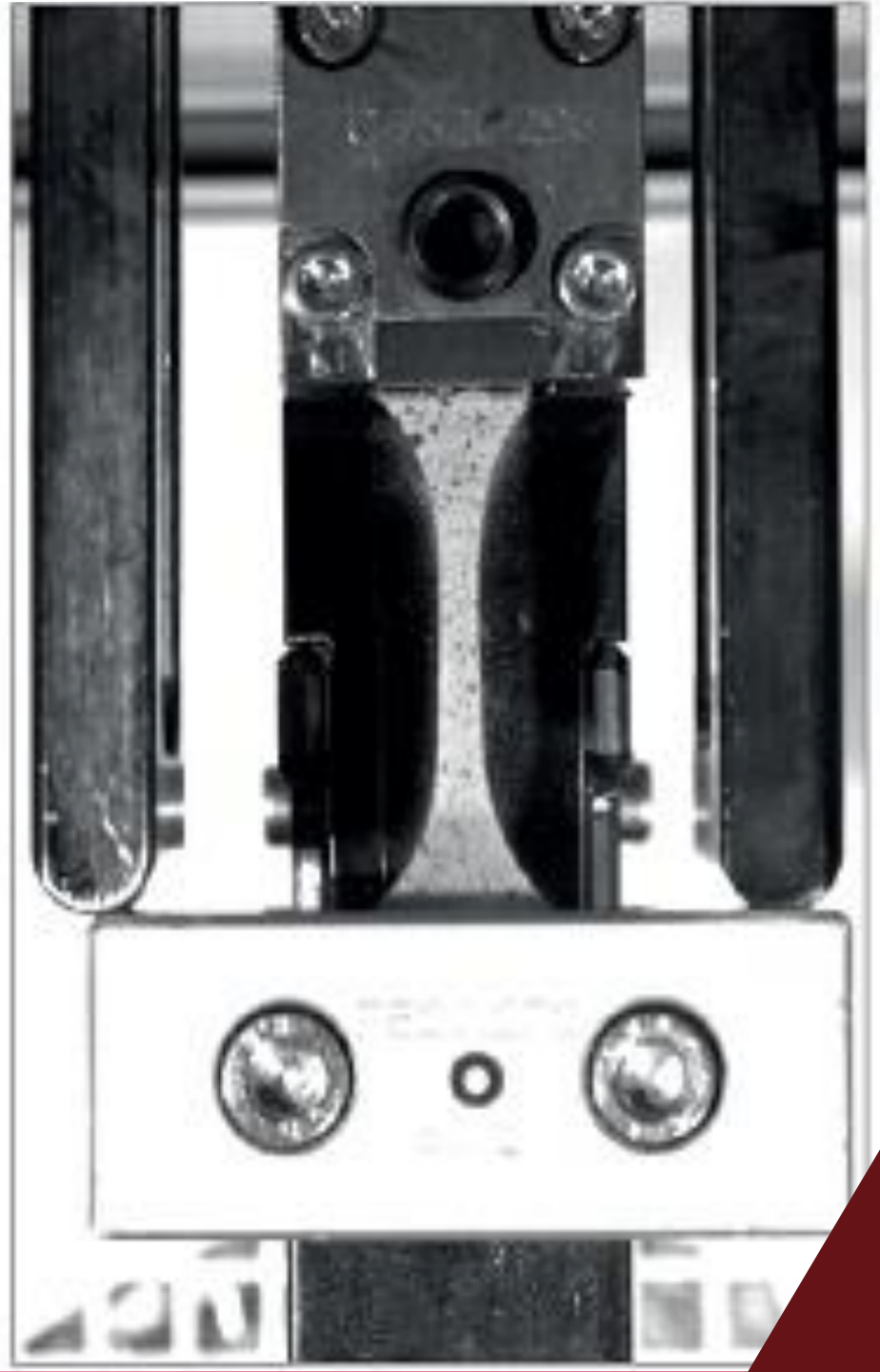


CSMT

Prova di impatto-trazione sui materiali polimerici con torre a caduta di grave: Recenti sviluppi strumentali

March 14th, 2023

INSTRON®

ITW

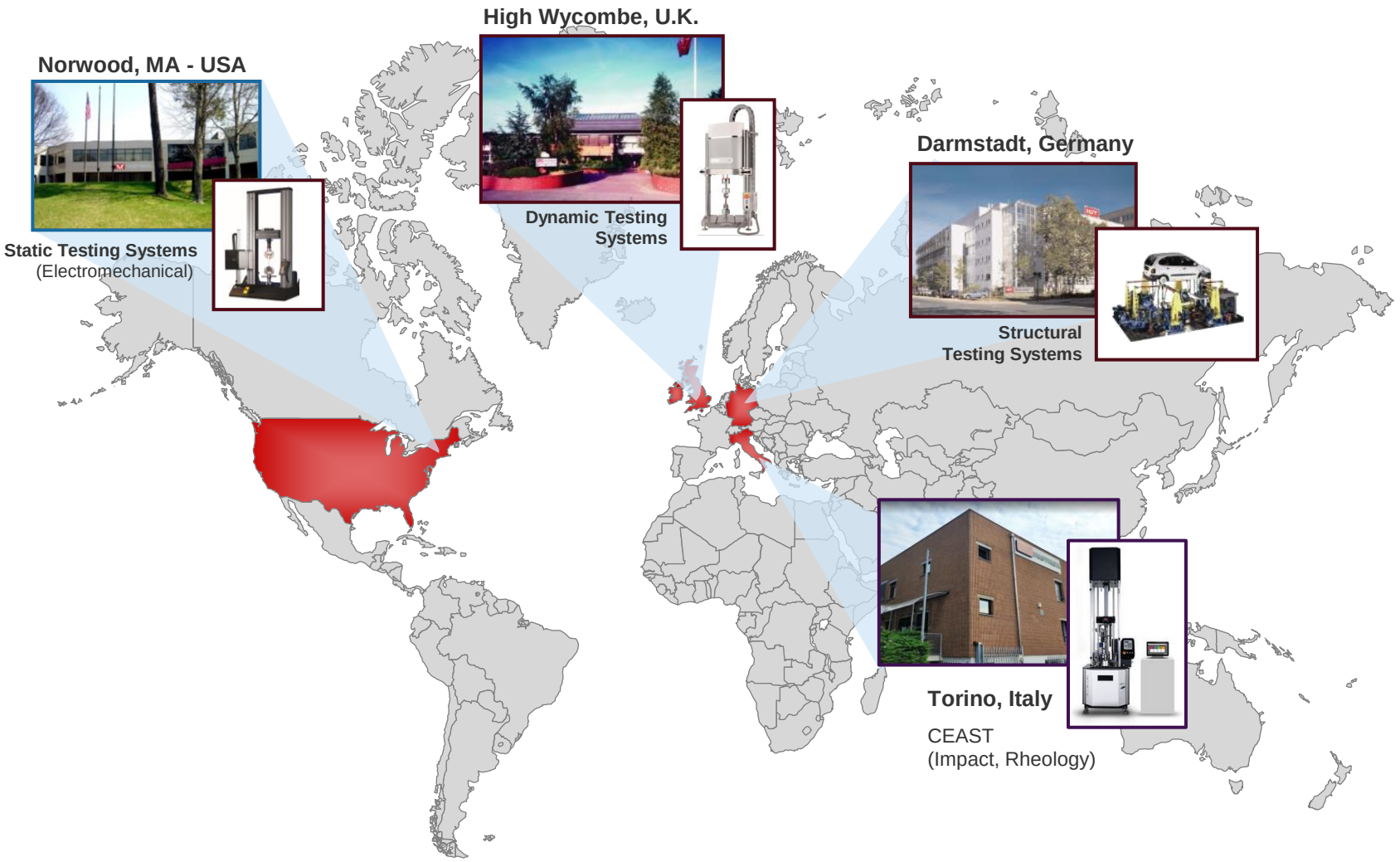
Agenda seminario

Proprietà dei materiali e trasferibilità da provino a manufatto: metodi, strumenti, successi nella caratterizzazione dei materiali polimerici

Prova di impatto-trazione sui materiali polimerici con torre a caduta di grave: Recenti sviluppi strumentali – A. Incardona e A. Calzolari

- INSTRON
- DROP TOWER
- TENSILE IMPACT
- HIGH SPEED CAMERA
- DIC ANALYSIS

Instron



INSTRON/CEAST GROUP

- Instron® was founded in1946 – material testing market leader
- CEAST (Italy) founded in 1953. In 2008 was acquired from INSTRON (*ITW Test and Measurement Division*)

