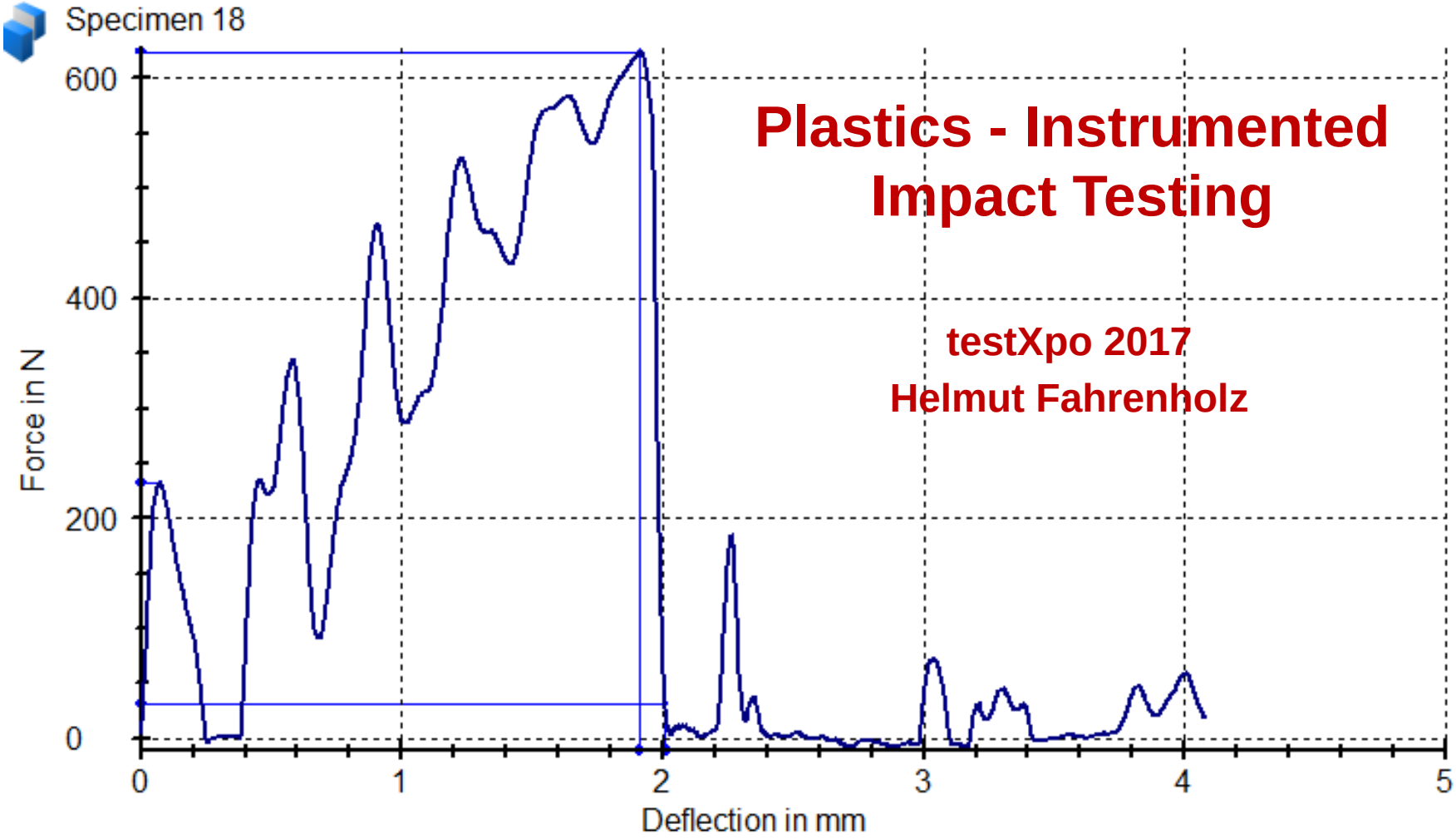
Zwick Roell

Prüfen mit Verstand



Plastics - Instrumented Impact Testing

testXpo 2017

Helmut Fahrenholz

Instrumented Impact Testing

Several methods and types of equipment are available to measure high speed properties.

Pendulum Impact

Drop Weight

Hydraulic High Speed

Instrumented Impact Testing

Instrumented Pendulum Impact Testing

Instrumented Drop-Weight Tester

High Speed Testing Machine

Pendulum Impact

Zwick’s HIT pendulum impact series - a complete product range for impact testing

5.5 / 25 / 50 Joule universal, digital

5 Joule ISO

Charpy

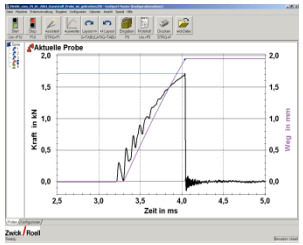
Izod

Notch cutting machine

tensile impact

Dynstat

Manual notch cutter



Instrumentation

Automation

Pendulum Impact – Conventional method

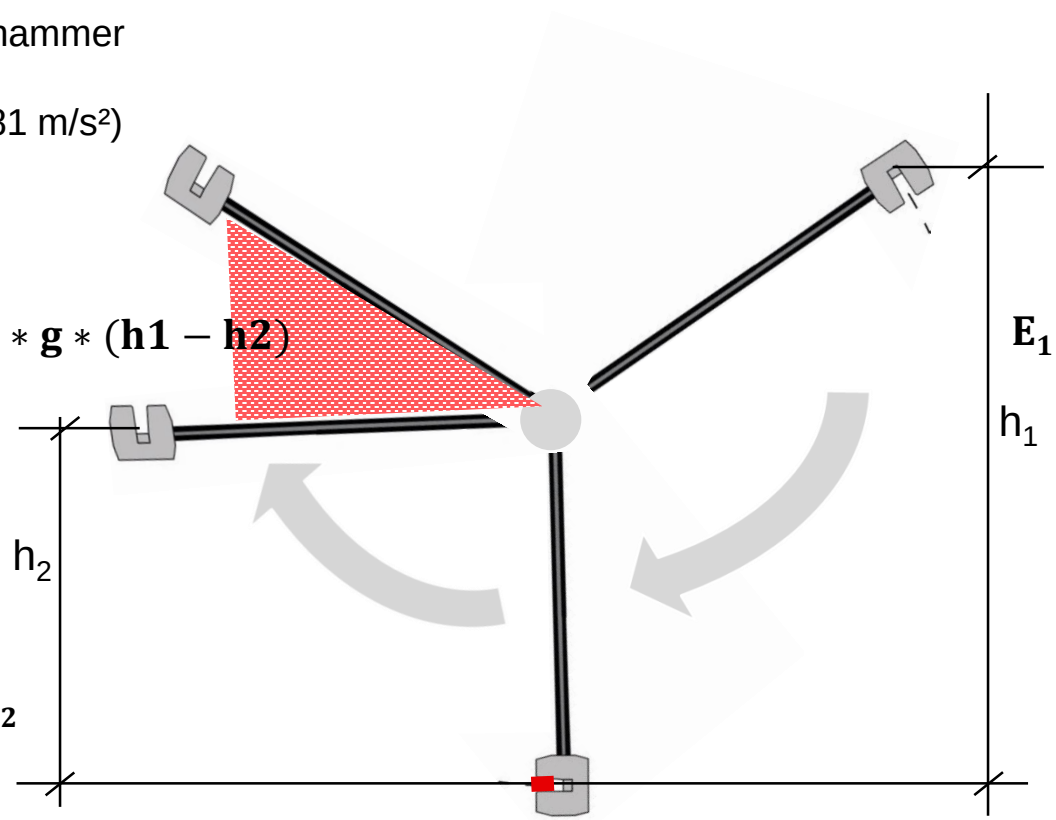
In the conventional method, impact resilience is measured by height difference and the mass of the pendulum hammer.

E – energy
m – mass of the pendulum hammer
h – drop height
g – gravity acceleration (9,81 m/s²)

$$\mathbf{E}_{\mathbf{Specimen}} = \mathbf{m} * \mathbf{g} * (\mathbf{h1} - \mathbf{h2})$$

$$\mathbf{E_1} = \mathbf{m} * \mathbf{g} * \mathbf{h_1}$$

$$\mathbf{E_2} = \mathbf{m} * \mathbf{g} * \mathbf{h_2}$$



Pendulum Impact – Conventional method

The type of break is an integral part of the result. Only same types of breaks supply comparable results.

