



LUND
UNIVERSITY

STRUCTURAL SAFETY OF GLASS COMPONENTS

MARCIN KOZLOWSKI

Structural
Mechanics

DEPARTMENT OF CONSTRUCTION SCIENCES
DIVISION OF STRUCTURAL MECHANICS

ISRN LUTVDG/TVSM--20/7169--SE (1-295) | ISSN 0281-6679

STRUCTURAL SAFETY OF GLASS COMPONENTS

MARCIN KOZŁOWSKI

Copyright © 2020 Division of Structural Mechanics,
Faculty of Engineering LTH, Lund University, Sweden.

First published December 2020 (*PI*).

For information, address:
Div. of Structural Mechanics,
Faculty of Engineering LTH, Lund University, Box 118, SE-221 00 Lund, Sweden.
Homepage: www.byggmek.lth.se

Preface

The report relates to the Research Study Contract (no. 1/RB6/2019) concluded on 08/04/2019 and signed by representatives of Division of Structural Mechanics, Faculty of Engineering, Lund University, Sweden represented by Prof. Erik Serrano and Silesian University of Technology, Gliwice, Poland represented by Marcin Kozłowski, PhD.

It reports the work carried out and summarizes main results of the work related to the project “Structural Safety of Glass Components” carried out by Marcin Kozłowski during his Postdoc position at the Division of Structural Mechanics, Faculty of Engineering, Lund University, Sweden from 01.01.2018 to 31.12.2018. It also provides information about dissemination presentation of the research outcomes.

Summary

An extensive experimental campaign was carried out in this research project. The testing program involved both the static and dynamic characterization of a double-tire impactor, as well as impact testing of glass panels mounted using various fixing methods. The fixing methods included linear clamping, bolted point fixings through holes in glass and local clamp fixings without penetration of glass. The investigation was made by varying glass thickness, types of glass and interlayer stiffness.

Numerical models were created to reproduce the structural behaviour found on the specimens subjected to the soft-body impact. Models were created using the commercial finite element analysis (FEA) software ABAQUS and were analysed using the Implicit Dynamic solver.

Several types of reduction methods were investigated. Such methods are used to reduce the computational effort needed to solve full 3D FE-models. The reduction methods can be categorised according to the type of degrees-of-freedom generated in the reduction process, where condensation methods involve only physical dofs, generalised coordinate methods are based solely on generalised coordinates, and hybrid reduction methods employ a combination of dofs of both types. In the current work on finding a suitable reduction scheme for soft body impact on glass, these methods were studied together with updated methods based on Ritz vectors.

The main results from the project include verified full 3D FE-models, and data from tests of soft body impact. Furthermore, the results from the project indicate that it is possible to predict the structural behaviour of free-standing glass balustrades subjected to soft-body impact using these full transient non-linear numerical models. However, these models are time consuming to use and require access to advanced commercial FE software and extensive user knowledge. Consequently, another important conclusion is that there is a strong need for reduced modelling techniques that are time efficient and allow for a quick check of alternative designs.

Content

1	Introduction	1
1.1	Glass barriers	3
1.2	Classification	3
1.3	Impact loads produced by humans in motion	4
2	Overview of Experimental Campaign	6
2.1	Static and dynamic characterization of a double-tire impactor	6
2.2	Soft body impact tests	6
3	Full Transient and Reduced Numerical modelling	10
3.1	Full modelling	10
3.2	Reduced modelling	11
4	Dissemination of results	12
	References	15
	Annex I	17

1 Introduction

During the last decades, an increase in structural applications of glass in modern architecture has been observed. This particularly applies to the building components that, in addition to serving as infill elements for openings in buildings, have a special role in ensuring the safety of building occupants. Although glass has been used in construction for almost 2000 years, only during the past decades a remarkable development in structural glass (balustrades, French windows, enclosures, facades, etc.) has been observed (Patterson 2011, Bedon et al. 2018). The development from an infill to a structural material enabled designs that are based on using a large amount of glass in e.g. atriums, skylights, partition walls and structural glass enclosures aiming to achieve a maximum amount of transparency in buildings (Bostic 2009; Louter 2011). Glass structures feature the ability to merge with their surroundings and become invisible, nearly dematerialized if the structural frame or fixings are kept to a minimum, see examples in Fig 1.

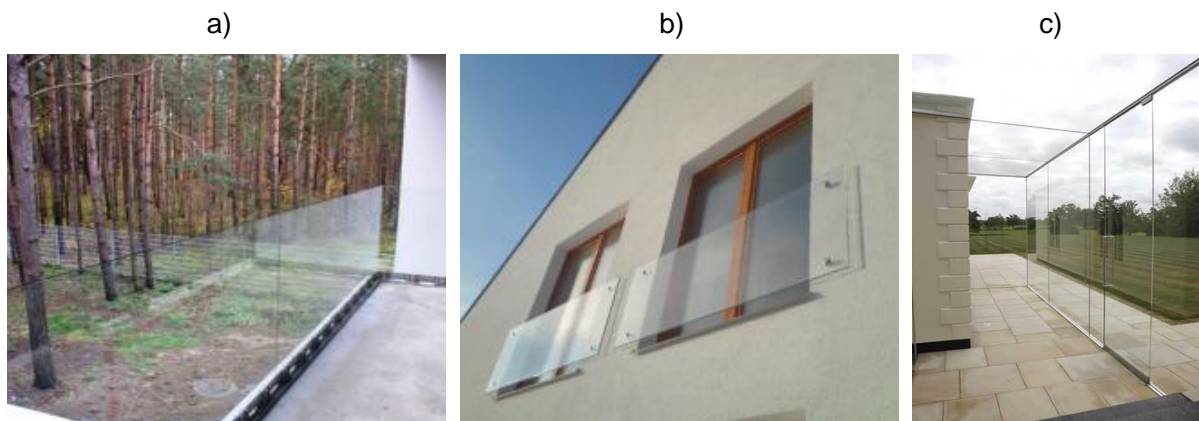


Fig. 1 Examples of structural glass in private houses (a, b) and public buildings (c).

It is important to stress that currently Europe lacks of standardized guidelines, design approaches or standards dedicated for design of structural glass to be used in everyday engineering practice. Practically, the regulation authorities do not follow the development and increasingly used structural glass in buildings. It is very difficult situation for structural engineers who are under constant pressure from architects willing to use more glass in structures. Engineers are expected to deliver the design without adequate background offered by authorities or by taking courses at universities. The research aims at development of current knowledge and contributes to the development of guidelines regarding safety of components.

Safety of a structure is one of the most important performance criteria for glass elements. It involves mechanical resistance, stability and accessibility in use for finishing elements, but primarily for structural (load-bearing) elements. (Regulation of EU parliament 2011, EN 1990). Whenever glass panels are mounted at identified risk areas (for example barriers), the owner of the building is responsible for ensuring that the design and construction is technically safe for general use and that it meets current and accepted technical standards. This applies

especially in situations when panels are required to ensure the protection of neighbouring walkways and have to bear the loads of persons leaning against or bumping into the glass.

Traditionally, well-known solutions for glass elements include steel members or handrail and glass panels as infill elements, thus the structural robustness is guaranteed primarily by steel elements, which in case of glass failure carry the full loading. However, nowadays, a common trend of resignation from steel members (handrails or posts) can be observed, see Fig. 1. In these cases, glass is the only load-bearing material - the only structural element which protects users from falling. This might be very dangerous, and even life-threatening, because the structural safety is based on a brittle material, whose behaviour is not fully recognized.

At this point it should be emphasized, that standard design approaches involve basic load requirements, such as wind load and static barrier load, however, impact loads are considered only in limited number of cases. This is due to the lack of clear requirements in standards. To the knowledge of the applicant, omitting dynamic calculations, such as soft body impact, happens very often in nowadays practice. This is caused by lack of detailed knowledge on dynamic transient analysis and lack of simulation tools.

The behaviour of glass panes under impact loading should play an important role in the design of glass structures and it is critical when it comes to the safety of users (Schneider et al. 2011). The brittleness of glass and its linear-elastic stress-strain-relation without plastic deformability can lead to an instantaneous and disastrous failure under both hard and soft body impact. It should be emphasized here that the resistance of glass to impact is usually lower than for most other building materials, therefore, if one wants to use glass as a replacement for commonly used structural materials, one has to make a precise (exact) analysis to ensure that its design ensures the safety of users (Schneider 2001).

A simple numerical example shows that the dynamic force from soft-body impact load may exceed several times the standard static loading (Kozłowski et al. 2018). Results from numerical studies on soft body impact with a 50 kg pendulum show, that even for the lowest value of drop height of 300 mm (as per DIN 18008-4) the contact force reaches a value of 12 kN, which is more than 10 times the static loading (usually 1kN/m). In cases when glass is not designed for such loading this could be a threat to human's health and life. Moreover, the numerical study shows that, for a more complicated geometry, the stress distribution can dramatically change over time and that stress concentrations can develop at certain locations at a late stage in the impact history (Kozłowski et al. 2018). This cannot be directly capture in a static analysis, normally performed by structural engineers.

The results of the project will be potentially used for the development of a structural design tool for glass components (Clearsight®) created at Structural Mechanics by Prof. Kent Persson. It is planned to add additional features for dynamic loading and the results will be used for validation of the models.

Another important aspect to mention is that the European Commission (CEN) has recently launched work on the codification of structural design of glass (working title is Eurocode 10 for glass – working group CEN/TC250-WG3) in order to provide common design approaches and achieve a harmonized safety level throughout the member states. To date this process has reached the stage when the first draft of a Eurocode for structural glass is under development and any work within this field would provide an important contribution to it.

1.1 Glass barriers

The main purpose of using barriers in buildings is to protect their users against falling from heights. Barrier elements are usually installed in places where there is a difference in levels between both sides of the barrier (Pinto and Reis 2016). To fulfil safety measures, barriers must meet the requirements regarding minimum height (calculated from the finished floor level to the top edge), load capacity for the strength design (statically and dynamically), and minimum stiffness to limit excessive deflections that may disturb its functionality or building occupants.

Barriers should fulfil their function under ordinary circumstances but also in exceptional cases, e.g. when one glass sheet of the laminate is fractured (Pinto and Reis 2016). Since glass components are susceptible to sudden and brittle fracture, it is important to consider other limit states in addition to the ultimate limit state (ULS) ensuring safety and the serviceability limit state (SLS) focusing on aesthetics and comfort. These novel limit states (fracture and post-fracture limit states) relate to the situation in which, e.g. one sheet in the laminated glass is damaged, to ensure sufficient damage tolerance and robustness (Honfi et al. 2014, Lenk and Honfi 2016, CEN 2019). In this case, the fractured element should meet the safety function, however, with reduced load. This limit state will be included in the new Eurocode on structural glass (Feldmann and Di Biase 2018).

To guarantee that barriers meet the code requirements, especially regarding impact loads, experiments are often performed. Such tests are costly and time-consuming and are usually limited to a single design case with fixed geometry, thus neglecting the influence of size effect and temperature on the stiffness of the components (Kozłowski 2019a). Finite Element (FE) simulations are an alternative and complementary method to experimental testing. Despite the good correlation to the results from experiments reported by e.g. Kozłowski (2019a), full nonlinear transient FE models of impact on glass are time consuming and usually require access to advanced commercial FE software and extensive knowledge of users. In the design process, however, time efficient reduction methods allow for a quick check of alternative designs (Fröling et al. 2013, Fröling et al. 2014).

1.2 Classification

The most common classification of glass barriers was originally included in the German regulations (TRAV2003) and later adapted in the German standard (DIN 18008-4). The classification of glass barriers protecting against falling depends on geometric features, fixing method and load-transferring function (primary structural element or secondary, non-structural infill). Three main classes of glass barriers are defined: Class A - full height protective barriers, Class B - free-standing glass safety barriers and Class C - barriers with glass infill panels. The correct classification of a barrier is a key element required for structural design and which governs the value of impact loading.

Full height protection barriers (Class A) are vertical glazings fastened linearly or locally, without a handrail to take the horizontal load. Such barriers can take on different shapes and usually consist of full glazing (from floor to ceiling). However, if a handrail carrying horizontal load is mounted in front of the barrier, such an element is classified as Class C (DIN 18008-4). Free-standing glass barriers (Class B) are panels mounted to the superstructure linearly or locally along its bottom edge. In the case of these barriers, glass is the only structural element carrying the load providing safety for the building users. A handrail along the top edge transfers loads to adjacent panels in the event of glass breakage. Glass filled barriers (Class C) involve a frame

carrying the horizontal loads. In this type of protective barrier, glass is only an infill element and does not contribute to the stiffness of the main frame.

There are barriers with glass infills that do not fit into any of the classes described above, see Fig. 1. In such solutions, glass elements are mounted between steel posts, which may seemingly indicate Class C. However, these panels can be defined as primary structural elements carrying horizontal loads and should therefore be classified as Class A.

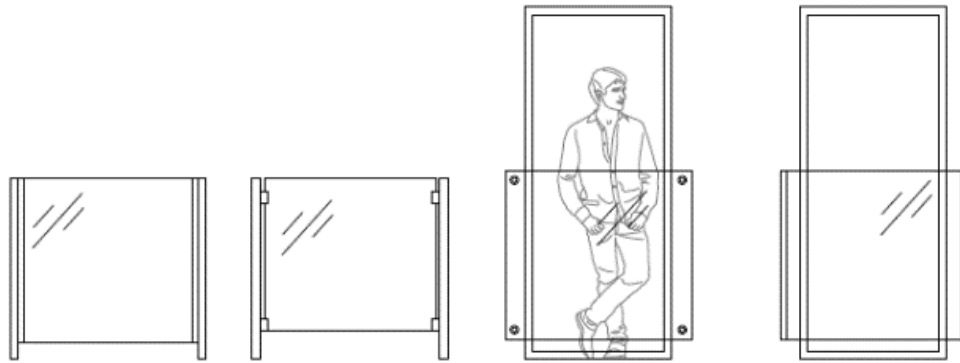


Fig. 1 Barriers classified as Class C.

1.3 Impact loads produced by humans in motion

According to the principles of classical mechanics, the kinetic energy of a moving body is a function of its speed and mass (Nilsson 1976). However, during an impact of a human body to an obstacle, only 30-60% of its mass takes part in the event and the reduction of mass is caused by the fact that the human body is not perfectly rigid but it is a complex dynamic system and some energy remains diffused during the impact (Nilsson 1982).

Nilsson (1982) conducted research to assess impact forces associated with various types of human activities. The researcher employed volunteers leaning on and kicking a glass pane with the dimensions of 1000×2000 mm² with a 10 mm thickness. The glass pane was equipped with a load cell measuring the applied impact force. The main aim of the research was to define factors to approximate the dynamic force based on the static mass of a human. For kicking, leaning and pushing a person on a glass pane, the dynamic amplification factor achieved was 1.5, 3.9 and 4.1, accordingly.

Huber (1995) carried out experiments with volunteers who shouldered a glass pane measuring 875 × 1938 mm² with a 10 mm thickness. The specimen was supported along all edges and equipped with a load cell. A maximum dynamic force of 2.2 kN was obtained.

Wörner and Schneider (2000) conducted human body impact tests using volunteers with the following weights 68, 83 and 90 kg. In the first stage, the volunteers ran from a defined distance of 2.5 m and hit a glass pane that measured 847 × 1910 mm² with a 10 mm thickness. The pane was supported along all edges. In the next stage, the same pane was hit with a 45 kg impactor from drop heights: 450, 700 and 1200 mm. During the experiments, the strain in the glass was measured with gauges mounted on the tensile stress side of the glass. The researchers observed that the microstrain in the glass was much lower as a result of human impact compared to the pendulum impact. The maximum measured strain in the glass,

recorded under human impact with a mass of 90 kg, was approximately 60% lower than the strain obtained when the pendulum was dropped from the highest drop height of 1200 mm. It was also observed that the contact time measured during tests with volunteers in relation to the pendulum impact was longer by approximately 50% and lasted in average 80 ms. This result is due to the lower rigidity of the human body as compared to the stiffness of the pendulum. Additional results research are presented in Schneider (2001).

Ummenhofer (2004) conducted research with volunteers running and hitting a wooden board with the dimensions 500 × 500 mm² and 12 mm in thickness. A load cell was attached to the board measuring the response during impact. An average force obtained in the experiments was 1.66 kN.

Bucak (2004) carried out a study in which a volunteer, weighing 82 kg, was skateboarding and shouldering a glass pane. The glass pane, supported along its short edges, measured 360 × 1100 mm² with a 8 mm thickness. Before each impact, the speed of the skateboard and the deflection of the pane were measured. The results of the tests were compared with results from a numerical model of a glass pane. The numerical results were based on a 50 kg pendulum load moving at the same velocity as the maximum speed of the skateboard measured during the tests. It was found that the results from the numerical model were approximately 50% greater than that observed during the experiments with the volunteer. Additional results are presented in Schuler et al. (2005).

Table 1 presents a comparison of impact energies given by standards and produced by experiments with volunteers. The impact energy calculated with the method in DIN 52337 was calculated based on the assumptions that an 80 kg human is moving at a velocity of 2.4 m/s (maximum speed of a human inside buildings) and that 80% of its mass is actively involved in the impact event. For comparison, Table 1 provides corresponding drop heights of a 50 kg double-tire impactor calculated from the impact energies achieved during the experiments with volunteers. The values were calculated using the formula for the potential energy $E_p = m \times g \times h$, where m is the impactor mass, g is the acceleration of gravity (9.81 m/s²) and h is the drop height (in meters).

Table 1: Comparison of impact energies given by standards and produced by experiments with volunteers.

Reference	Drop height of 50 kg double-tire impactor [mm]	Impact energy [J]
EN 12600	190	93
	450	220
	1200	589
DIN 18008-4	450	220
	700	343
	900	442
DIN 52337	281*	138
Experiments with volunteers (Schneider 2001, Schuler et al. 2005)	148-358*	73-176

* calculated values

2 Overview of Experimental Campaign

2.1 Static and dynamic characterization of a double-tire impactor







An extensive experimental campaign was carried out in this research project. The testing program involved both the static and dynamic characterization of a double-tire impactor, as well as impact testing of glass panels mounted using various fixing methods. The fixing methods included linear clamping, bolted point fixings through holes in glass and local clamp fixings without penetration of glass. The investigation was made by varying glass thickness, types of glass and interlayer stiffness.

In the project, a double-tire impactor according to EN 12600 was used. The 50 kg impactor consists of two pneumatic tires, inflated to 3.5 bar air pressure, and a central steel cylinder. To define the parameters of the hyperelastic material model assumed for the rubber in the tire, a tensile test of a strip cut from the tire was tested in tension. In addition, static compression of the inflated impactor was performed to obtain stiffness features under static loads. Details of the set-up and results can be found in (Kozłowski 2019a, Kozłowski 2019b). Dynamic characterization of the impactor was performed by setting the impactor into pendulum motion from different drop heights and hitting an obstacle of very high stiffness. By regarding the obstacle as rigid, it was possible to determine the dynamic characteristics of the impactor. In the study, five drop heights were investigated: 100, 200, 300, 450 and 700 mm resulting in impact energies ranging from 49.1 to 343.4 J. To measure the acceleration and contact time of the pendulum during impact, a single-axis accelerometer was mounted to the steel cylinder above the top tire. Acceleration measurements were carried out with data acquisition of 5 kHz.

2.2 Soft body impact tests

An overview of the specimens tested in the soft-body impact tests is presented in Table 2. The specimen type and the boundary conditions employed in the study represent the most prevalent fixing techniques applied in buildings. The glass specimens in this study were regular soda-lime silicate float glass, which is the most common glass type in the building industry. Two types of heat treated glass were applied: heat-strengthened (HS) and fully tempered (FT) glass. Three types of interlayers were applied: regular polyvinyl butyral (PVB), ethylene vinyl acetate (EVA) and SentryGlas® (SG).

Table 2: Overview of tested specimens.

Specimen type	Sketch	Boundary conditions	Specimen dimensions [mm]	Glass type	Glass build-up [mm]	Interlayer [mm]
I		Simply-supported, restrained along vertical edges	1000 × 800	Monolithic, toughened	8 10 12	-
				Laminated, toughened	8 + 8	1.52 PVB 1.52 SGP
				Laminated, heat-strengthened	8 + 8	1.52 PVB 1.52 SGP
II		Point-fixed at corners		Laminated, toughened	5 + 5	1.52 PVB
III		Clamp-fixed at corners			5 + 5	1.52 PVB
IV		Simply-supported along all edges (IGU)			5 / 16 mm / 5 5 + 5 / 16 mm / 5	- 1.52 PVB
V		Cantilevered, restrained along whole bottom edge (steel shoe)	1100 × 1000		10 + 10	1.52 PVB
VI		Cantilevered panels restrained at bottom edge (four point-fixings)	1100 × 1393	Laminated, toughened	10 + 10	0.76 EVA

The research project included the following elements:

- Glass panels supported along their vertical edges. Panels with dimensions of 1000 × 800 mm² supported linearly along their vertical edges were investigated. Three monolithic panels of various thickness: 8, 10 and 12 mm made of toughened glass were tested to obtain data to calibrate numerical models. Moreover, two laminated glass panels (8+8 mm) made of toughened and heat-strengthened glass with two interlayer materials: PVB and SG 1.52 mm in thickness were investigated.

- Point and clamp fixed panels. These types of elements are usually installed as infill panels for steel balustrades. Panels measuring $1000 \times 800 \text{ mm}^2$ supported locally (with point fixings and clamps) at points located approximately 50 mm from the corners were investigated. A single laminated panel composed of two 5 mm toughened glass panes laminated with a 1.52 mm PVB interlayer was investigated.
- Insulated glass units. Two specimens with symmetric and asymmetric configuration were investigated. The first specimen consisted of two single 5 mm panes, while the second specimen had a laminated ply with 5+5 mm glass, and a 1.52 mm thick PVB layer on one side. In both cases, the gas-filled cavity was 16 mm in width and the glass was fully toughened. The panels were simply supported along all edges.
- Free-standing glass balustrades (Biolzi et al. 2018, Baidjoe et al. 2018). These are cantilevered elements supported at the bottom edge only. In the research project, both line and point fixed configurations were tested in both static and dynamic loading. Laminated glass panels were composed of two 10 mm plies made of toughened glass laminated with a 1.52 mm thick PVB interlayer for the line fixed configuration and a 0.76 mm EVA interlayer for the point fixed configuration.



Fig. 2 Soft-body impact test set-up: a) steel rig, b) computers logging data from strain gauges and accelerometers, c) strain gauge and accelerometer mounted to the glass specimen, d) accelerometer mounted to the impactor.

Specimens I-V were tested in a custom-made steel frame of high stiffness (Fig. 2a). The set-up allowed for fixing the various specimens and releasing the impactor from defined drop heights. To measure the structural response of the glass elements during soft-body impact, two systems with a number of sensors were installed (Fig. 2b). To measure strains in glass, strain gauges with a measurement length of 10 mm and a single axis accelerometer were bonded to the specimens (Fig. 2c). The signals from the strain gauges were logged at a frequency of 600 Hz, whereas the readings from the accelerometers were recorded at 5 kHz. A single-axis accelerometer was also mounted to the impactor (Fig. 2d). To obtain statistically reliable results, at least six repetitions for each drop height were performed. All tests were carried out at a temperature of 22 ± 1 °C.

The specimens were tested in both an intact (Fig 3a) and a damaged state (Fig 3b) to investigate the behaviour of specimens, where one of the plies were intentionally fractured. To brake one of the panes in the laminate, a hammer and a steel chisel were used. Due to the energy stored in the heat-treated glass (introduced to the glass in a tempering process), the damaged ply increased its volume and some of the strain gauges bonded to the cracked glass were damaged.

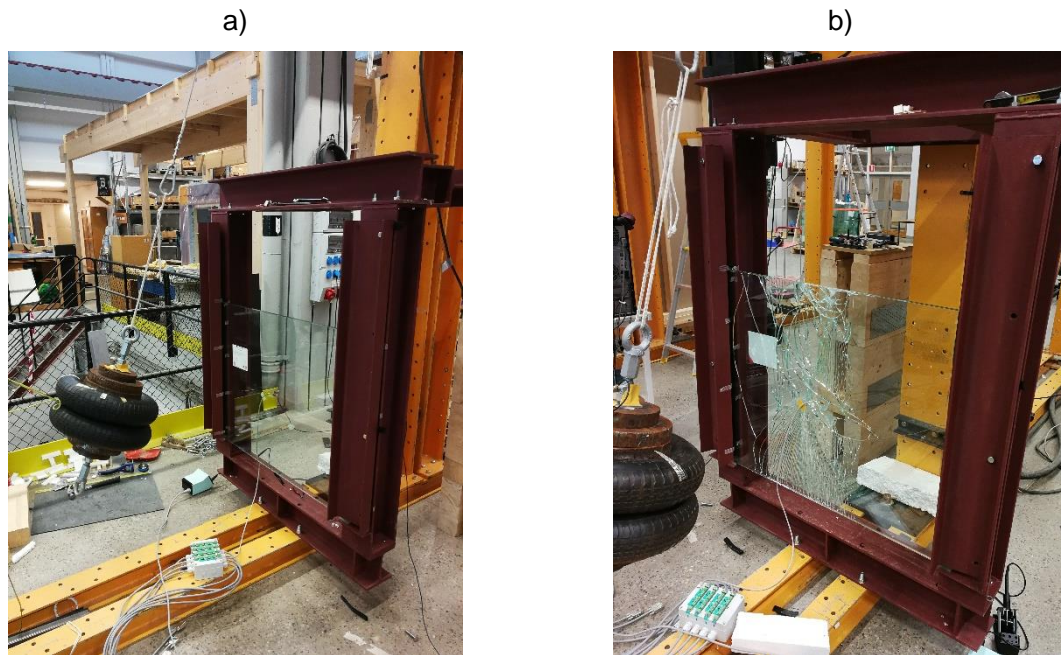


Fig. 3 Soft-body impact test set-up: a) intact specimen, b) specimen with one glass pane in the laminate fractured.

Specimen VI was tested at another laboratory and in a different set-up, as described in Williams Portal et al. (2019). Static and impact tests were conducted on a self-supporting glass balustrade with point-fixings. The specimen was subjected to both static and impact loading (with various drop heights). The dynamic structural response of the glass specimen was analysed by three-dimensional Digital Image Correlation (3D-DIC) measurements using a stereoscopic camera setup with two high-speed cameras. This measurement technique makes it possible to determine the strain and deformation of any point on the specimen surface and to study its deformed shape in detail.

3 Full Transient and Reduced Numerical modelling

3.1 Full modelling

Numerical models were created to reproduce the structural behaviour found on the specimens subjected to the soft-body impact. Models were created using the commercial finite element analysis (FEA) software ABAQUS and were analysed using the Implicit Dynamic solver (Simulia 2018). An example of a numerical model of a free-standing glass balustrade and the impactor is shown in Fig. 4a.

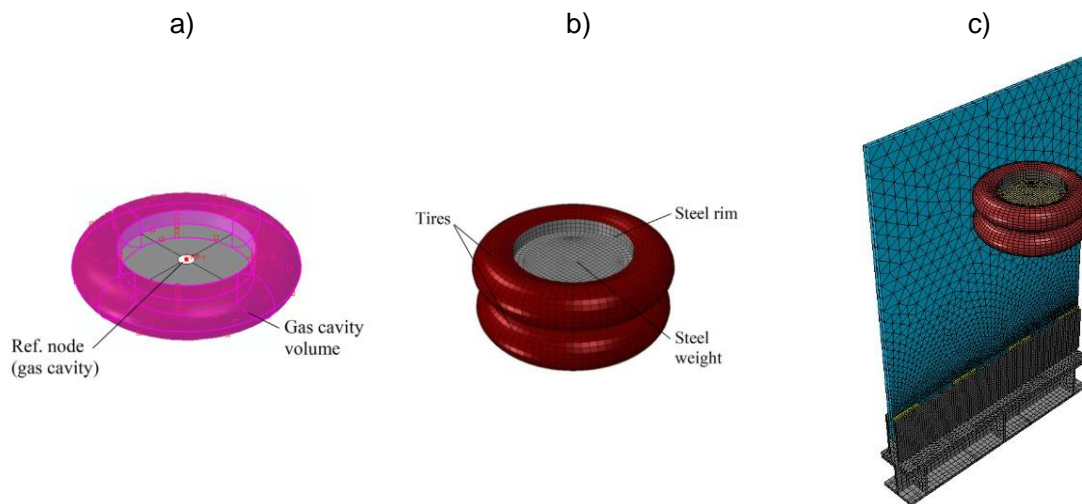


Fig. 3 Soft-body impact test set-up: a) gas volume with reference point, b) double-tire impactor, c) numerical model of the glass balustrade subjected to soft body impact

The model of the impactor followed that of EN-12600 and consisted of two tires and a steel weight (Fig. 4a). The model of a single pneumatic tire was created by revolving a curve corresponding to the mid cross-section of the tire and the steel rim around its perimeter. To achieve a realistic behaviour of the tire, the reinforcement (nylon cords) was included and modelled by using a smeared approach in membrane elements. The displacements of the shell and the membrane elements were fully coupled. In this way, high tensile but low bending stiffness of the tire was achieved. The air inside the tires was modelled using pneumatic elements in the closed cavity. This required the definition of a closed volume between the inner surface of the tires and the outer surface of the rim, the volume of the cavity being controlled by a cavity reference point. In such a case, the stiffness of the tire depends not only on the rubber material and the initial pressure exerted by the gas entrapped inside but also on the volume change of the cavity that is affected by the external loading and deformation of the tire. To achieve equilibrium with the initial pressure of 3.5 bar, as required to conform with EN 12600, an overpressure of 4.25 bar was applied which after equilibrium iterations and tire deformations, settled at 3.5 bar. Laminated glass elements, including the glass panes and the interlayer, were modelled using eight-node continuum shell finite elements. Details of the tire model and the material properties can be found in Kozłowski (2019a).

Laminated glass elements, including the glass panes and the interlayer, were modelled using six-node continuum shell finite elements. Other elements of the model, such as steel elements of the test set-up, setting blocks and other glass fixing elements were modelled using solid elements. A non-regular, triangular mesh pattern was applied for the laminated glass components. A finer mesh with an element size of 5 mm was used for the lower part of the panel where the highest stresses were expected, while the remaining zones were meshed with a coarser pattern with an average

element size of 30 mm. For other components of the model, such as the steel plates and fastening elements made of polyoxymethylene (POM), a 10 mm element size was applied. Details of the numerical model and material properties can be found in Kozłowski (2019a).

3.2 Reduced modelling

Full nonlinear transient finite element analyses of impact events are advanced, time consuming and may require access to advanced commercial finite element programs and trained users. In the design process, it is important that the design tools used are such that alternative designs may be tested in an interactive fashion. To achieve this, there is a need to have methods that are very time efficient. A solution may be to employ Model Order Reduction (MOR) methods for the FE-models. This means reducing the initial large number of degrees of freedom with the aim of keeping the dynamics of the original model as intact as possible. In many cases, only a very few degrees of freedom (dofs) are sufficient to provide a good solution, in many cases even only one dof can be sufficient.

In an ongoing study on model reduction of glass impact, the aim is to, in an efficient and simplified manner, be able to determine the maximum principal stress of a glass plate subjected to a dynamic impact load. The method must be valid for glass supported by various types of fixings and with different sizes and laminations. In Fröling et al. (2014) a reduction method for impact on glass based on Ritz vectors was suggested. The method includes two Ritz vectors, calculated from two static load cases representing the glass structure, as well as a spring, dashpot and mass representing the impactor. The load cases are schematically shown in Fig. 4b. Although this method has been shown to provide very good results for many glass types, dimensions and supports, it is not fully general. Since the method is based on two Ritz vectors determined from static load cases, the validity of the solution is dependent on that these load cases are valid.

A vast number of methods for model order reduction of dynamic problems have been developed within structural mechanics where various mode-based methods are the most frequently used methods. Fairly recently, methods originating from control theory have been employed within structural mechanics. In contrast to mode-based methods which have an explicit physical interpretation, the modern reduction methods are developed from a purely mathematical point of view.

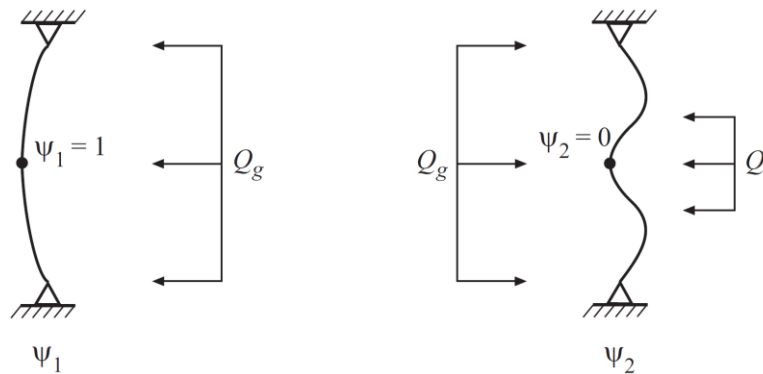


Fig. 4 Static load cases used for calculating the two Ritz vectors for model order reduction of a glass pane.

An FE formulation of a structural dynamics problem results in a linear equation of motion of the following form

$$\mathbf{M}\ddot{\mathbf{u}} + \mathbf{C}\dot{\mathbf{u}} + \mathbf{K}\mathbf{u} = \mathbf{F} \quad (1)$$

where \mathbf{M} , \mathbf{C} and \mathbf{K} are the mass, damping and stiffness matrices respectively, $\mathbf{F}=\mathbf{F}(t)$ is the load vector and $\mathbf{u}=\mathbf{u}(t)$ is the displacement vector with n number of dofs. A dot denotes differentiation with respect to time, t . The objective of model reduction here is to find a system of m number of

dofs in which $m \ll n$, one of which preserves the dynamic characteristics of the full model. The general approach is to approximate the state vector using transformation

$\mathbf{u} = \mathbf{T}\mathbf{u}_R$, where \mathbf{T} is a transformation matrix of size $(m \times n)$ and \mathbf{u}_R is a reduced state vector of size $(m \times 1)$. Applying the transformation in question to Eq. (1) results in

$$\mathbf{M}_R \ddot{\mathbf{u}}_R + \mathbf{C}_R \dot{\mathbf{u}}_R + \mathbf{K}_R \mathbf{u}_R = \mathbf{F}_R \quad (2)$$

$$\mathbf{M}_R = \mathbf{T}^T \mathbf{M} \mathbf{T}, \mathbf{C}_R = \mathbf{T}^T \mathbf{C} \mathbf{T}, \mathbf{K}_R = \mathbf{T}^T \mathbf{K} \mathbf{T}, \mathbf{F}_R = \mathbf{T}^T \mathbf{F} \quad (3)$$

where $\mathbf{M}_R, \mathbf{C}_R, \mathbf{K}_R$ are the reduced mass, damping and stiffness matrices, respectively of size $(m \times m)$.

The reduction methods can be categorised according to the type of dofs generated in the reduction process, where condensation methods involve only physical dofs, generalised coordinate methods are based solely on generalised coordinates, and hybrid reduction methods employ a combination of dofs of both types. A number of important methods within each category described further by Flodén et al. (2014) are listed below:

- Condensation methods: Guyan reduction, Dynamic reduction, Improved reduction system and System equivalent expansion reduction process
- Generalized coordinate methods: Modal truncation, Component mode synthesis by Craig–Chang, Krylov subspace methods and Balanced truncation
- Hybrid methods: Component mode synthesis by Craig–Bampton, Component mode synthesis by MacNeal and Component mode synthesis by Rubin

In the current work on finding a suitable reduction scheme for soft body impact on glass, these methods were studied together with updated methods based on Ritz vectors.

4 Dissemination of results

The results of the project were disseminated at different levels. This involves journal paper, conference contributions, a published project report, a monography and two Master theses. Currently, a journal contribution is being prepared. Links to the published contributions are given in the text, first pages are provide as annexes to the report.

A journal paper “Experimental and numerical assessment of structural behaviour of glass balustrade subjected to soft body impact” by Marcin Kozłowski was published in the Composite Structures journal (Impact Factor 5.138). The paper provides design principles and a review of existing standards regarding glass balustrades with a special emphasis on dynamic loads. It also presents results of an experimental campaign and numerical studies on the evaluation of the structural safety of fully-glazed balustrades subjected to soft-body impact. It includes experimental characterisation of the impactor and soft body impact tests on a glass balustrade in two states: intact and in post-failure state (with single glass ply damaged). The results of the numerical studies show good agreement with experiments in terms of displacement of the balustrade, stress in glass and acceleration of the impactor.

Link to the document:

<https://www.sciencedirect.com/science/article/abs/pii/S026382231930460X>

A conference contribution “Structural Behaviour of Glass Panels Under Soft-body Impact” prepared by Marcin Kozłowski, Kent Persson (LTH), Dániel Honfi (RISE), Natalie Williams Portal (RISE) was published after the Challenging Glass conference (September 2020). The paper reports results of the research project involving testing of glass balustrades and infill panels mounted with different fixing methods, such as linear clamps, local clamp fixings and bolted point fixings through holes in the glass. A reduced numerical model for prediction of strength of glass under soft body impact is also presented. In the experimental study toughened and heat-strengthened glass was used in single pane as well as in laminated glass where two interlayer materials of different stiffness were used.

Link to the document: <https://journals.open.tudelft.nl/cgc/article/view/4479>

A conference contribution “The dynamic structural response of a laminated glass balustrade analysed with optical measurements” prepared by Natalie Williams Portal (RISE), Mathias Flansbjerg (RISE), Daniel Honfi (RISE), Marcin Kozłowski was submitted to the “Engineered transparency” conference. A recent research project investigating the structural safety of self-supporting glass components aims to contribute to the development of future guidelines for architectural glazing applications. A specific task within the project was concerned with extending the current knowledge about the effect of impact loading and related testing methods regarding the safety of glass structures. The method described in the paper combines high-speed 3D-DIC and FEA to gain a deeper understanding of the dynamic structural response of self-supporting glass balustrade components, which in turn can enhance product development and user safety.

Due to the COVID-19 situation, the conference was postponed to June 2021.

The above mentioned conference contribution was based on the project report “Testing of self-supporting laminated glass balustrades” prepared by Natalie Williams Portal (RISE), Mathias Flansbjerg (RISE) and Daniel Honfi (RISE). The main goal of this project was to improve the understanding about the structural safety of self-supporting glass components. In particular, the results of the project intended to extend the current knowledge about the effect of impact and related testing methods regarding the safety of glass structures. Static and impact tests were conducted on a self-supporting glass balustrade with point-fixings. A static line load was cyclically applied to the top of the specimen to gain an understanding of the static behaviour of the glass structure and to minimize the settlement in the structure prior to applying impact loading. The specimen was subsequently subjected to dynamic loading by impact tests based on EN 12600 (pendulum impact) with different drop heights until attaining failure. The dynamic structural response of the glass balustrade was analysed by three-dimensional Digital Image Correlation (3D-DIC). This measurement technique made it possible to directly relate the measurement of any point to the specimen and to study the deformed 3D shape in detail during the impact test. The FE-analysis (FEA) conducted using SJ Mepla was found to correlate rather well with the dynamic test results particularly up to the initial peak displacement.

Link to the document:

<http://www.diva-portal.org/smash/record.jsf?pid=diva2%3A1372865&dswid=-25>

The results of the project were also included in the monography “Glass balustrades. experimental and numerical analyses, basis of design” (ISBN) written by Marcin Kozłowski and published at Silesian University of Technology. The monograph is a methodical and synthetic scientific study in the field of experimental and numerical analyses of glass balustrades protecting against falling and subjected to dynamic loading in the form of a soft-body impact with a mass of 50 kg. The work describes the current state of knowledge on the design and testing of glass elements. Subsequently, the basic information about glass necessary in the

design process is given and the current state of European regulations and standards is presented. Next, the contemporary classification of barriers and requirements resulting from norms and regulations are presented. The monography also describes the current state of knowledge on the dynamic loads generated by users of buildings and presents a review of world standards for the verification of experimental resistance of glass barriers to impact. The main part of the work is experimental research and numerical implementation of the tyre and pendulum. The current state of knowledge about the current numerical models of the pendulum is presented, as well as the methodology and results of own research. The author's own numerical model of the tyre and pendulum, validated by experimental research, is also described. The main part of the work are experimental studies of a glass balustrade subjected to a pendulum impact in the intact state and in the damage situation. An analytical algorithm for estimating the dynamic force for glass balustrades subjected to soft-body impact was proposed. The last element of the monography are author's guidelines for the design of glass balustrades with particular emphasis on dynamic loads and suggestions of the author concerning the procedure and scope of research for technical evaluation of balustrades' performance.

Withing the project two Master theses were prepared, defended and published. The first thesis "Numerical Analysis of Point-Fixed Glass Balustrades" was defended by Johan Höier and Simon Lago at the Halmstad University in Sweden. The purpose of the study was to analyze glass balustrades with point-fixings and to test a structural verification approach using a Finite Element (FE) software. Different models of varying configurations and geometries are created from the evaluation of balustrades with point-fixings available on the Swedish market and the theory. The structural analysis of point-fixed glass balustrades on the Swedish market indicated a lower stress and deflection resistance capacity than the pre-normative Eurocode criterion. Based on the FE calculations, some guidelines for fulfilling the criterion were proposed. The study suggests that the FE approach is an effective method for a relatively quick and easy verification of glass balustrades. The second thesis "Computational modelling and experimental verification of soft-body impact on glass structures" was defended by Ernest Björklund and Axel Christoffersson at the Lund University in Sweden. The purpose of this thesis was to investigate the viability of a numerical method for verifying the resistance of an arbitrary glass panel to soft-body impact. The numerical study is carried out using the finite element program Abaqus. This consisted of high-fidelity models alongside reduced models. The latter were created in an effort to reduce computational costs. To verify the results, the models are compared to data extracted from an extensive experimental campaign carried out at LTH. Both the experimental campaign and the finite element models considered a variety of glass thicknesses, both monolithic and laminated, various interlayer materials, three different fastener configurations, and five different drop heights for the pendulum impactor. For pedagogical reasons, a semi-analytical model of the glass-impactor system was also derived, yielding a damped 2DOF system. The results of the finite element simulations are in good agreement with their experimental counterparts: the stress maxima deviate by approximately 9% for the high-fidelity models, and 6% for the reduced dynamic models. The results demonstrated that numerical methods is a viable approach for designing glass structures to resist soft-body impact.

Link to the documents:

<http://hh.diva-portal.org/smash/record.jsf?pid=diva2%3A1343526&dswid=-25>,
<https://lup.lub.lu.se/student-papers/search/publication/9024292>

References

Books and articles:

Baidjoe, Y., Van Lancker, B. & Belis, J. Calculation methods of glass parapets in aluminium clamping profiles. *Glass Struct Eng* 3, 321–334 (2018)

Bedon, C., Zhang, X., Santos, F., Honfi, F. Kozłowski, M. Arrigoni, M. Figuli, L., Lange, D.: Performance of structural glass facades under extreme loads – Design methods, existing research, current issues and trends, *Construction and Building Materials* 163, 921–937 (2018)

Luigi Biolzi, Antonio Bonati, and Sara Cattaneo, “Laminated Glass Cantilevered Plates under Static and Impact Loading,” *Advances in Civil Engineering*, vol. 2018, Article ID 7874618, 11 pages, 2018.

C. W. Bostic, Architectural trends thru the looking glass, in: *Glass Performance days*, 2009, 2009

Bucak Ö.: Bauteilversuche zur Ermittlung der Schultersteifigkeit beim Anprall an Glas, Forschungsbericht, Fachhochschule München (2004)

Feldmann M, Di Biase P. The CEN-TS Structural Glass – Design and Construction Rules as pre-standard for the Eurocode. *Proceedings of Engineering Transparency*, Duesseldorf 2018:90–8.

Flodén, O, Persson, K., Sandberg, G., Reduction methods for the dynamic analysis of substructure models of lightweight building structures. *Computers and Structures*, 138, 46-61, (2014)

Fröling M., Persson K., Austrell P.E.: A reduced model for glass structures subjected to dynamic impact loads. *Proceedings of COST Action TU0905 Mid-Term Conference on Structural Glass*, 9-13 (2013)

Fröling M., Persson K., Austrell P.E.: A reduced model for the design of glass structures subjected to dynamic impulse load. *Eng. Str.* 80, 53-60 (2014)

Honfi D., Reith E., Vigh L.G., Stocker Gy.: Why glass structures fail? – Learning from failures of glass structures, *Proc. Challenging Glass 4 & COST Action TU0905 Final Conference* (2014)

P. C. Louter, Fragile yet ductile: Structural aspects of reinforced glass beams, Ph.D. thesis, TU Delft (2011).

Kozłowski, M.: Glass balustrades. Experimental and numerical analyses, basis of design, Silesian University of Technology Publishing, Gliwice (2019a), ISBN 978-83-7880-618-9

Nilsson L.: Impact Loads Produced by Human Motion, Part 1: Background and experimental investigation, Lund University, Lund (1976)

Nilsson L.: Impact loads produced by human motion, Lund University, Lund (1982)

M. Patterson, *Structural Glass Facades and Enclosures*, John Wiley & Sons Ltd, 2011

Pinto A., Reis L.: Barrier for buildings: analysis of mechanical resistance requirements, Proc. Str. Integ. 1, 281–288 (2016)

Schneider J., Festigkeit und Bemessung punktgelagerter Gläser und stoßbeanspruchter Gläser, Technische Universität Darmstadt Institut für Statik, Dissertation (2001)

Schneider J, Schula S, Burmeister A.: Zwei Verfahren zum rechnerischen Nachweis der dynamischen Beanspruchung von Verglasungen durch weichen Stoß. Stahlbau 2011; 80:81–7.

Schneider, J.: Impact Loading on Glass Panes by Soft Body Impact – Theoretical Analysis and Experimental Verification. Glass Processing Days, 18–21 June 2001, 682-687

Schuler C., Koch S., Binder M., Bucak Ö.: Comparative studies to shock loads during the construction project Zoo Wuppertal, University of Applied Sciences Munich (2005), unpublished

Ummenhofer T.: Auswertung von Anprallszenarien von Menschen auf Kraftmessdosen, Institutsbericht unveröffentlicht, Technischen Universität (2004)

Wörner J., Schneider J.: Zwischenbericht zur Durchführung von Versuchen zum weichen Stoß mit dem Pendel nach DIN EN 12600, Institut für Statik, Darmstadt (2000)

Standards and other documents:

prCEN/TS xxxx-1:2019 Design of glass structures — Part 1: Basis of design and materials (2019)

TRAV 2003 Technische Regeln für die Verwendung von absturzsichernden Verglasungen (TRAV), Fassung (2003)

DIN 18008-4 Glass in Building–Design and construction rules - Part 4: Additional requirements for barrier glazing (2013)

DIN 18008-4 Glass in Building–Design and construction rules - Part 4: Additional requirements for barrier glazing (2013)

European Parliament – Regulation (EU) No. 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC, Official Journal of the European Union, 88: pp. 5–43, 2011.

EN 1990 Eurocode - Basis of structural design

Annex I

#Nr	Date_____	Test	Glass	Int	Int	Spec	Series	Drop	Notes
#	_____	type	_____		_thk		height		
# Monolithic glass 8mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind the impactor									
001	2018.12.07	IMP	8	no_interlayer	0	1	1	100	"monolithic 8 mm ESG"
002	2018.12.07	IMP	8	no_interlayer	0	2	1	100	"monolithic 8 mm ESG"
003	2018.12.07	IMP	8	no_interlayer	0	3	1	100	"monolithic 8 mm ESG"
004	2018.12.07	IMP	8	no_interlayer	0	1	1	200	"monolithic 8 mm ESG"
005	2018.12.07	IMP	8	no_interlayer	0	2	1	200	"monolithic 8 mm ESG"
006	2018.12.07	IMP	8	no_interlayer	0	3	1	200	"monolithic 8 mm ESG"
007	2018.12.07	IMP	8	no_interlayer	0	4	1	200	"monolithic 8 mm ESG"
008	2018.12.07	IMP	8	no_interlayer	0	5	1	200	"monolithic 8 mm ESG"
009	2018.12.07	IMP	8	no_interlayer	0	1	1	300	"monolithic 8 mm ESG"
010	2018.12.07	IMP	8	no_interlayer	0	2	1	300	"monolithic 8 mm ESG"
011	2018.12.07	IMP	8	no_interlayer	0	3	1	300	"monolithic 8 mm ESG"
012	2018.12.07	IMP	8	no_interlayer	0	4	1	300	"monolithic 8 mm ESG"
013	2018.12.07	IMP	8	no_interlayer	0	1	1	400	"monolithic 8 mm ESG"
014	2018.12.07	IMP	8	no_interlayer	0	2	1	400	"monolithic 8 mm ESG"
015	2018.12.07	IMP	8	no_interlayer	0	3	1	400	"monolithic 8 mm ESG"
016	2018.12.07	IMP	8	no_interlayer	0	1	1	500	"monolithic 8 mm ESG"
017	2018.12.07	IMP	8	no_interlayer	0	2	1	500	"monolithic 8 mm ESG"
018	2018.12.07	IMP	8	no_interlayer	0	3	1	500	"monolithic 8 mm ESG"
019	2018.12.07	IMP	8	no_interlayer	0	1	1	800	"monolithic 8 mm ESG"
020	2018.12.07	IMP	8	no_interlayer	0	1	1	800	"monolithic 8 mm ESG"

Monolithic glass 10mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind the impactor

021	2018.12.07	IMP	10	no_interlayer	0	1	1	100	"monolithic 10 mm ESG"
022	2018.12.07	IMP	10	no_interlayer	0	2	1	100	"monolithic 10 mm ESG"
023	2018.12.07	IMP	10	no_interlayer	0	3	1	100	"monolithic 10 mm ESG"
024	2018.12.07	IMP	10	no_interlayer	0	1	1	200	"monolithic 10 mm ESG"
025	2018.12.07	IMP	10	no_interlayer	0	2	1	200	"monolithic 10 mm ESG"
026	2018.12.07	IMP	10	no_interlayer	0	3	1	200	"monolithic 10 mm ESG"
027	2018.12.07	IMP	10	no_interlayer	0	1	1	300	"monolithic 10 mm ESG"
028	2018.12.07	IMP	10	no_interlayer	0	2	1	300	"monolithic 10 mm ESG"
#029	2018.12.07	IMP	10	no_interlayer	0	3	1	300	"no file dyn"
030	2018.12.07	IMP	10	no_interlayer	0	1	1	400	"monolithic 10 mm ESG"
031	2018.12.07	IMP	10	no_interlayer	0	2	1	400	"monolithic 10 mm ESG"
032	2018.12.07	IMP	10	no_interlayer	0	3	1	400	"monolithic 10 mm ESG"
033	2018.12.07	IMP	10	no_interlayer	0	4	1	400	"monolithic 10 mm ESG"
034	2018.12.07	IMP	10	no_interlayer	0	1	1	500	"monolithic 10 mm ESG"
035	2018.12.07	IMP	10	no_interlayer	0	2	1	500	"monolithic 10 mm ESG"
036	2018.12.07	IMP	10	no_interlayer	0	3	1	500	"monolithic 10 mm ESG"
037	2018.12.07	IMP	10	no_interlayer	0	4	1	500	"monolithic 10 mm ESG"
038	2018.12.07	IMP	10	no_interlayer	0	5	1	500	"monolithic 10 mm ESG"

Monolithic glass 12mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind the impactor

039	2018.12.07	IMP	12	no_interlayer	0	1	1	100	"monolithic 12 mm ESG"
040	2018.12.07	IMP	12	no_interlayer	0	2	1	100	"monolithic 12 mm ESG"
041	2018.12.07	IMP	12	no_interlayer	0	3	1	100	"monolithic 12 mm ESG"
042	2018.12.07	IMP	12	no_interlayer	0	1	1	200	"monolithic 12 mm ESG"
043	2018.12.07	IMP	12	no_interlayer	0	2	1	200	"monolithic 12 mm ESG"

044	2018.12.07	IMP	12	no_interlayer	0	3	1	200	"monolithic 12 mm ESG"
045	2018.12.07	IMP	12	no_interlayer	0	1	1	300	"monolithic 12 mm ESG"
046	2018.12.07	IMP	12	no_interlayer	0	2	1	300	"monolithic 12 mm ESG"
047	2018.12.07	IMP	12	no_interlayer	0	3	1	300	"monolithic 12 mm ESG"
048	2018.12.07	IMP	12	no_interlayer	0	4	1	300	"monolithic 12 mm ESG"
049	2018.12.07	IMP	12	no_interlayer	0	5	1	300	"monolithic 12 mm ESG"
050	2018.12.07	IMP	12	no_interlayer	0	1	1	400	"monolithic 12 mm ESG"
051	2018.12.07	IMP	12	no_interlayer	0	2	2	400	"monolithic 12 mm ESG"
052	2018.12.07	IMP	12	no_interlayer	0	3	3	400	"monolithic 12 mm ESG"
053	2018.12.07	IMP	12	no_interlayer	0	4	4	400	"monolithic 12 mm ESG"
054	2018.12.07	IMP	12	no_interlayer	0	1	4	500	"monolithic 12 mm ESG"
055	2018.12.07	IMP	12	no_interlayer	0	2	4	500	"monolithic 12 mm ESG"
056	2018.12.07	IMP	12	no_interlayer	0	3	4	500	"monolithic 12 mm ESG"

Laminated glass 88.2mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind teh impactor

057	2018.12.07	TVG	88.2	TVG	1.52	1	1	100	"laminated 88.2 TVG PVB"
058	2018.12.07	TVG	88.2	TVG	1.52	2	1	100	"laminated 88.2 TVG PVB"
059	2018.12.07	TVG	88.2	TVG	1.52	3	1	100	"laminated 88.2 TVG PVB"
060	2018.12.07	TVG	88.2	TVG	1.52	1	1	200	"laminated 88.2 TVG PVB"
061	2018.12.07	TVG	88.2	TVG	1.52	2	1	200	"laminated 88.2 TVG PVB"
062	2018.12.07	TVG	88.2	TVG	1.52	3	1	200	"laminated 88.2 TVG PVB"
063	2018.12.07	TVG	88.2	TVG	1.52	1	1	300	"laminated 88.2 TVG PVB"
064	2018.12.07	TVG	88.2	TVG	1.52	2	1	300	"laminated 88.2 TVG PVB"
065	2018.12.07	TVG	88.2	TVG	1.52	3	1	300	"laminated 88.2 TVG PVB"
066	2018.12.07	TVG	88.2	TVG	1.52	4	1	300	"laminated 88.2 TVG PVB"

067 PVB"	2018.12.07	TVG	88.2	TVG	1.52	1	1	400	"laminated 88.2 TVG
068 PVB"	2018.12.07	TVG	88.2	TVG	1.52	2	1	400	"laminated 88.2 TVG
069 PVB"	2018.12.07	TVG	88.2	TVG	1.52	3	1	400	"laminated 88.2 TVG
070 PVB"	2018.12.07	TVG	88.2	TVG	1.52	1	1	500	"laminated 88.2 TVG
071 PVB"	2018.12.07	TVG	88.2	TVG	1.52	2	1	500	"laminated 88.2 TVG
072 PVB"	2018.12.07	TVG	88.2	TVG	1.52	3	1	500	"laminated 88.2 TVG
073 PVB"	2018.12.07	TVG	88.2	TVG	1.52	4	1	500	"laminated 88.2 TVG
074 PVB,Cracked glass at impactor side"	2018.12.07	TVG	88.2	TVG	1.52	1	1	100	"laminated 88.2 TVG
075 PVB,Cracked glass at impactor side"	2018.12.07	TVG	88.2	TVG	1.52	1	1	200	"laminated 88.2 TVG
076 PVB,Cracked glass at impactor side"	2018.12.07	TVG	88.2	TVG	1.52	1	1	300	"laminated 88.2 TVG
077 PVB,Cracked glass at impactor side"	2018.12.07	TVG	88.2	TVG	1.52	1	1	400	"laminated 88.2 TVG
078 PVB,Cracked glass at impactor side"	2018.12.07	TVG	88.2	TVG	1.52	1	1	500	"laminated 88.2 TVG
079 PVB,Cracked glass opposite to impactor side, TAKE ONLY STRAIN, check raw files!"	2018.12.07	TVG	88.2	TVG	1.52	1	1	100	"laminated 88.2 TVG
080 PVB,Cracked glass opposite to impactor side, TAKE ONLY STRAIN"	2018.12.07	TVG	88.2	TVG	1.52	1	1	200	"laminated 88.2 TVG
# Laminated glass 88.2mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind teh impactor									
081 PVB"	2018.12.07	ESG	88.2	PVB	1.52	1	1	100	"laminated 88.2 ESG
082 PVB"	2018.12.07	ESG	88.2	PVB	1.52	2	1	100	"laminated 88.2 ESG
083 PVB"	2018.12.07	ESG	88.2	PVB	1.52	3	1	100	"laminated 88.2 ESG
084 PVB"	2018.12.07	ESG	88.2	PVB	1.52	1	1	200	"laminated 88.2 ESG
085 PVB"	2018.12.07	ESG	88.2	PVB	1.52	2	1	200	"laminated 88.2 ESG
086 PVB"	2018.12.07	ESG	88.2	PVB	1.52	3	1	200	"laminated 88.2 ESG
087 PVB"	2018.12.07	ESG	88.2	PVB	1.52	4	1	200	"laminated 88.2 ESG
088 PVB"	2018.12.07	ESG	88.2	PVB	1.52	1	1	300	"laminated 88.2 ESG
089 PVB"	2018.12.07	ESG	88.2	PVB	1.52	2	1	300	"laminated 88.2 ESG

090 PVB"	2018.12.07	ESG	88.2	PVB	1.52	3	1	300	"laminated 88.2 ESG
091 PVB"	2018.12.07	ESG	88.2	PVB	1.52	1	1	400	"laminated 88.2 ESG
092	2018.12.07	ESG	88.2	PVB	1.52	2	1	400	"laminated 88.2 ESG PVB"
093 PVB"	2018.12.07	ESG	88.2	PVB	1.52	3	1	400	"laminated 88.2 ESG
094 PVB"	2018.12.07	ESG	88.2	PVB	1.52	1	1	500	"laminated 88.2 ESG
095 PVB"	2018.12.07	ESG	88.2	PVB	1.52	2	1	500	"laminated 88.2 ESG
096 PVB"	2018.12.07	ESG	88.2	PVB	1.52	3	1	500	"laminated 88.2 ESG
097 PVB,cracked glass on pendulum side"	2018.12.07	ESG	88.2	PVB	1.52	1	1	100	"laminated 88.2 ESG
098 PVB,cracked glass on pendulum side"	2018.12.07	ESG	88.2	PVB	1.52	1	1	200	"laminated 88.2 ESG
099 PVB,cracked glass on pendulum side"	2018.12.07	ESG	88.2	PVB	1.52	1	1	300	"laminated 88.2 ESG
100 PVB,cracked glass on pendulum side"	2018.12.07	ESG	88.2	PVB	1.52	1	1	400	"laminated 88.2 ESG
101 PVB,cracked glass on pendulum side"	2018.12.07	ESG	88.2	PVB	1.52	1	1	500	"laminated 88.2 ESG

Laminated glass 88.1mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind teh impactor

110 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	100	"laminated 88.1 ESG
111 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	100	"laminated 88.1 ESG
112 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	100	"laminated 88.1 ESG
113 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	200	"laminated 88.1 ESG
114 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	200	"laminated 88.1 ESG
115 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	200	"laminated 88.1 ESG
116 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	300	"laminated 88.1 ESG
117 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	300	"laminated 88.1 ESG
118 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	300	"laminated 88.1 ESG
119 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	400	"laminated 88.1 ESG
120 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	400	"laminated 88.1 ESG
121 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	400	"laminated 88.1 ESG

122 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	500	"laminated 88.1 ESG
122 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	500	"laminated 88.1 ESG
124 SGP"	2018.12.07	ESG	88.1	SGP	0.76	1	1	500	"laminated 88.1 ESG
125 SGP,cracked glass on pendulum side"	2018.12.07	ESG	88.1	SGP	0.76	1	1	100	"laminated 88.1 ESG
126 SGP,cracked glass on pendulum side"	2018.12.07	ESG	88.1	SGP	0.76	1	1	200	"laminated 88.1 ESG
127 SGP,cracked glass on pendulum side"	2018.12.07	ESG	88.1	SGP	0.76	1	1	300	"laminated 88.1 ESG
128 SGP,cracked glass on pendulum side"	2018.12.07	ESG	88.1	SGP	0.76	1	1	400	"laminated 88.1 ESG
129 SGP,cracked glass on pendulum side"	2018.12.07	ESG	88.1	SGP	0.76	1	1	500	"laminated 88.1 ESG

Laminated glass 88.1mm supported at vertical edges, hit location (centre), strain gauge mounted horizontally right behind teh impactor

130 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	100	"laminated 88.1 TVG
131 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	100	"laminated 88.1 TVG
132 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	100	"laminated 88.1 TVG
133 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	200	"laminated 88.1 TVG
134 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	200	"laminated 88.1 TVG
135 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	200	"laminated 88.1 TVG
136 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	300	"laminated 88.1 TVG
137 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	300	"laminated 88.1 TVG
138 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	300	"laminated 88.1 TVG
139 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	400	"laminated 88.1 TVG
140 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	400	"laminated 88.1 TVG
141 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	400	"laminated 88.1 TVG
142 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	500	"laminated 88.1 TVG
143 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	500	"laminated 88.1 TVG
144 SGP"	2018.12.07	TVG	88.1	SGP	0.76	1	1	500	"laminated 88.1 TVG

145	2018.12.07	TVG	88.1	SGP	0.76	1	1	100	"laminated 88.1 TVG SGP,cracked glass on pendulum side"
146	2018.12.07	TVG	88.1	SGP	0.76	1	1	200	"laminated 88.1 TVG SGP,cracked glass on pendulum side"
147	2018.12.07	TVG	88.1	SGP	0.76	1	1	300	"laminated 88.1 TVG SGP,cracked glass on pendulum side"
148	2018.12.07	TVG	88.1	SGP	0.76	1	1	400	"laminated 88.1 TVG SGP,cracked glass on pendulum side"
149	2018.12.07	TVG	88.1	SGP	0.76	1	1	500	"laminated 88.1 TVG SGP,cracked glass on pendulum side"
150	2018.12.07	TVG	88.1	SGP	0.76	1	1	100	"laminated 88.1 TVG SGP,cracked glass on glass side"
# Laminated glass, point fixings d=50mm, 55.2mm, hit location (centre), strain gauge mounted horizontally right behind the impactor									
151	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated point-fixed 55.2 ESG PVB"
152	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated point-fixed 55.2 ESG PVB"
153	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated point-fixed 55.2 ESG PVB"
154	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated point-fixed 55.2 ESG PVB"
155	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated point-fixed 55.2 ESG PVB"
156	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated point-fixed 55.2 ESG PVB"
157	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated point-fixed 55.2 ESG PVB"
158	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated point-fixed 55.2 ESG PVB"
159	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated point-fixed 55.2 ESG PVB"
160	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated point-fixed 55.2 ESG PVB"
161	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated point-fixed 55.2 ESG PVB"
162	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated point-fixed 55.2 ESG PVB"
163	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated point-fixed 55.2 ESG PVB"
164	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated point-fixed 55.2 ESG PVB"
165	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated point-fixed 55.2 ESG PVB"
167	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"
168	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"

169	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"
170	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"

IGU, 5/16/5, hit location (centre), strain gauge mounted horizontally right behind the impactor

171	2018.12.07	ESG	5.16.5	na	0.00	1	1	100	"IGU, 5/16/5 ESG"
172	2018.12.07	ESG	5.16.5	na	0.00	1	1	100	"IGU, 5/16/5 ESG"
173	2018.12.07	ESG	5.16.5	na	0.00	1	1	100	"IGU, 5/16/5 ESG"
174	2018.12.07	ESG	5.16.5	na	0.00	1	1	200	"IGU, 5/16/5 ESG"
175	2018.12.07	ESG	5.16.5	na	0.00	1	1	200	"IGU, 5/16/5 ESG"
176	2018.12.07	ESG	5.16.5	na	0.00	1	1	200	"IGU, 5/16/5 ESG"
177	2018.12.07	ESG	5.16.5	na	0.00	1	1	300	"IGU, 5/16/5 ESG"
178	2018.12.07	ESG	5.16.5	na	0.00	1	1	300	"IGU, 5/16/5 ESG"
179	2018.12.07	ESG	5.16.5	na	0.00	1	1	300	"IGU, 5/16/5 ESG"
180	2018.12.07	ESG	5.16.5	na	0.00	1	1	300	"IGU, 5/16/5 ESG"
181	2018.12.07	ESG	5.16.5	na	0.00	1	1	400	"IGU, 5/16/5 ESG"
182	2018.12.07	ESG	5.16.5	na	0.00	1	1	400	"IGU, 5/16/5 ESG"
183	2018.12.07	ESG	5.16.5	na	0.00	1	1	400	"IGU, 5/16/5 ESG"
184	2018.12.07	ESG	5.16.5	na	0.00	1	1	500	"IGU, 5/16/5 ESG,specimen broke on pendulum side"

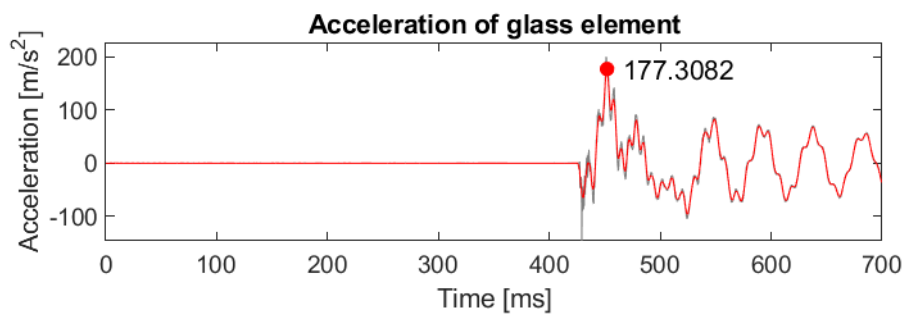
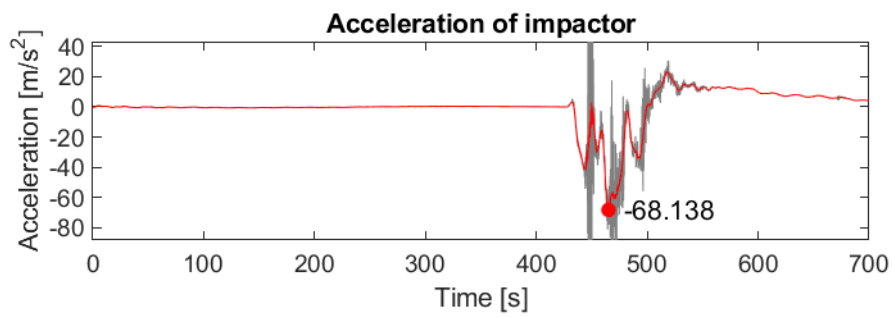
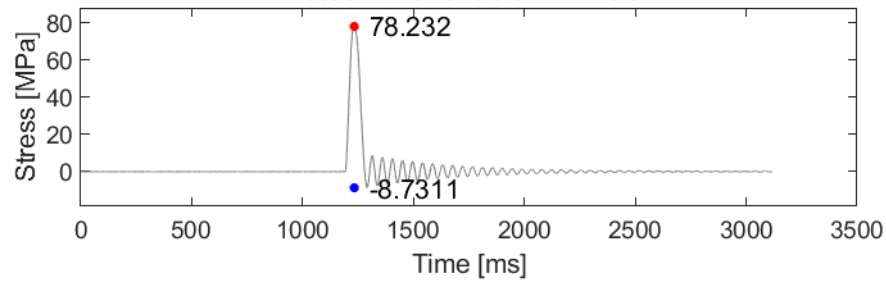
IGU, 55.2/16/5, hit location (centre), strain gauge mounted horizontally right behind the impactor

185	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	100	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
186	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	100	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
187	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	100	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
188	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	200	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
189	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	200	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
190	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	200	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
191	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	300	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
192	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	300	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
193	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	300	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
194	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	400	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
195	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	400	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
196	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	400	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"

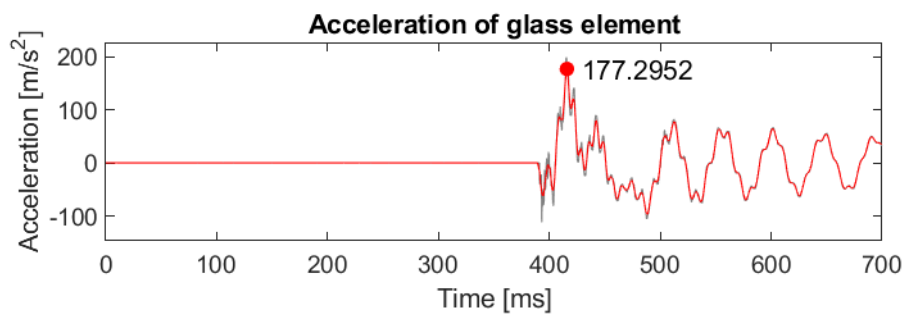
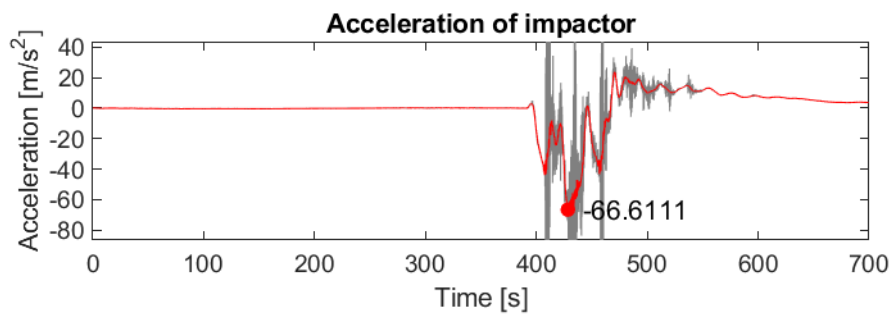
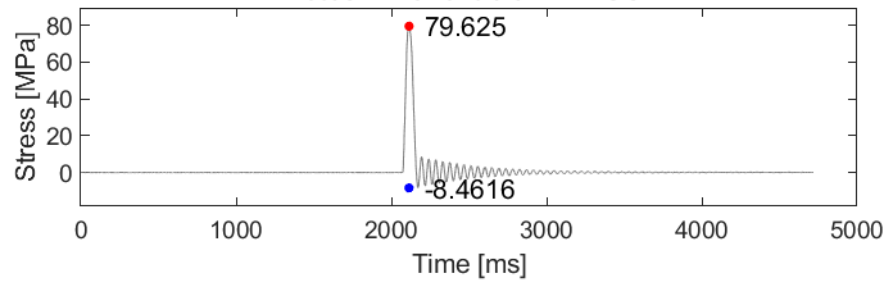
197	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	500	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
198	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	500	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
199	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	500	"IGU, 55.2/16/5 ESG PVB, laminated on pend side"
201	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	100	"IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"
202	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	200	"IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"
203	2018.12.07	ESG	5.16.5	PVB	1.52	1	1	300	"IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"
# Laminated glass, clamp fixings, 55.2mm, hit location (centre), strain gauge mounted horizontally right behind the impactor									
204	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp-fixed 55.2 ESG PVB"
205	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp-fixed 55.2 ESG PVB"
206	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp-fixed 55.2 ESG PVB"
207	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated clamp-fixed 55.2 ESG PVB"
208	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated clamp-fixed 55.2 ESG PVB"
209	2018.12.07	ESG	55.2	PVB	1.52	1	1	200	"laminated clamp-fixed 55.2 ESG PVB"
210	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated clamp-fixed 55.2 ESG PVB"
211	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated clamp-fixed 55.2 ESG PVB"
212	2018.12.07	ESG	55.2	PVB	1.52	1	1	300	"laminated clamp-fixed 55.2 ESG PVB"
213	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated clamp-fixed 55.2 ESG PVB"
214	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated clamp-fixed 55.2 ESG PVB"
215	2018.12.07	ESG	55.2	PVB	1.52	1	1	400	"laminated clamp-fixed 55.2 ESG PVB"
216	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated clamp-fixed 55.2 ESG PVB"
217	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated clamp-fixed 55.2 ESG PVB"
218	2018.12.07	ESG	55.2	PVB	1.52	1	1	500	"laminated clamp-fixed 55.2 ESG PVB"
220	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp-fixed 55.2 ESG PVB,cracked glass on pendulum side"
221	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp-fixed 55.2 ESG PVB,cracked glass on pendulum side"

222	2018.12.07	ESG	55.2	PVB	1.52	1	1	100	"laminated clamp- fixed 55.2 ESG PVB,cracked glass on pendulum side"
-----	------------	-----	------	-----	------	---	---	-----	---

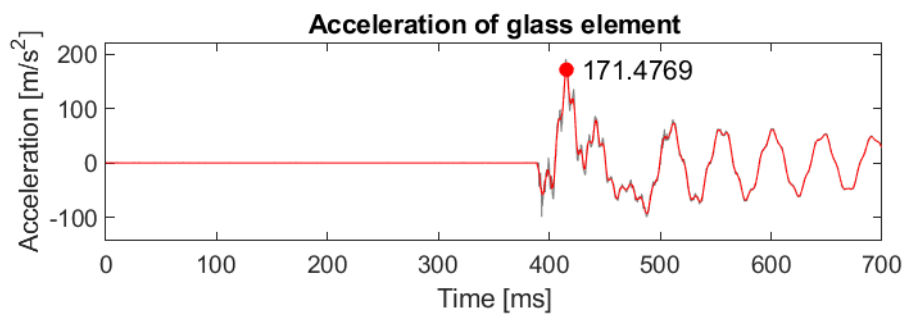
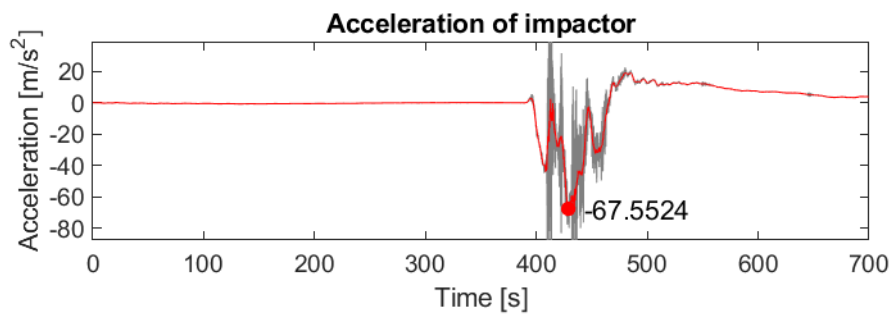
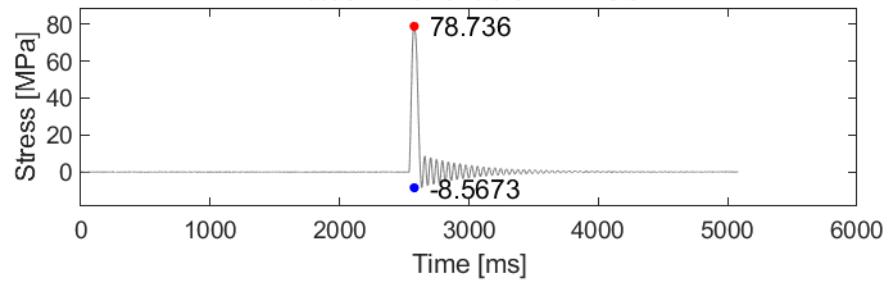
Data nr: 001
Glass: 8mm
Drop height: 100mm
Notes: "monolithic 8 mm ESG"



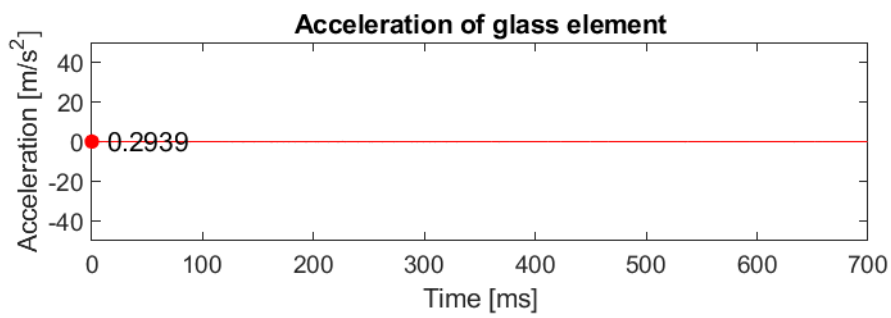
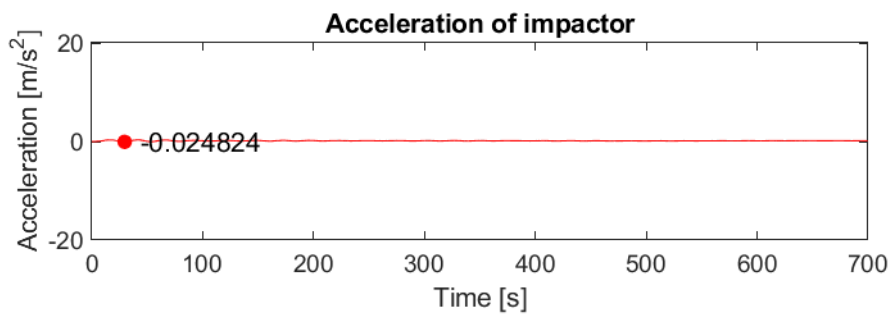
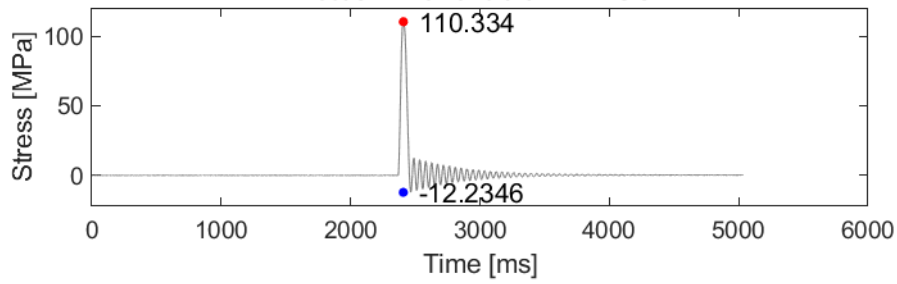
Data nr: 002
Glass: 8mm
Drop height: 100mm
Notes: "monolithic 8 mm ESG"



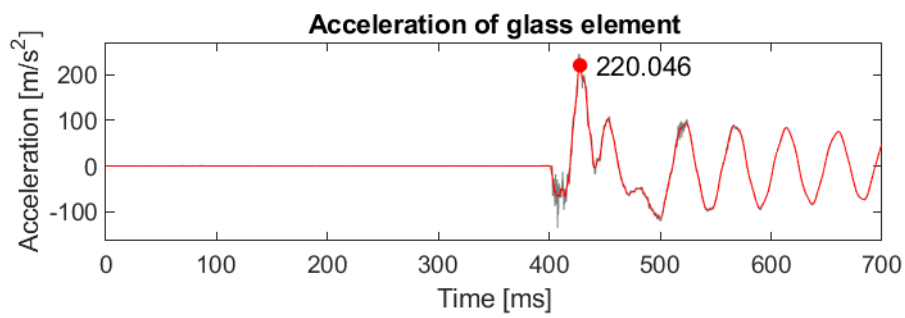
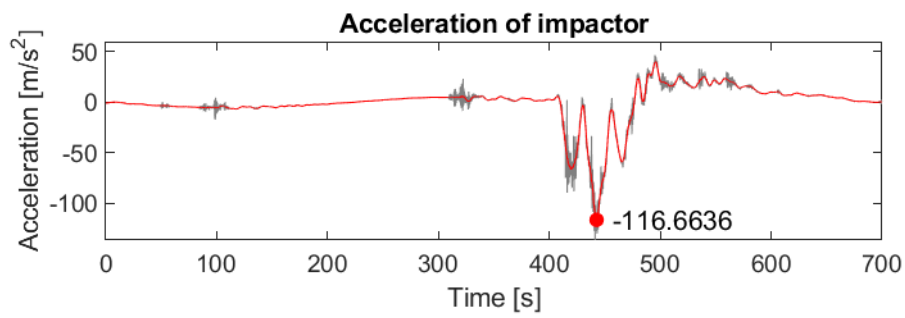
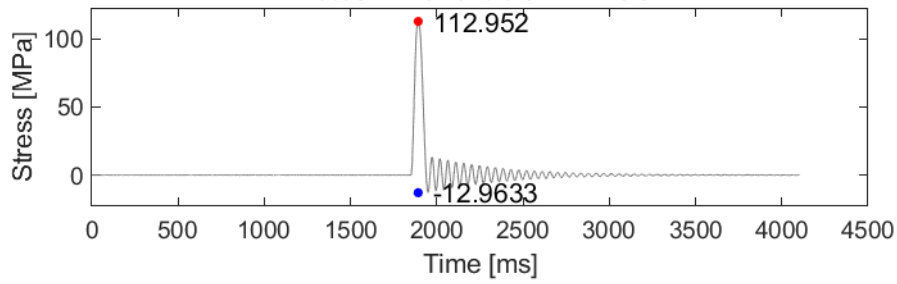
Data nr: 003
Glass: 8mm
Drop height: 100mm
Notes: "monolithic 8 mm ESG"



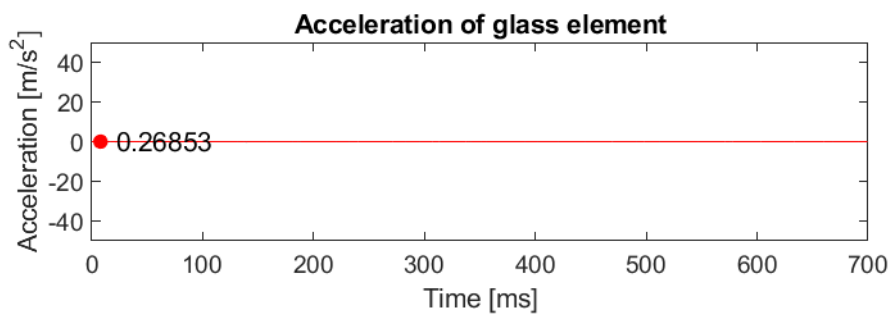
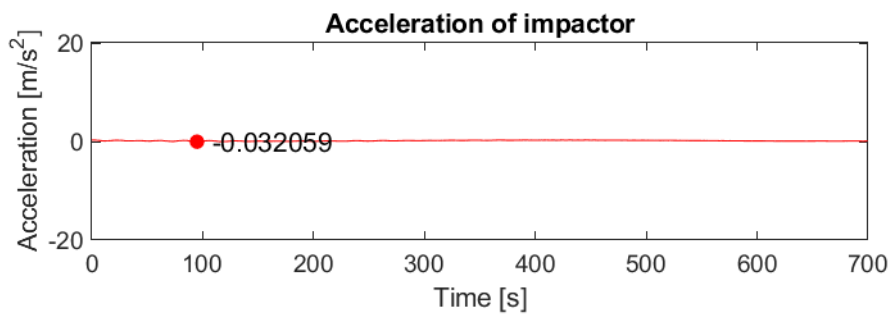
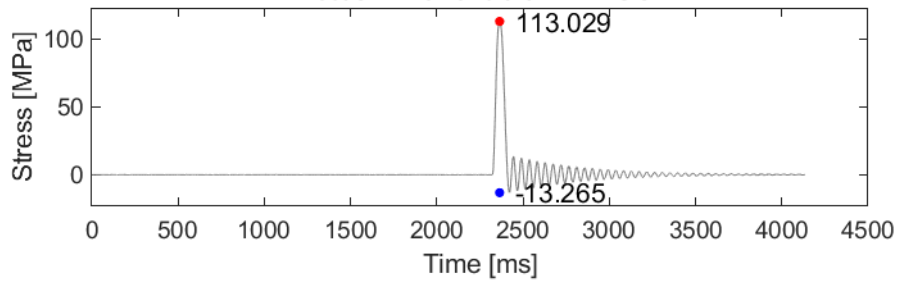
Data nr: 004
Glass: 8mm
Drop height: 200mm
Notes: "monolithic 8 mm ESG"



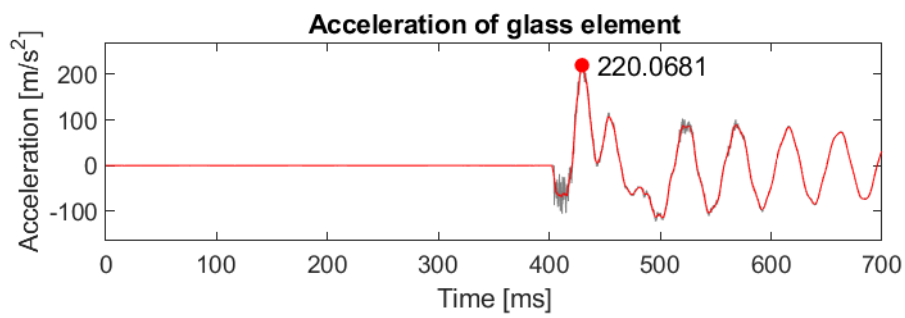
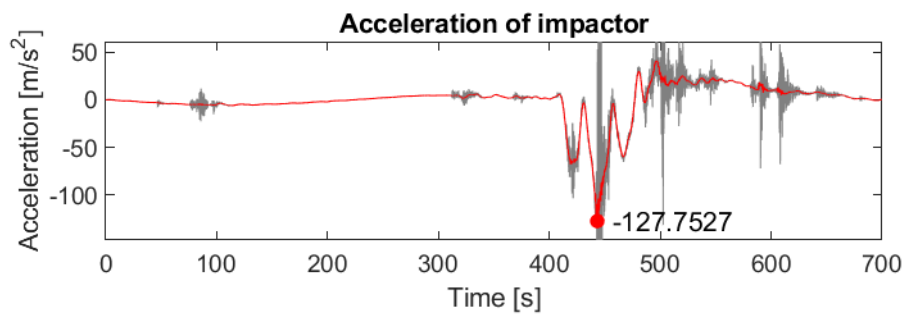
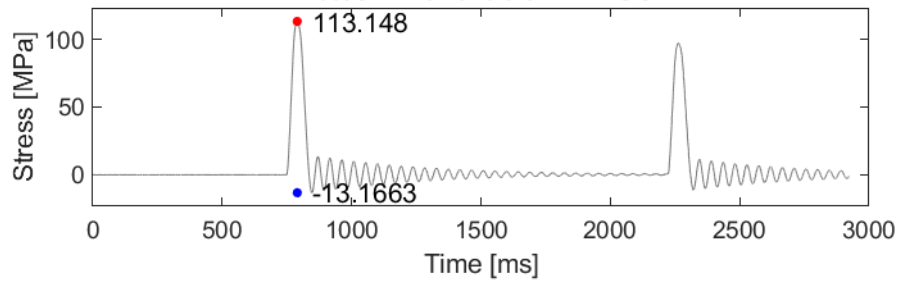
Data nr: 005
Glass: 8mm
Drop height: 200mm
Notes: "monolithic 8 mm ESG"



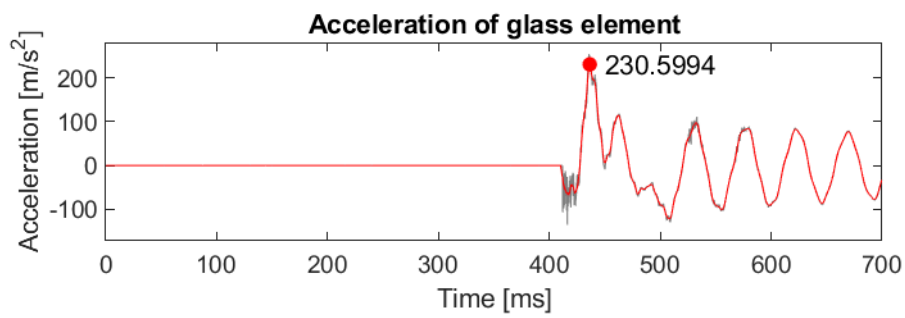
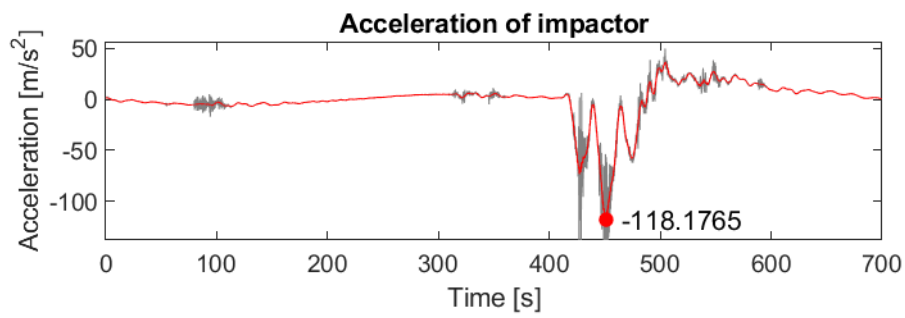
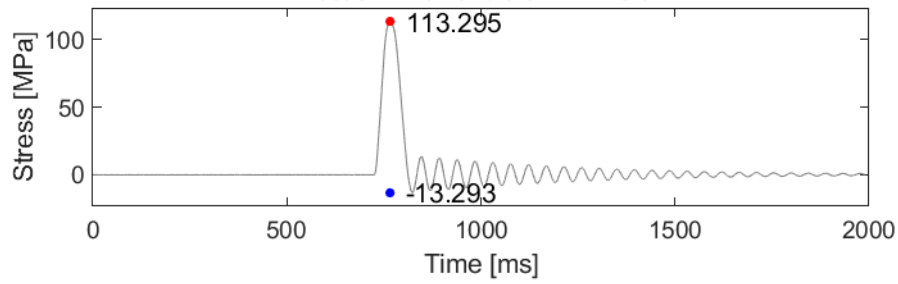
Data nr: 006
Glass: 8mm
Drop height: 200mm
Notes: "monolithic 8 mm ESG"



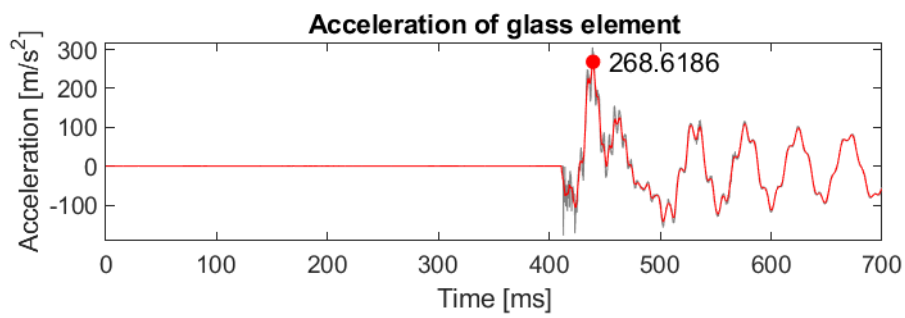
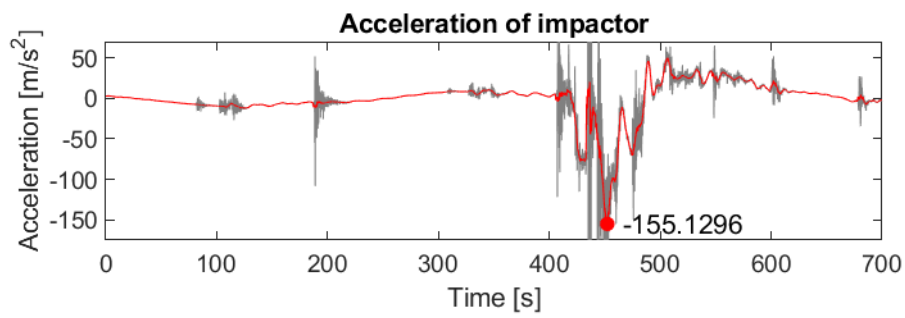
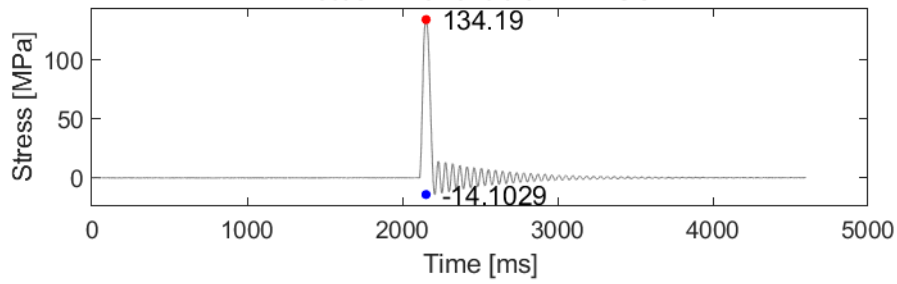
Data nr: 007
Glass: 8mm
Drop height: 200mm
Notes: "monolithic 8 mm ESG"