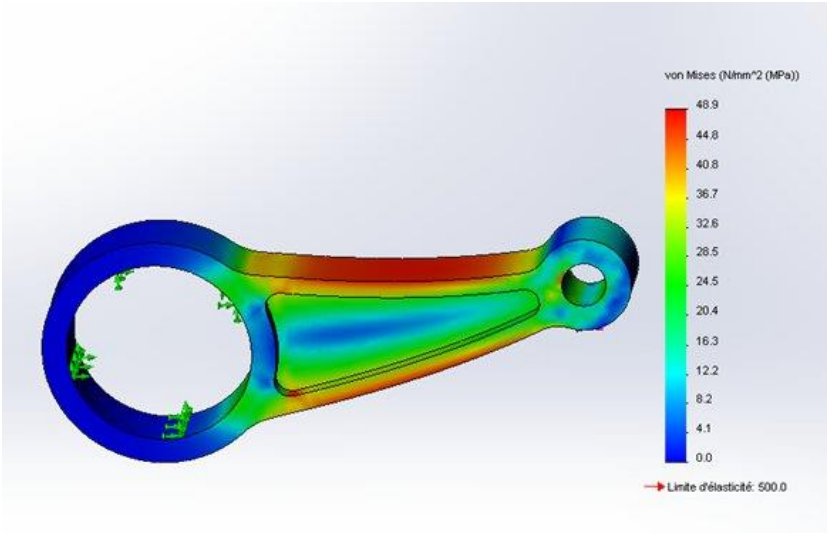
Why Impact Test?

Computer Aided Engineering (CAE)

Disagreement between simulation and test results has been pointed out for drop and impact evaluations

A wide variety of polymeric materials involved in the product development have a sensitivity to strain rate.

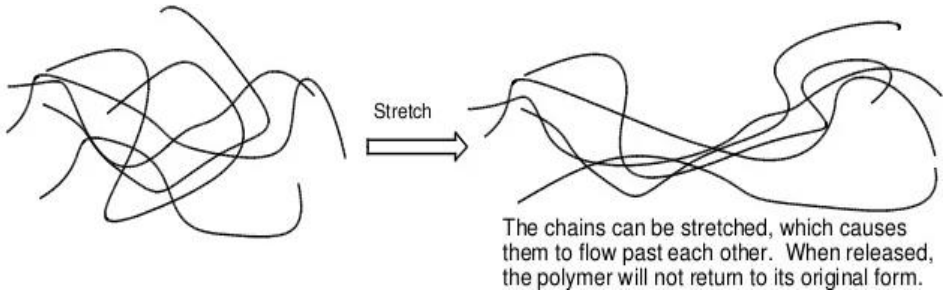
Quasi-static tensile tests are not enough to obtain the mechanical properties used for the CAE analysis



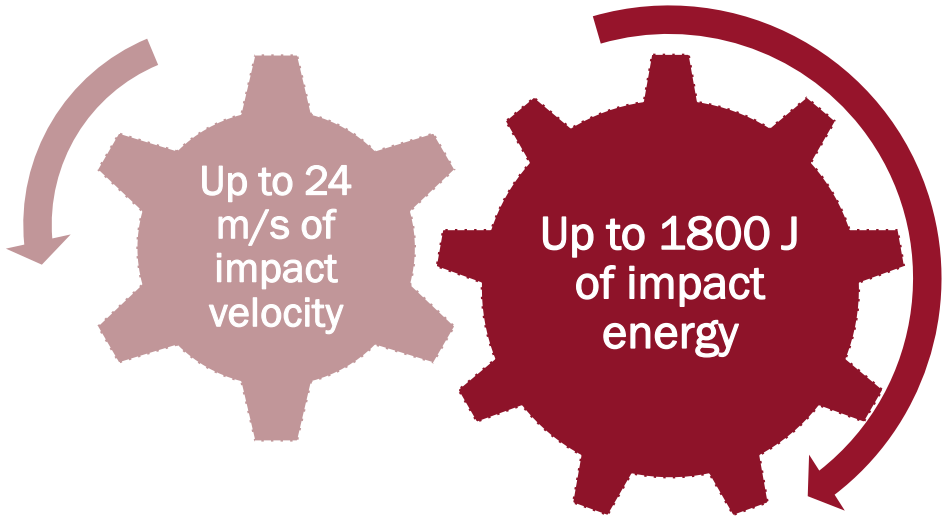
To make an evaluation of the mechanical properties at different strain rates is needed to:

- Perform a tensile-impact test at a moderate-high or high velocities;
- Disclose all the effects that affects the Force acquisition;
- Understand how strain and strain rate is distributed throughout specimens

$$\sigma = E \cdot \varepsilon + \eta \cdot \dot{\varepsilon}$$

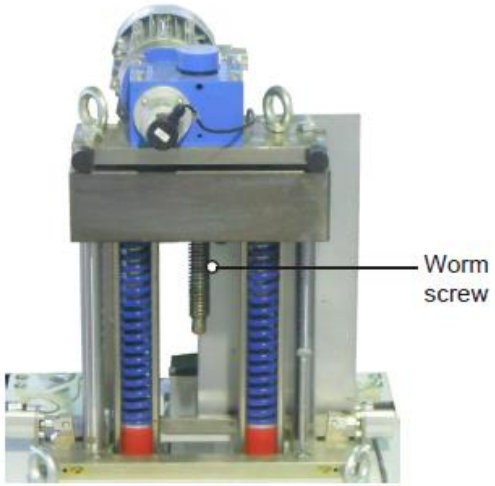


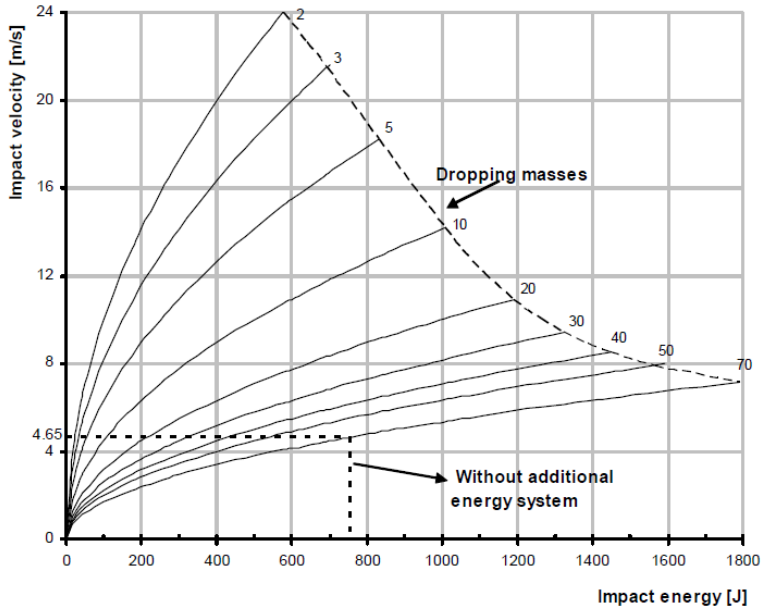
The Tool: INSTRON 9450 Drop Tower



	9450	9450 High Energy
Energy Range	0,59 – 757 J	0,59 – 1800 J
Impact velocity	0,77 - 4,65 m/s	0,77 - 24,0 m/s
Drop Height	0,03 - 1,10 m	0,03 - 29,4* m
Mass Range	2,00 - 70,0 kg	2,00 - 70,0 kg
Mass increments	0,5 kg	0,5 kg