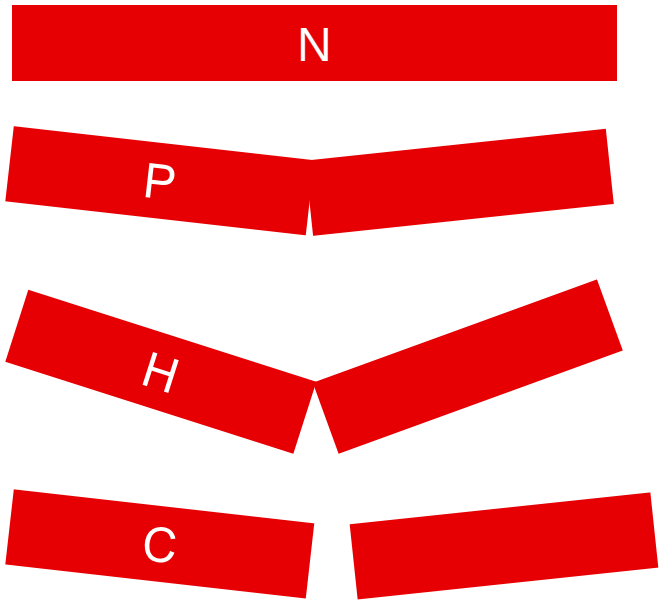
Standardized types of break:

N – non-break (no valid result)

P – partial break

H – hinge break

C – complete break



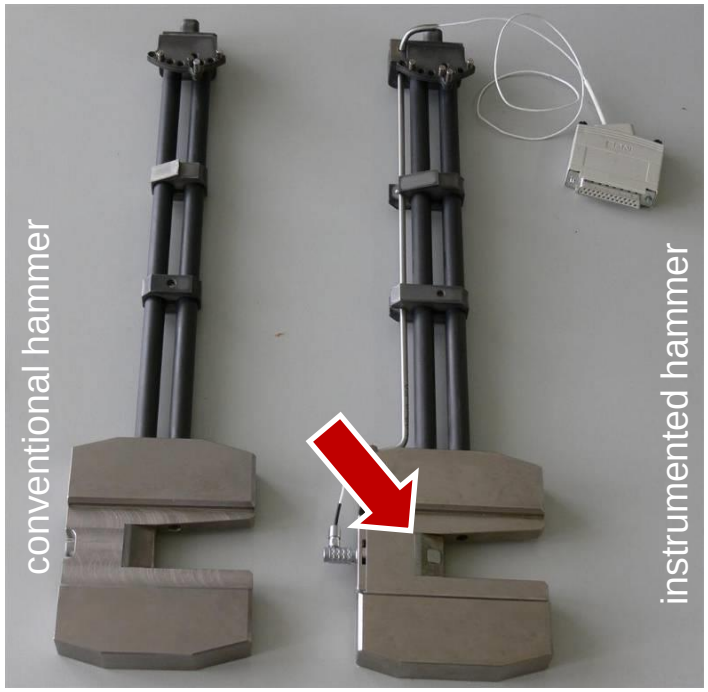
The most frequent type of break within a test series determines the results to be used in the statistics.

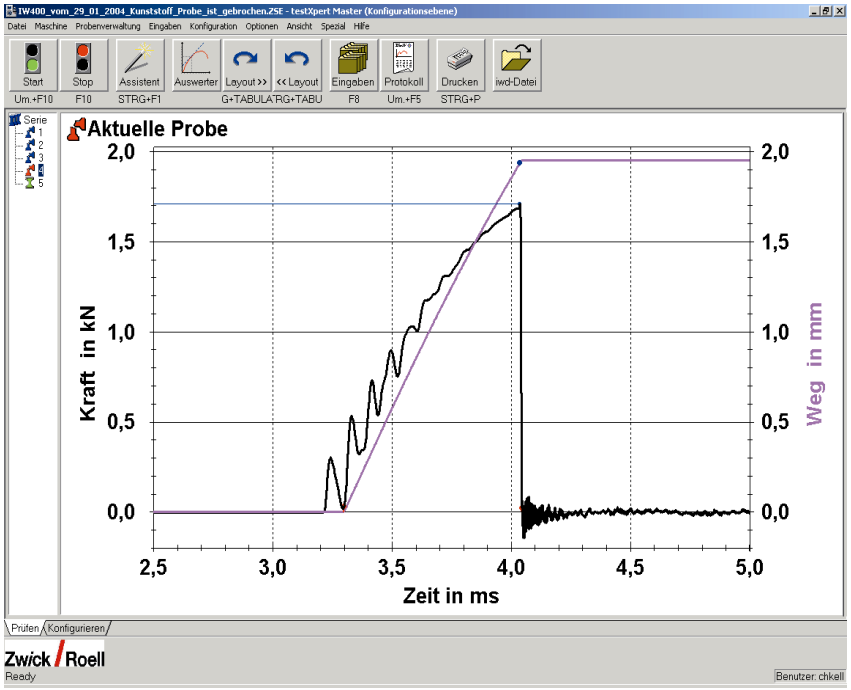
Instrumented Pendulum Impact Testing

Instrumented pendulum impact means force measurement during impact. This offers supplementary characteristics.

- used in R&D, TS and QA

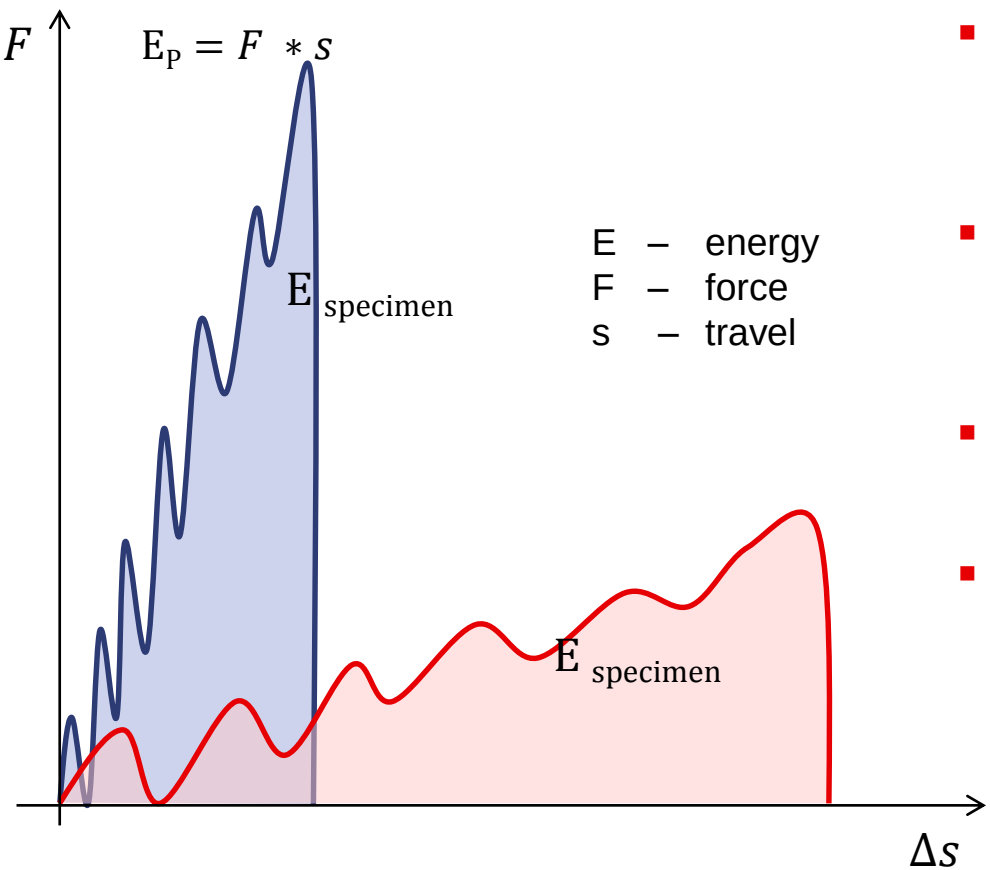
- Charpy
- Izod
- tensile impact
- Fracture mechanics





Instrumented Impact Testing

The force-travel diagram provides supplementary materials data obtained under high deformation rates.



- The conventional method may show same results for completely different stress-strain behavior.
- Instrumented impact methods allow to distinguish such situations, while conventional impact can't.
- Break types can automatically be detected
- Information about fracture mechanical characteristics can be obtained.

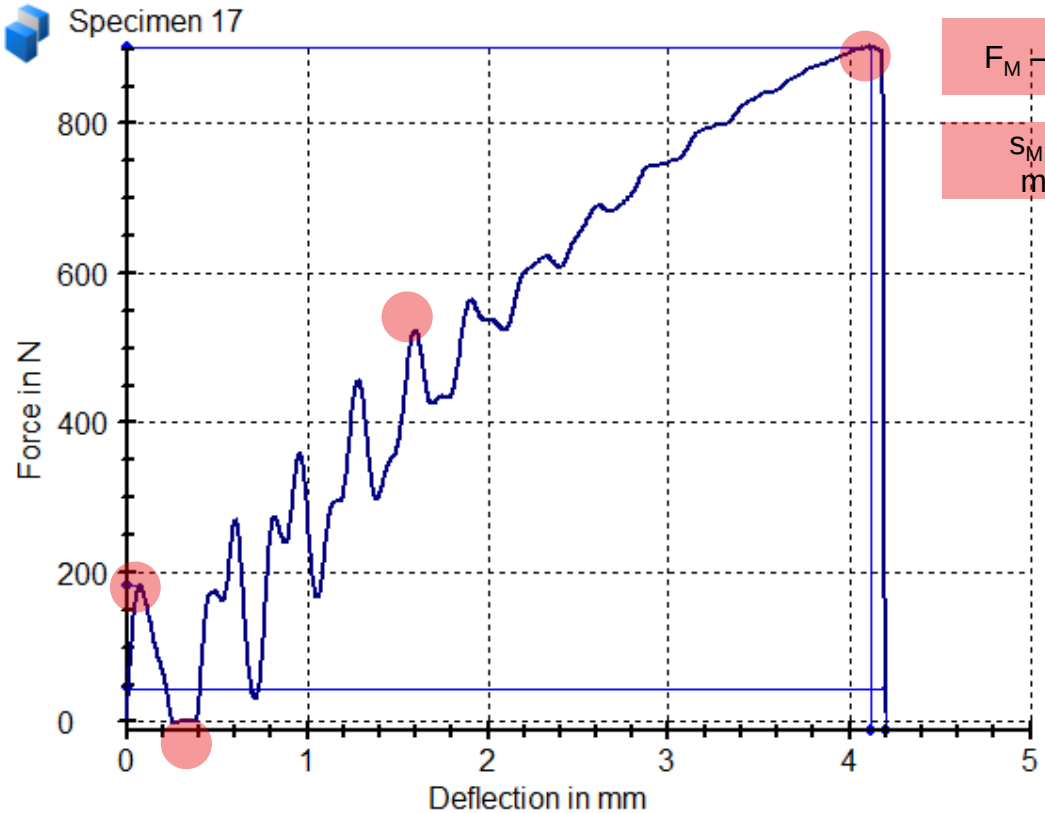
Pendulum Impact - Tests and Curves

Several points in a travel-deflection diagram are characteristic for instrumented Charpy tests