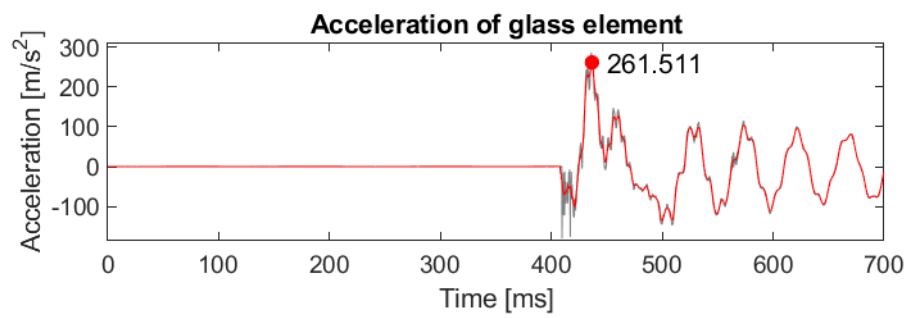
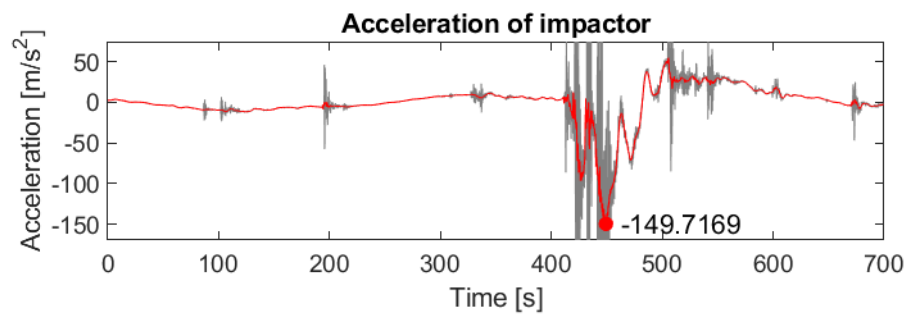
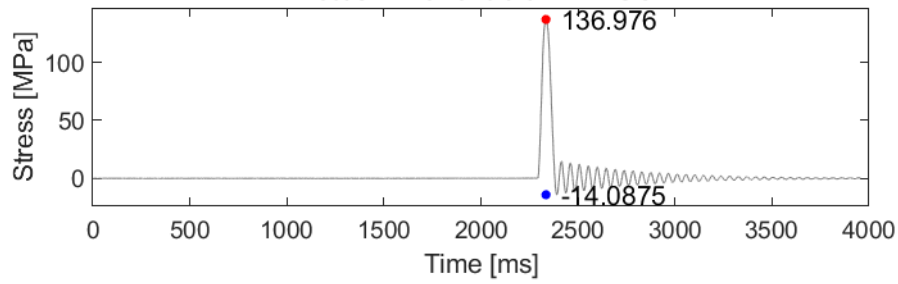
Data nr: 008
Glass: 8mm
Drop height: 200mm
Notes: "monolithic 8 mm ESG"



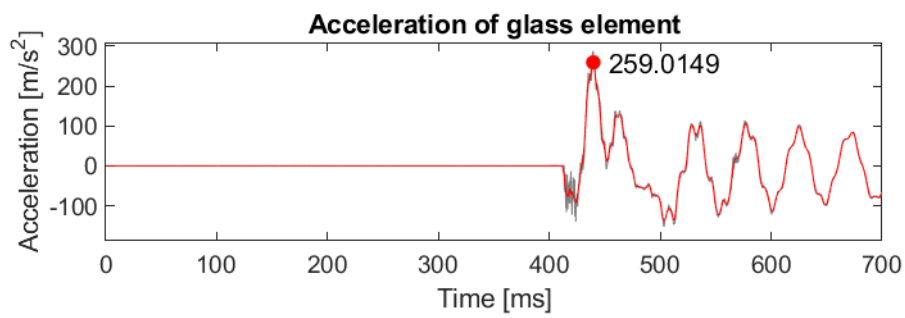
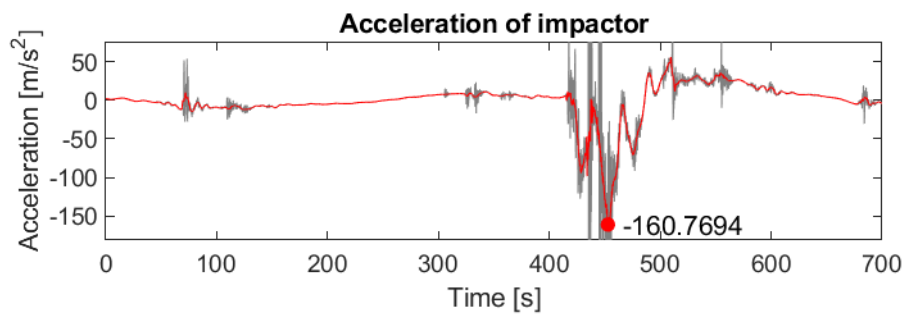
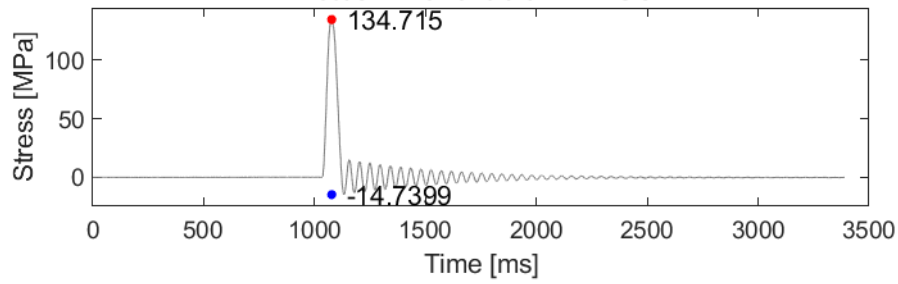
Data nr: 009
Glass: 8mm
Drop height: 300mm
Notes: "monolithic 8 mm ESG"



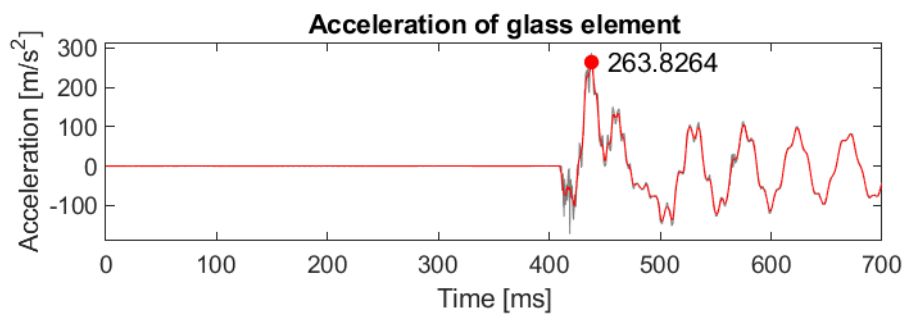
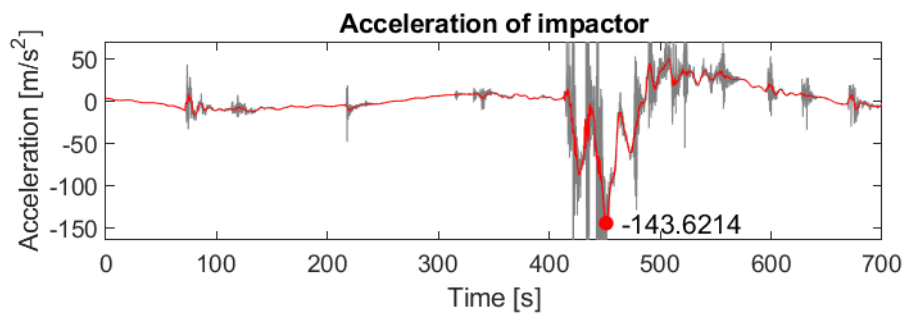
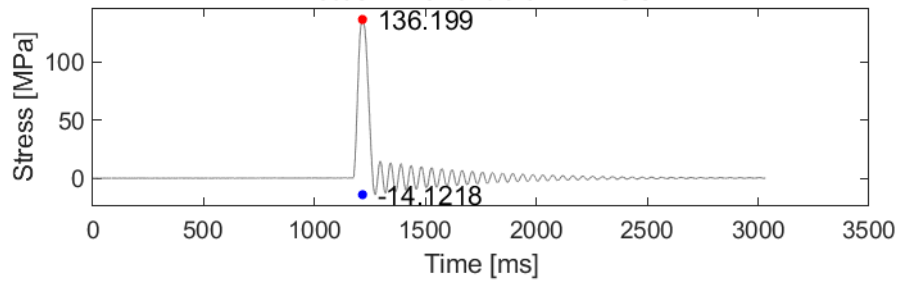
Data nr: 010
Glass: 8mm
Drop height: 300mm
Notes: "monolithic 8 mm ESG"



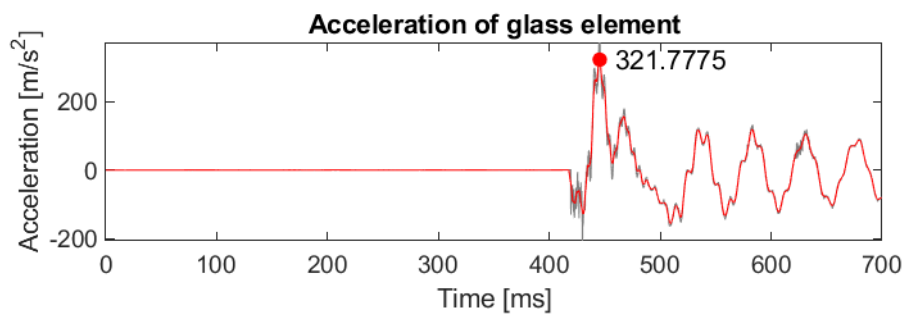
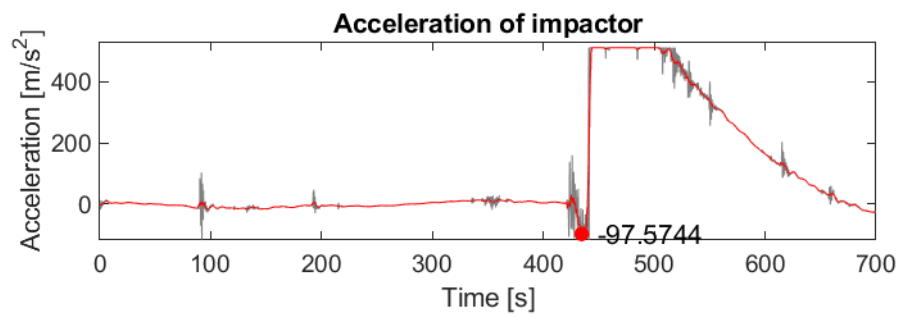
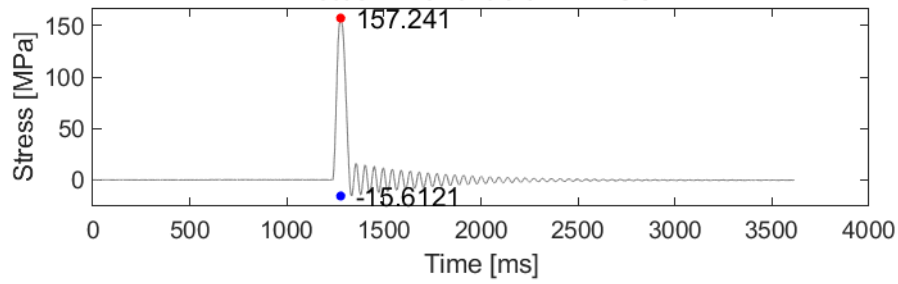
Data nr: 011
Glass: 8mm
Drop height: 300mm
Notes: "monolithic 8 mm ESG"



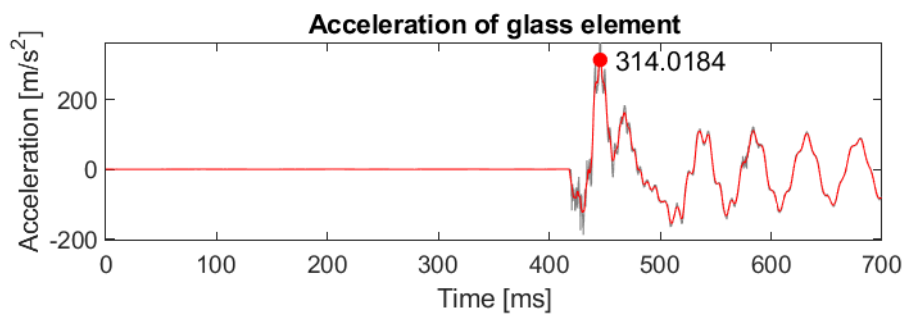
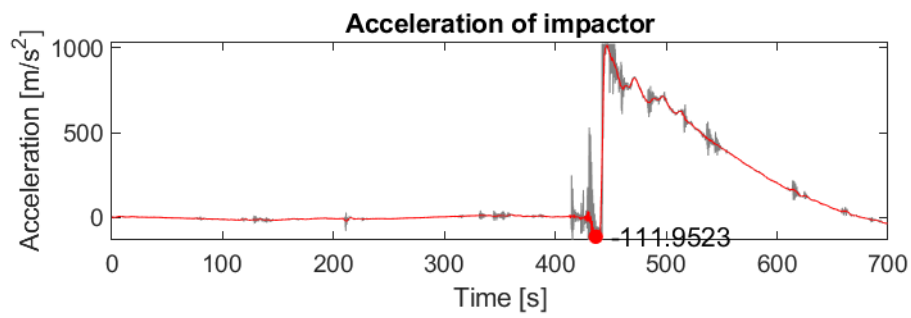
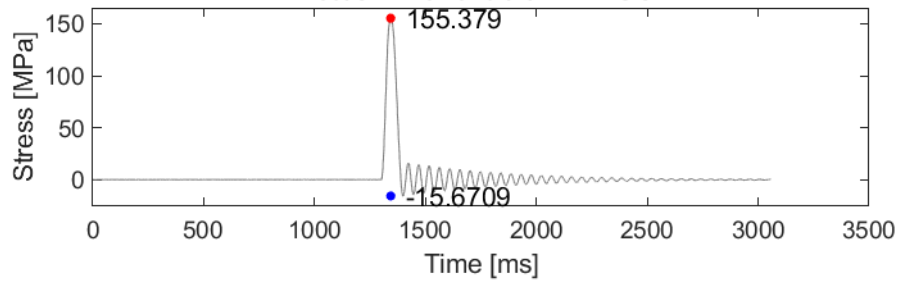
Data nr: 012
Glass: 8mm
Drop height: 300mm
Notes: "monolithic 8 mm ESG"



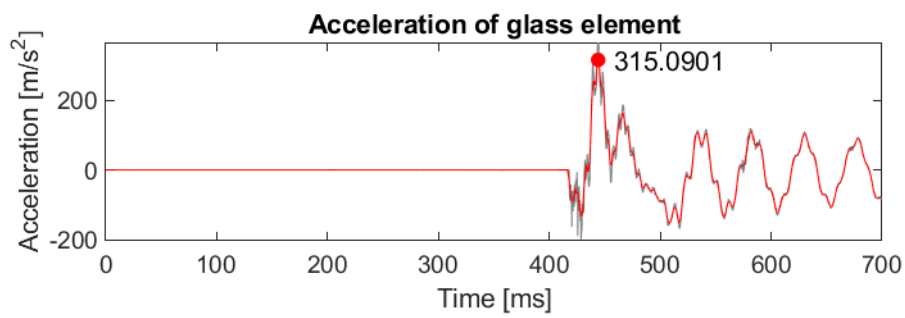
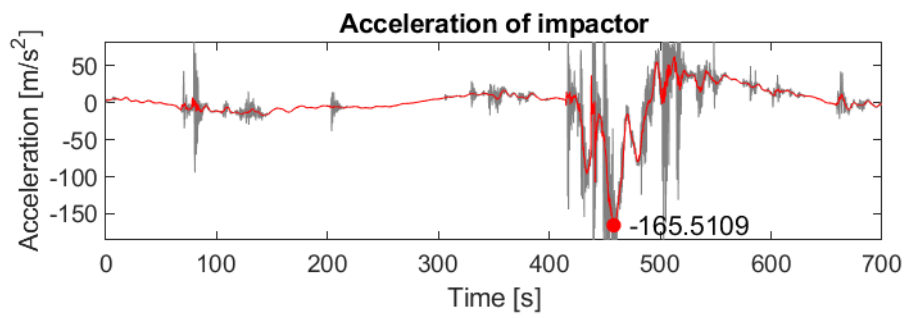
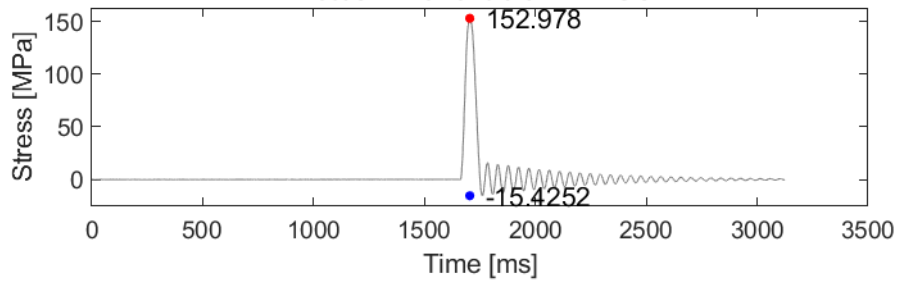
Data nr: 013
Glass: 8mm
Drop height: 400mm
Notes: "monolithic 8 mm ESG"



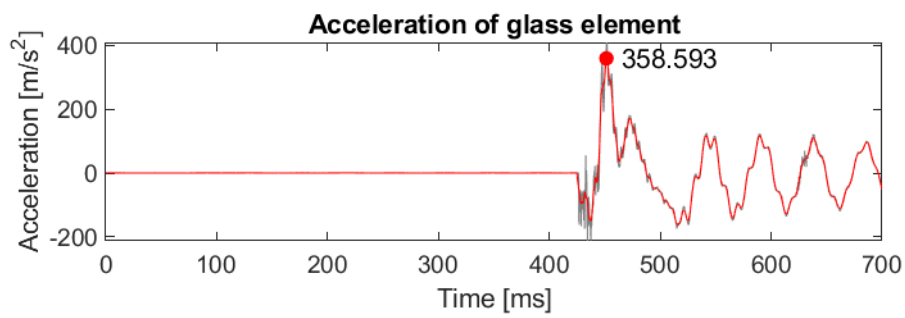
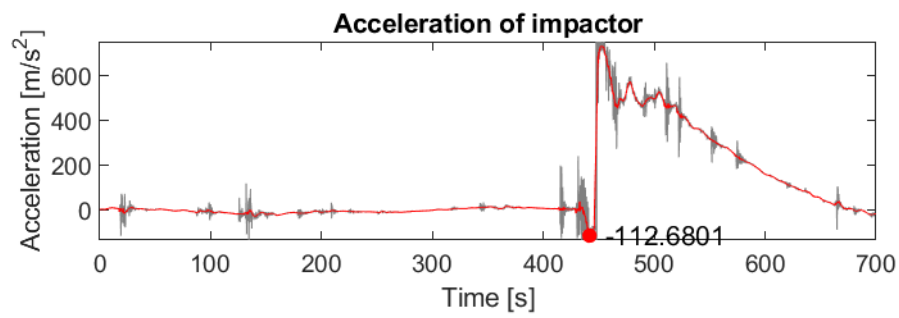
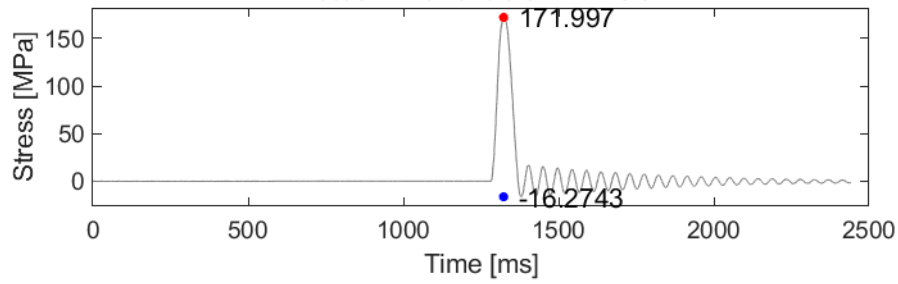
Data nr: 014
Glass: 8mm
Drop height: 400mm
Notes: "monolithic 8 mm ESG"

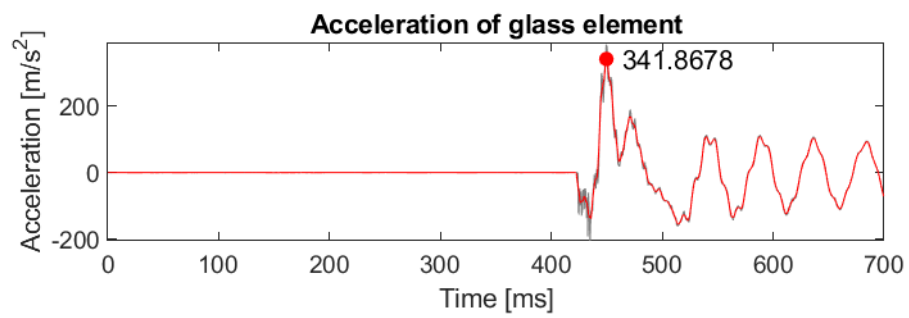
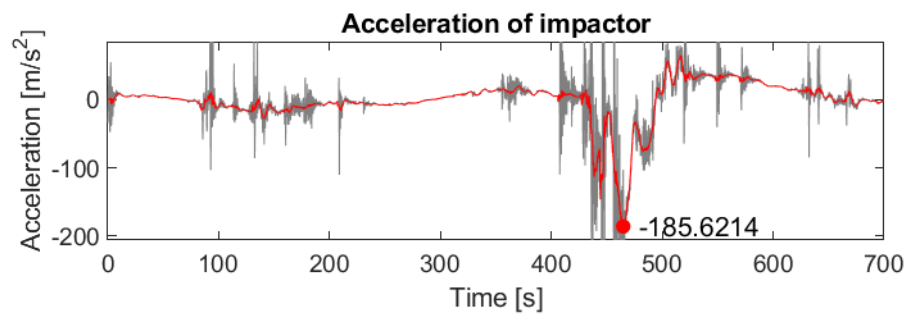
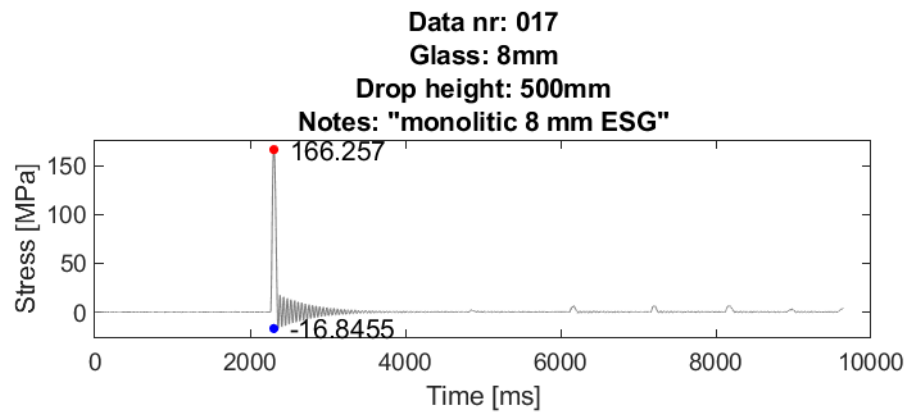


Data nr: 015
Glass: 8mm
Drop height: 400mm
Notes: "monolithic 8 mm ESG"

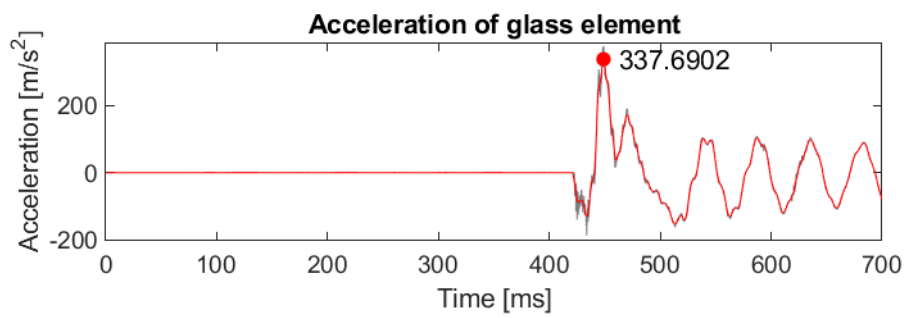
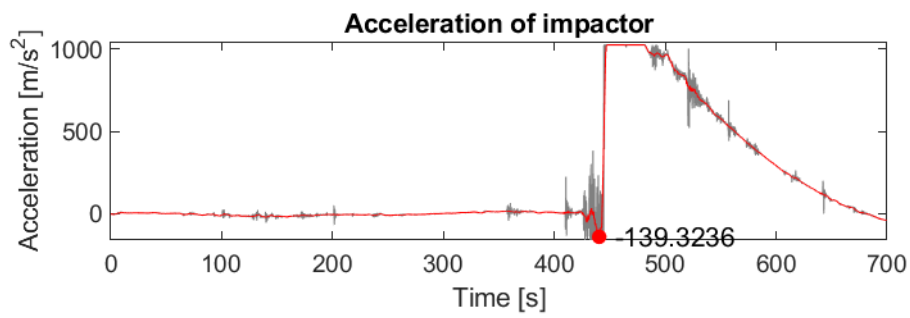
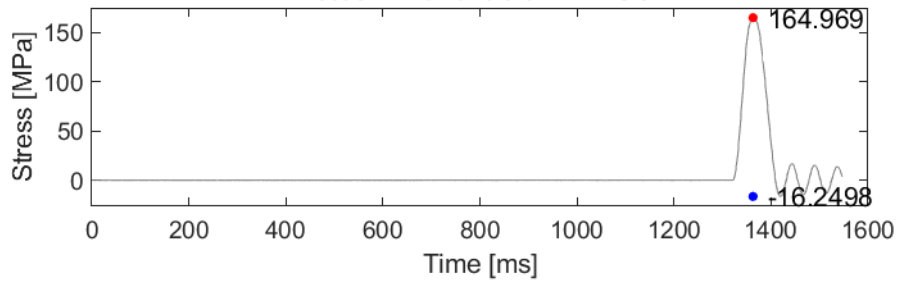


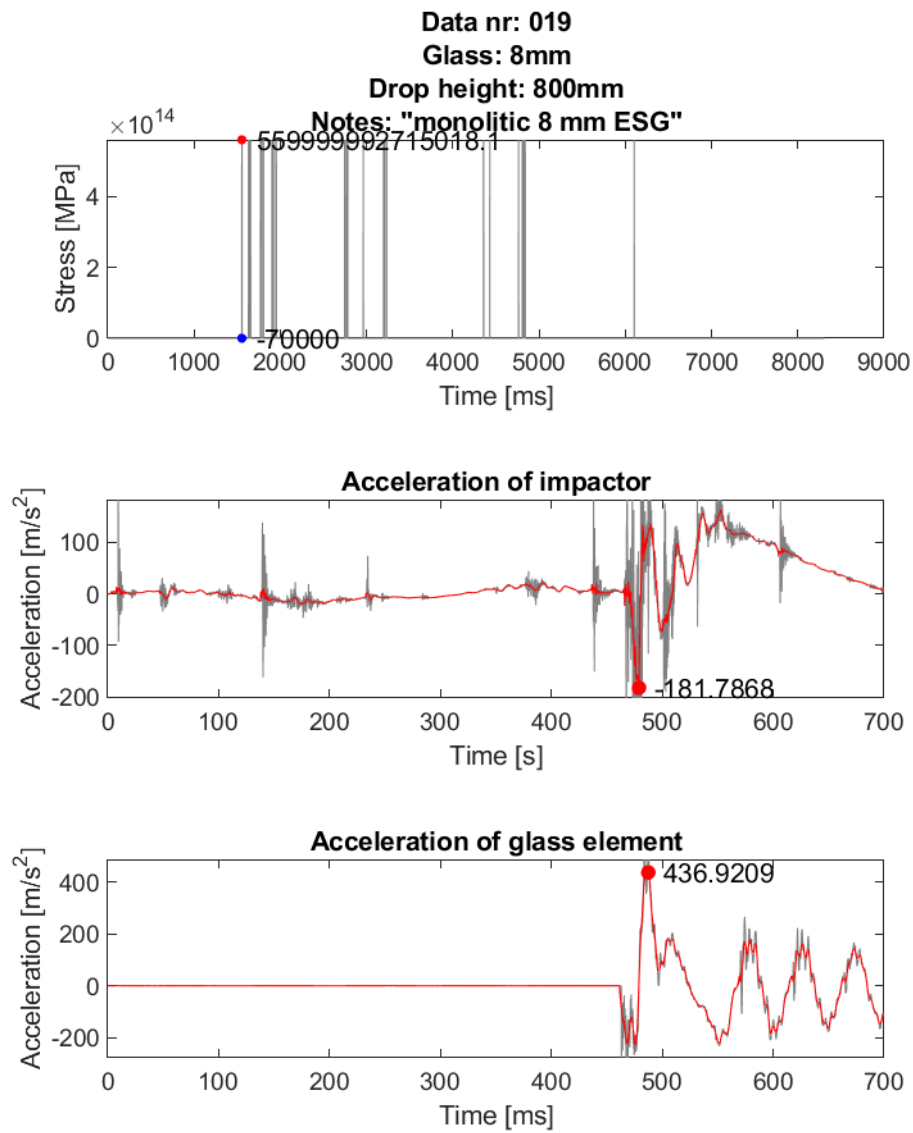
Data nr: 016
Glass: 8mm
Drop height: 500mm
Notes: "monolithic 8 mm ESG"

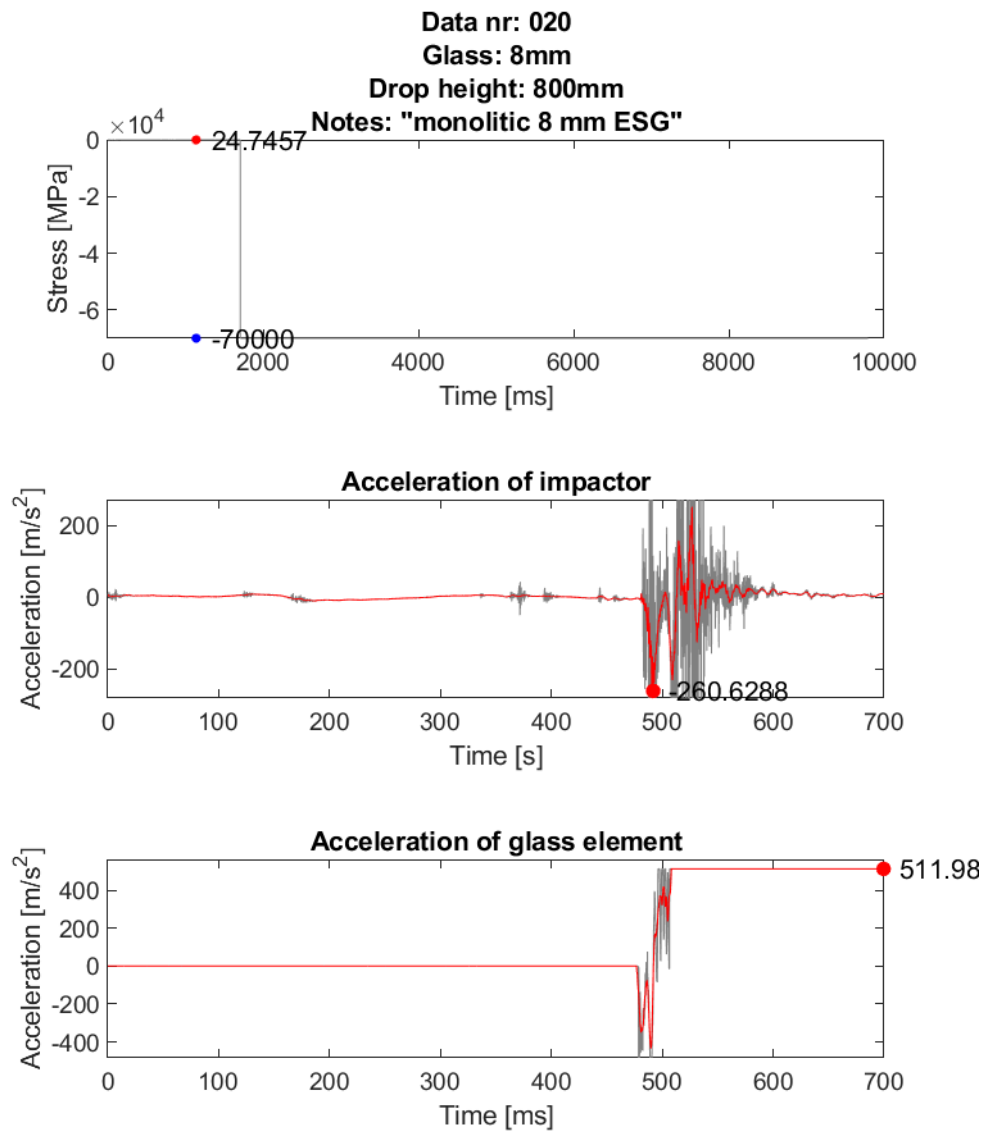




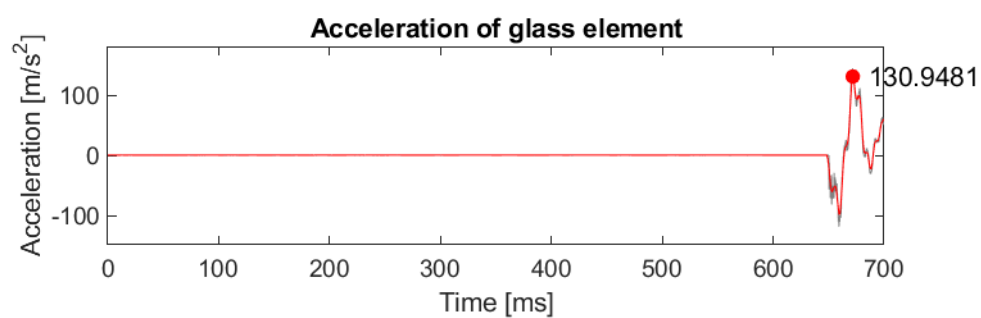
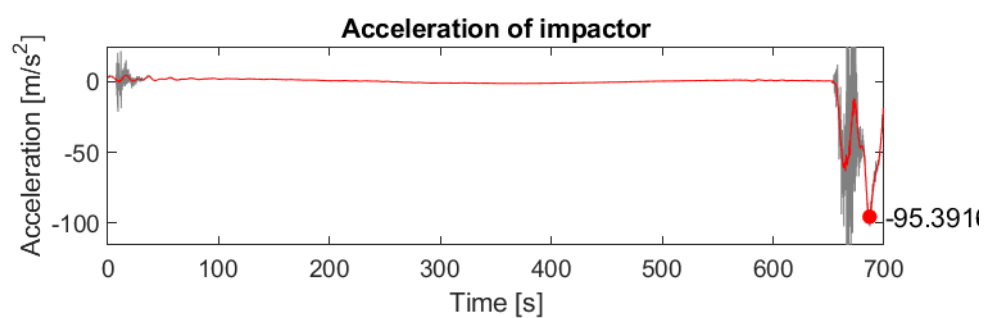
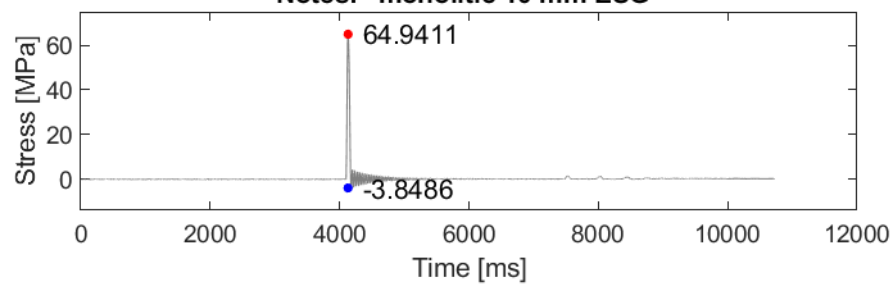
Data nr: 018
Glass: 8mm
Drop height: 500mm
Notes: "monolithic 8 mm ESG"



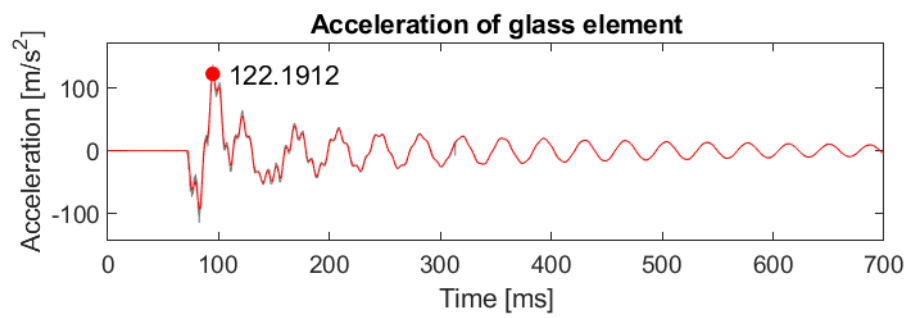
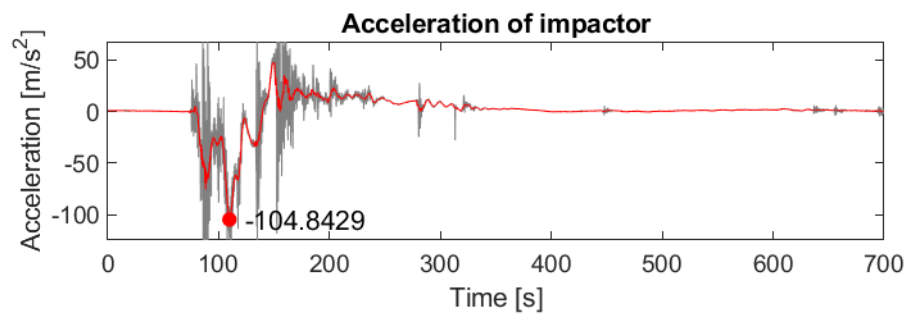
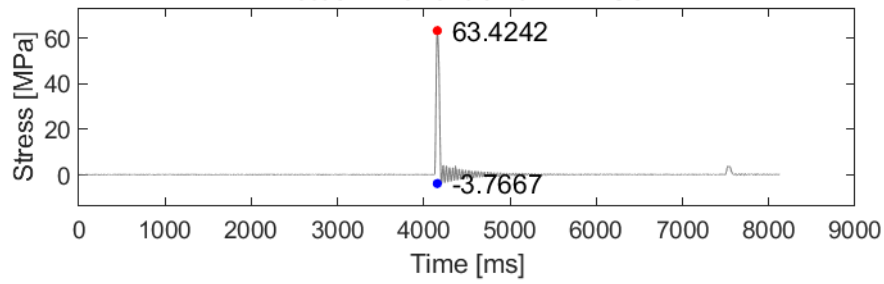




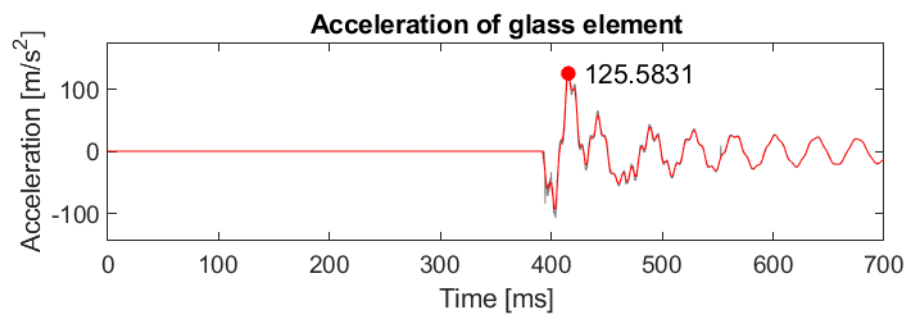
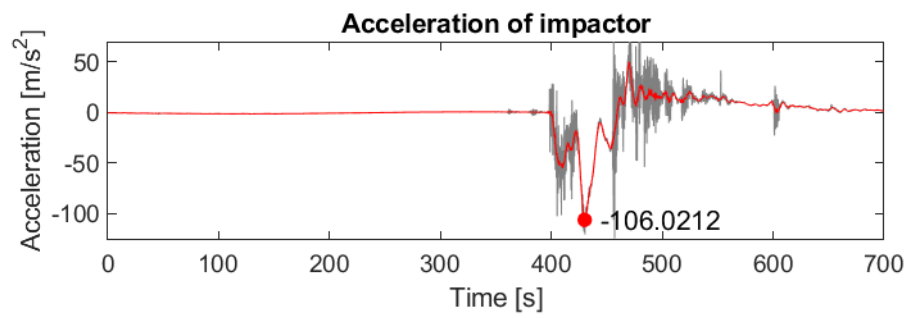
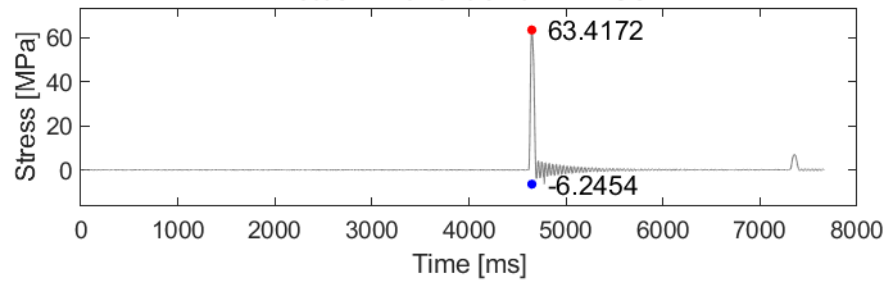
Data nr: 021
Glass: 10mm
Drop height: 100mm
Notes: "monolithic 10 mm ESG"



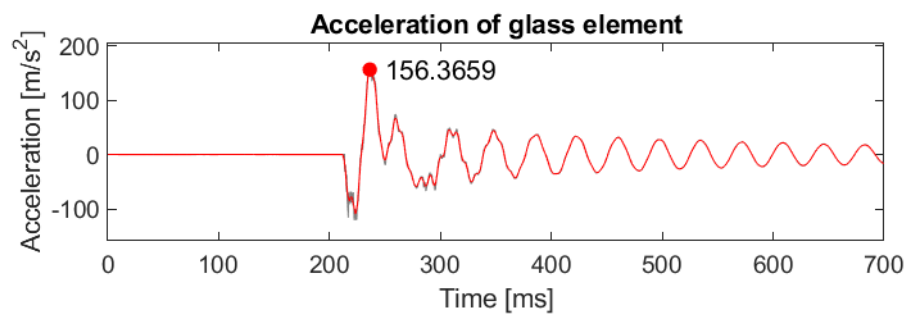
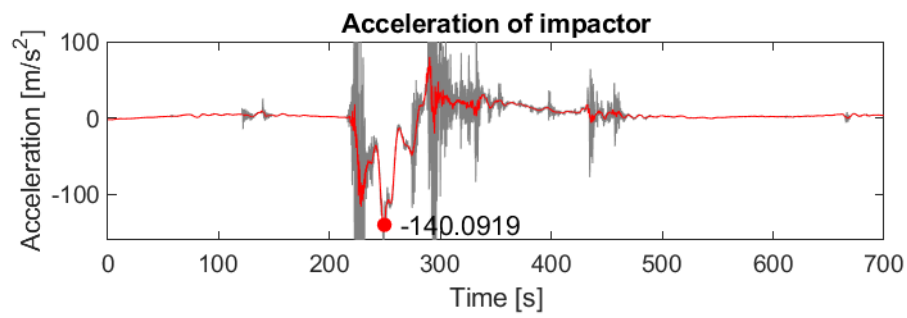
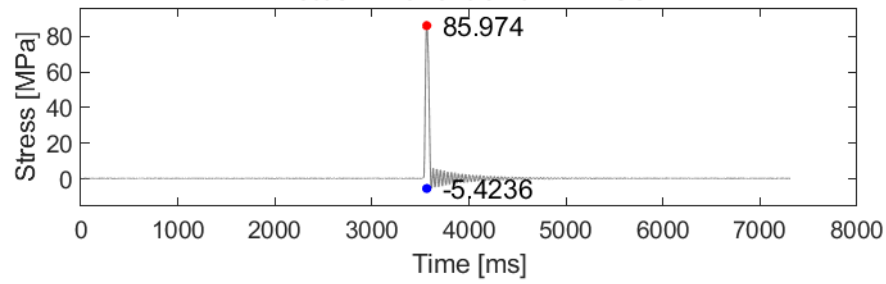
Data nr: 022
Glass: 10mm
Drop height: 100mm
Notes: "monolithic 10 mm ESG"



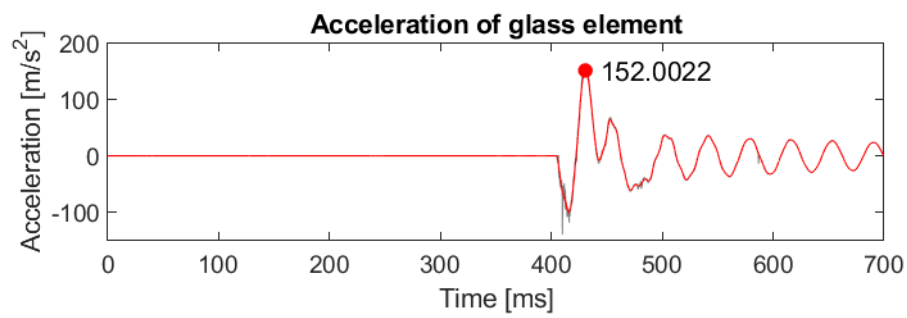
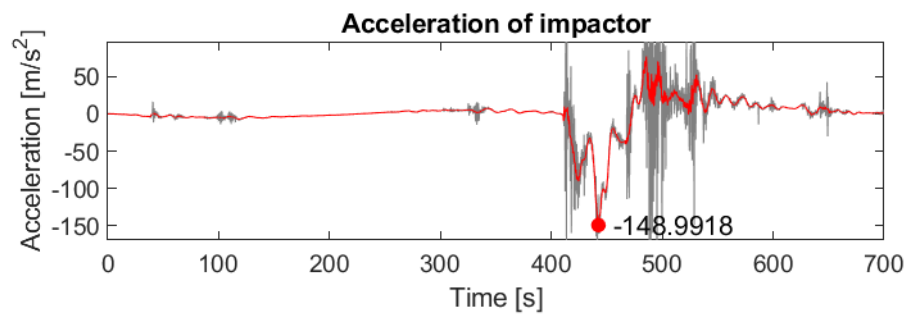
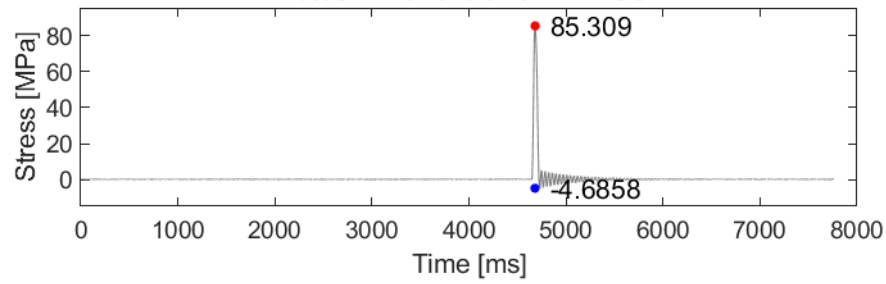
Data nr: 023
Glass: 10mm
Drop height: 100mm
Notes: "monolithic 10 mm ESG"



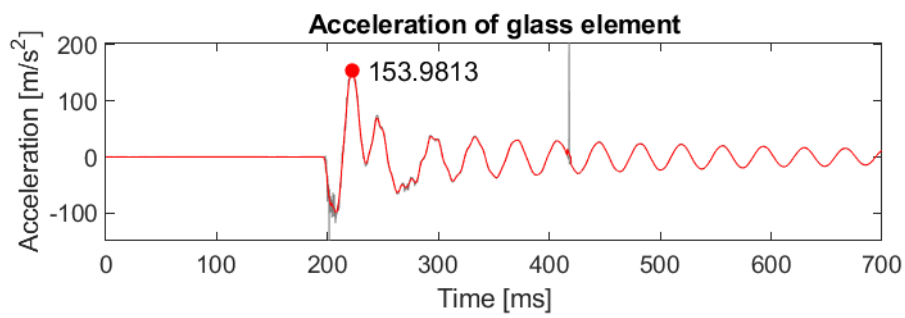
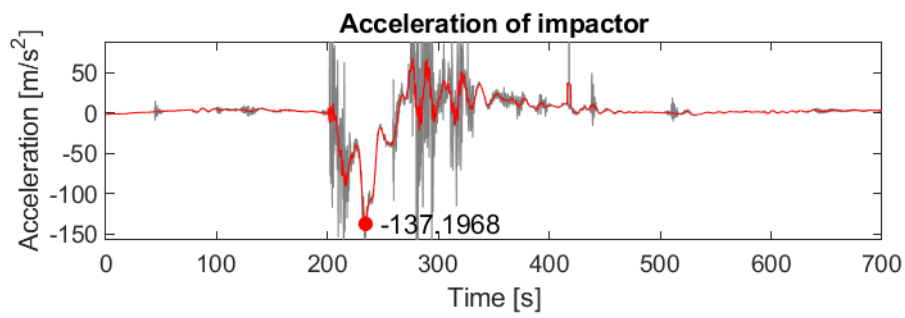
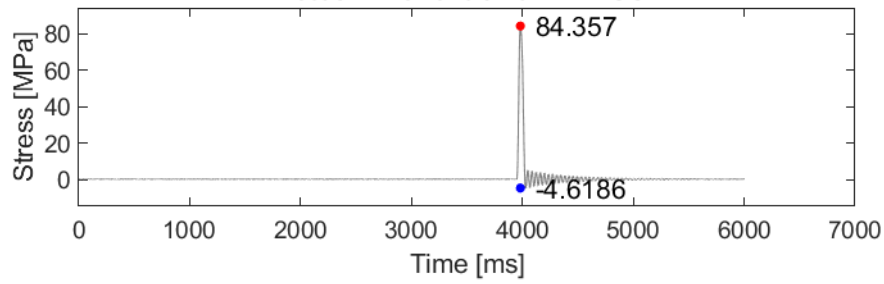
Data nr: 024
Glass: 10mm
Drop height: 200mm
Notes: "monolithic 10 mm ESG"



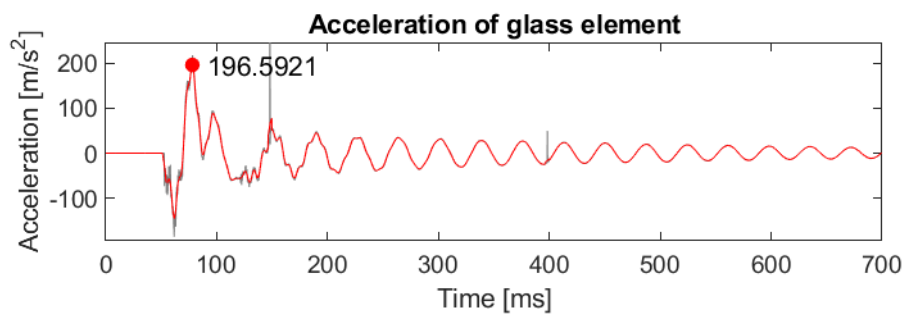
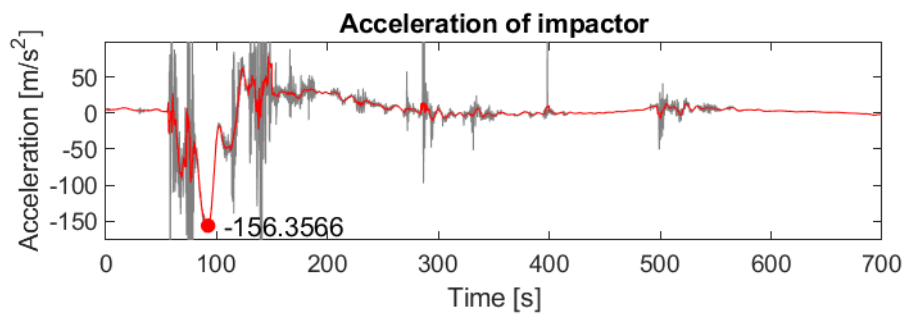
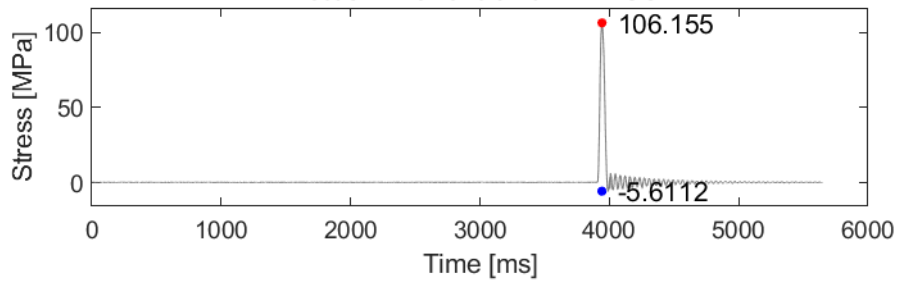
Data nr: 025
Glass: 10mm
Drop height: 200mm
Notes: "monolithic 10 mm ESG"



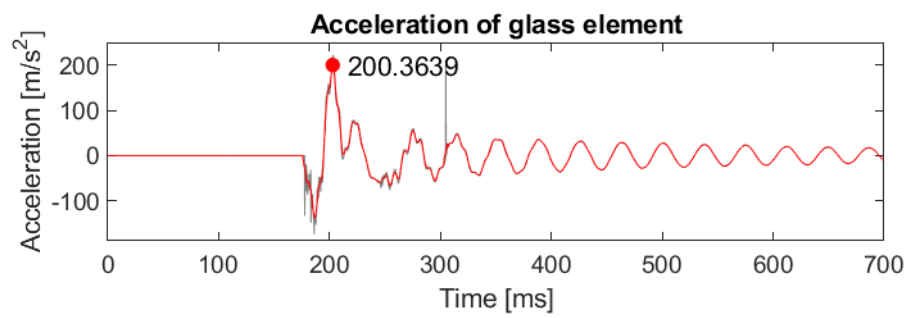
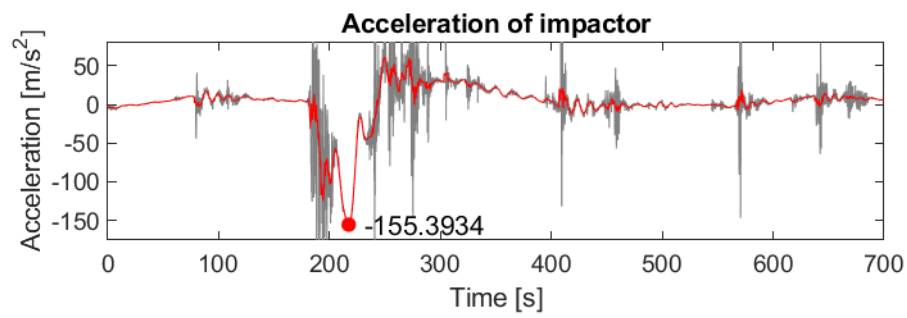
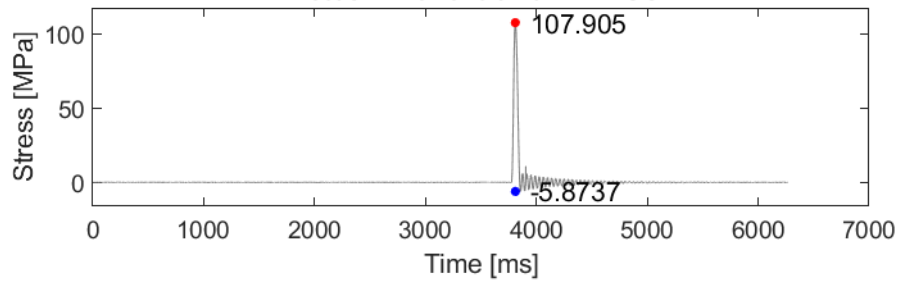
Data nr: 026
Glass: 10mm
Drop height: 200mm
Notes: "monolithic 10 mm ESG"



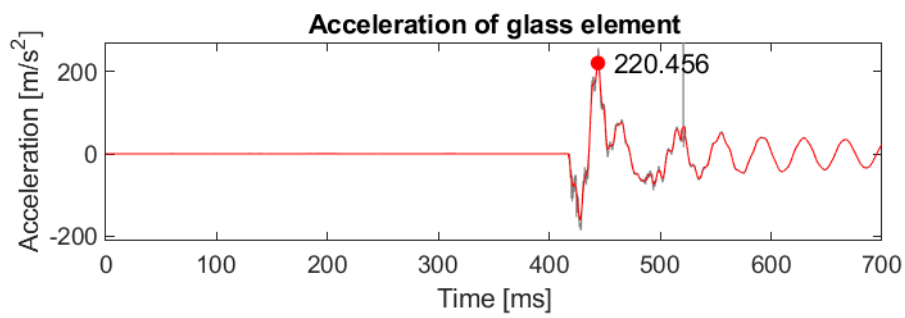
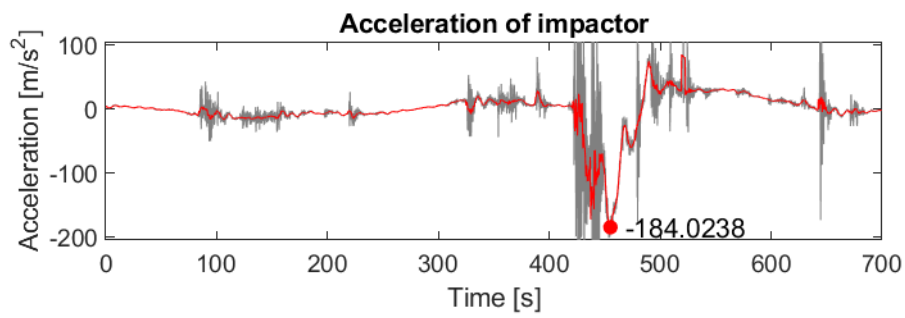
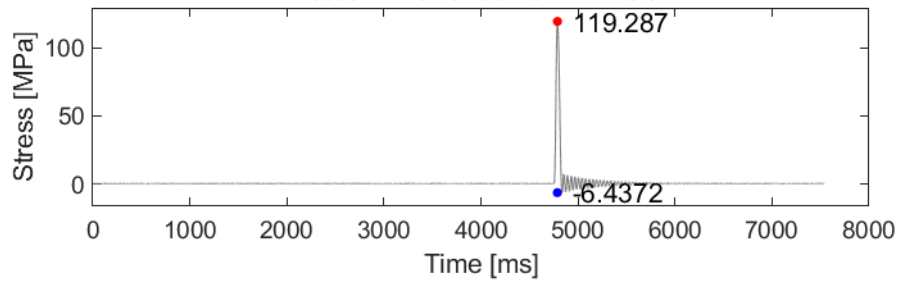
Data nr: 027
Glass: 10mm
Drop height: 300mm
Notes: "monolithic 10 mm ESG"



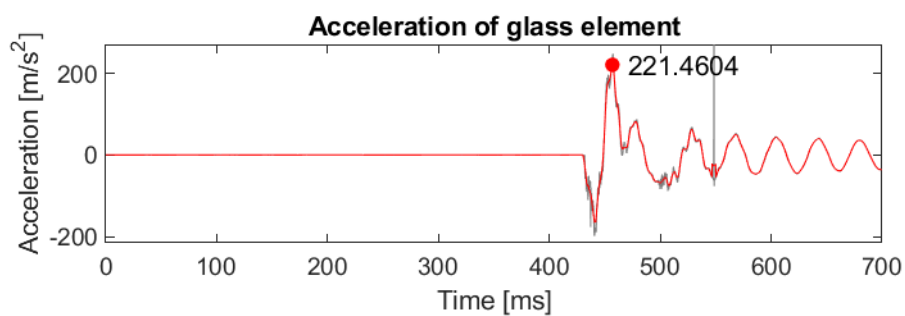
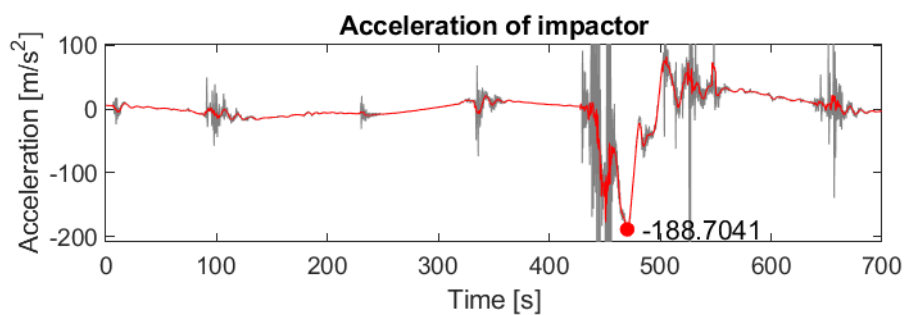
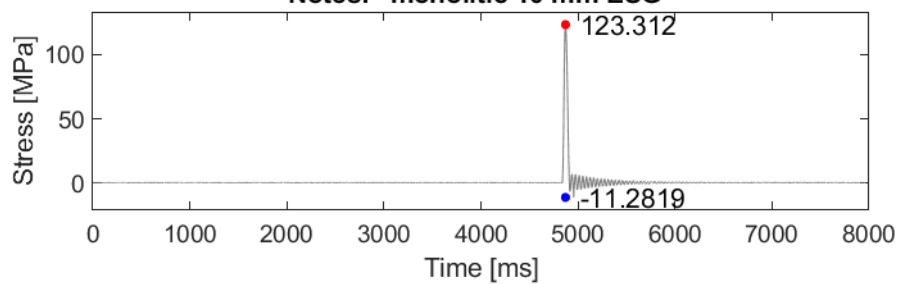
Data nr: 028
Glass: 10mm
Drop height: 300mm
Notes: "monolithic 10 mm ESG"



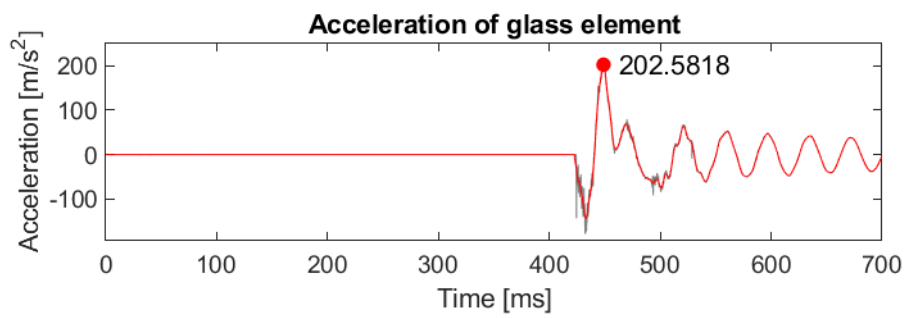
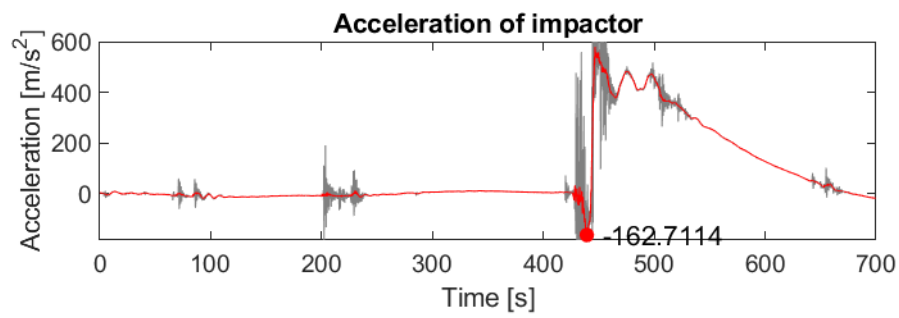
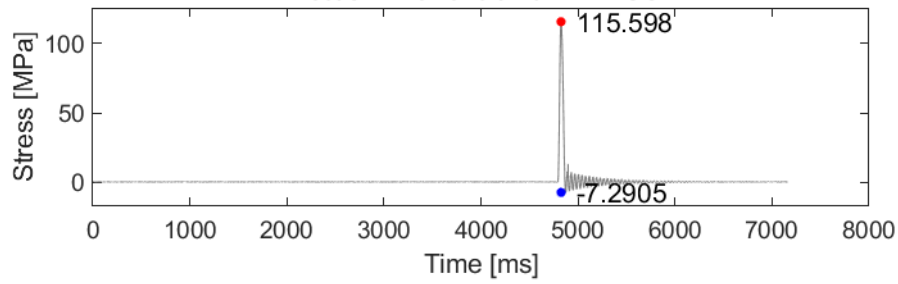
Data nr: 030
Glass: 10mm
Drop height: 400mm
Notes: "monolithic 10 mm ESG"



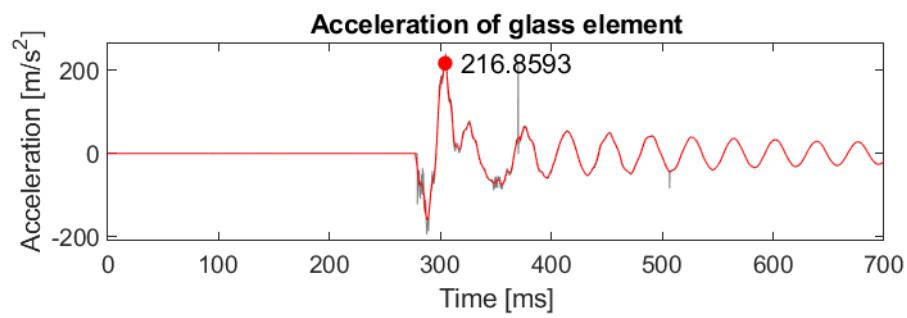
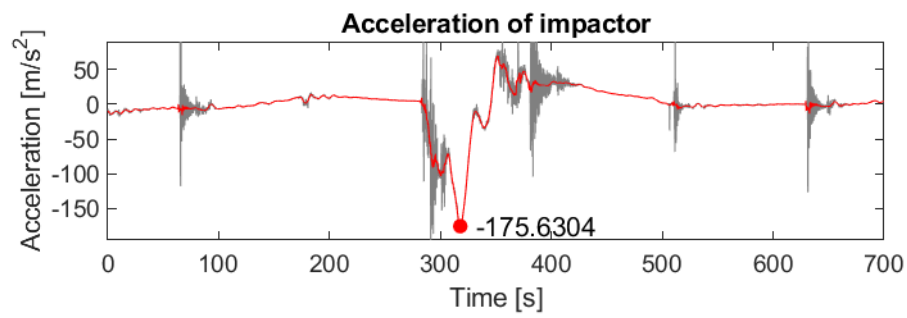
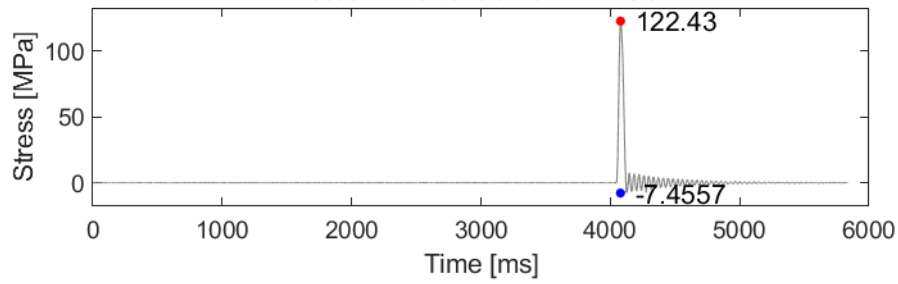
Data nr: 031
Glass: 10mm
Drop height: 400mm
Notes: "monolithic 10 mm ESG"



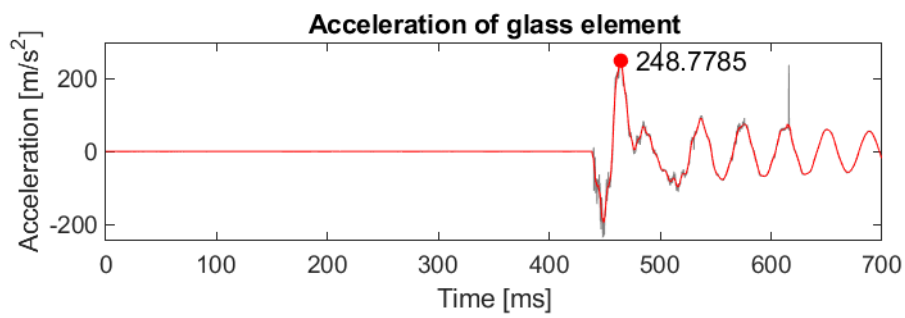
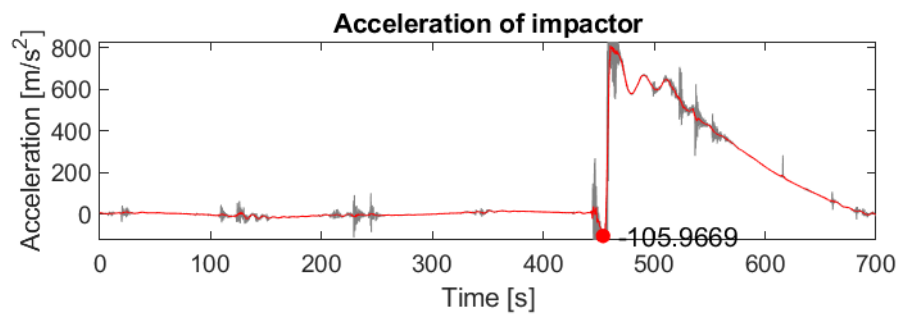
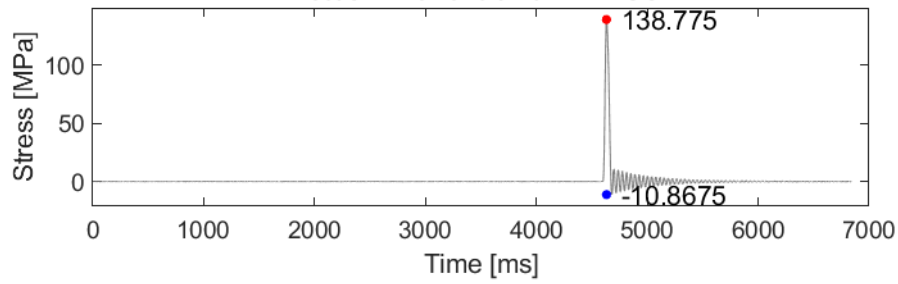
Data nr: 032
Glass: 10mm
Drop height: 400mm
Notes: "monolithic 10 mm ESG"



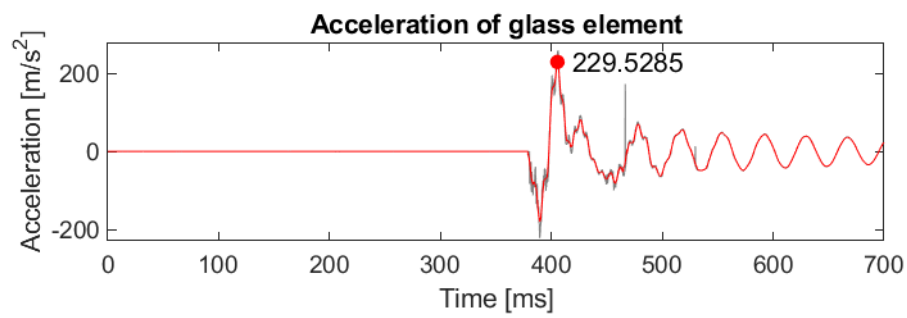
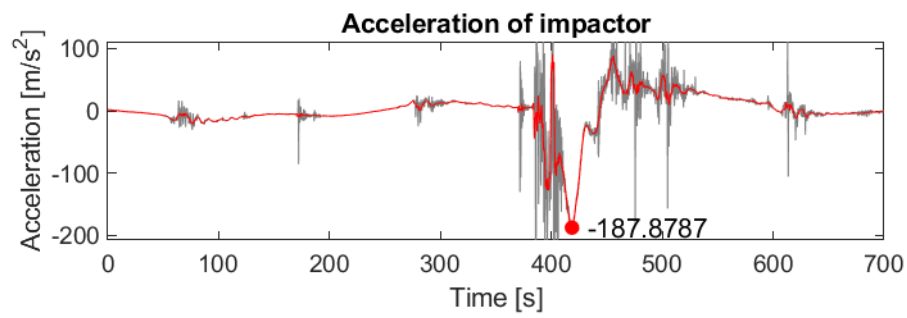
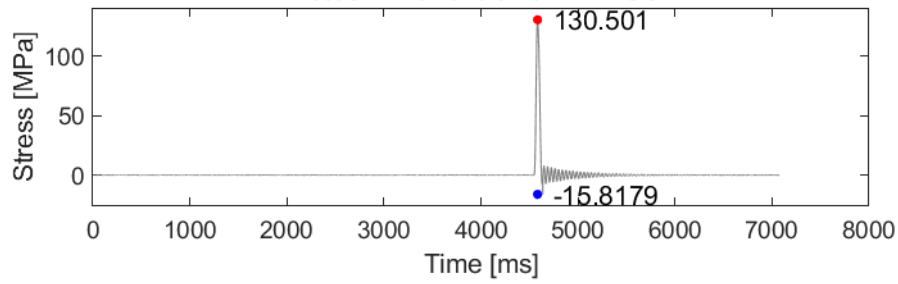
Data nr: 033
Glass: 10mm
Drop height: 400mm
Notes: "monolithic 10 mm ESG"



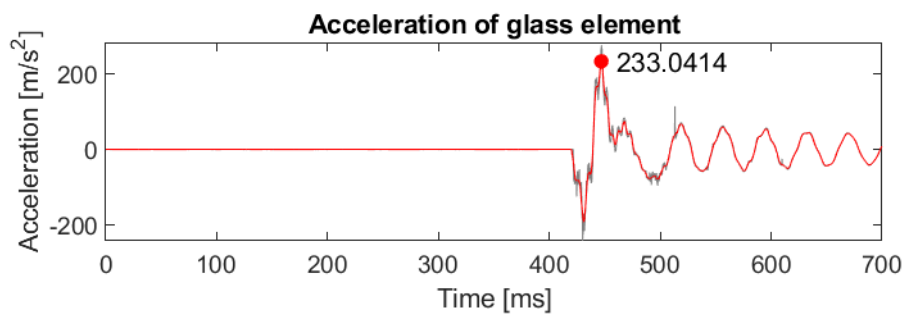
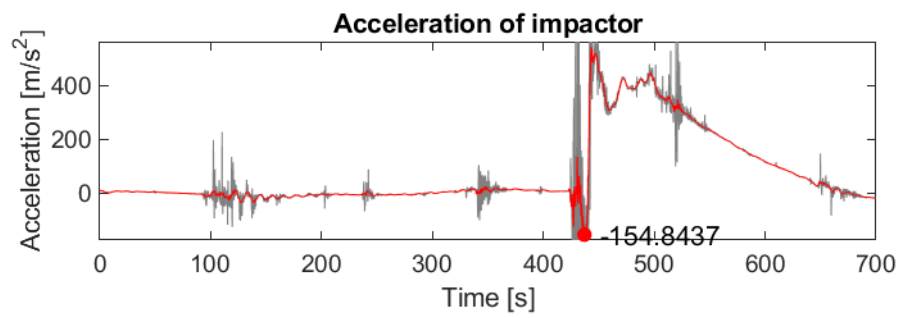
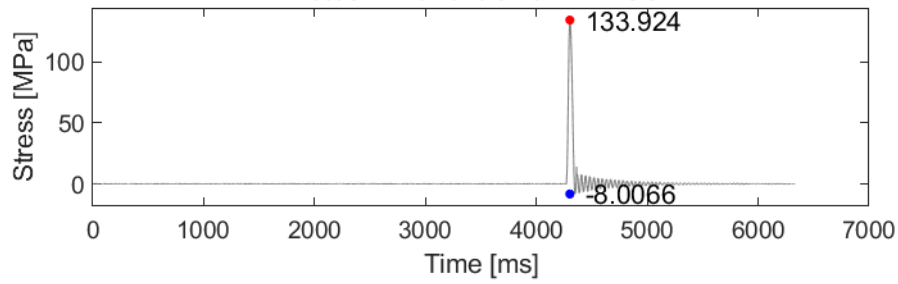
Data nr: 034
Glass: 10mm
Drop height: 500mm
Notes: "monolithic 10 mm ESG"



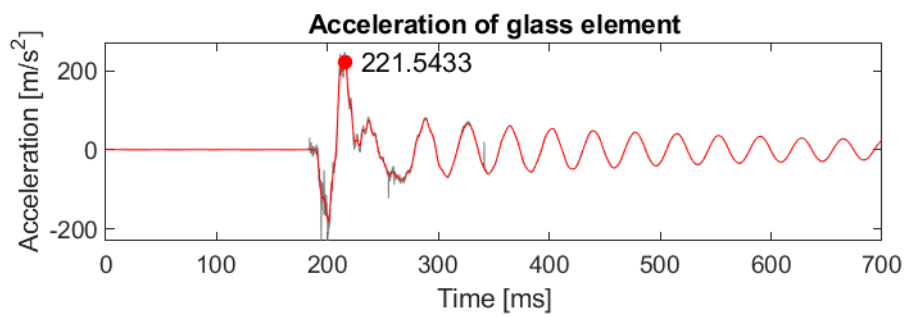
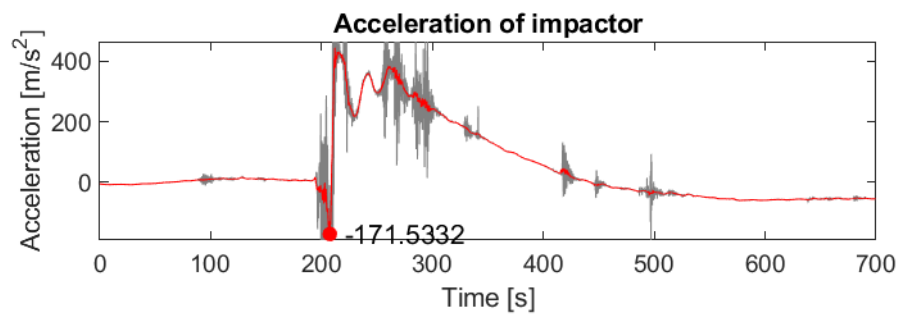
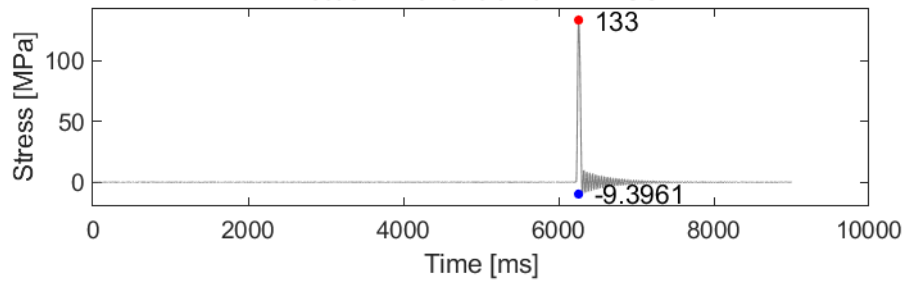
Data nr: 035
Glass: 10mm
Drop height: 500mm
Notes: "monolithic 10 mm ESG"



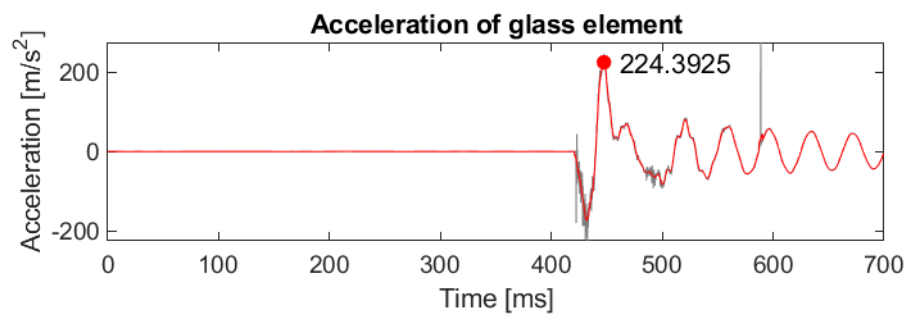
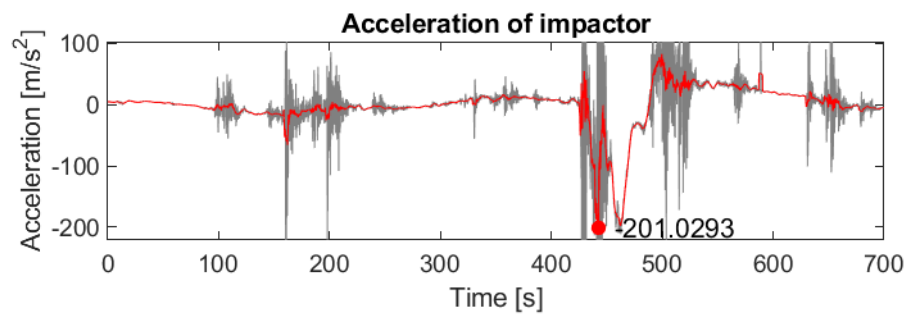
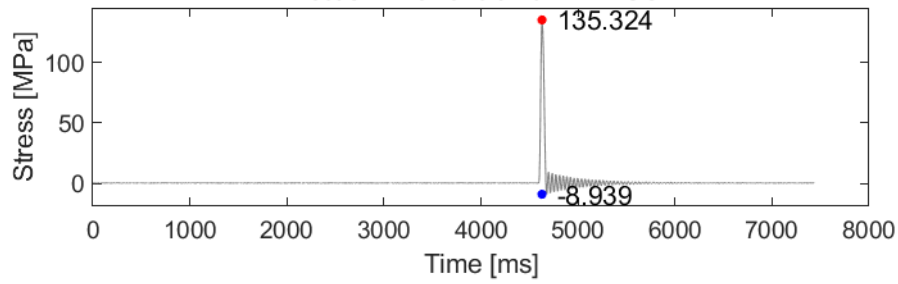
Data nr: 036
Glass: 10mm
Drop height: 500mm
Notes: "monolithic 10 mm ESG"



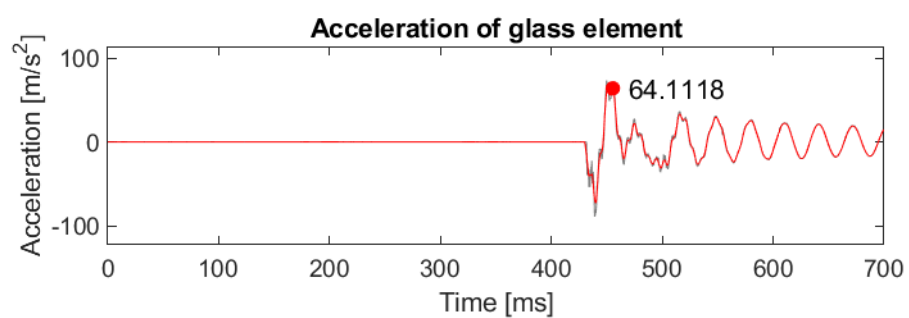
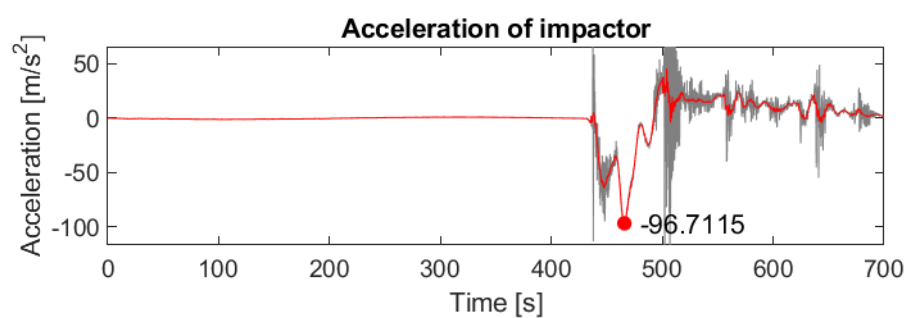
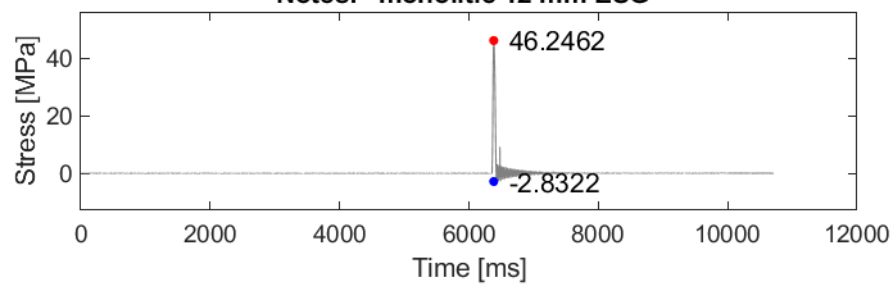
Data nr: 037
Glass: 10mm
Drop height: 500mm
Notes: "monolithic 10 mm ESG"



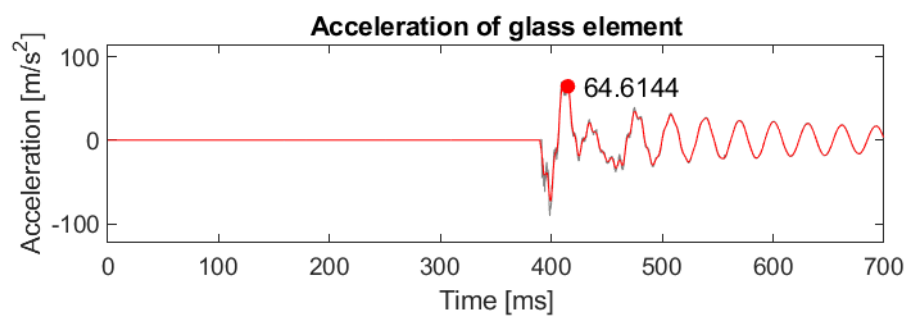
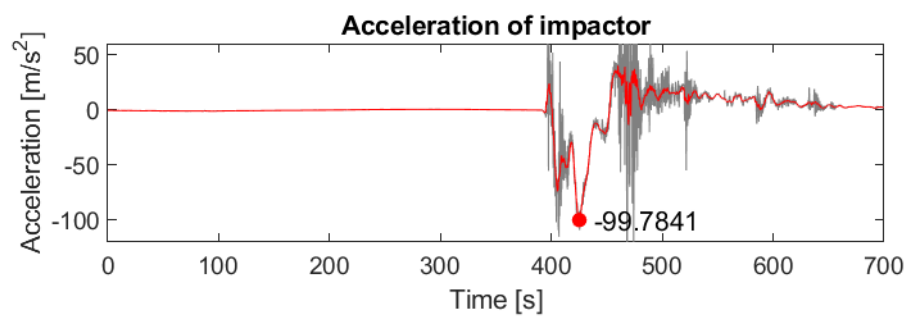
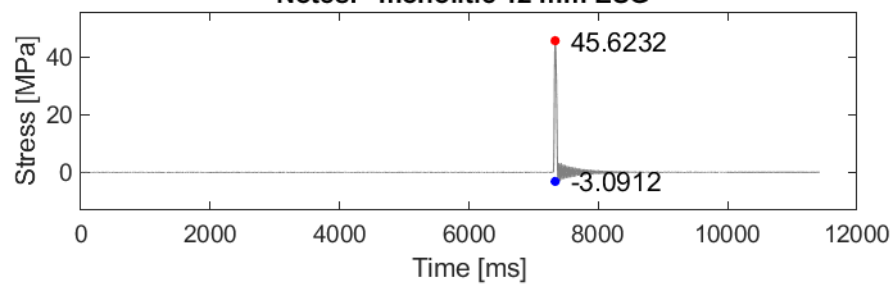
Data nr: 038
Glass: 10mm
Drop height: 500mm
Notes: "monolithic 10 mm ESG"



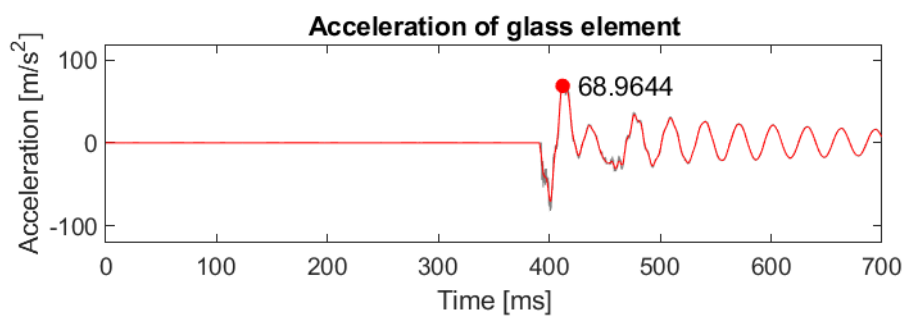
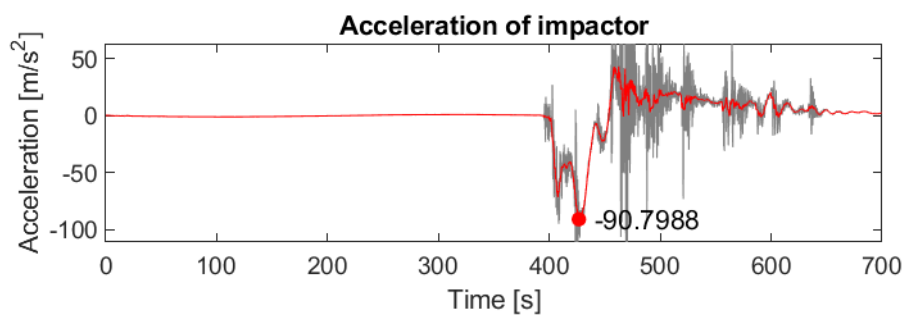
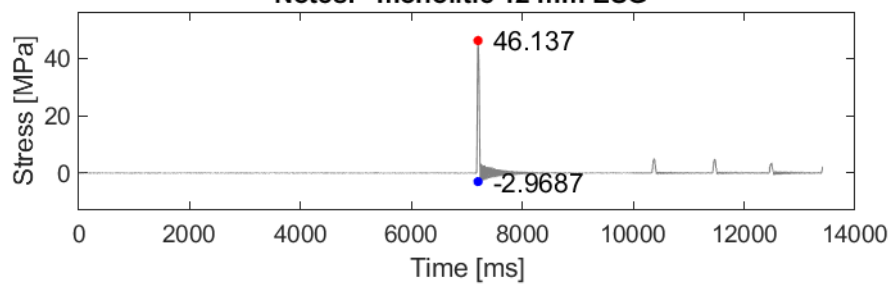
Data nr: 039
Glass: 12mm
Drop height: 100mm
Notes: "monolithic 12 mm ESG"