The Tool: INSTRON 9450 Drop Tower





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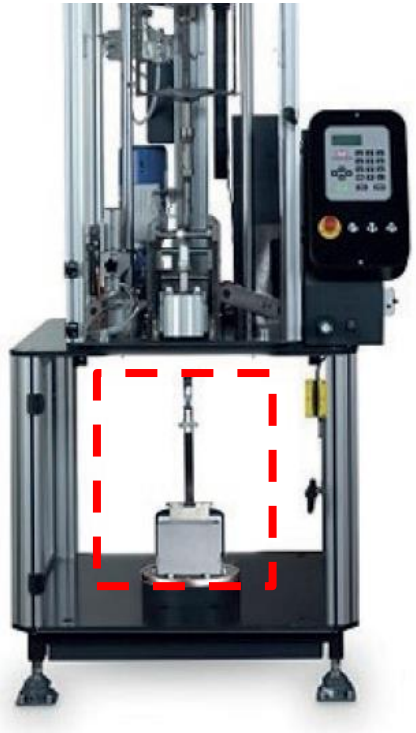
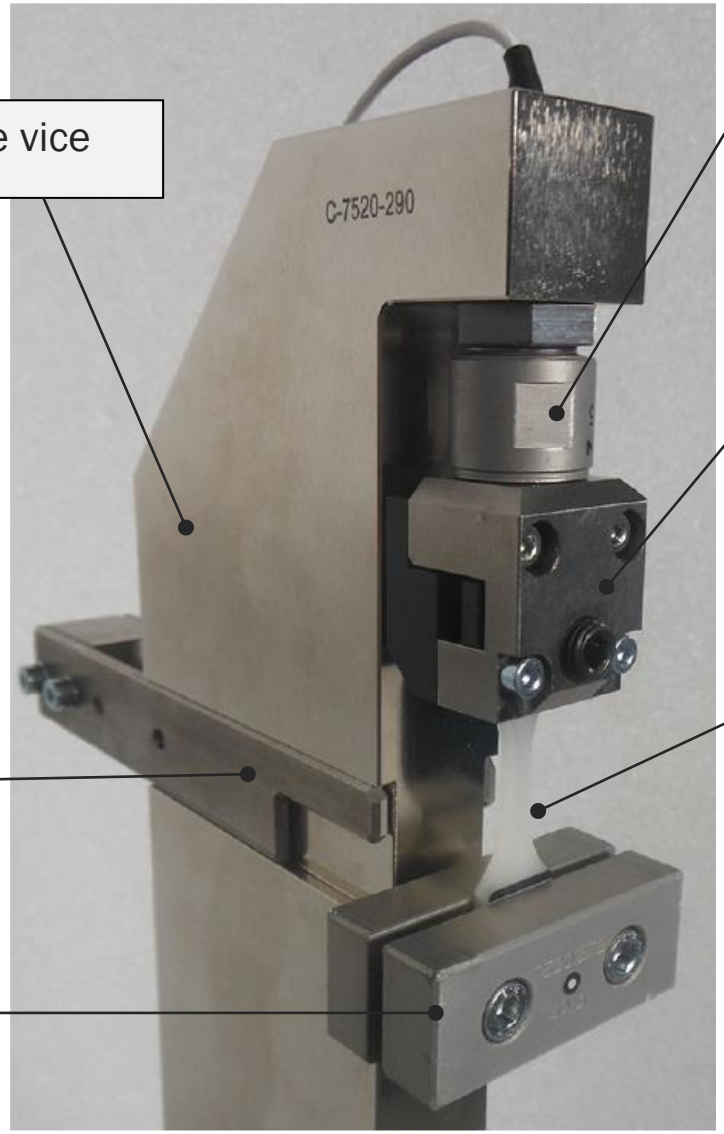
The Tensile Impact Test

The specific setup for the tensile-impact test involves:

A Tensile Impact Vice, with:

- A piezoelectric load cell (up to 2.2 kN) or a strain-gauge sensor (up to 30 kN);
- A screw grip with V-shaped jaw faces;
- A calibrated free tensile grip;





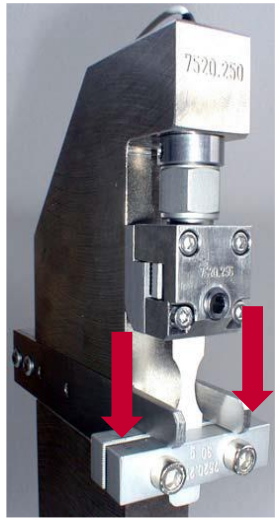
The Tensile Impact Test

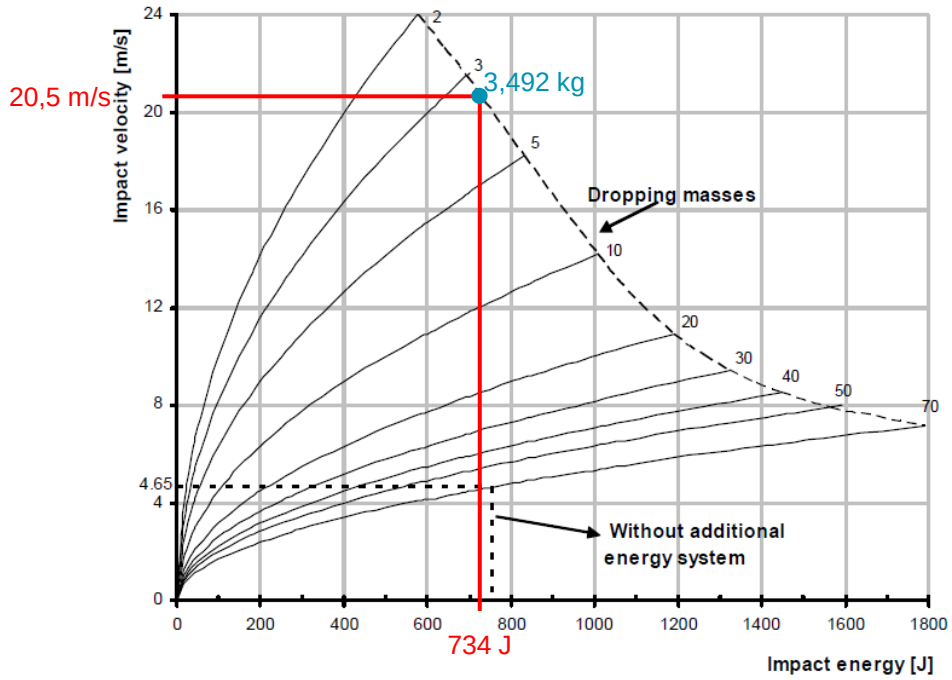
The specific setup for the tensile-impact test involves:

A dedicated striker for ISO 8256 method A

Light Tup holder: 1,3 kg

Striker for tensile impact: 2,192 kg





Total falling mass: 3,492 kg

Maximum Impact Energy: 734 J

Maximum Impact velocity: 20,5 m/s

The Tensile Impact Test

The specific setup for the tensile-impact test involves:

A Data Acquisition System

DAS (Data Acquisitio System)

- ✓ Max sampling frequency 4MHz, selectable
- ✓ Max N° points 64.000
- ✓ 4 channels of acquisition available
- ✓ Selectable Working Range 10-20-50-100%
- ✓ low noise: 0.04% of selected working range

The Tensile Impact Test

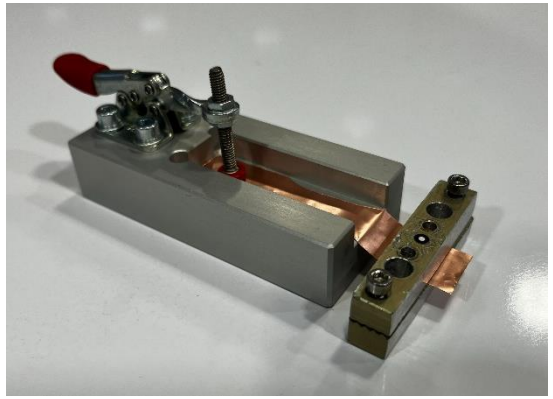
The specific setup for the tensile-impact test involves:

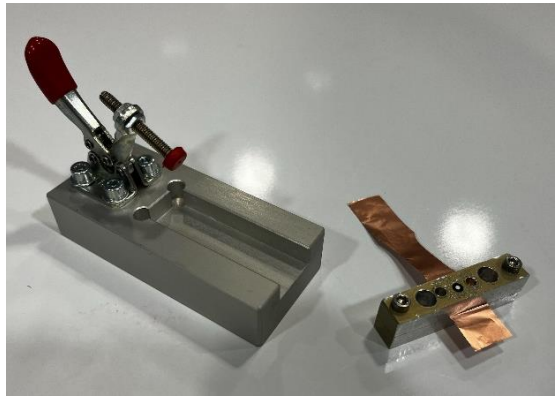
The BlueHill Impact Software

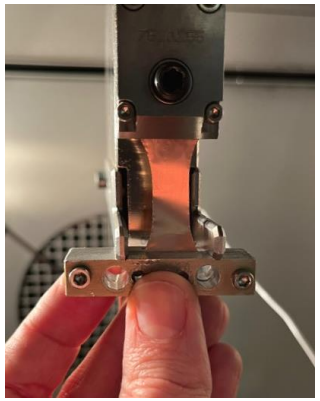
	Width [mm]	Thickness [mm]	Velocity at Start [m/s]	Velocity variation [m/s]	Slow down [%]	Force at Peak [N]	Energy at Peak [J]	Displacement at Total [mm]	Energy at Total [J]	Time at Total [µs]
1	3.15	3.04	0.97	0.06	6.4	840.869	0.627	7.754	5.313	8218.00000
2	3.15	3.04	0.97	0.07	6.8	839.042	0.657	7.660	5.393	8147.00000
3	3.15	3.04	0.97	0.06	6.5	828.901	0.610	7.616	5.281	8086.00000
Average	3.15	3.04	0.97	0.06	6.6	836.271	0.631	7.677	5.329	8150.33333
Std dev	0.00	0.00	0.00	0.00	0.18	6.45	0.02	0.07	0.06	66.06
Coefficient of variation	0.00	0.00	0.00	2.73	2.73	0.77	3.74	0.91	1.08	0.81
Maximum	3.15	3.04	0.97	0.07	6.8	840.869	0.657	7.754	5.393	8218.00000
Minimum	3.15	3.04	0.97	0.06	6.4	828.901	0.610	7.616	5.281	8086.00000

Drop Tower System: How to get valid datas

Repeatability:
To get repeatable results is very important to align properly the specimen and its free grip (crosshead) in the vice prior to impact. For this reason, the vice is equipped with an alignment plate. Use it to check carefully the specimen position.