The specimens natural frequency has a square-root function with the materials tensile modulus

F_I – First impact maximum

No contact between pendulum hammer and specimen

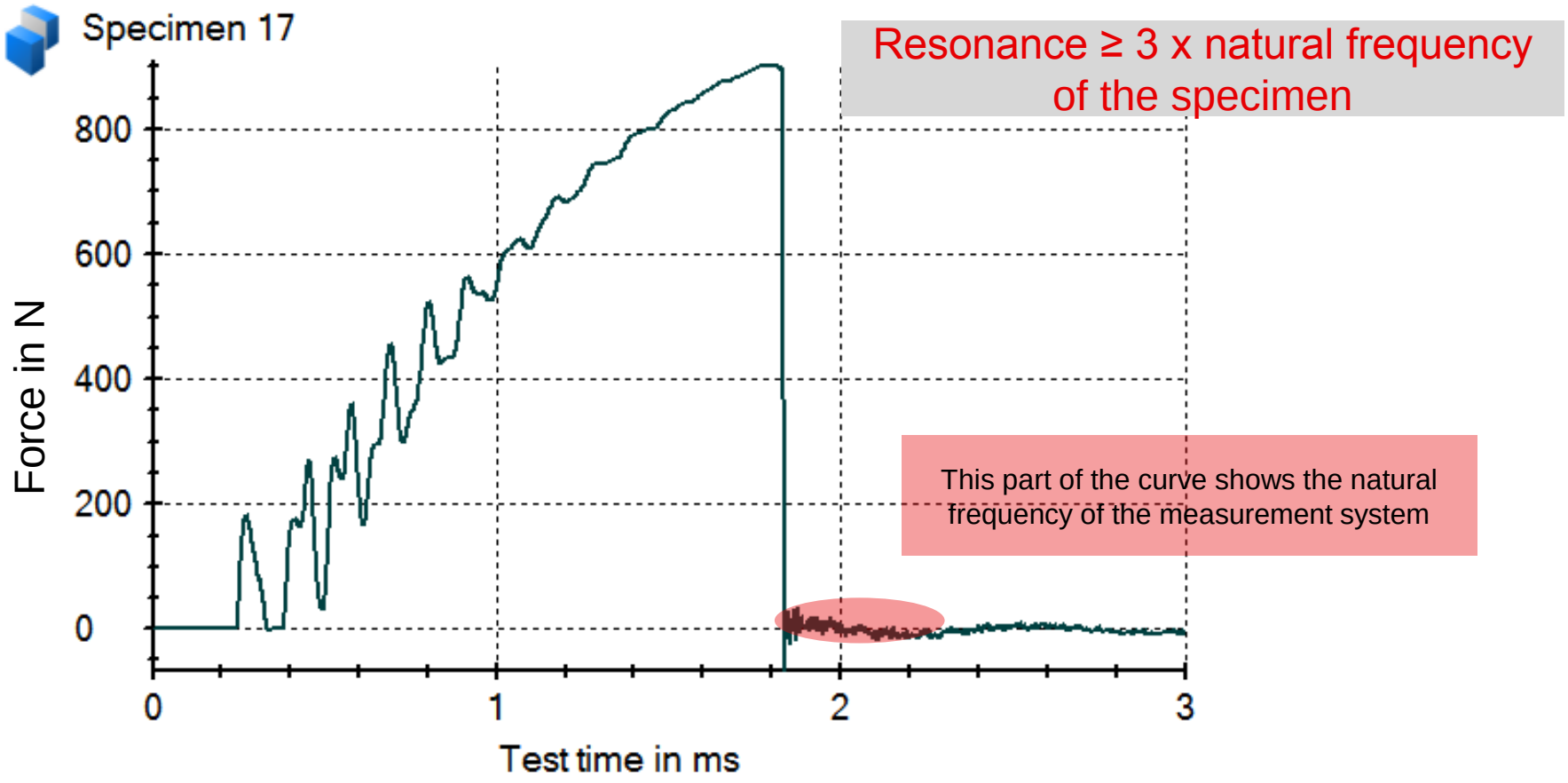


F_M – maximum force

s_M – deflection at maximum force

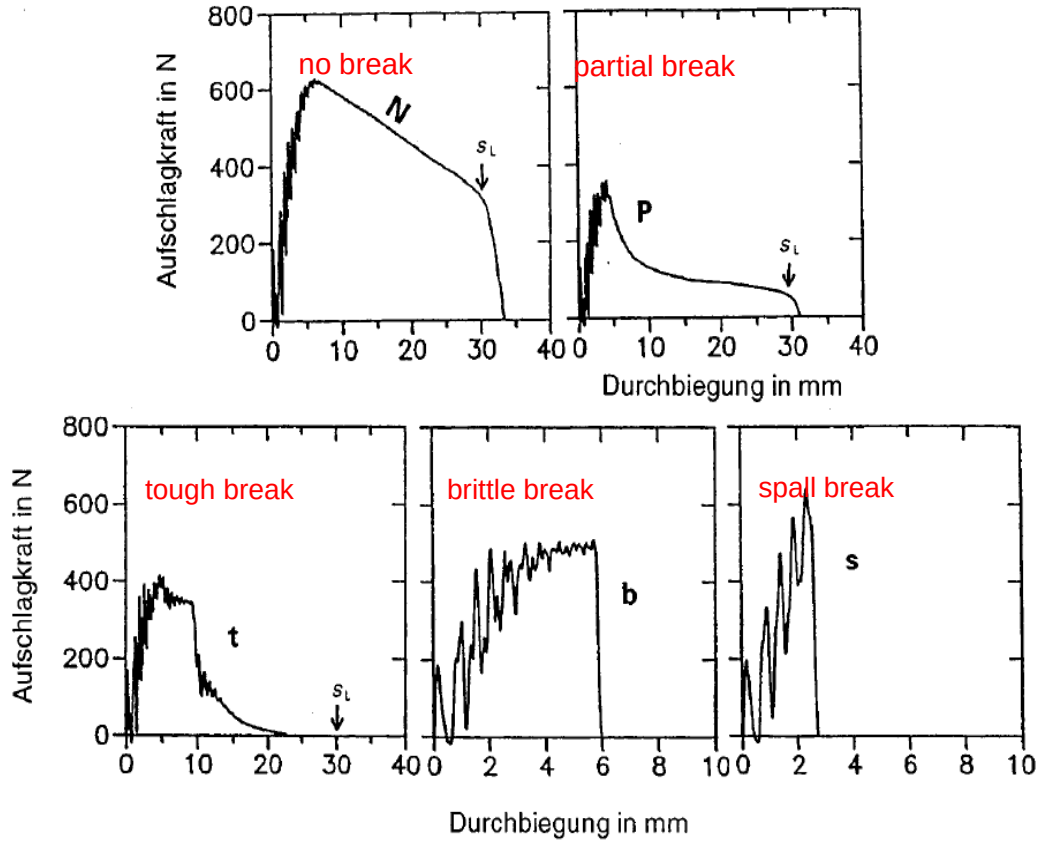
Pendulum Impact - Tests and Curves

The curve directly after break shows the resonance frequency of the measurement system. No measurement beyond this frequency is possible.



Pendulum Impact - Tests and Curves

Zwick developed an automatic recognition of test curve types according to ISO 179 part 2 in collaboration with Borealis.



