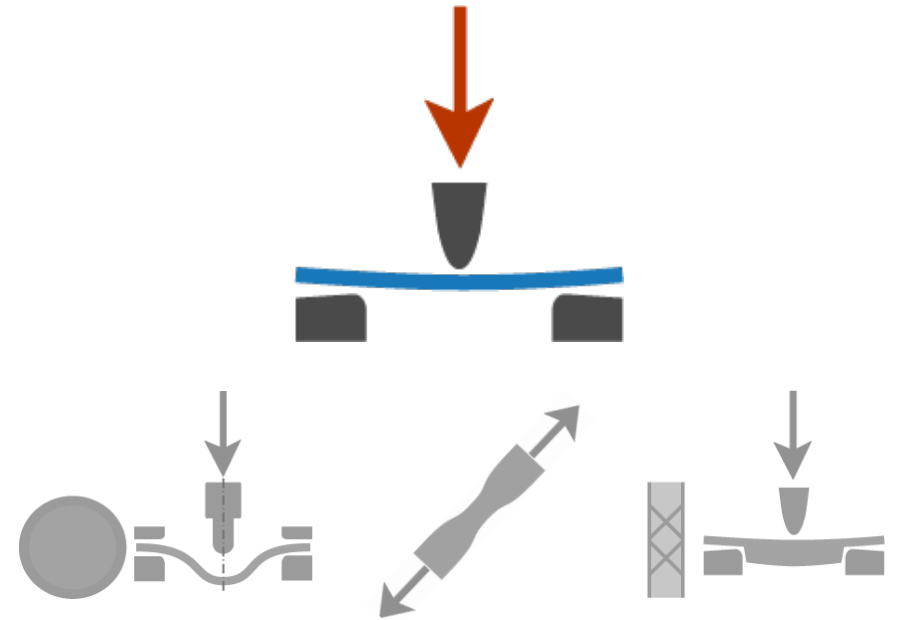
anisotropic-elastic, visco-plastic material model
composite/micro-mechanics based approach



based on 3-point bending test setups conducted
at 2 static and 3 dynamic velocities up
to 4.4 m/s



damage initiation and evolution model



Typical exemplary material card:
LS-DYNA **MAT_157*, **MAT_215*
Pam-Crash *MMATER*



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