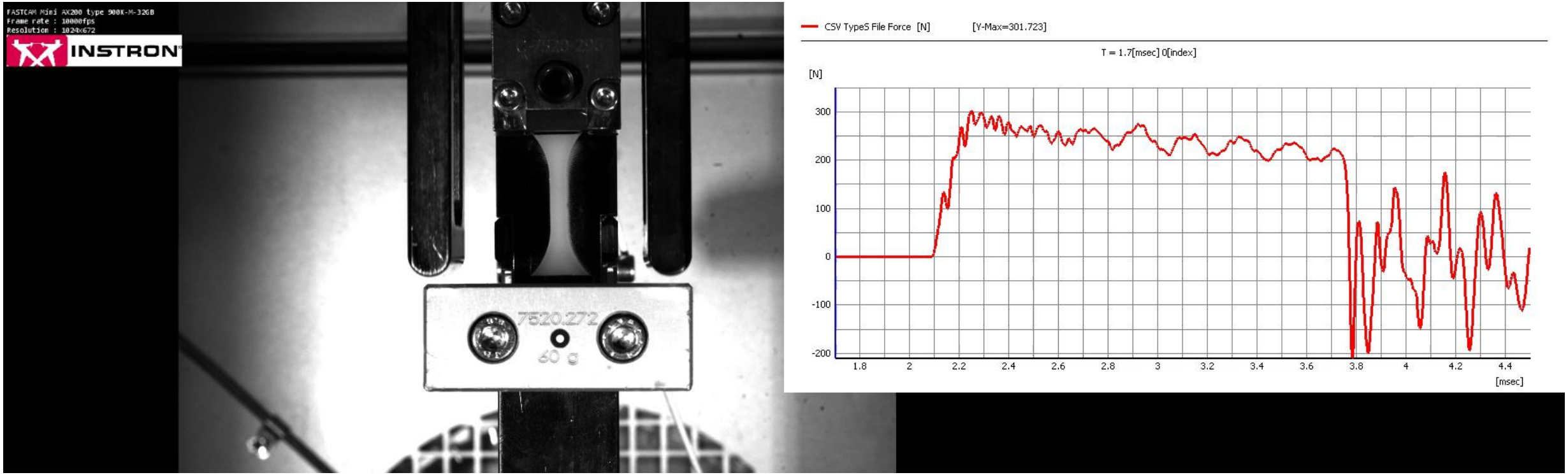




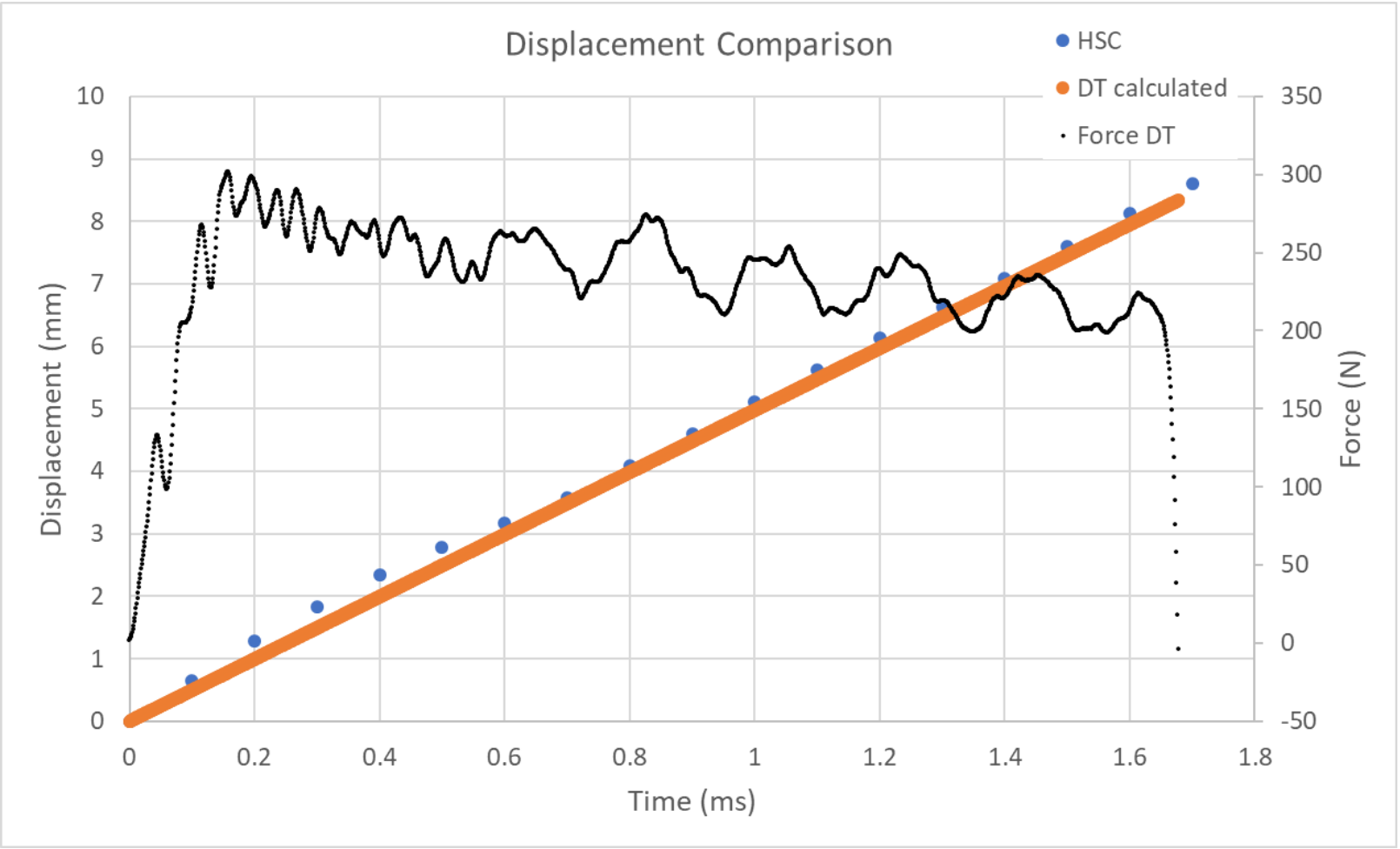
High Speed Camera:
The design of the new striker allows to combine the use of the Drop Tower system with High Speed Camera acquisition. The 9450 model has a dedicated trigger output for an easy synchronization of the video and the force signal.