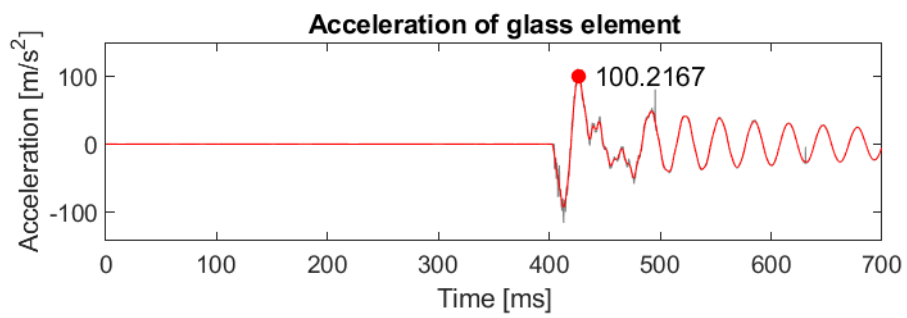
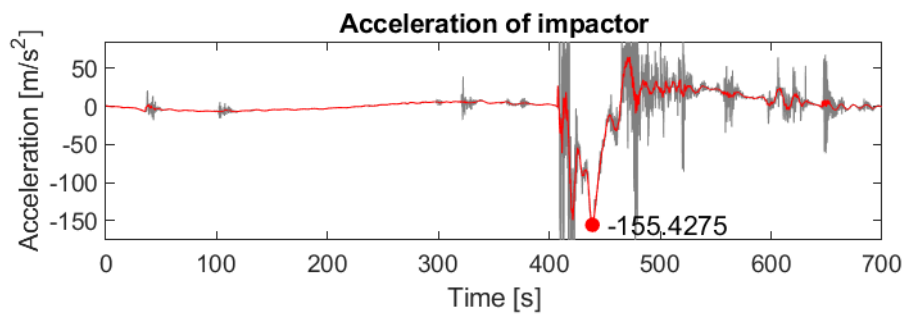
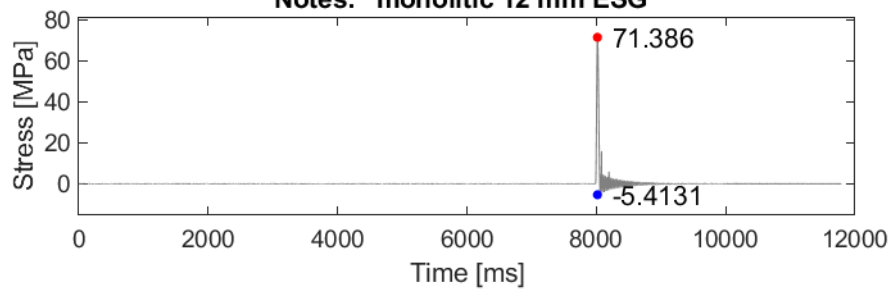
Data nr: 040
Glass: 12mm
Drop height: 100mm
Notes: "monolithic 12 mm ESG"



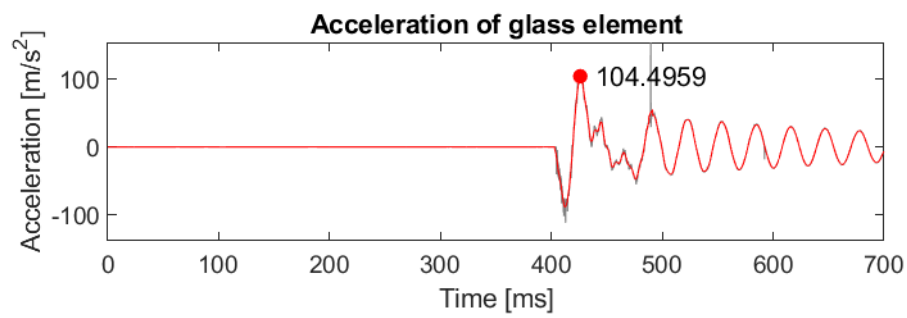
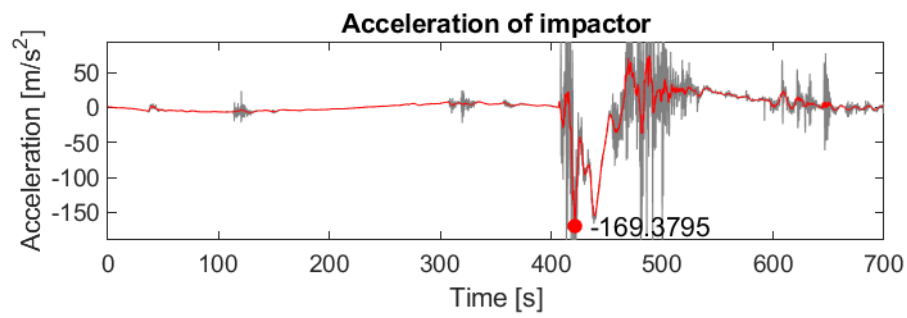
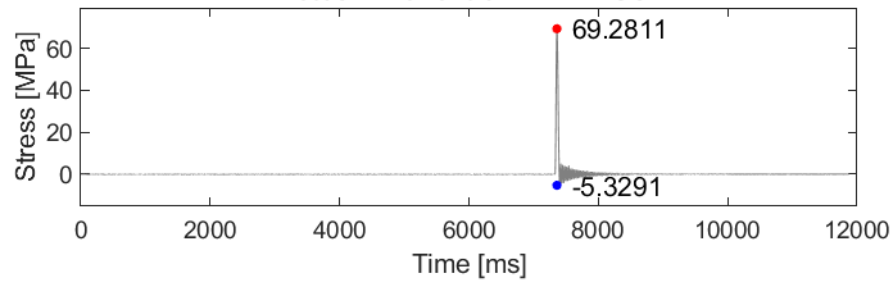
Data nr: 041
Glass: 12mm
Drop height: 100mm
Notes: "monolithic 12 mm ESG"



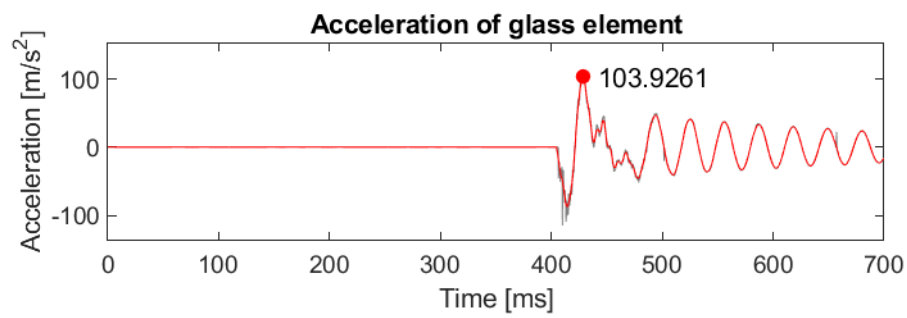
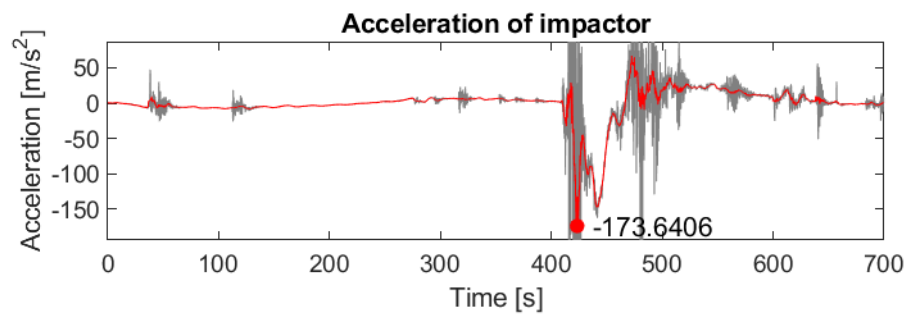
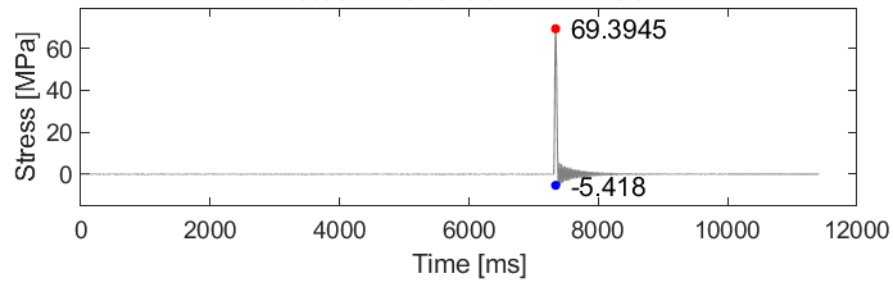
Data nr: 042
Glass: 12mm
Drop height: 200mm
Notes: "monolithic 12 mm ESG"



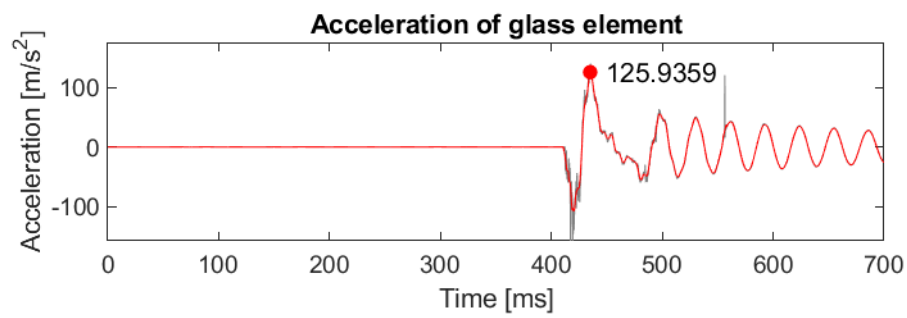
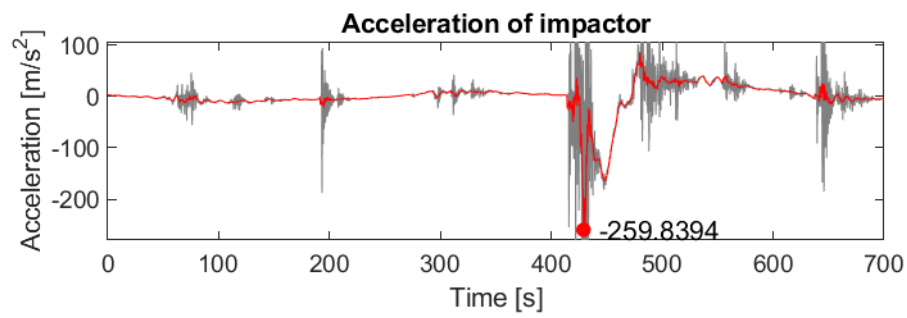
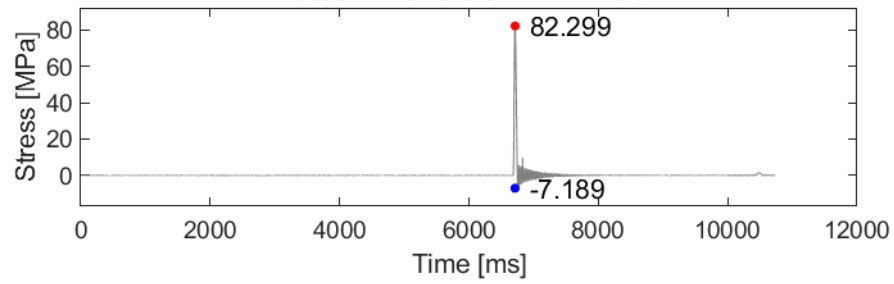
Data nr: 043
Glass: 12mm
Drop height: 200mm
Notes: "monolithic 12 mm ESG"



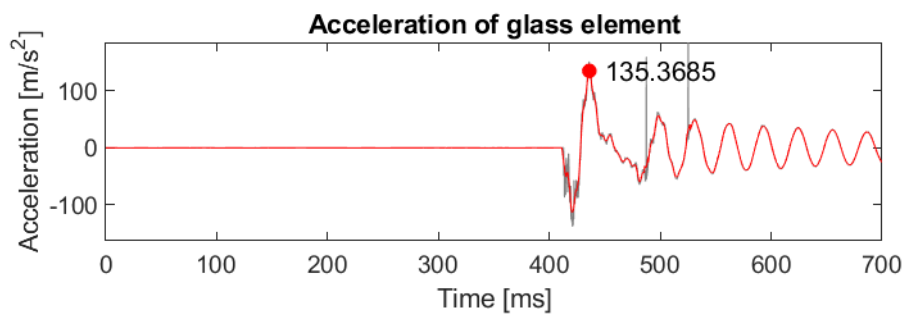
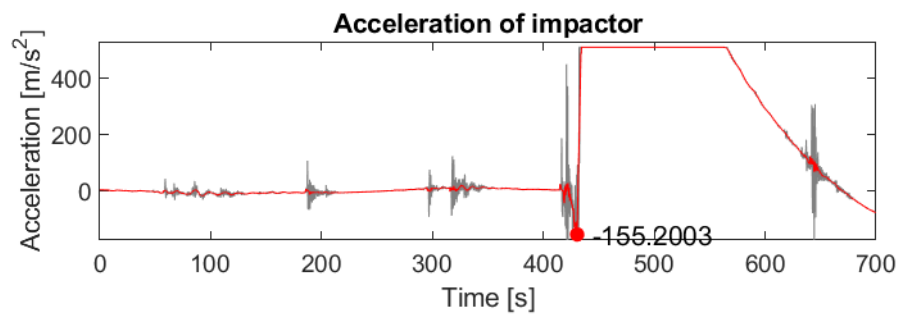
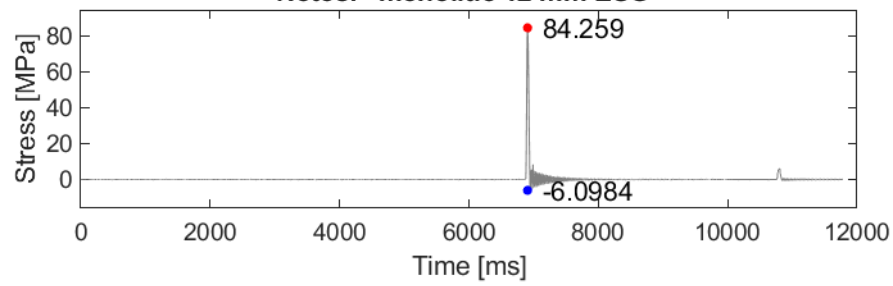
Data nr: 044
Glass: 12mm
Drop height: 200mm
Notes: "monolithic 12 mm ESG"



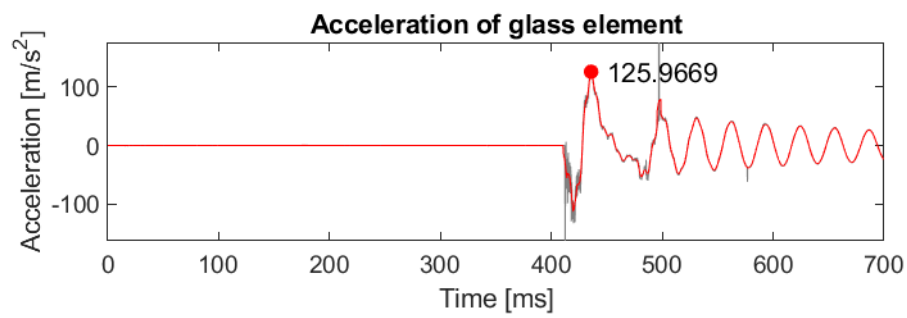
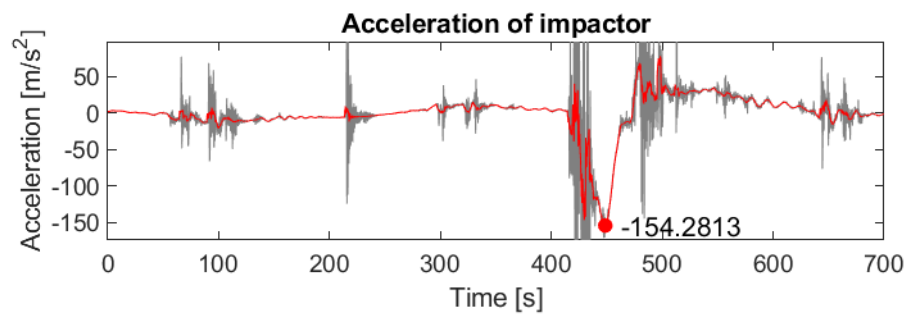
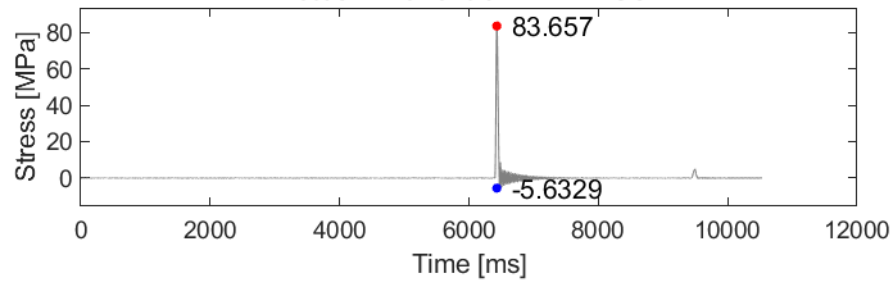
Data nr: 045
Glass: 12mm
Drop height: 300mm
Notes: "monolithic 12 mm ESG"



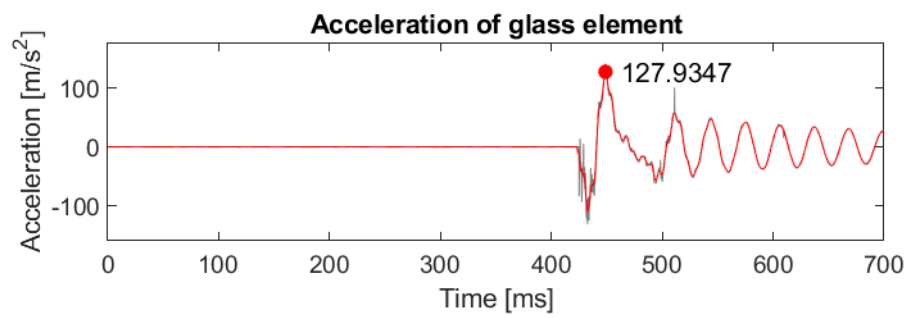
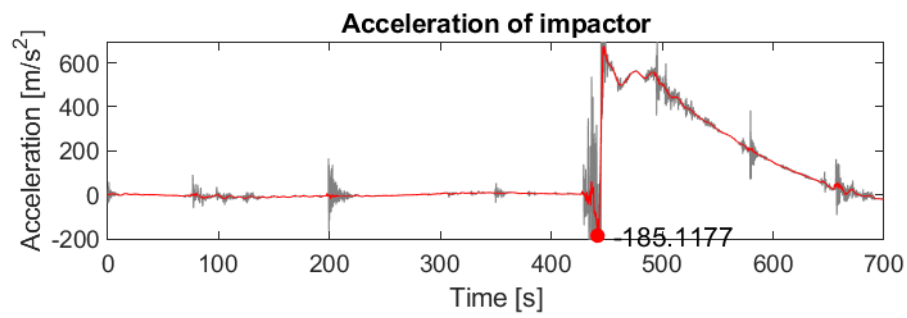
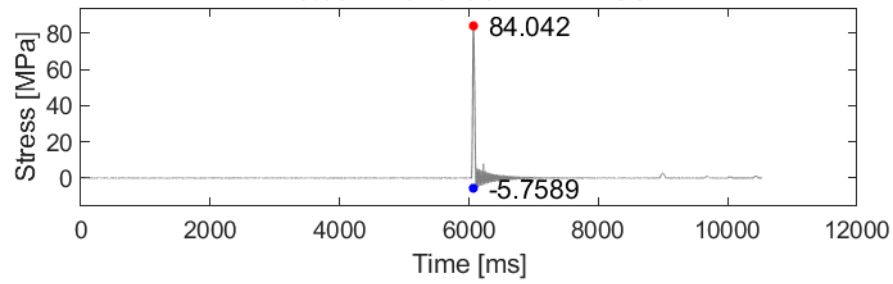
Data nr: 046
Glass: 12mm
Drop height: 300mm
Notes: "monolithic 12 mm ESG"



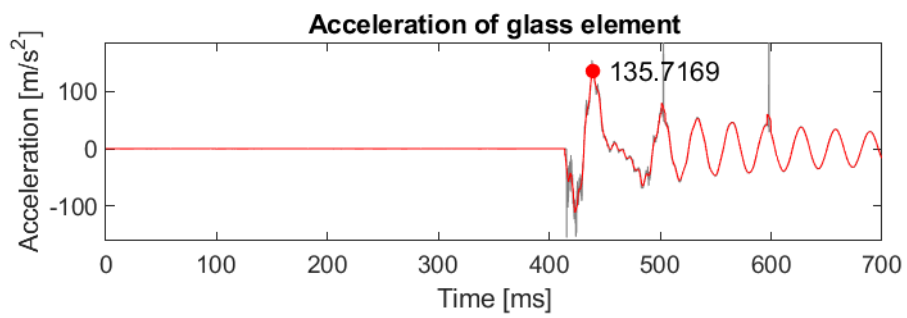
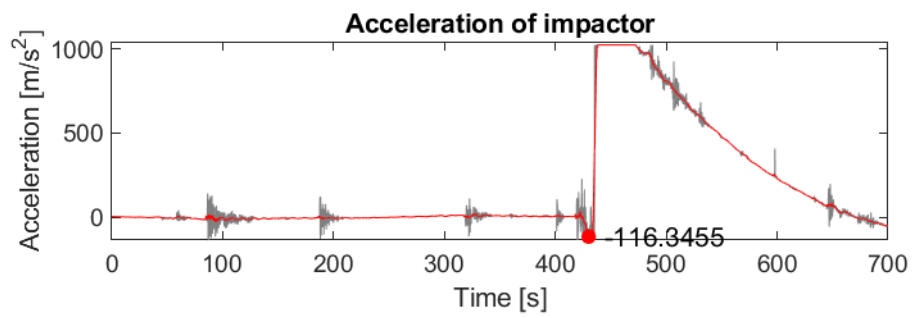
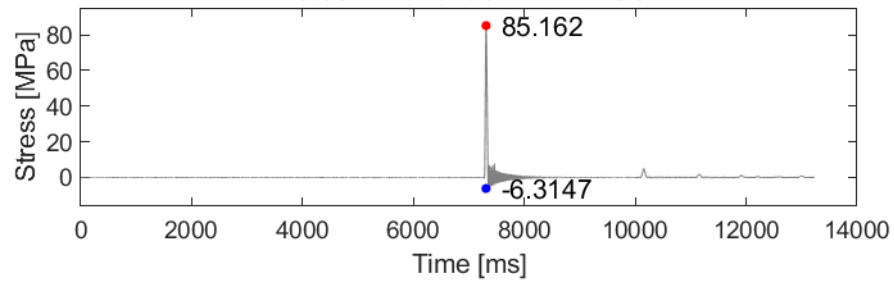
Data nr: 047
Glass: 12mm
Drop height: 300mm
Notes: "monolithic 12 mm ESG"



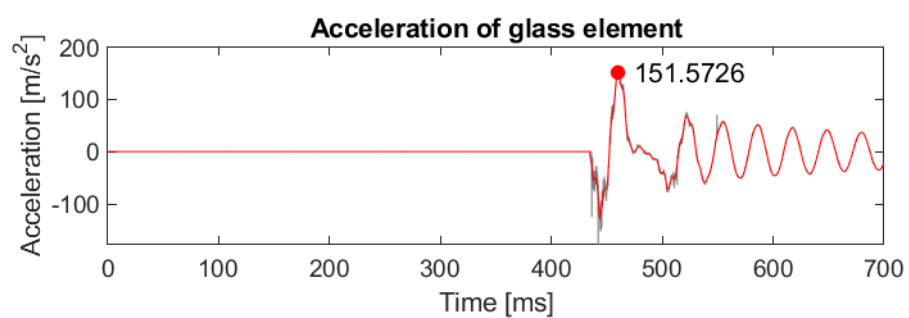
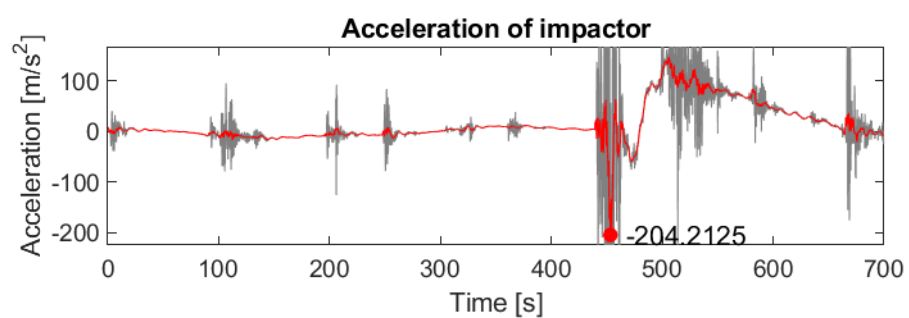
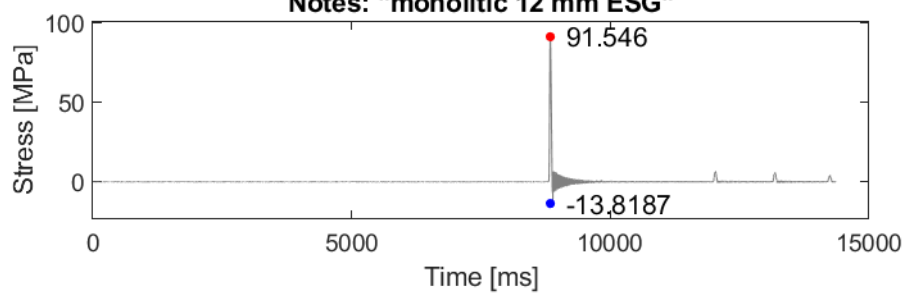
Data nr: 048
Glass: 12mm
Drop height: 300mm
Notes: "monolithic 12 mm ESG"



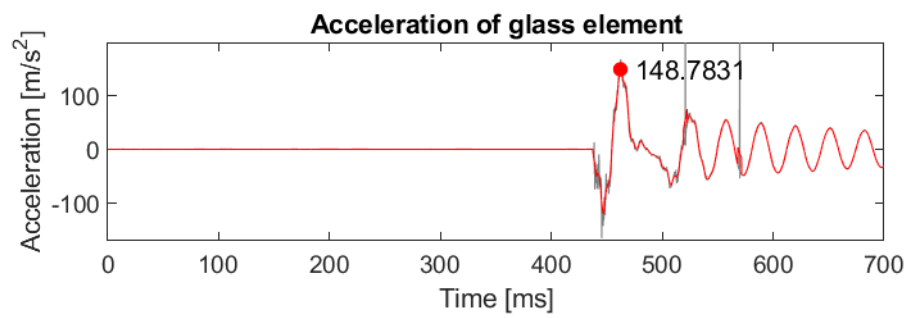
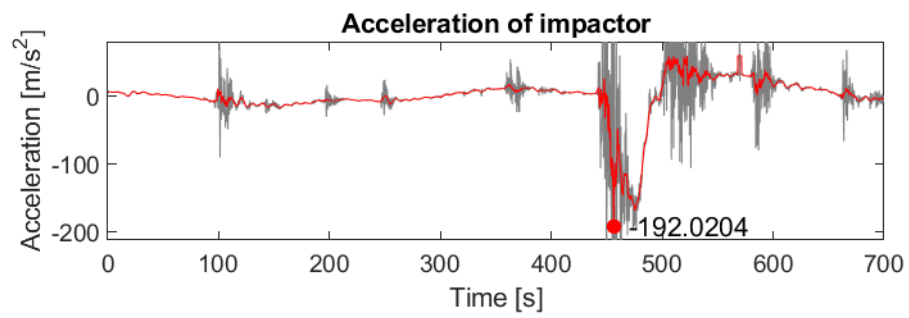
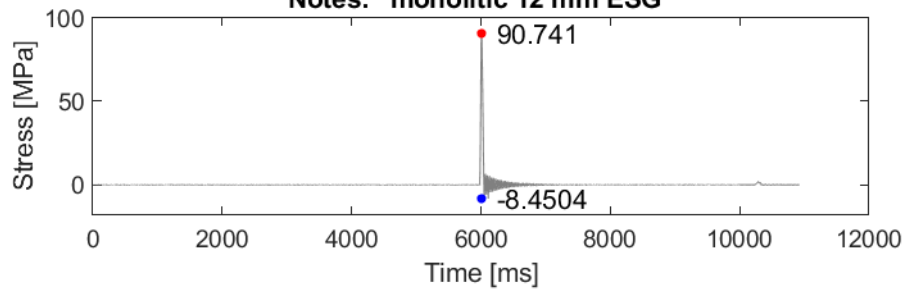
Data nr: 049
Glass: 12mm
Drop height: 300mm
Notes: "monolithic 12 mm ESG"



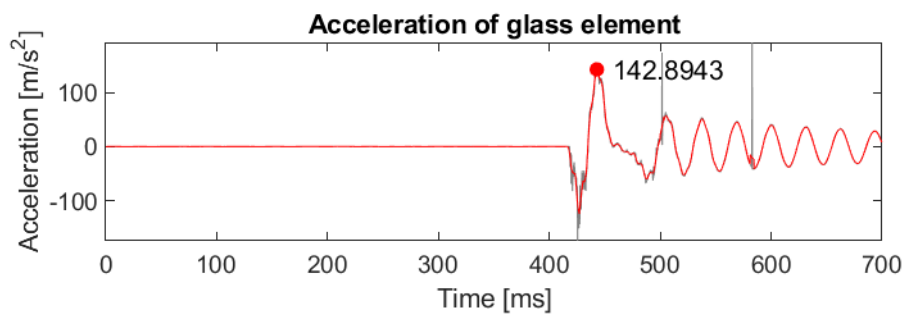
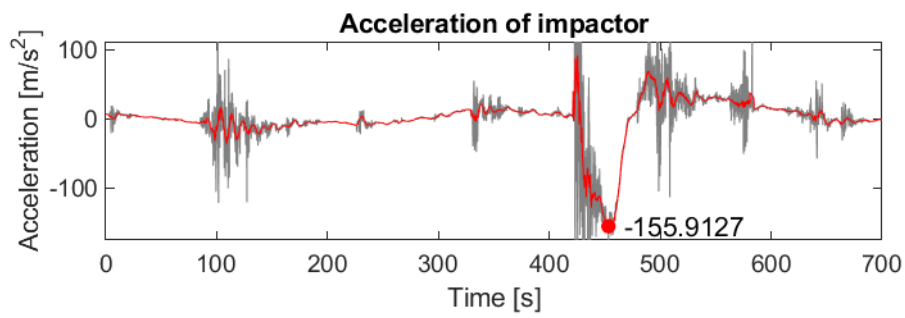
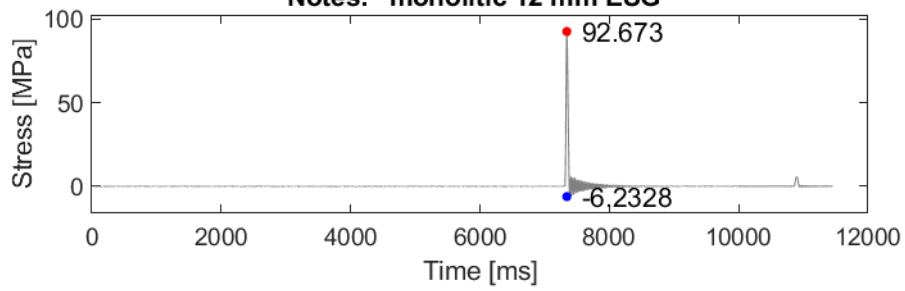
Data nr: 050
Glass: 12mm
Drop height: 400mm
Notes: "monolithic 12 mm ESG"

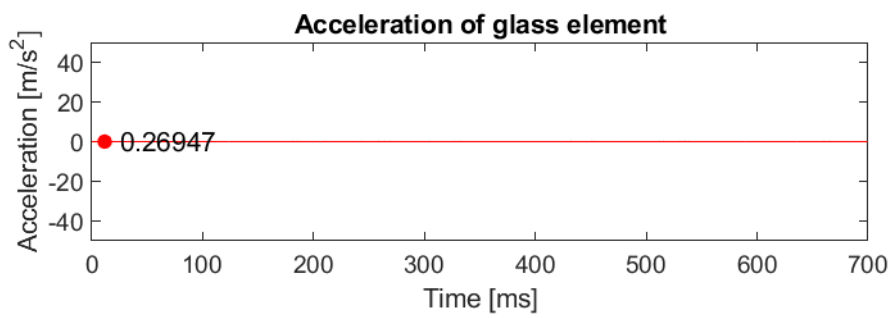
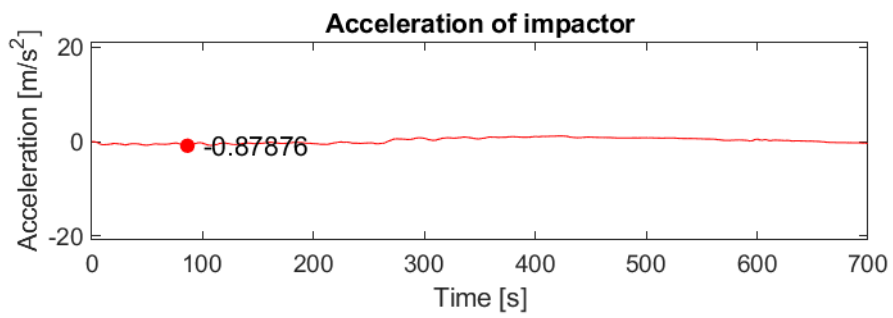
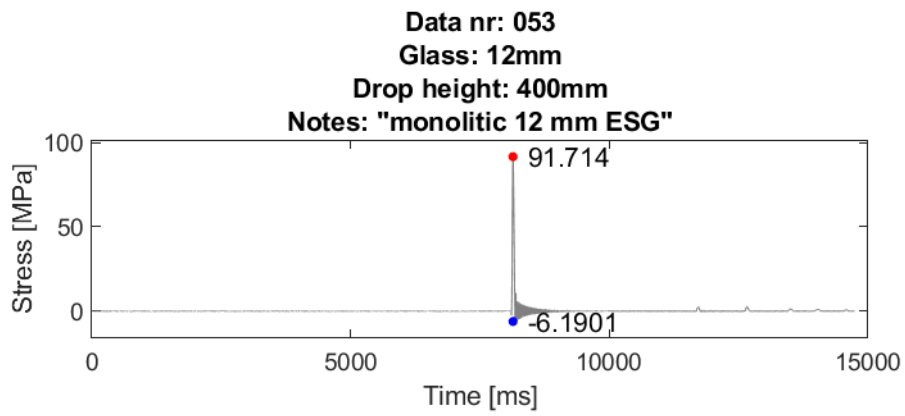


Data nr: 051
Glass: 12mm
Drop height: 400mm
Notes: "monolithic 12 mm ESG"

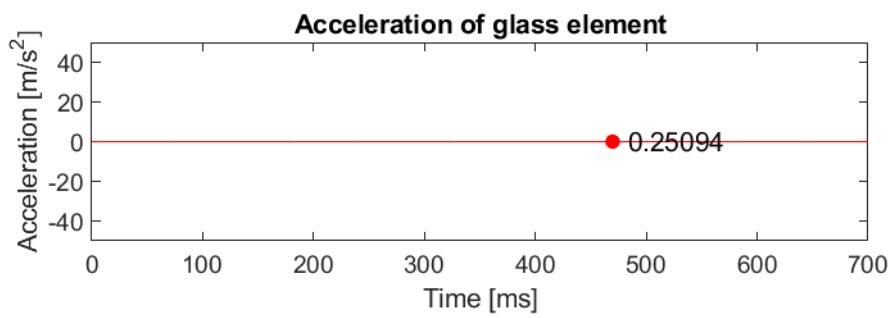
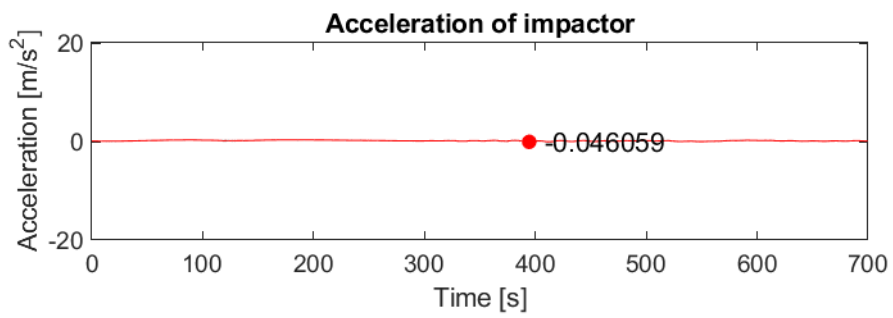
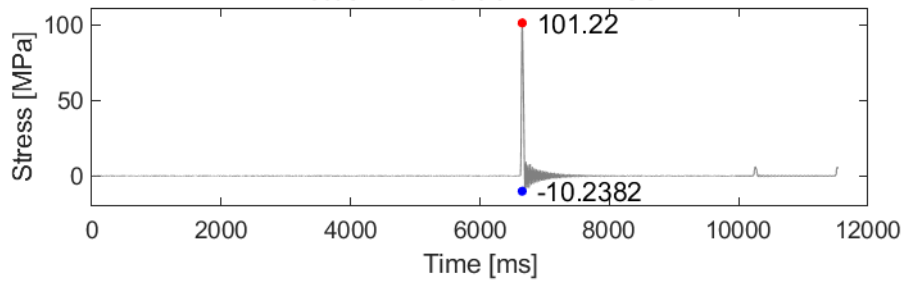


Data nr: 052
Glass: 12mm
Drop height: 400mm
Notes: "monolithic 12 mm ESG"

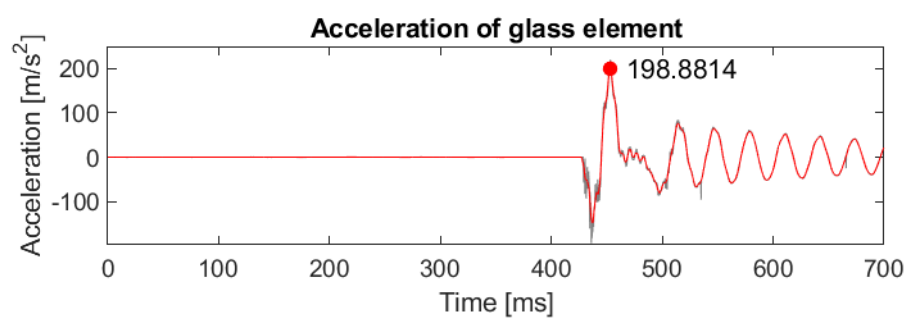
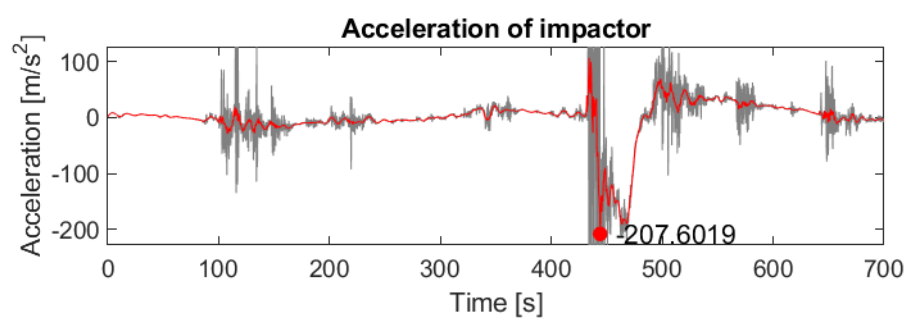
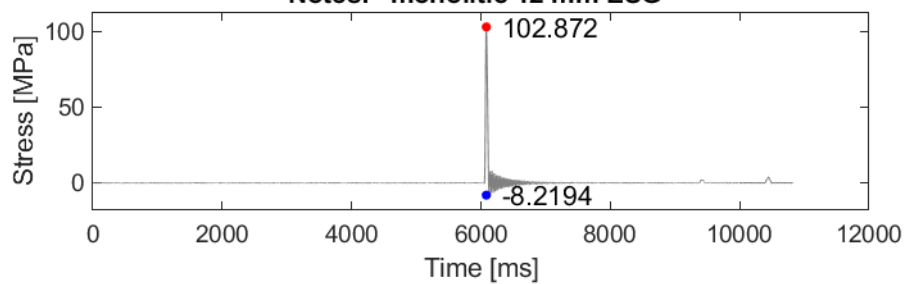




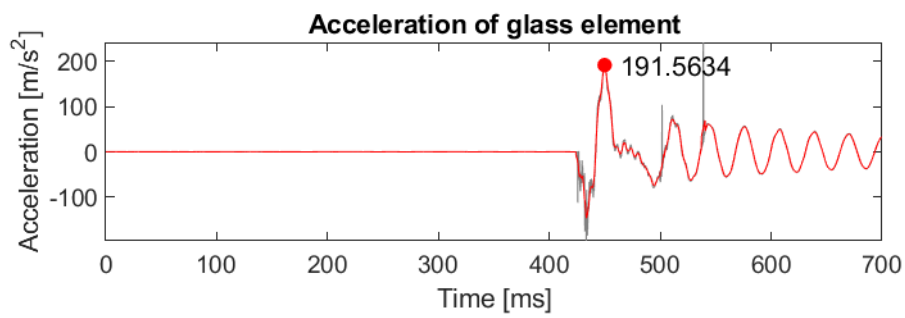
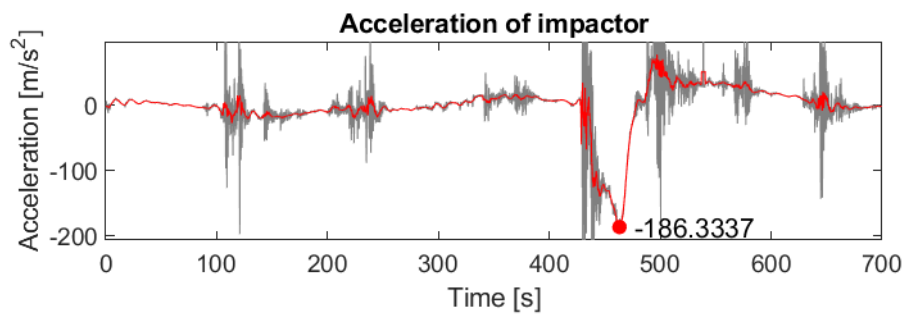
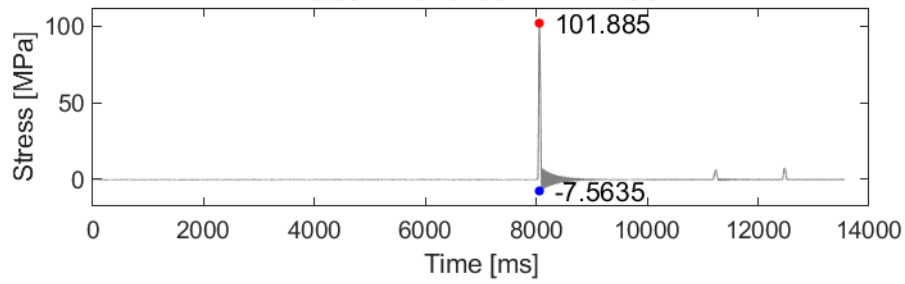
Data nr: 054
Glass: 12mm
Drop height: 500mm
Notes: "monolithic 12 mm ESG"



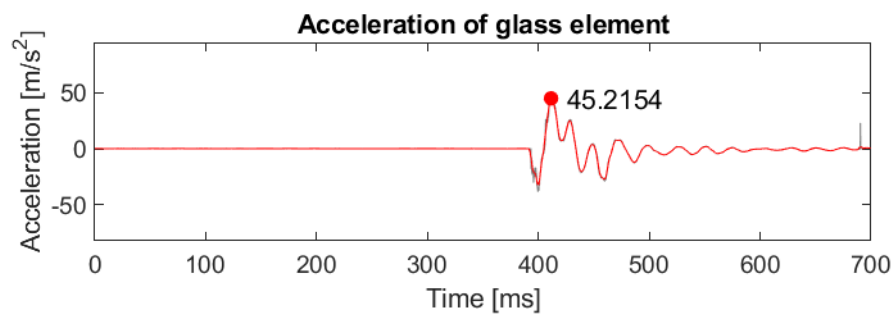
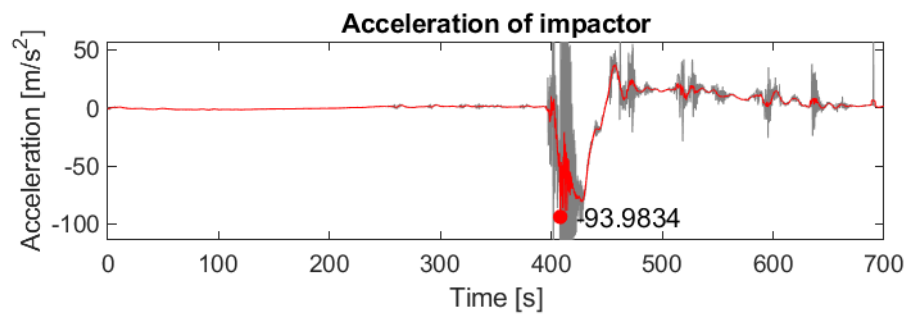
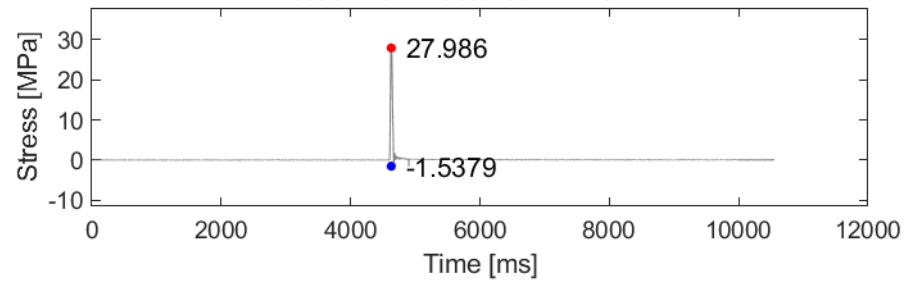
Data nr: 055
Glass: 12mm
Drop height: 500mm
Notes: "monolithic 12 mm ESG"



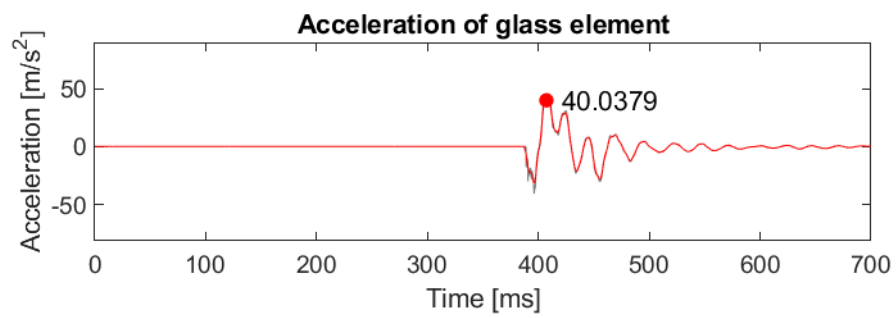
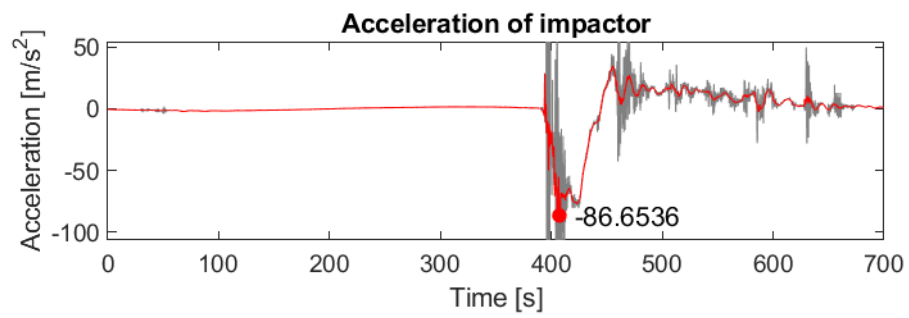
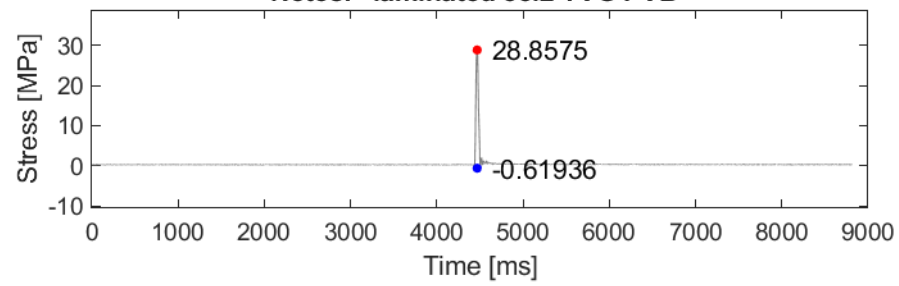
Data nr: 056
Glass: 12mm
Drop height: 500mm
Notes: "monolithic 12 mm ESG"



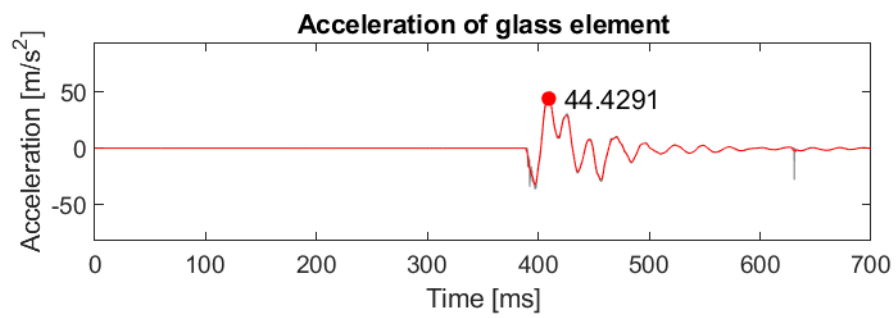
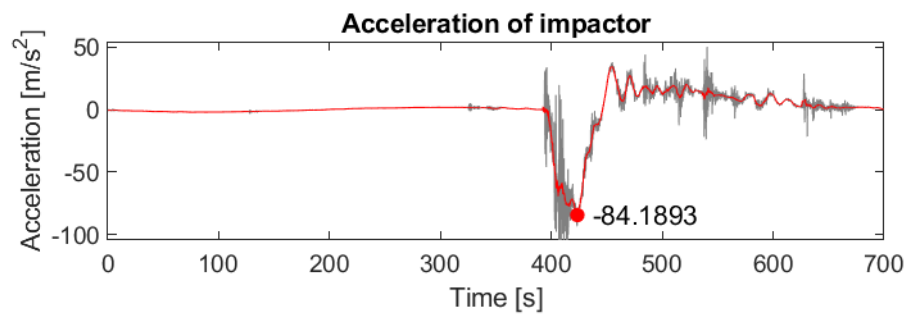
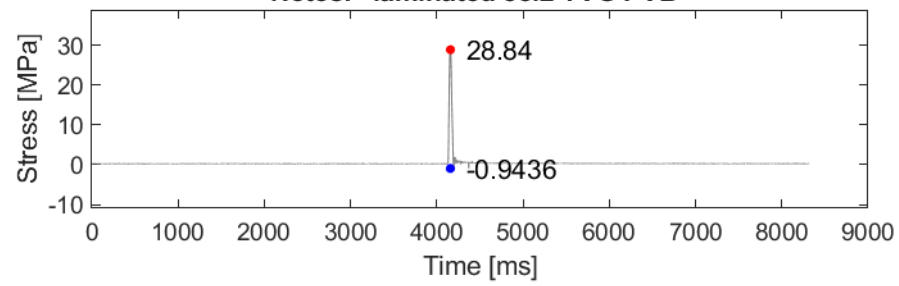
Data nr: 057
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 TVG PVB"



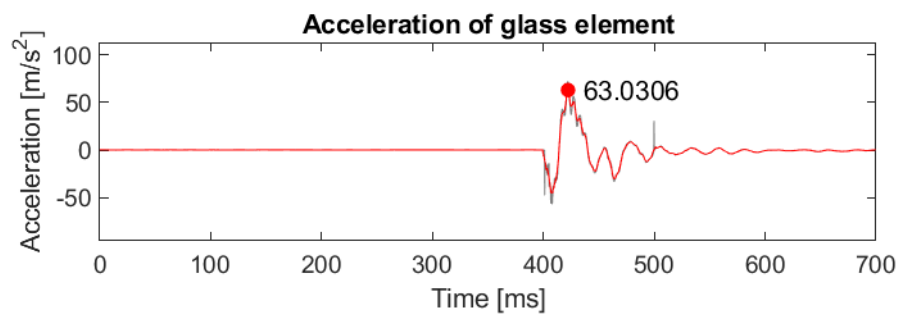
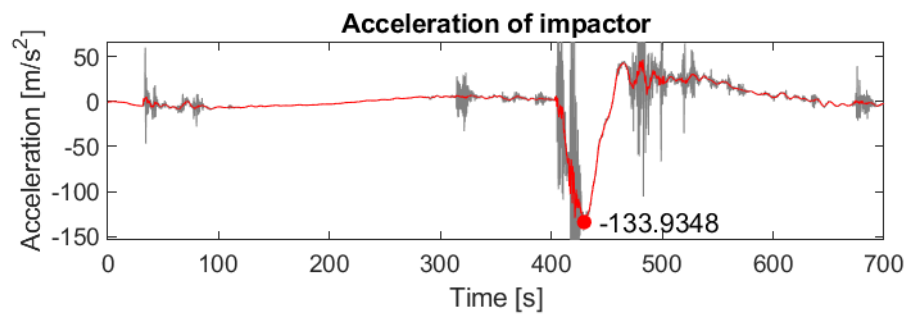
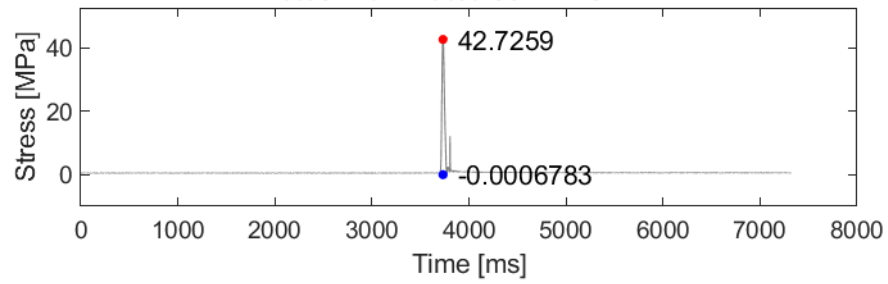
Data nr: 058
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 TVG PVB"



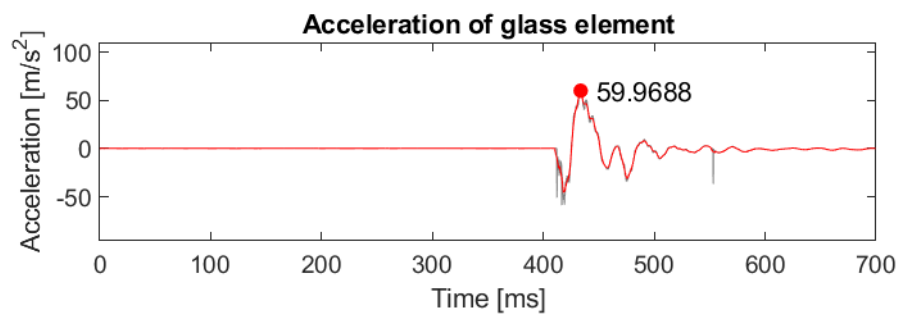
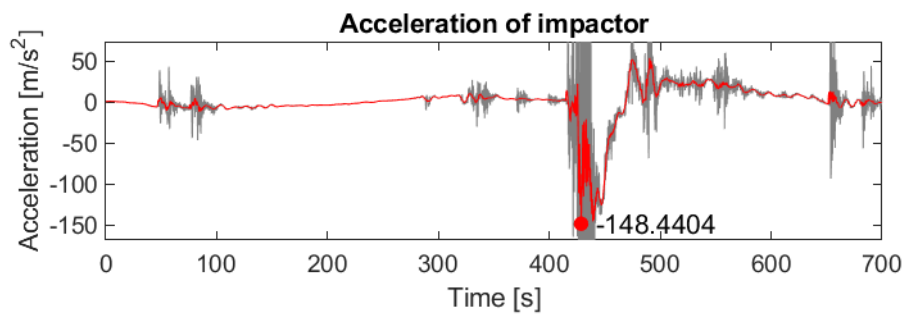
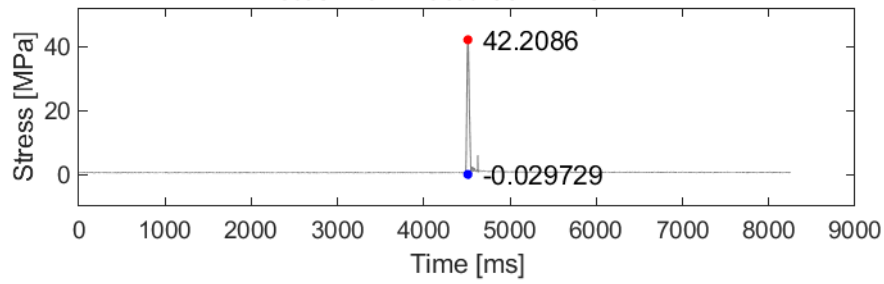
Data nr: 059
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 TVG PVB"



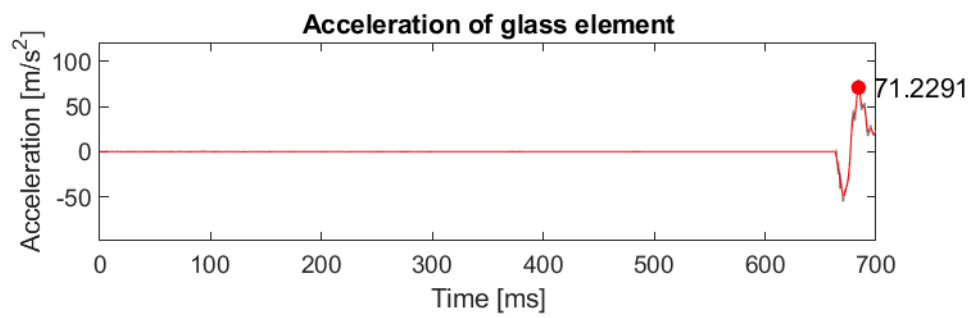
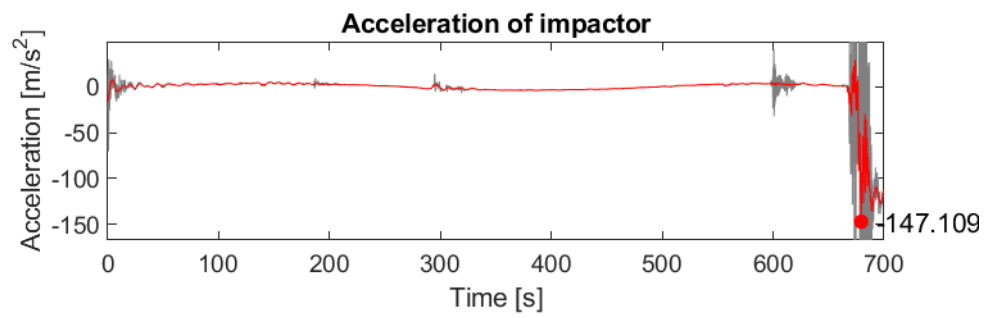
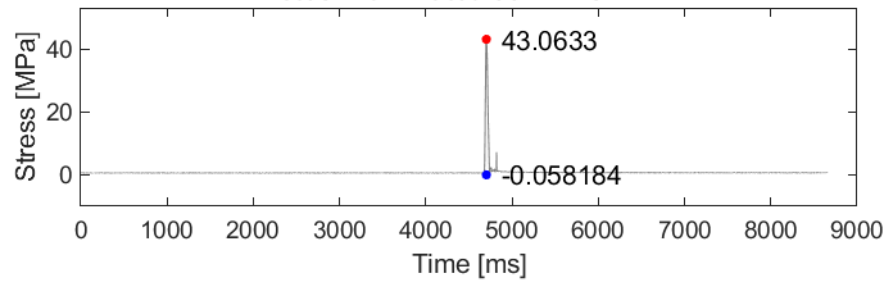
Data nr: 060
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 TVG PVB"



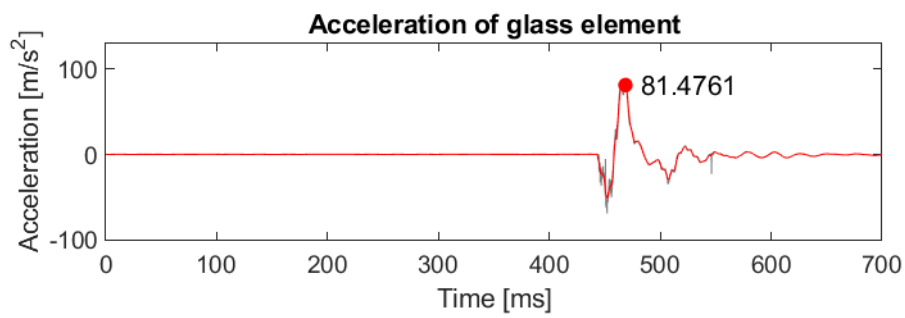
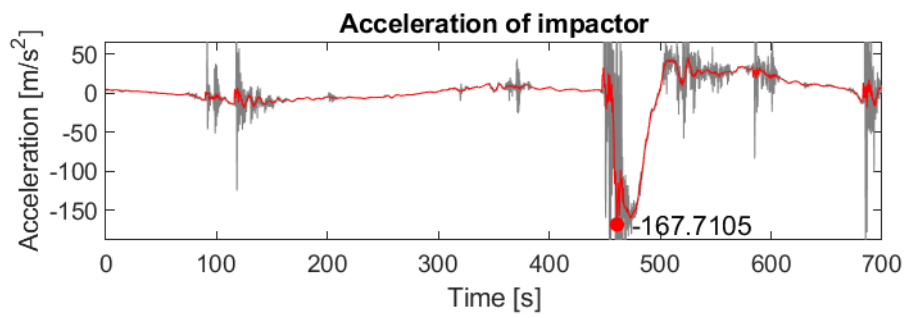
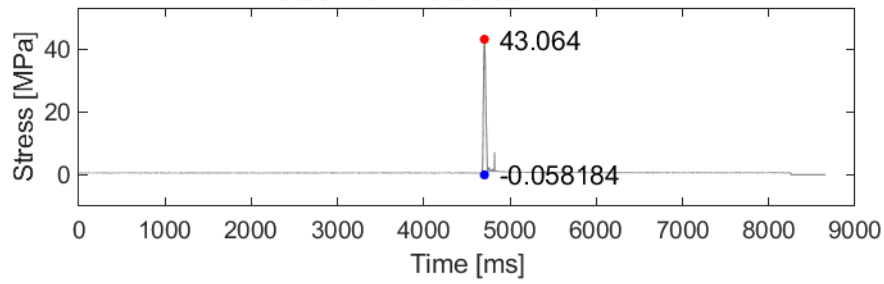
Data nr: 061
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 TVG PVB"



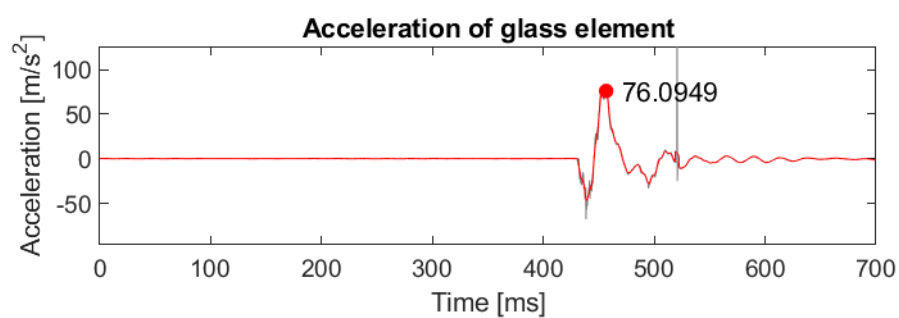
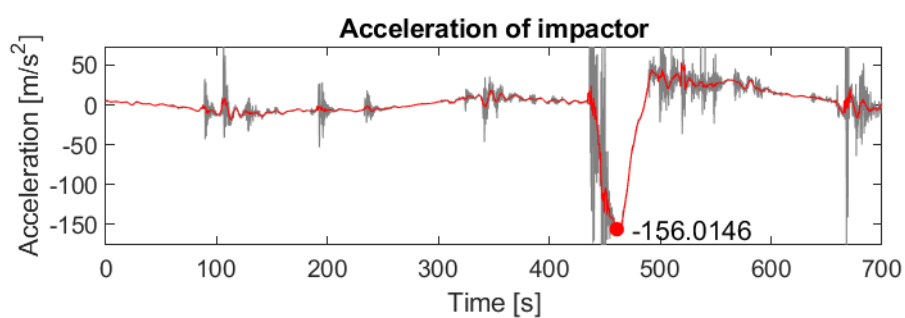
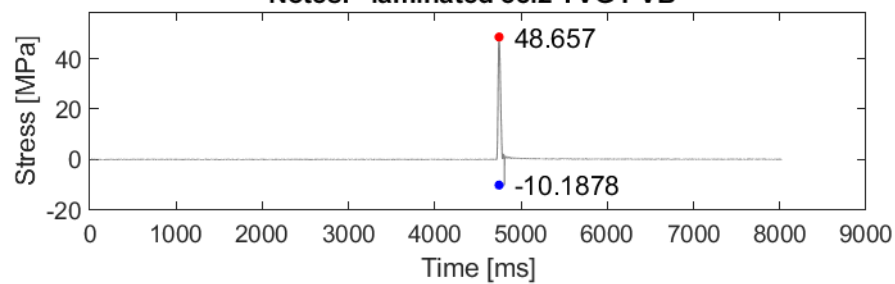
Data nr: 062
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 TVG PVB"



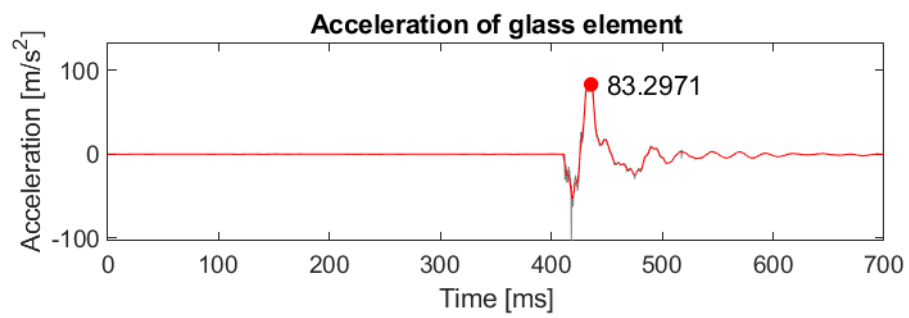
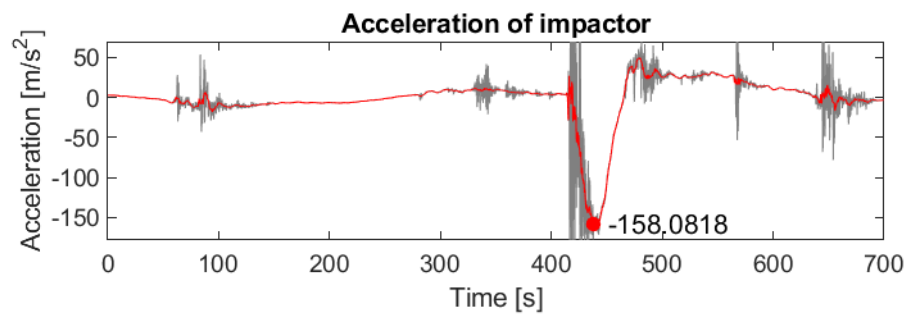
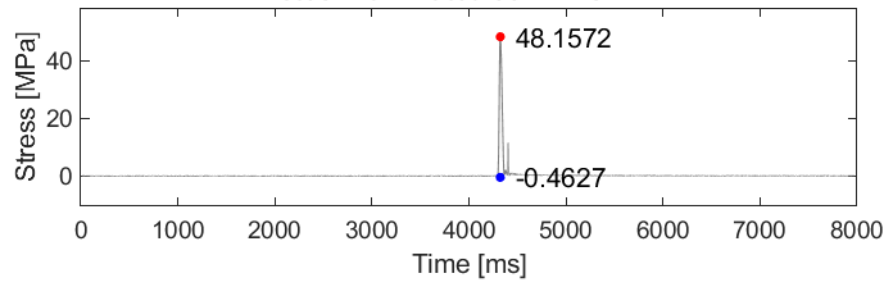
Data nr: 063
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 TVG PVB"



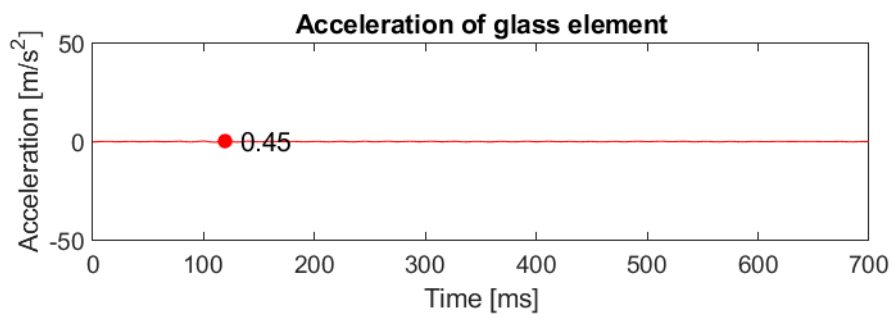
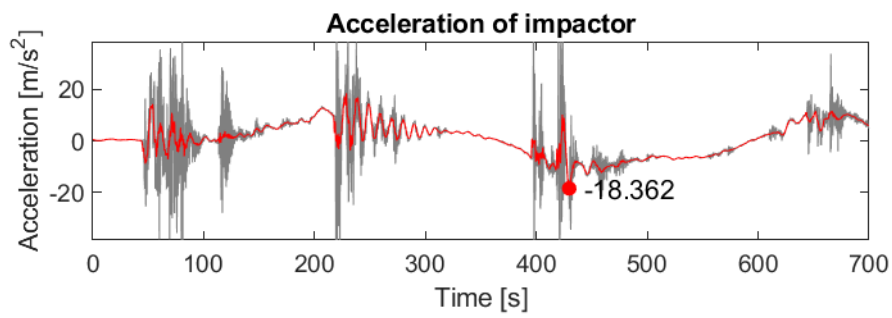
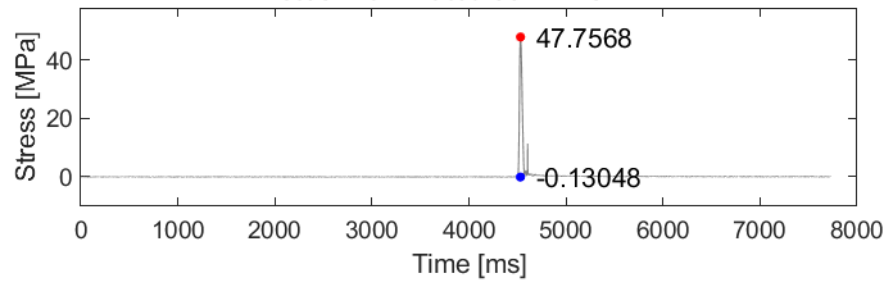
Data nr: 064
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 TVG PVB"



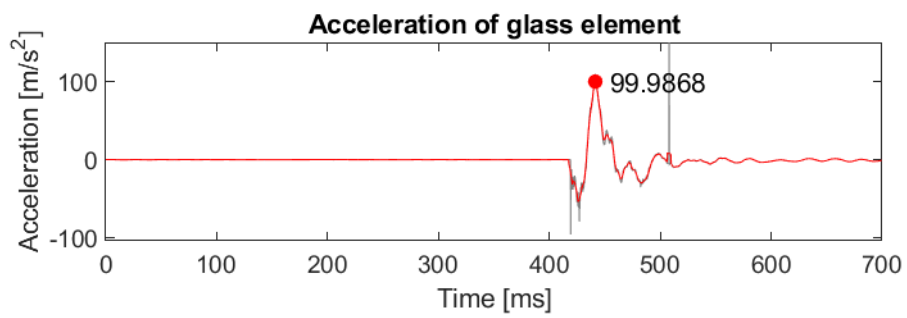
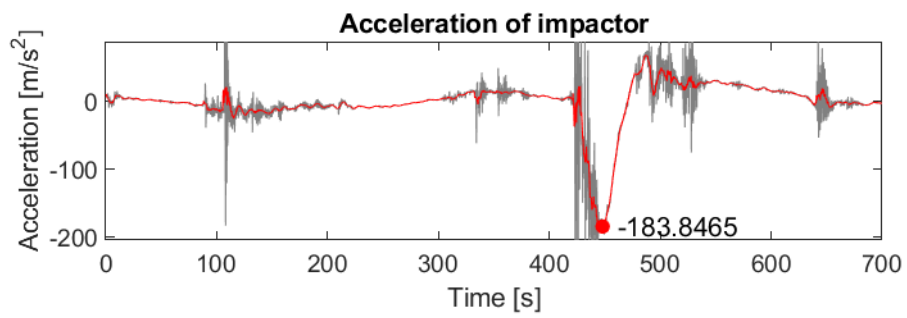
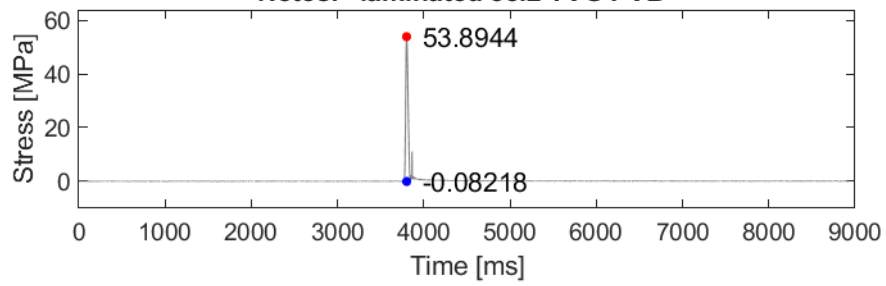
Data nr: 065
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 TVG PVB"



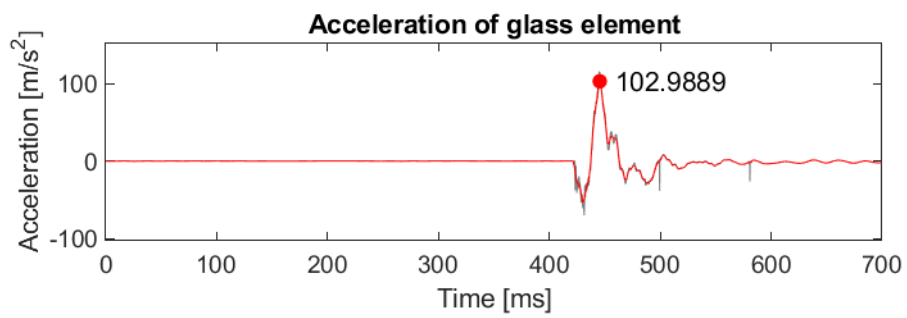
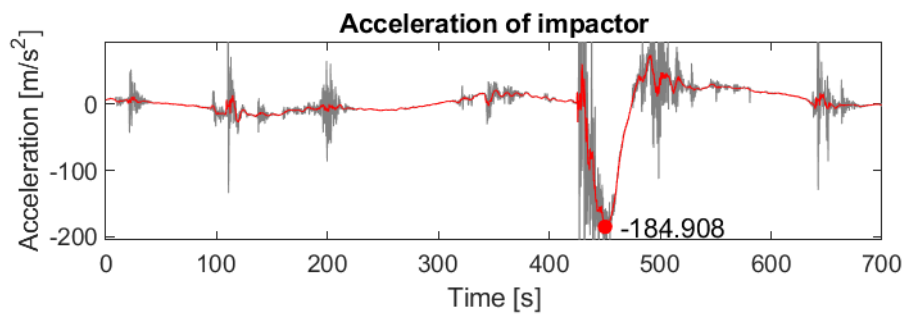
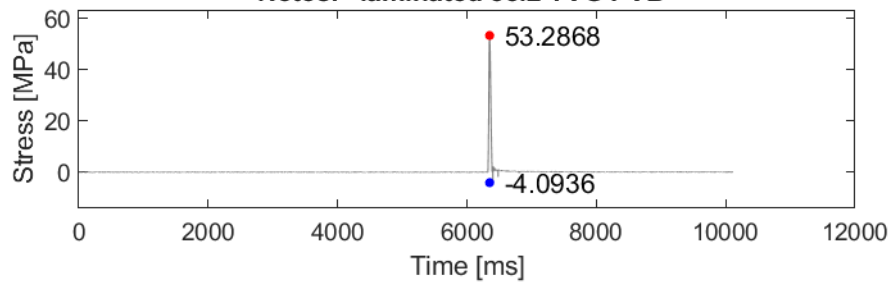
Data nr: 066
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 TVG PVB"



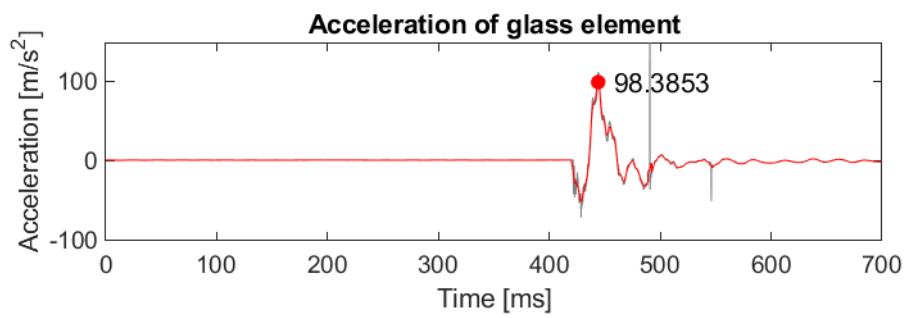
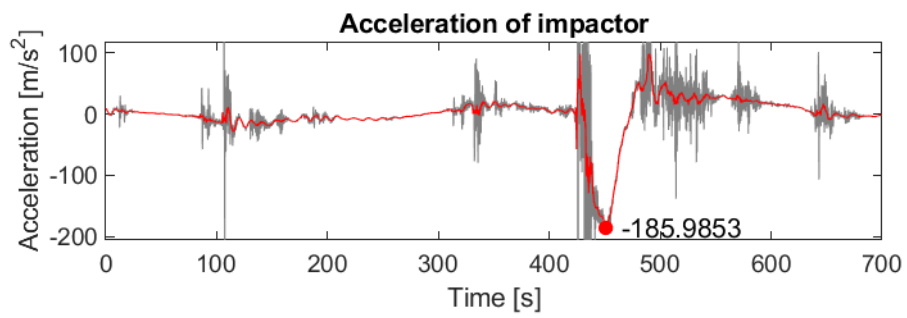
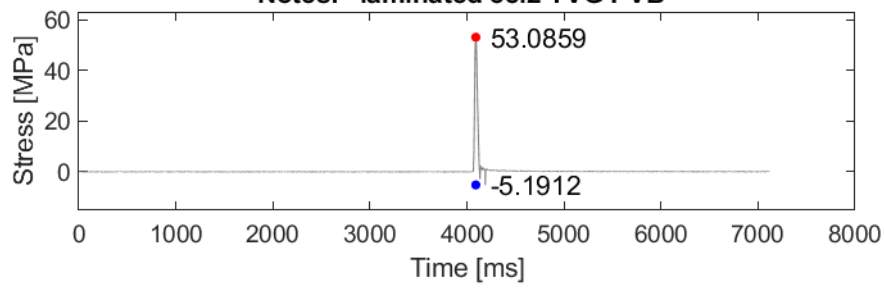
Data nr: 067
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 TVG PVB"



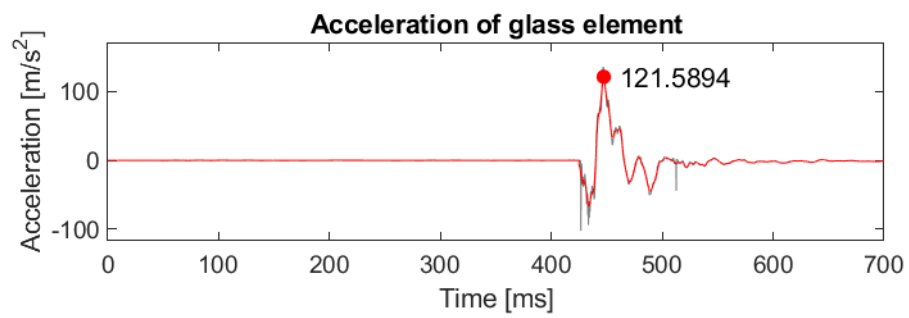
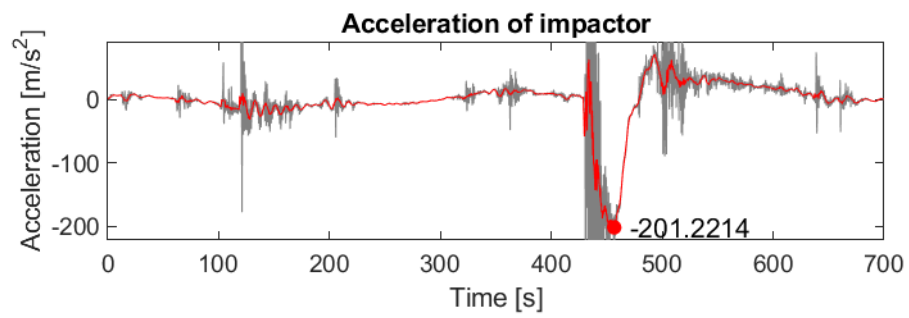
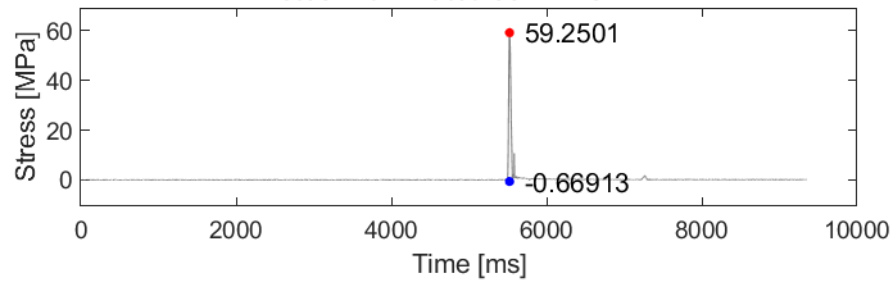
Data nr: 068
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 TVG PVB"



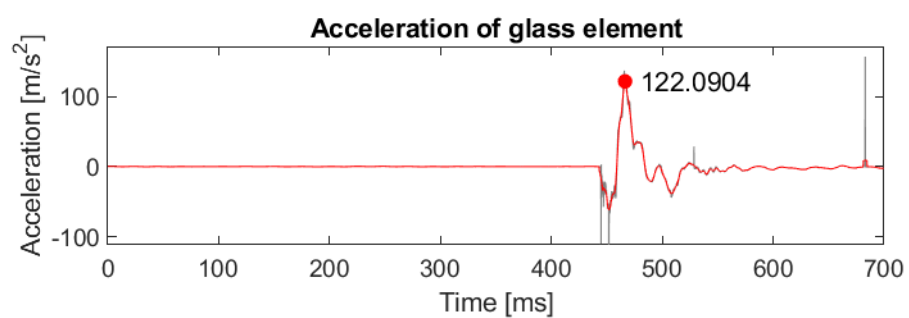
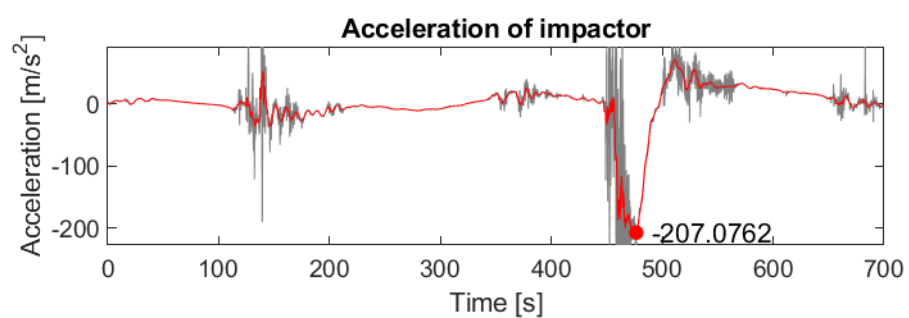
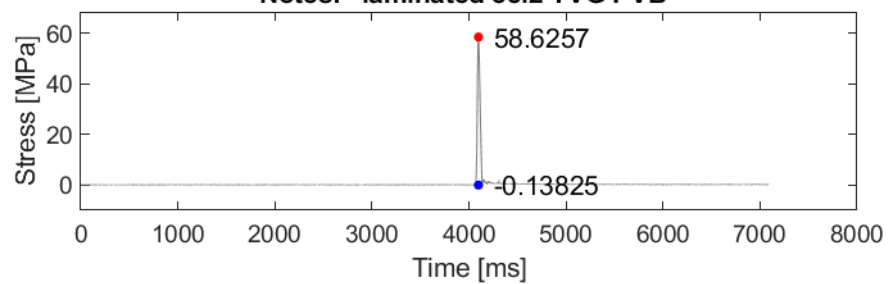
Data nr: 069
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 TVG PVB"



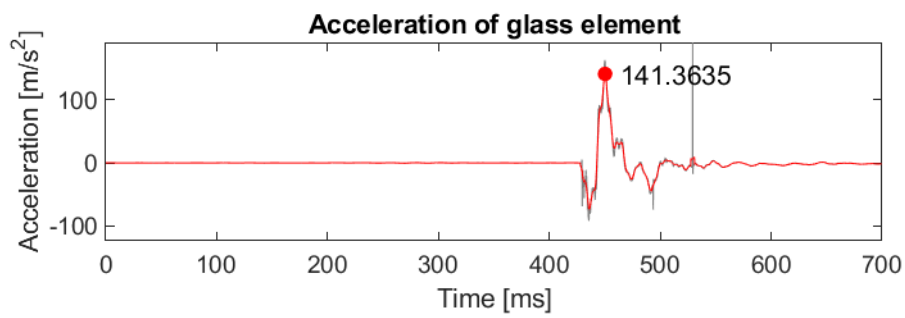
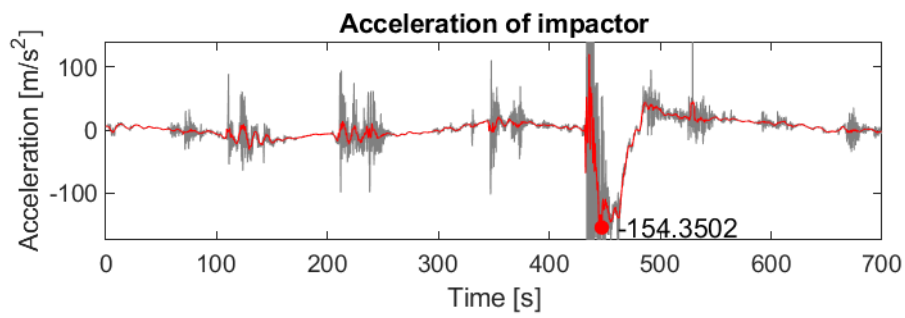
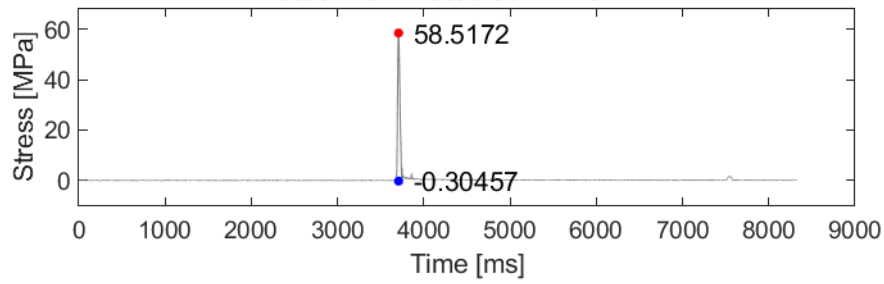
Data nr: 070
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 TVG PVB"



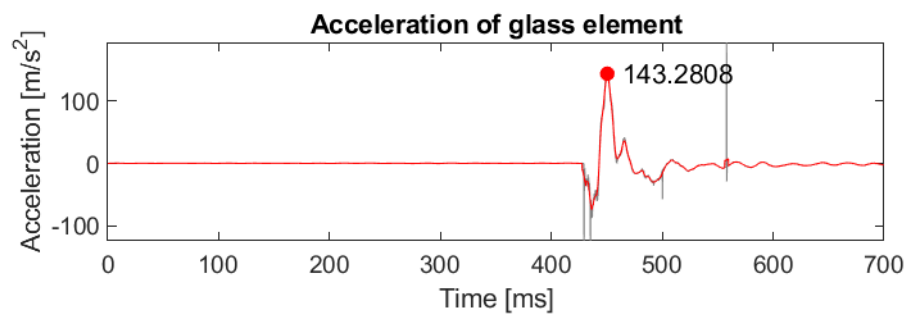
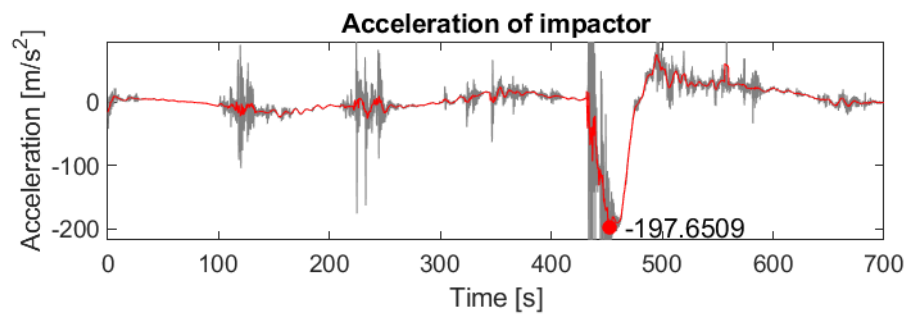
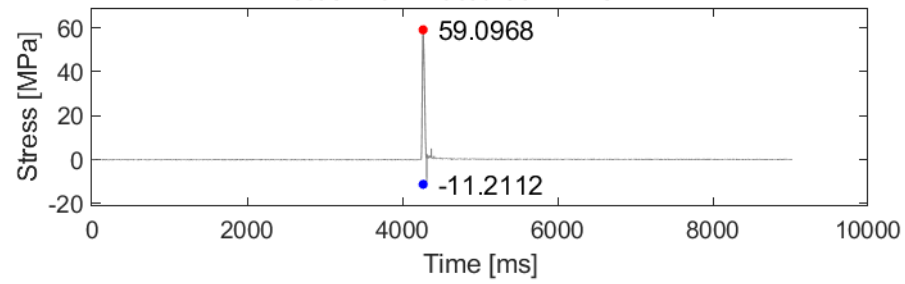
Data nr: 071
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 TVG PVB"