Hinge break

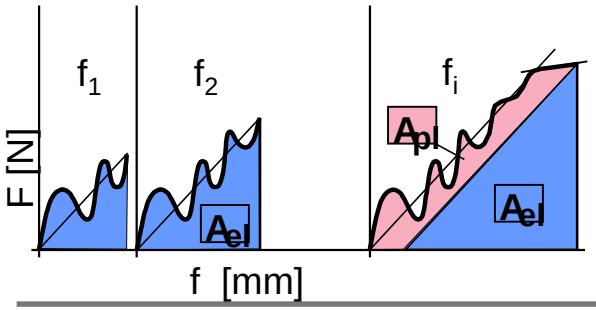
Complete break types

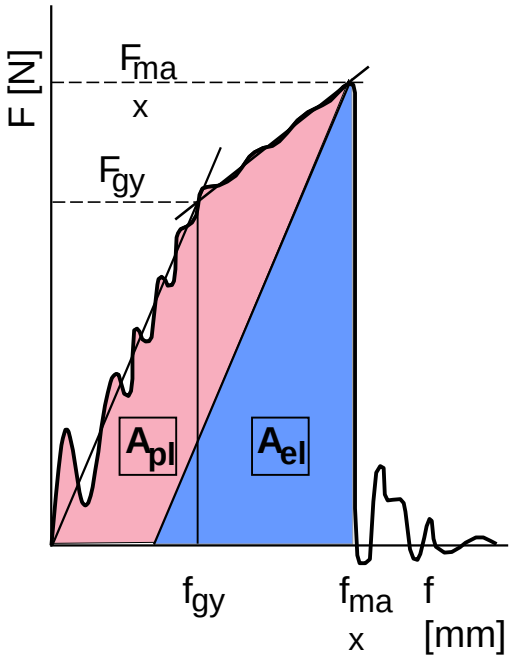
- Type of break can be identified by instrumentation
- Automatic classification of the statistics by the type of break
- Safe and reliable test results are obtained even with many operators and in night shifts
- Problems in test setup and specimen handling become visible and thus also traceable.

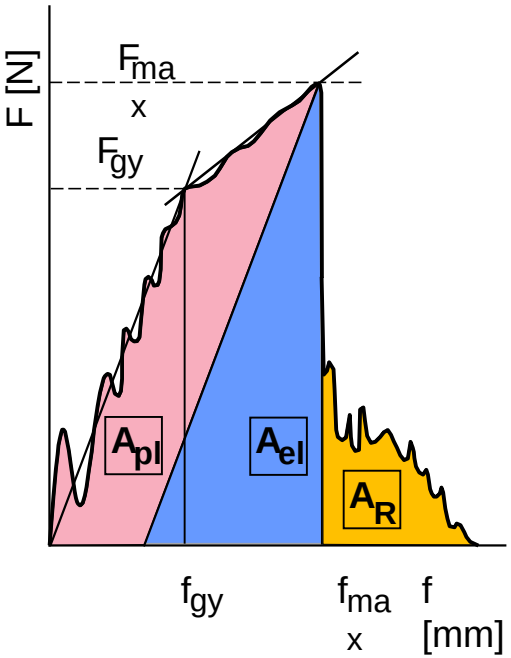
Pendulum Impact - Tests and Curves

Fracture mechanic data can be obtained by using instrumented impact and a stop-bloc.

- Pre-cracked specimen are submitted to impact in Charpy configuration
- The impact is stopped at a given deflection
- Under condition of stable crack growth, the crack can be stopped and its length measured.
- The result are R-curves.







Elastic materials behavior without and including crack propagation energy

Agenda

Instrumented Pendulum Impact Testing

Instrumented Drop-Weight Tester

High Speed Testing Machine

Instrumented Drop-Weight Testers

Zwick / Roell

The products range from single purpose instruments to universal drop weight testers, covering materials characterization and parts testing.

HIT230F Multiaxial

H= 2600mm
Mass $_{Min}$= 23.5kg
V1= 4.40m/s
E= 230J

HIT230F CAI

H= 2600mm
Mass $_{Min}$= 2.02kg
Mass $_{Max}$= 10.08kg
V1= 4.40m/s
E= 120J

HIT600F CAI

H= 3150mm
Mass $_{Min}$= 2.04 kg
Mass $_{Max}$= 10.03kg
V_1= 5m/s
E= 125J

HIT600F Multiaxial

H= 3150mm
Mass $_{Min}$= 4.43kg
Mass $_{Max}$ = 40.43kg
V_1= 5m/s
V_2= 8.15m/s @ 4.43kg
E= 647J

HIT1100F

H= 3270mm
Mass $_{Min}$= 9.27kg
Mass $_{Max}$= 29.42kg
V_1= 4.4m/s
V_2= 14.1m/s @ 9.27kg
E= 1126J

HIT2000F

H= 3870mm
Mass $_{Min}$= 9.27kg
Mass $_{Max}$= 29.42kg
V_1= 5.42m/s
V_2= 19.4m/s @ 9.27kg
E= 2044J

Remark: H=Machine Height, V_1= Max Velocity without acc, V_2= Max Velocity with acc, E= Max Energy

Amsler HIT230F

The small instrumented drop weight tester for multiaxial impact and CAI.

MULTIAXIAL IMPACT

23.5 kg

4.4 m/s

230 J

CAI

2.0…
10.08 kg

4.4 m/s

120 J

ERGONOMICS & EFFICIENCY

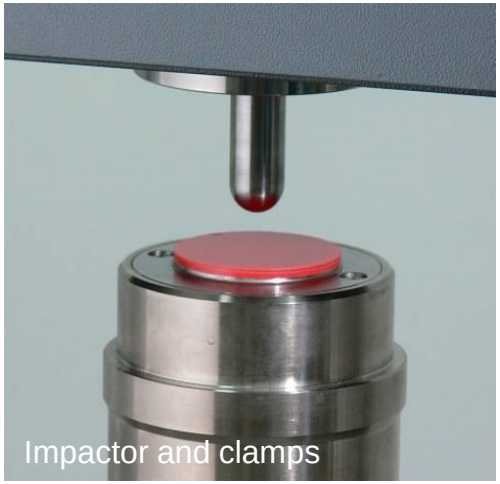
- Excellent test area accessibility
- Easy manual feed of cooled specimens
- Automatic series mode in testXpert III allows testing with no operator intervention between individual specimens

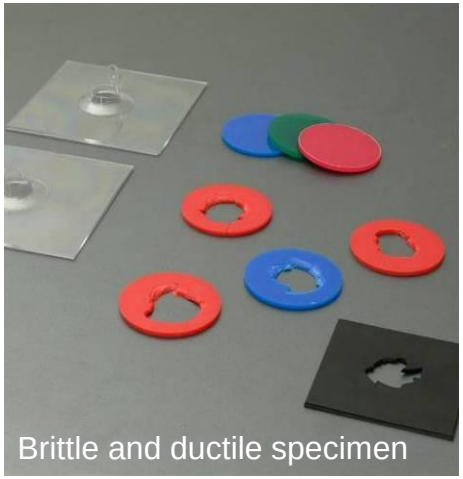
Instrumented Drop-Weight Testers, HIT230F

The Amsler HIT230F are single purpose drop-weight testers.

Purpose: Multiaxial impact tests

- Standards: ISO 6603-2, ASTM D 3763
- Puncture test at a speed up to 4,4 m/s
- Spherical impactor, diam. 20 mm or 10 mm
- Design of clamps as fixed by the standards
- Fast and easy operation for pre-cooled specimen


Impactor and clamps


Brittle and ductile specimen

Amsler HIT230F in multiaxial impact configuration

Instrumented Drop-Weight Testers, HIT230F

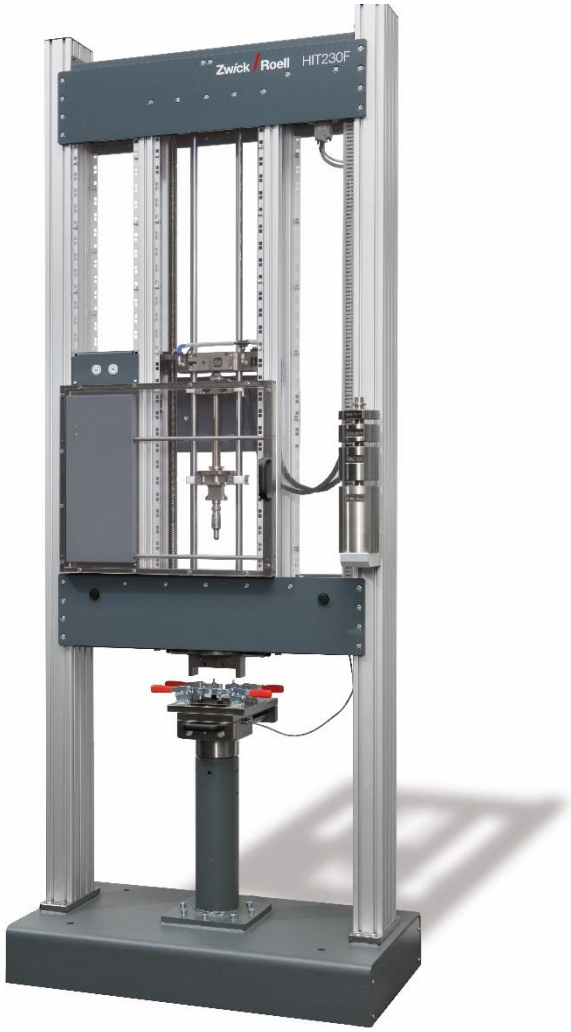
The Amsler HIT230F are single purpose drop-weight testers.