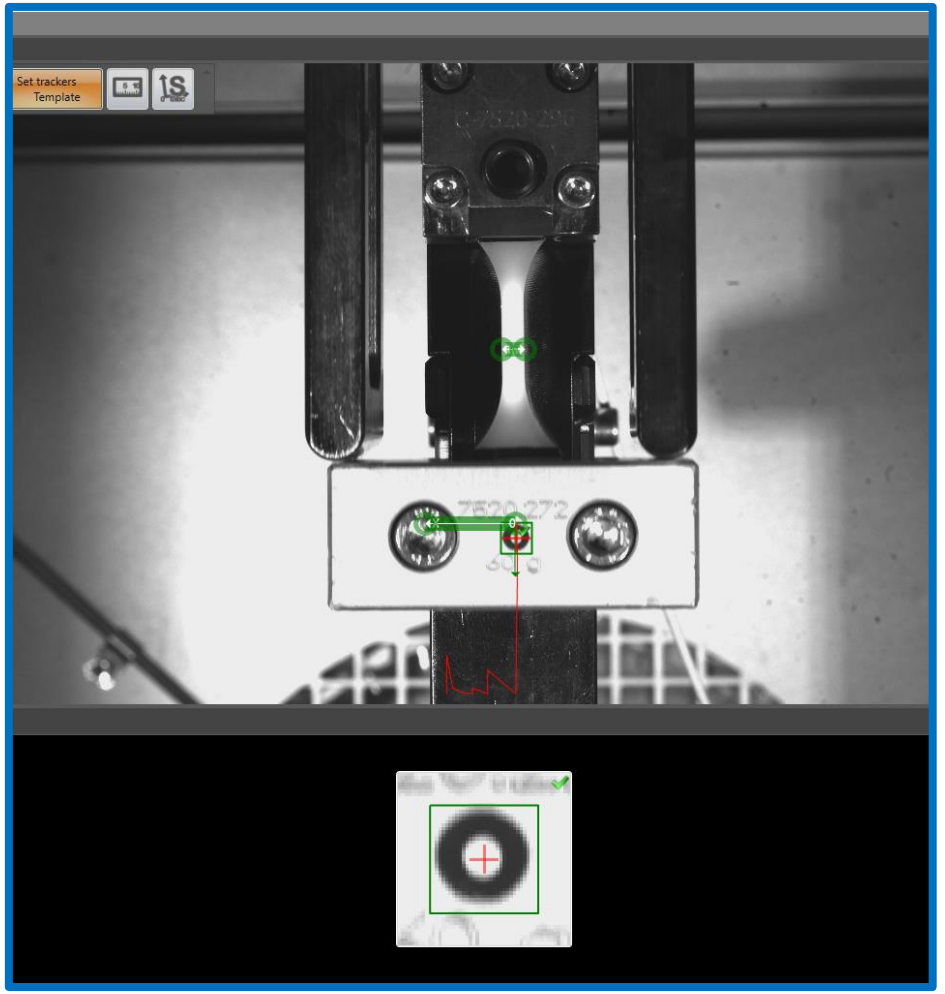
High Speed Camera

Full control of the failure mechanism of the material combining the results of the Force sensor with the images: PP material at 5 m/s