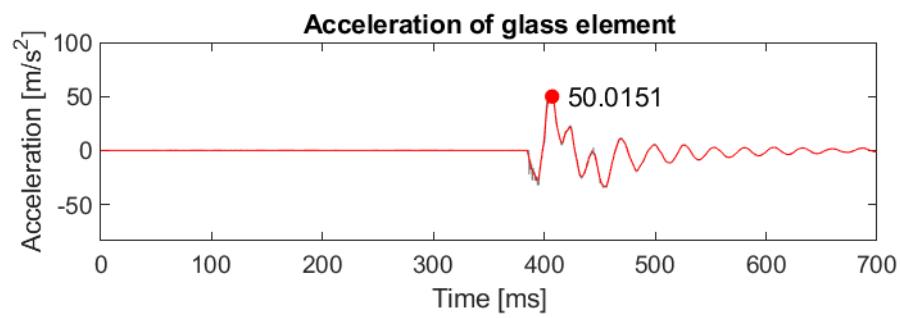
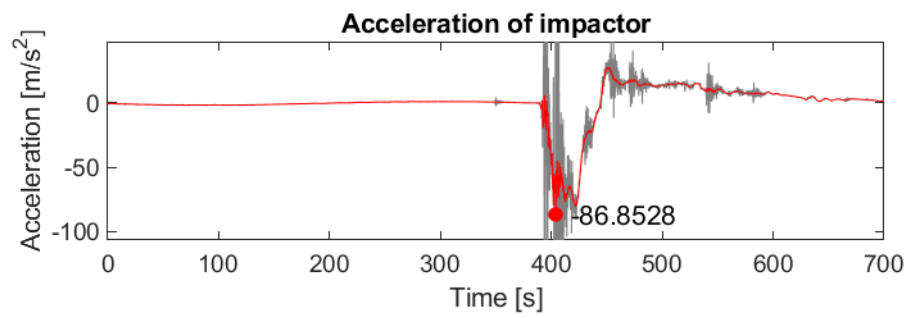
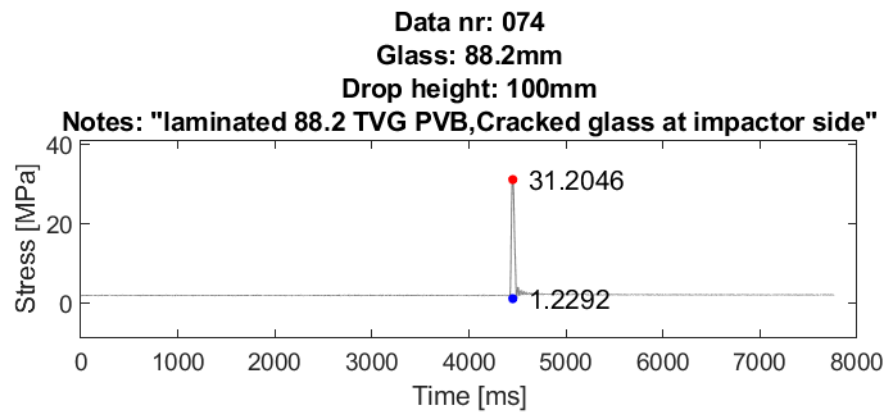


Data nr: 072
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 TVG PVB"

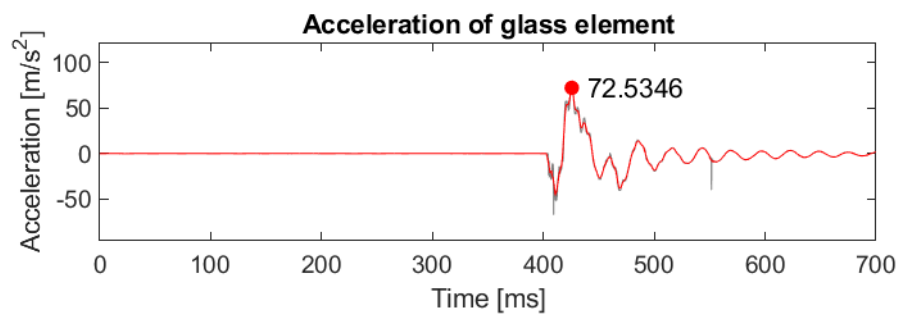
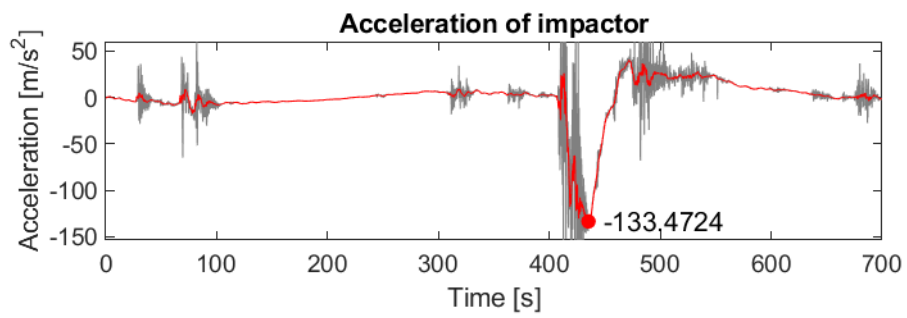
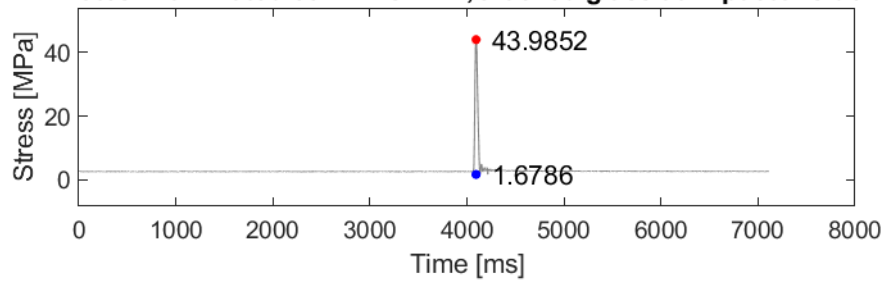


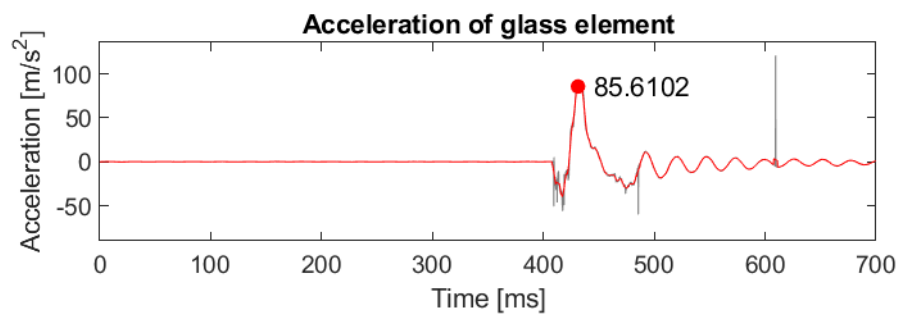
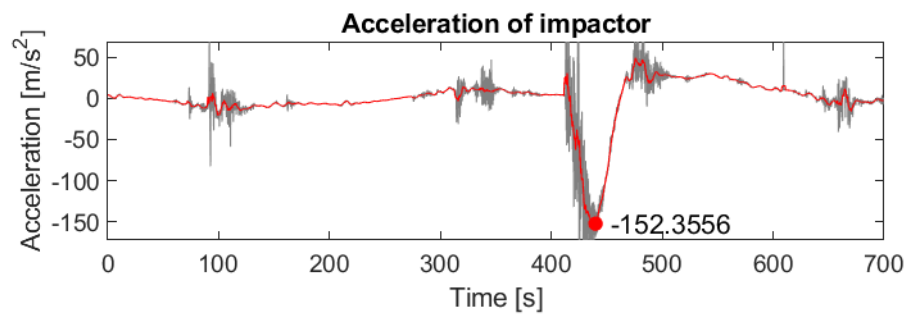
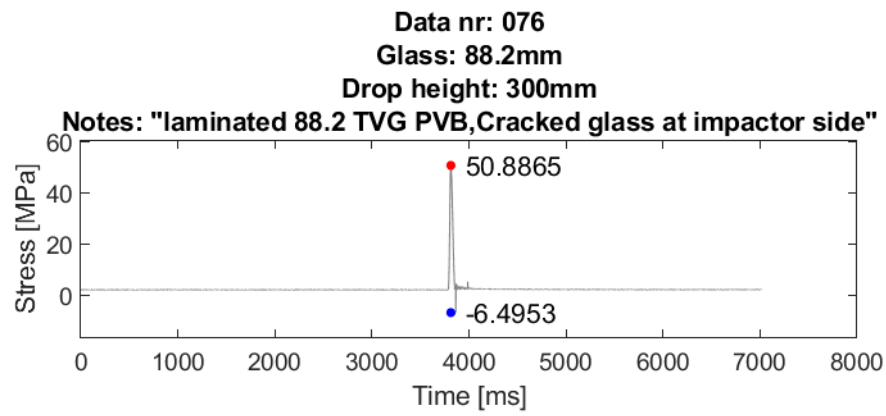
Data nr: 073
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 TVG PVB"



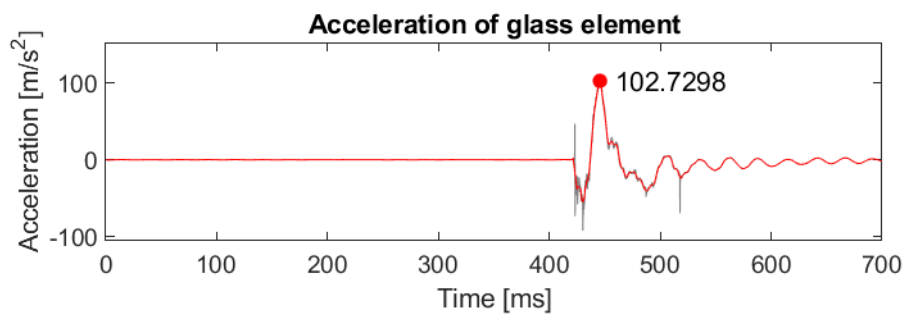
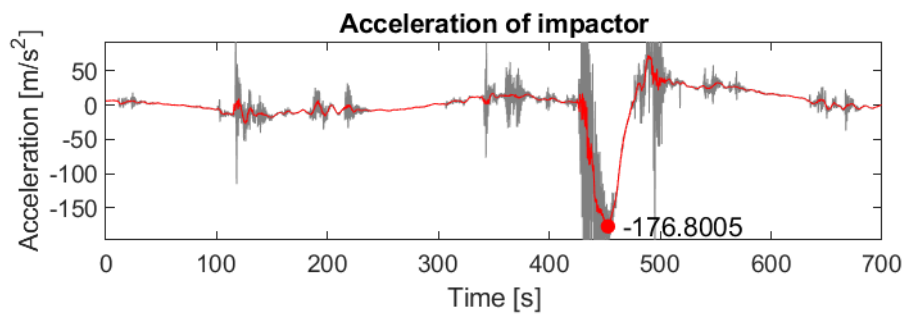
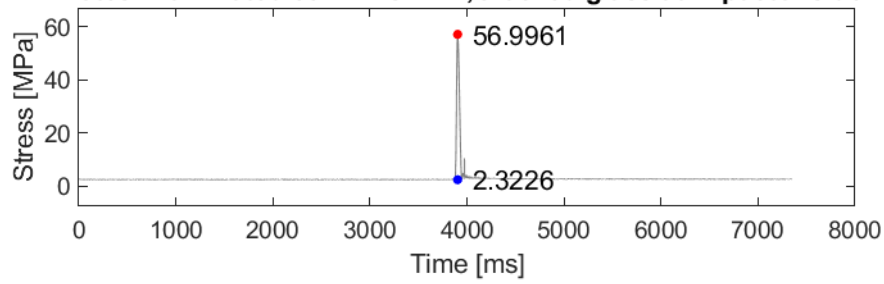


Data nr: 075
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 TVG PVB,Cracked glass at impactor side"

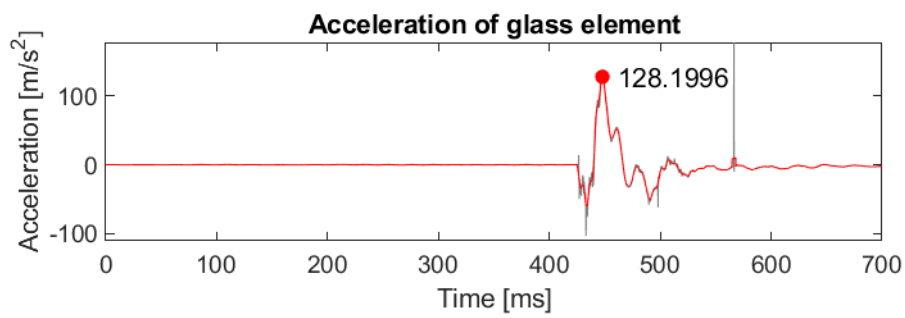
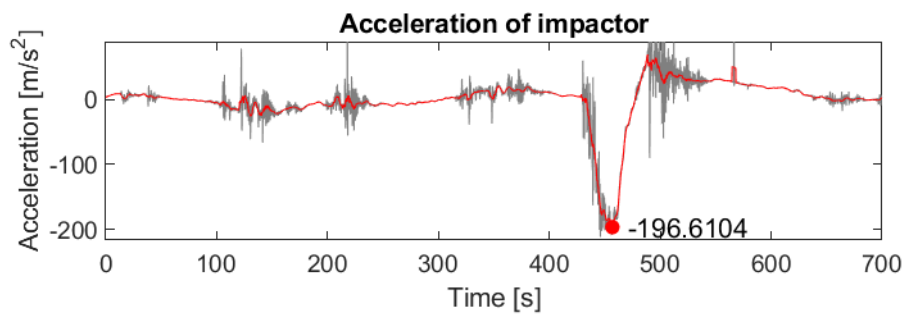
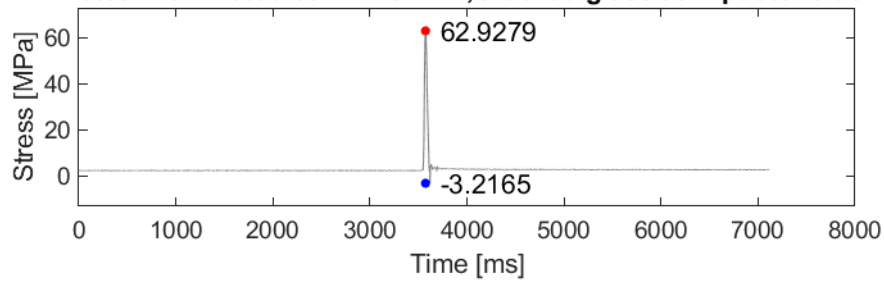




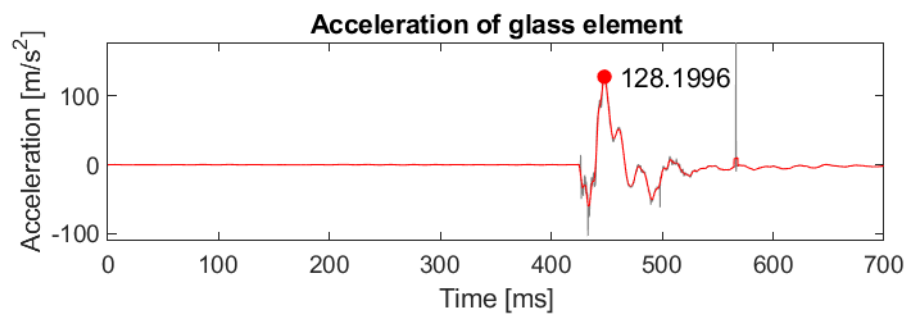
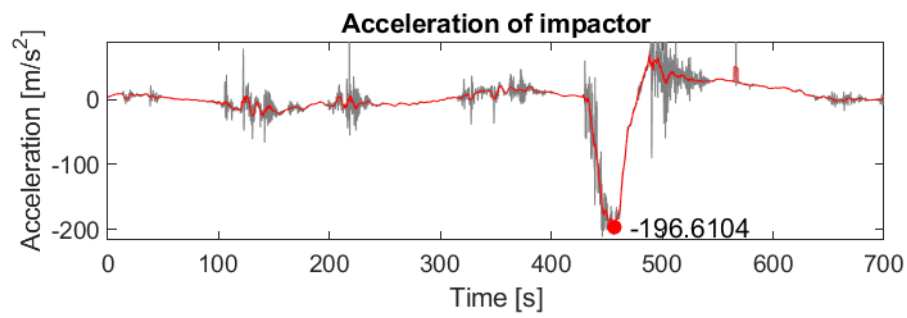
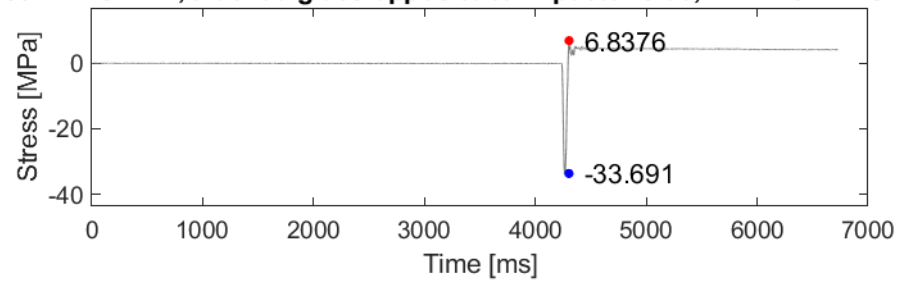
Data nr: 077
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 TVG PVB,Cracked glass at impactor side"



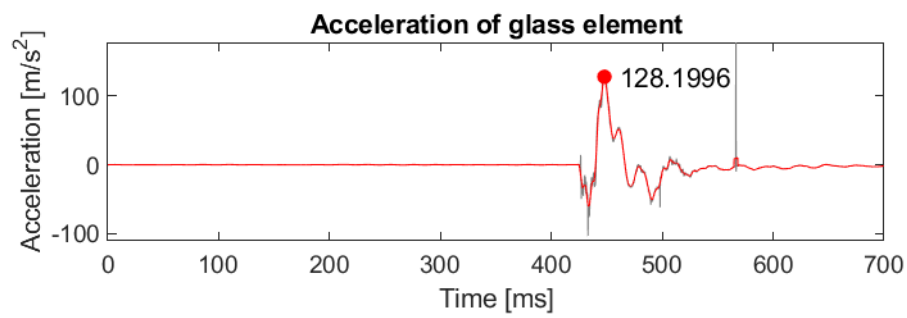
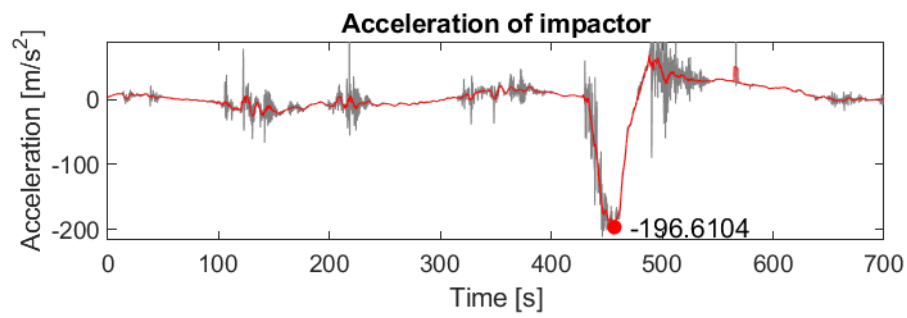
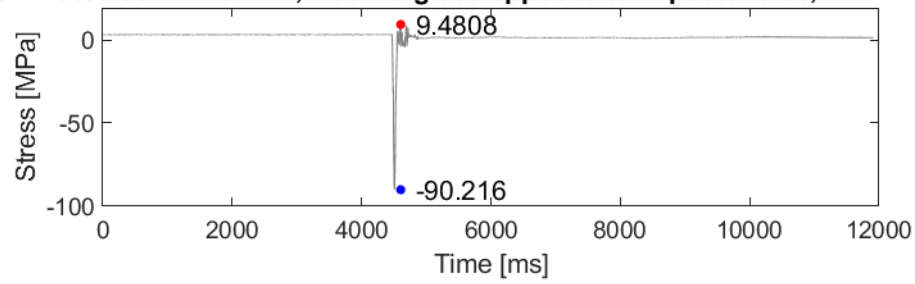
Data nr: 078
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 TVG PVB,Cracked glass at impactor side"



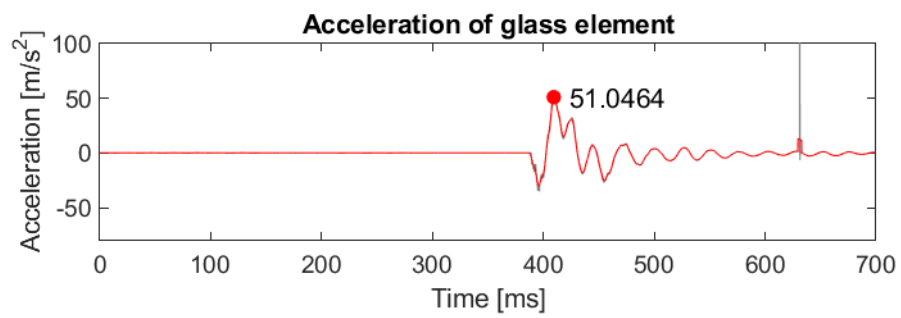
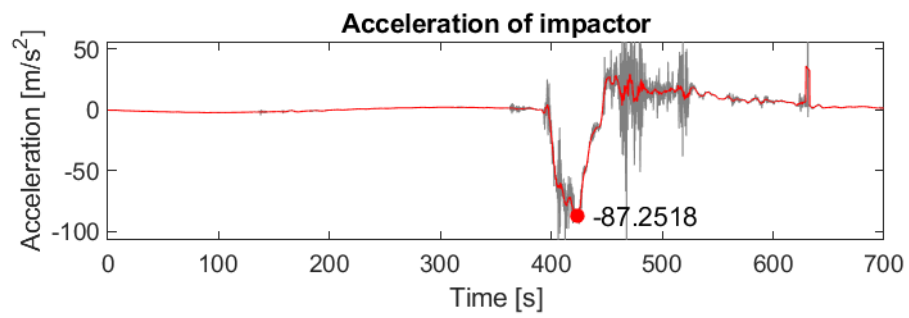
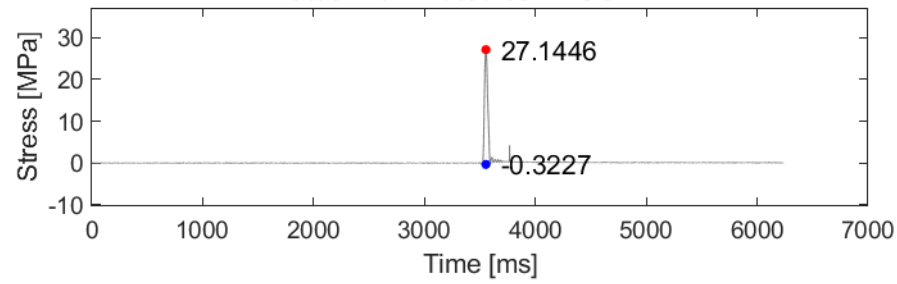
Data nr: 079
Glass: 88.2mm
Drop height: 100mm
ted 88.2 TVG PVB,Cracked glass opposite to impactor side, TAKE ONLY STRAIN



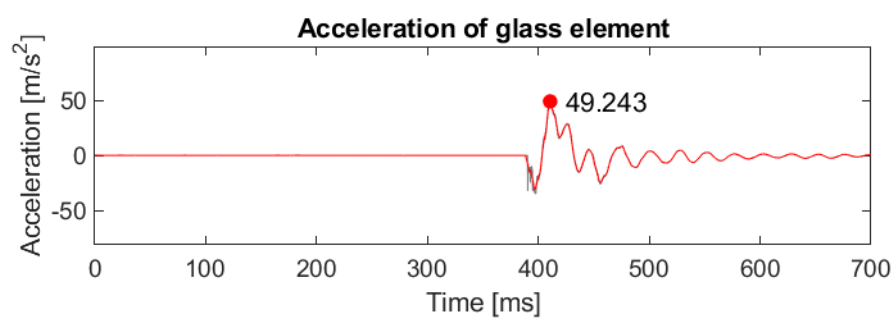
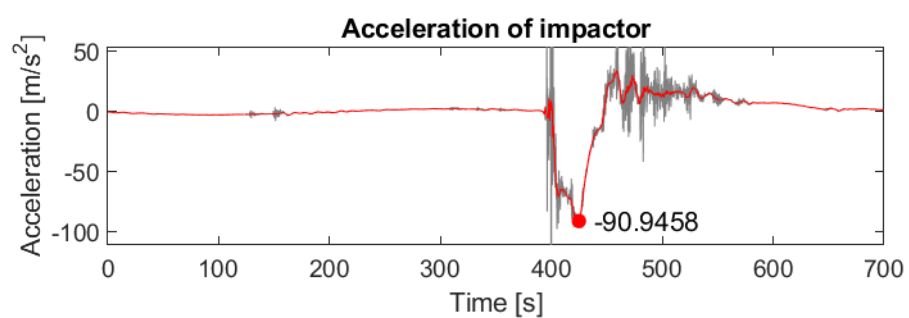
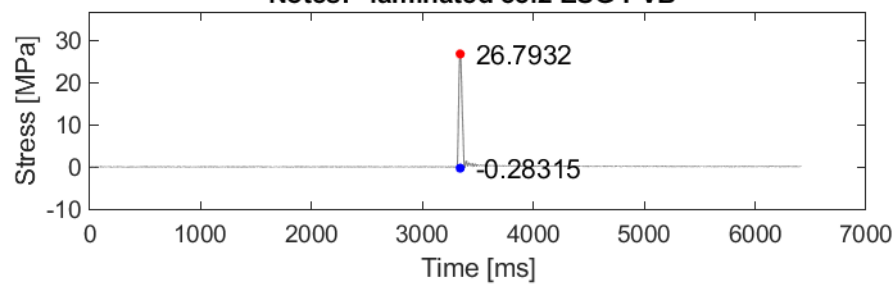
Data nr: 080
Glass: 88.2mm
Drop height: 200mm
"laminated 88.2 TVG PVB,Cracked glass opposite to impactor side, TAKE ONLY



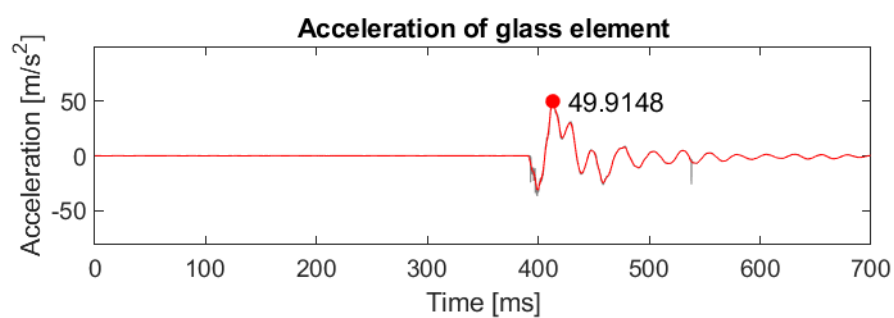
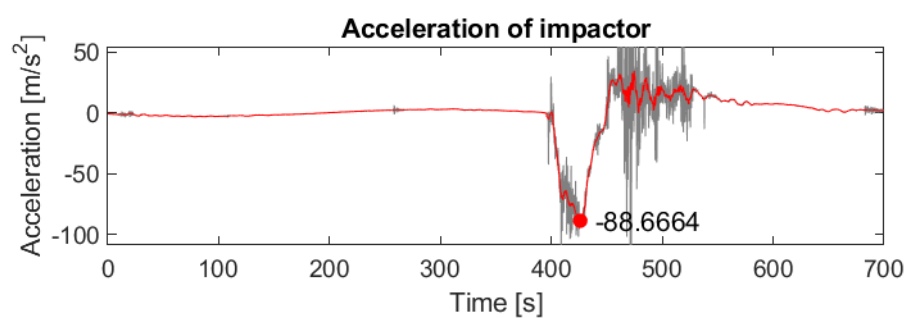
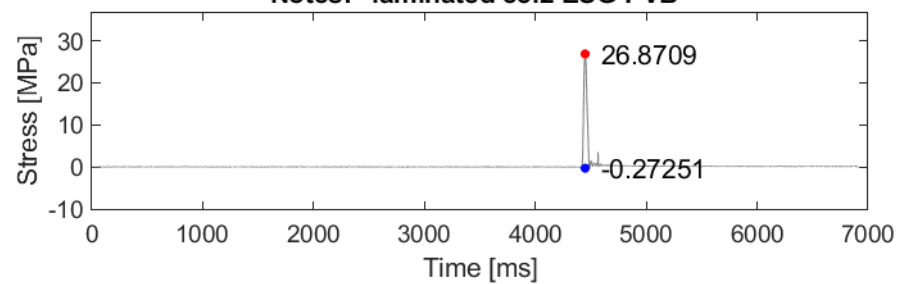
Data nr: 081
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 ESG PVB"



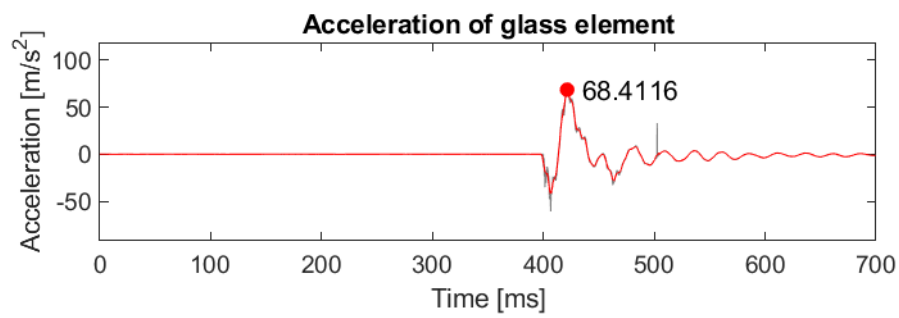
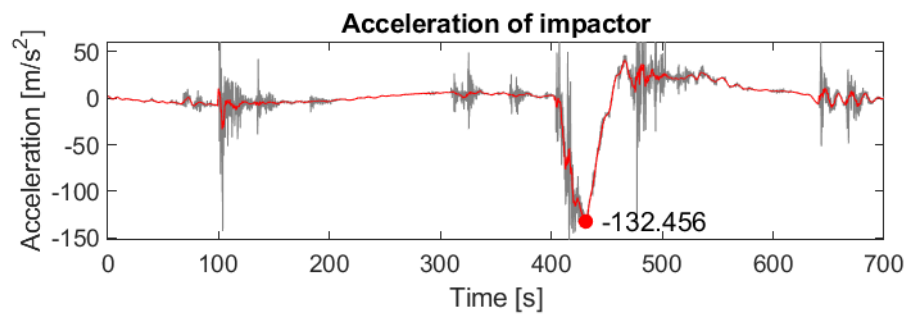
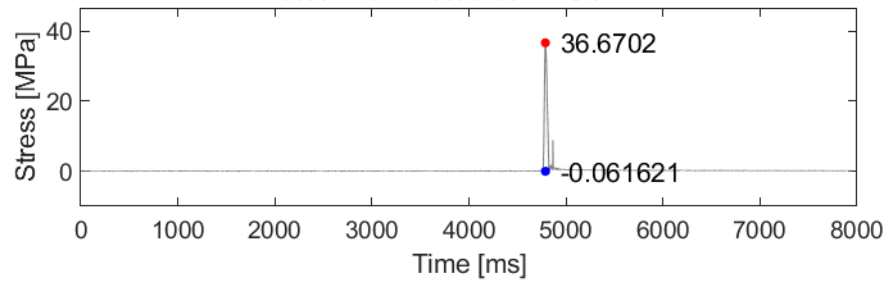
Data nr: 082
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 ESG PVB"



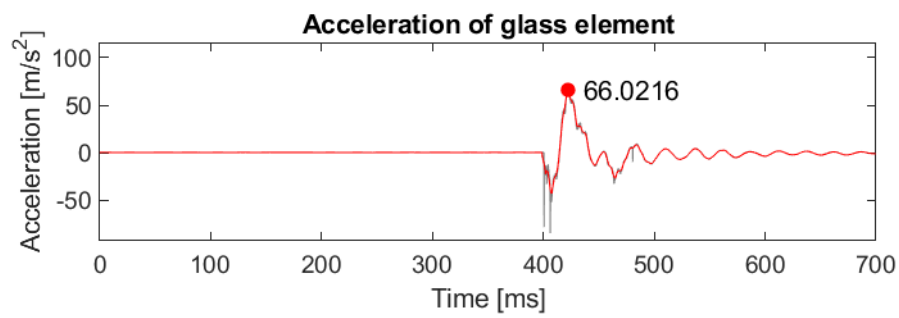
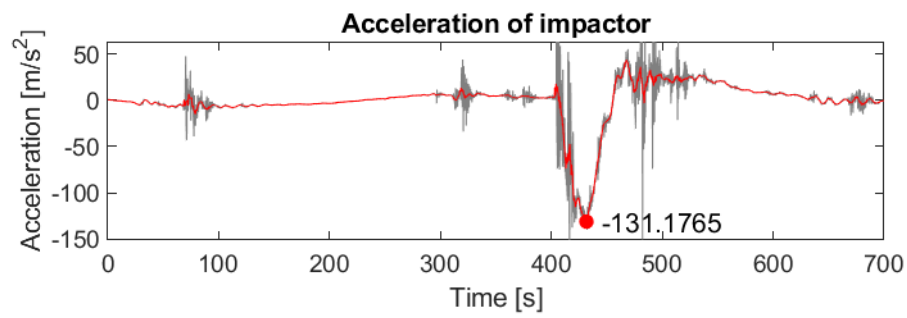
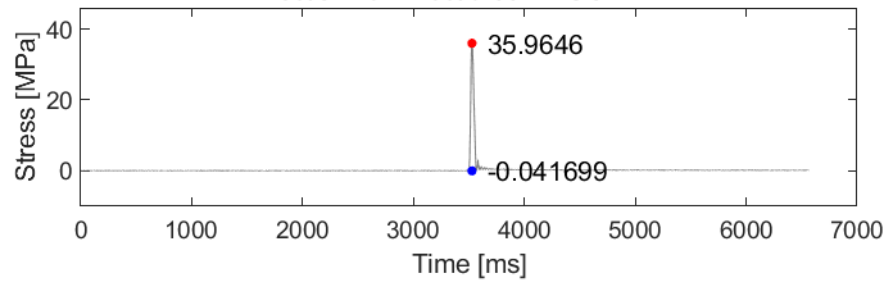
Data nr: 083
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 ESG PVB"



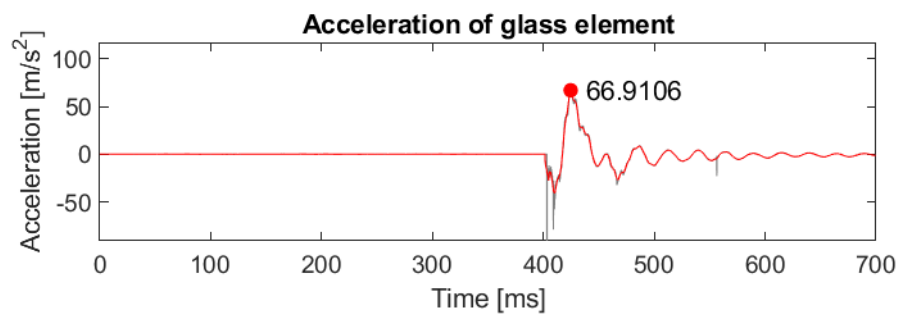
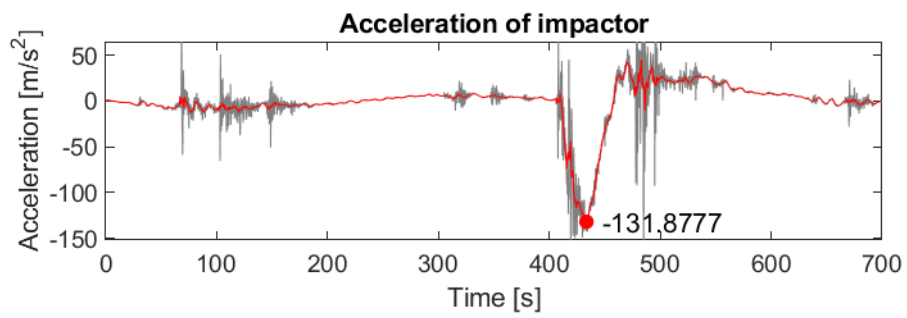
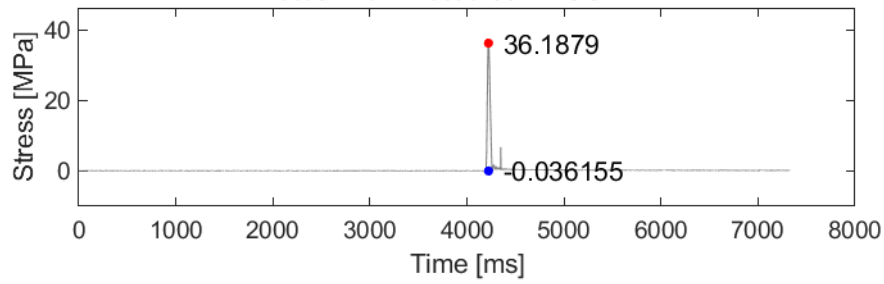
Data nr: 084
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 ESG PVB"



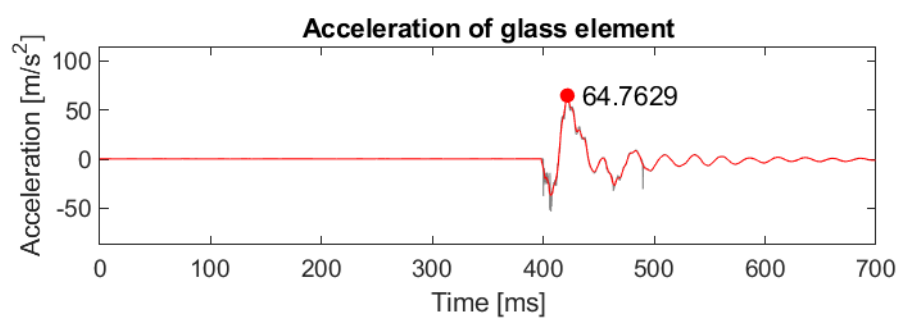
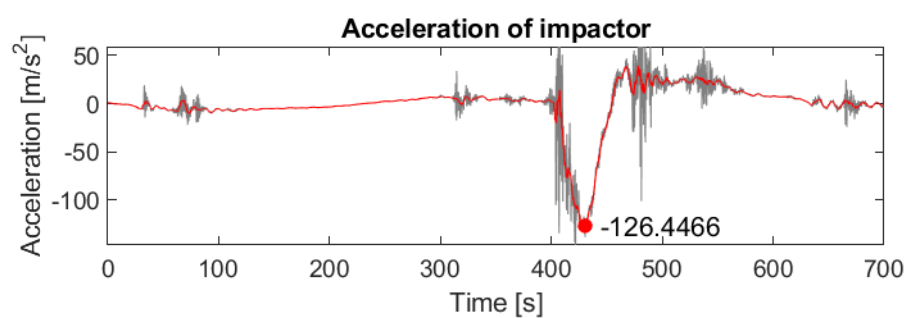
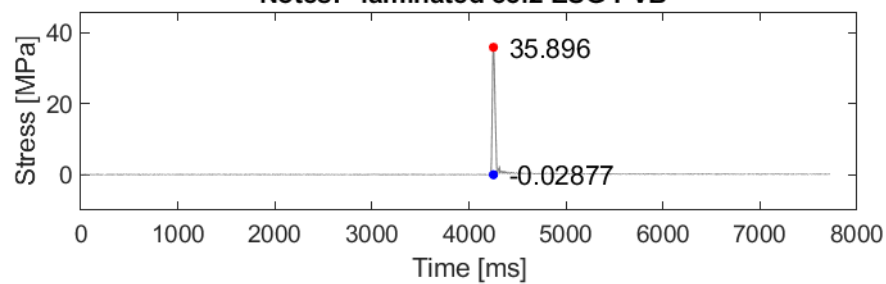
Data nr: 085
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 ESG PVB"



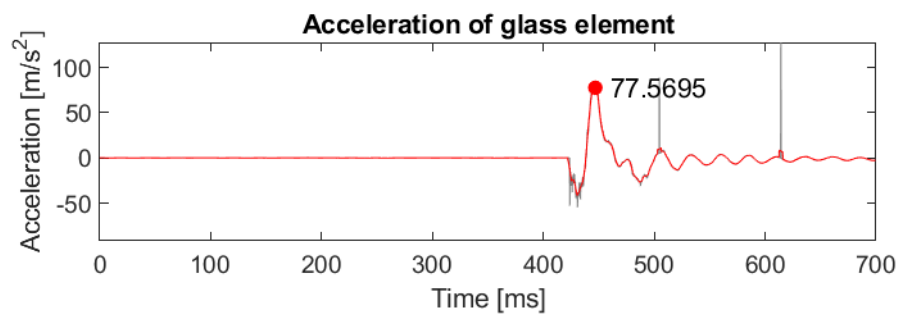
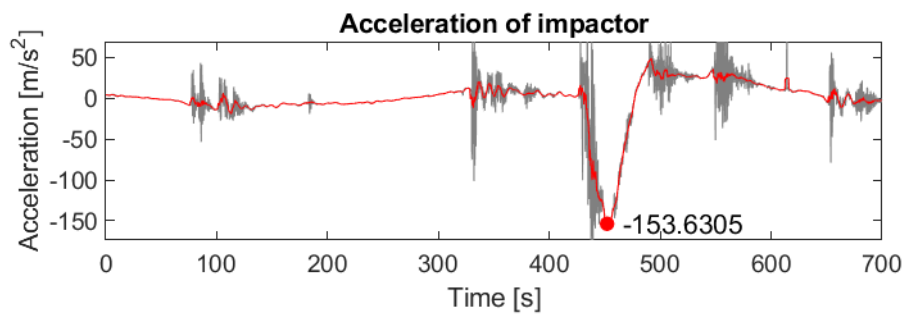
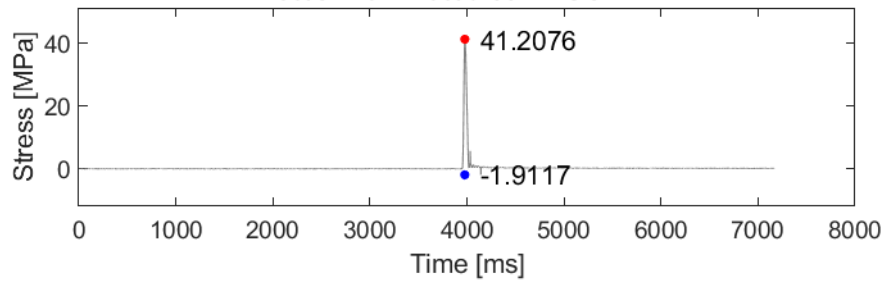
Data nr: 086
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 ESG PVB"



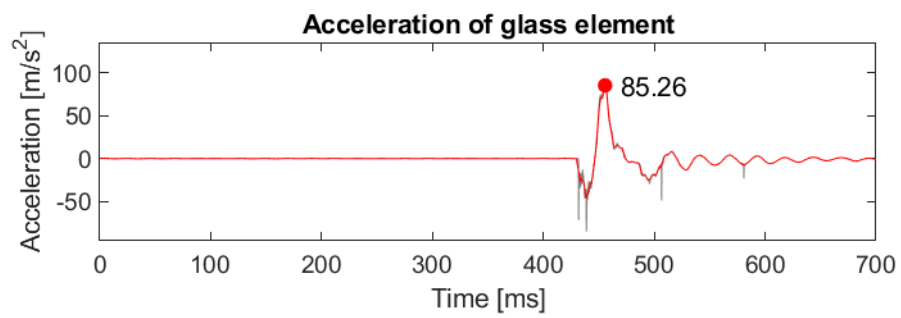
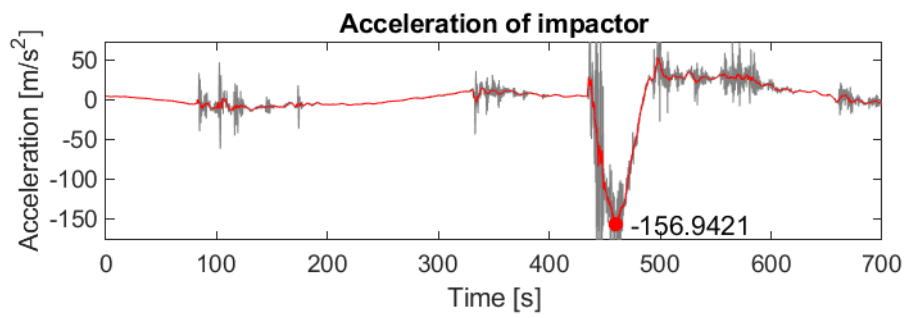
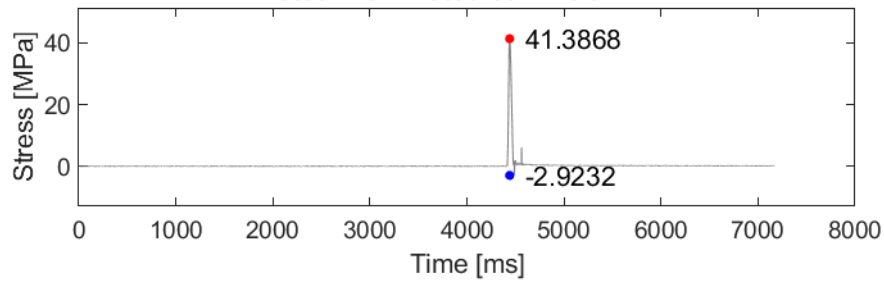
Data nr: 087
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 ESG PVB"



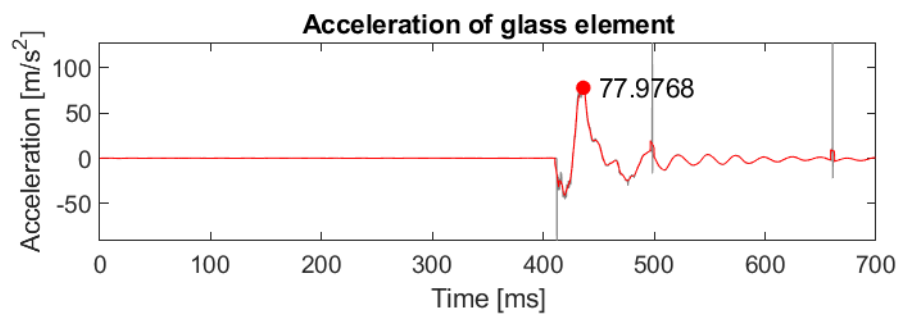
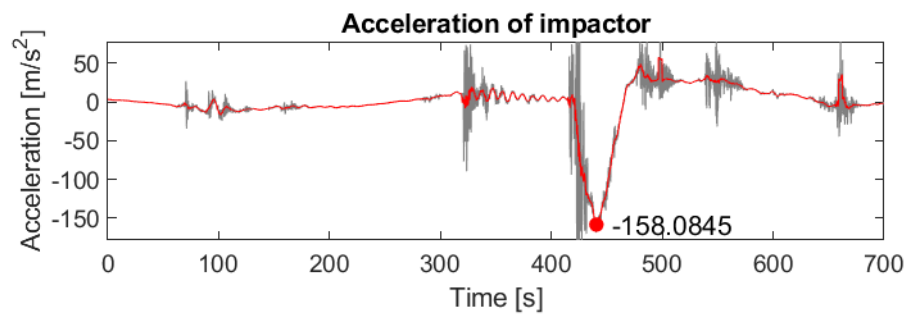
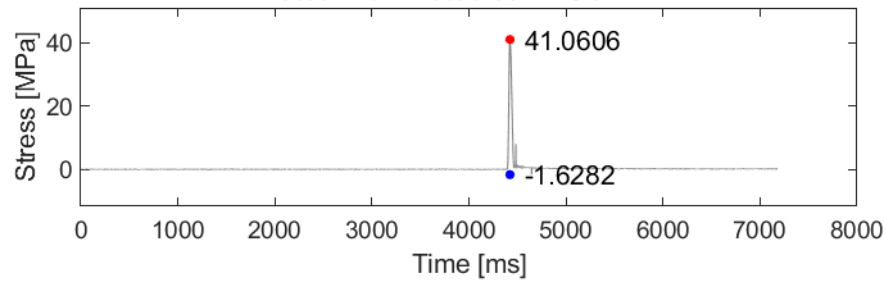
Data nr: 088
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 ESG PVB"



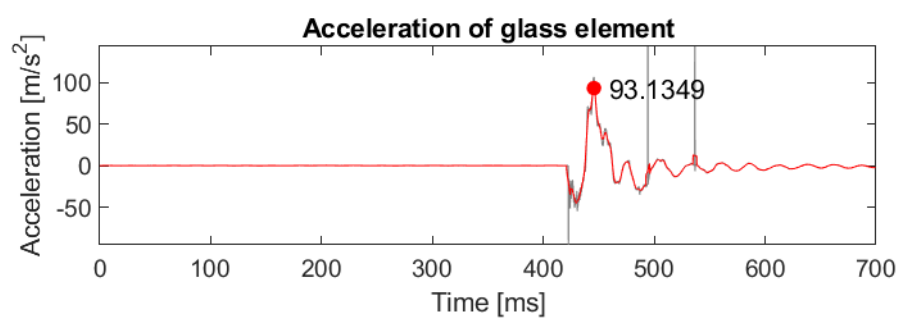
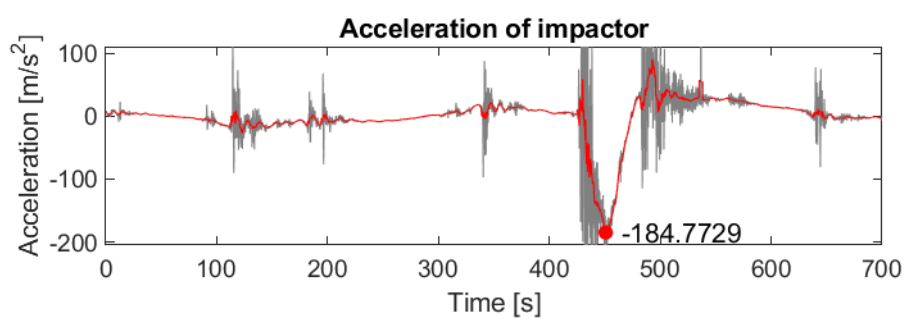
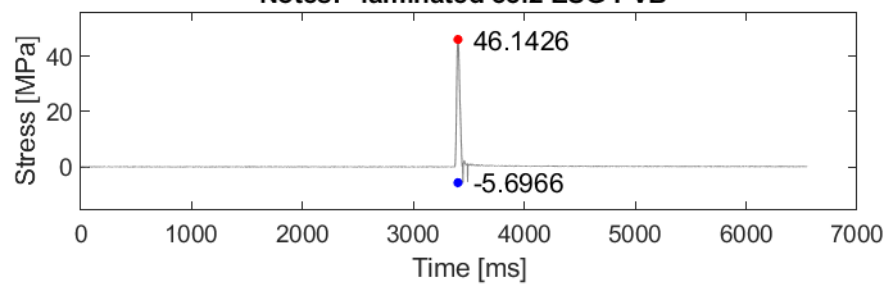
Data nr: 089
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 ESG PVB"



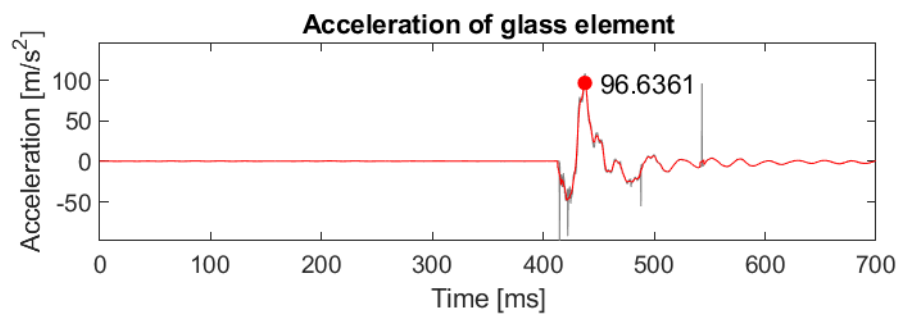
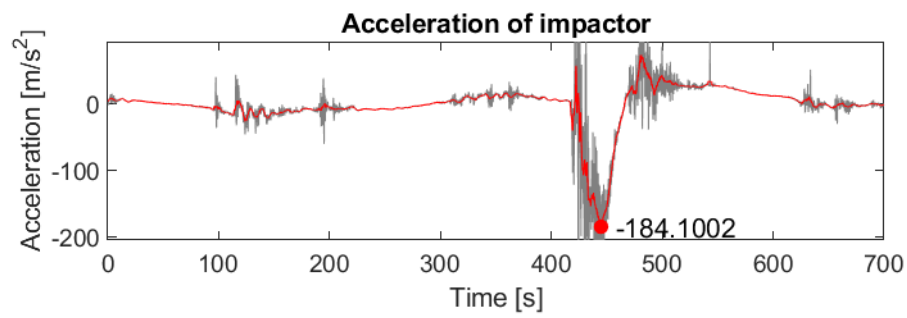
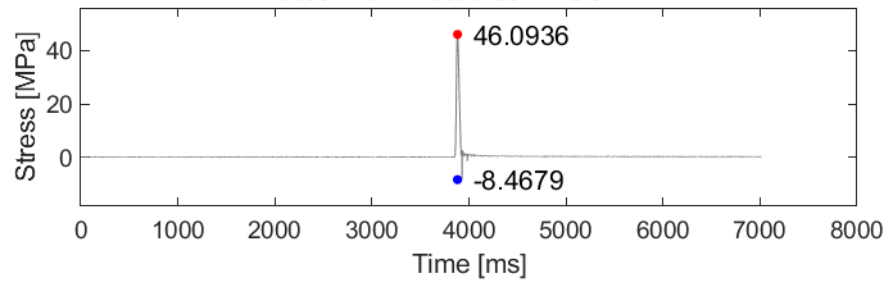
Data nr: 090
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 ESG PVB"



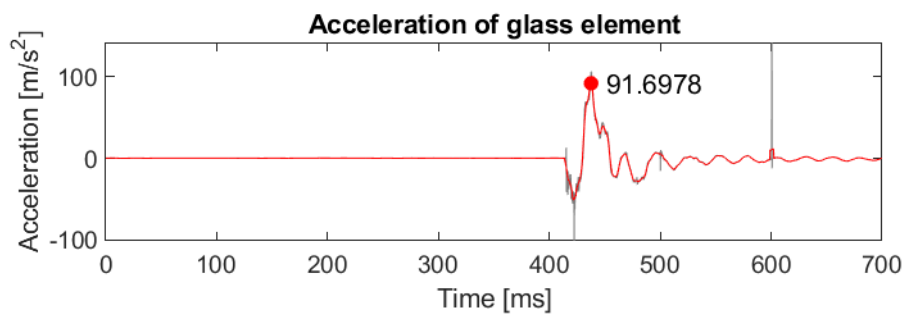
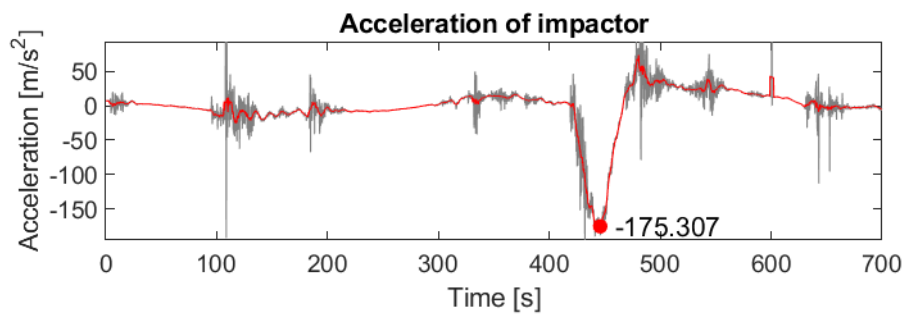
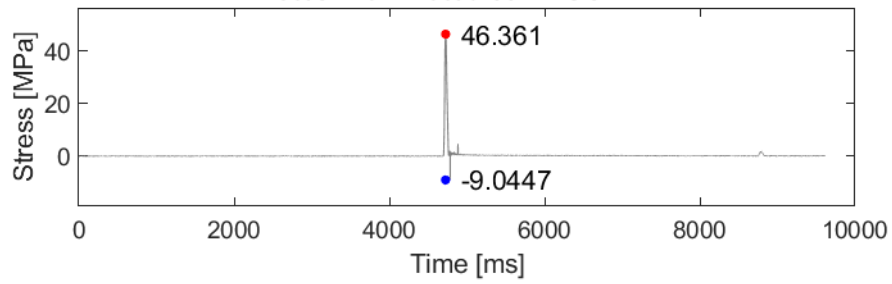
Data nr: 091
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 ESG PVB"



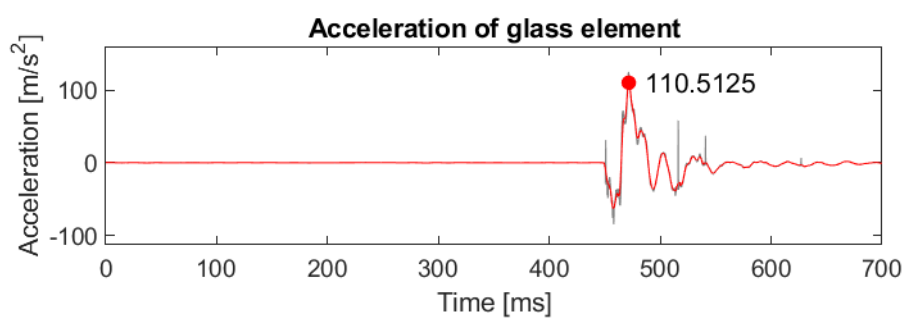
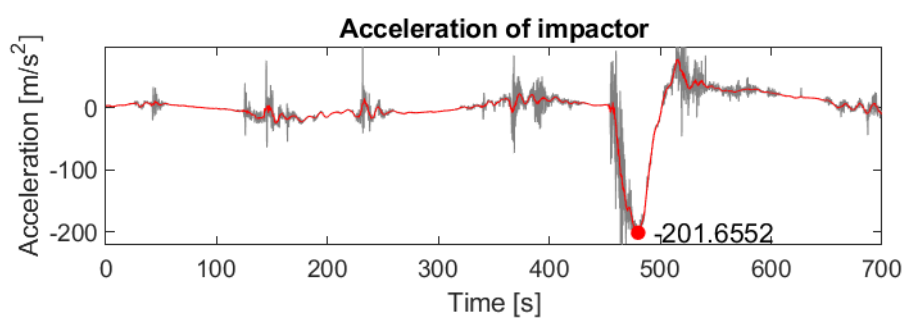
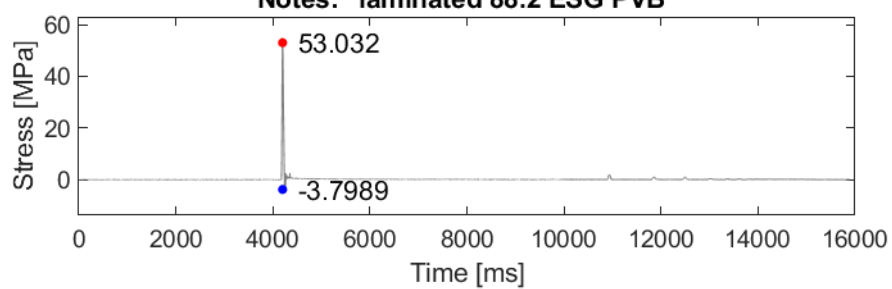
Data nr: 092
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 ESG PVB"



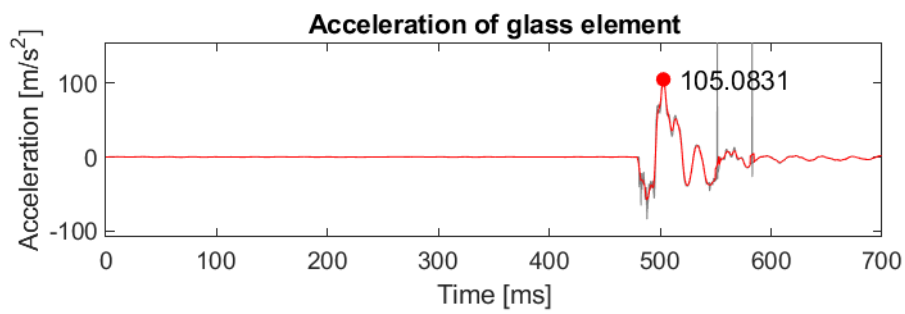
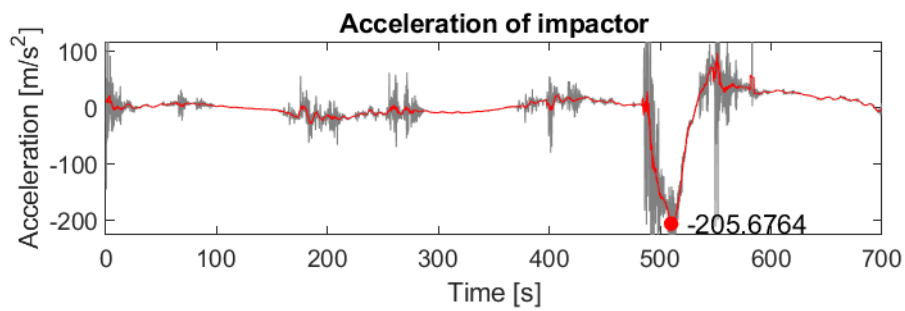
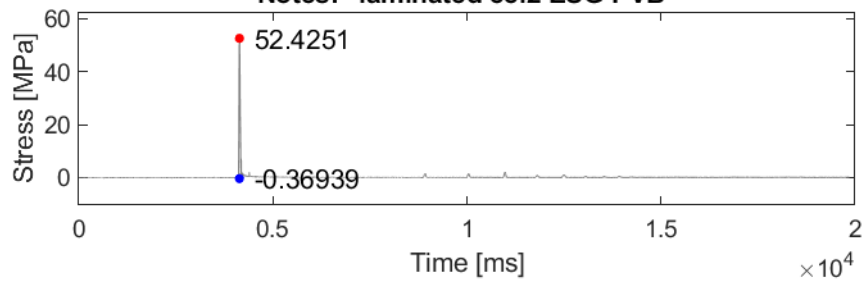
Data nr: 093
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 ESG PVB"



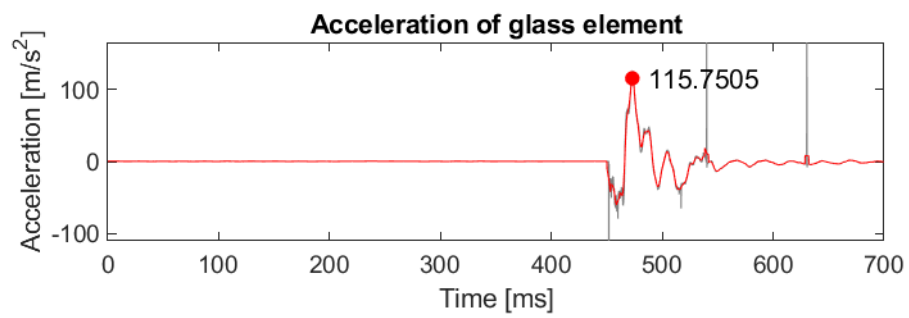
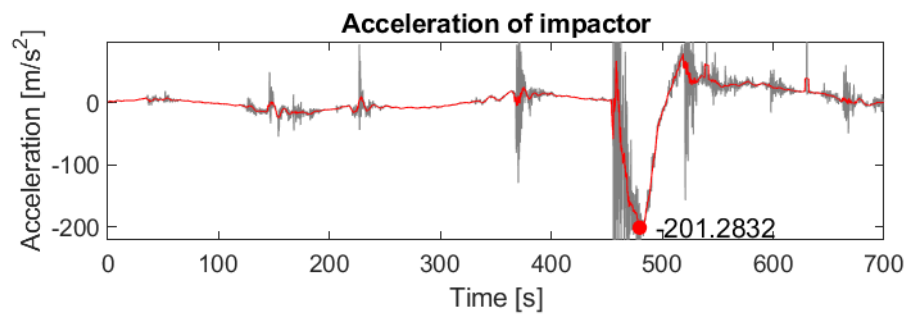
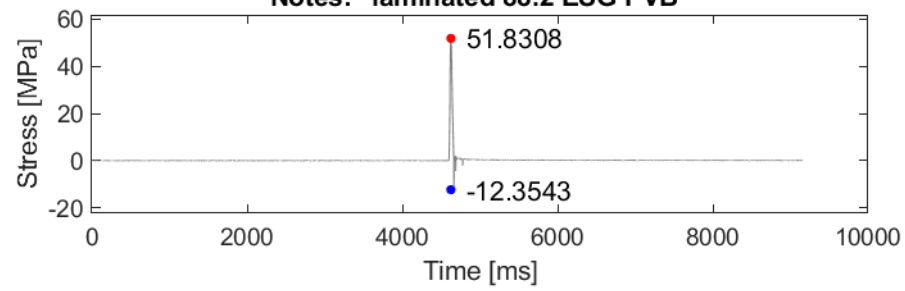
Data nr: 094
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 ESG PVB"



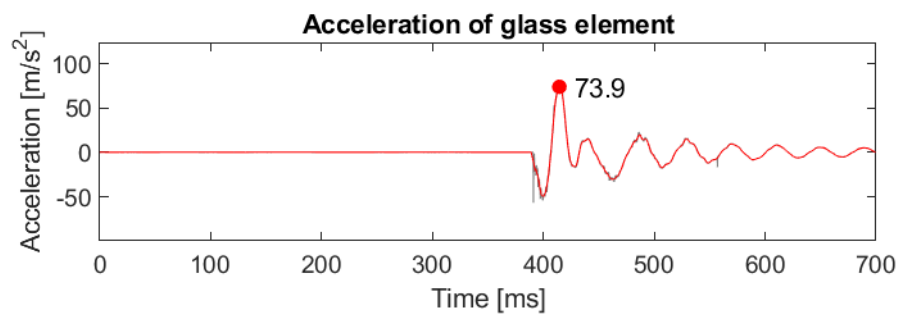
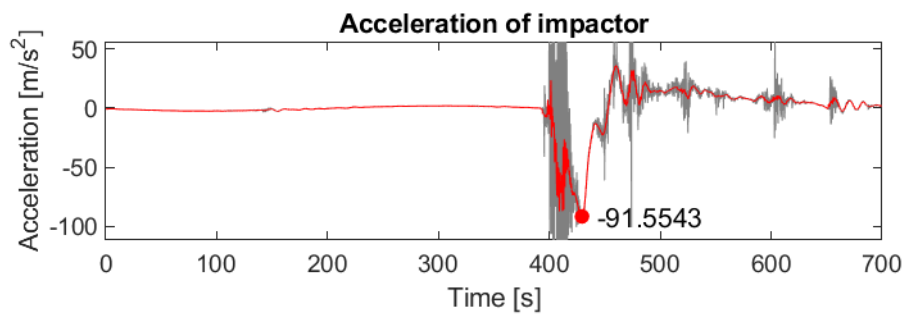
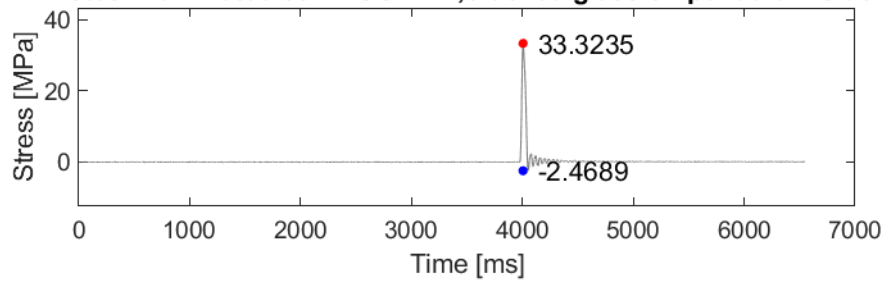
Data nr: 095
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 ESG PVB"



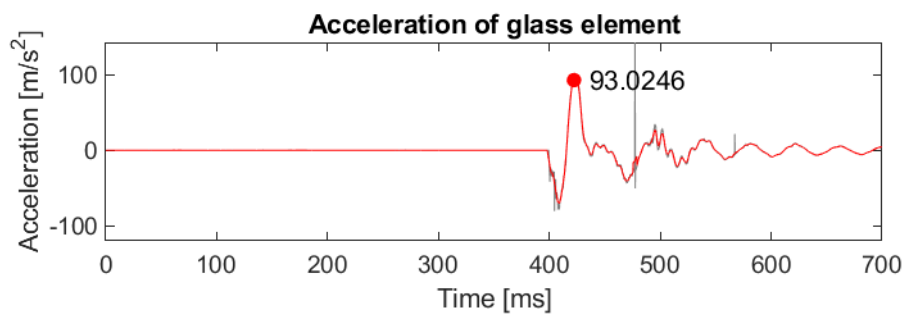
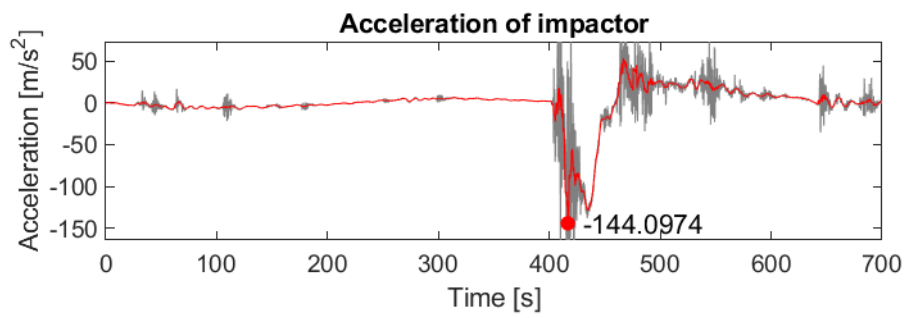
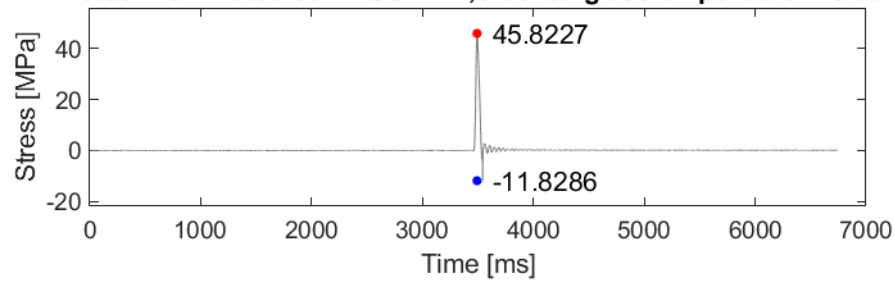
Data nr: 096
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 ESG PVB"



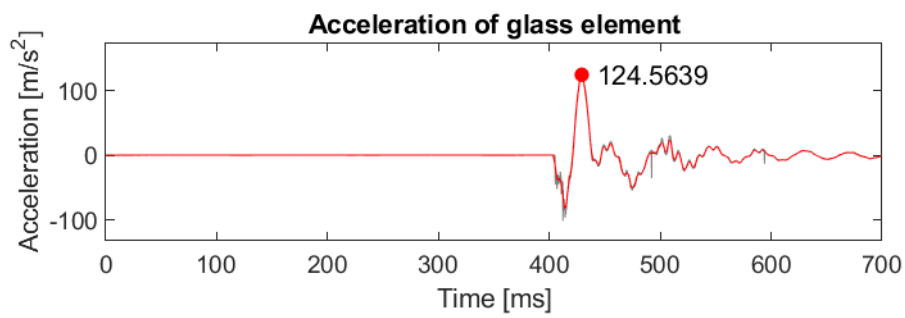
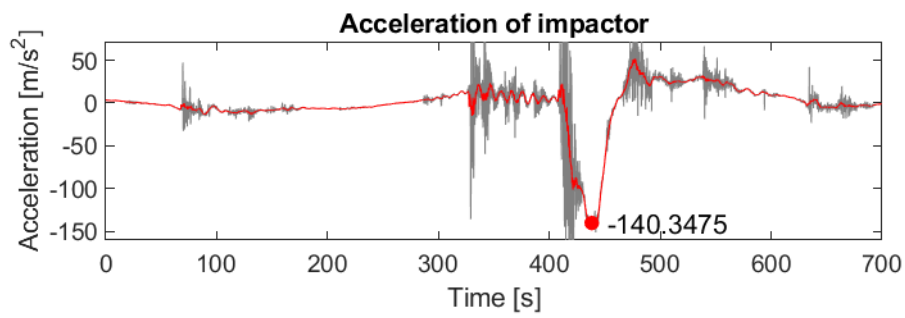
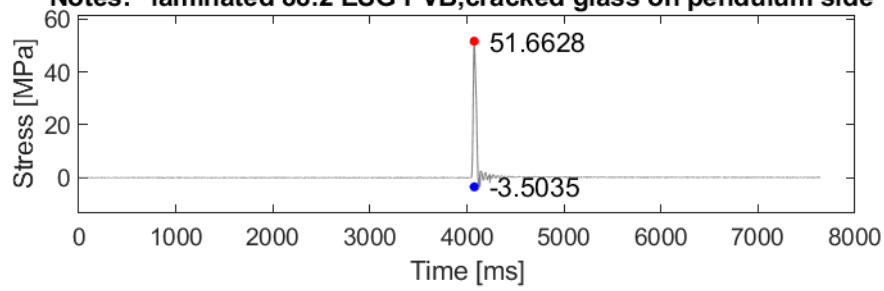
Data nr: 097
Glass: 88.2mm
Drop height: 100mm
Notes: "laminated 88.2 ESG PVB,cracked glass on pendulum side"



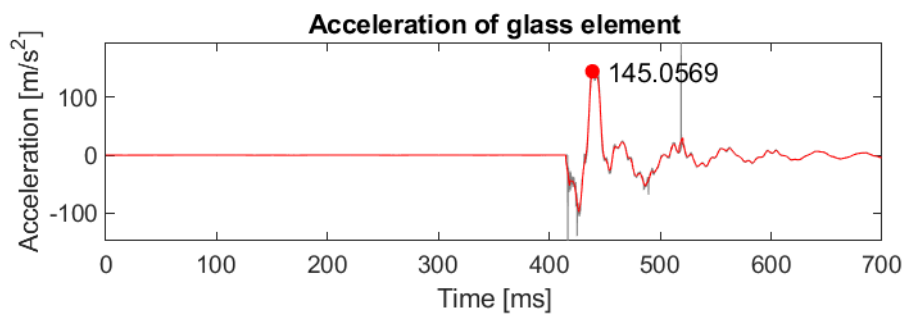
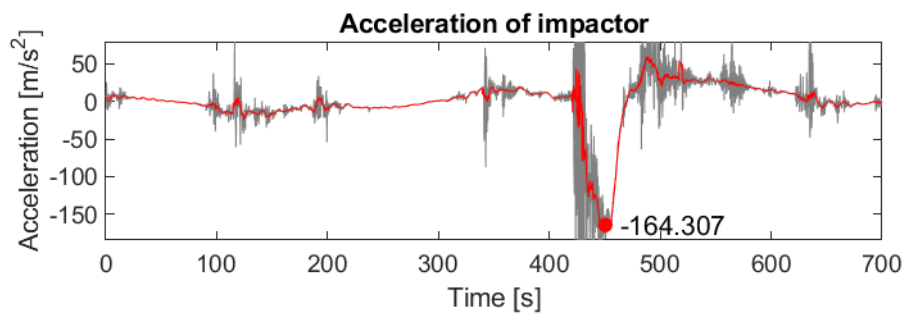
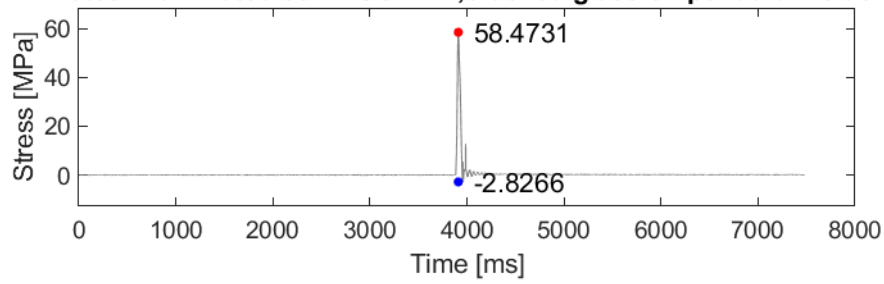
Data nr: 098
Glass: 88.2mm
Drop height: 200mm
Notes: "laminated 88.2 ESG PVB,cracked glass on pendulum side"



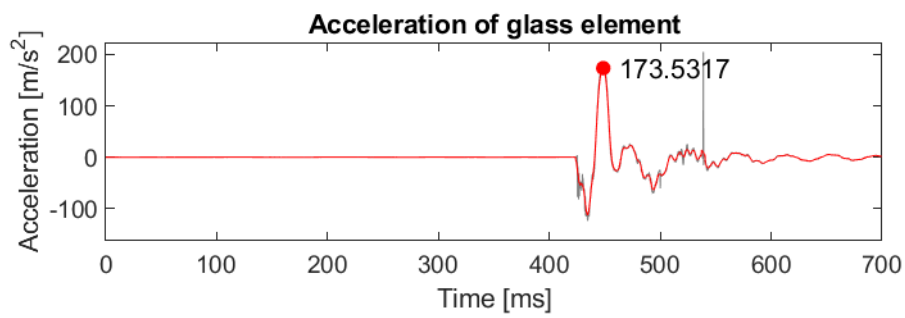
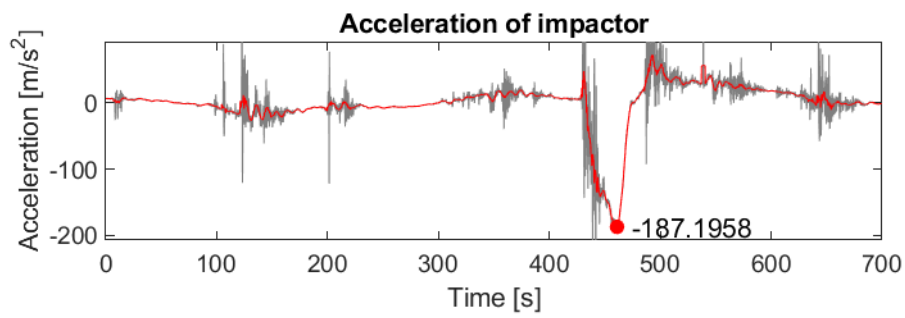
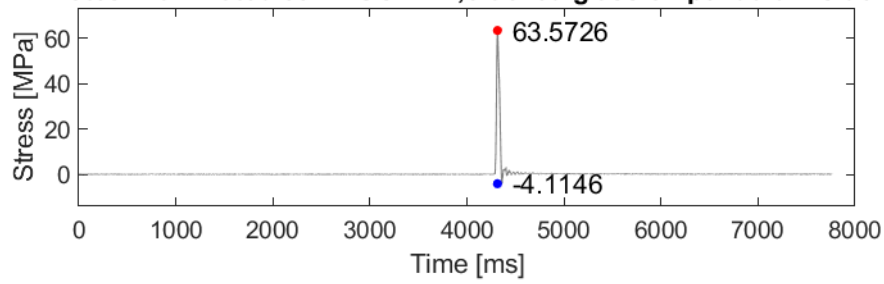
Data nr: 099
Glass: 88.2mm
Drop height: 300mm
Notes: "laminated 88.2 ESG PVB,cracked glass on pendulum side"



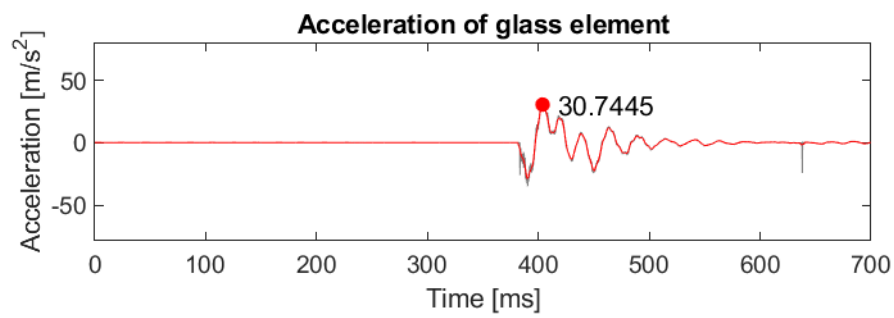
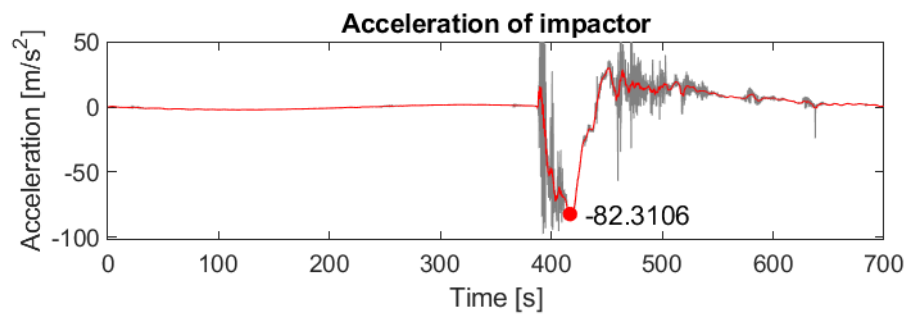
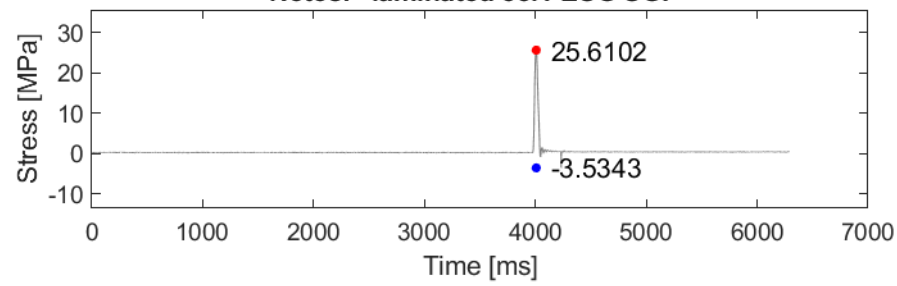
Data nr: 100
Glass: 88.2mm
Drop height: 400mm
Notes: "laminated 88.2 ESG PVB,cracked glass on pendulum side"



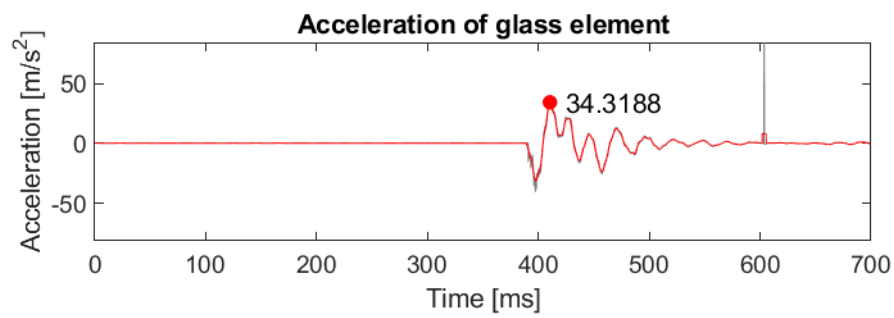
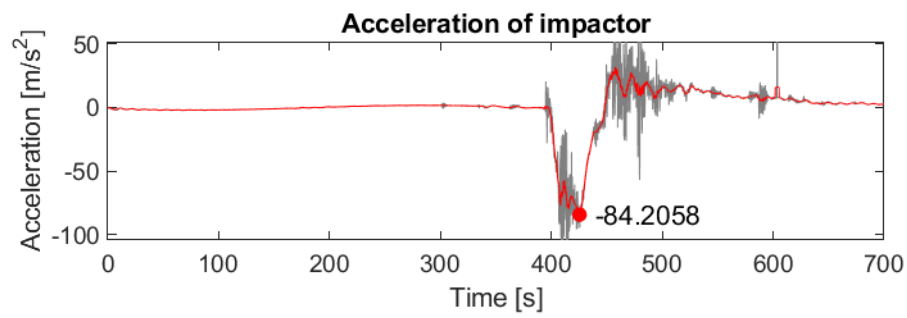
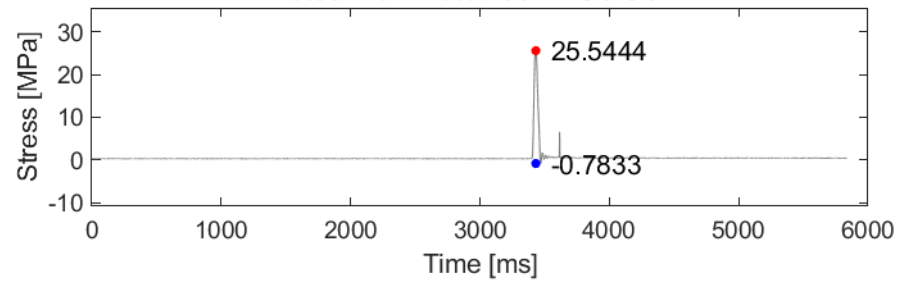
Data nr: 101
Glass: 88.2mm
Drop height: 500mm
Notes: "laminated 88.2 ESG PVB,cracked glass on pendulum side"



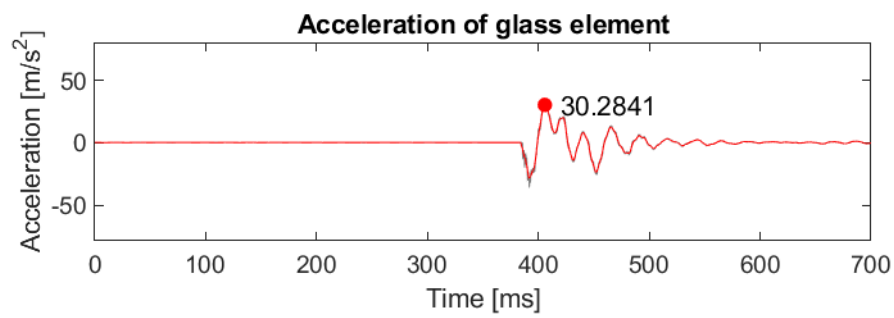
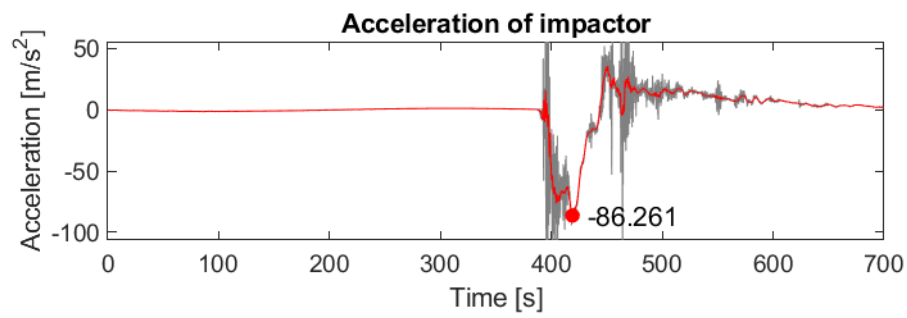
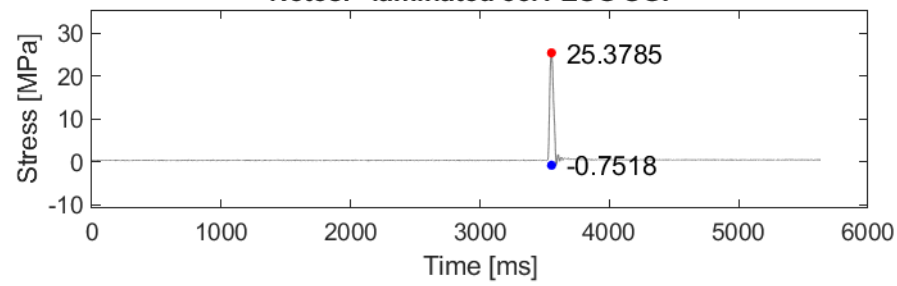
Data nr: 110
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 ESG SGP"



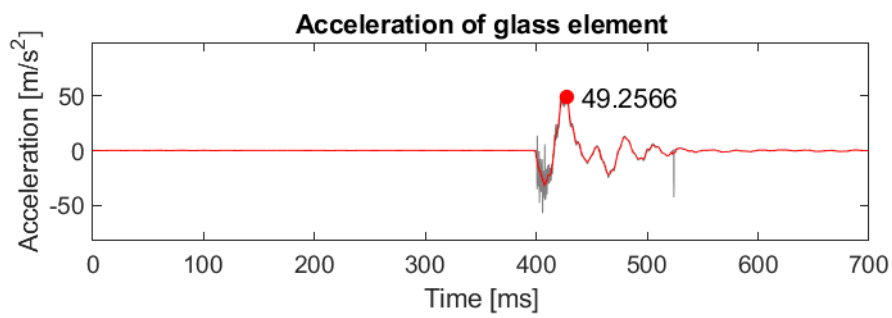
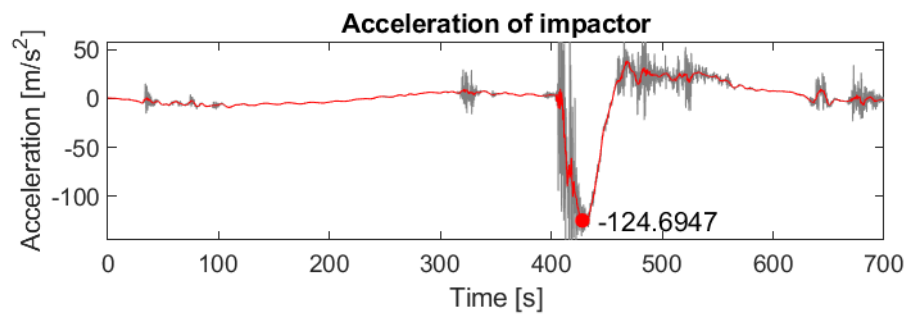
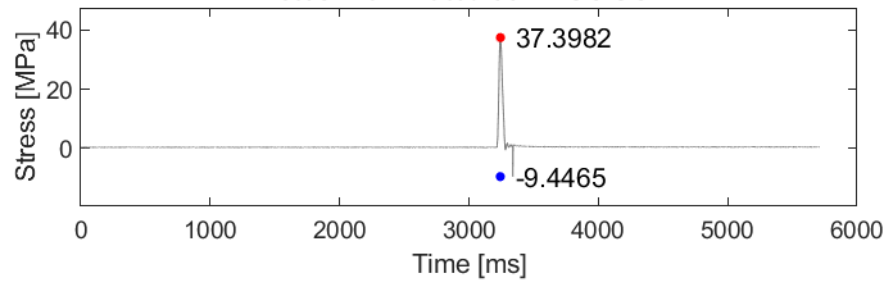
Data nr: 111
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 ESG SGP"