Purpose: Specimen pre-damaging for CAI

- Standards: ISO 18352, ASTM D 7136, DIN 65561, AITM 1,0010, BSS 7260 type II, ..
- Drop height up to 1 m
- 16 mm diameter instrumented striker
- Modular weight set
- Second impact prevention
- Design of clamps fixed by the standards

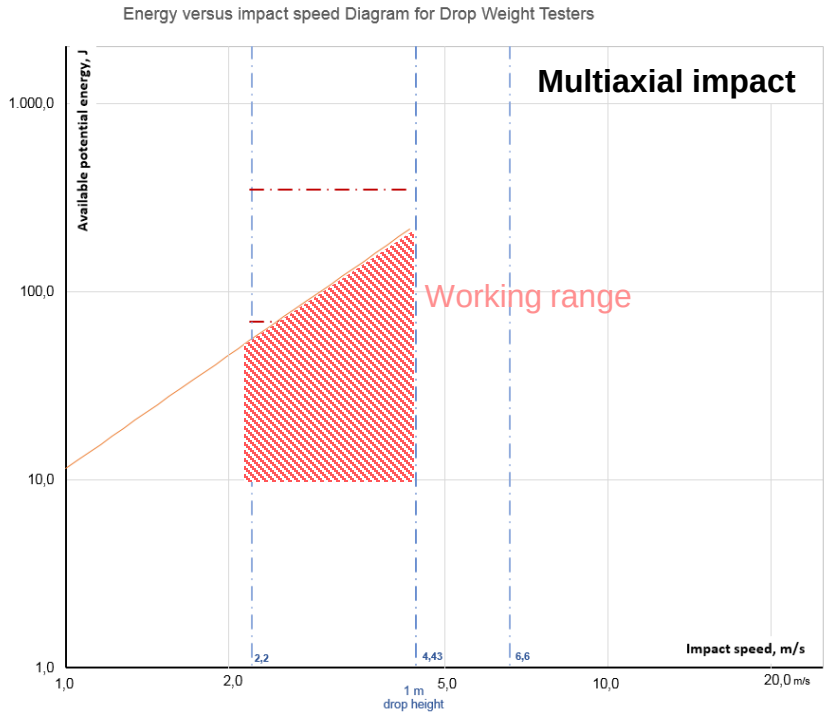
CAI specimen holder

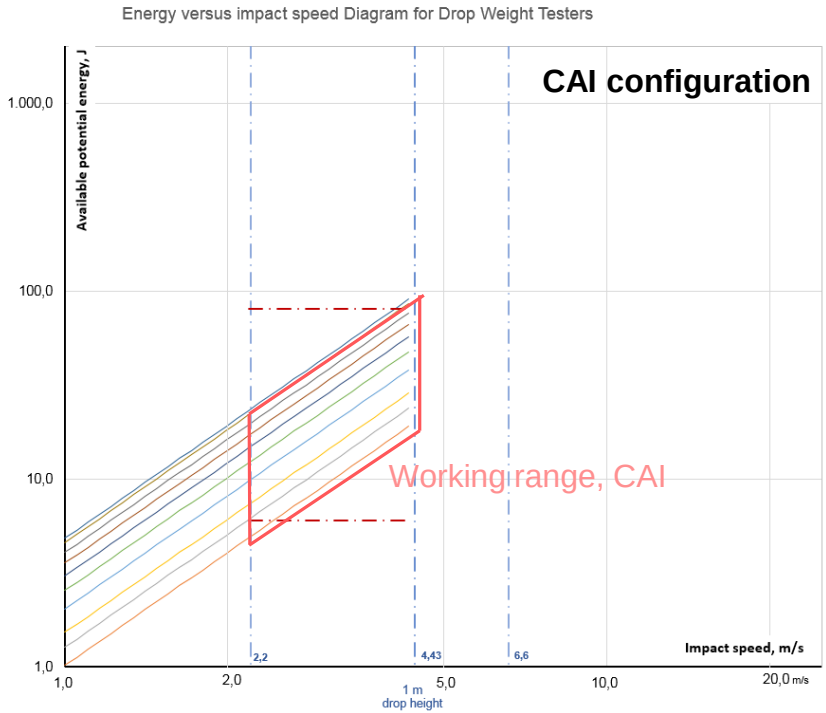
Weight change



Instrumented Drop-Weight Testers, HIT230F

The Energy/Speed diagram shows the characteristics of the HIT230F and its working ranges.





HIT230F in multiaxial impact configuration

This instrument is optimized for the typical speed point of 4.43 m/s used in ISO 6603-2. The available energy at this point is 230 Joule.

HIT230F in CAI configuration

The work range covers the needed low energy range from less than 10J@2.2 m/s up to over 100J@1 m drop height. (4.43 m/s)

Amsler HIT600F

The universal drop weight tester for materials testing.

MULTIAXIAL IMPACT – CAI – CHARPY – IZOD

2.04…
40.43 kg

8.15 m/s
@ 4.43 kg

5.7 m/s
@ 40 kg

647 J

ERGONOMICS & EFFICIENCY

- Excellent test area accessibility
- Easy manual feed of cooled specimens
- Automatic series mode in testXpert III allows testing with no operator intervention between individual specimens

FLEXIBILITY

- Modular design
  - Multiaxial impact on platens and films
  - Charpy, IZOD
  - CAI
- Coverage of automotive standards
  - Small impact velocity of 2.2 m/s with high masses
  - High impact velocity of 6.6 m/s with acceleration

Instrumented Drop-Weight Testers, HIT600F

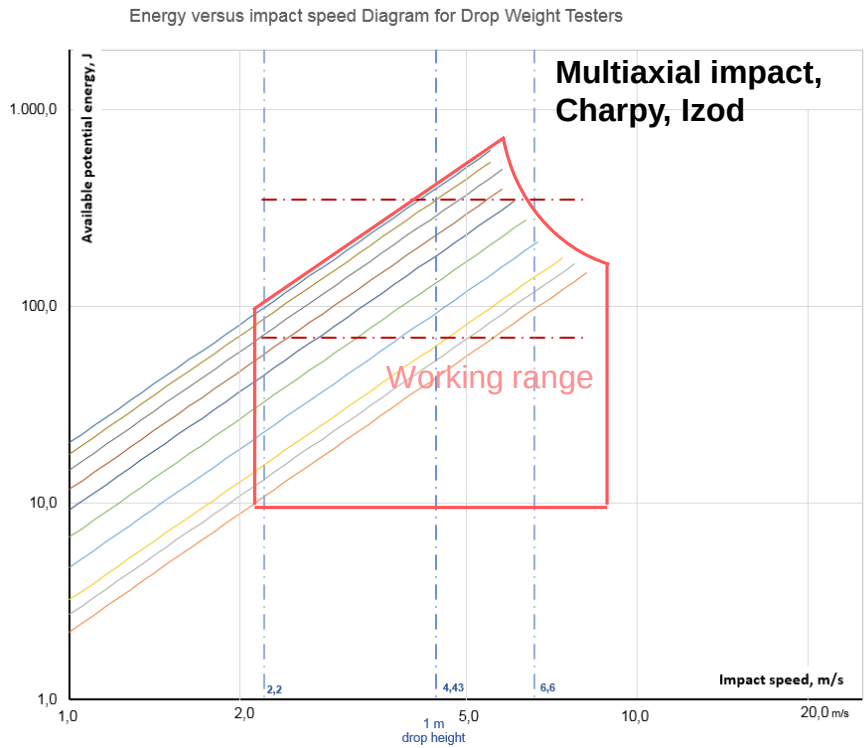
Zwick Roell

The Amsler HIT600F is a universal drop-weight tester for materials testing, covering many standards and methods.

- Multiaxial impact tests to ISO and ASTM standards at 1 m drop height (4.43 m/s)
- Multiaxial impact to automotive specifications at low speed of 2.2 m/s
- Multiaxial impact to automotive specifications at higher speed of 6.6 m/s
- Multiaxial impact for research purposes at up to 8 m/s
- Multiaxial impact testing with pre-cooled specimen
- Multiaxial impact tests for plastic film, ISO 7765-2
- Instrumented Charpy and Izod tests
- CAI tests at variable and low impact work including second impact prevention

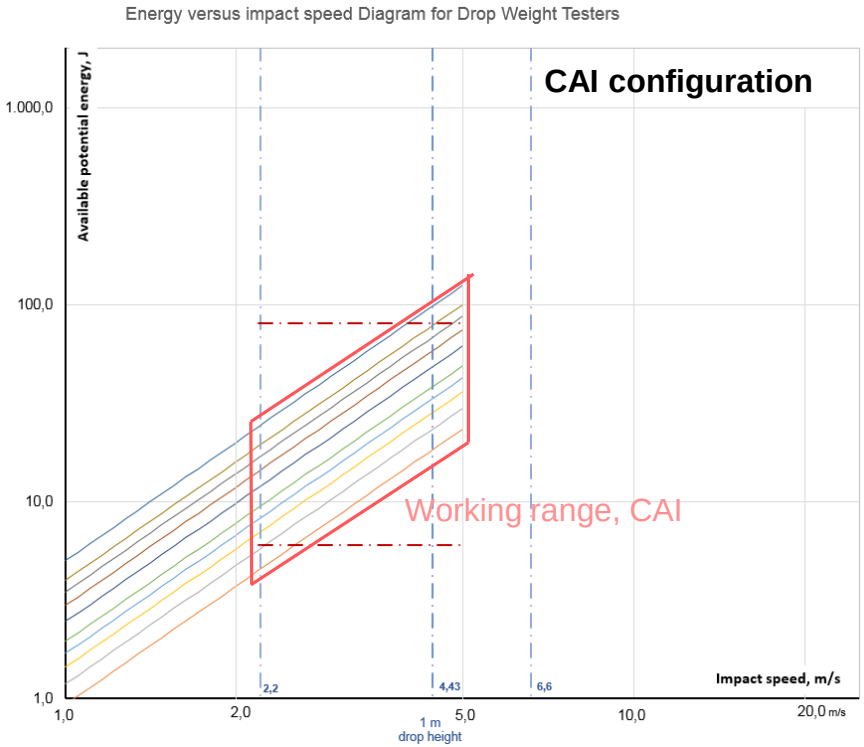
Instrumented Drop-Weight Testers, HIT600F

The HIT600F provides a large working range covering different test methods and automotive specifications.