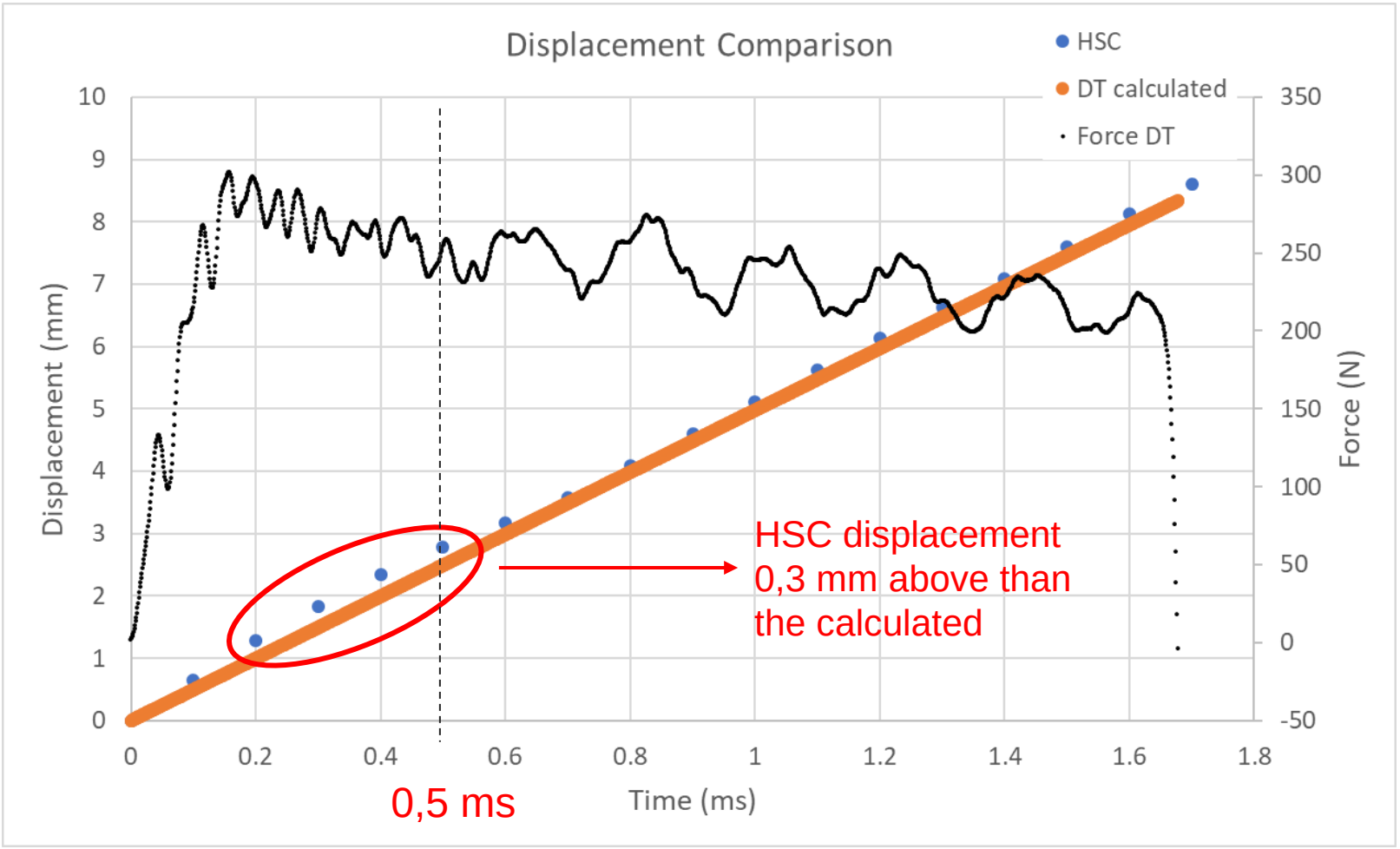


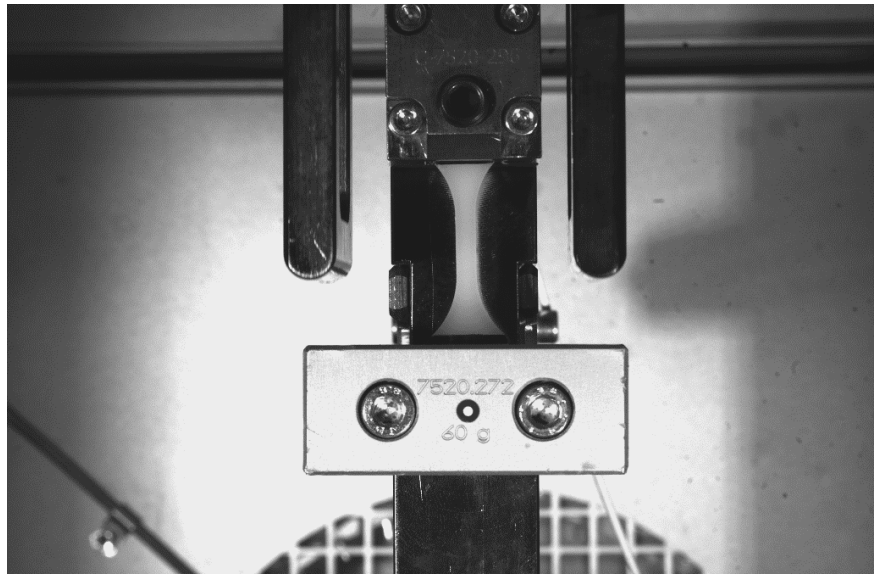
Displacement: Calculated vs Evaluated





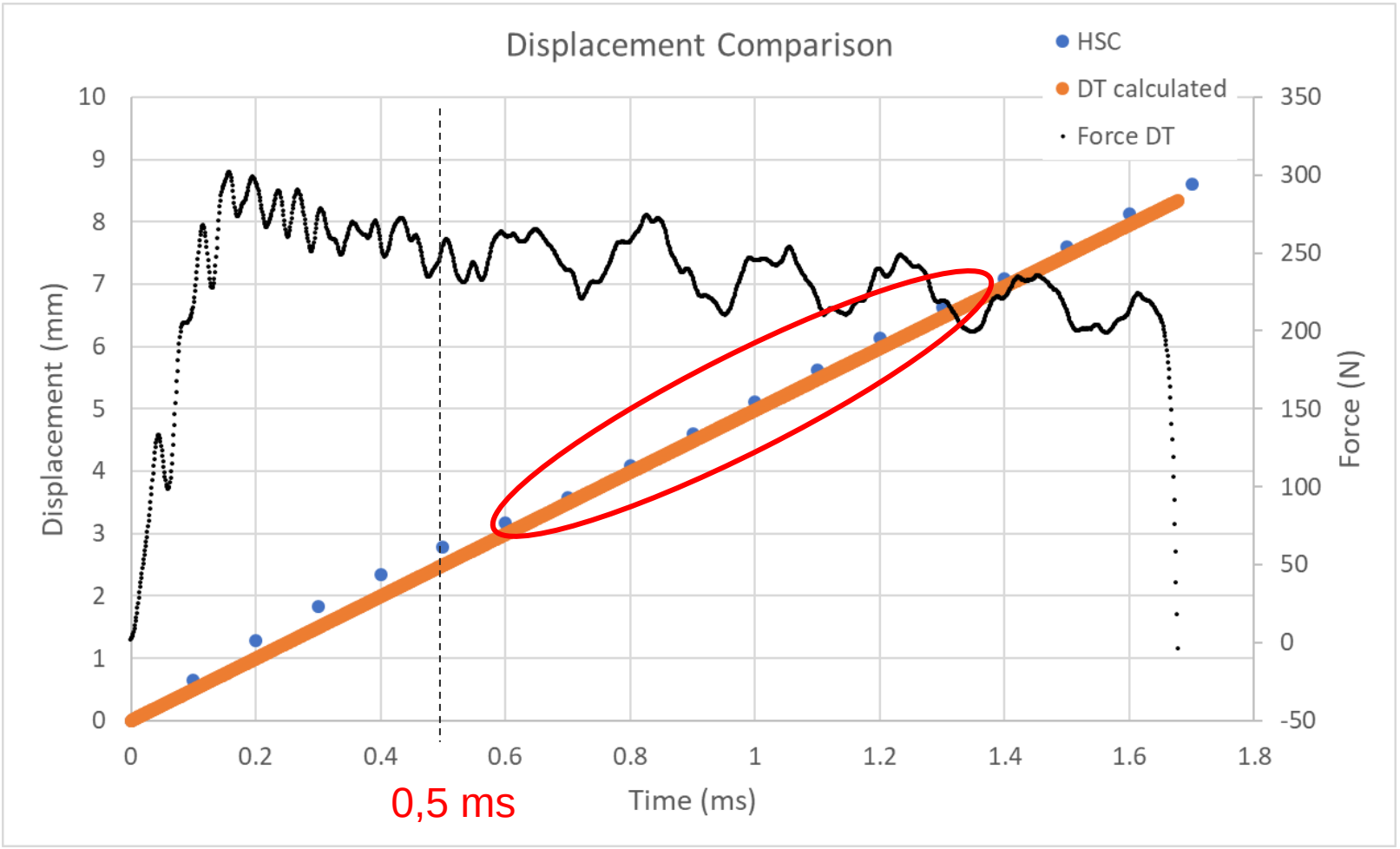
Displacement: Calculated vs Evaluated

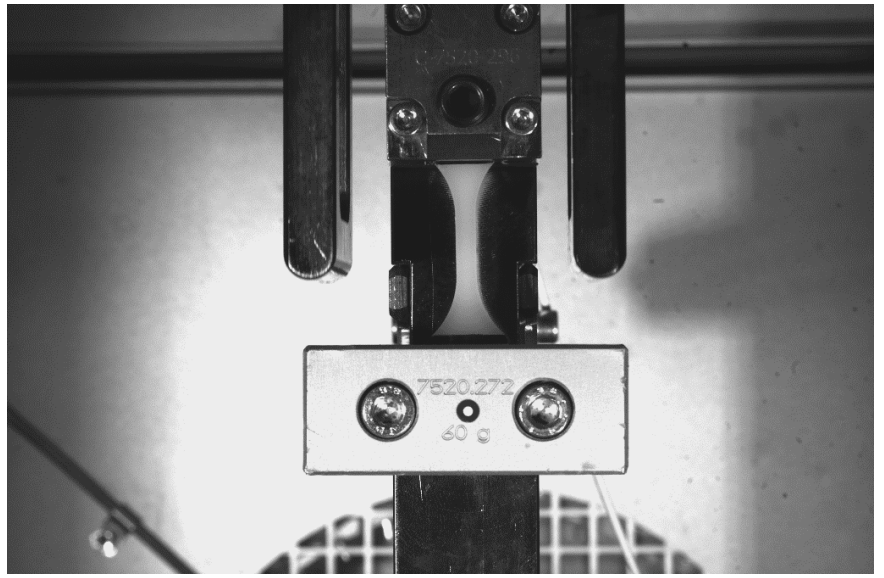




At high impact velocity, before 0,5 ms, the inertia accelerates the free grip at a velocity slightly higher than the one of the striker

Displacement: Calculated vs Evaluated

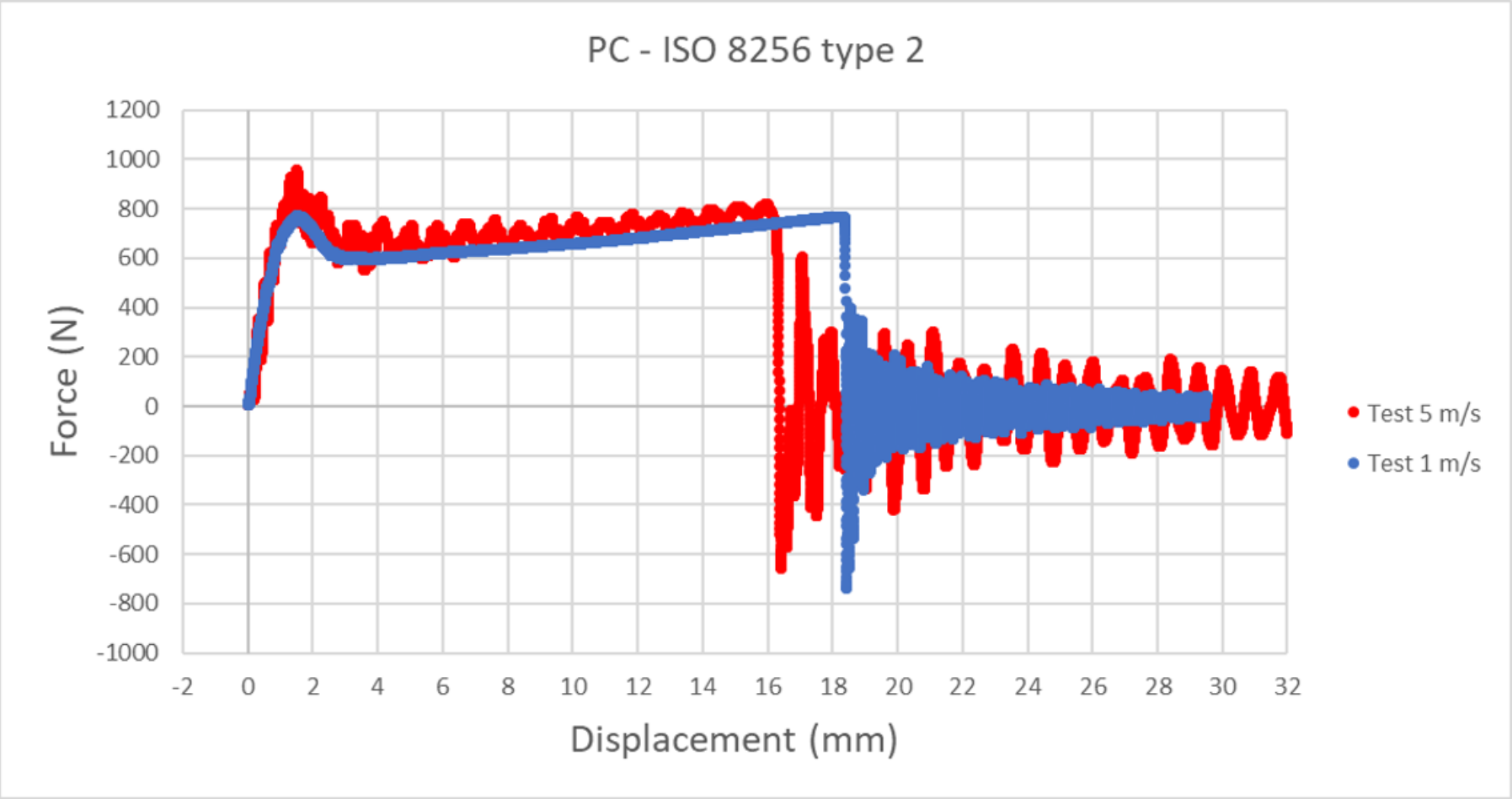




After0,5 ms, more dynamic effect occurs, optimal contact between striker and free grip is re-estableshed