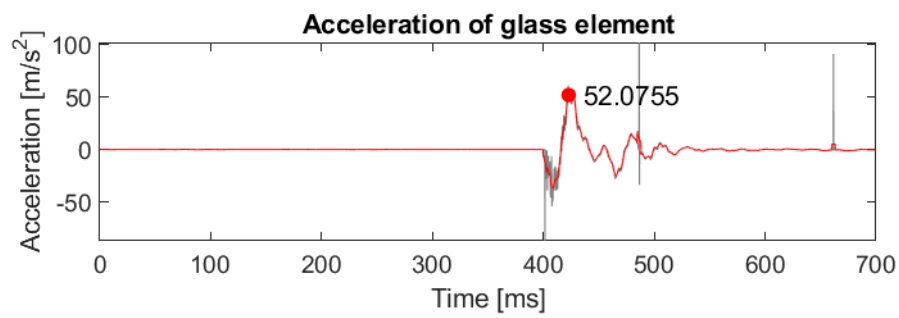
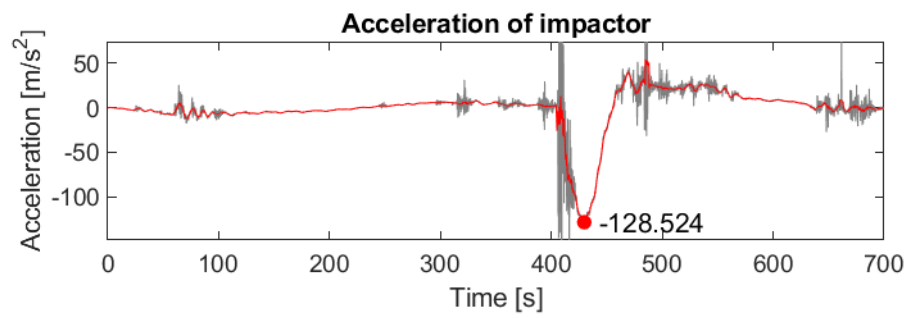
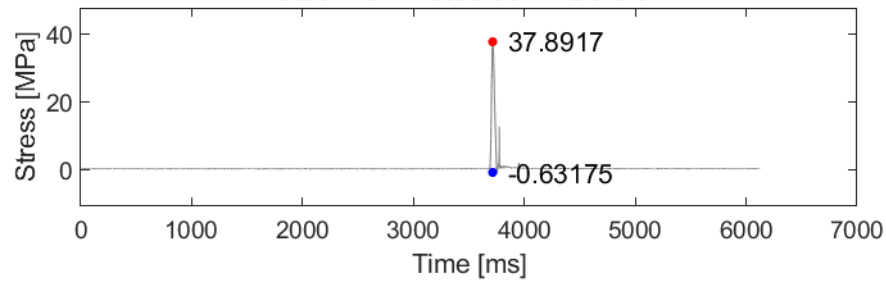
Data nr: 112
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 ESG SGP"



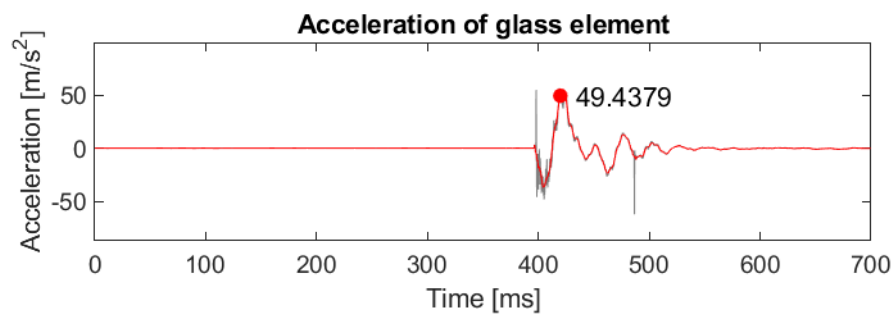
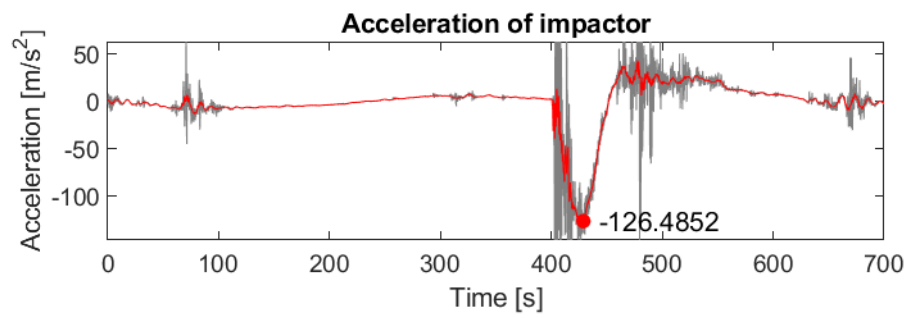
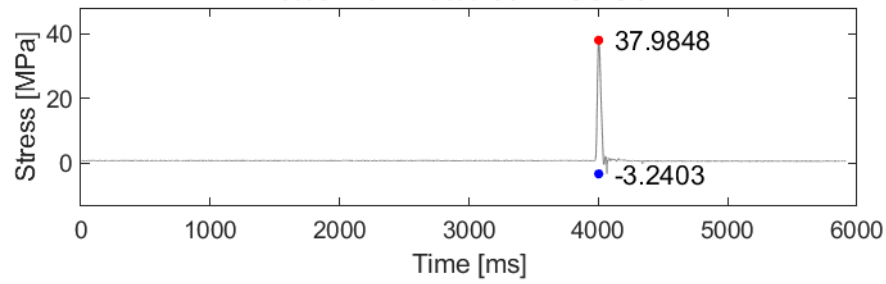
Data nr: 113
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 ESG SGP"



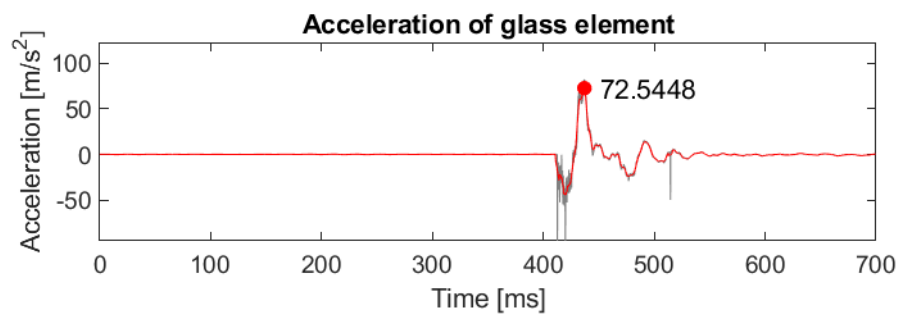
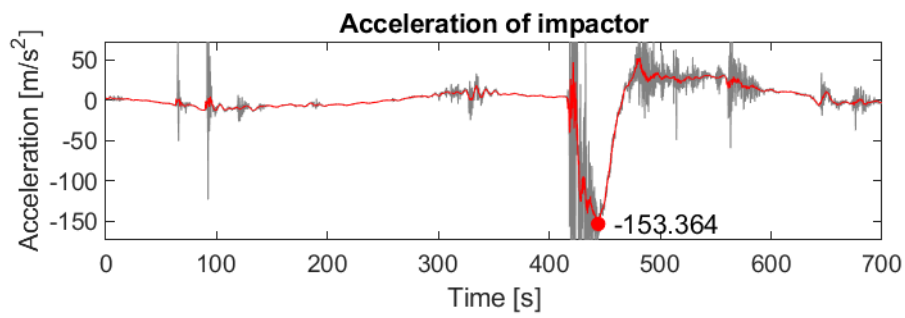
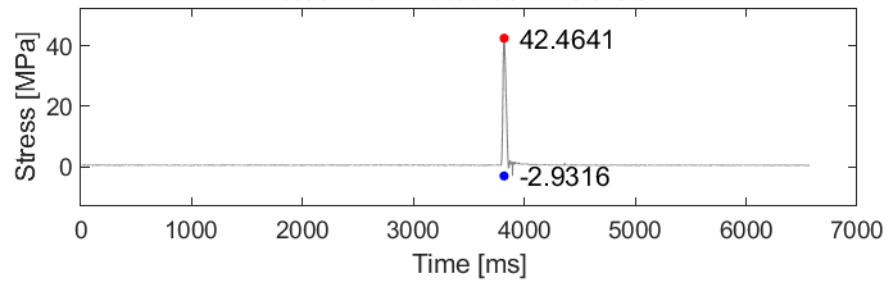
Data nr: 114
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 ESG SGP"



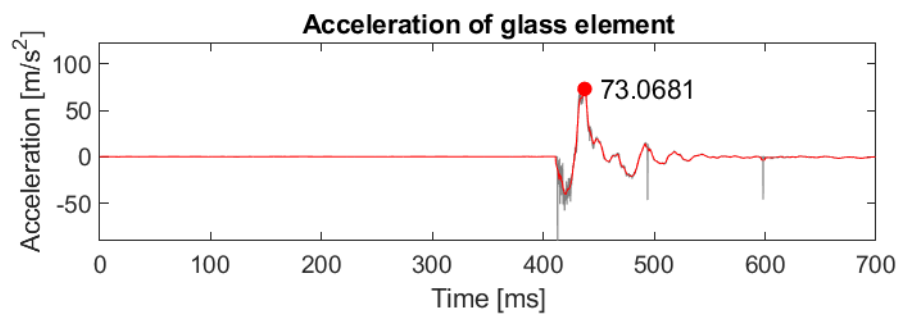
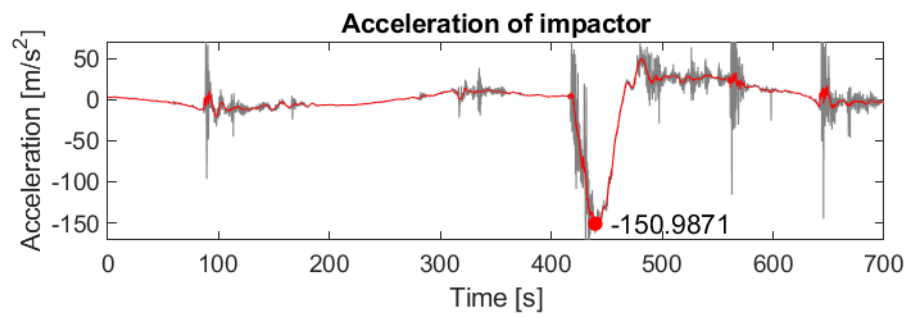
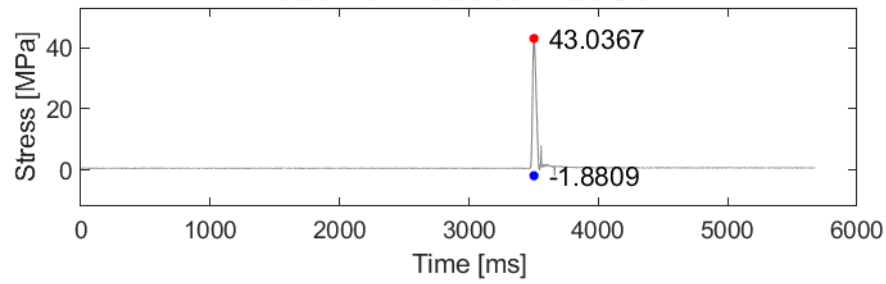
Data nr: 115
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 ESG SGP"



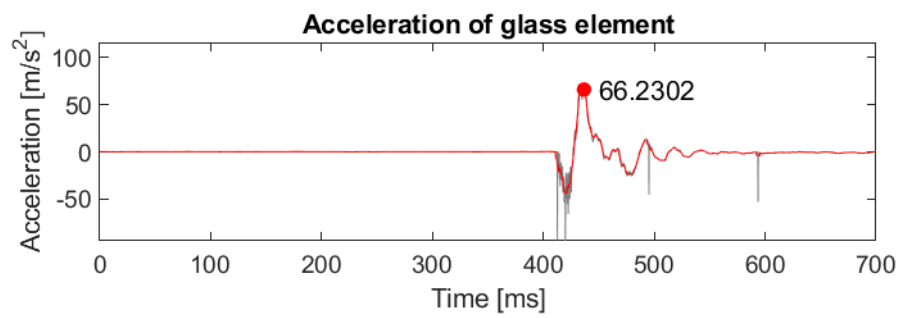
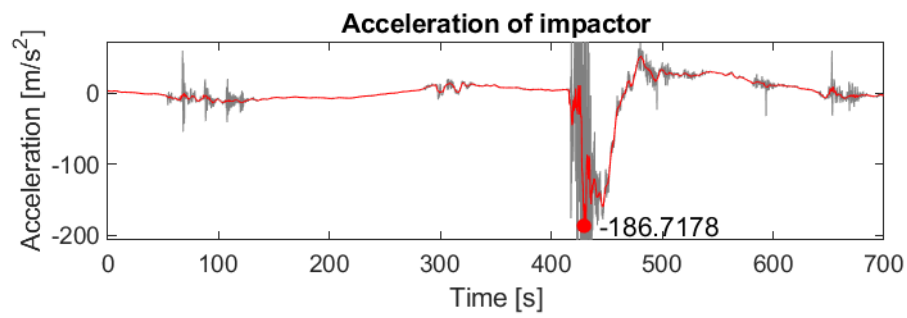
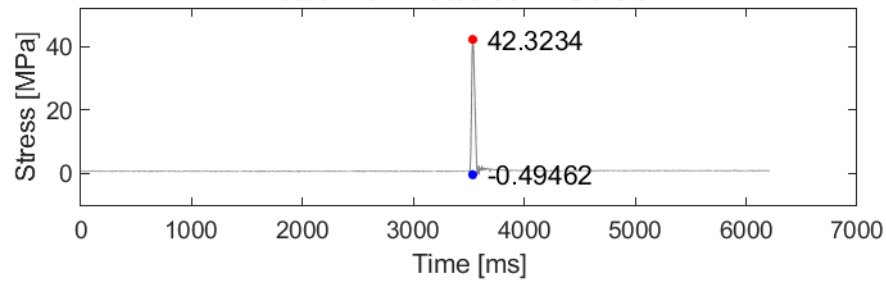
Data nr: 116
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 ESG SGP"



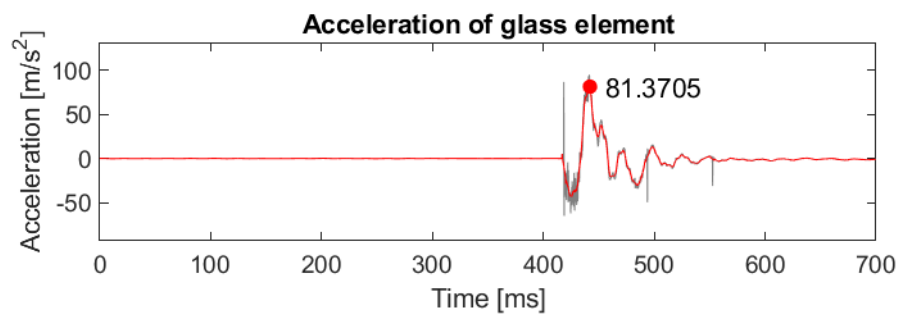
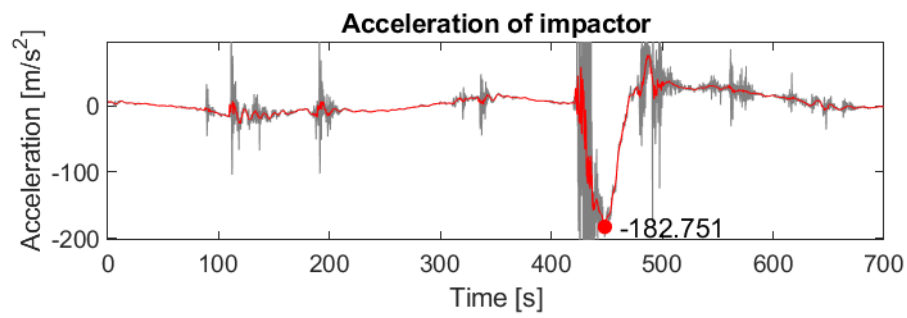
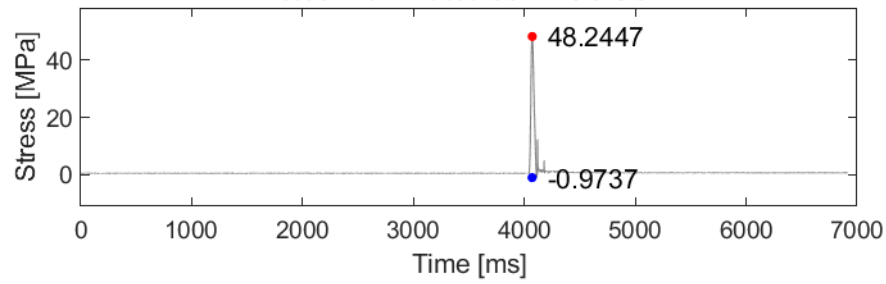
Data nr: 117
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 ESG SGP"



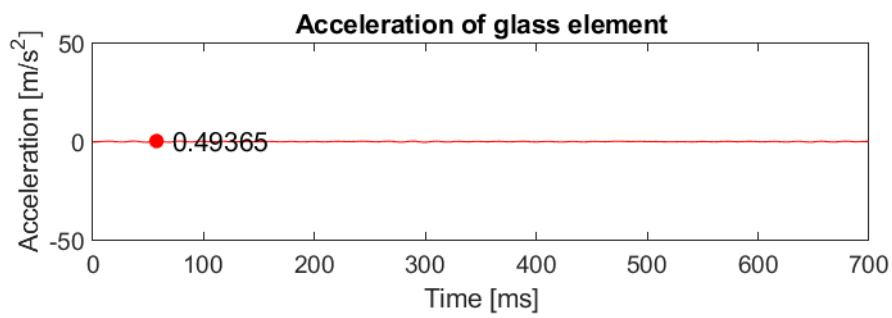
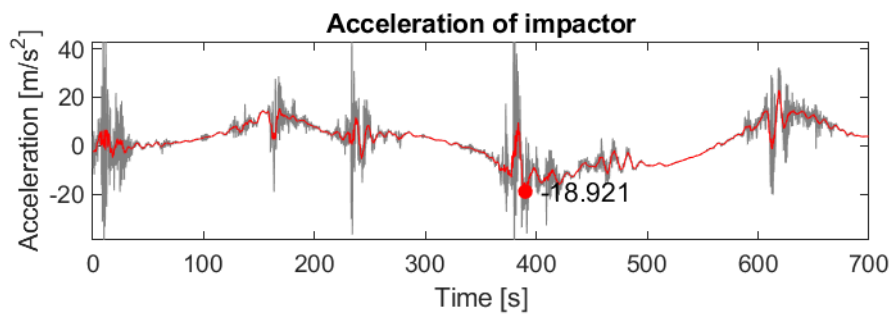
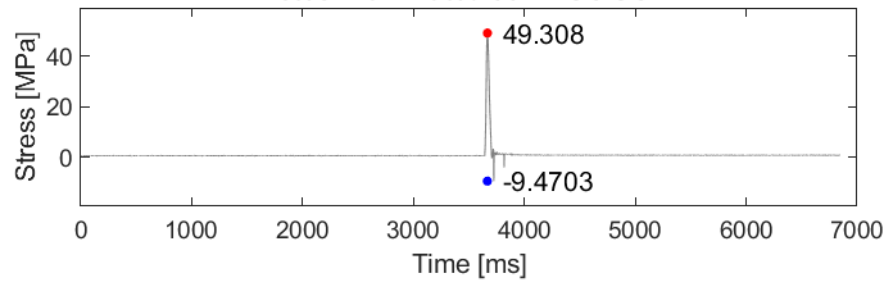
Data nr: 118
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 ESG SGP"



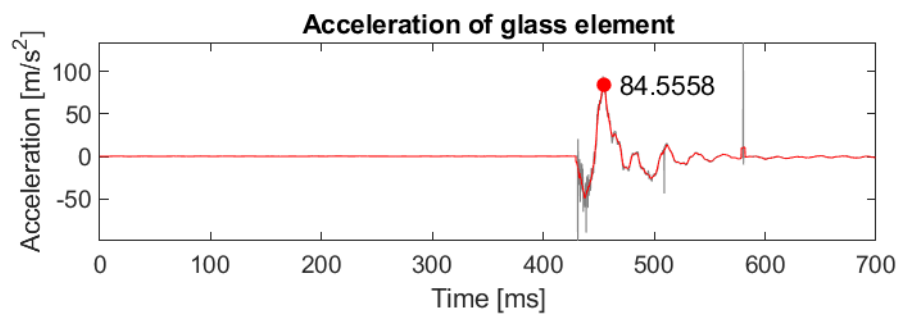
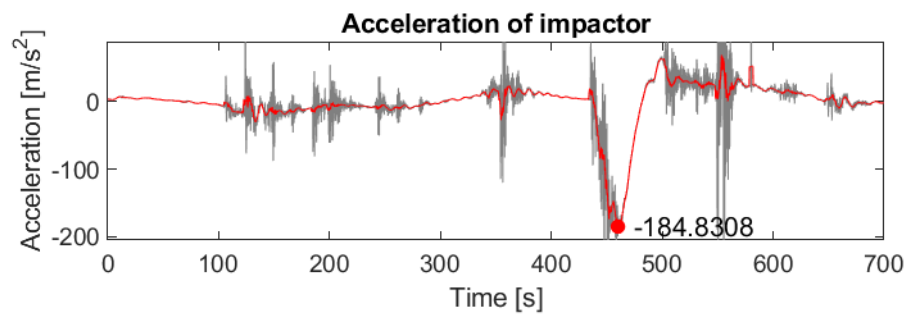
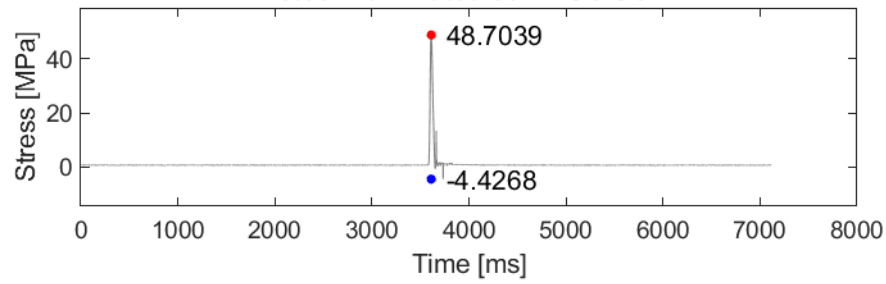
Data nr: 119
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 ESG SGP"



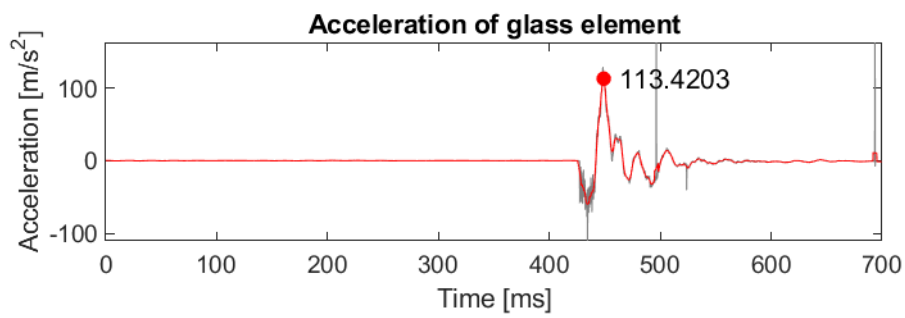
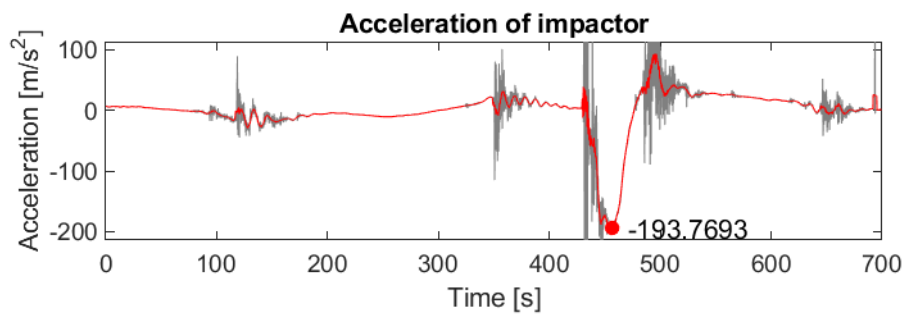
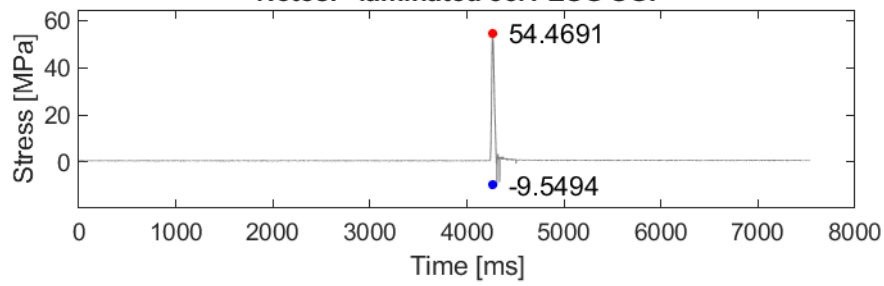
Data nr: 120
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 ESG SGP"



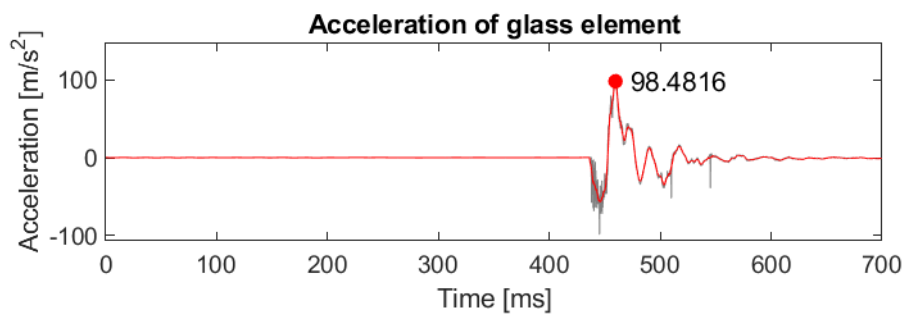
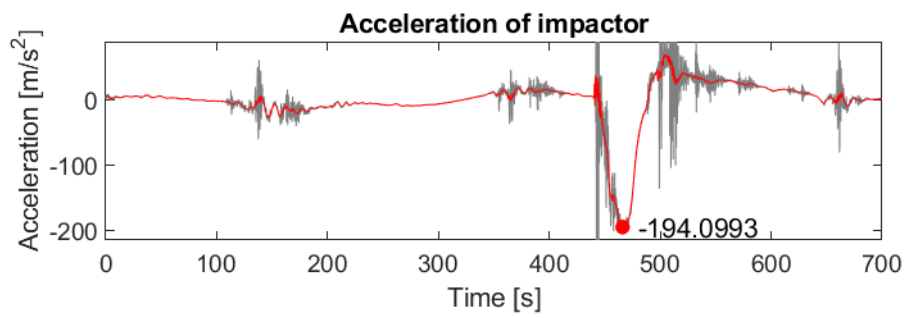
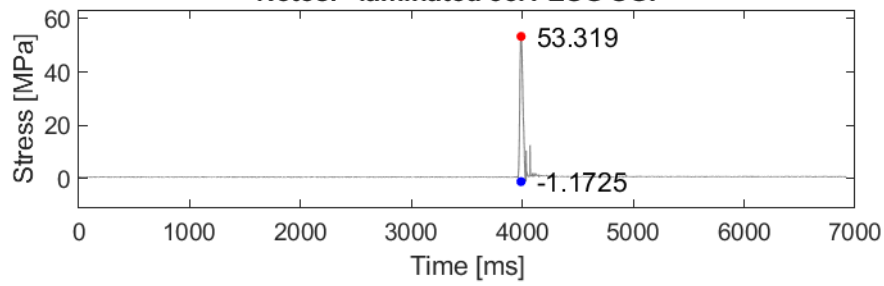
Data nr: 121
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 ESG SGP"

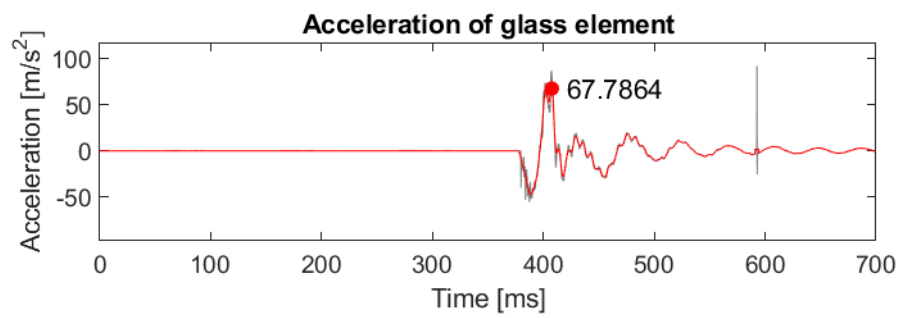
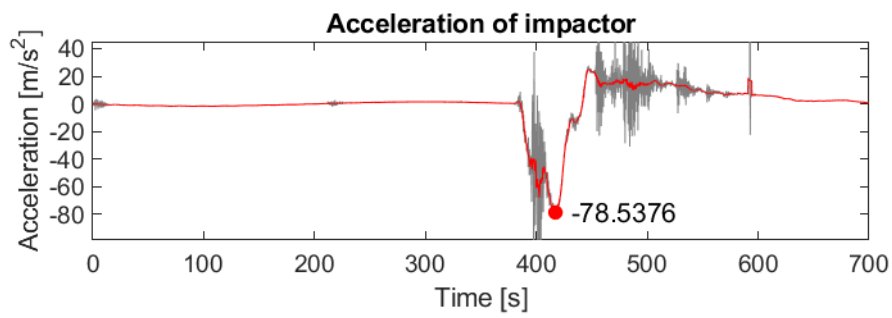
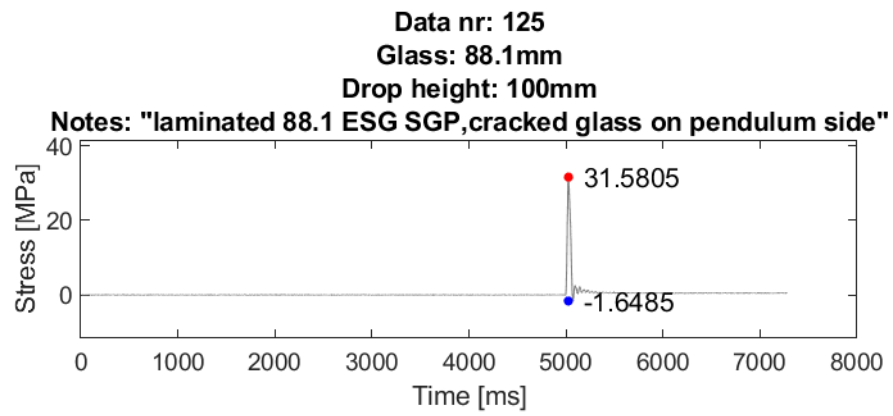


Data nr: 122
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 ESG SGP"

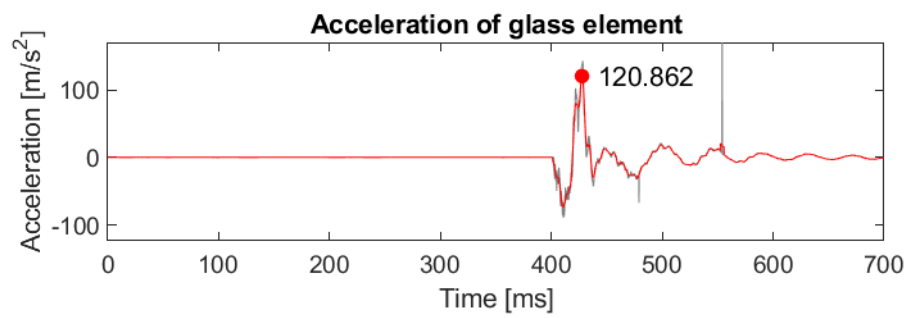
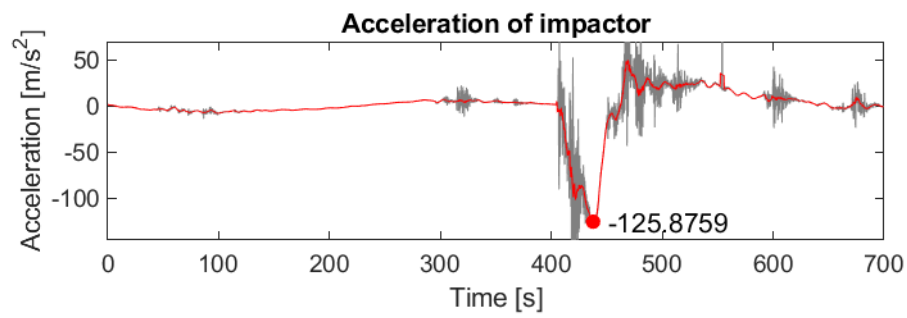
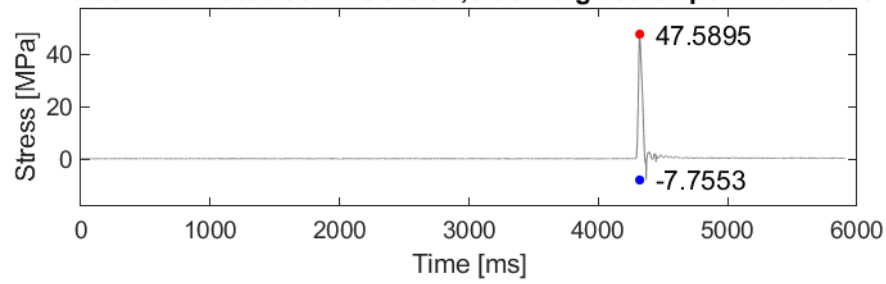


Data nr: 124
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 ESG SGP"

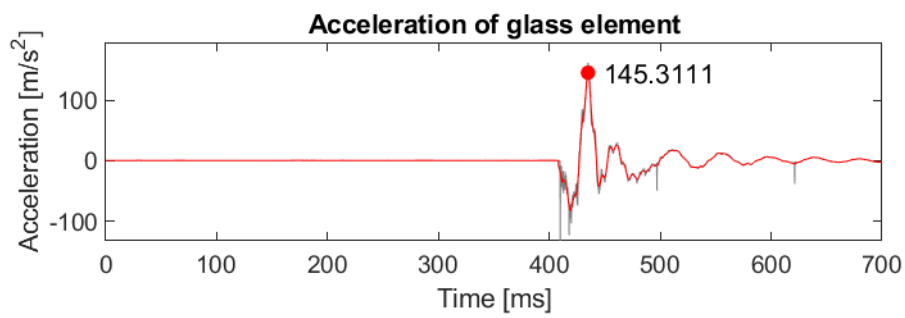
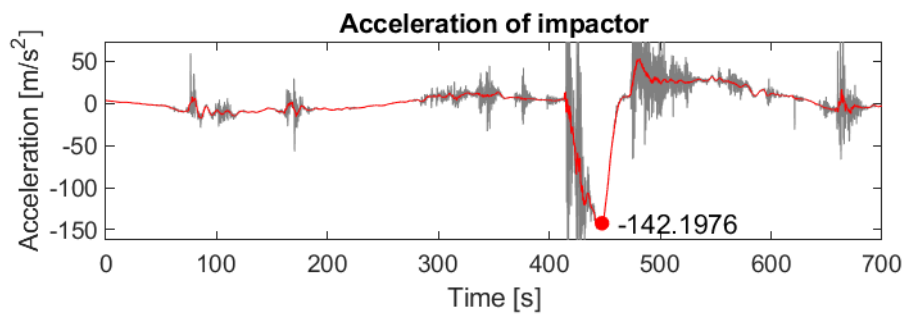
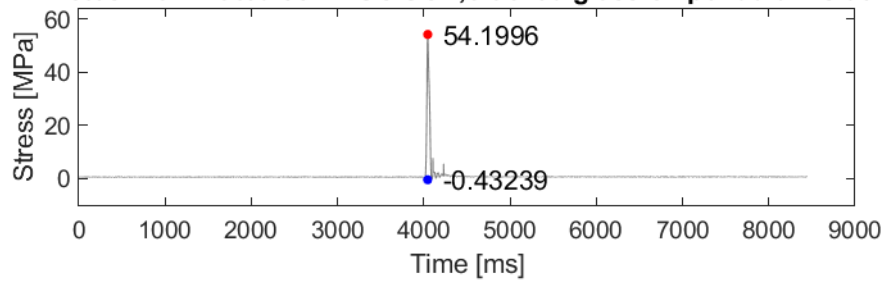




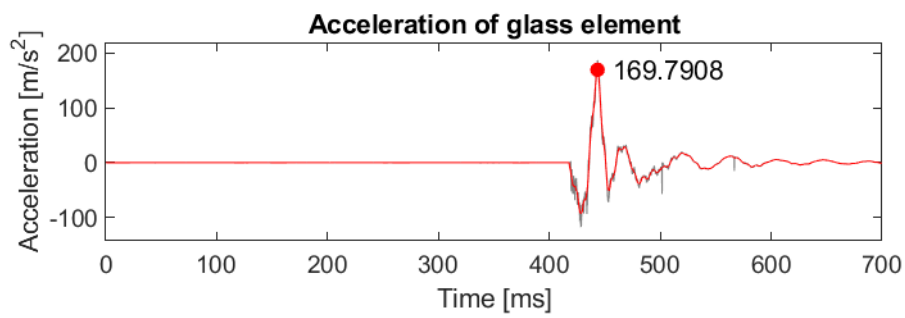
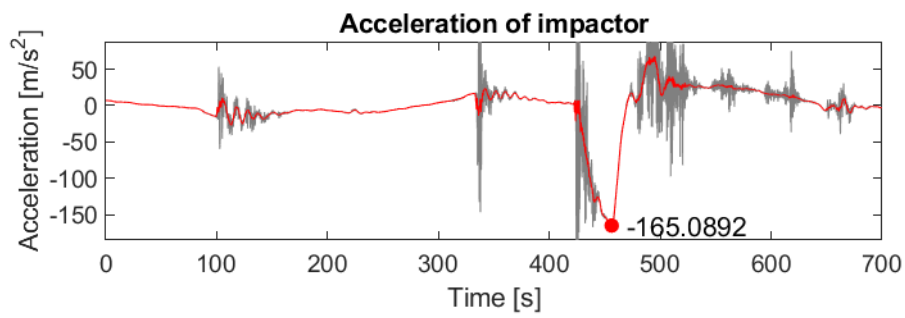
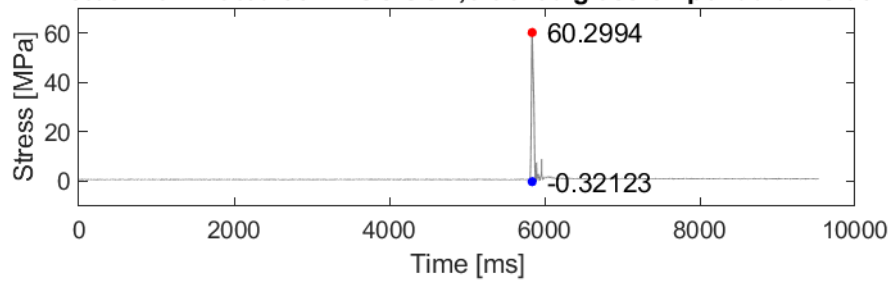
Data nr: 126
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 ESG SGP,cracked glass on pendulum side"



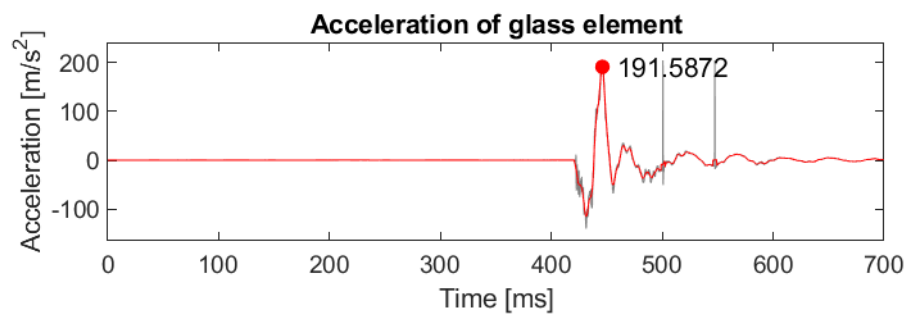
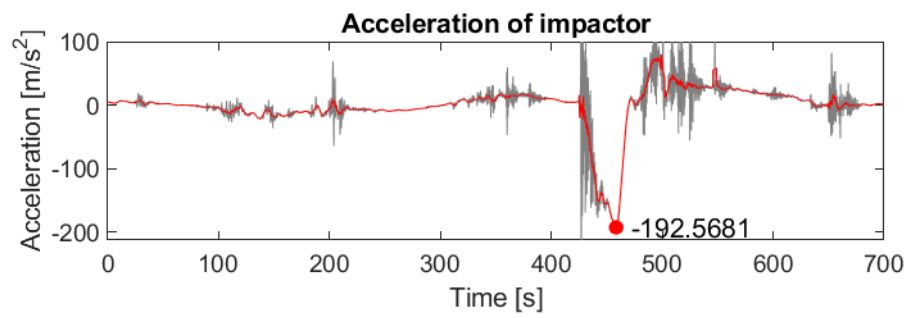
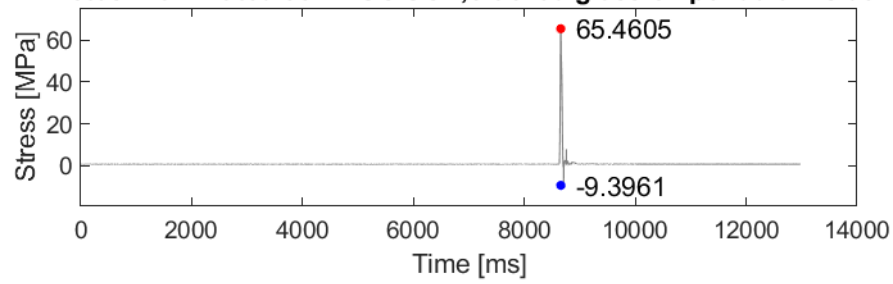
Data nr: 127
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 ESG SGP,cracked glass on pendulum side"



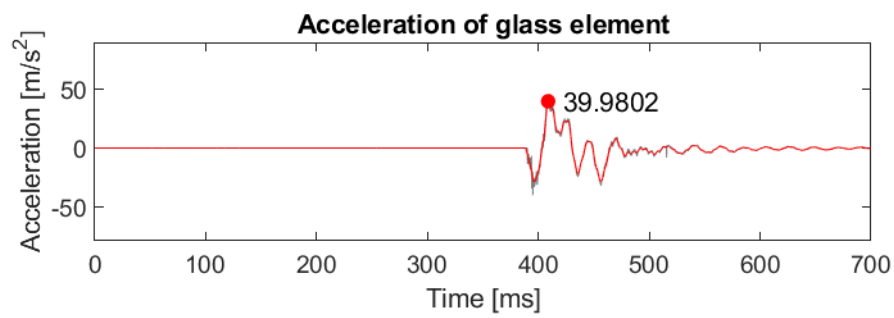
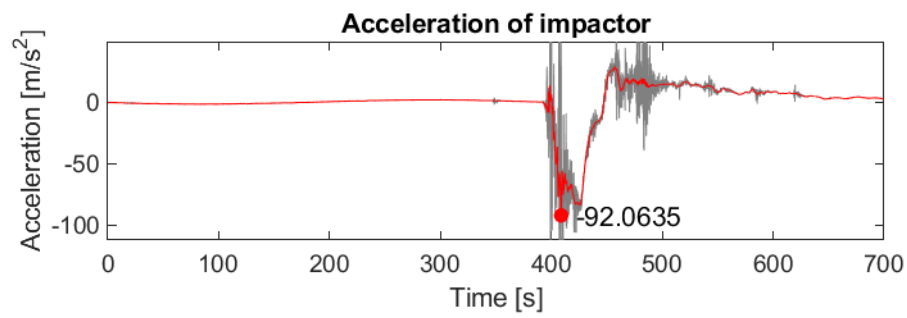
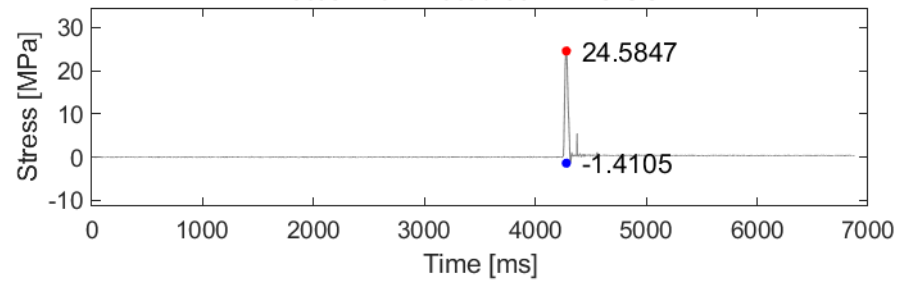
Data nr: 128
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 ESG SGP,cracked glass on pendulum side"



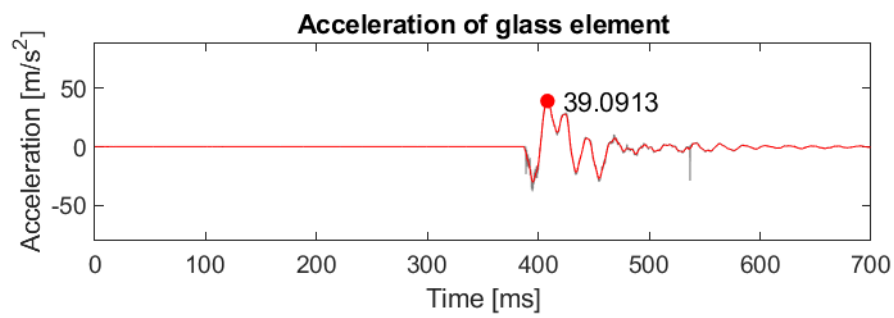
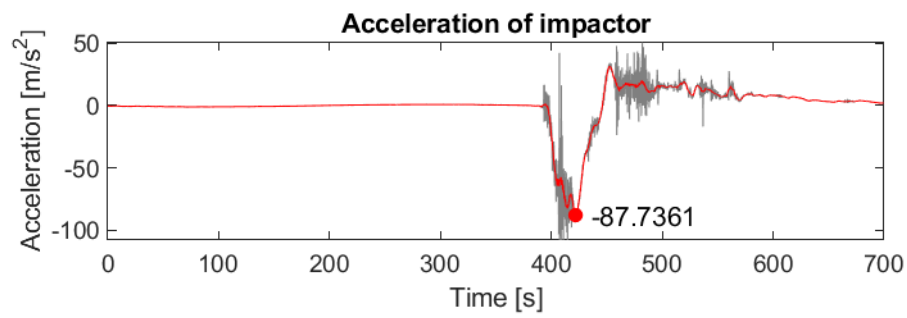
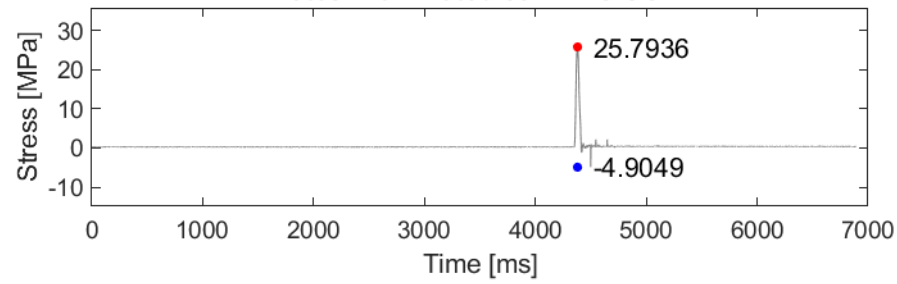
Data nr: 129
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 ESG SGP,cracked glass on pendulum side"



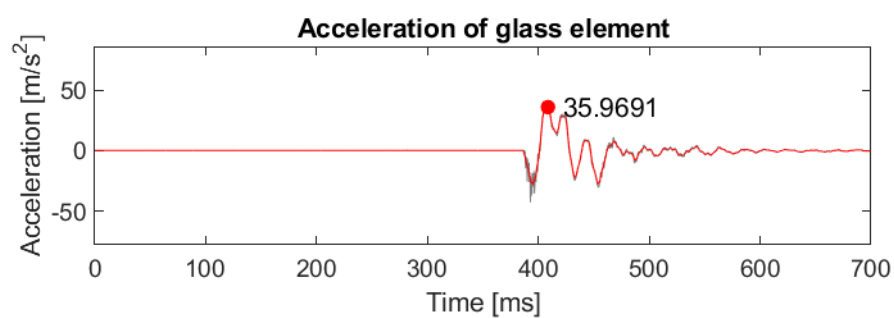
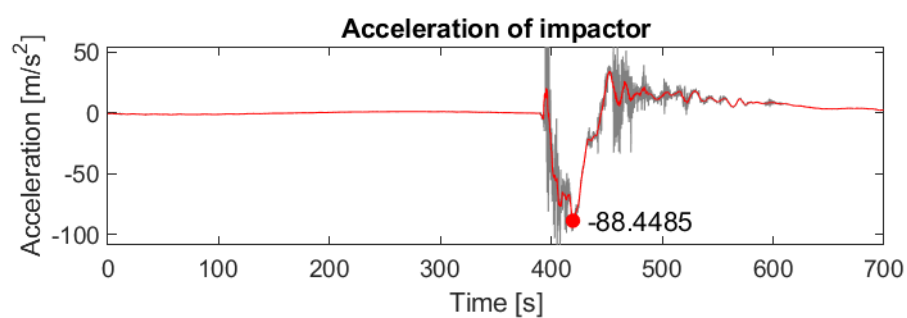
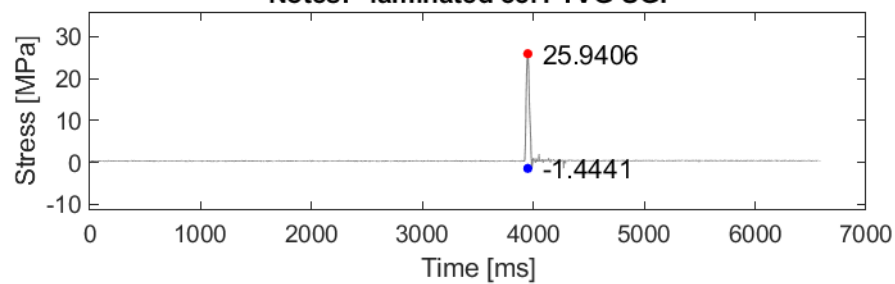
Data nr: 130
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 TVG SGP"



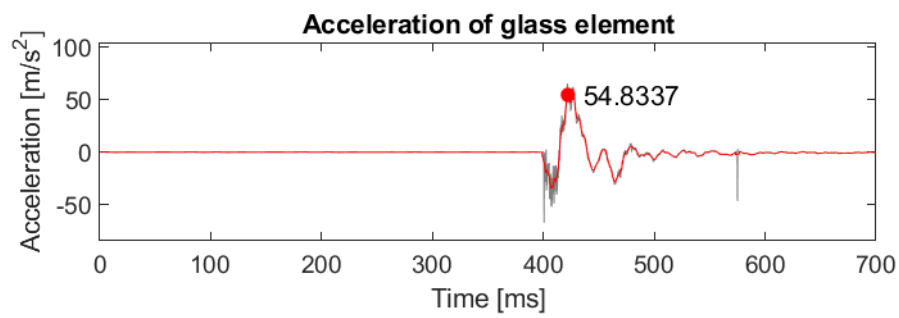
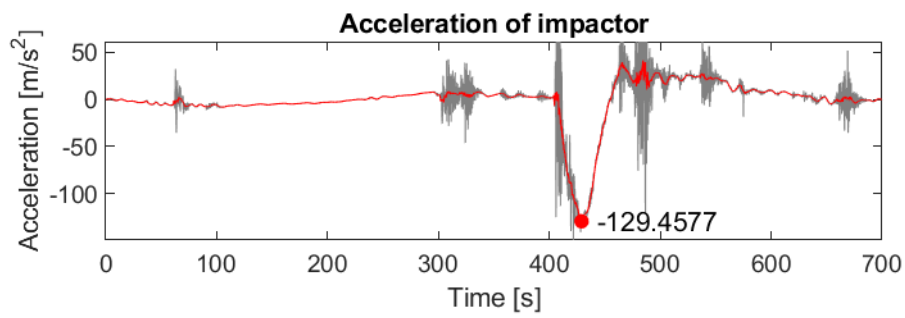
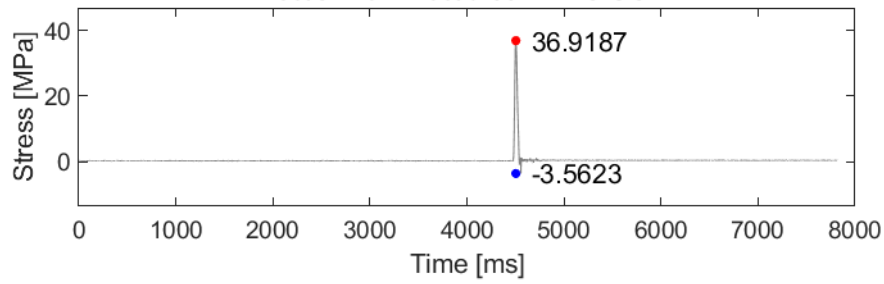
Data nr: 131
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 TVG SGP"



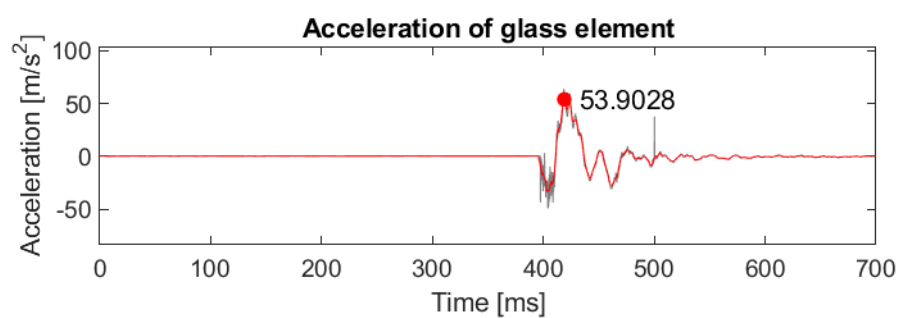
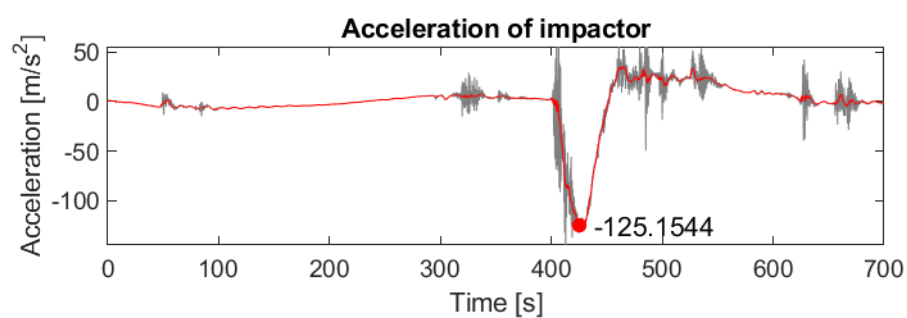
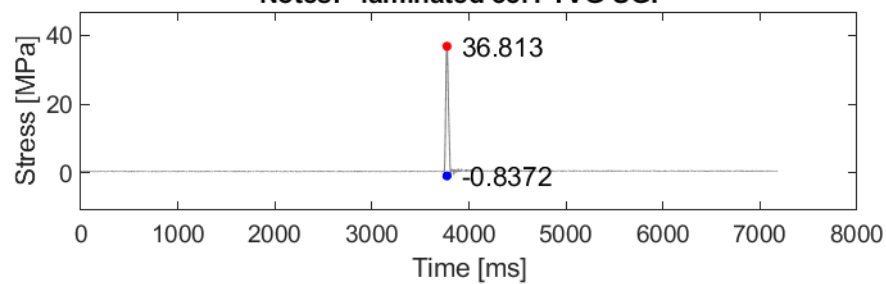
Data nr: 132
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 TVG SGP"



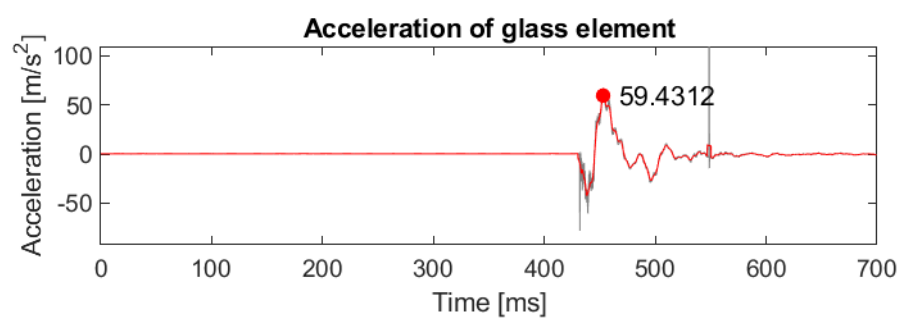
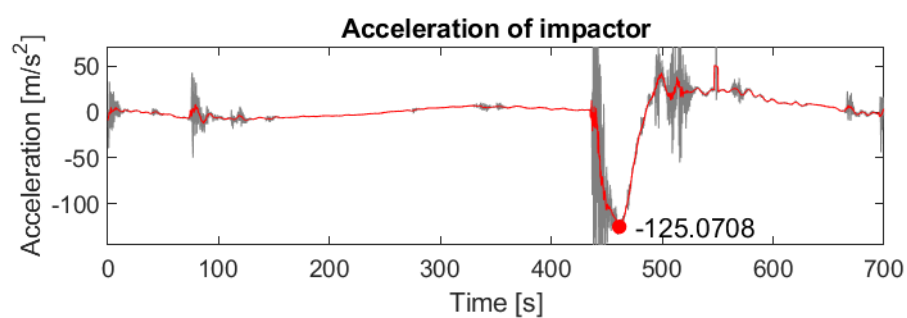
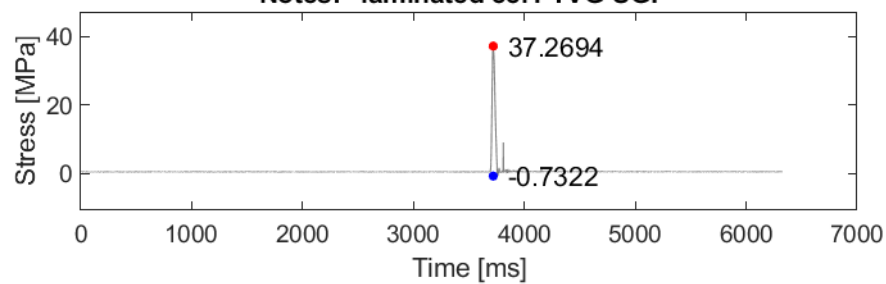
Data nr: 133
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 TVG SGP"



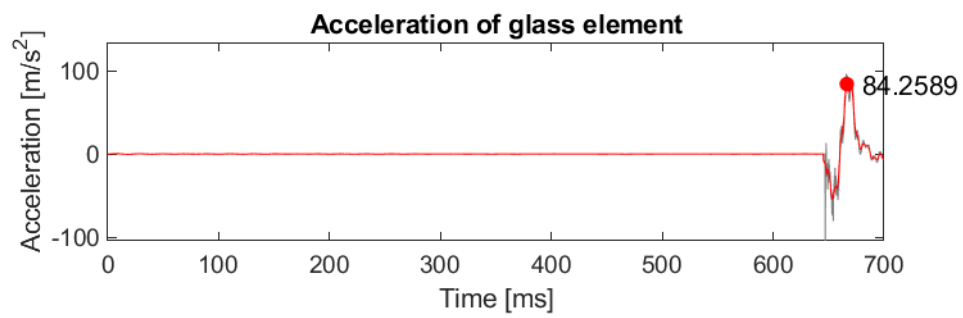
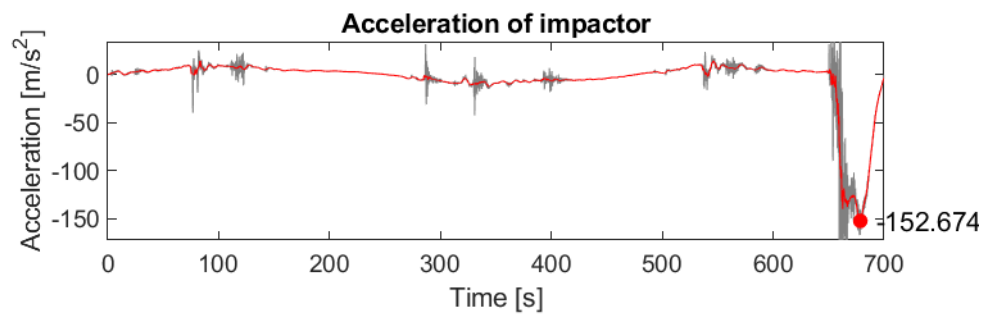
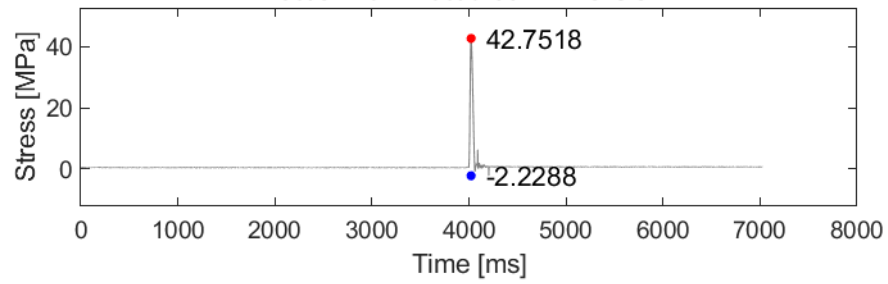
Data nr: 134
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 TVG SGP"



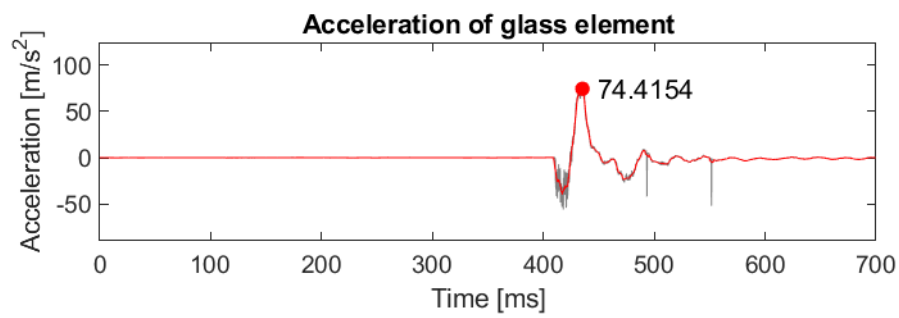
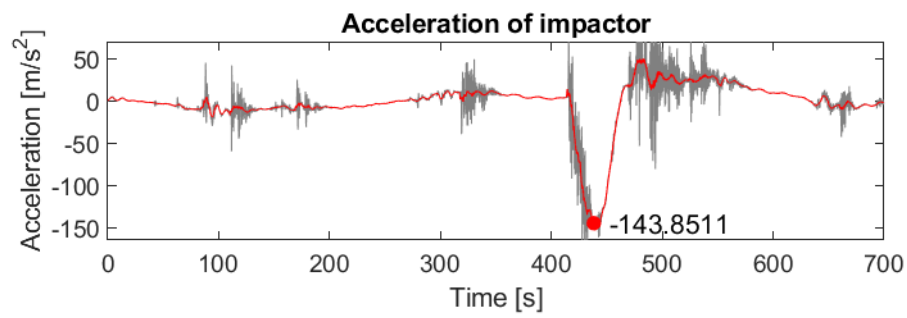
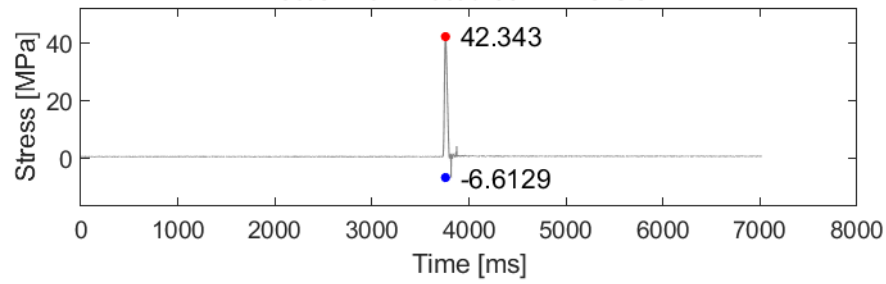
Data nr: 135
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 TVG SGP"



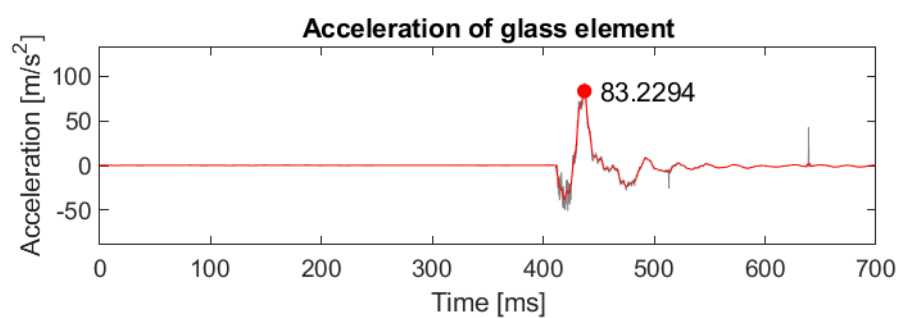
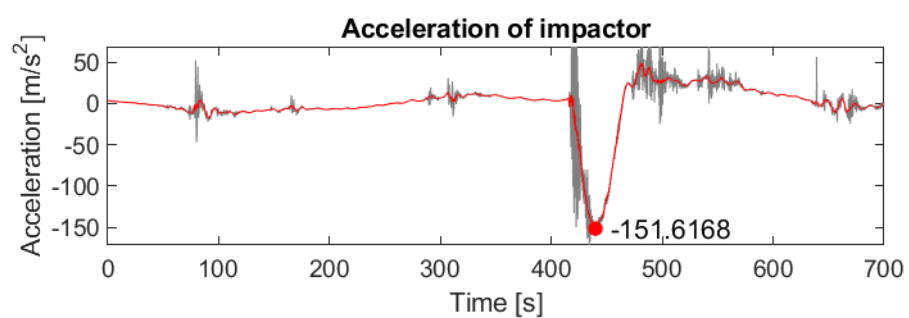
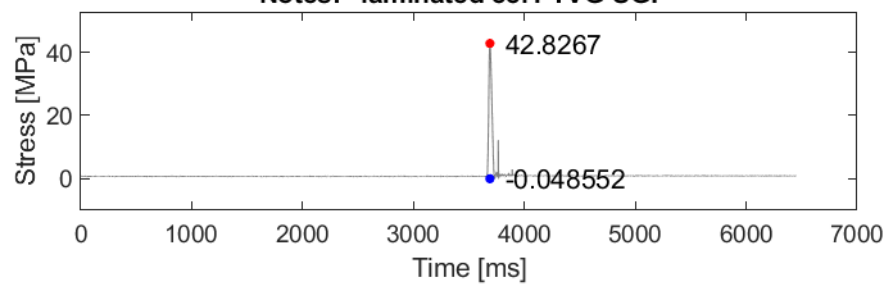
Data nr: 136
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 TVG SGP"



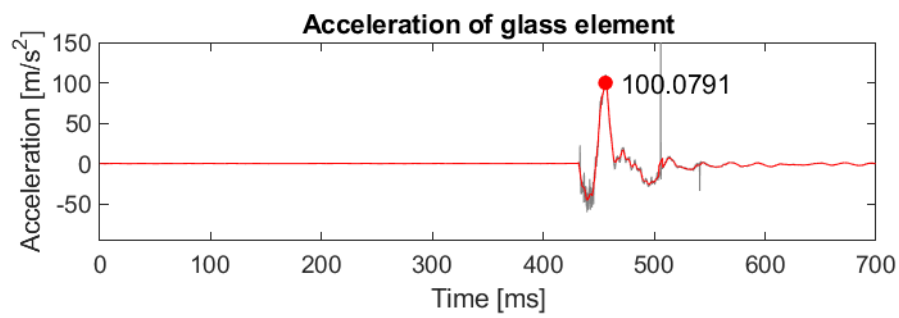
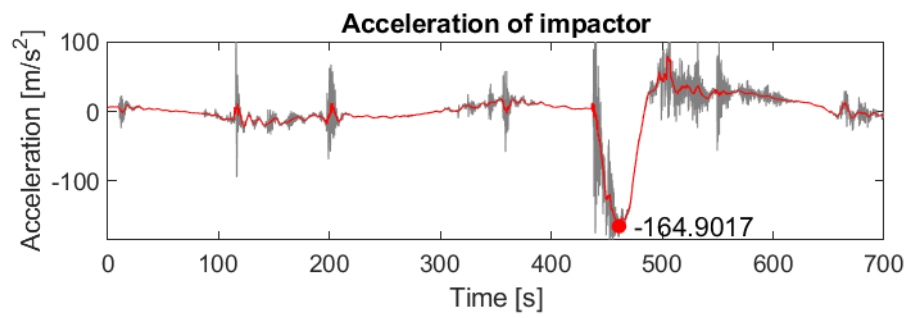
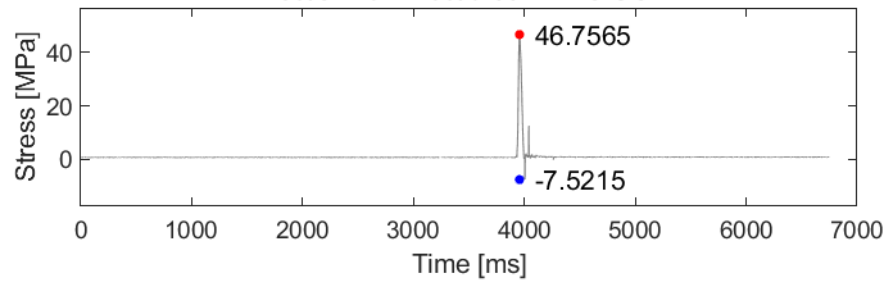
Data nr: 137
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 TVG SGP"



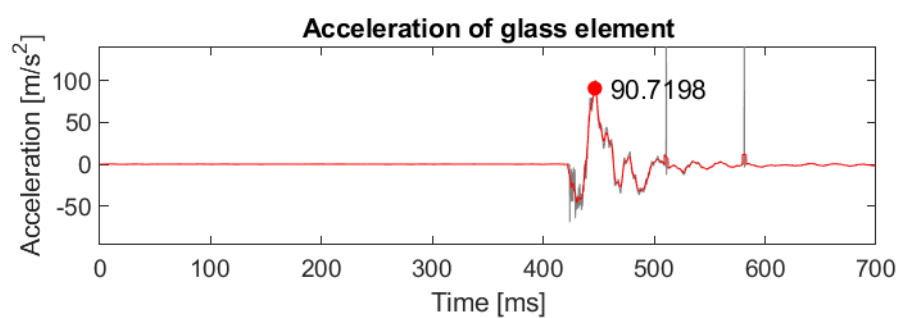
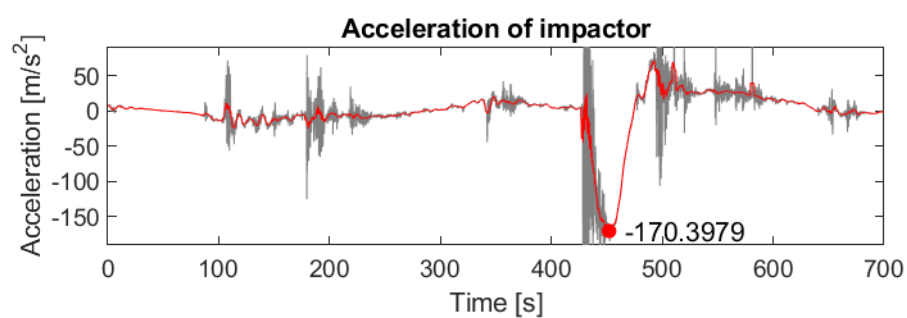
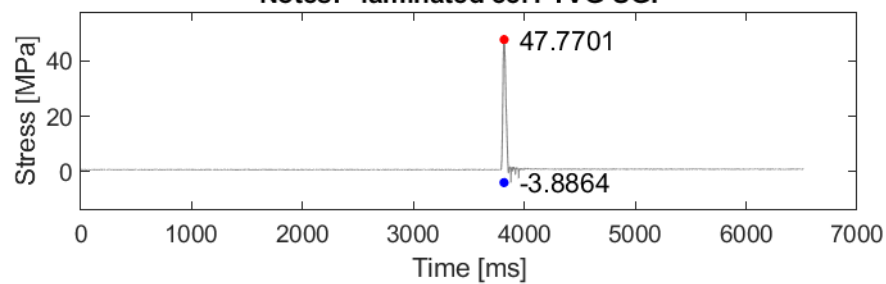
Data nr: 138
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 TVG SGP"



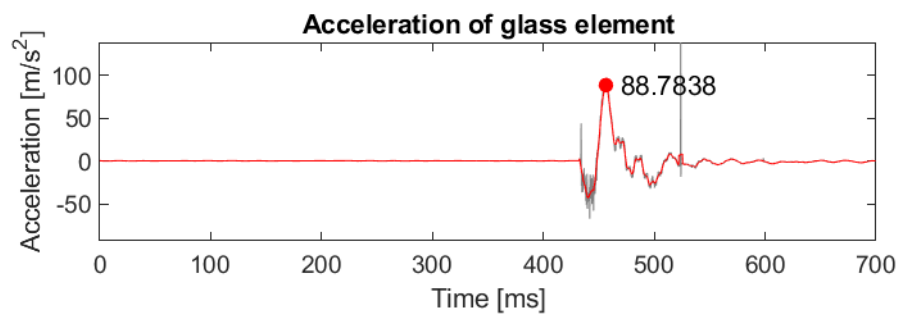
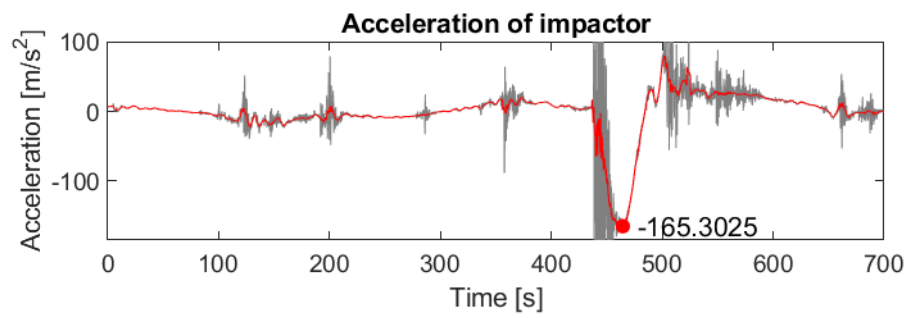
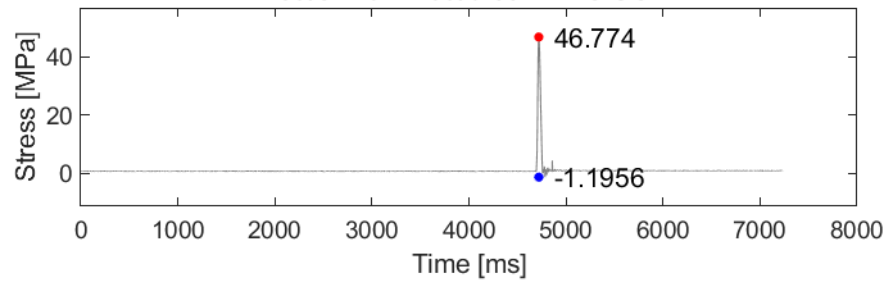
Data nr: 139
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 TVG SGP"



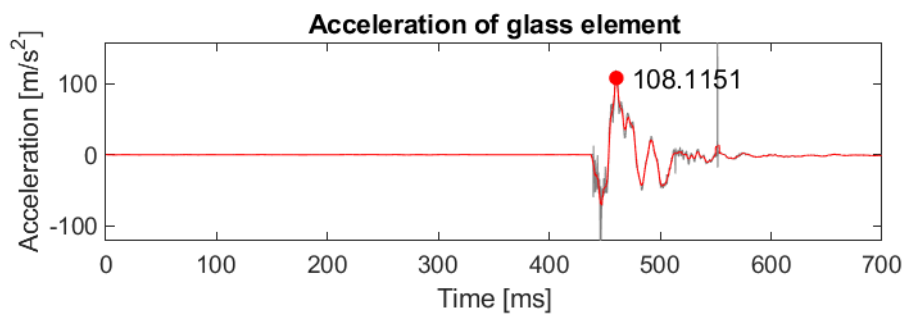
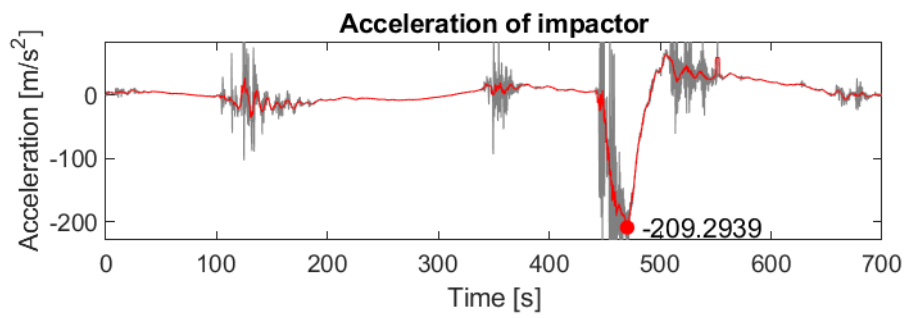
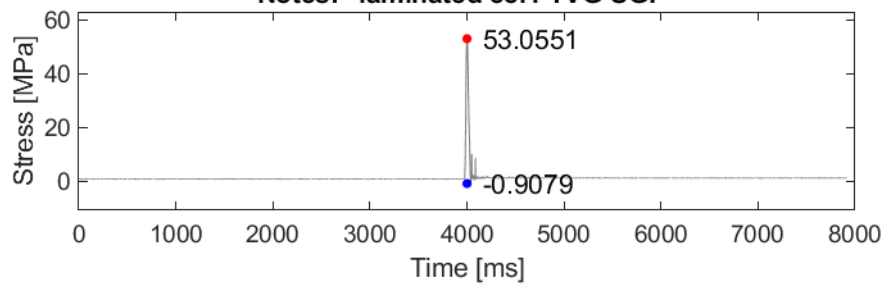
Data nr: 140
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 TVG SGP"



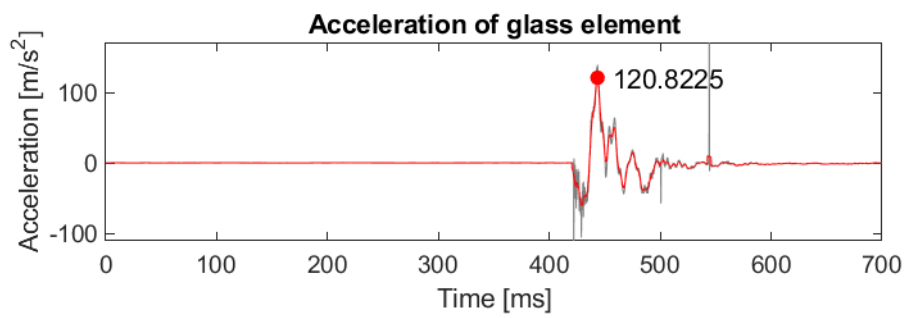
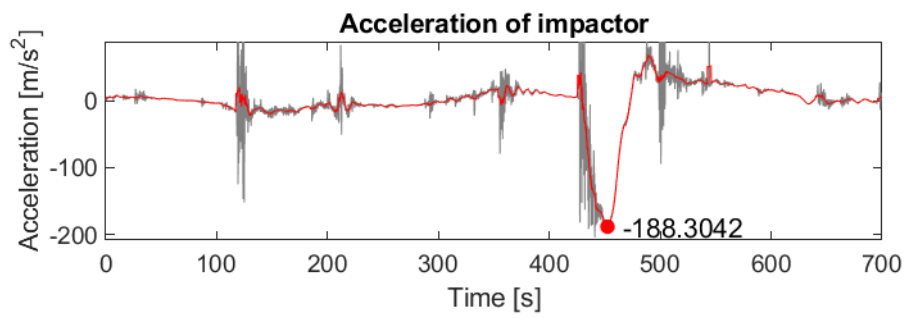
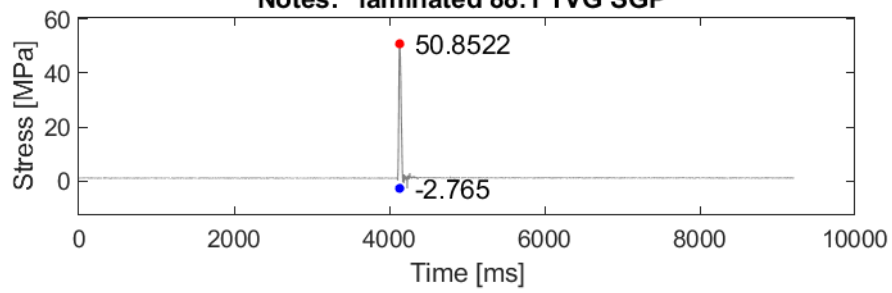
Data nr: 141
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 TVG SGP"



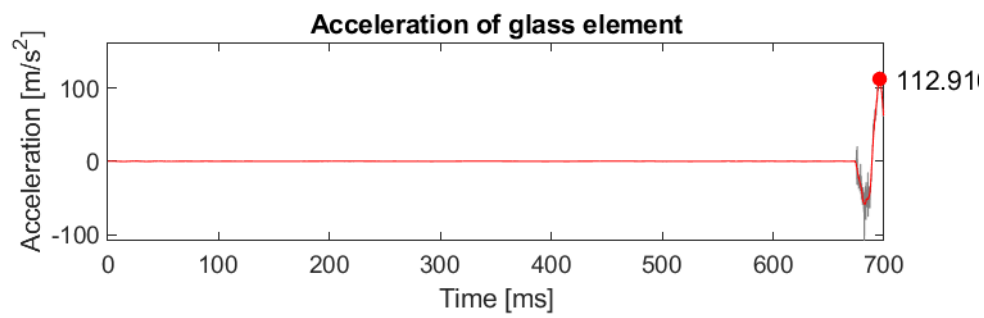
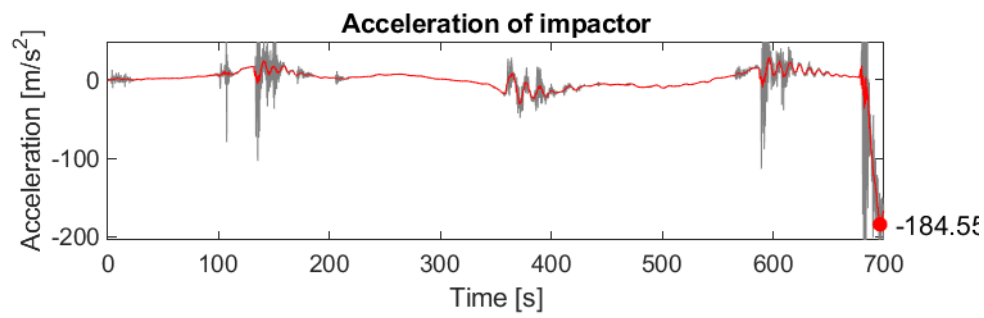
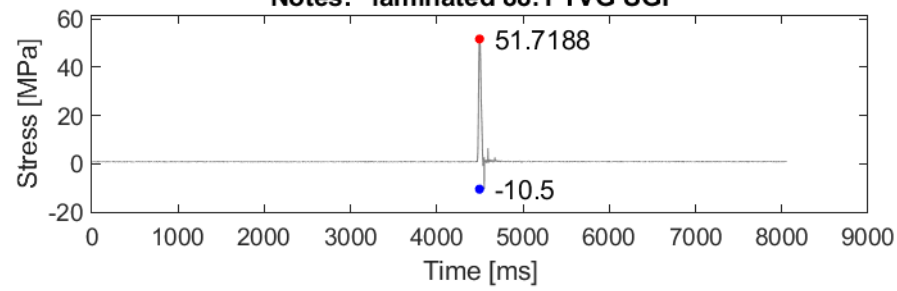
Data nr: 142
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 TVG SGP"



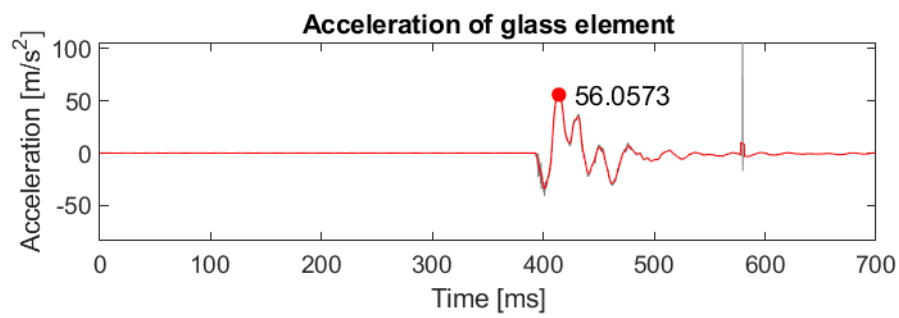
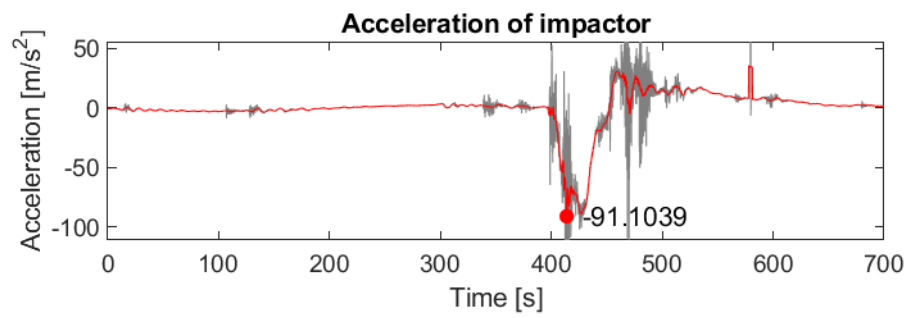
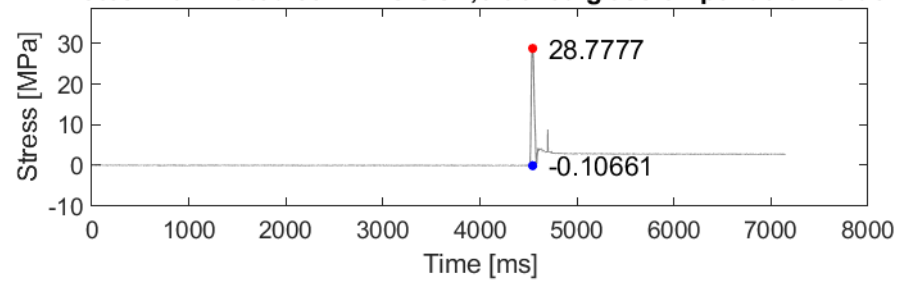
Data nr: 143
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 TVG SGP"



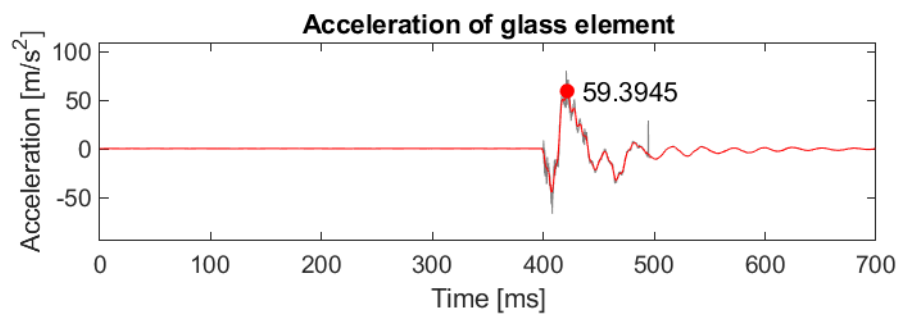
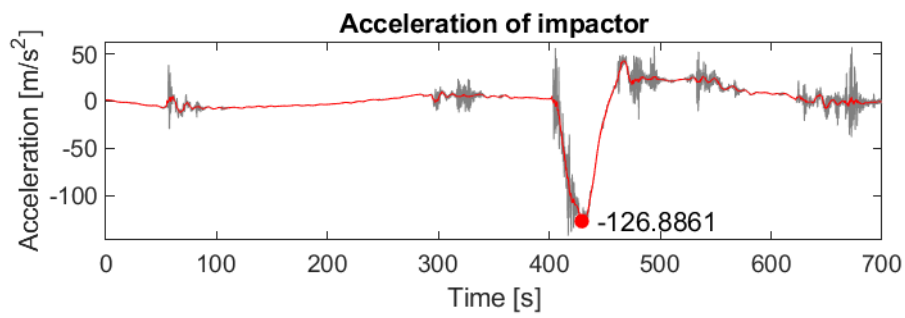
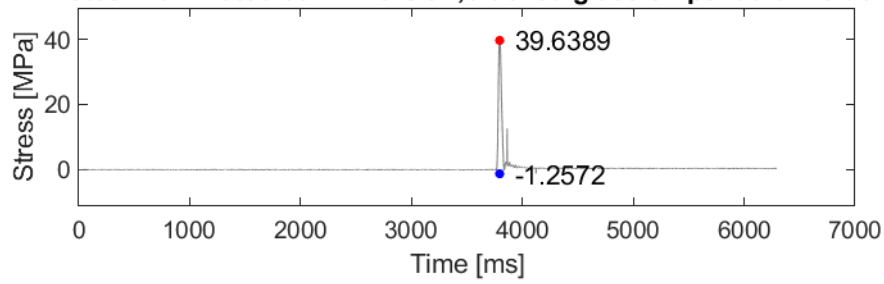
Data nr: 144
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 TVG SGP"