HIT600F in multiaxial impact configuration

The working range covers the whole speed range from 2.2 m/s to 8.1 m/s with a maximum available potential energy of more than 600 J.



HIT600F in CAI configuration

The work range covers the needed low energy range from less than 10J@2.2 m/s up to over 125J@5 m/s

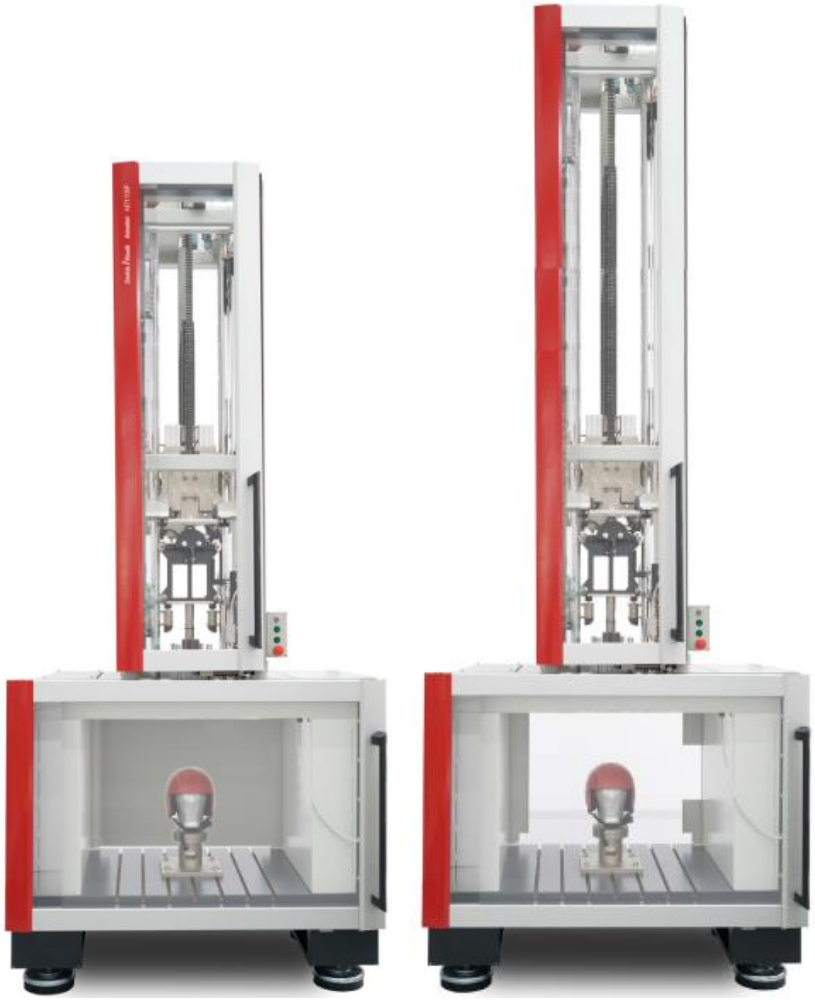
Amsler HIT1100F and HIT2000F

Combination of component testing and materials testing

COMPONENTS - MULTIAXIAL IMPACT – CHARPY – IZOD	
	9.3…29.4 kg
	14.1/19.4 m/s @ 9.3 kg
	8.75/11.8 m/s @ 29.4 kg
	1126 J / 2044 J

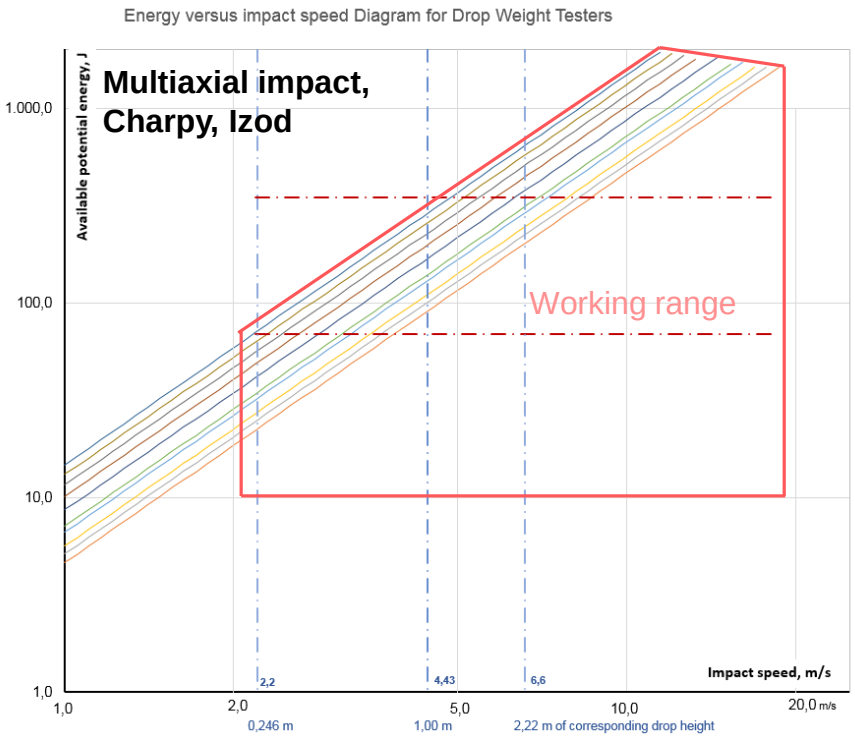
FLEXIBILITY

- T-slotted mounting platform allow flexible attachment of various test arrangements
- Optional temperature chamber
- Component and materials testing
  - Sturdy guides
  - Tools for multiaxial impact, Charpy and IZOD



Instrumented Drop-Weight Testers,

Amsler HIT1100F and HIT2000F procure the largest working range in terms of test speed and available impact energy.



HIT1100F - high energy at moderate machine height

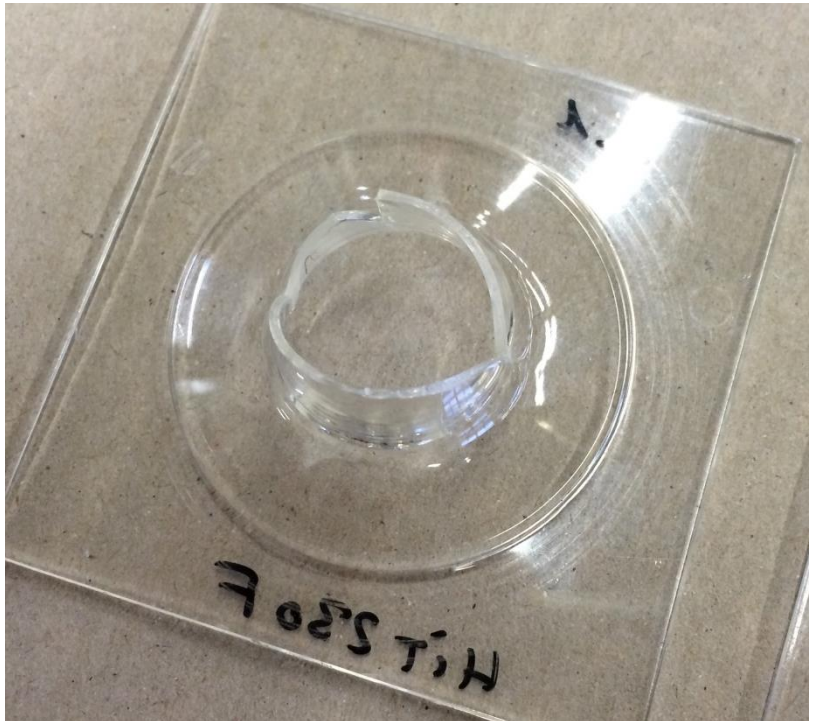
The working range covers a large speed range from 2.2 m/s to 14 m/s with a maximum available potential energy of more than 1100 J.