Study Case

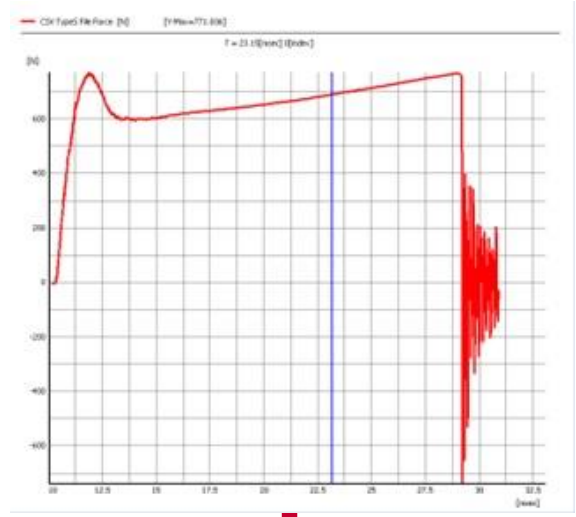
Test Case: PC specimen with shape in accordance with ISO 8256 type 2 compared for impact tests at different speeds

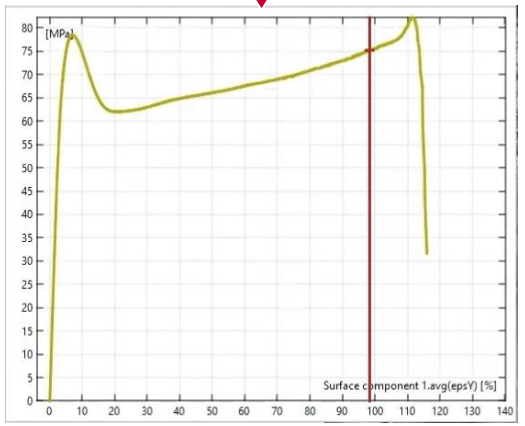


- The test at 1 m/s: lasts about 20 ms, thus a lower sampling frequency is enough.
- Test at 5 m/s: the same material fractures in less than 4 ms requiring much higher sampling frequency.

High Speed Camera & DIC Analysis

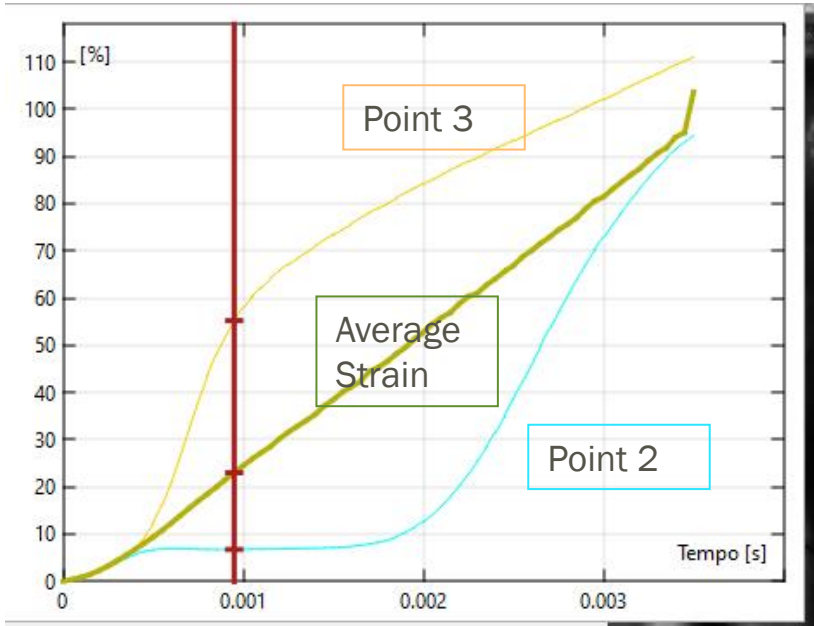
Quantitative Analysis of the Mechanical Properties at high strain rate.

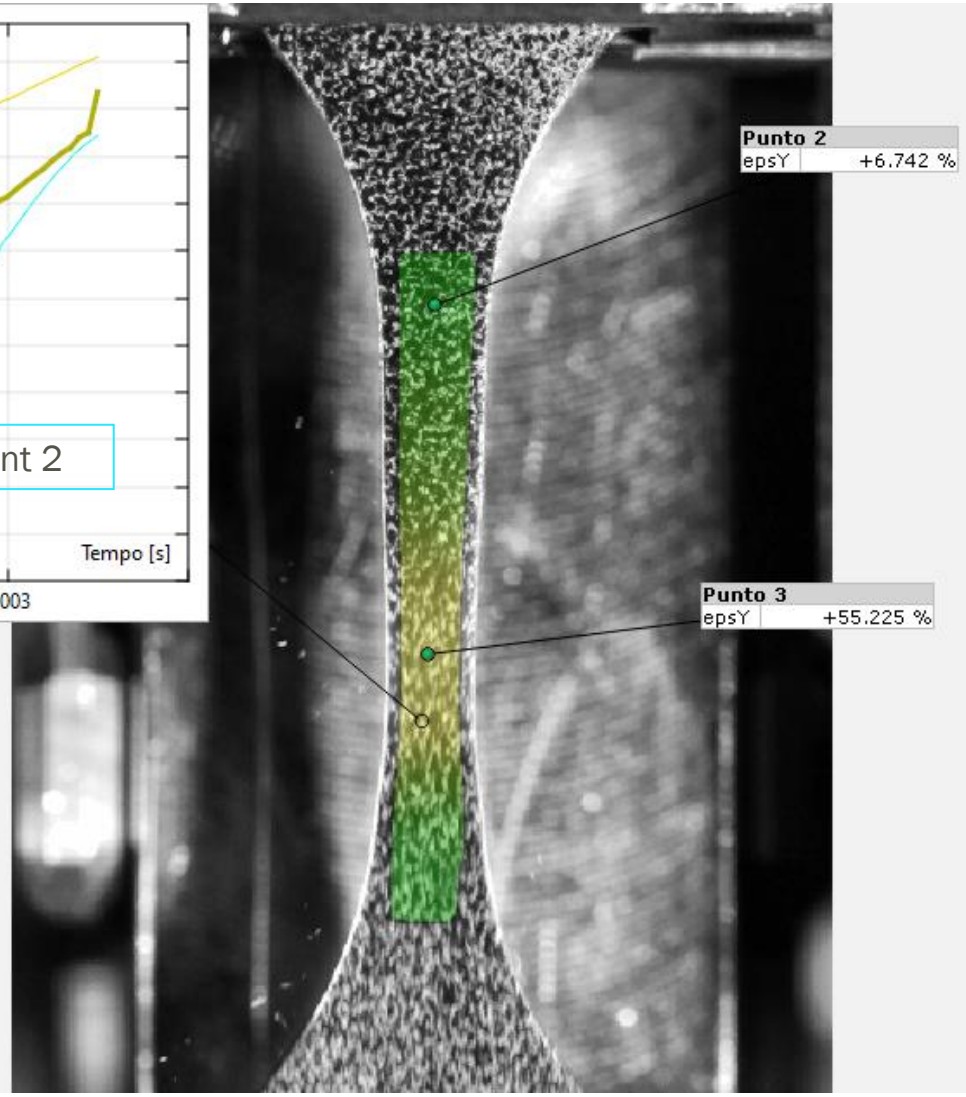




DIC Analysis Study Case

1- Quantitative evaluation of local Strain.