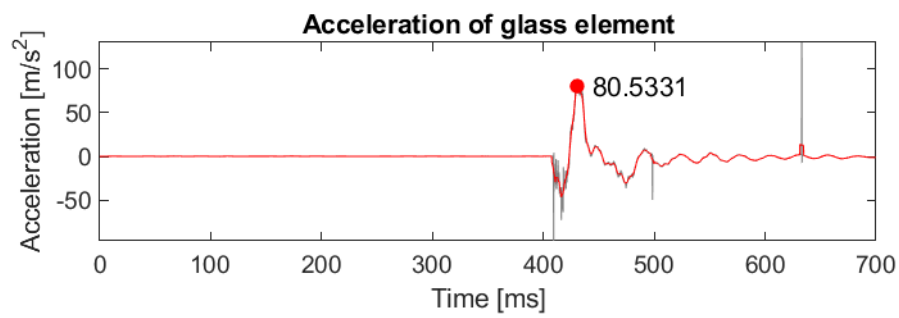
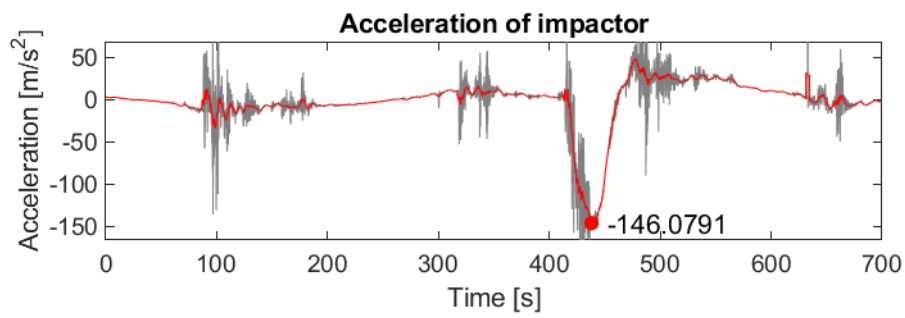
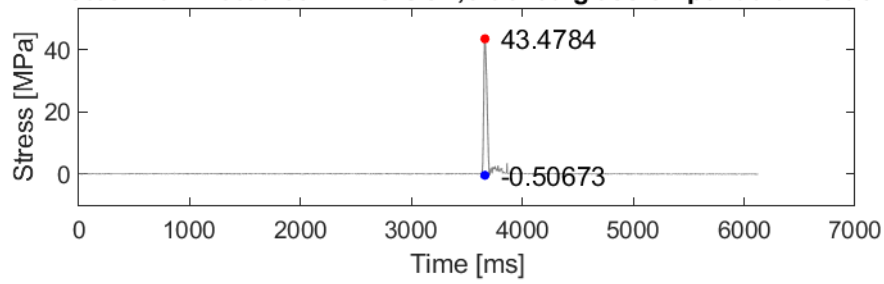
Data nr: 145
Glass: 88.1mm
Drop height: 100mm
Notes: "laminated 88.1 TVG SGP,cracked glass on pendulum side"



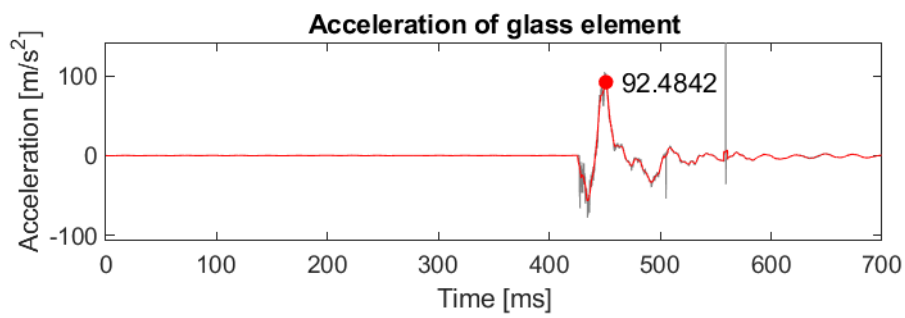
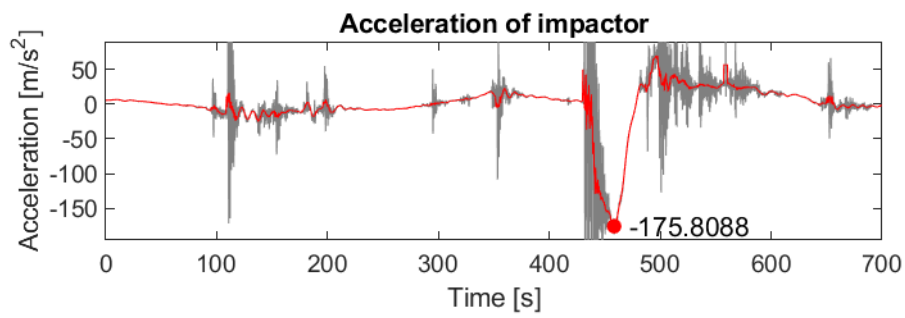
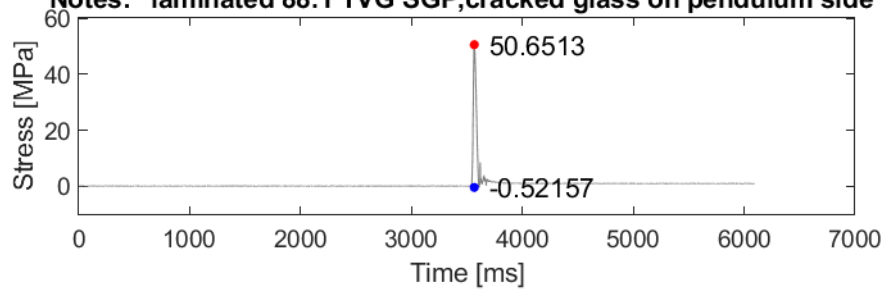
Data nr: 146
Glass: 88.1mm
Drop height: 200mm
Notes: "laminated 88.1 TVG SGP,cracked glass on pendulum side"



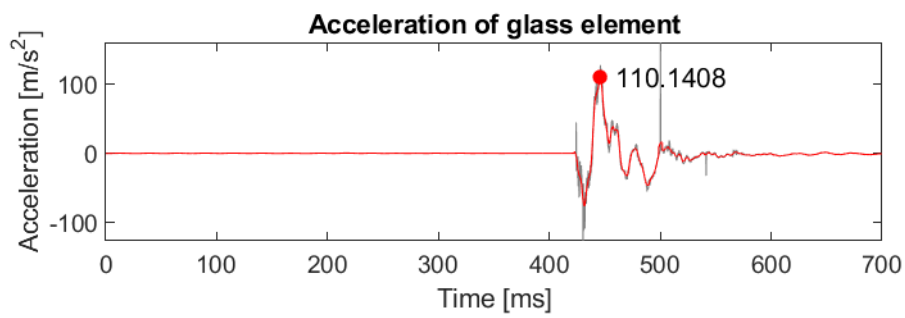
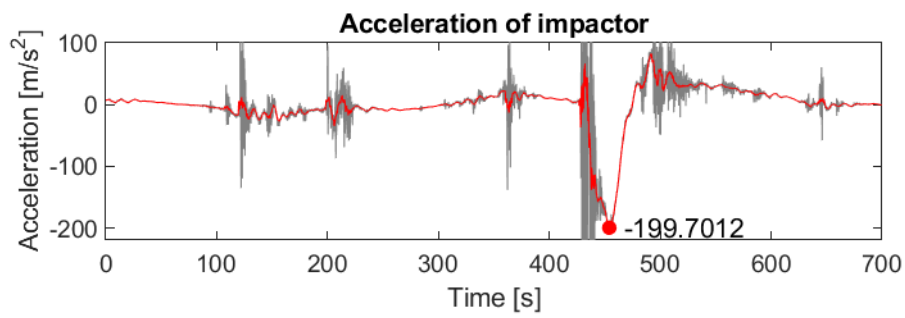
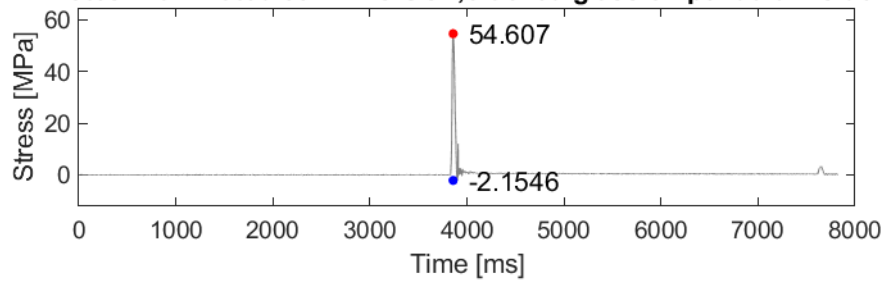
Data nr: 147
Glass: 88.1mm
Drop height: 300mm
Notes: "laminated 88.1 TVG SGP,cracked glass on pendulum side"

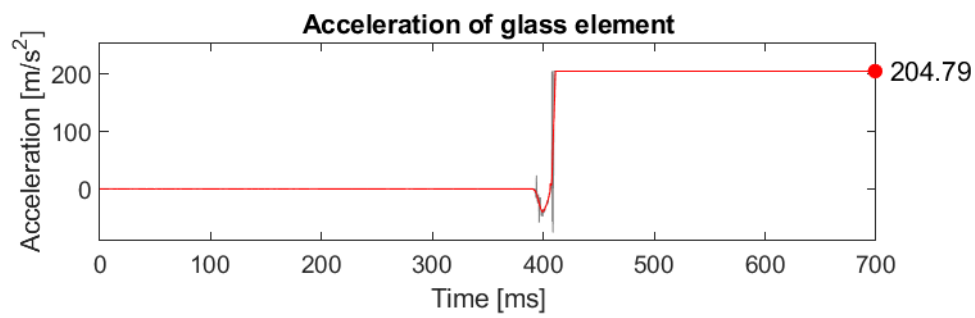
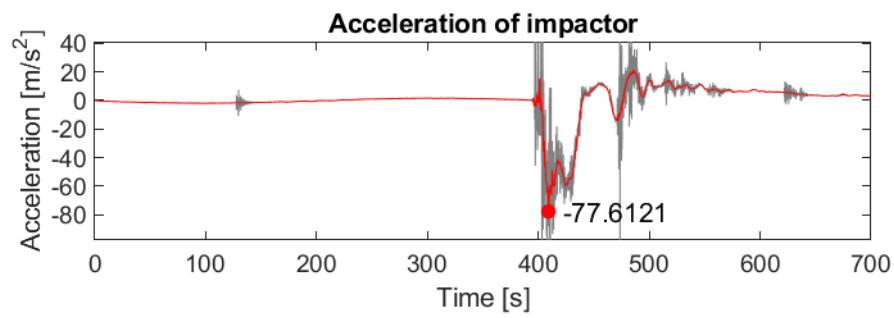
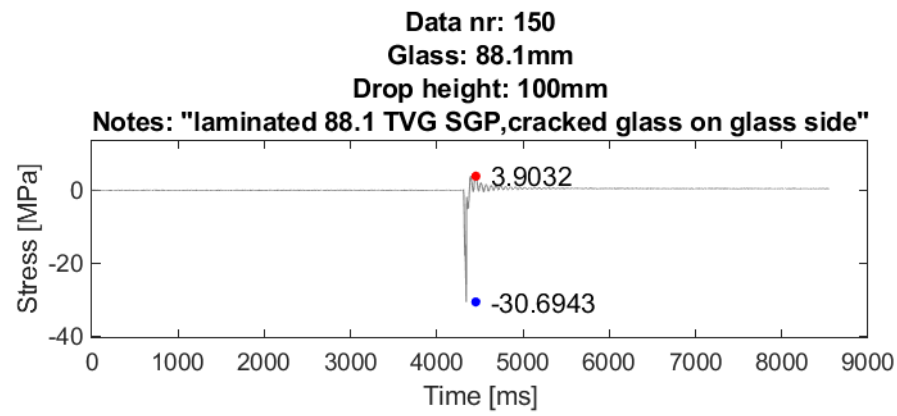


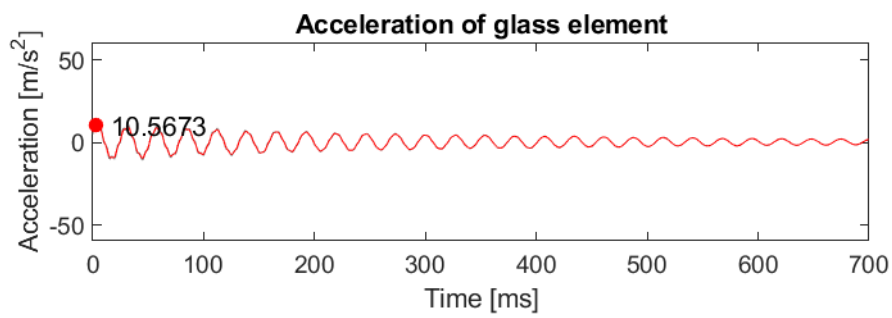
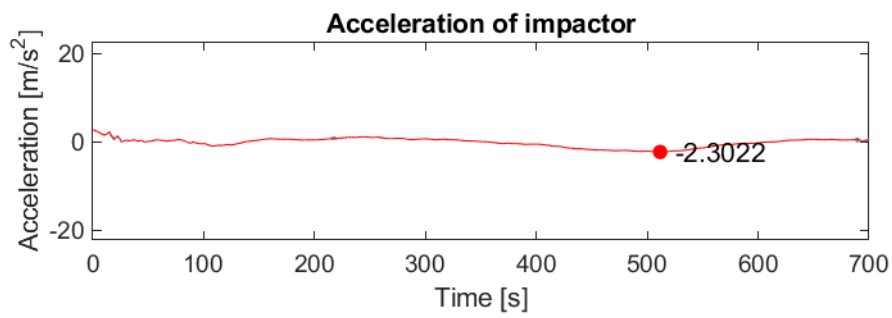
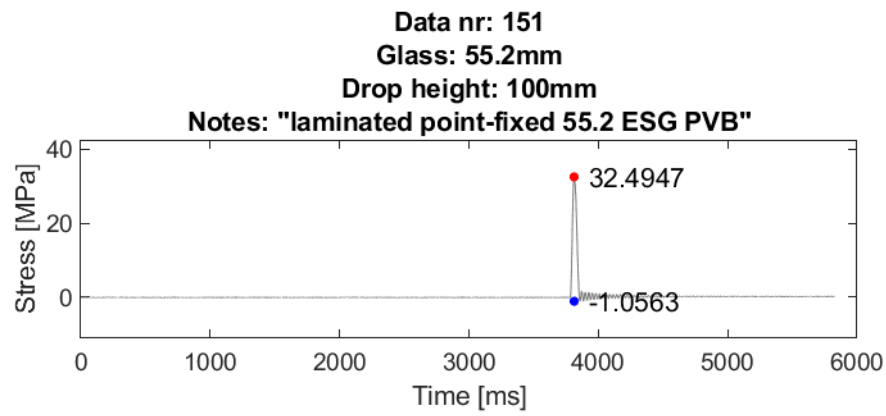
Data nr: 148
Glass: 88.1mm
Drop height: 400mm
Notes: "laminated 88.1 TVG SGP,cracked glass on pendulum side"

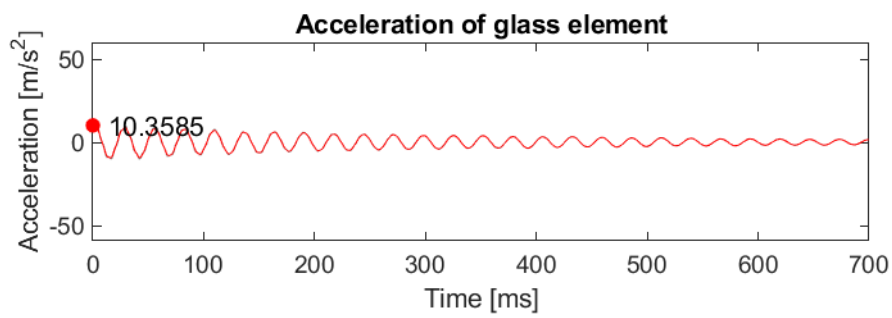
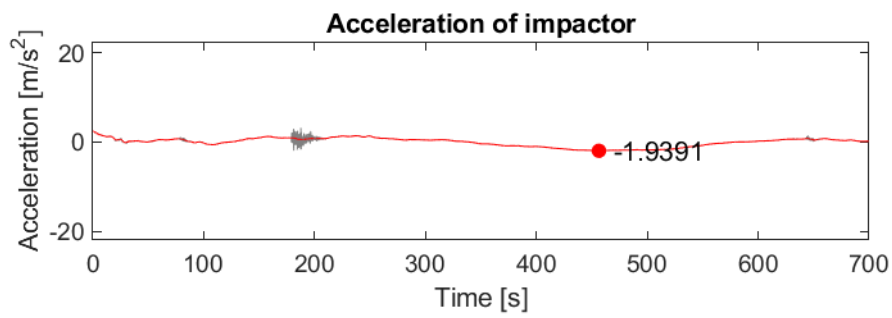
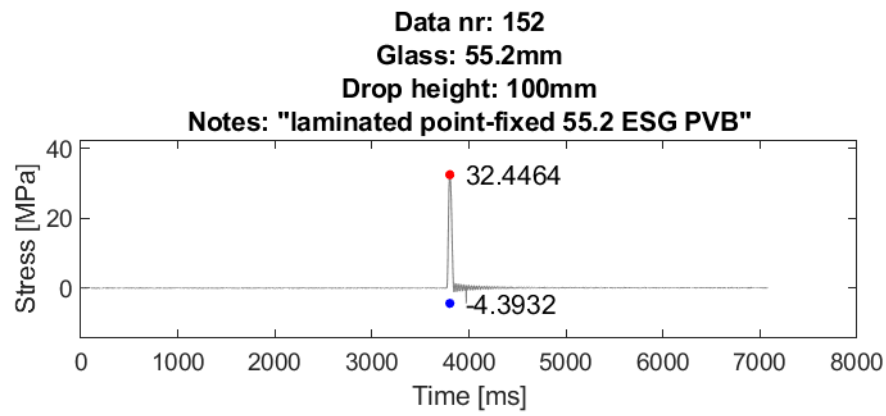


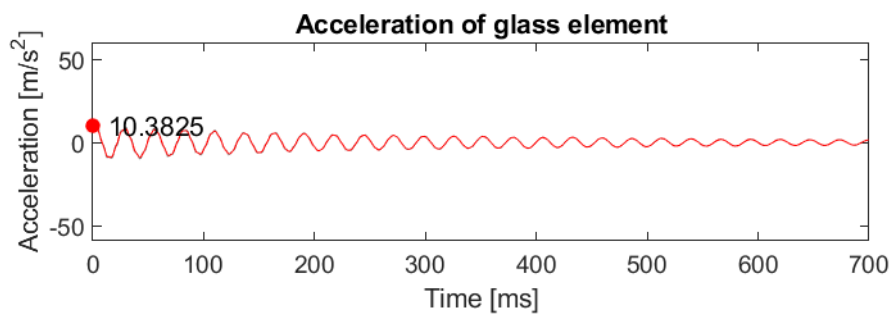
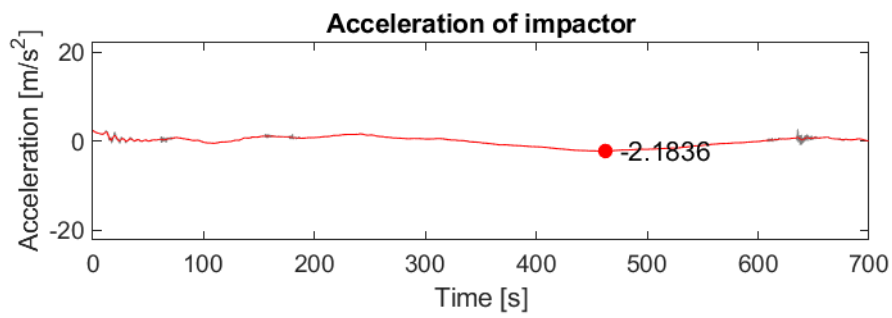
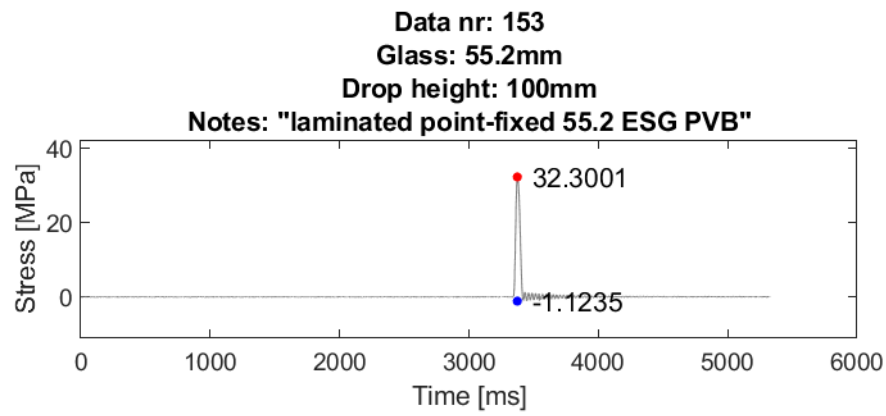
Data nr: 149
Glass: 88.1mm
Drop height: 500mm
Notes: "laminated 88.1 TVG SGP,cracked glass on pendulum side"

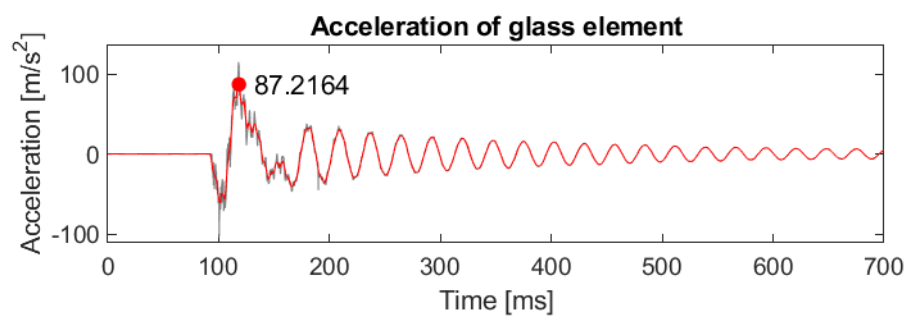
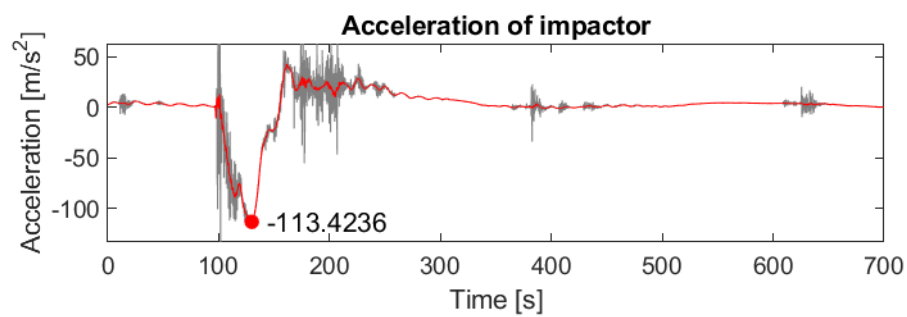
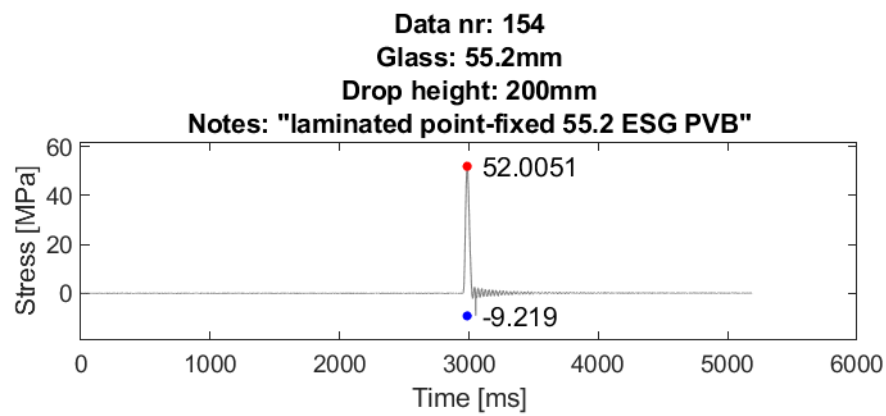


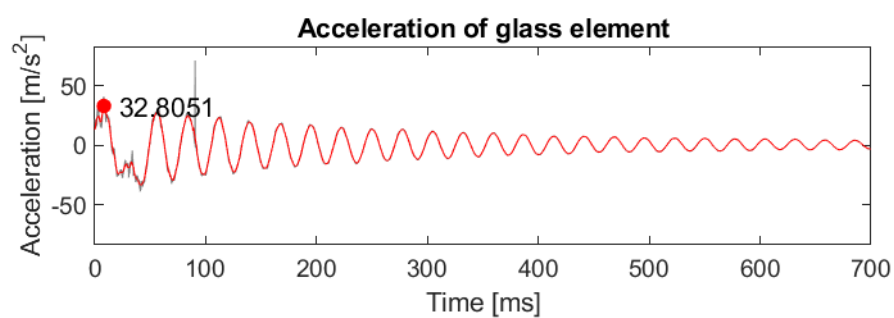
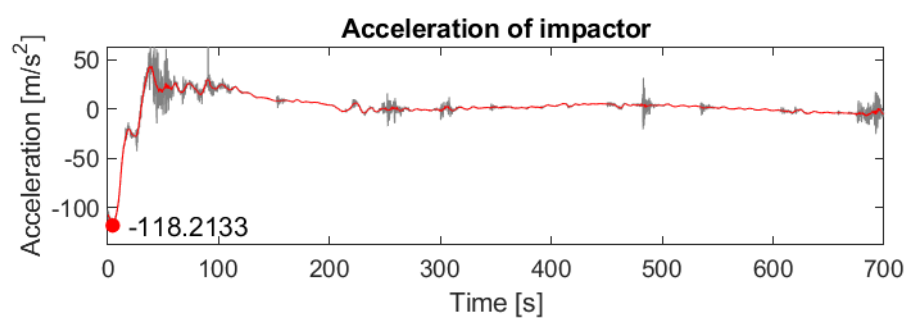
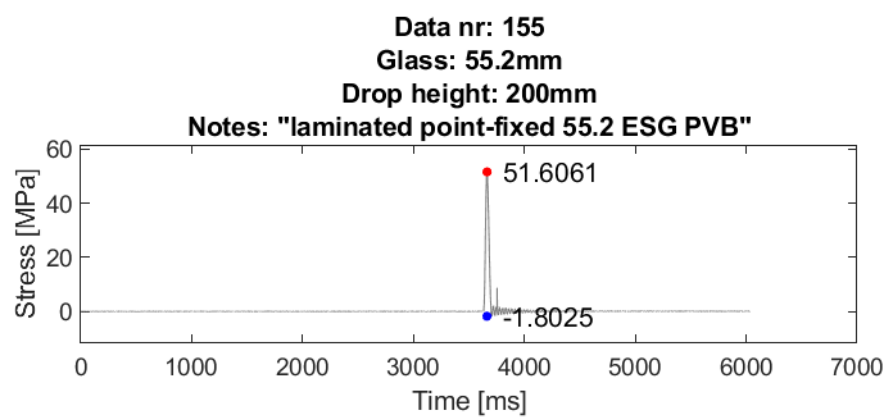


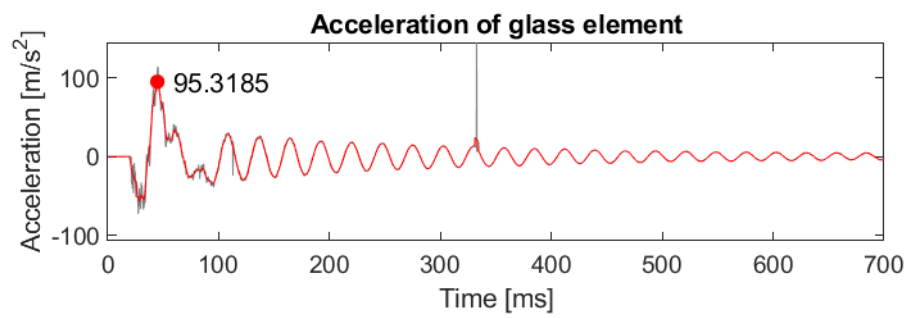
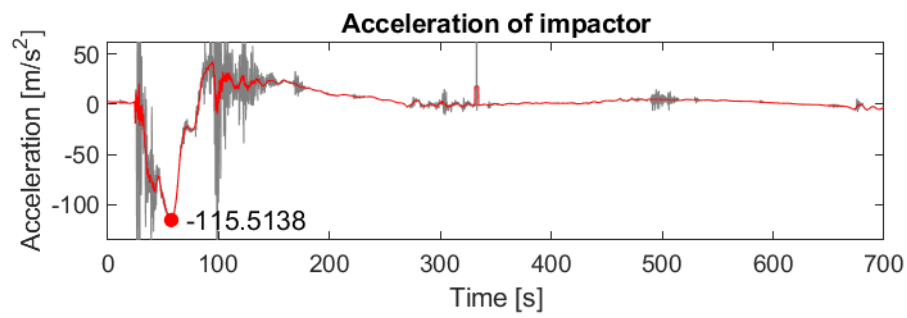
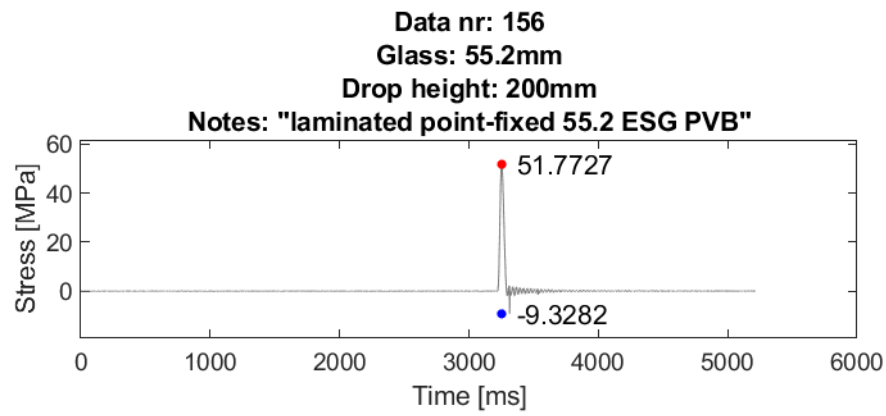


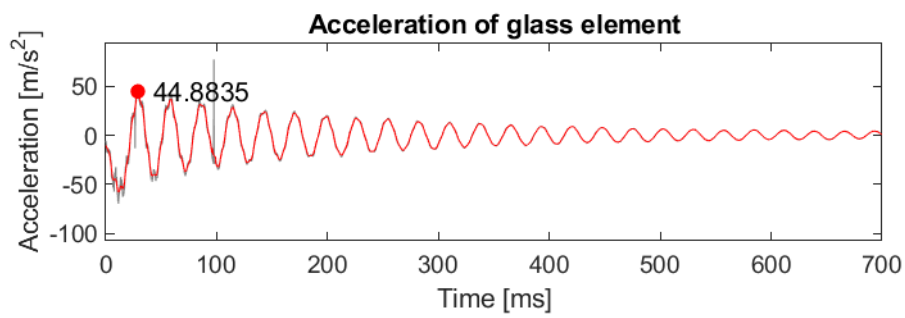
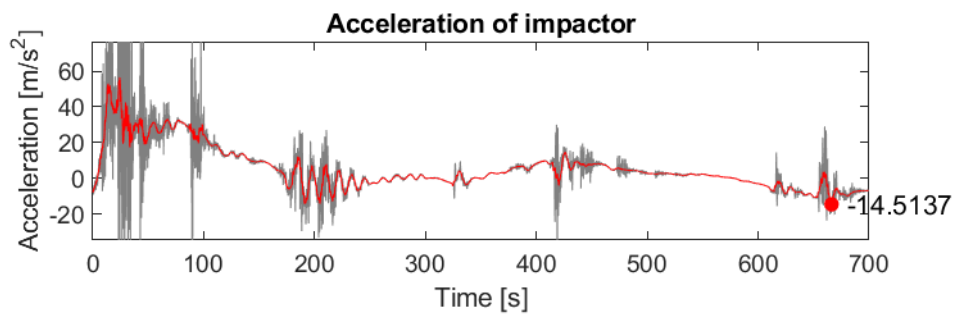
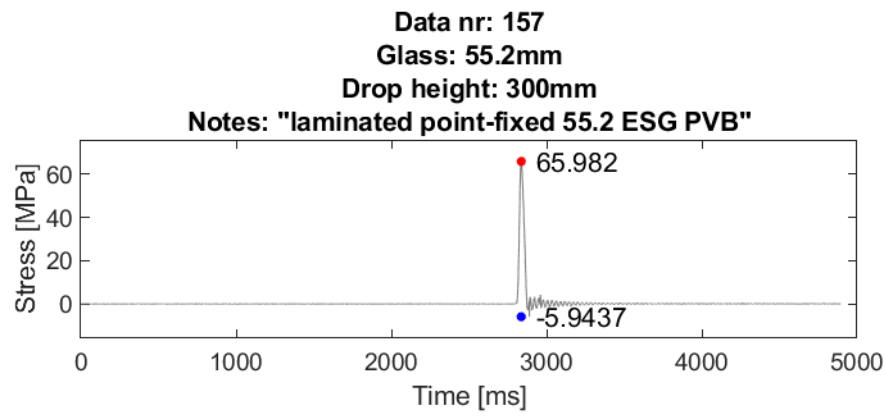




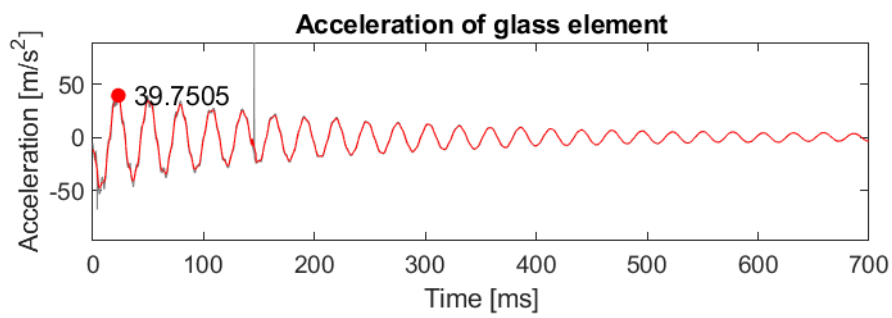
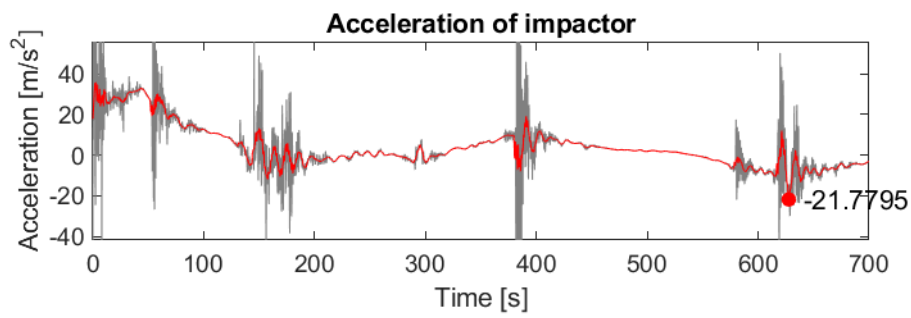
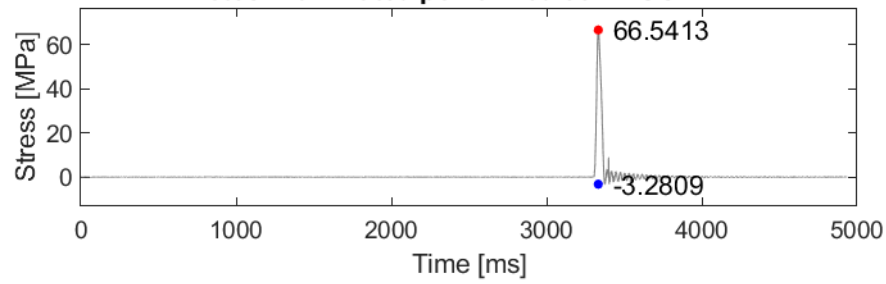




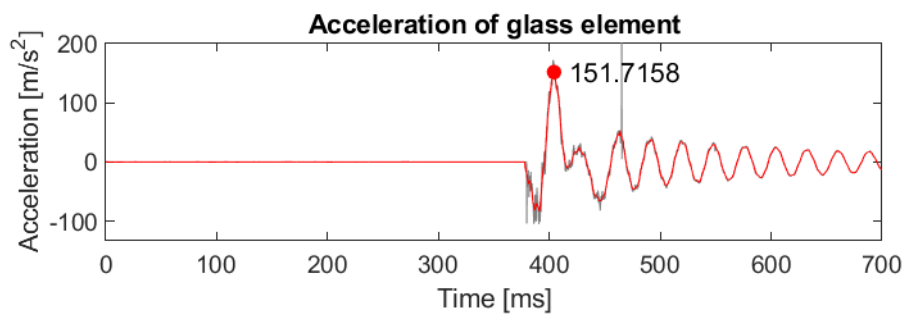
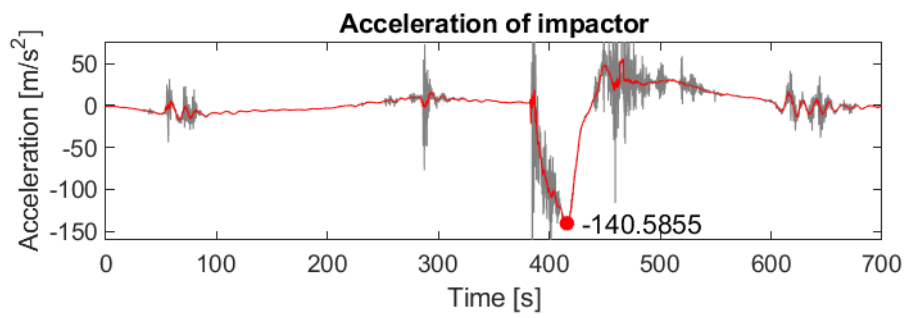
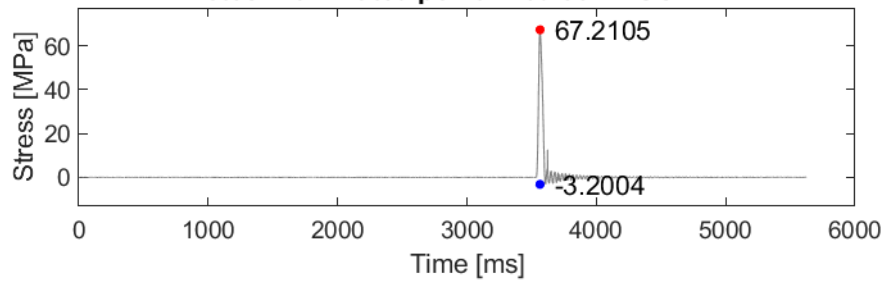


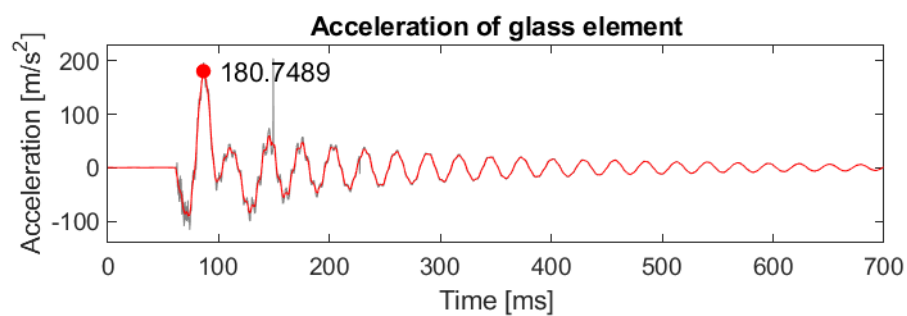
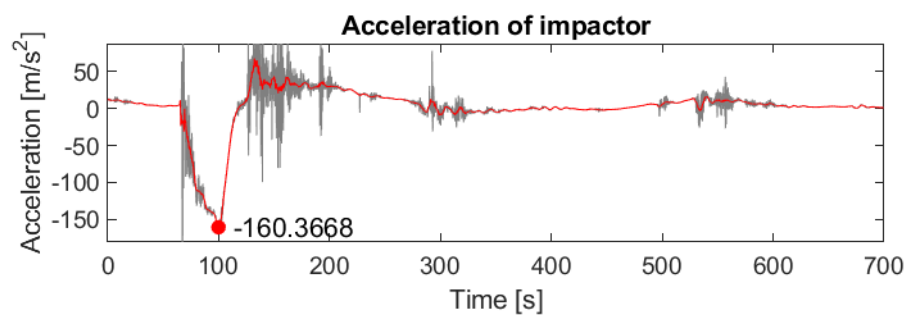
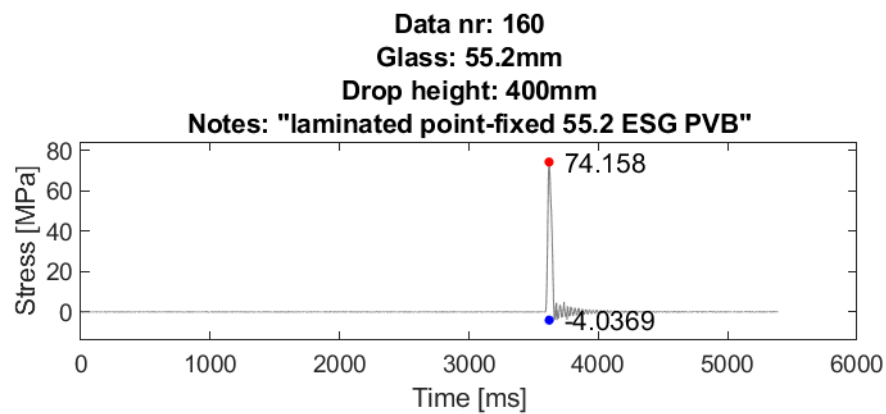


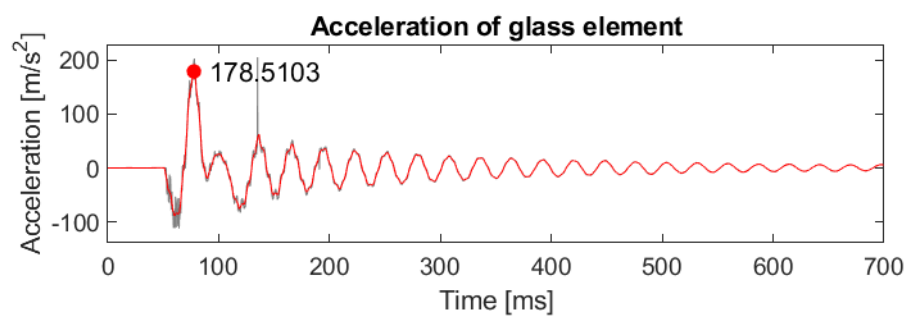
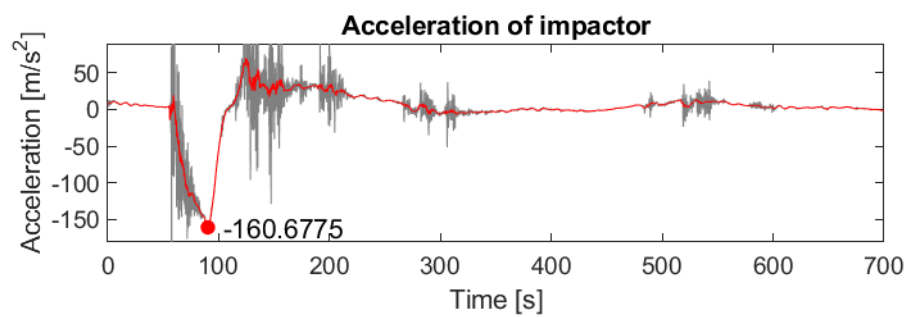
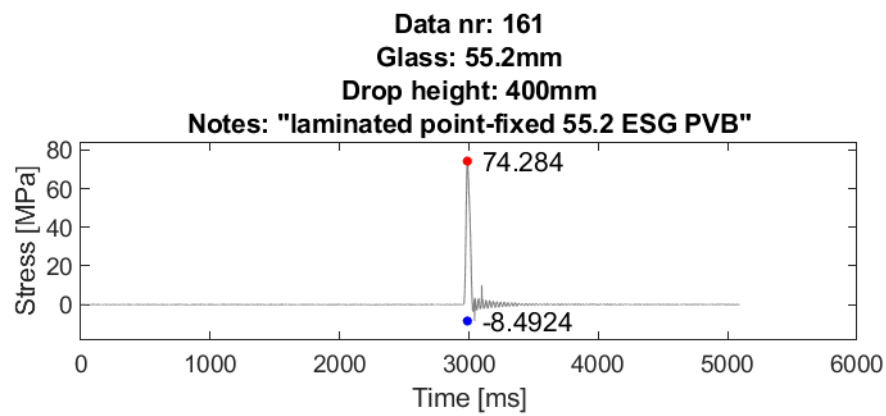
Data nr: 158
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated point-fixed 55.2 ESG PVB"

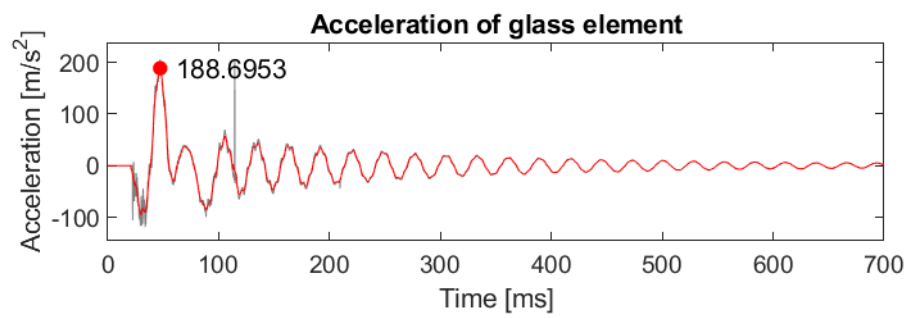
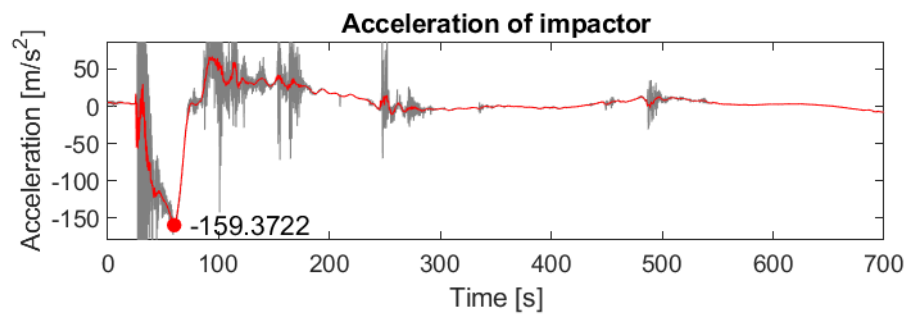
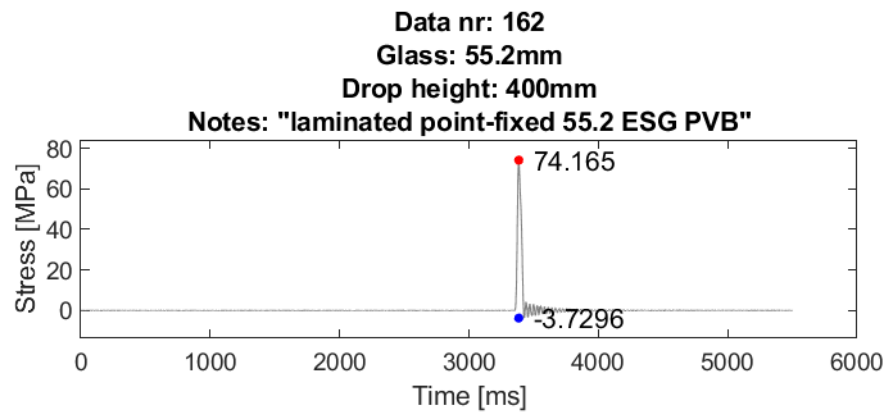


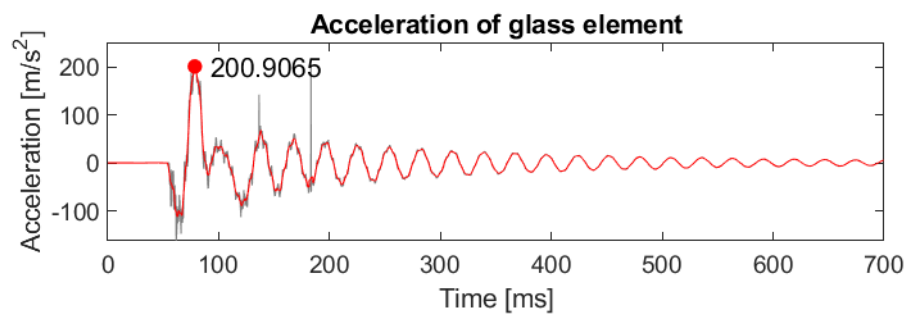
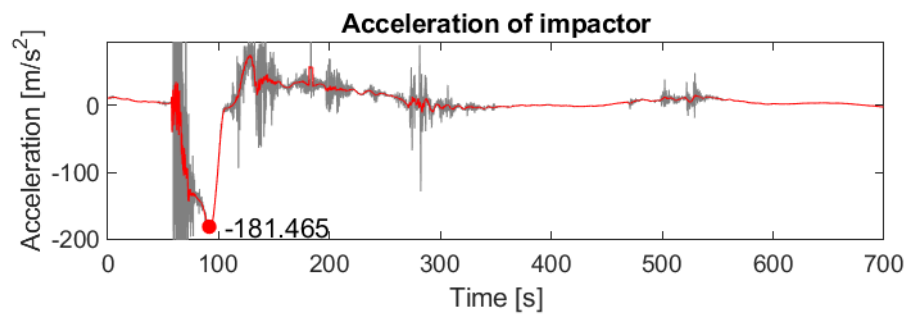
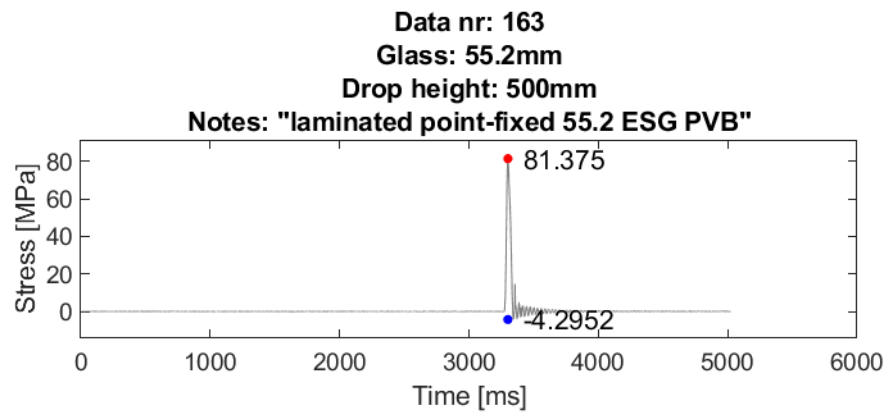
Data nr: 159
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated point-fixed 55.2 ESG PVB"

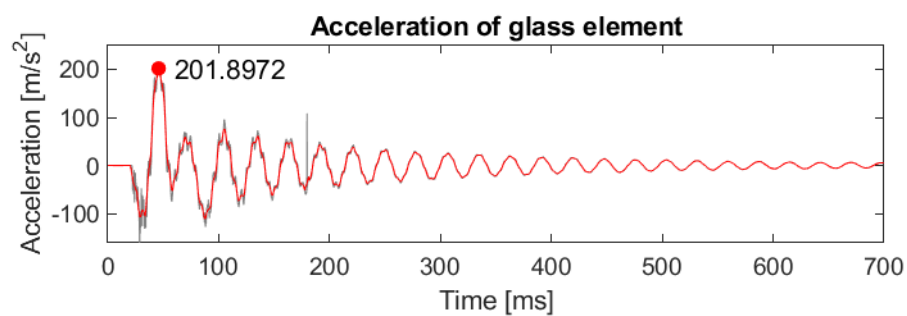
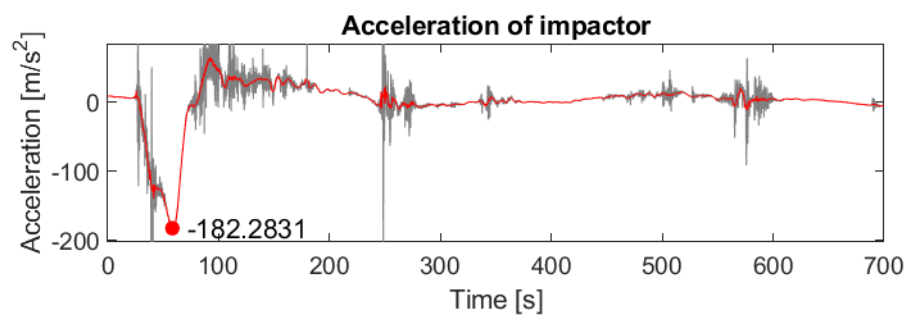
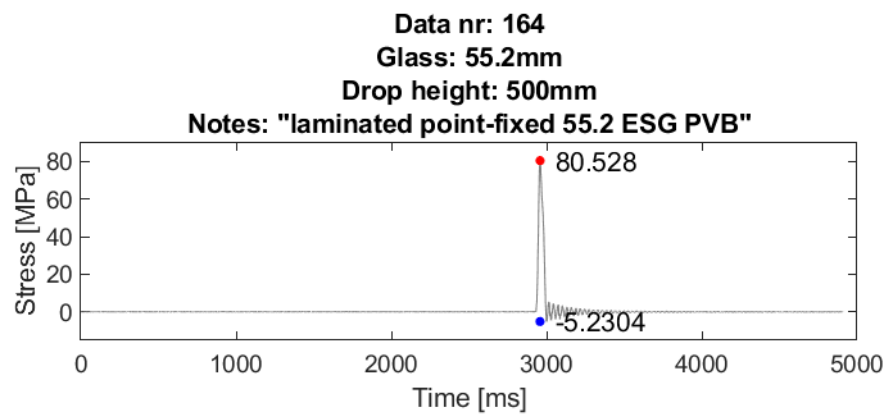


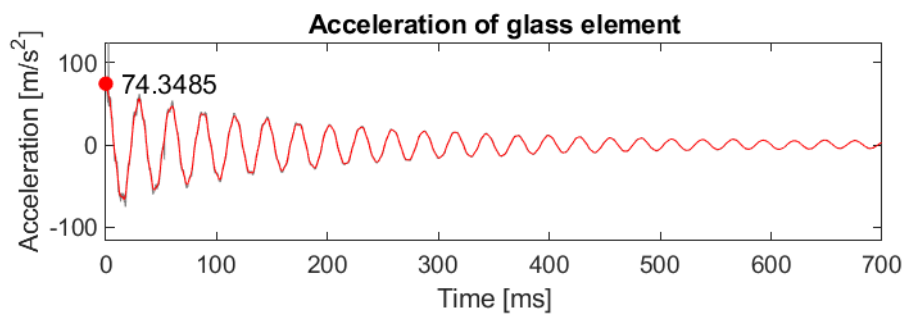
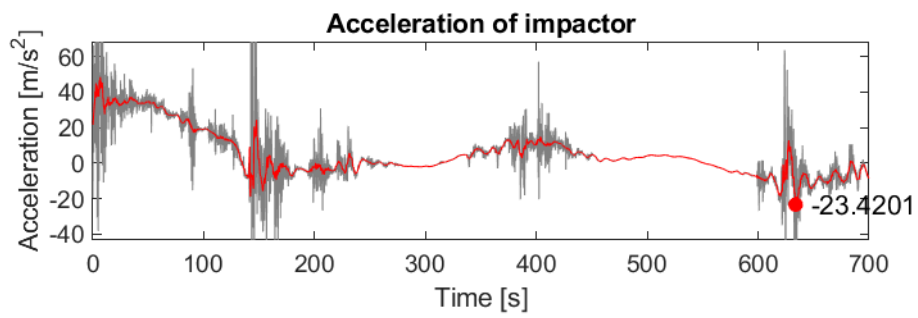
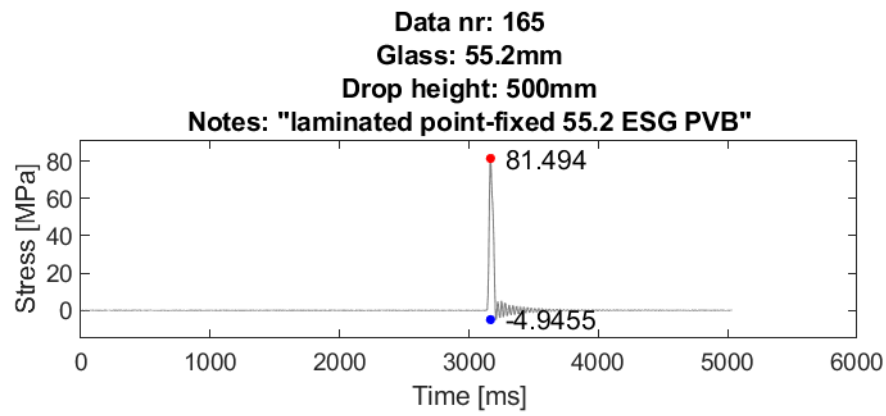




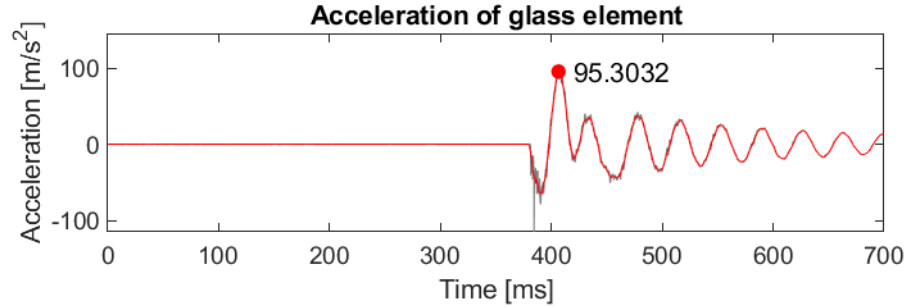
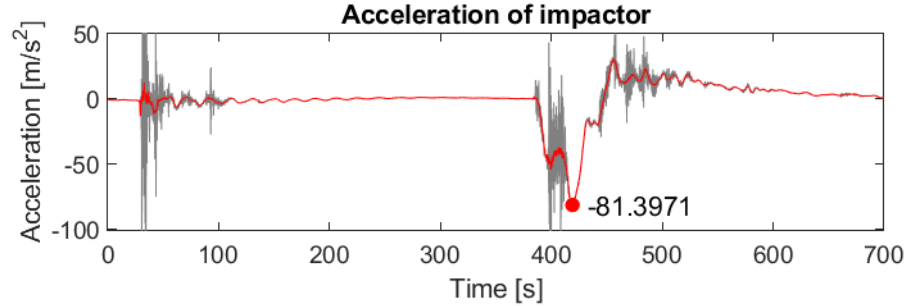
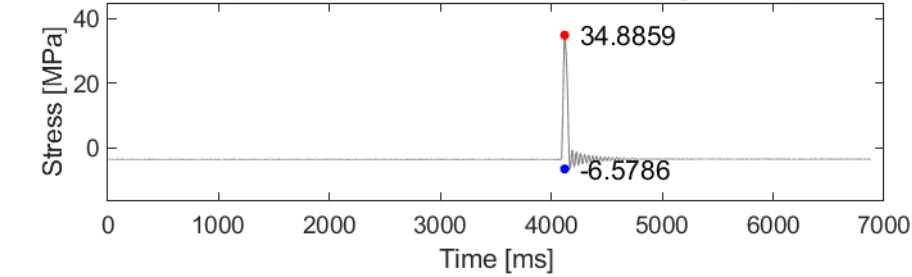




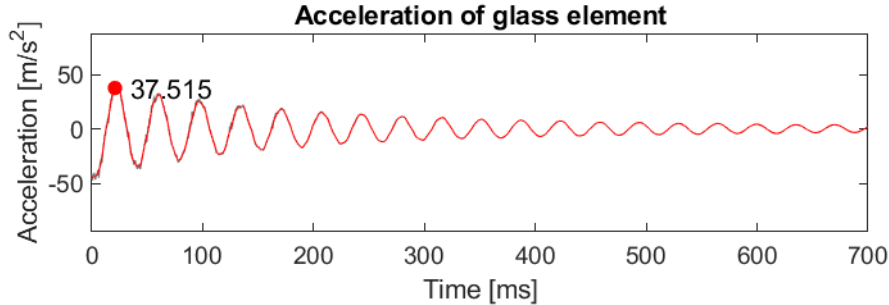
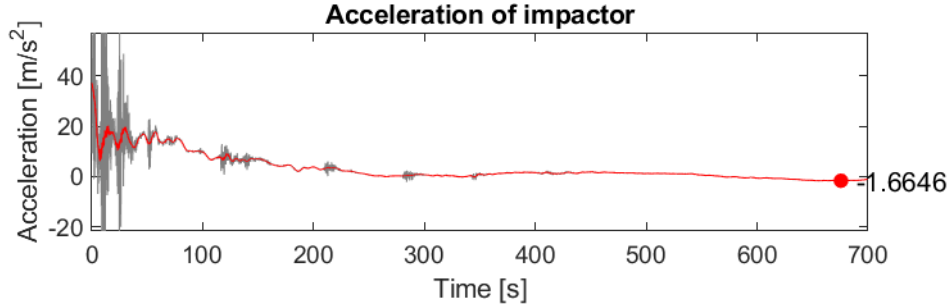
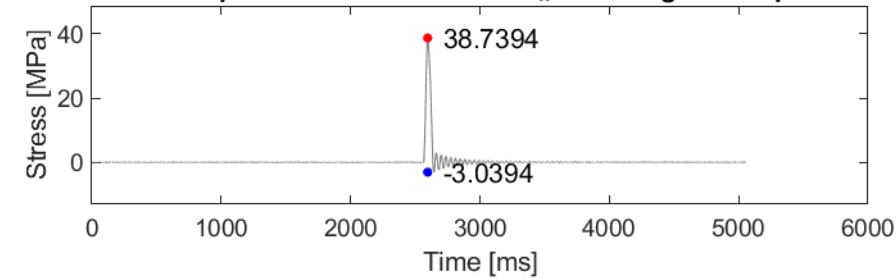




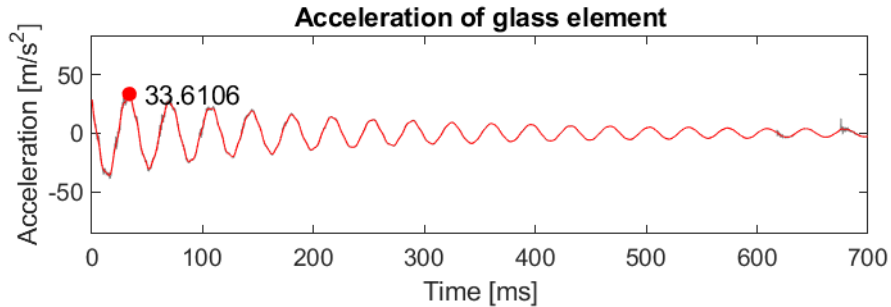
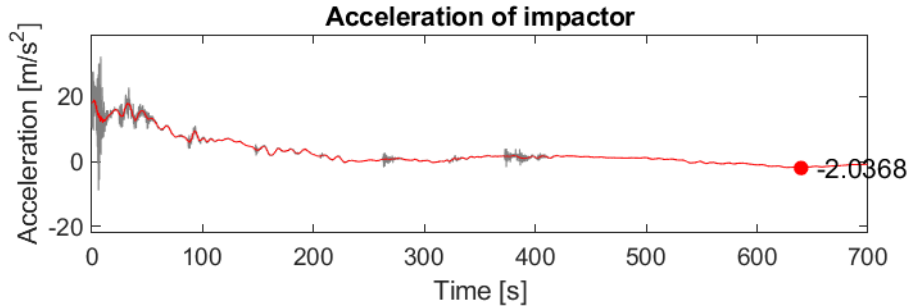
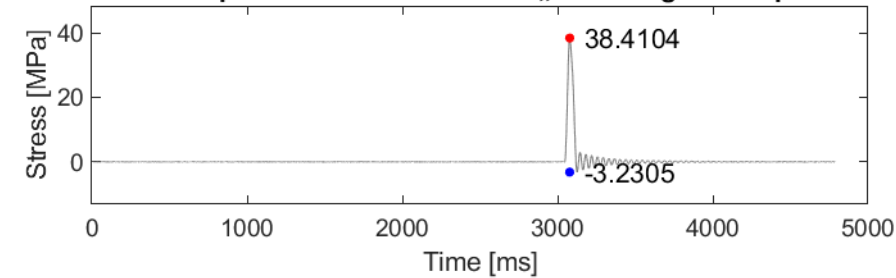
Data nr: 167
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"



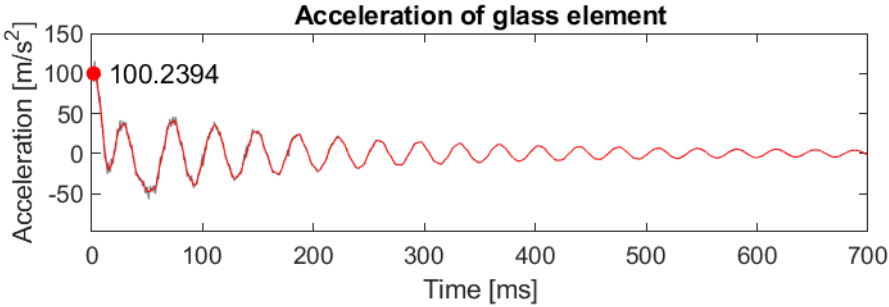
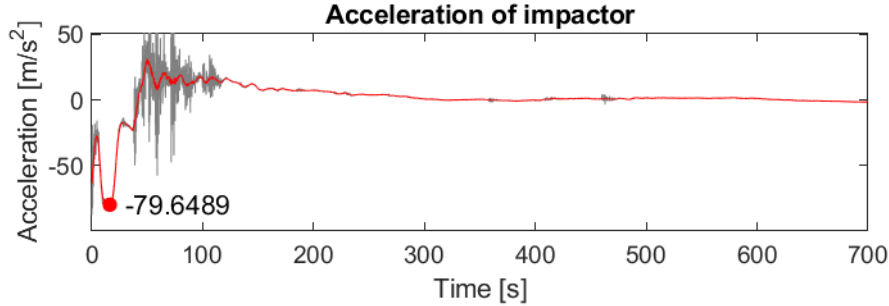
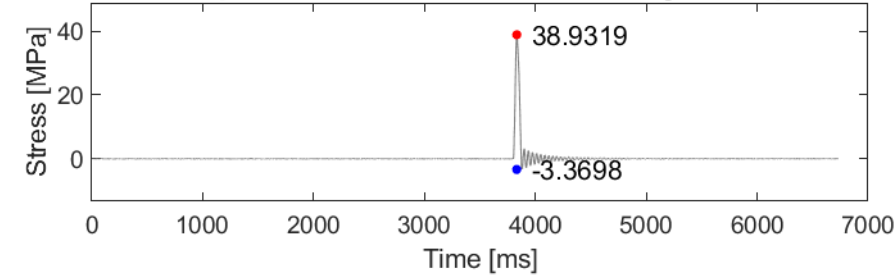
Data nr: 168
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"



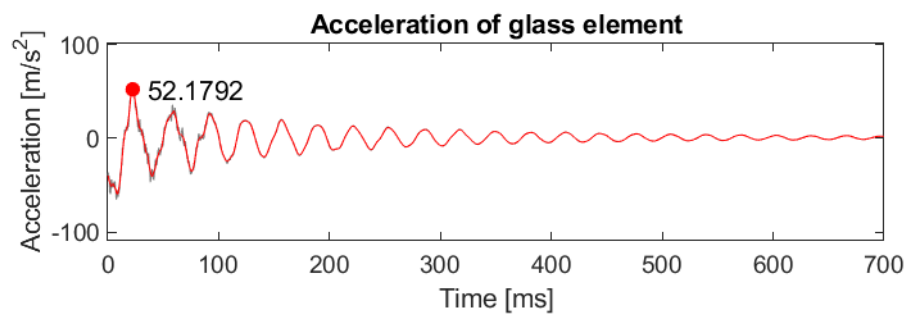
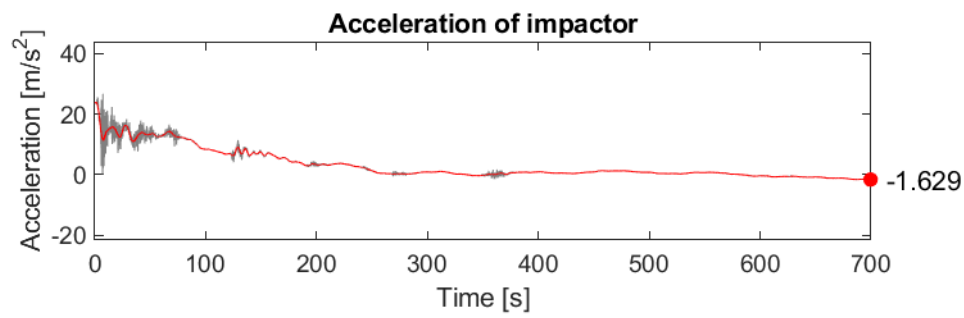
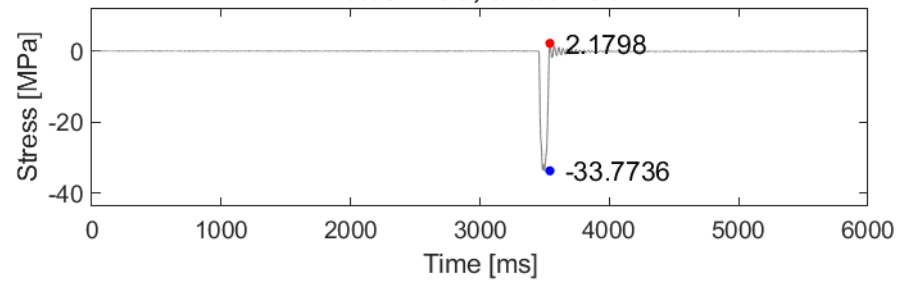
Data nr: 169
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"



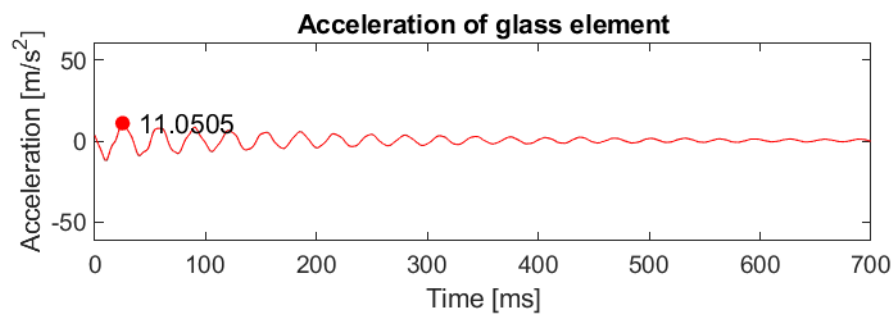
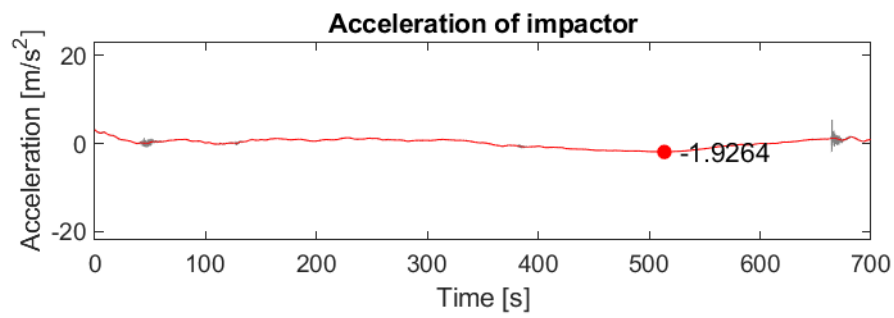
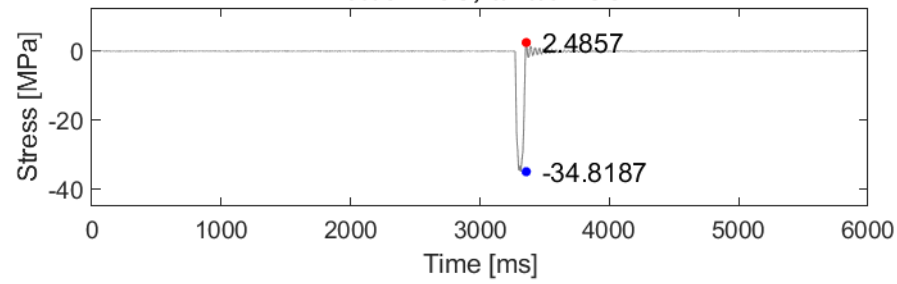
Data nr: 170
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated point-fixed 55.2 ESG PVB,,cracked glass on pendulum side"



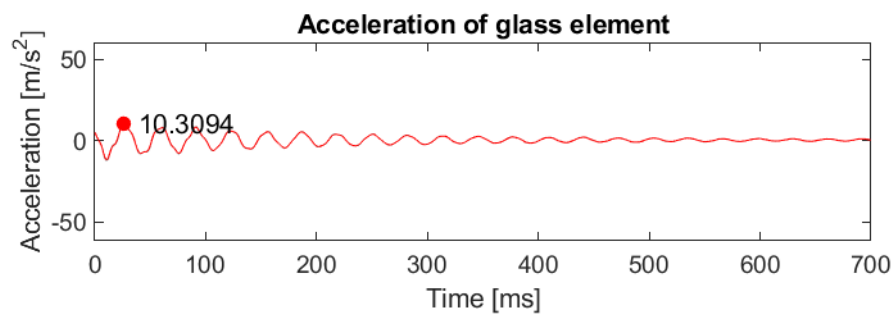
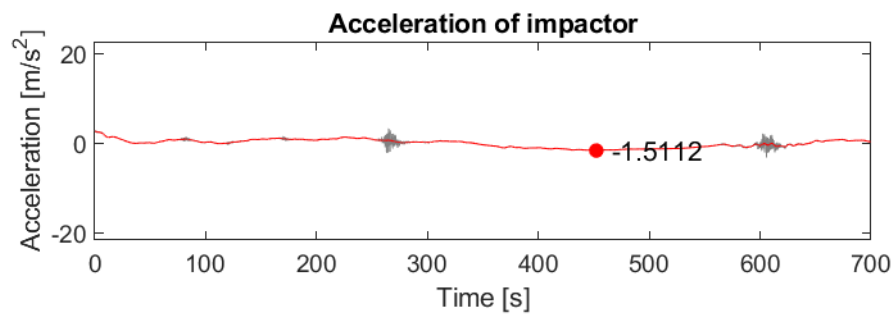
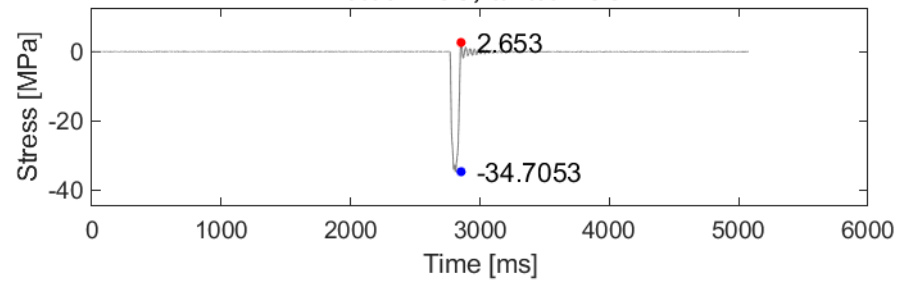
Data nr: 171
Glass: 5.16.5mm
Drop height: 100mm
Notes: "IGU, 5/16/5 ESG"



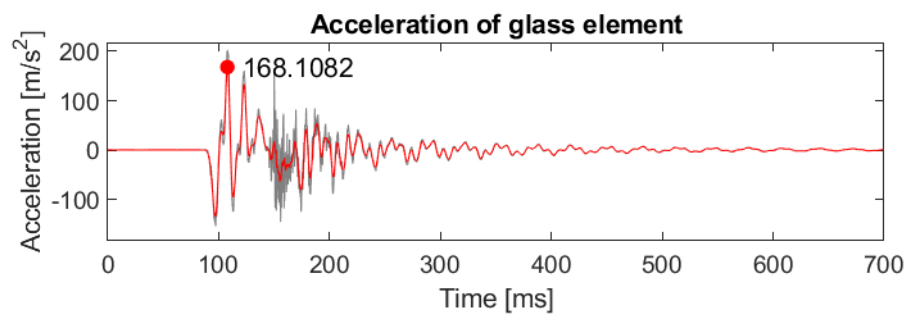
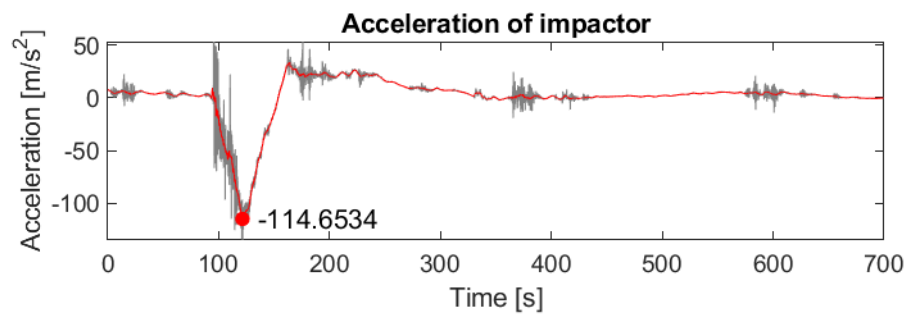
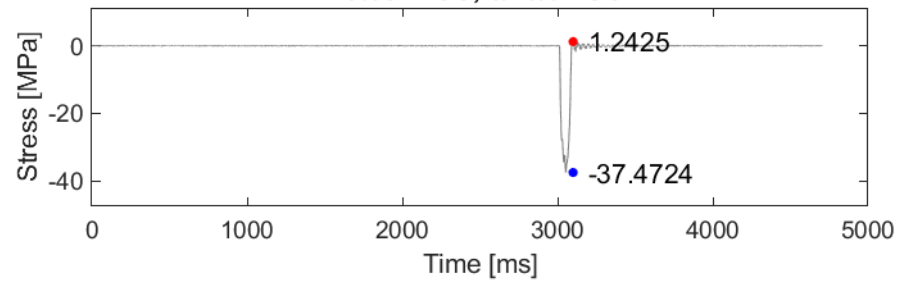
Data nr: 172
Glass: 5.16.5mm
Drop height: 100mm
Notes: "IGU, 5/16/5 ESG"



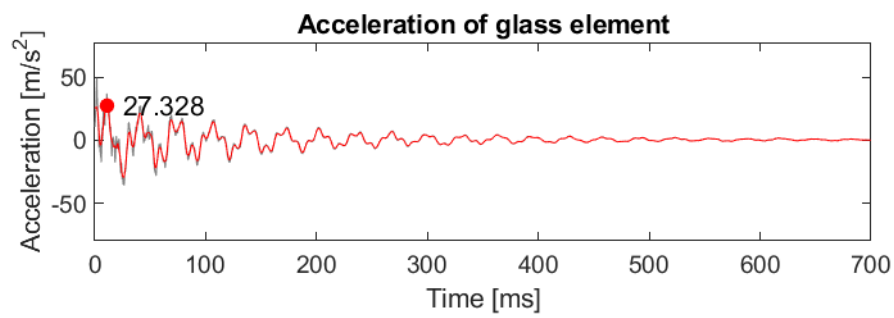
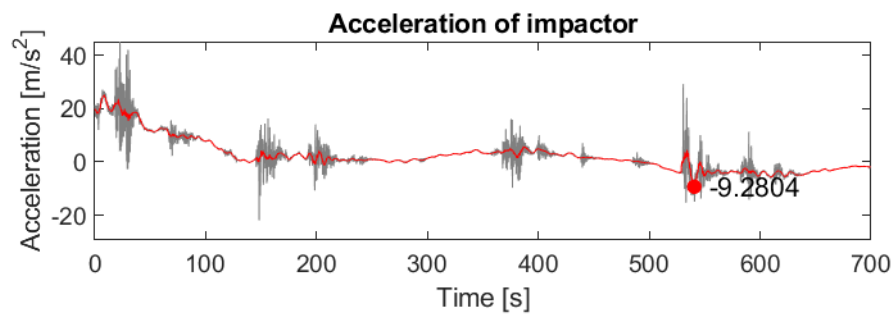
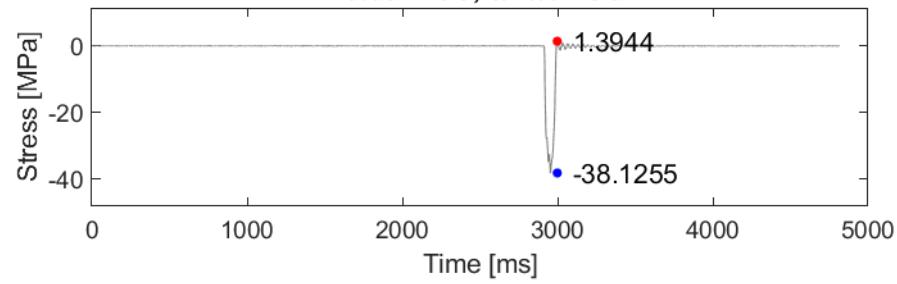
Data nr: 173
Glass: 5.16.5mm
Drop height: 100mm
Notes: "IGU, 5/16/5 ESG"



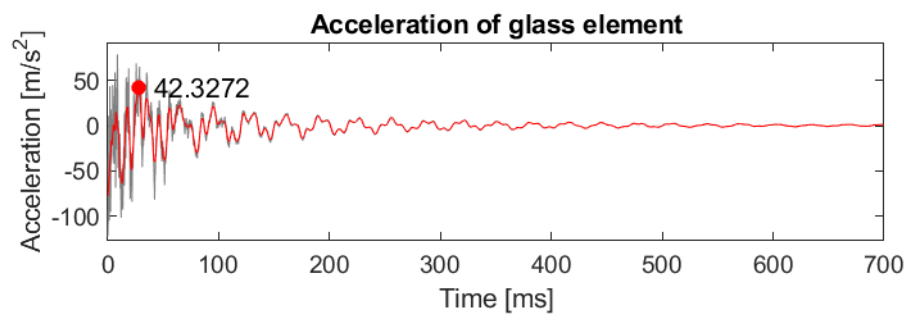
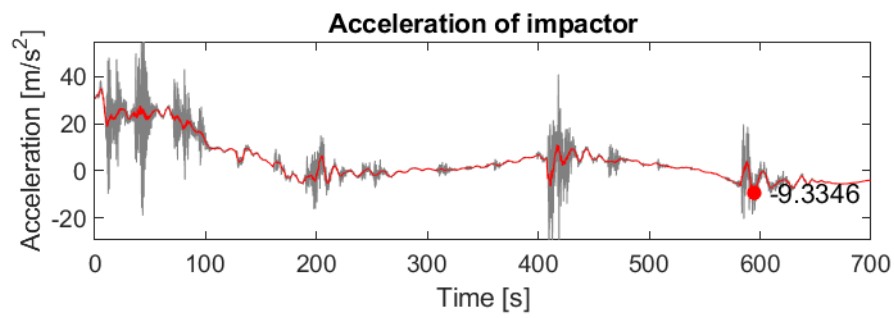
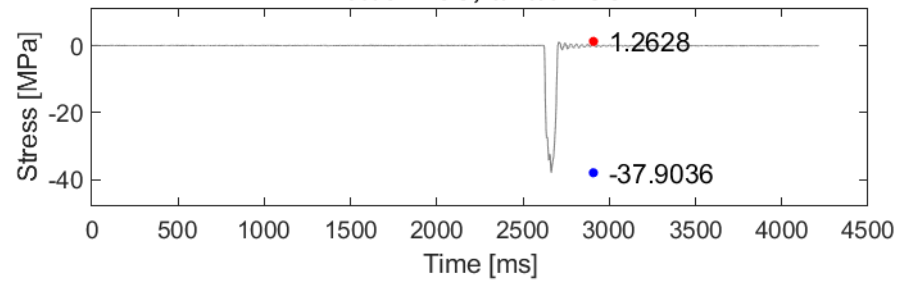
Data nr: 174
Glass: 5.16.5mm
Drop height: 200mm
Notes: "IGU, 5/16/5 ESG"



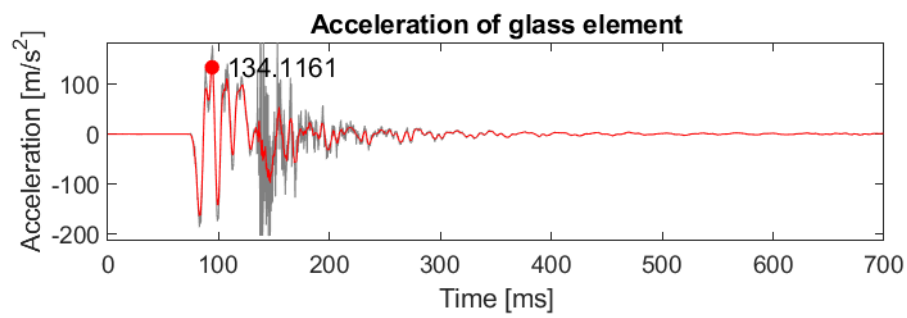
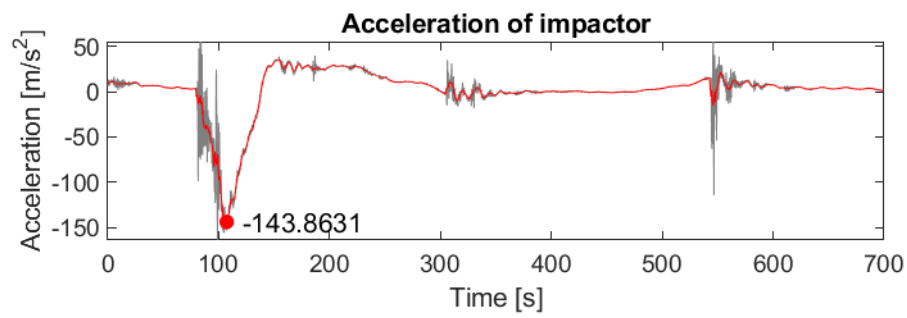
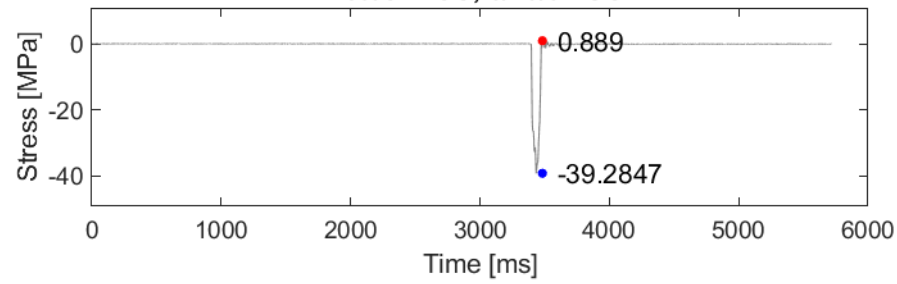
Data nr: 175
Glass: 5.16.5mm
Drop height: 200mm
Notes: "IGU, 5/16/5 ESG"



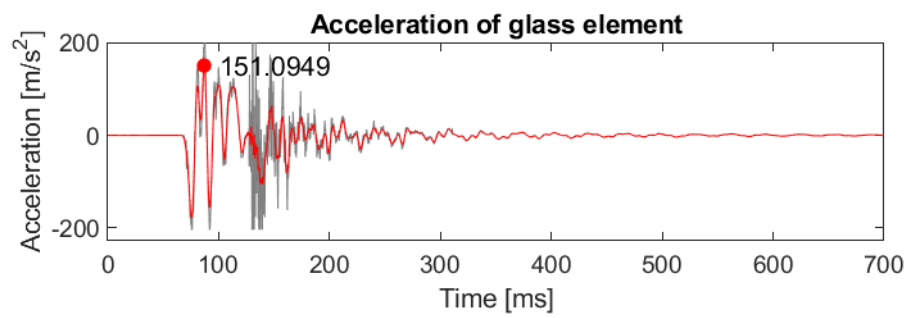
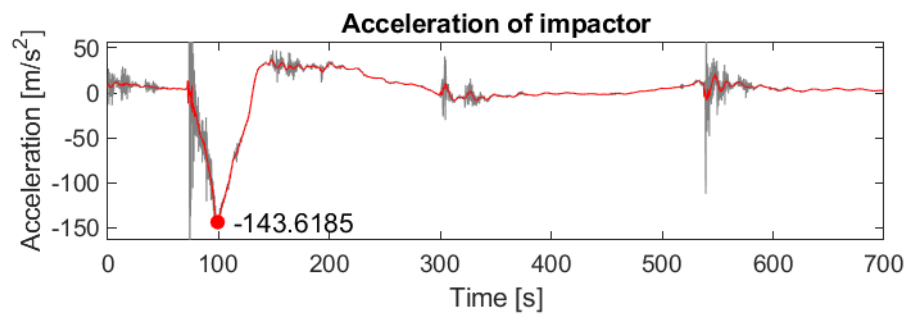
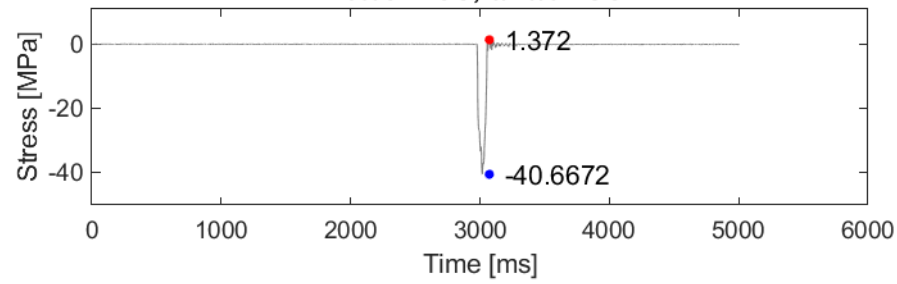
Data nr: 176
Glass: 5.16.5mm
Drop height: 200mm
Notes: "IGU, 5/16/5 ESG"