HIT2000F – The largest working range

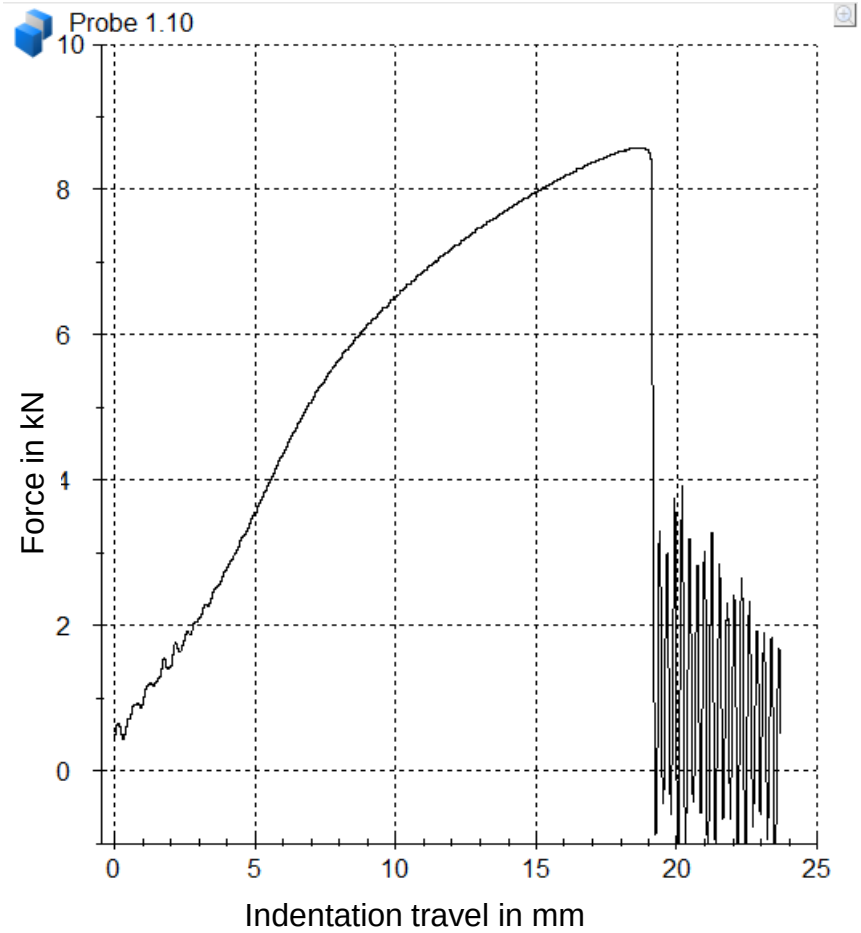
This instrument offers the largest working range covering speed from 2.2 m/s to 19 m/s with a maximum available energy of more than 2000 J.

Instrumented drop-weight

Ductile materials show less oscillations in the diagram, but the indenter needs to be greased to avoid excessive friction .

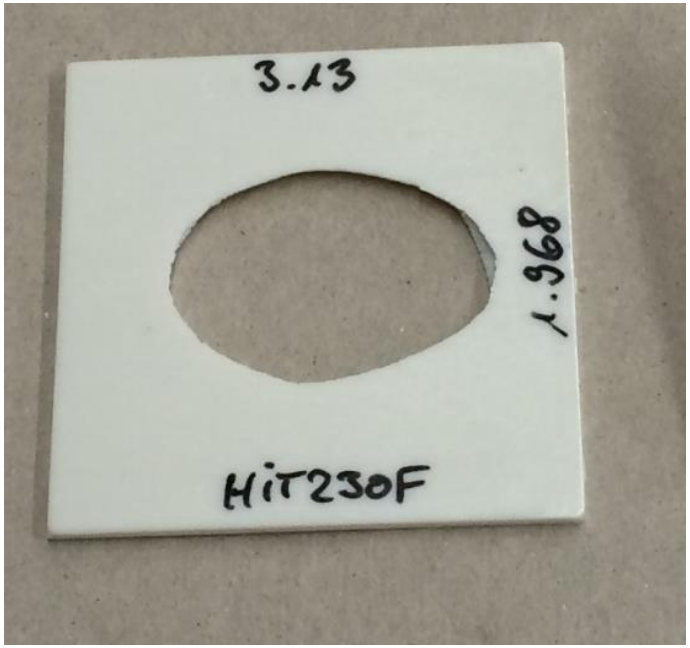


Ductile PC specimen of 2 mm thickness tested in multiaxial impact

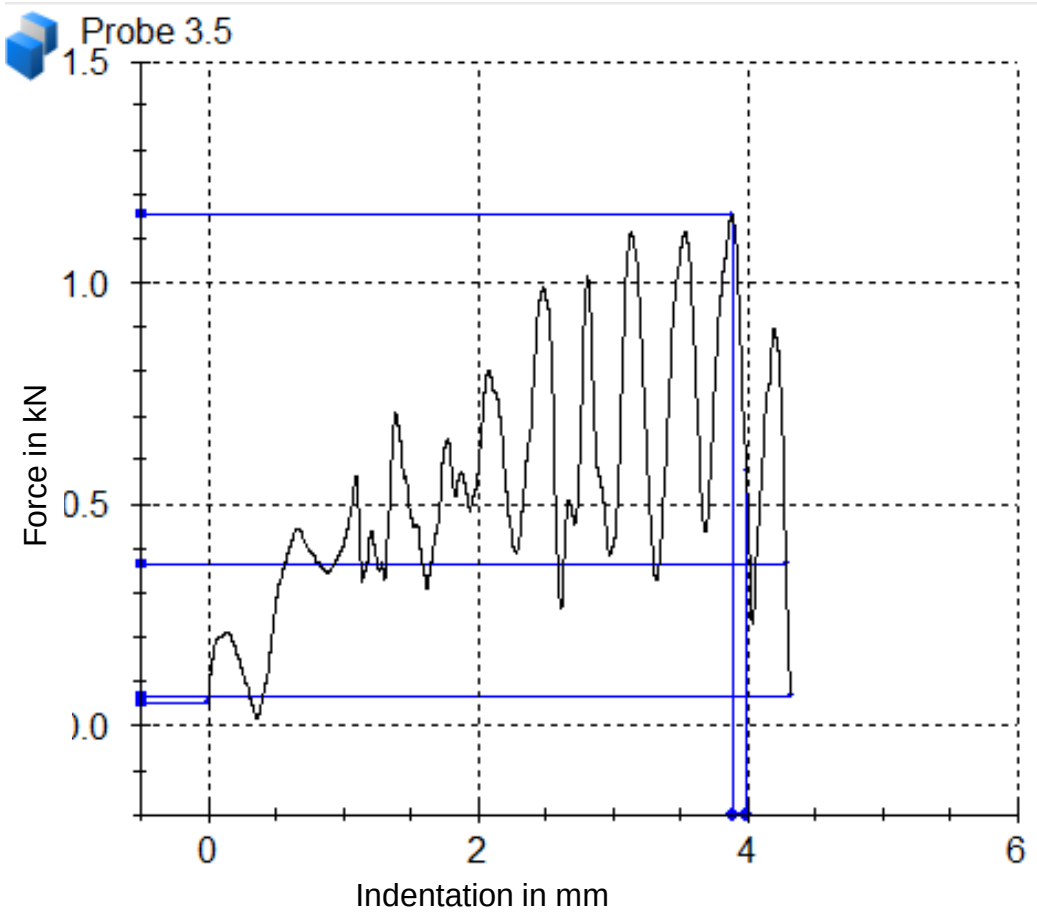


Instrumented drop-weight

When measuring brittle specimen, the frequency of the measurement system is visible as the test time is very short.