PC material at 5 m/s
According to ISO 8256
Type 2

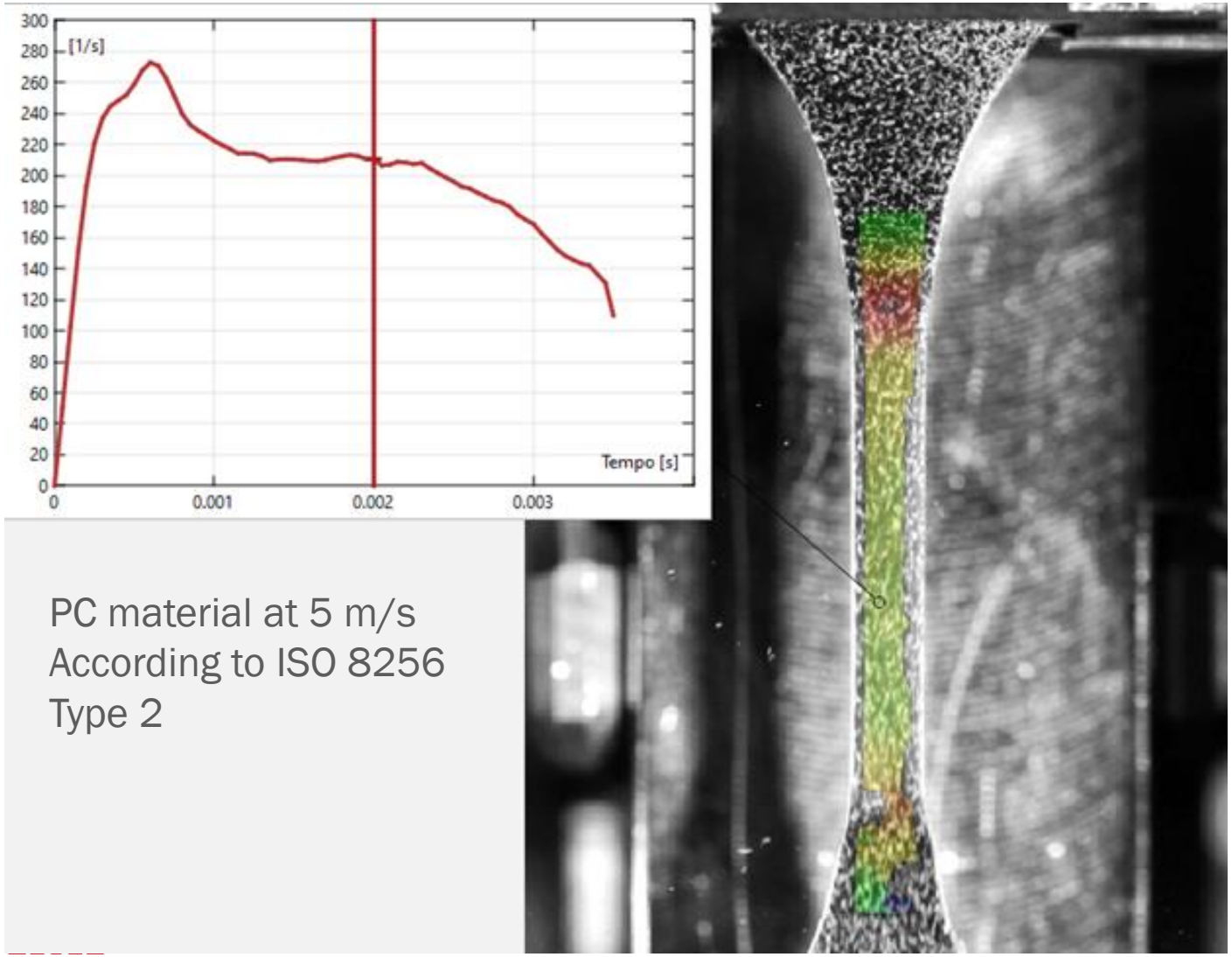
The strain evolution of:

- The average Strain (thicker curve);
- the spot closer to the grip (cyan curve – Point 2);
- the spot closer to the failure point (orange curve – Point 3).

The plot presented is referred to the test at 5 m/s.

DIC Analysis Study Case

2 - Quantitative evaluation of the Strain Rate.



PC material at 5 m/s
According to ISO 8256
Type 2

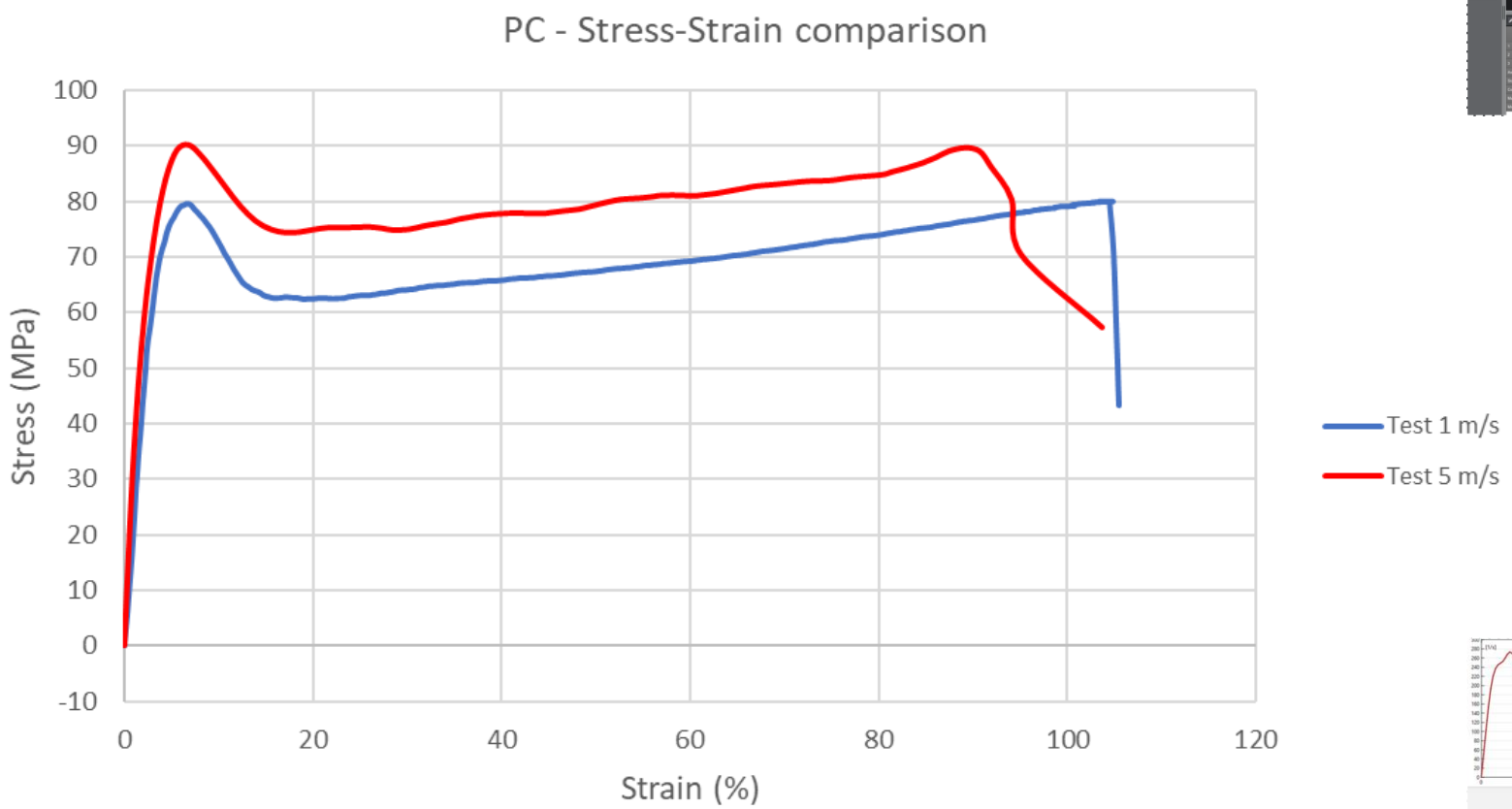
Evaluated vs theoretical strain rate:

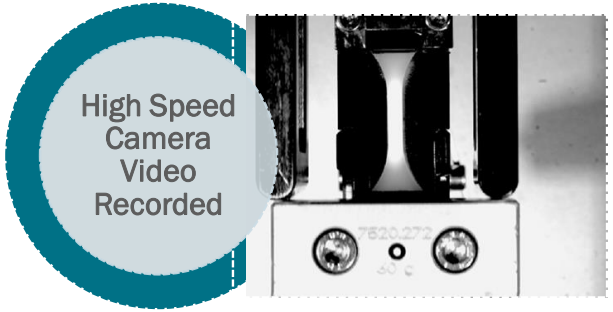
- Theoretical strain rate at 5 m/s = 200 s^{-1} (5 ms^{-1}/0,025m)

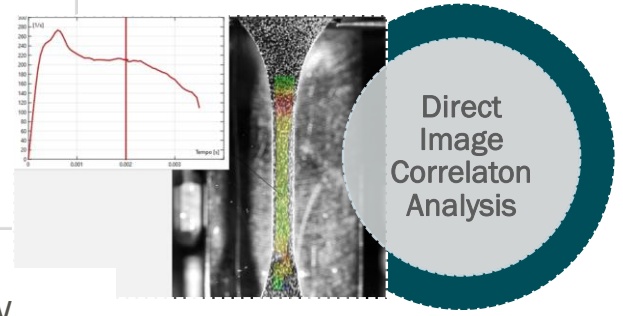
The strain-rate evaluated by using the Digital Image Correlation analysis shows that the nominal value is only achieved for a limited part of the test, at the beginning the specimen is subjected to higher values while in the last part we assist to a decrease.

DIC Analysis Study Case

3- Stress - Strain Curve







The stress is automatically calculated by the DIC software importing the raw force data and imposing the dimensions of the specimen tested

THANKS YOU FOR YOR ATTENTION