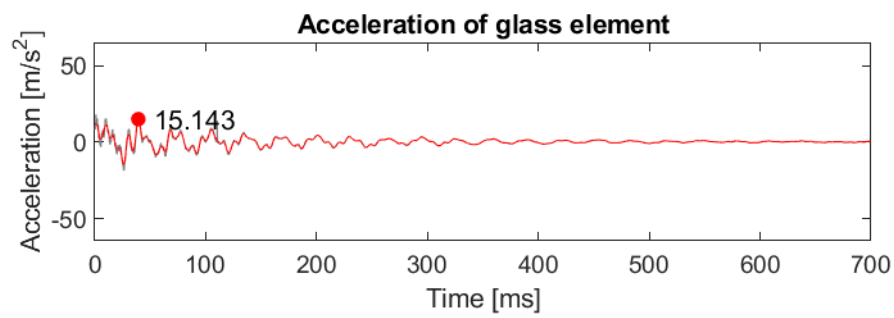
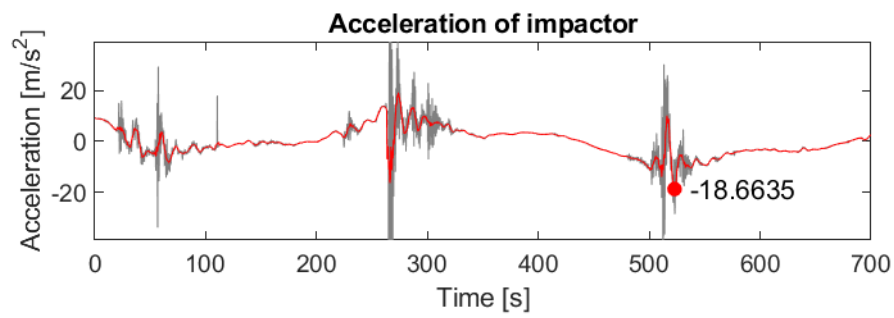
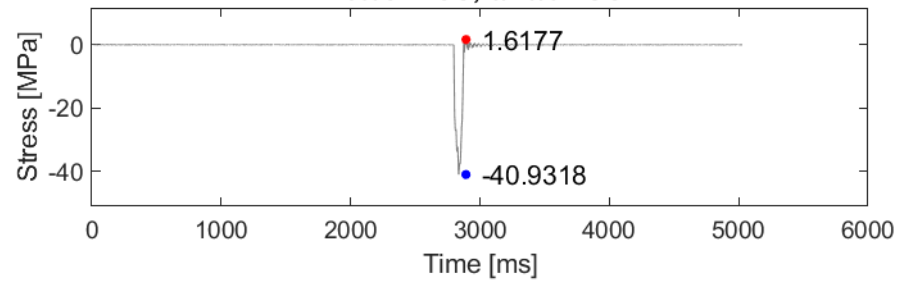
Data nr: 177
Glass: 5.16.5mm
Drop height: 300mm
Notes: "IGU, 5/16/5 ESG"



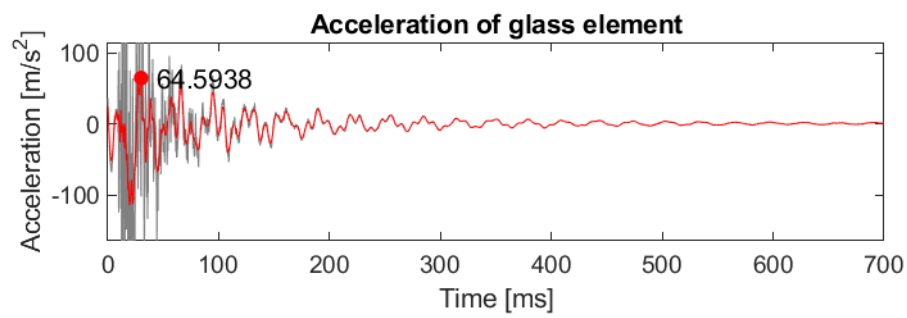
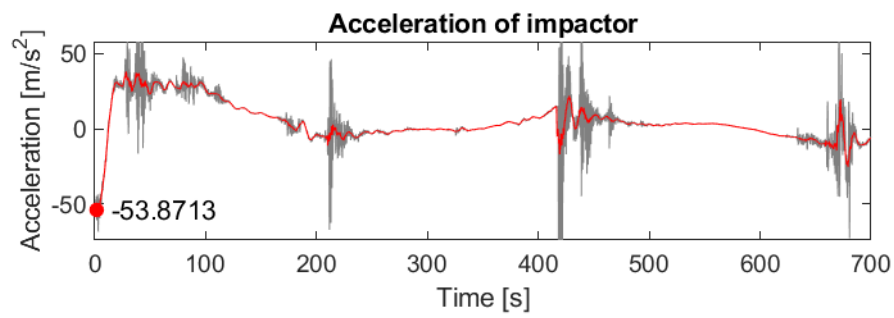
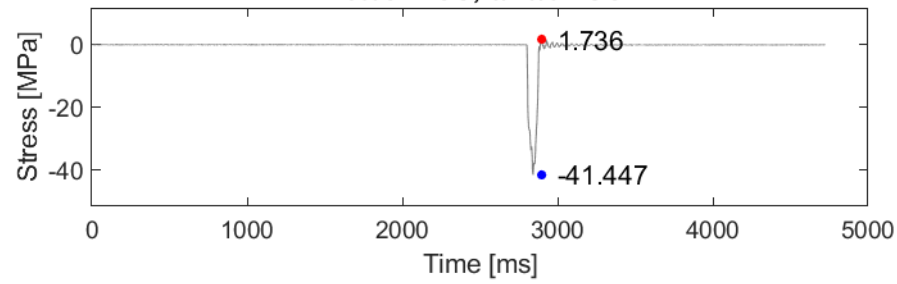
Data nr: 178
Glass: 5.16.5mm
Drop height: 300mm
Notes: "IGU, 5/16/5 ESG"



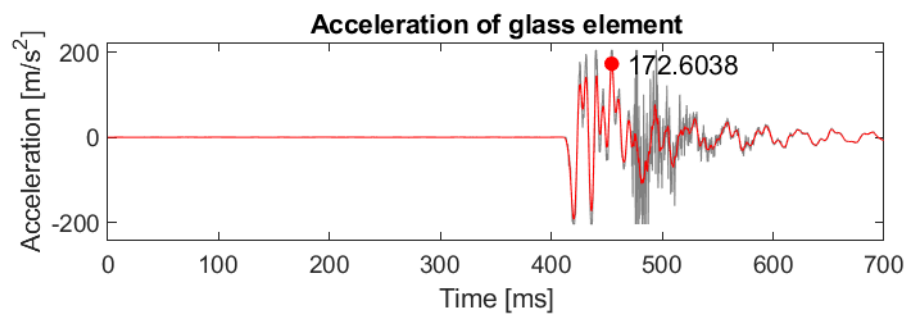
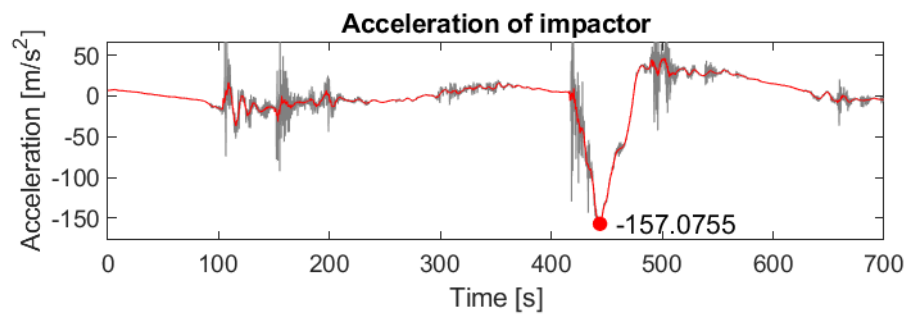
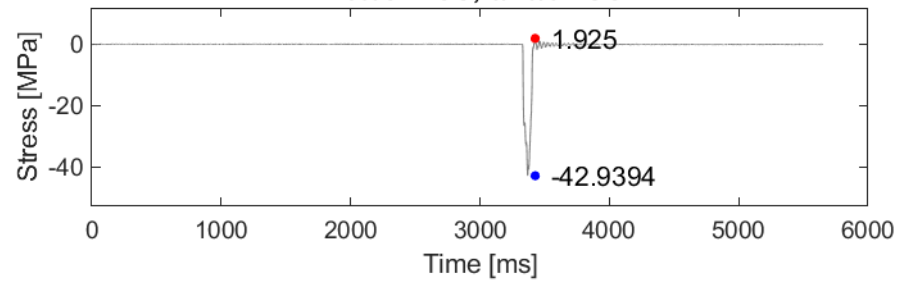
Data nr: 179
Glass: 5.16.5mm
Drop height: 300mm
Notes: "IGU, 5/16/5 ESG"



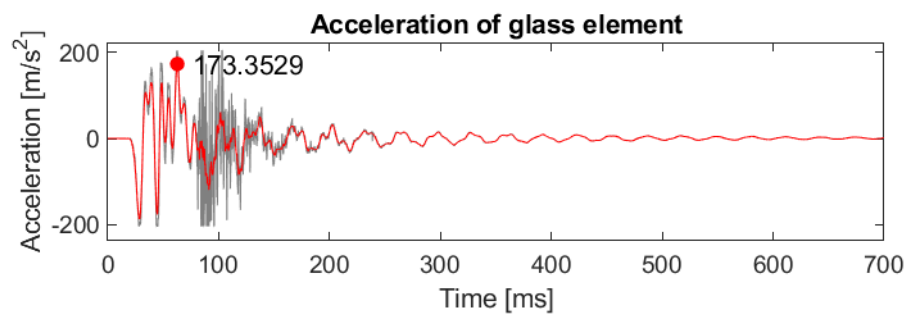
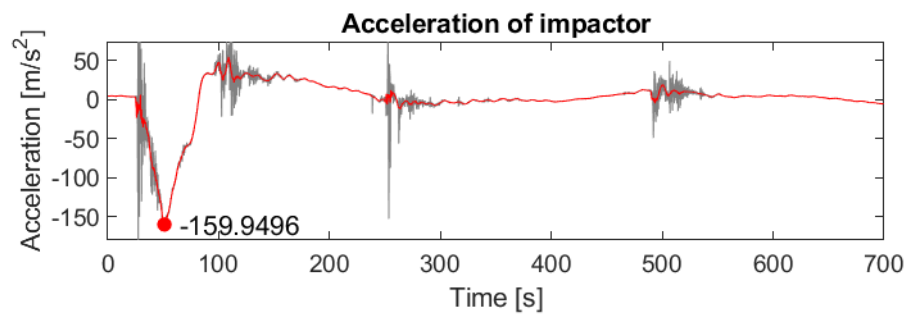
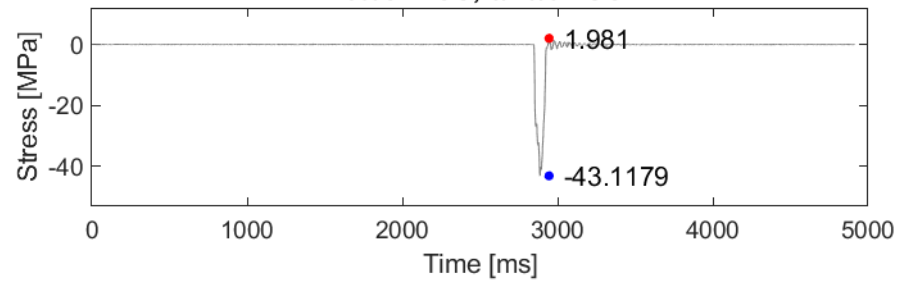
Data nr: 180
Glass: 5.16.5mm
Drop height: 300mm
Notes: "IGU, 5/16/5 ESG"



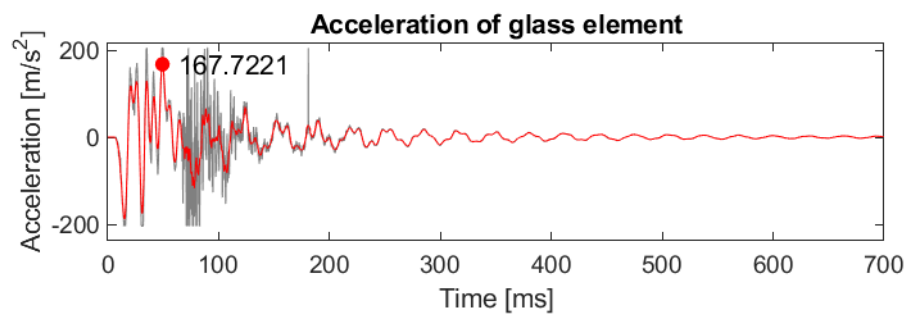
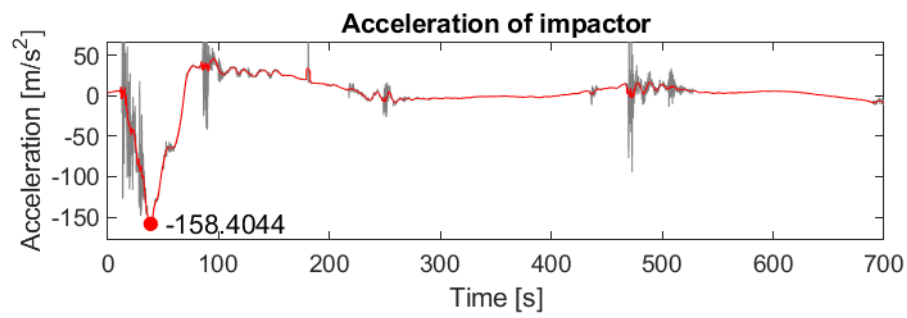
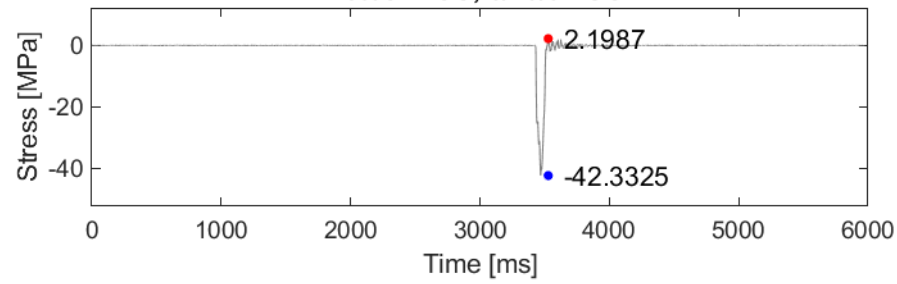
Data nr: 181
Glass: 5.16.5mm
Drop height: 400mm
Notes: "IGU, 5/16/5 ESG"

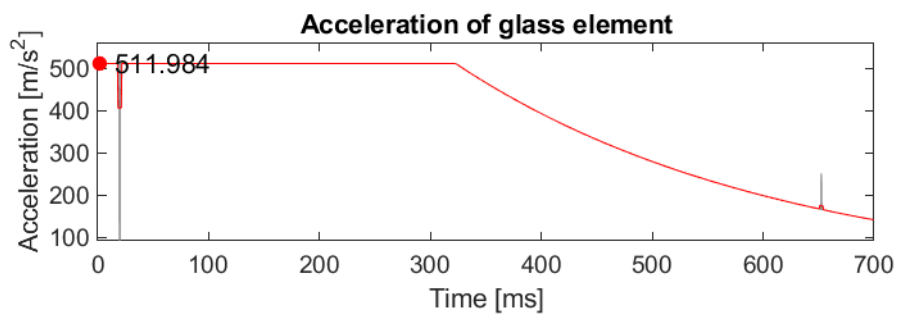
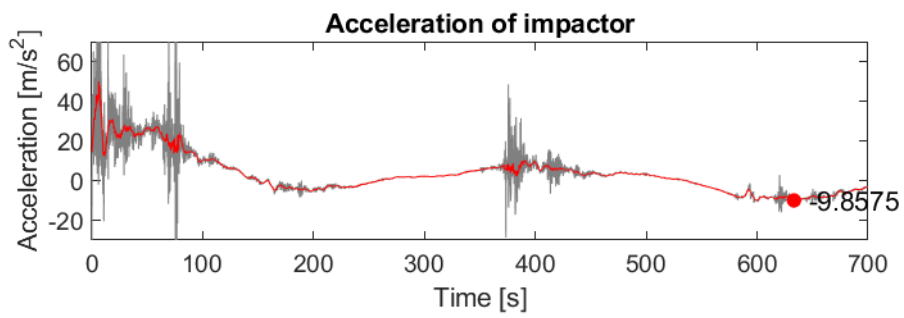
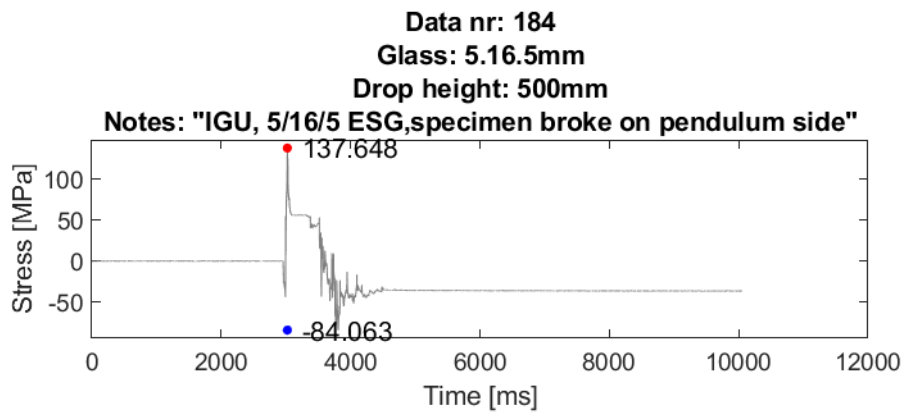


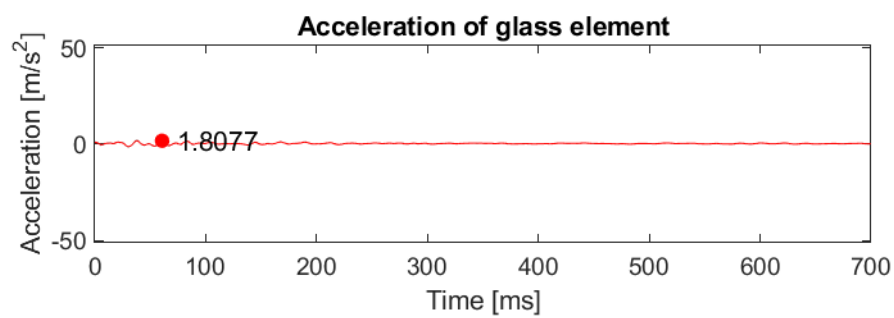
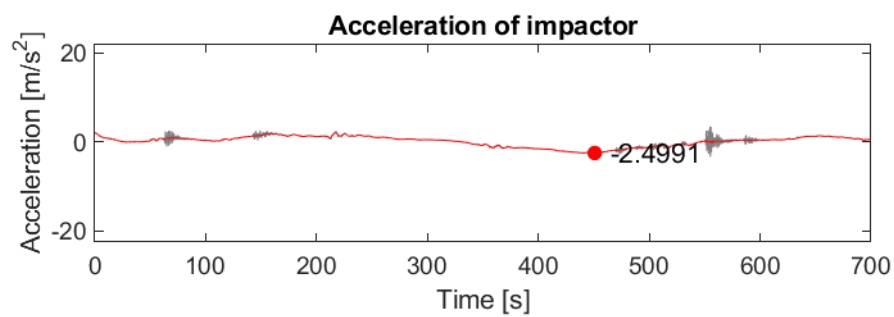
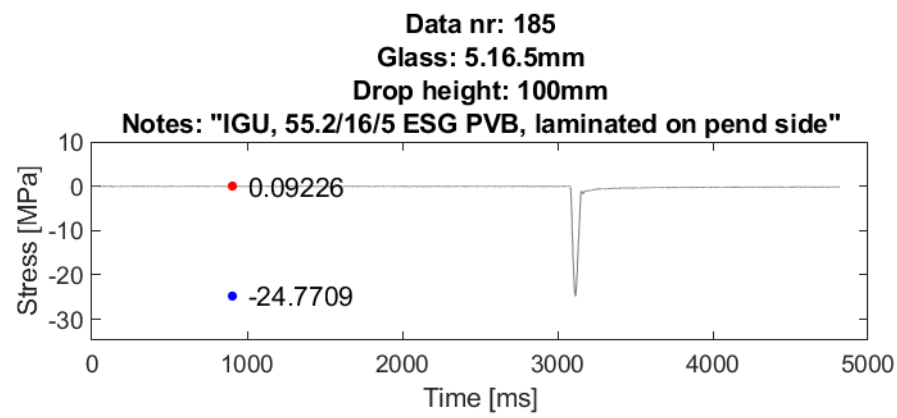
Data nr: 182
Glass: 5.16.5mm
Drop height: 400mm
Notes: "IGU, 5/16/5 ESG"

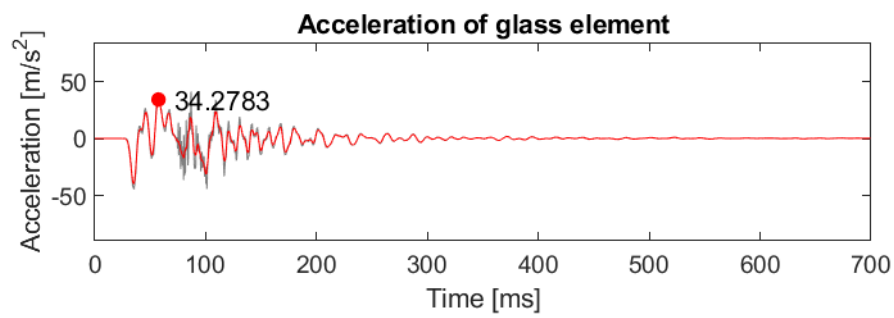
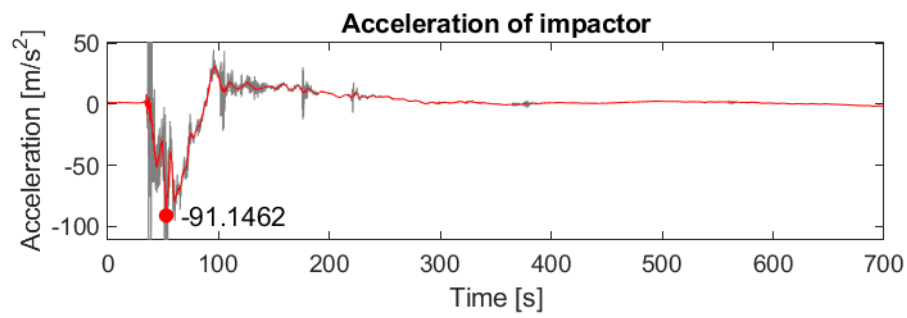
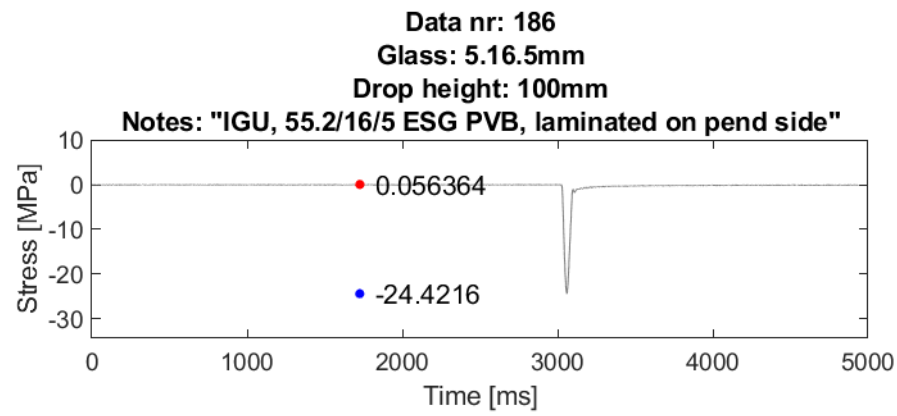


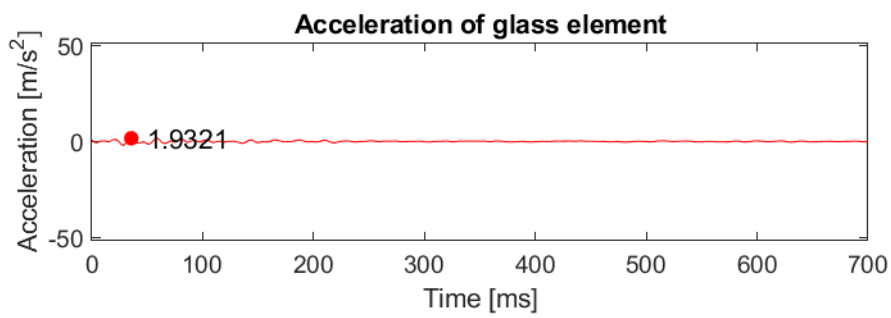
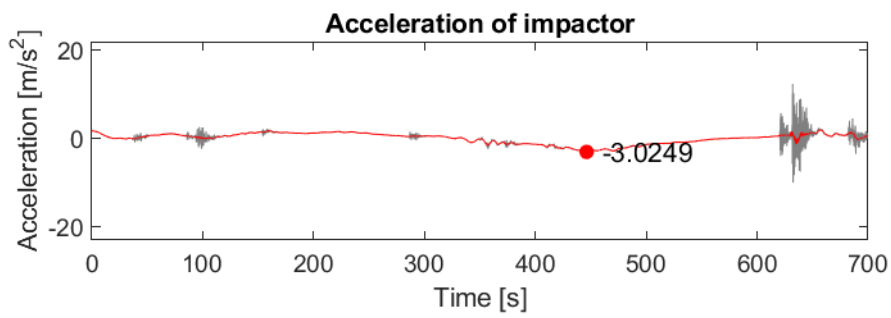
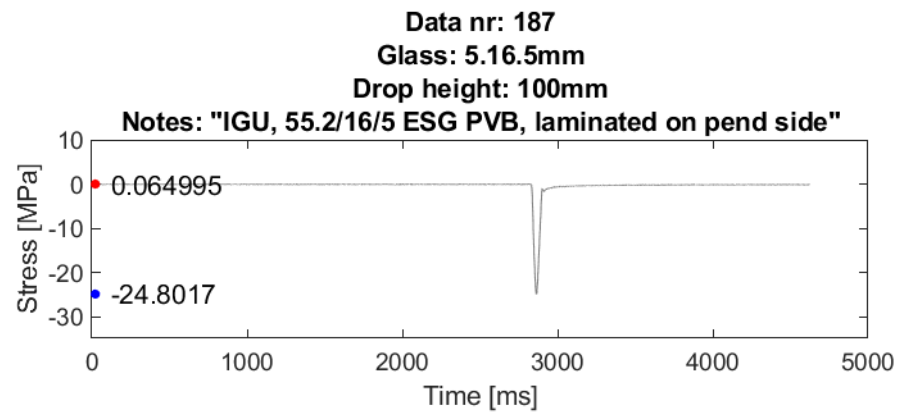
Data nr: 183
Glass: 5.16.5mm
Drop height: 400mm
Notes: "IGU, 5/16/5 ESG"

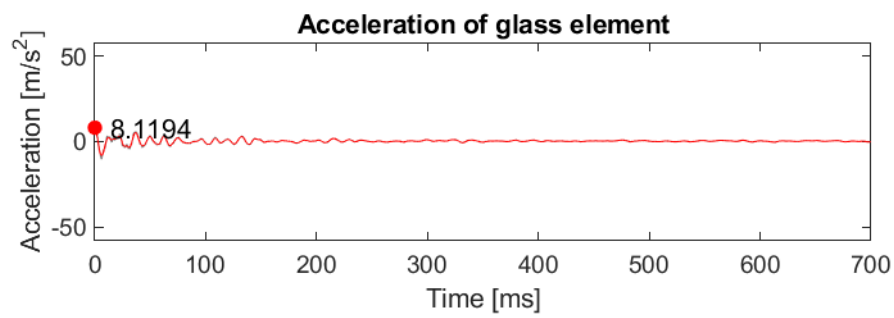
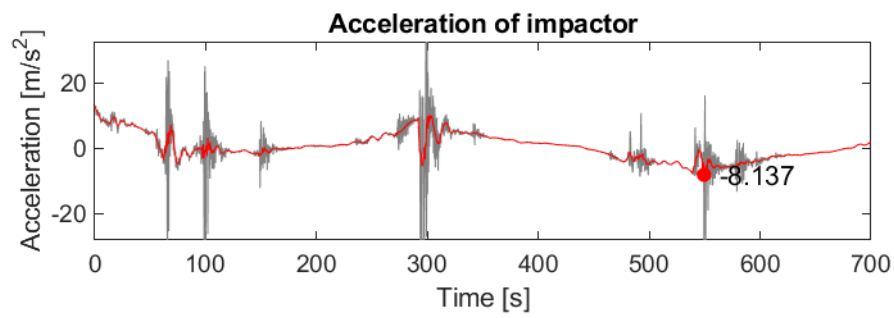
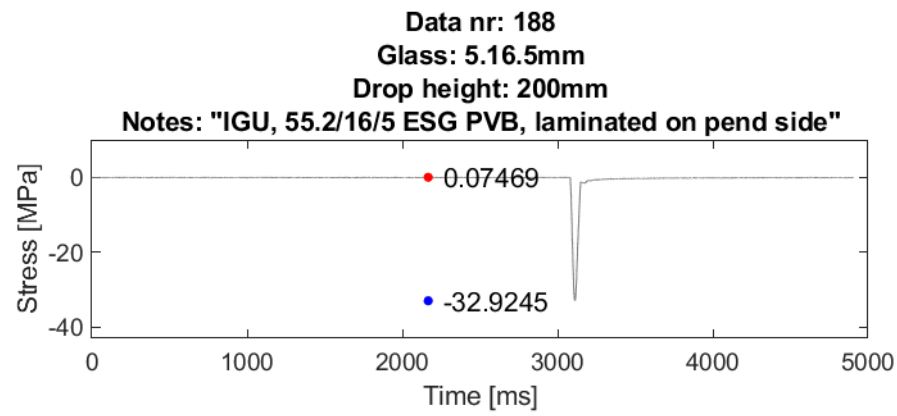


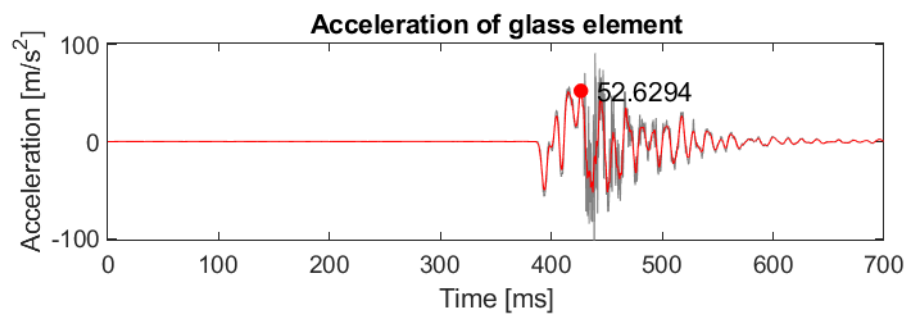
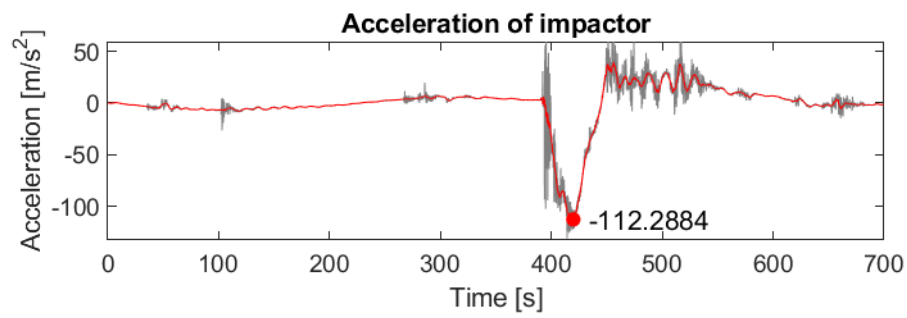
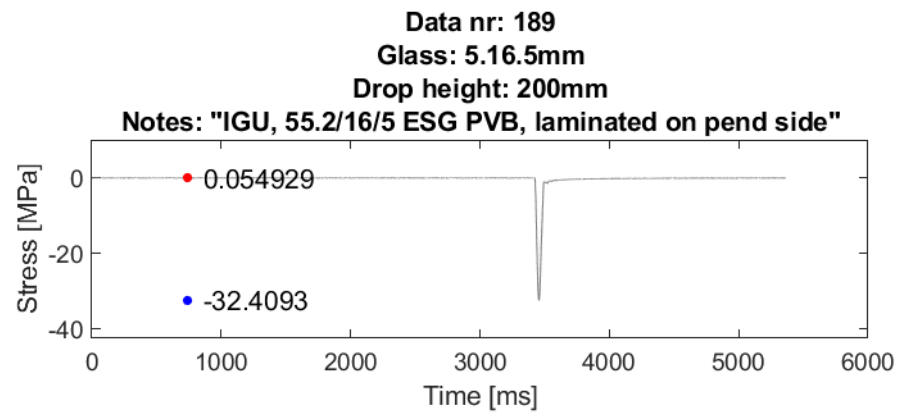


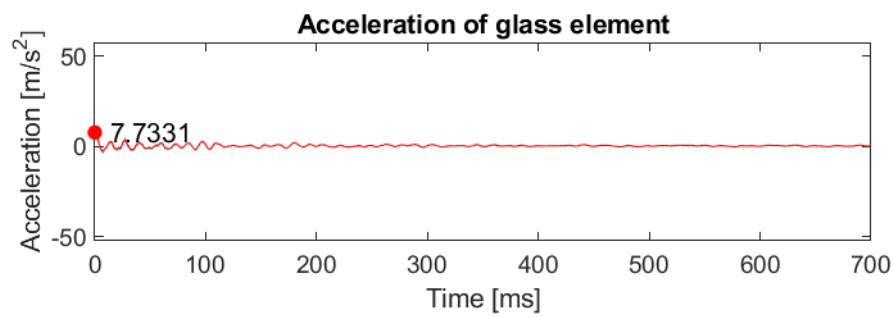
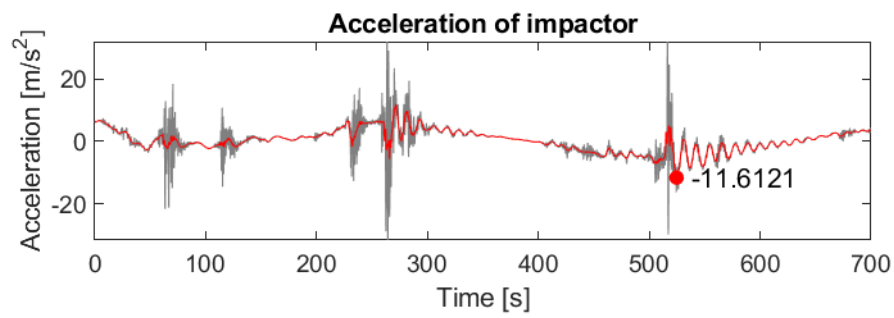
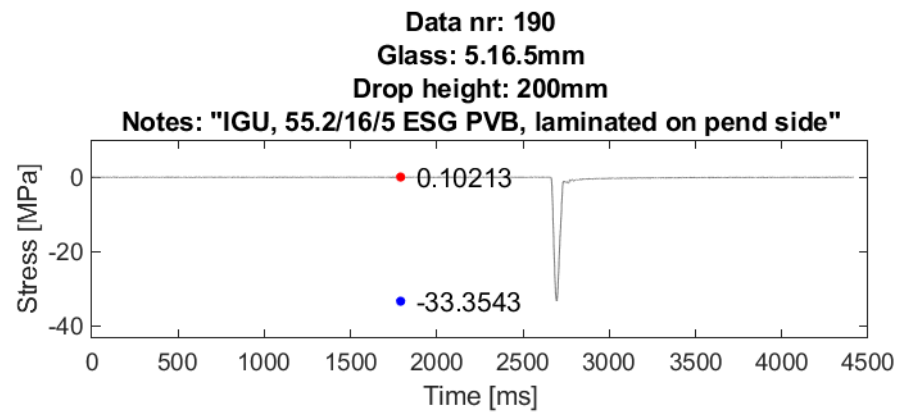


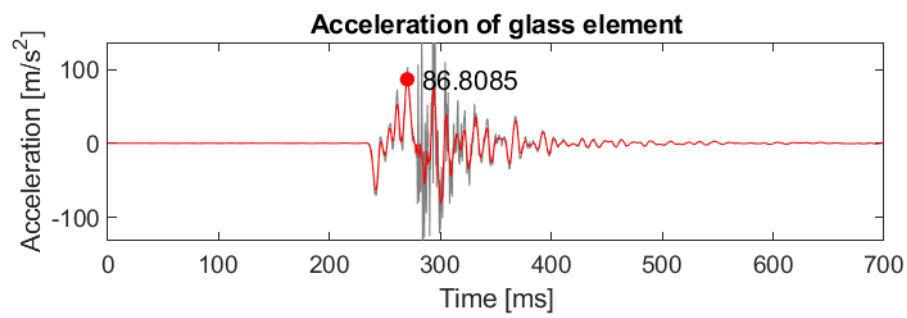
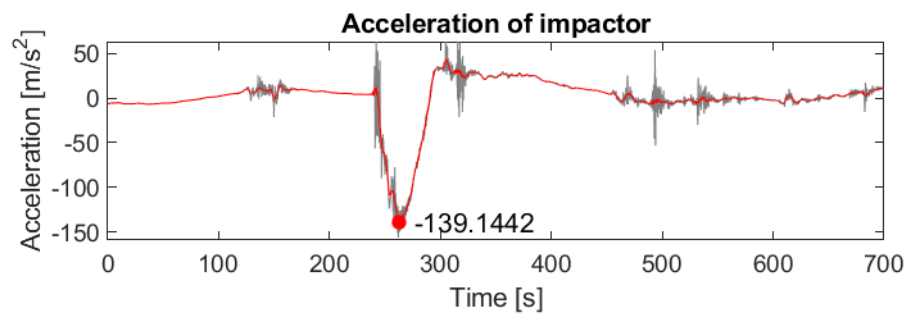
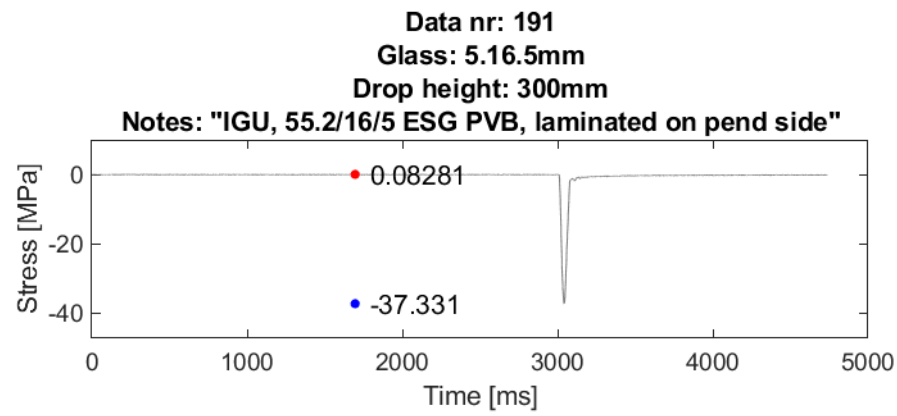


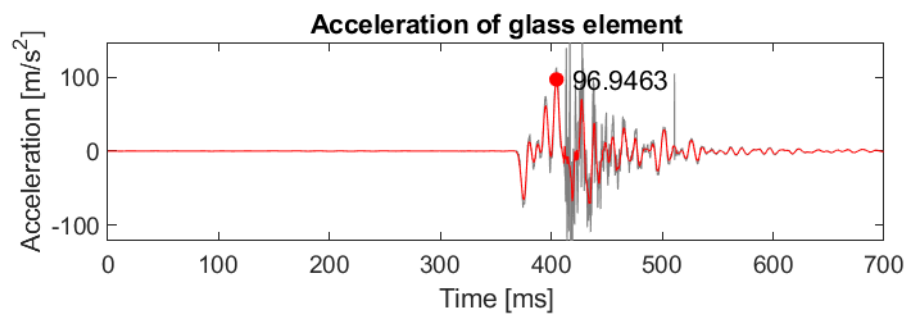
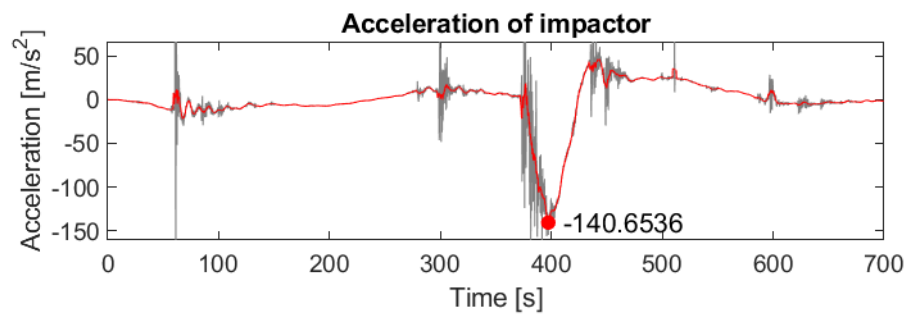
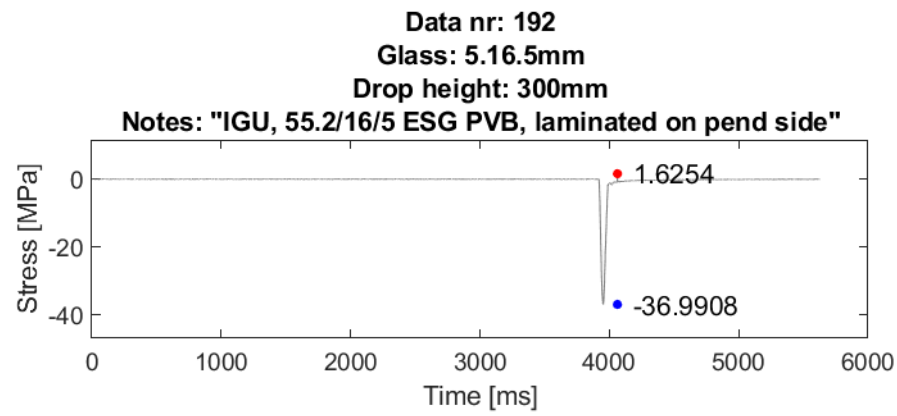


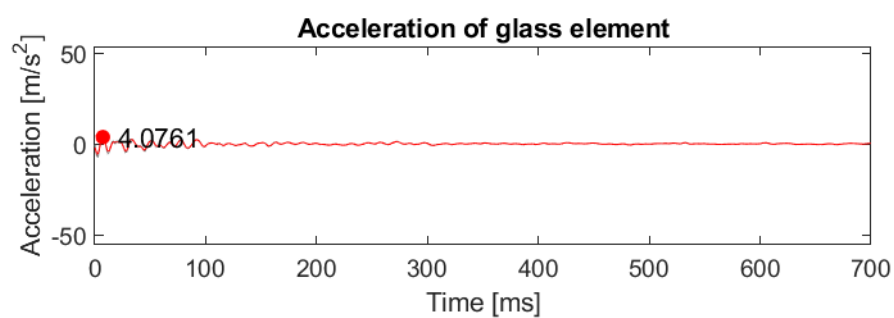
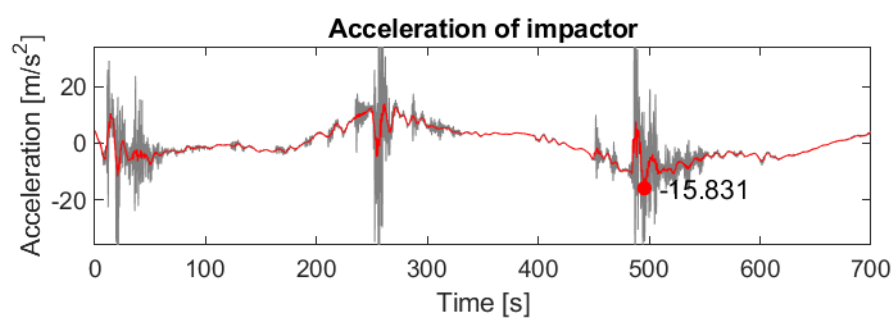
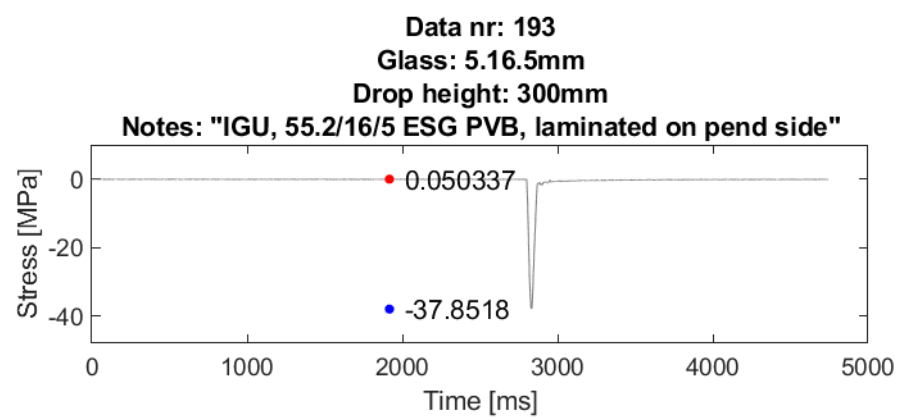


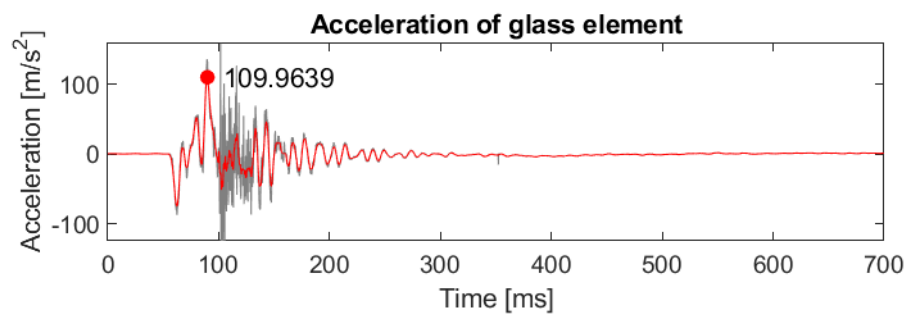
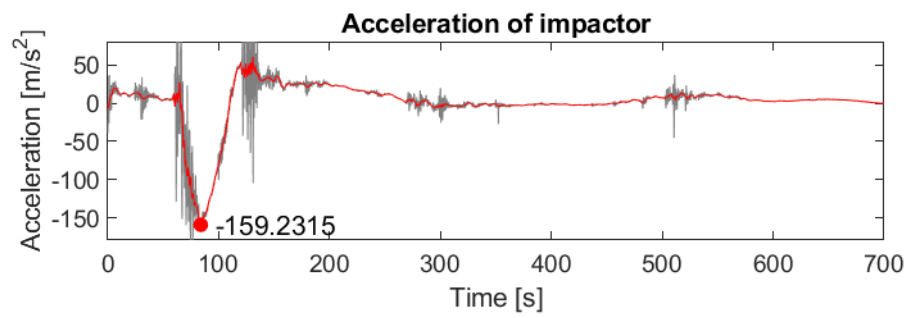
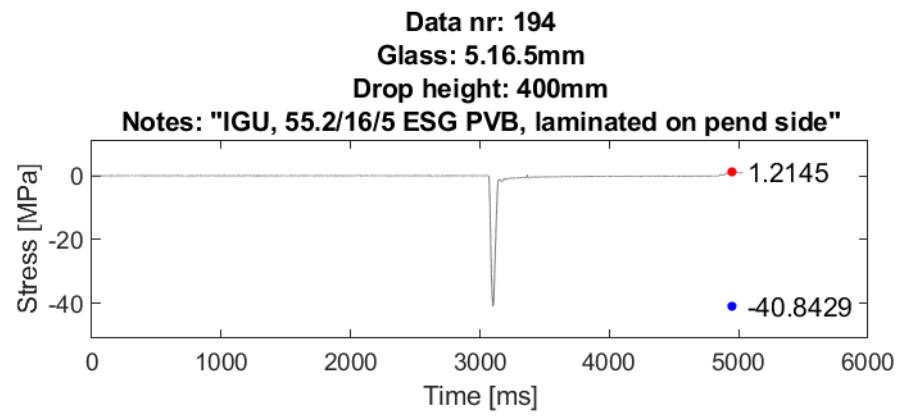


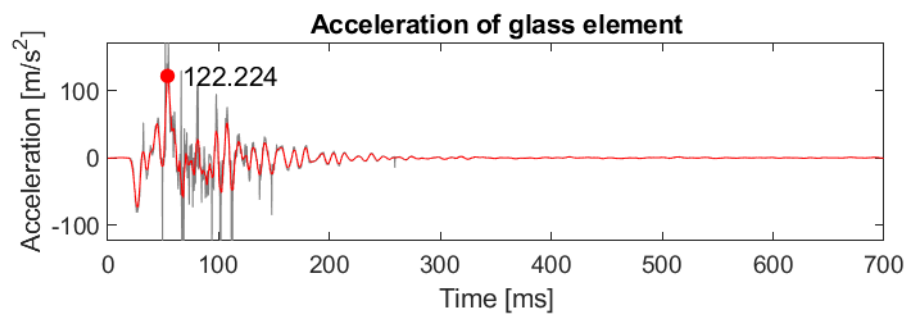
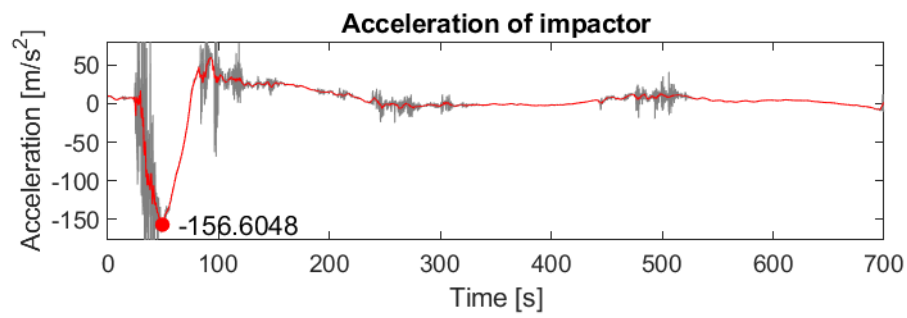
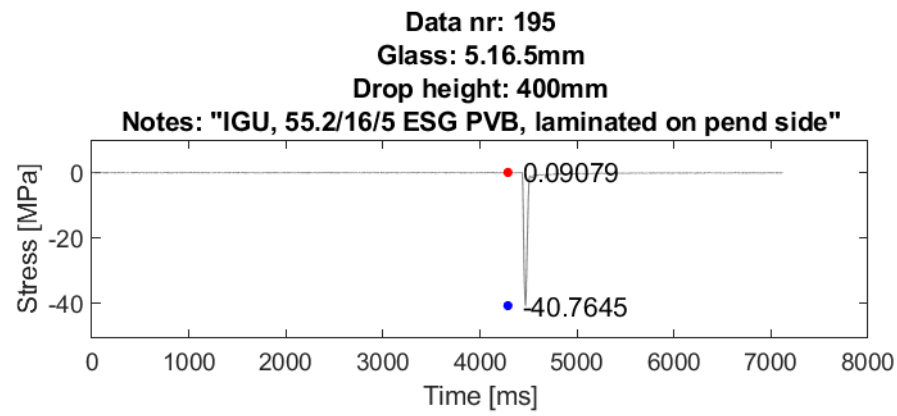


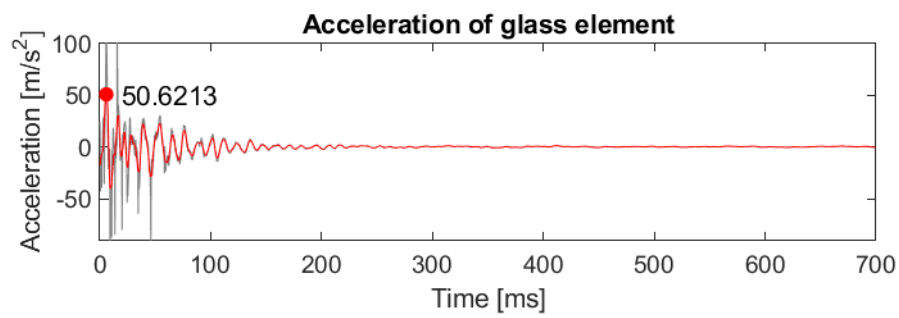
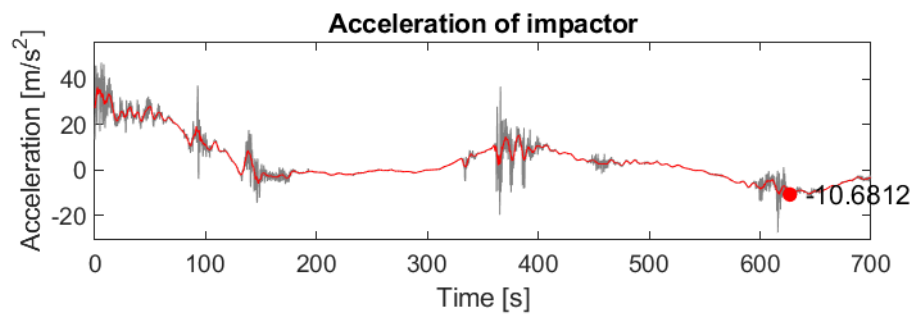
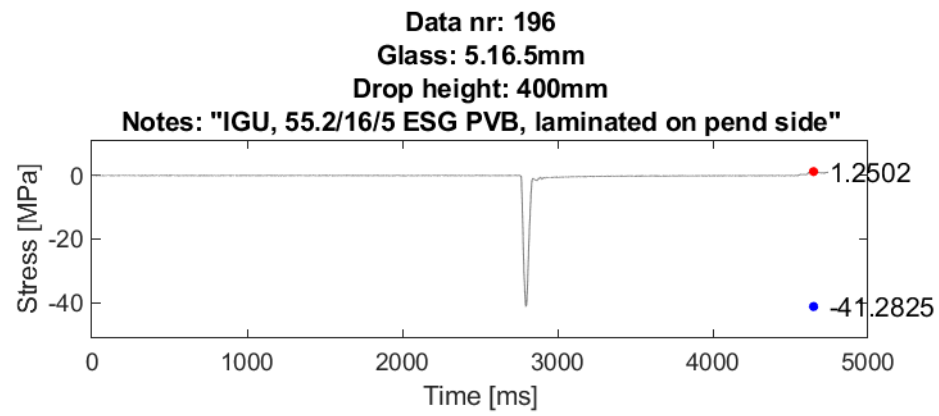


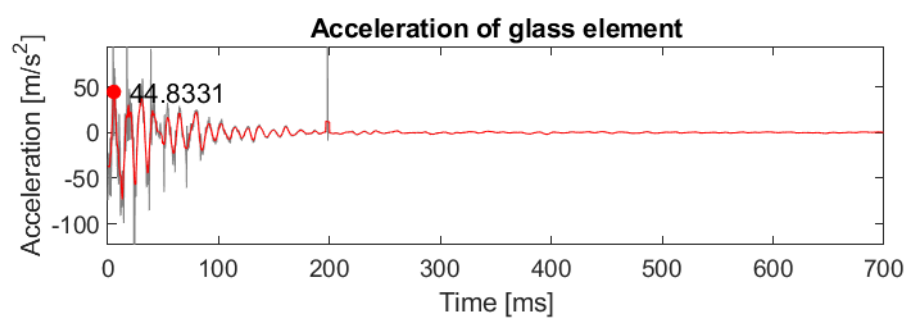
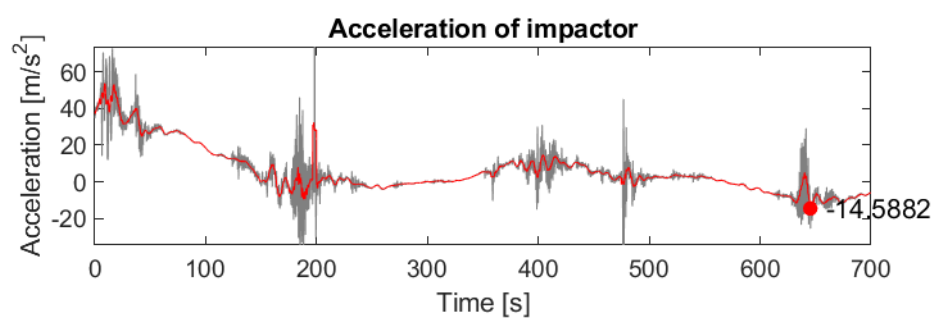
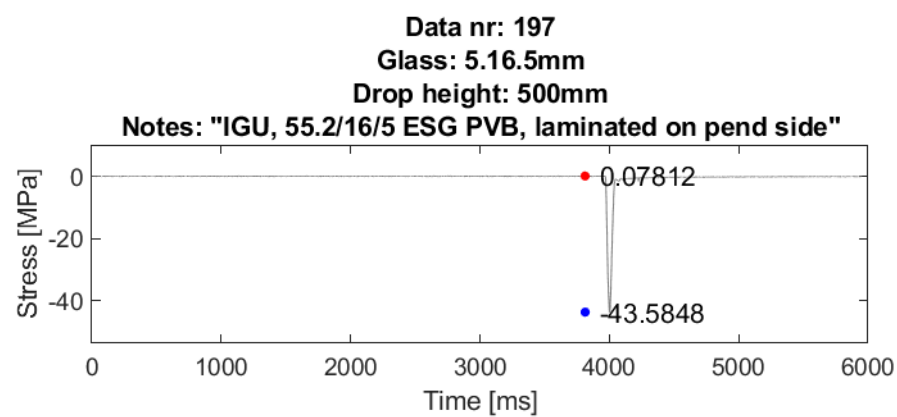


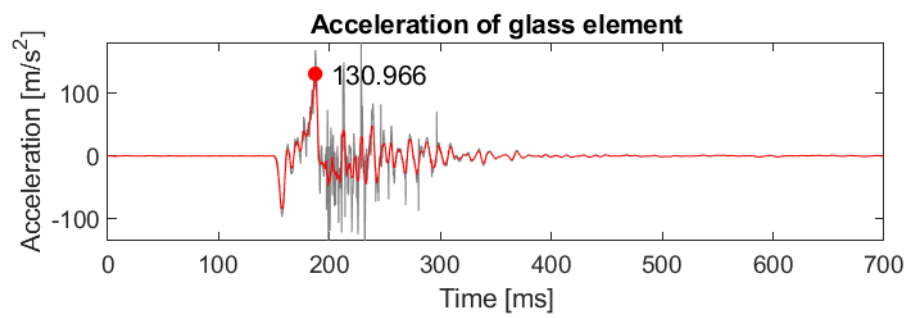
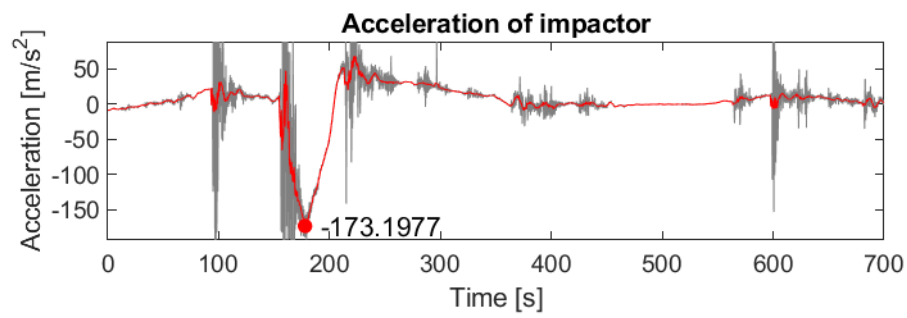
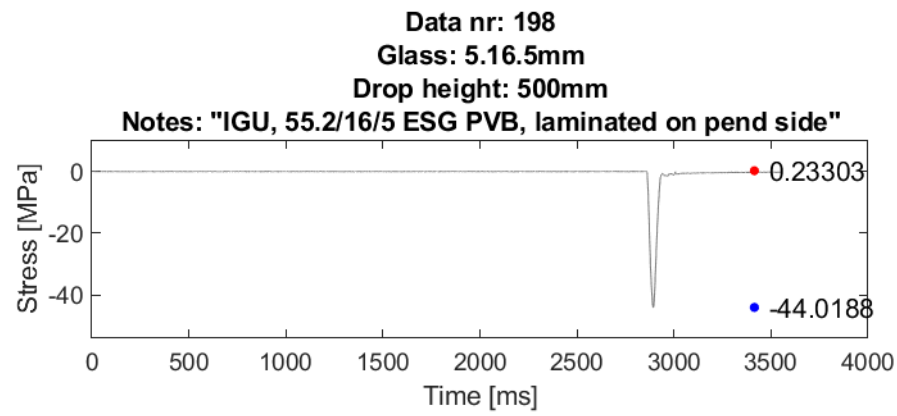


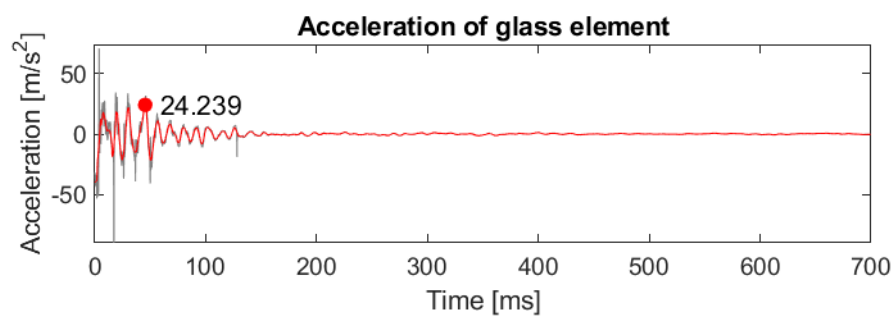
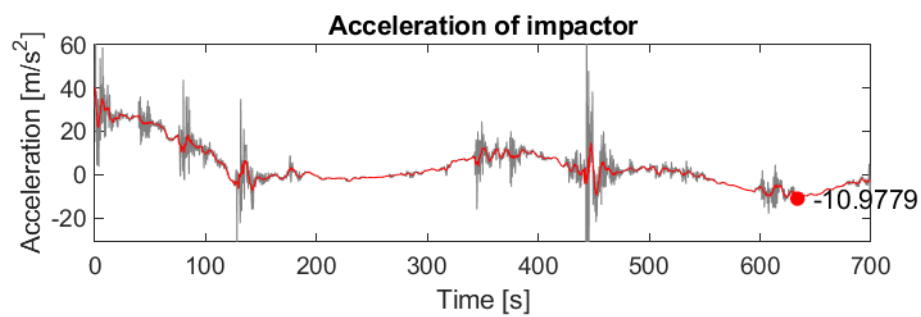
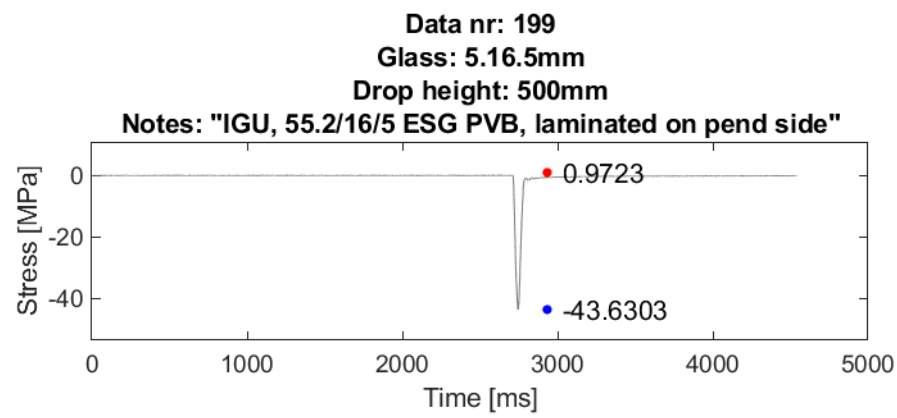




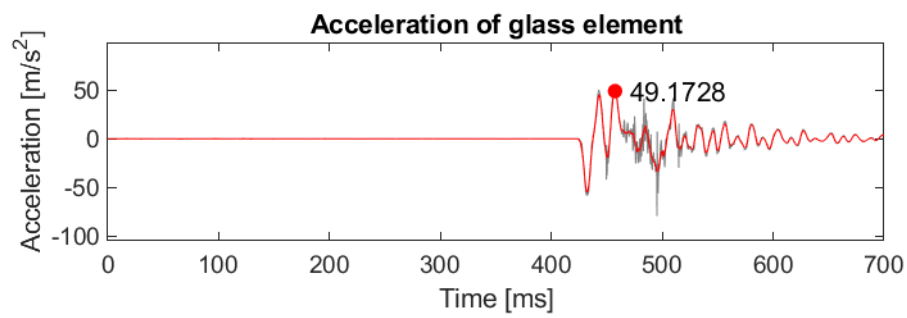
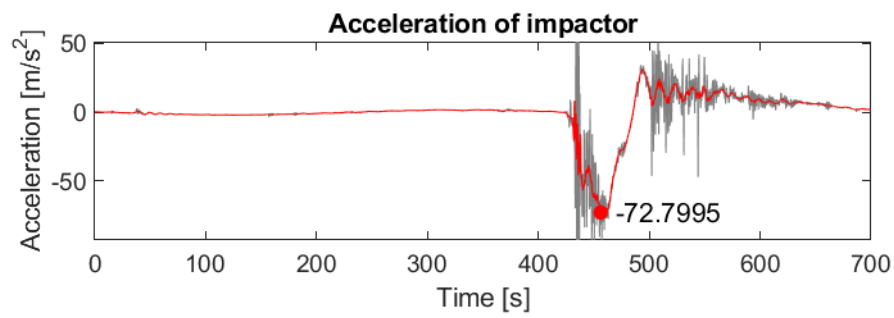
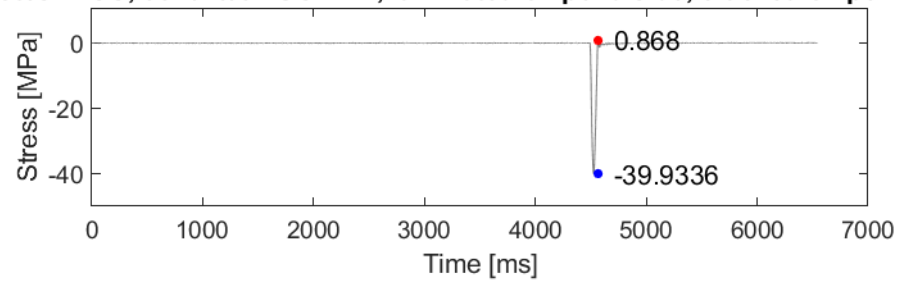




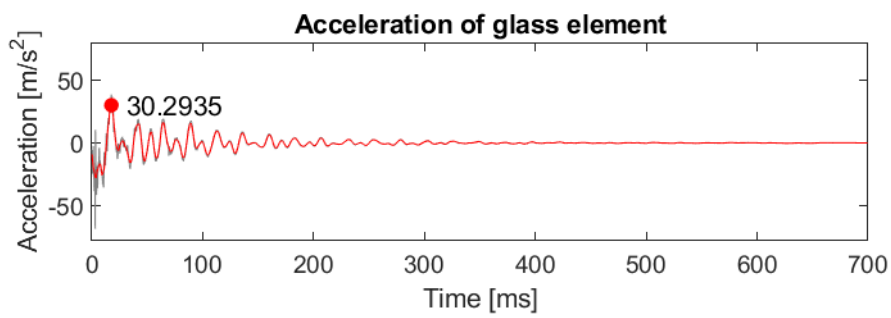
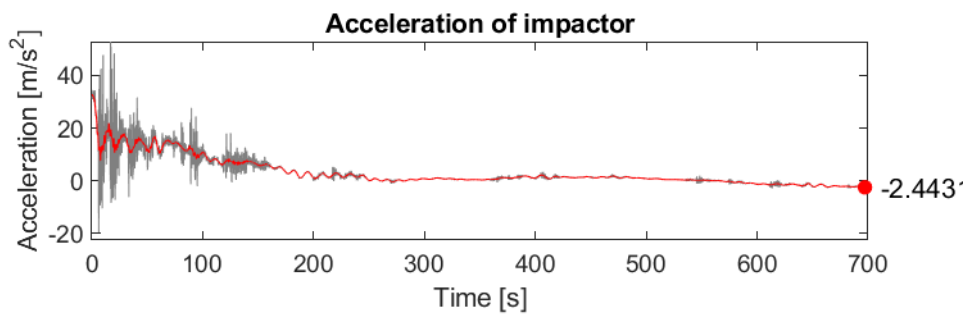
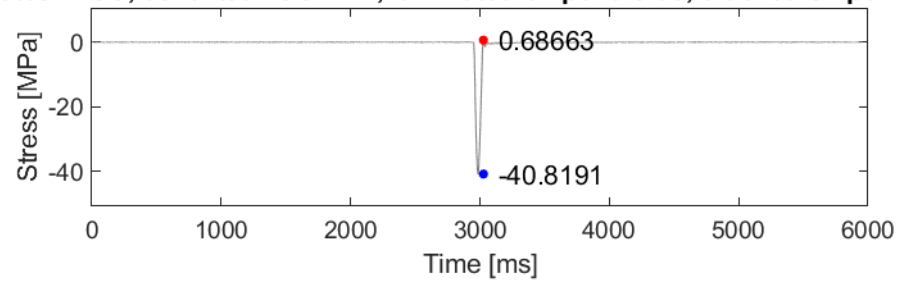




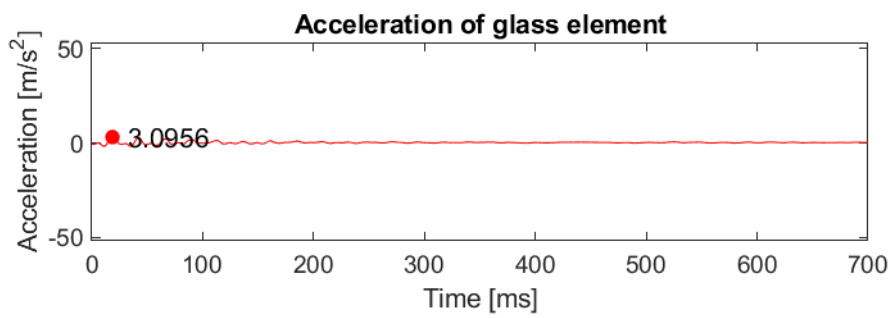
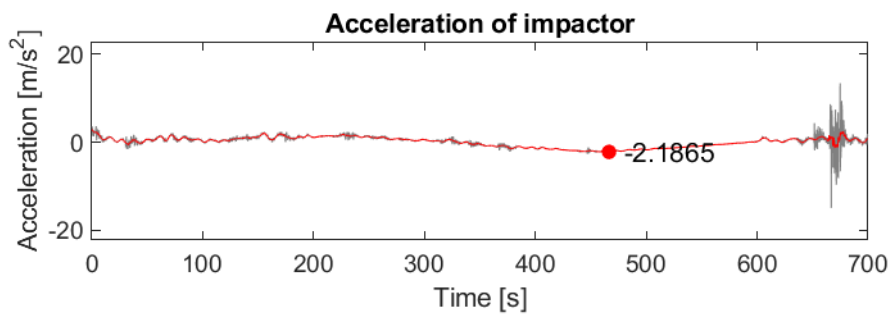
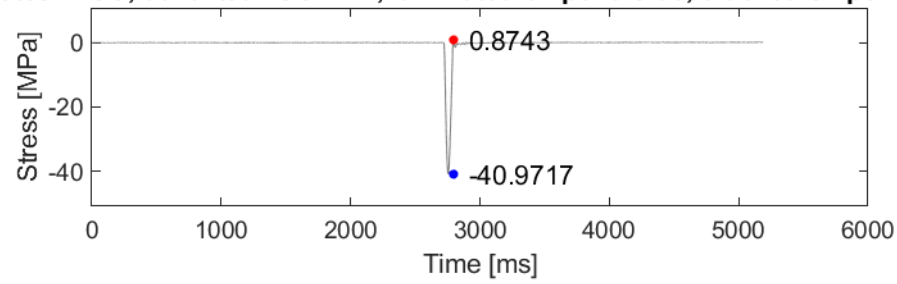
Data nr: 201
Glass: 5.16.5mm
Drop height: 100mm
Notes: "IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"

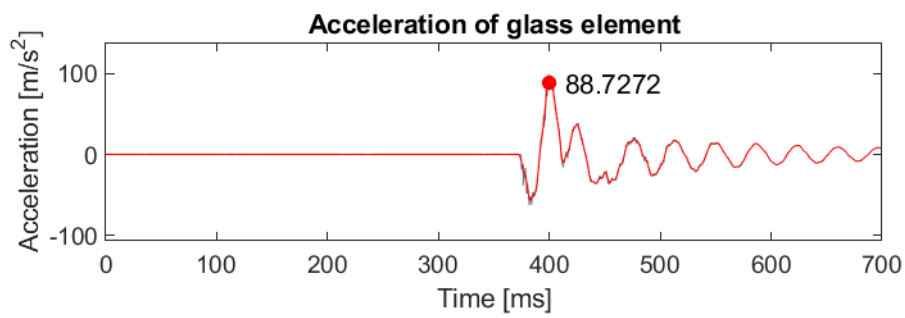
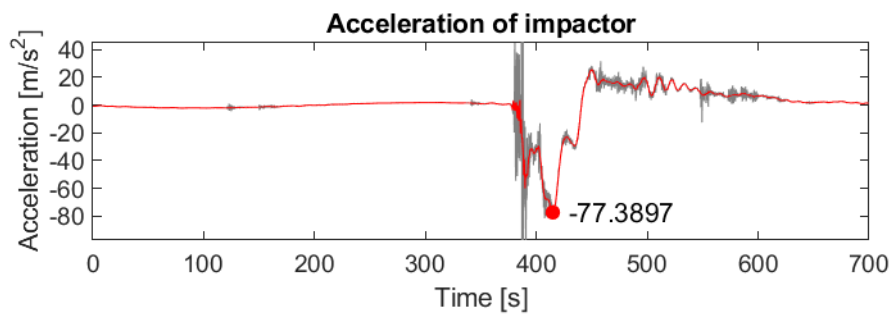
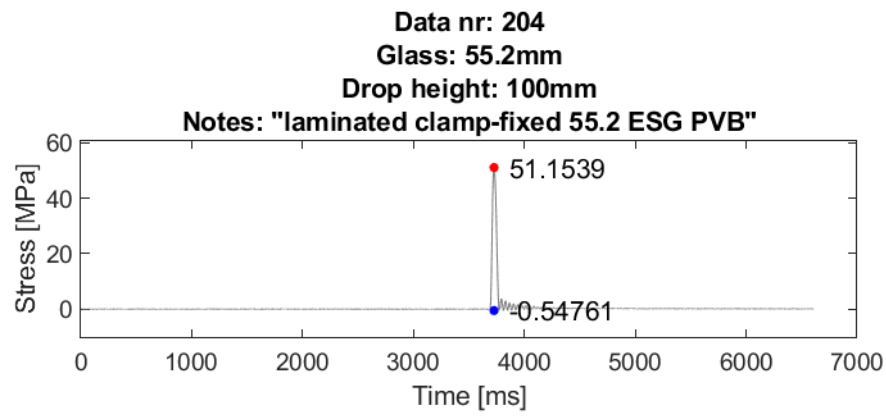


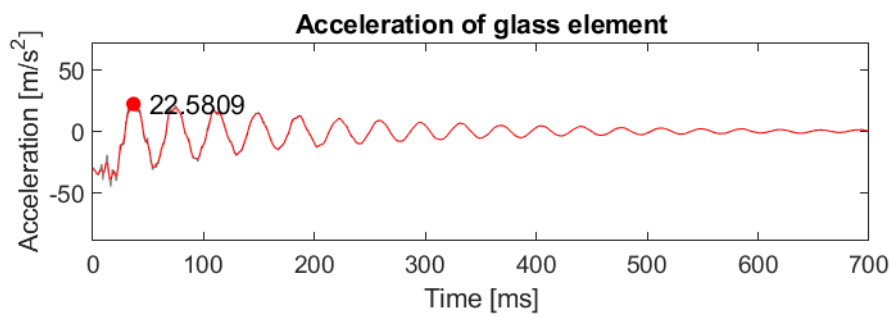
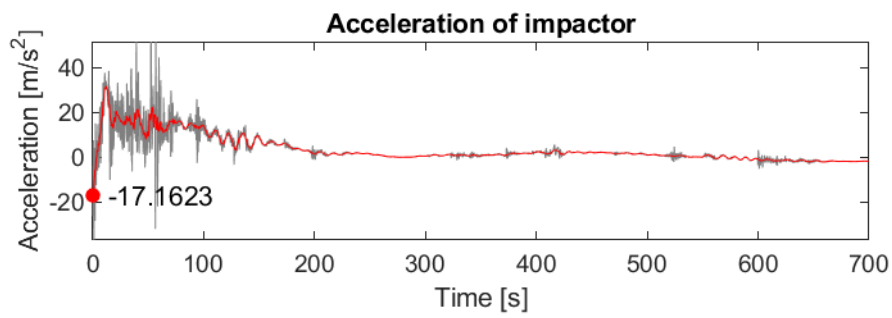
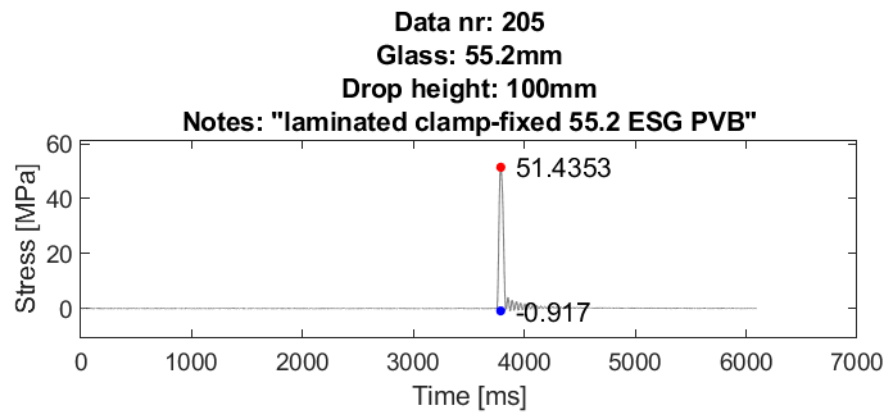
Data nr: 202
Glass: 5.16.5mm
Drop height: 200mm
Notes: "IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"

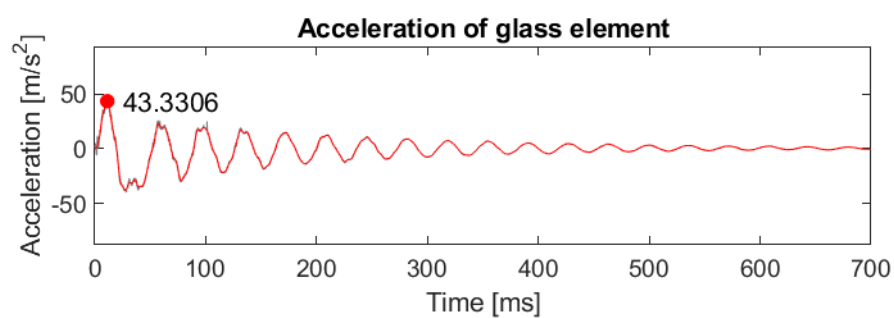
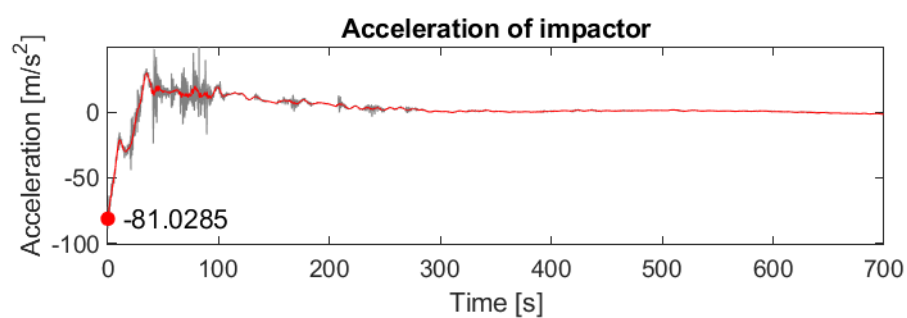
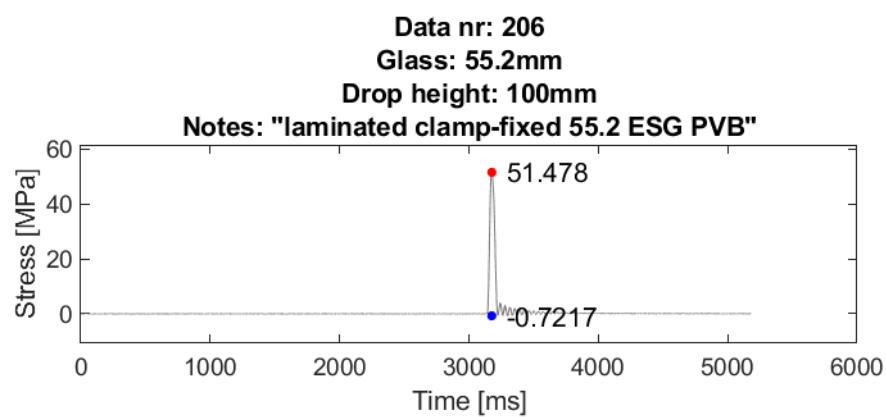


Data nr: 203
Glass: 5.16.5mm
Drop height: 300mm
Notes: "IGU, 55.2/16/5 ESG PVB, laminated on pend side, cracked on pend side"

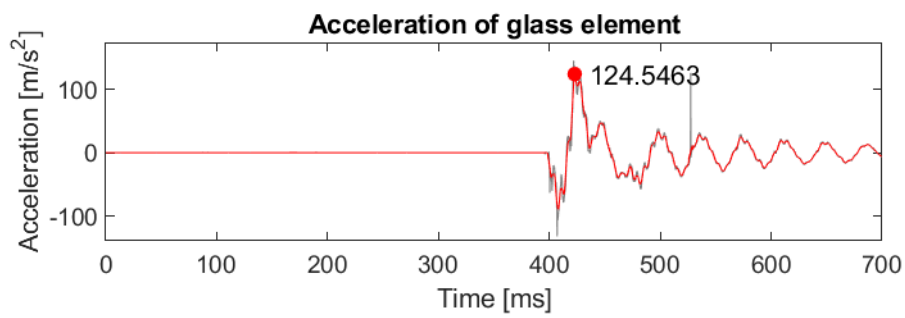
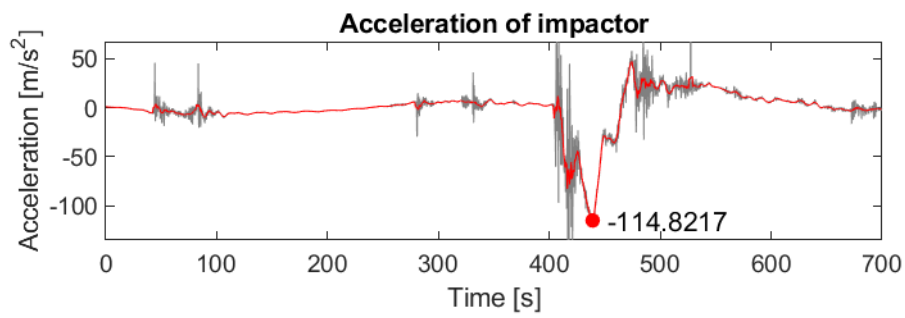
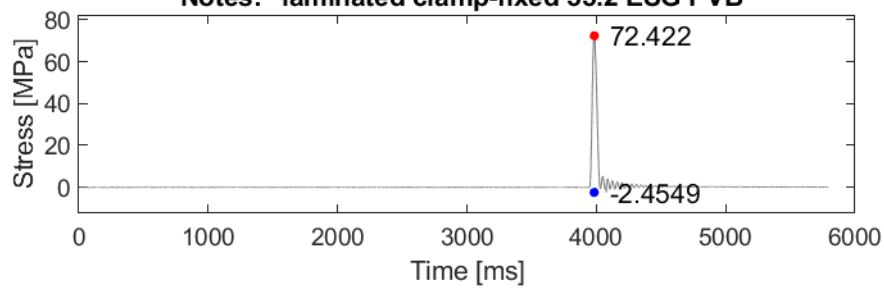




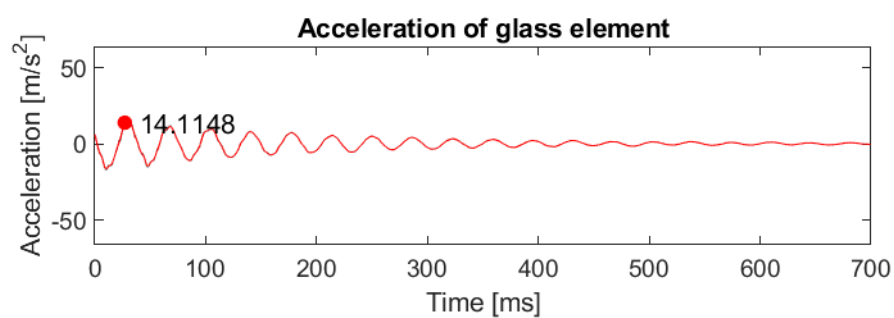
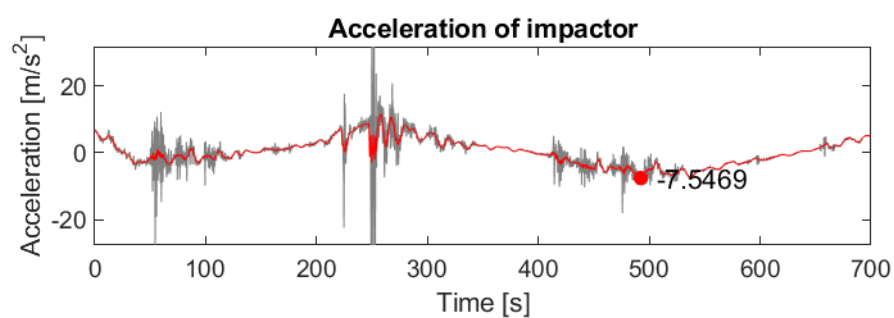
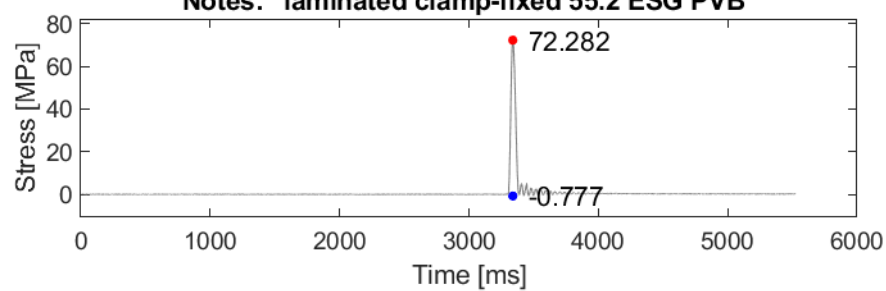


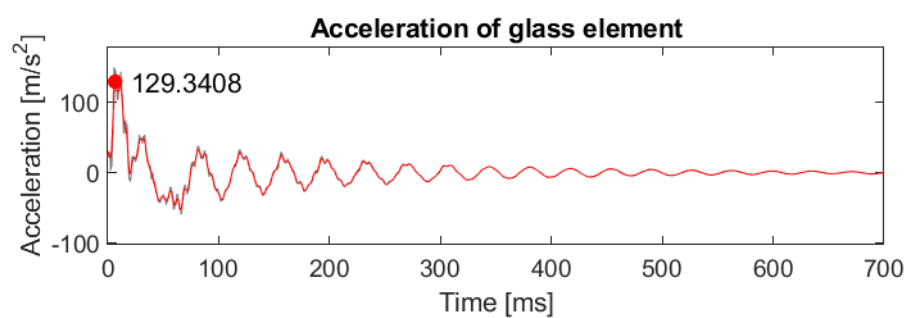
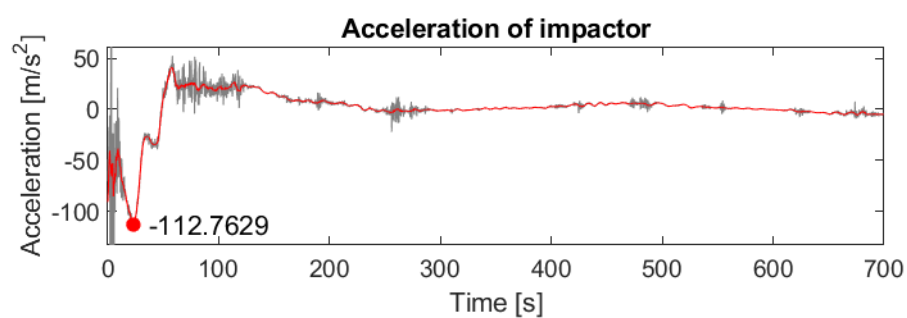
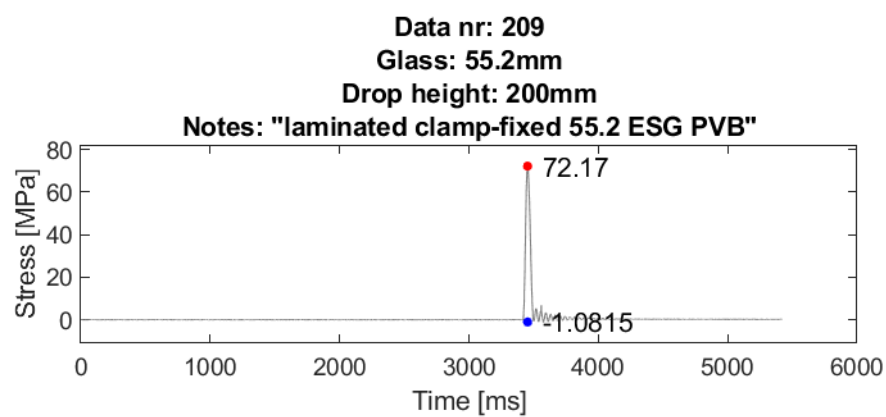


Data nr: 207
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"

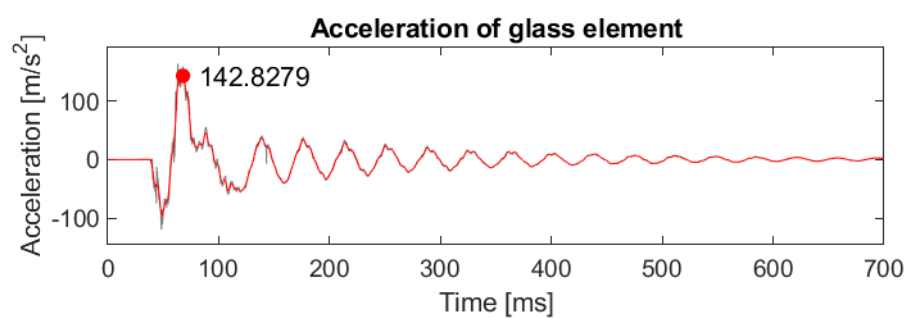
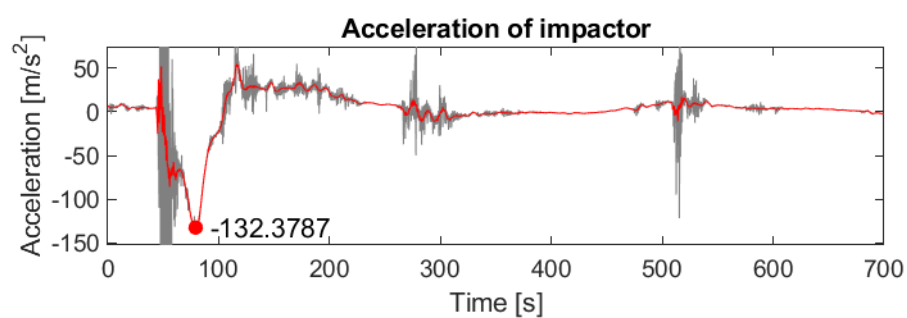
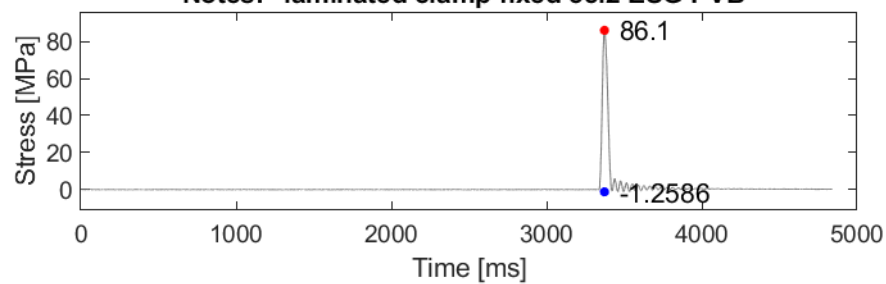