Brittle PBT GF specimen tested in multiaxial impact

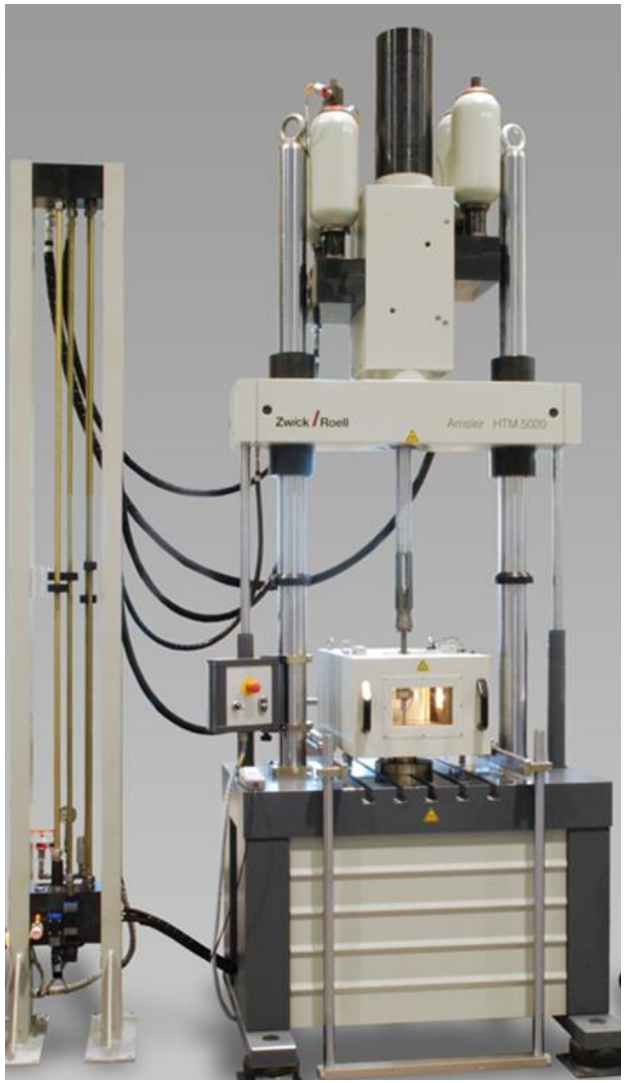


Agenda

Instrumented Pendulum Impact Testing

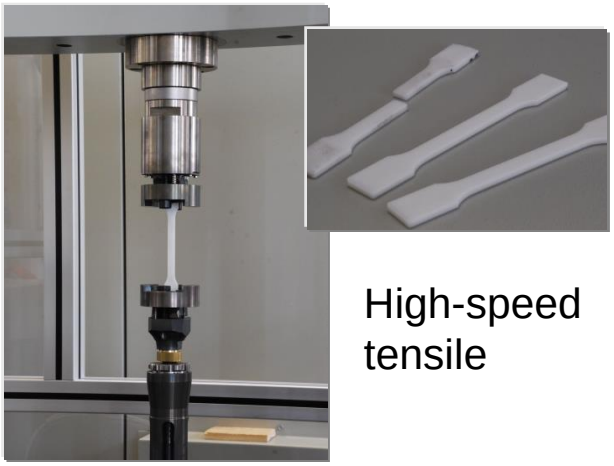
Instrumented Drop-Weight Tester

High Speed Testing Machine

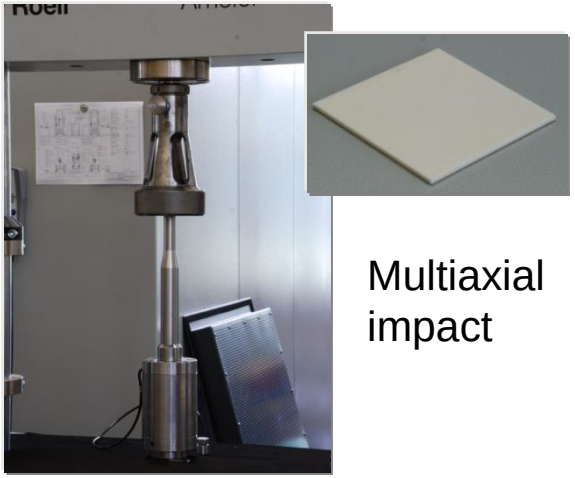


High speed Testing Machines, HTM

High Speed Testing Machines can be used for tensile tests and high strain rates as well as for multiaxial impact.



High-speed tensile

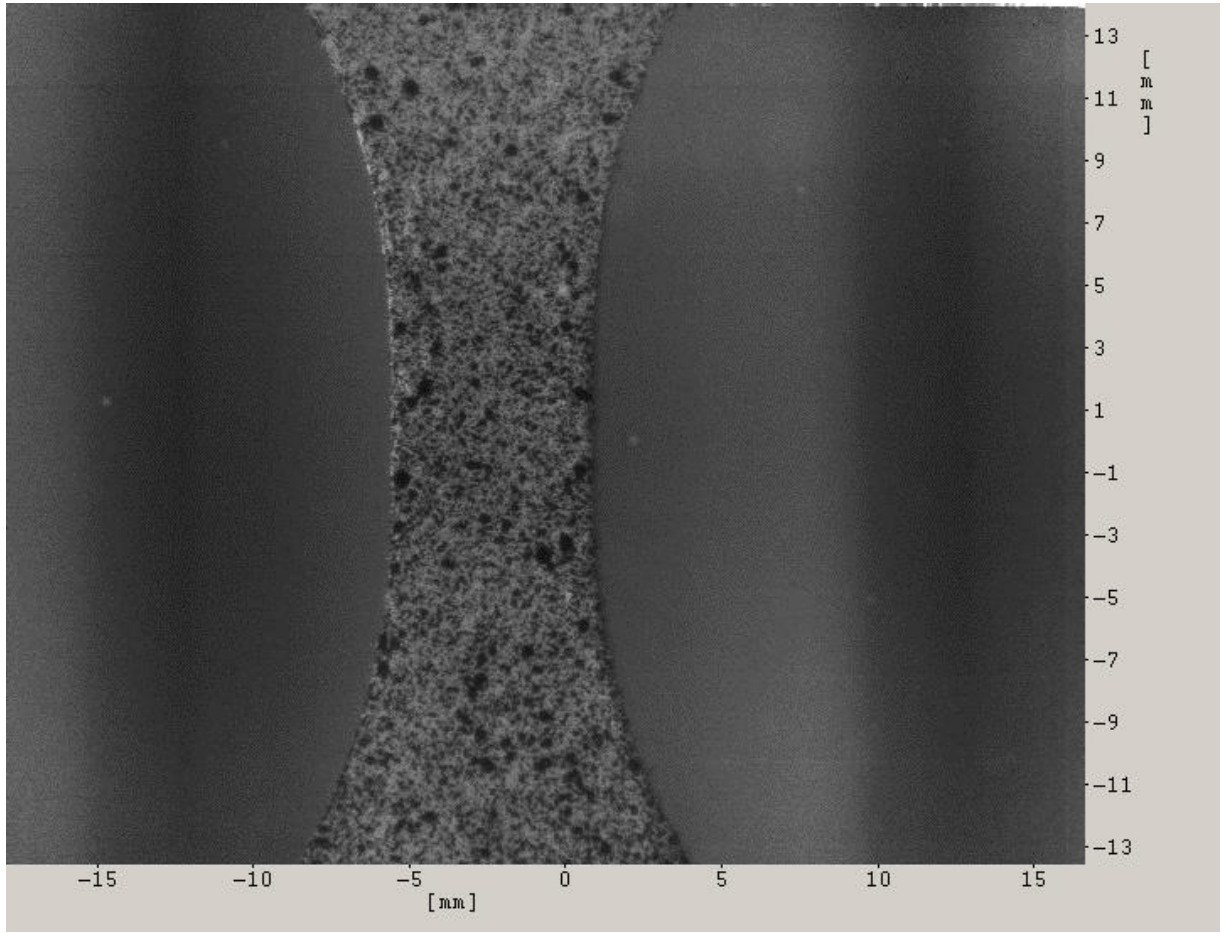


Multiaxial impact

High speed Testing Machines, HTM

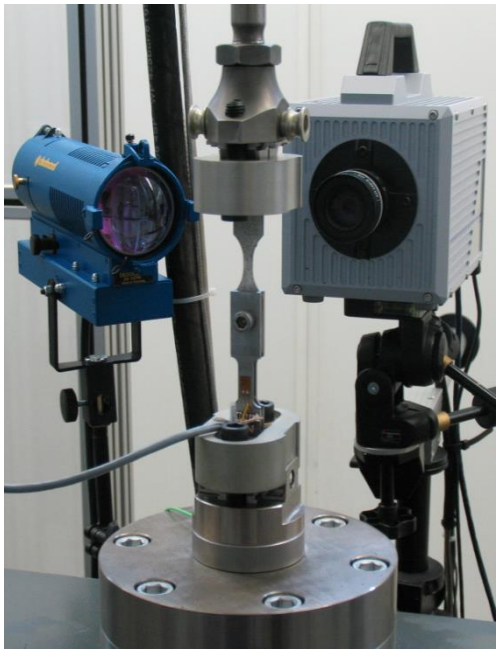
Impressive things happen during a high speed tensile test.

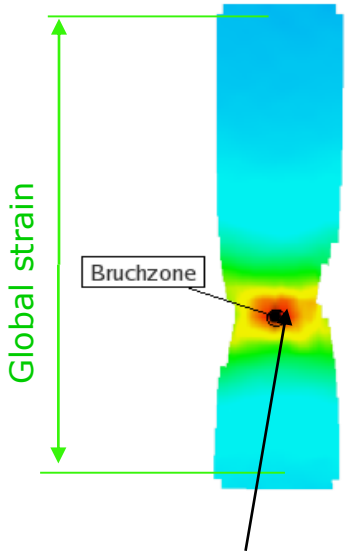
- HTM testing machine
- High-Speed camera
- Test speed: 7 m/s
- Material:
  Pocan 3235 coated



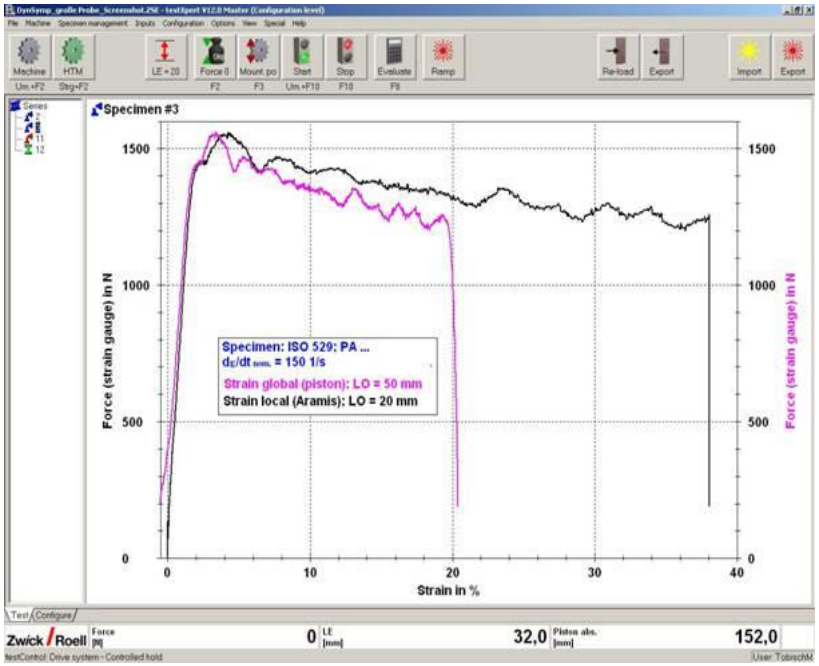
High speed Testing Machines, HTM

HTM-machines have an integrated interface for high-speed cameras allowing measurement of local strain.





Local strain



gom Optical Measuring Techniques

Difference between global und local strain measurement

High speed Testing Machines, HTM

Robotized specimen feeding for multiaxial impact tests with an HTM machine.

Thank you for your attention !