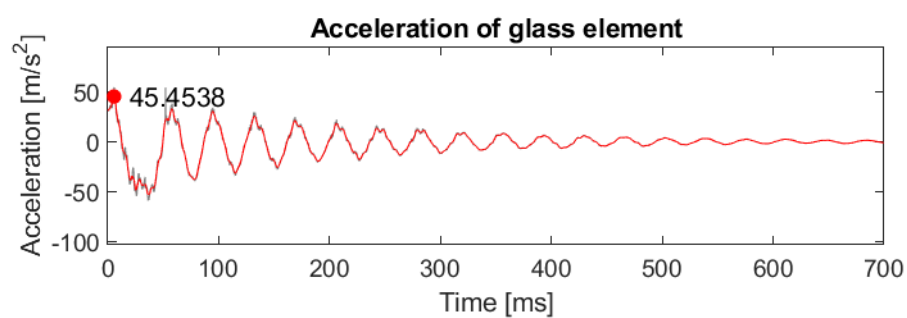
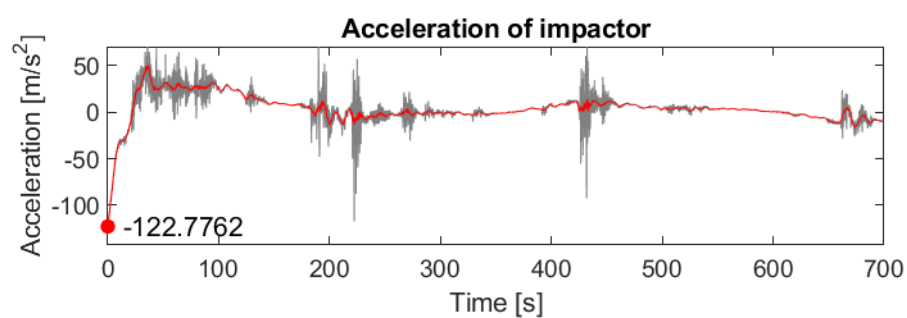
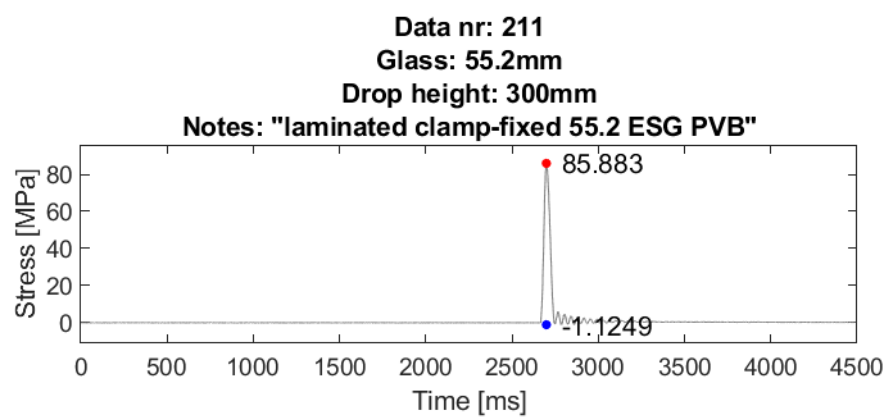
Data nr: 208
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



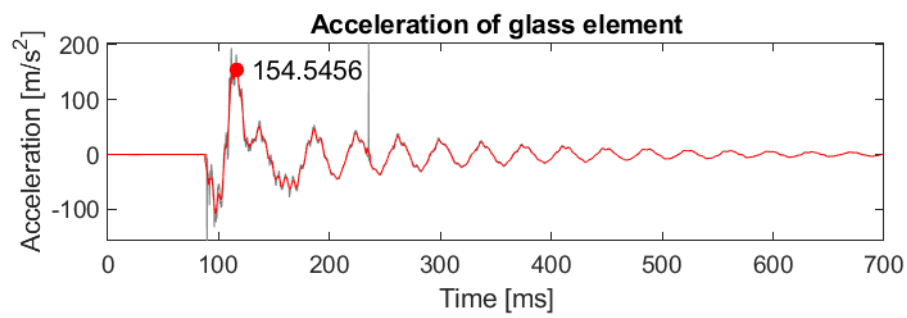
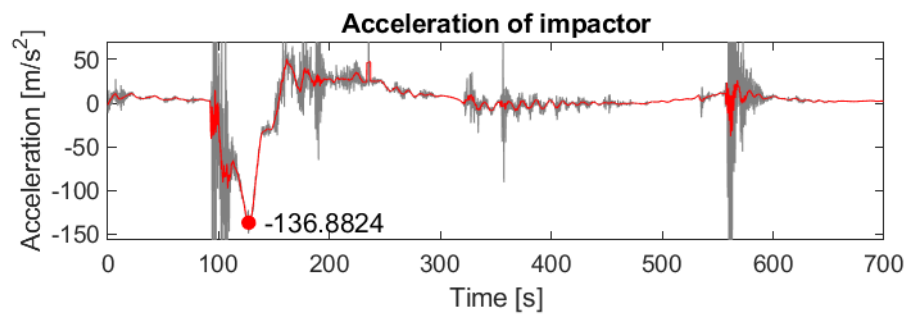
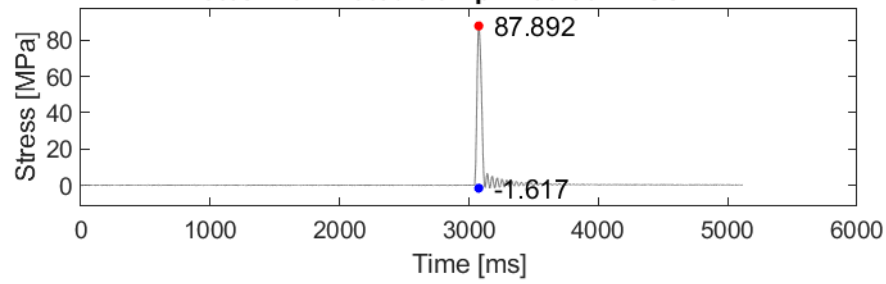


Data nr: 210
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"

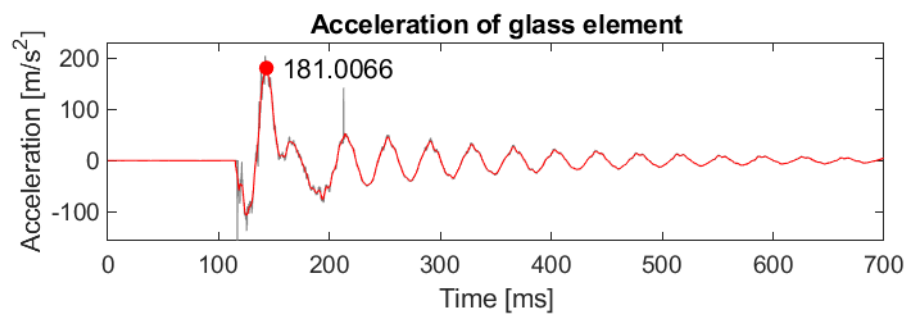
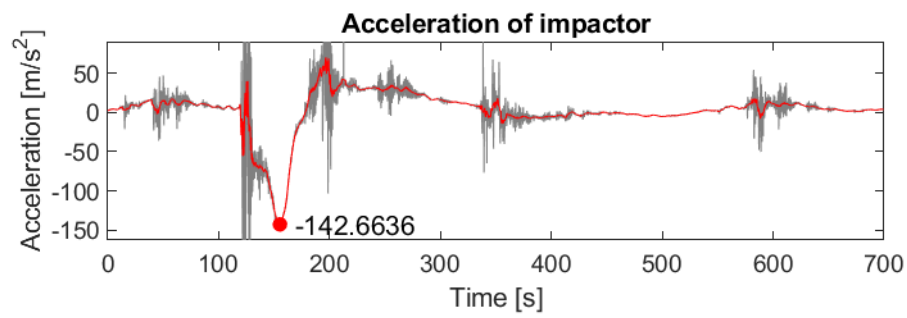
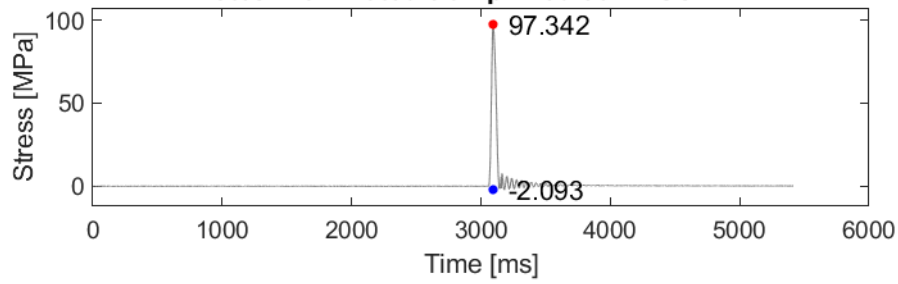




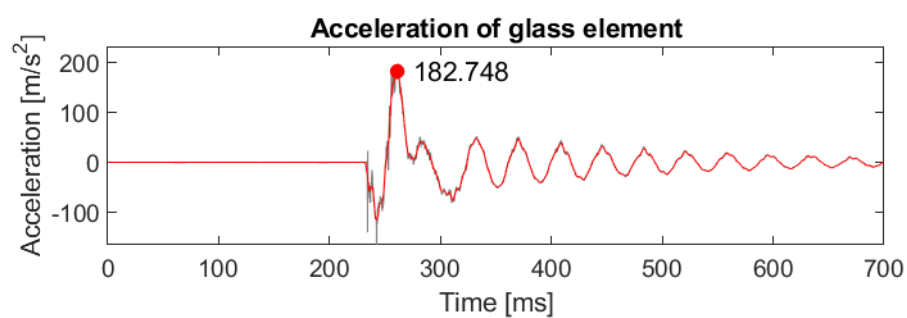
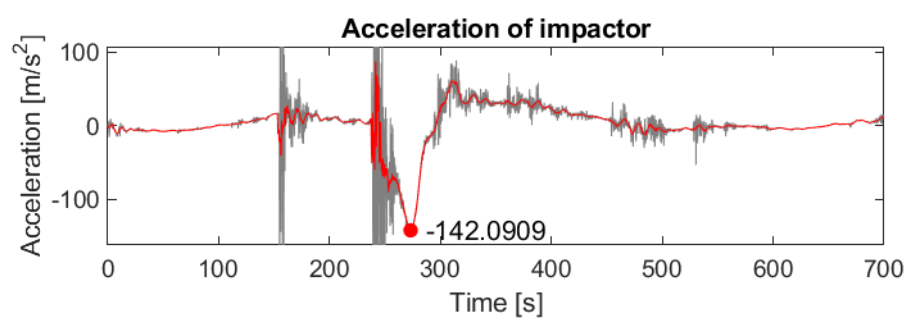
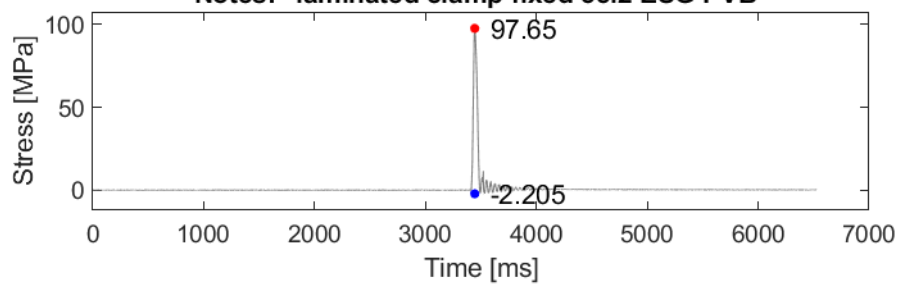
Data nr: 212
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



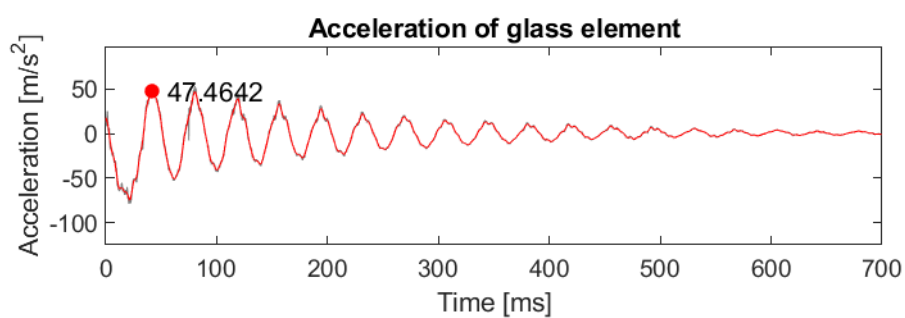
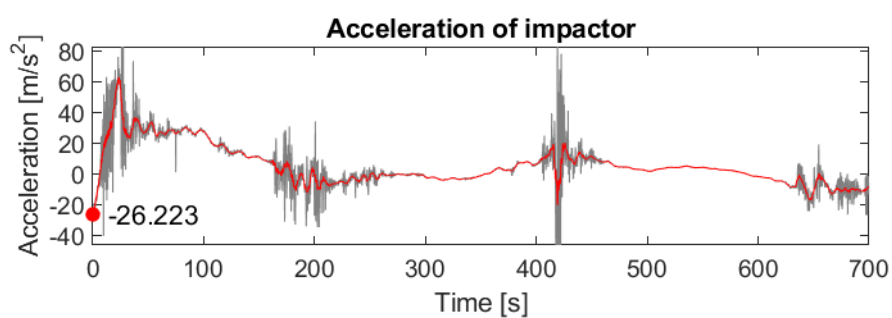
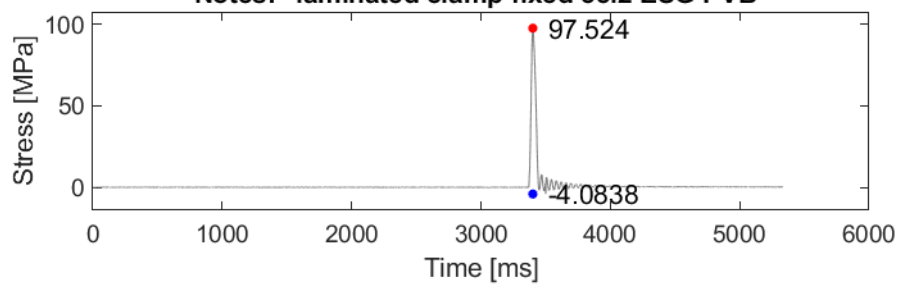
Data nr: 213
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



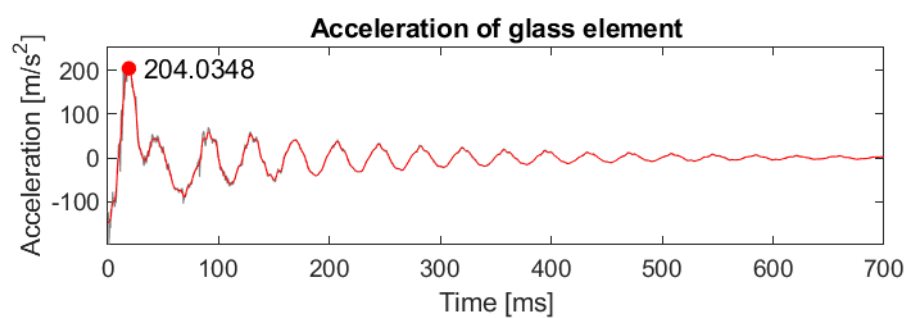
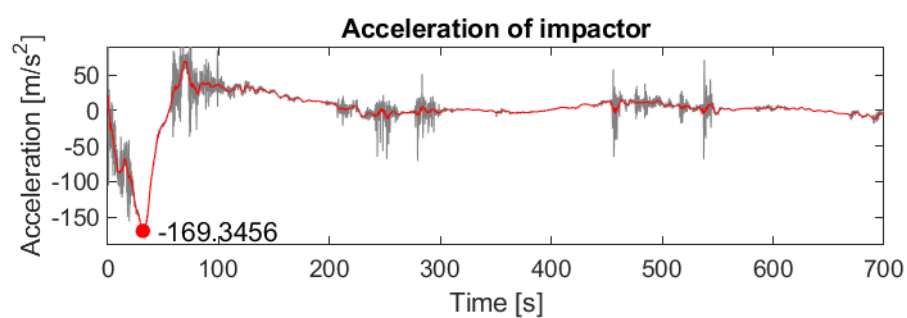
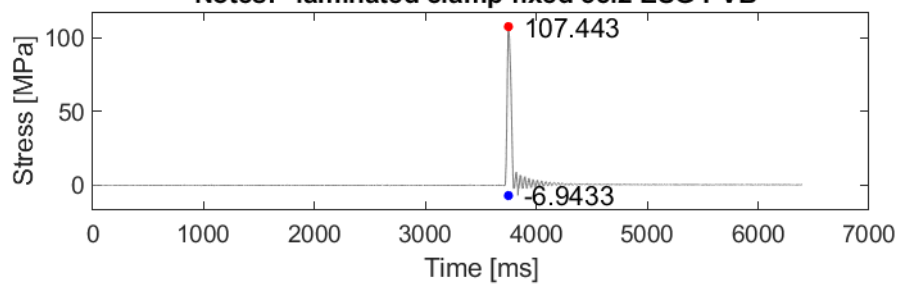
Data nr: 214
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



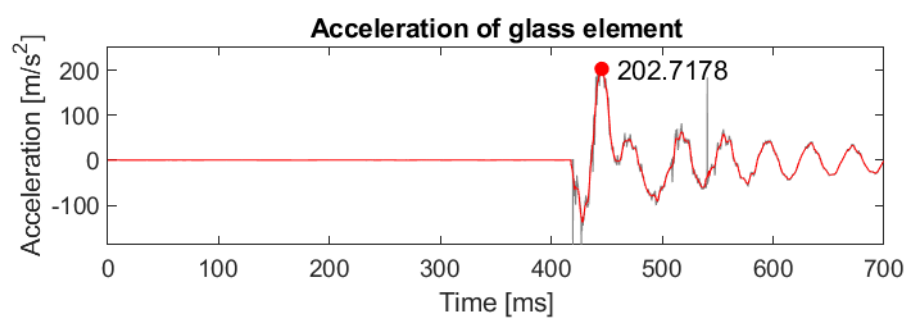
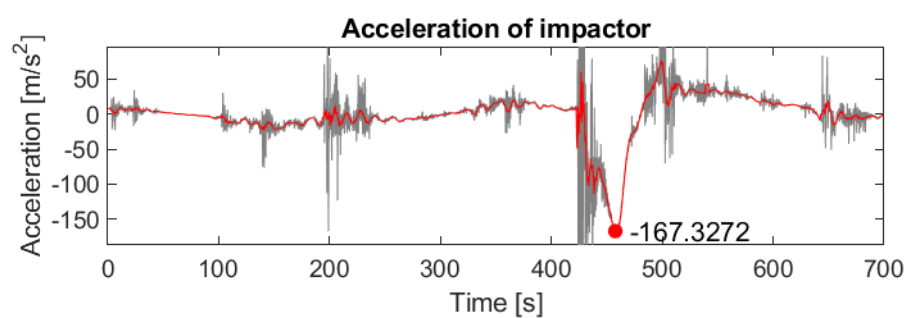
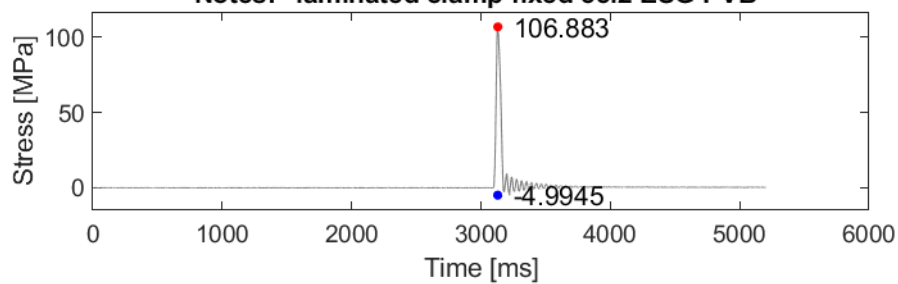
Data nr: 215
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



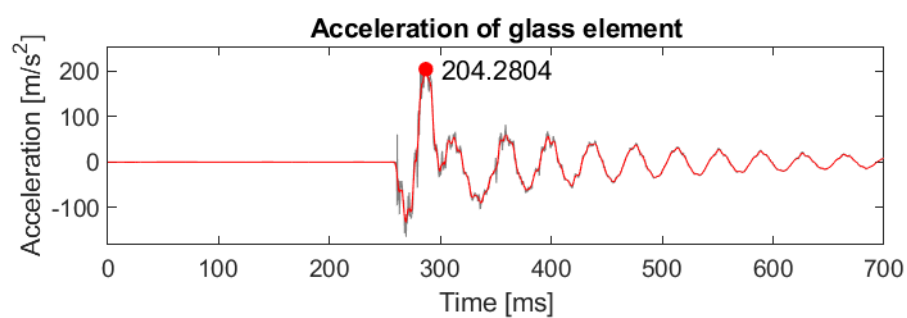
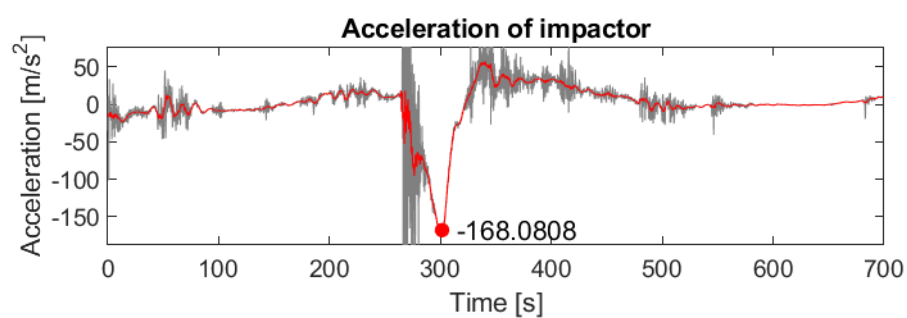
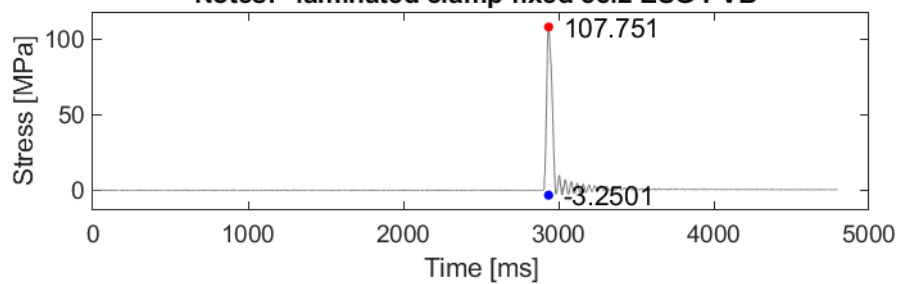
Data nr: 216
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



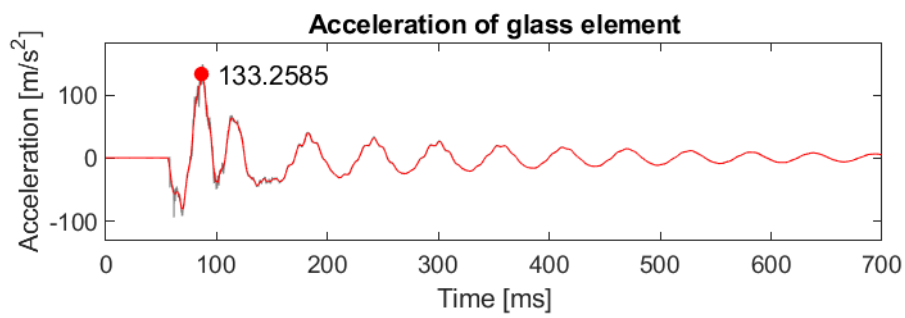
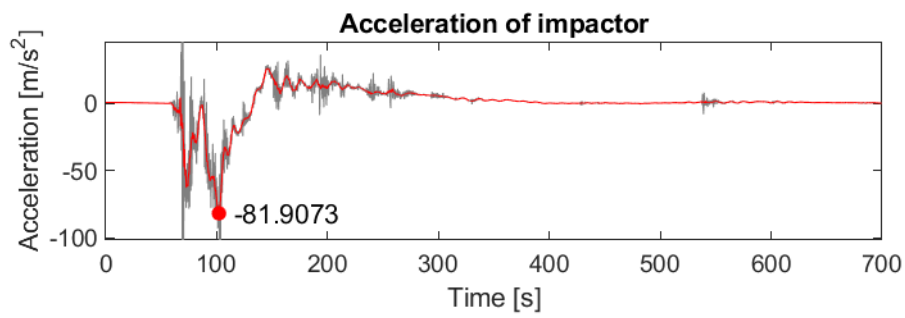
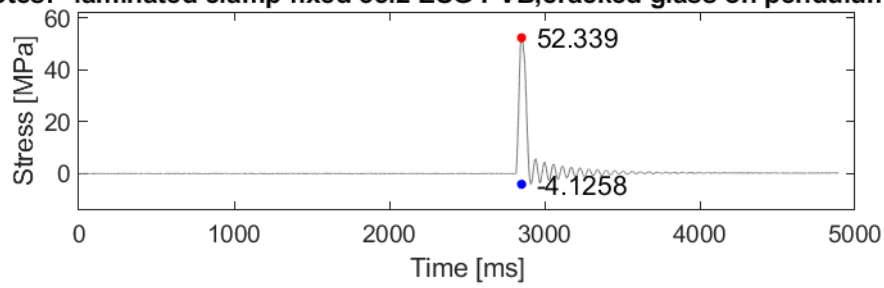
Data nr: 217
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



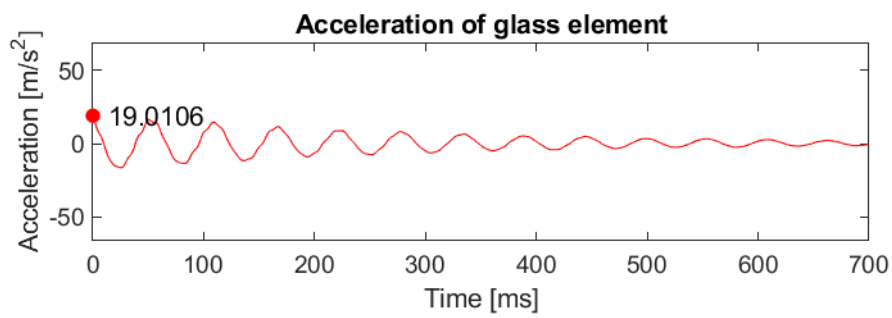
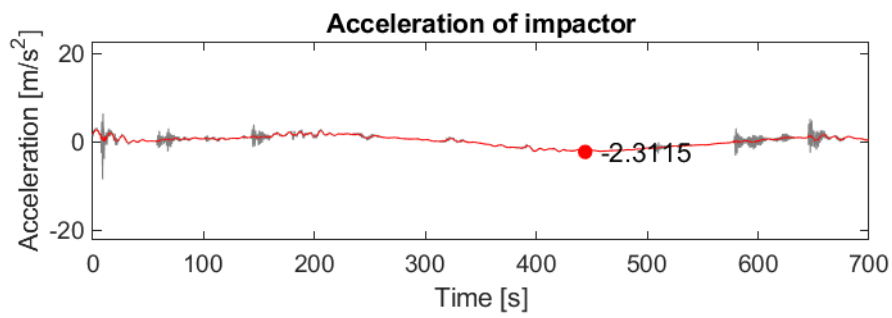
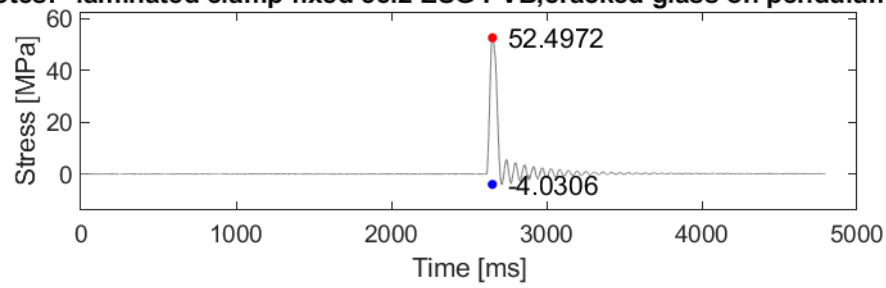
Data nr: 218
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 55.2 ESG PVB"



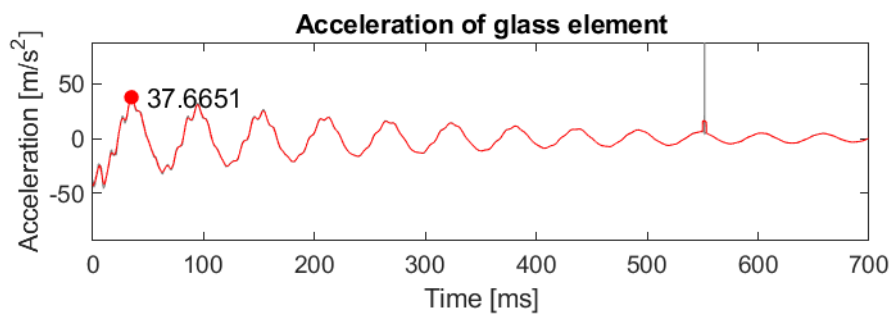
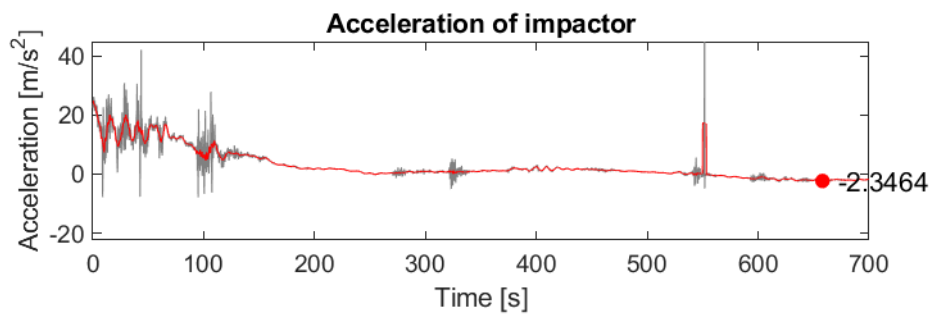
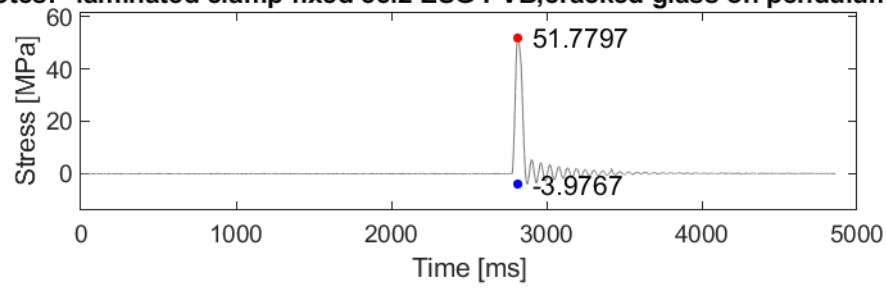
Data nr: 220
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG PVB,cracked glass on pendulum side



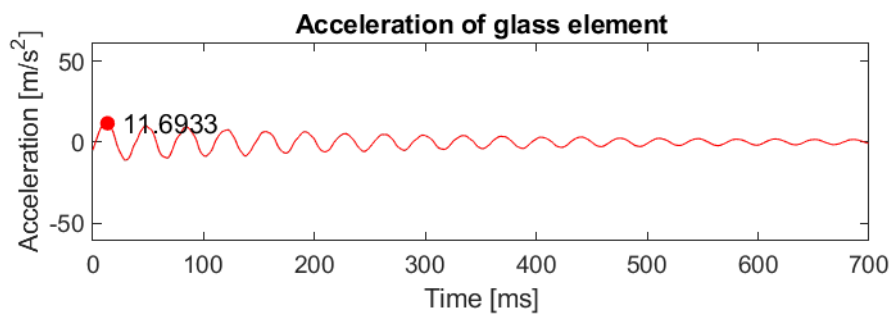
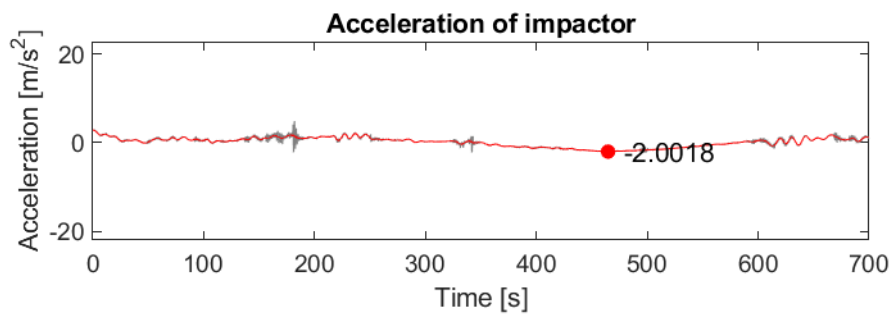
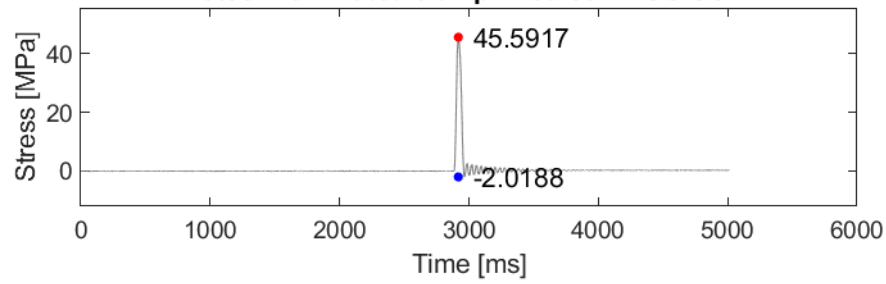
Data nr: 221
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG PVB,cracked glass on pendulum side



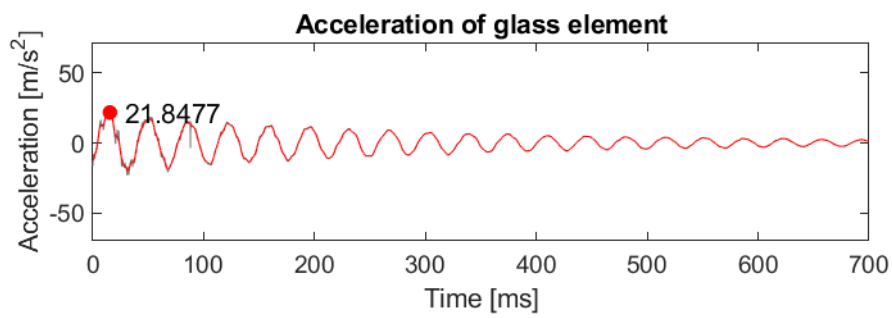
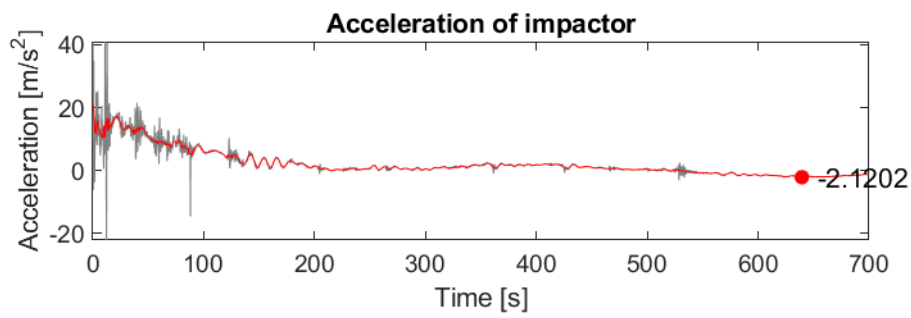
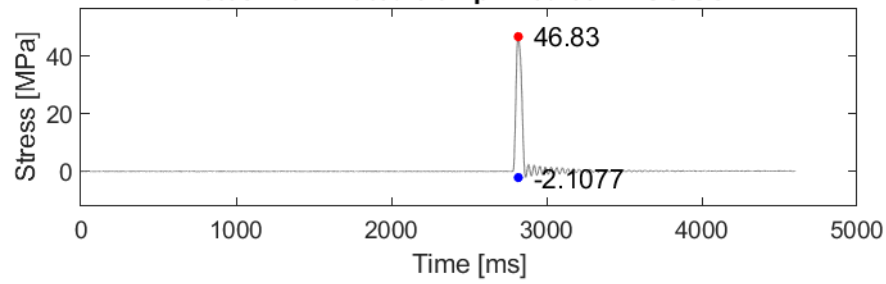
Data nr: 222
 Glass: 55.2mm
 Drop height: 100mm
 Notes: "laminated clamp-fixed 55.2 ESG PVB,cracked glass on pendulum side



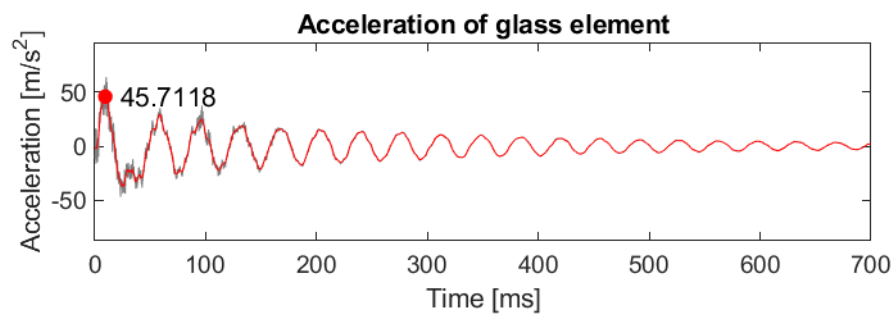
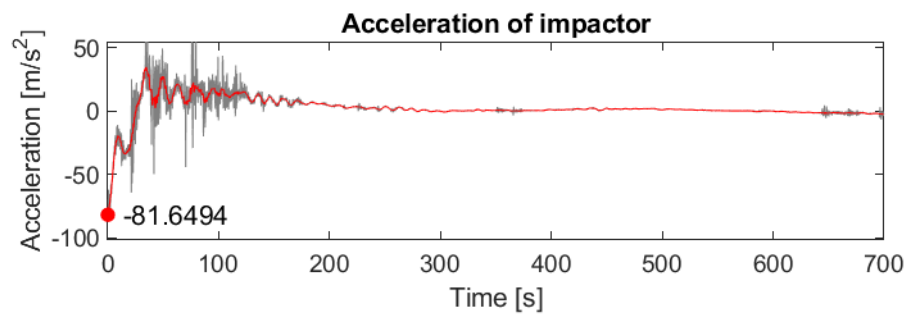
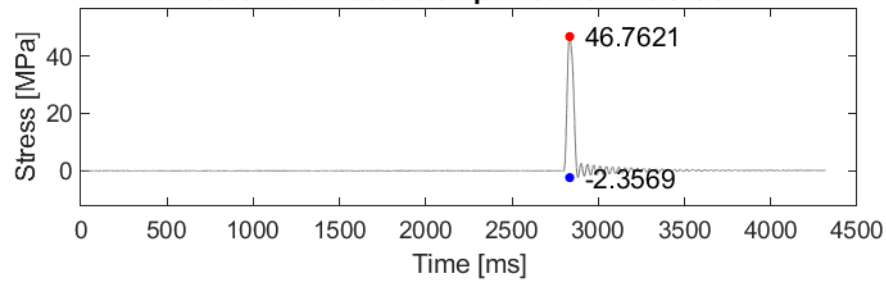
Data nr: 223
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



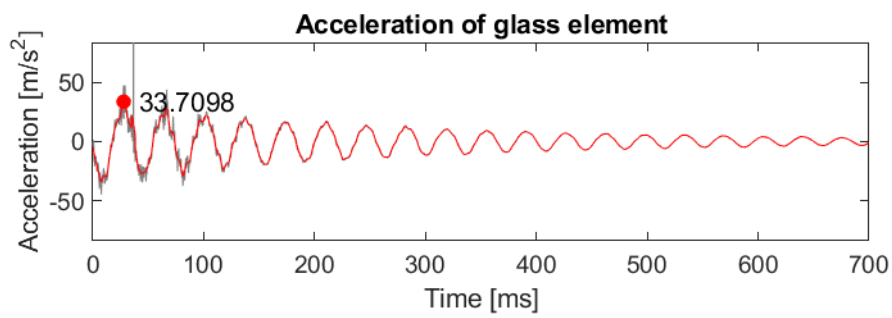
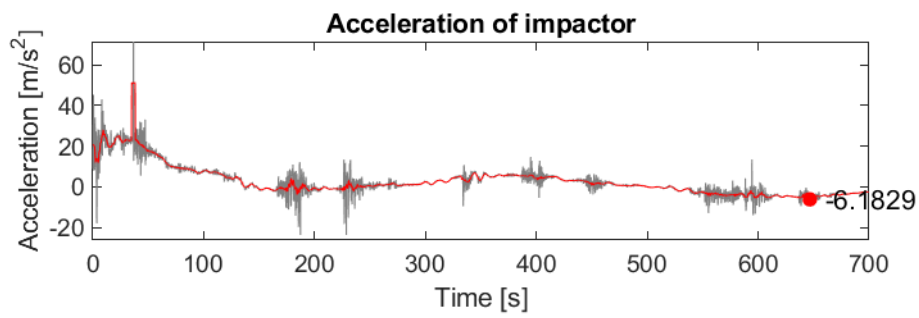
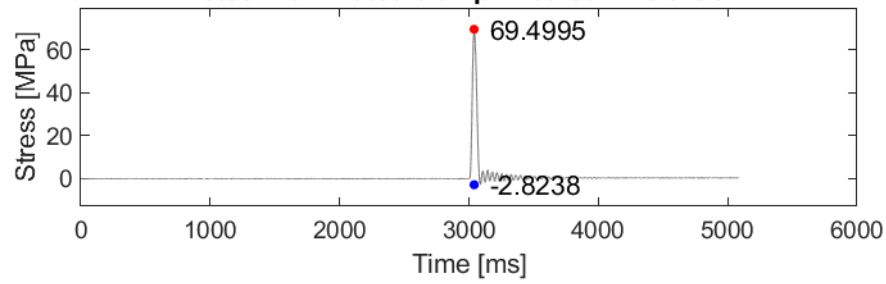
Data nr: 224
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



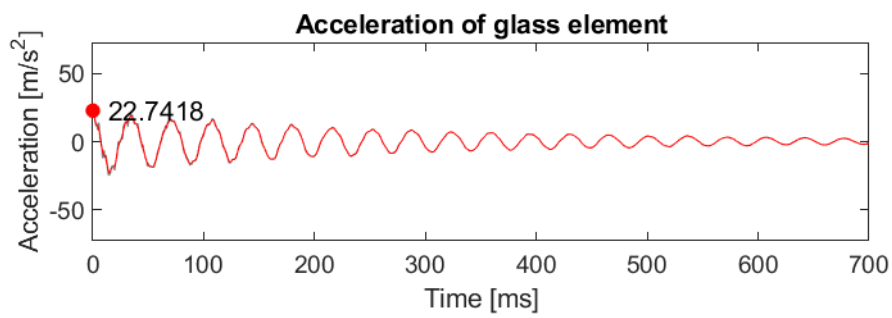
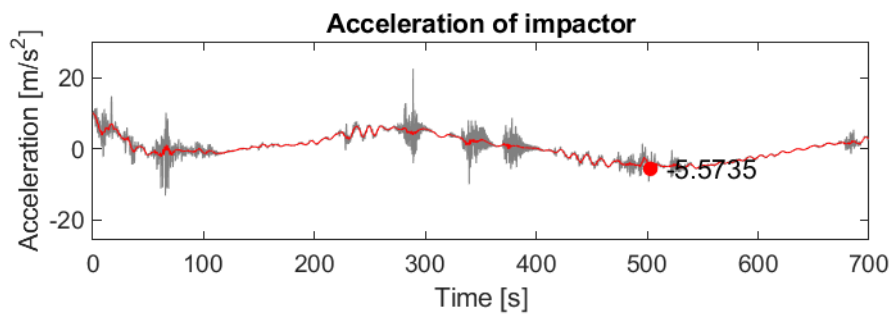
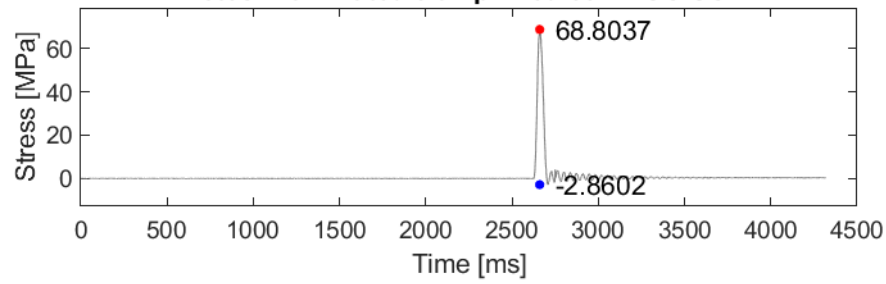
Data nr: 225
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"

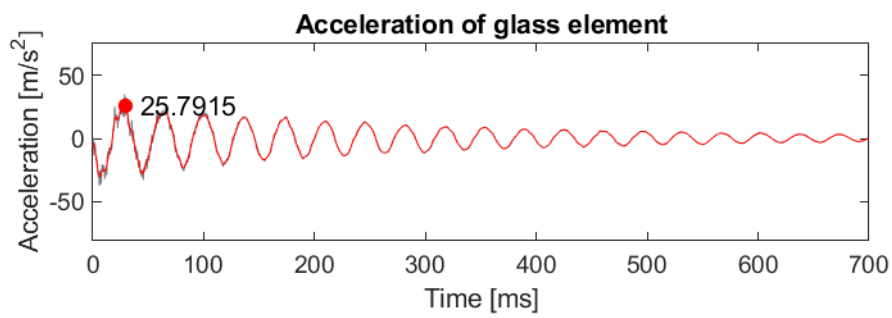
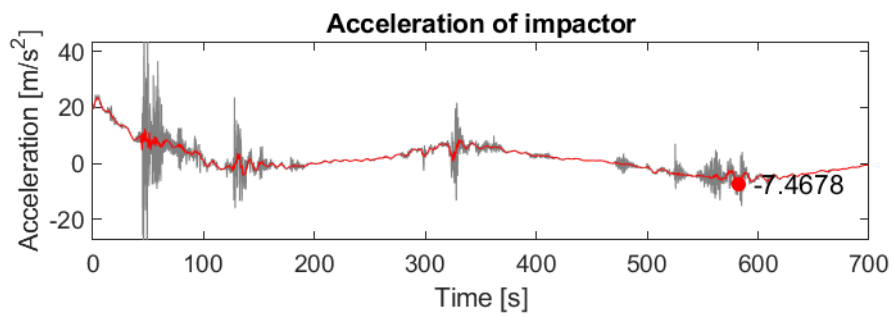
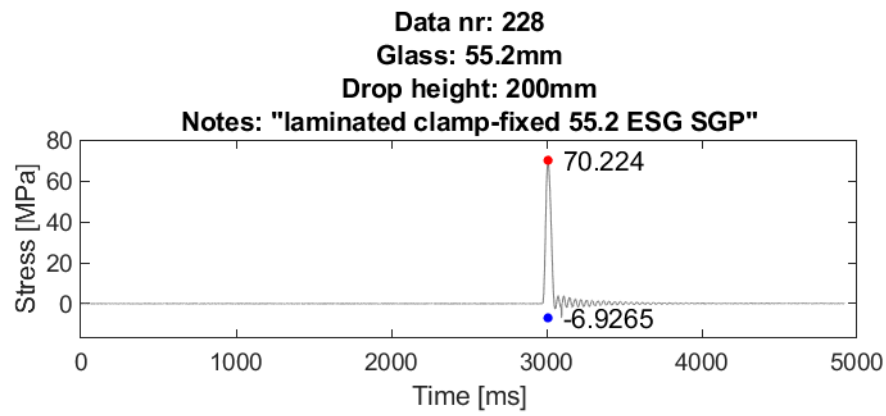


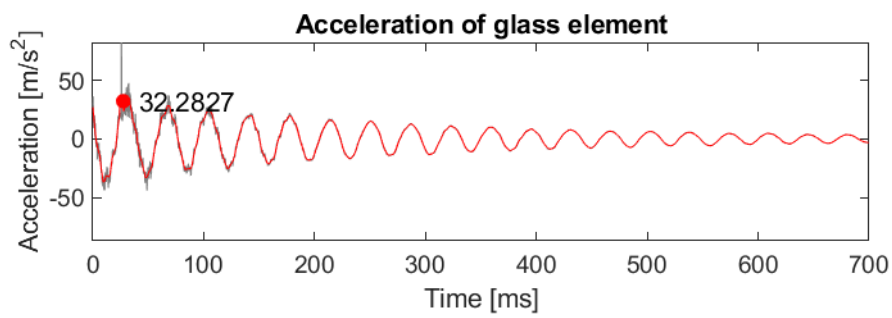
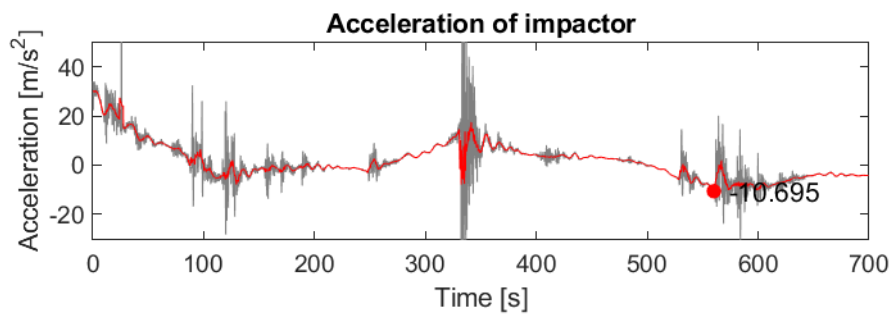
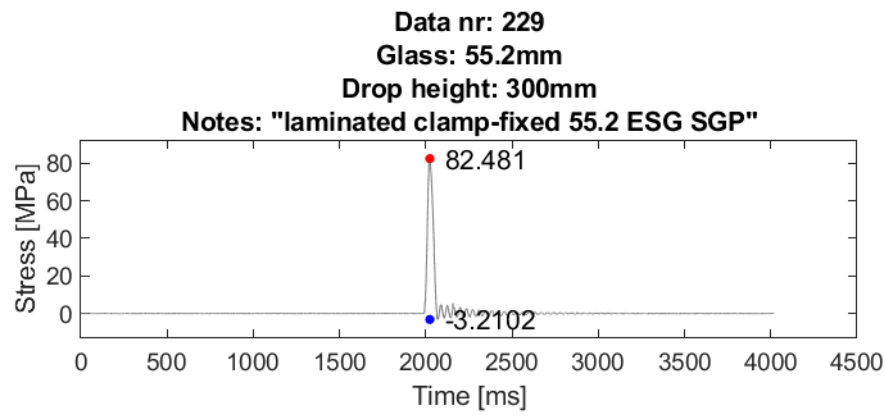
Data nr: 226
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



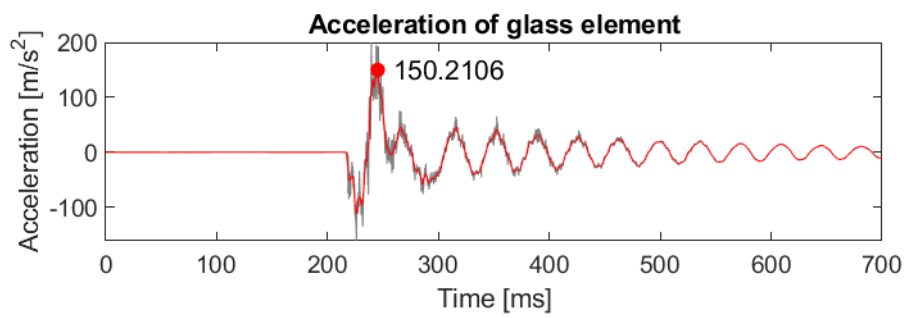
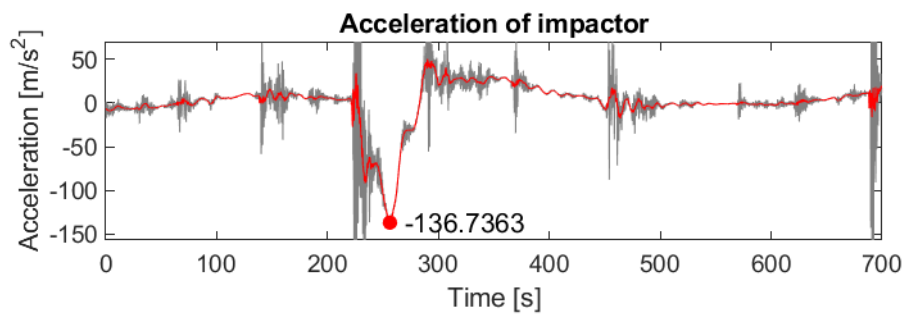
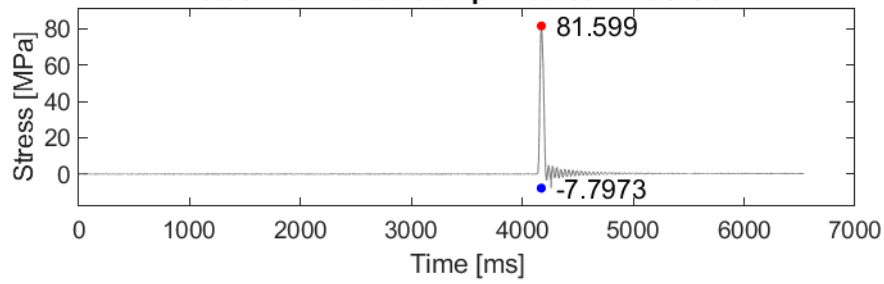
Data nr: 227
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



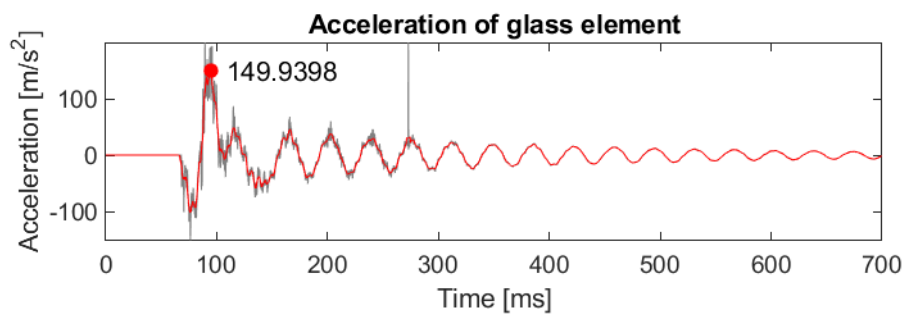
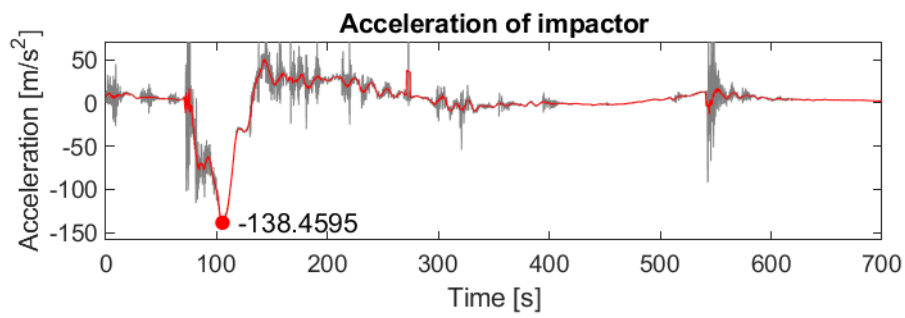
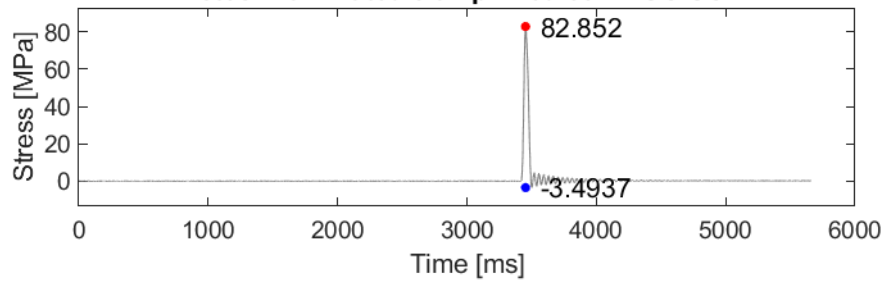


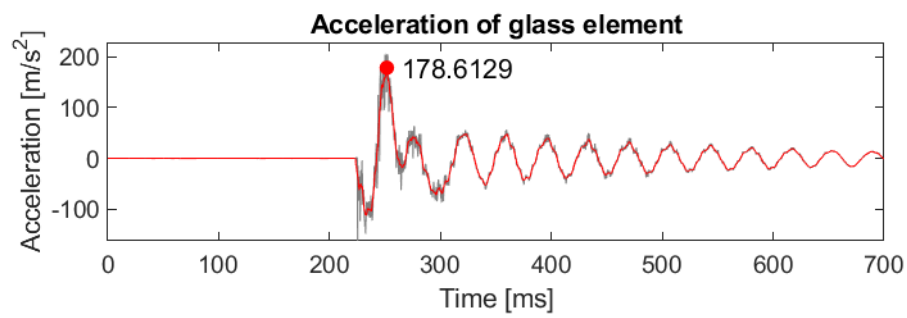
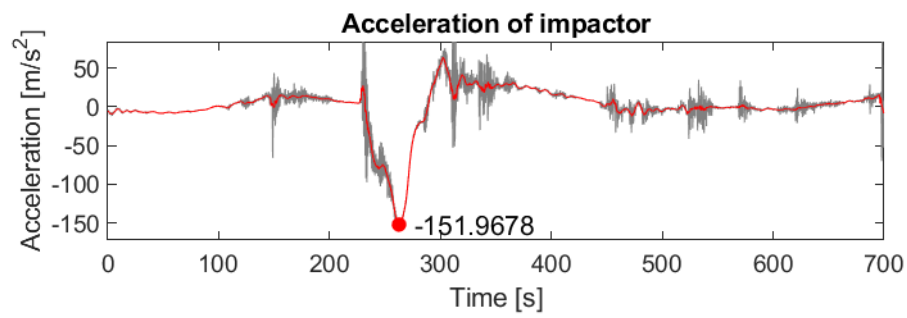
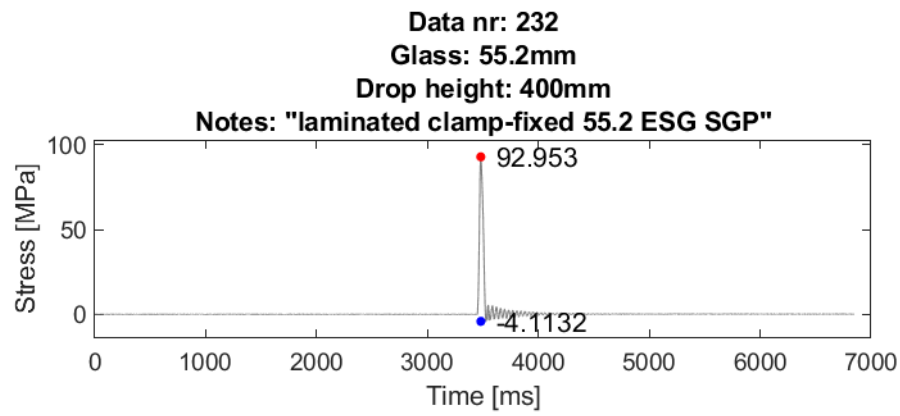


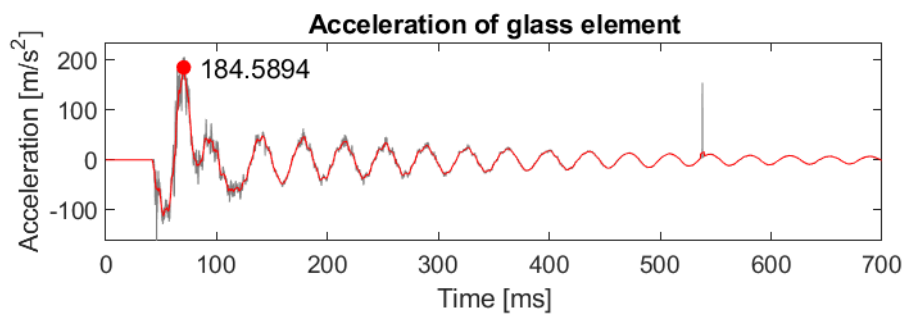
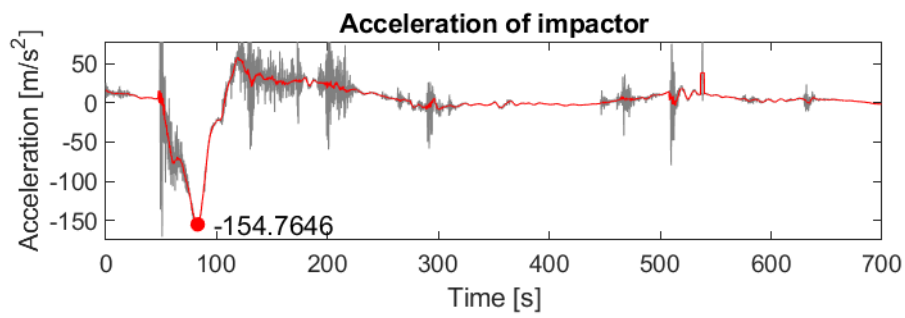
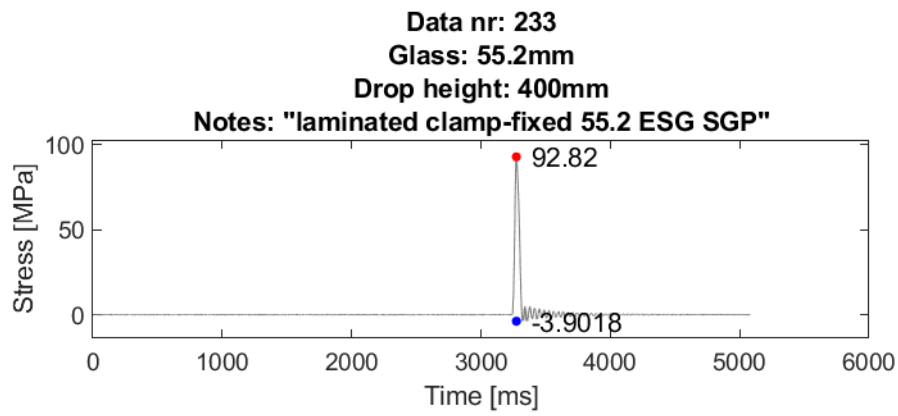
Data nr: 230
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"

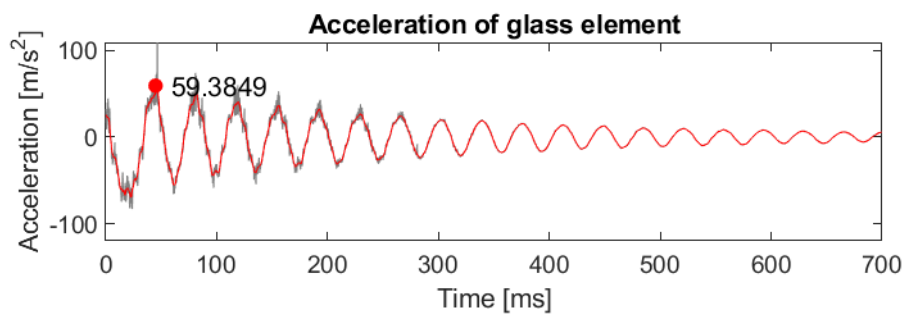
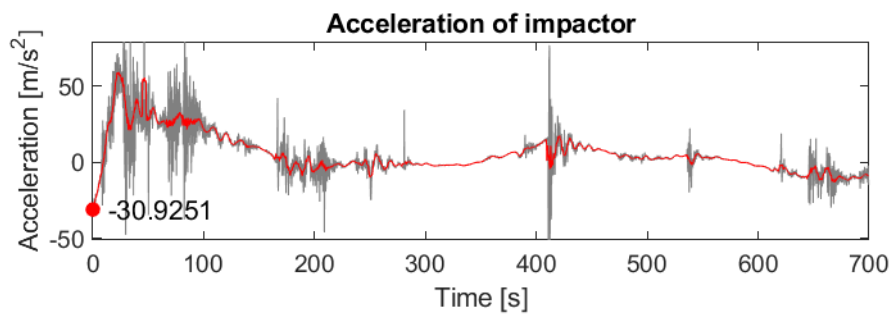
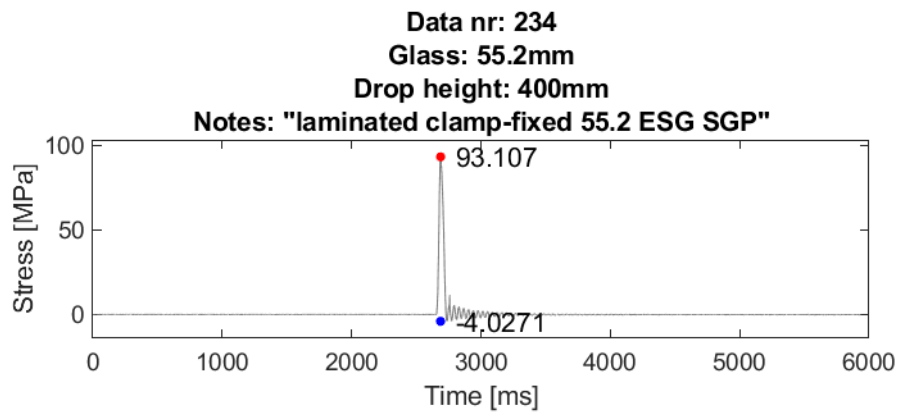


Data nr: 231
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"

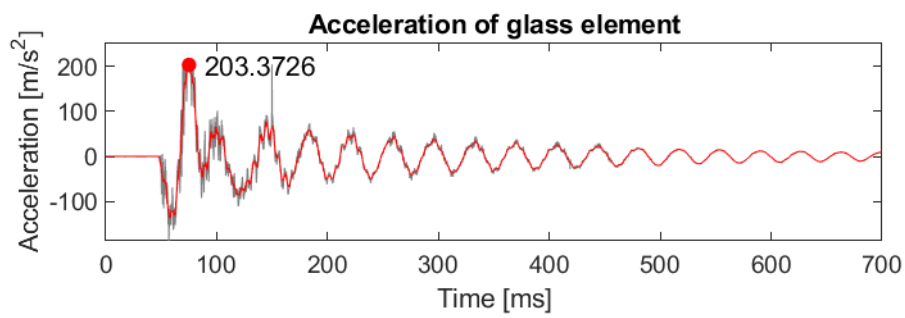
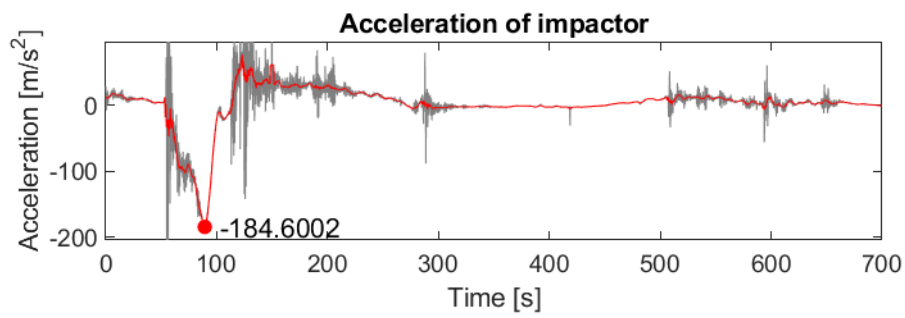
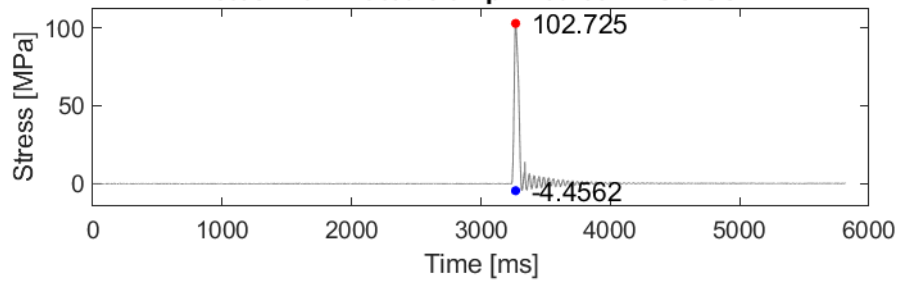


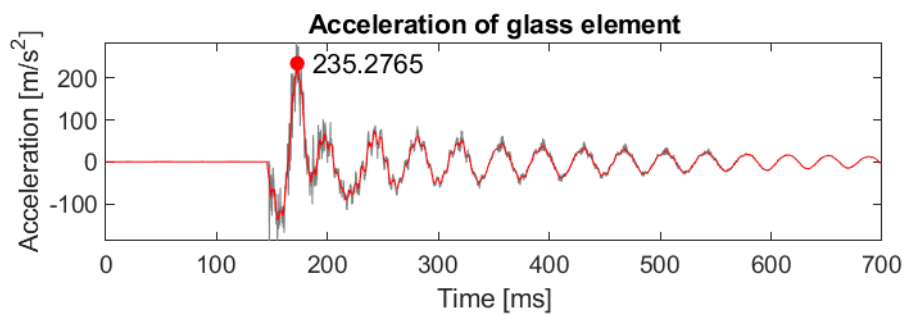
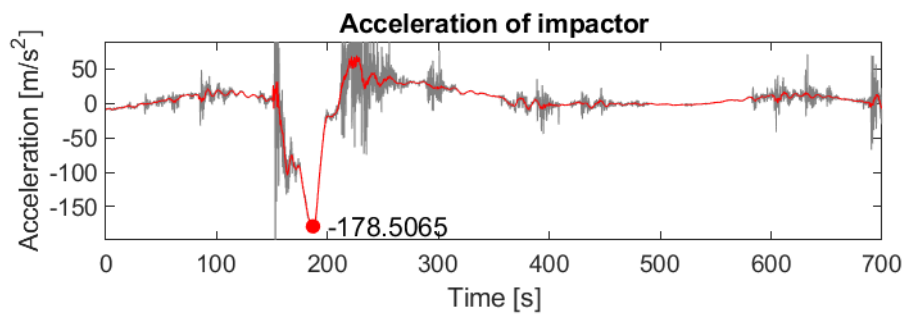
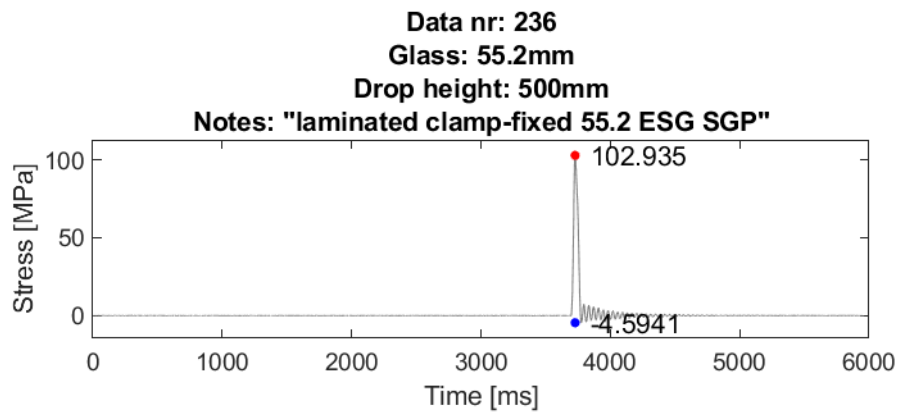


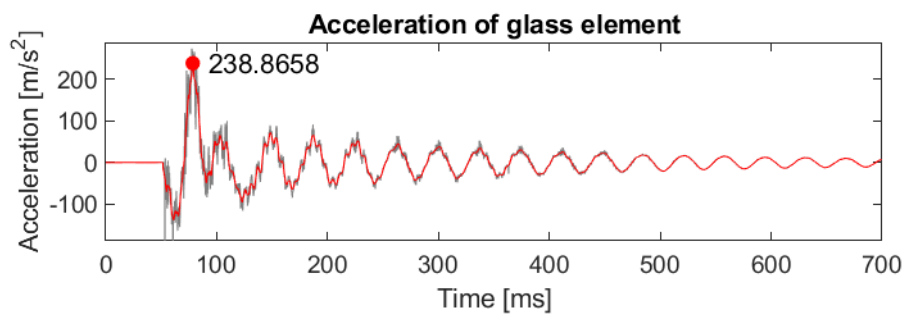
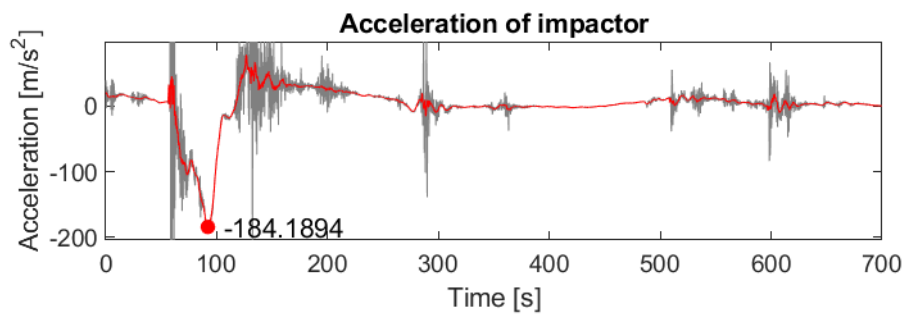
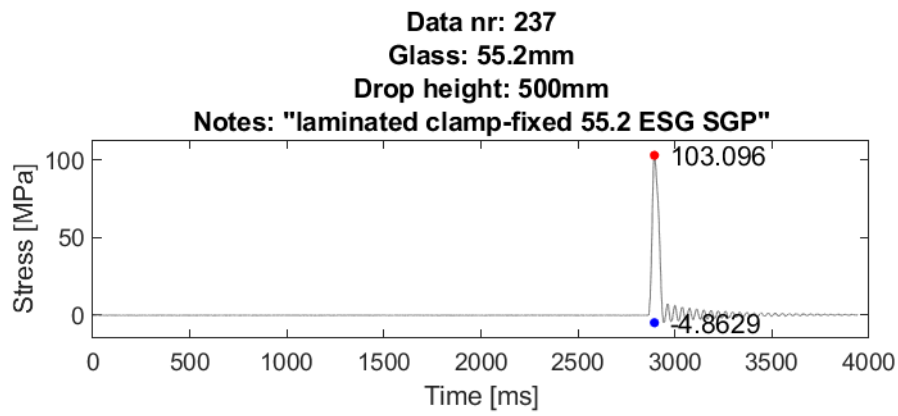




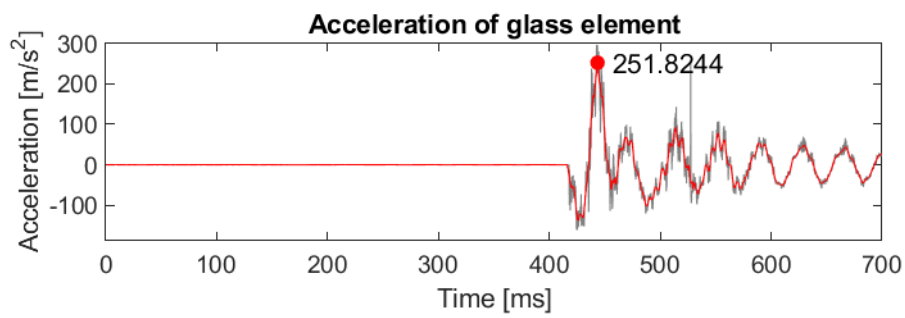
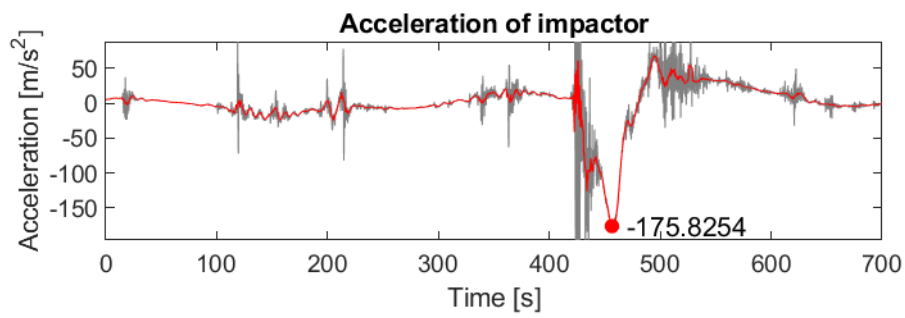
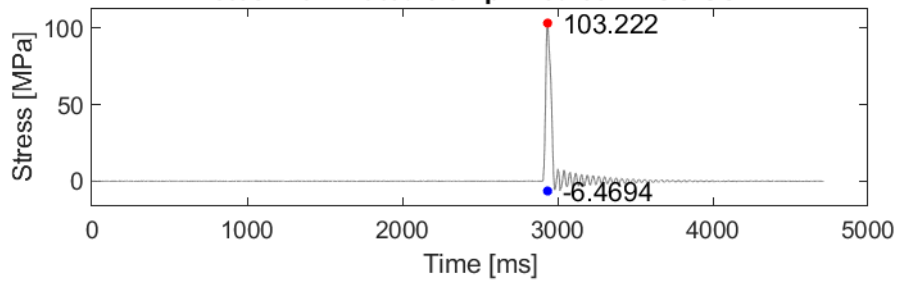
Data nr: 235
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



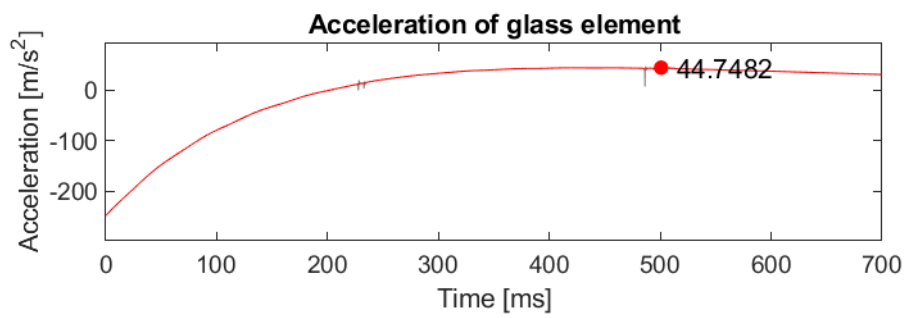
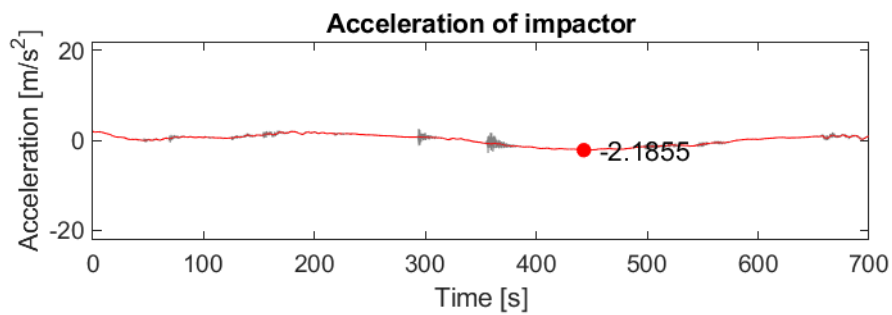
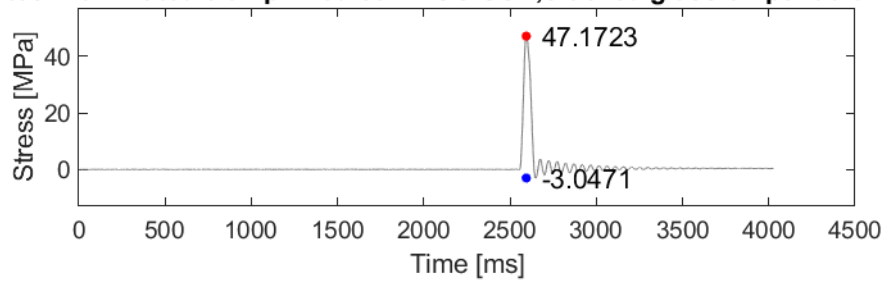




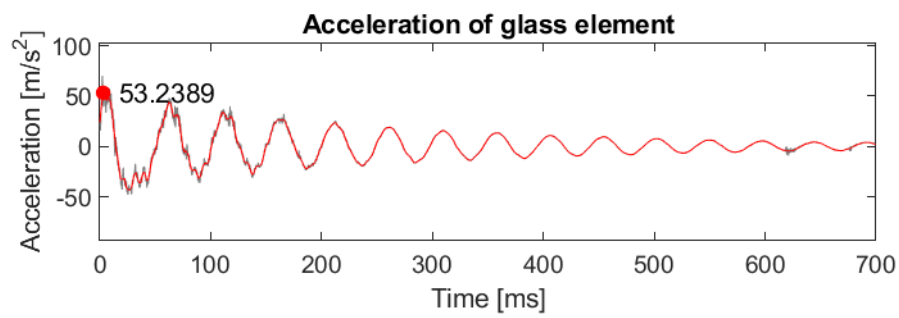
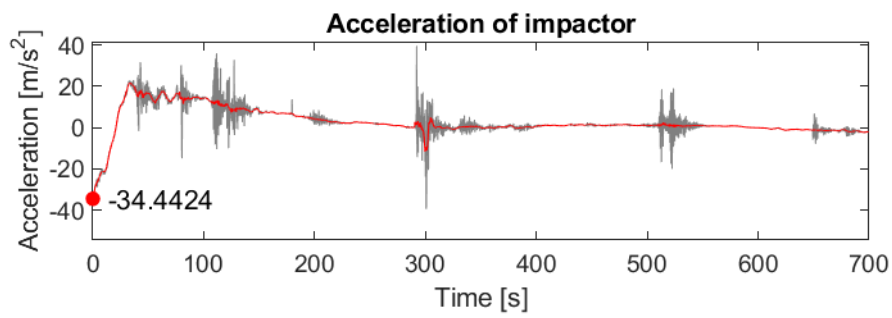
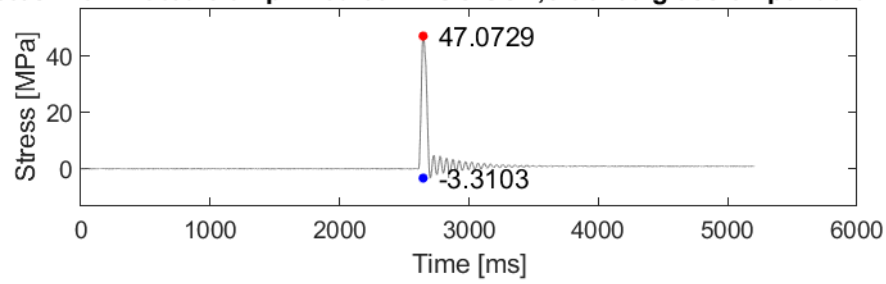
Data nr: 238
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 55.2 ESG SGP"



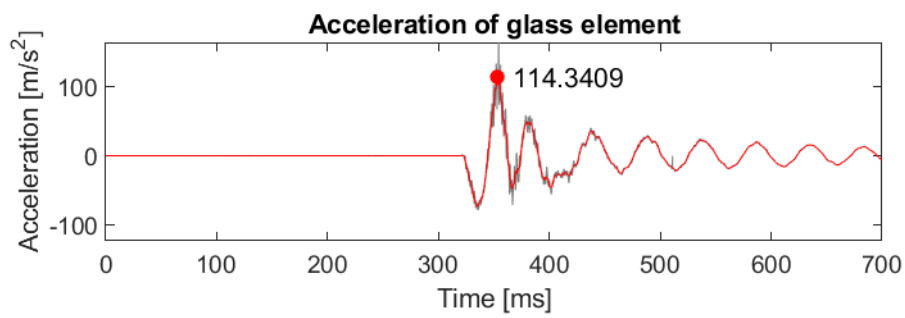
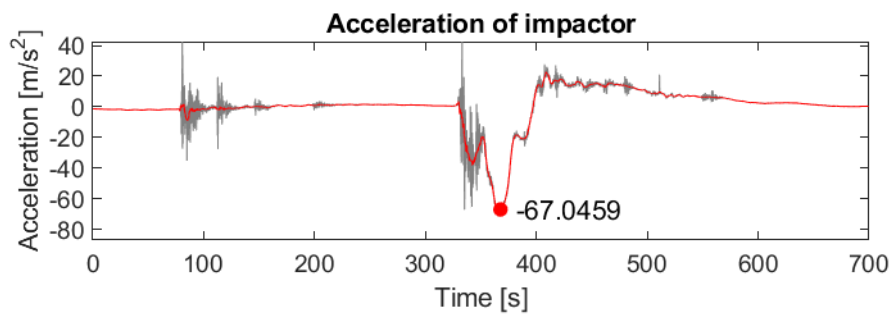
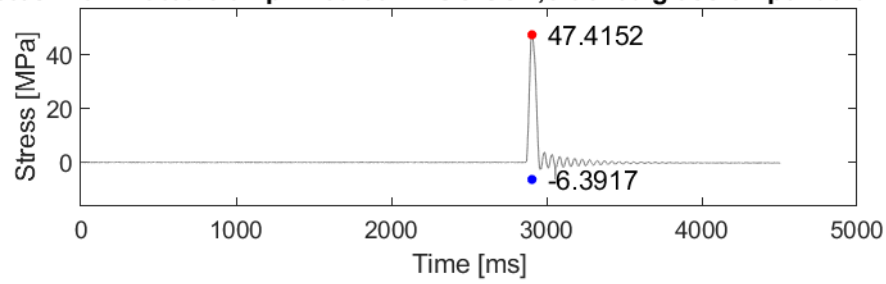
Data nr: 240
 Glass: 55.2mm
 Drop height: 100mm
 Notes: "laminated clamp-fixed 55.2 ESG SGP,cracked glass on pendulum side



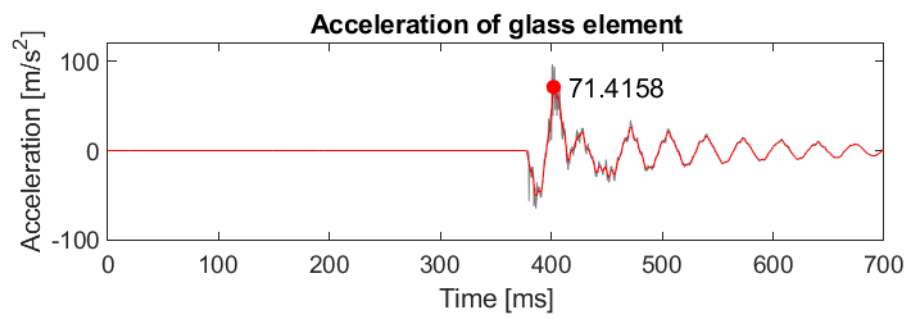
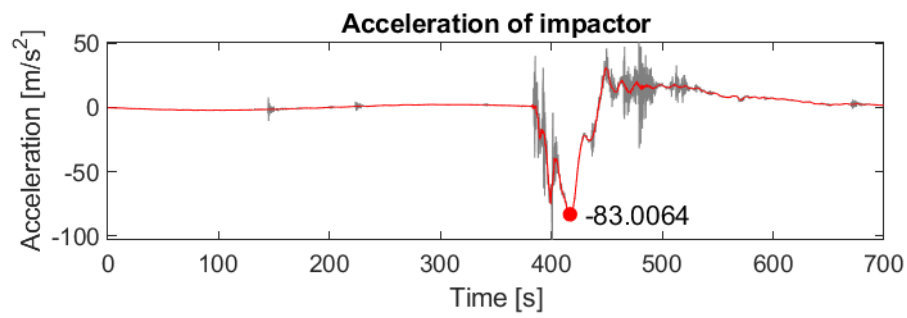
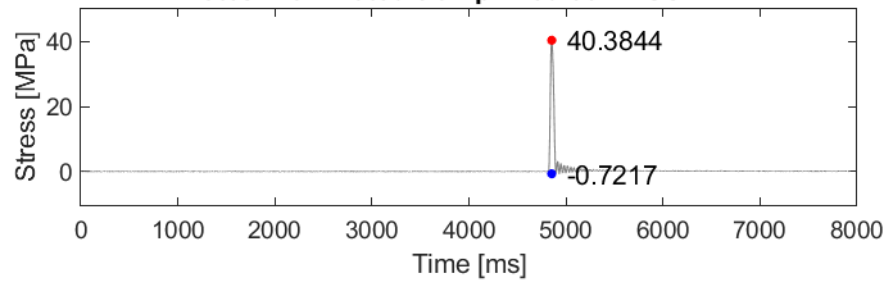
Data nr: 241
 Glass: 55.2mm
 Drop height: 100mm
 Notes: "laminated clamp-fixed 55.2 ESG SGP,cracked glass on pendulum side



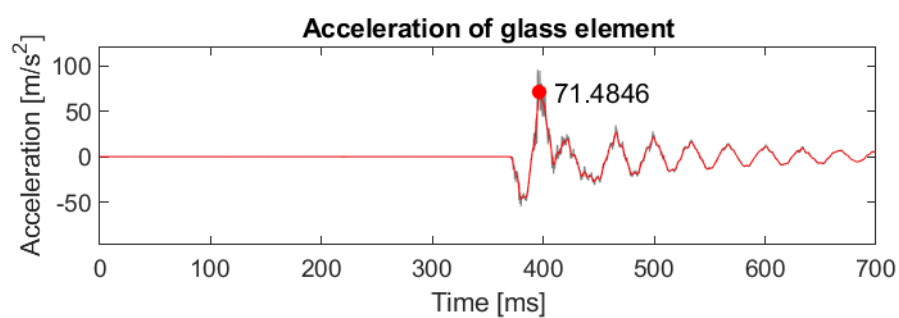
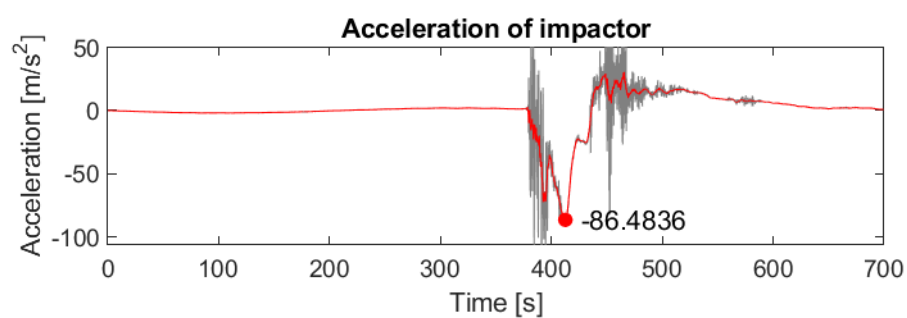
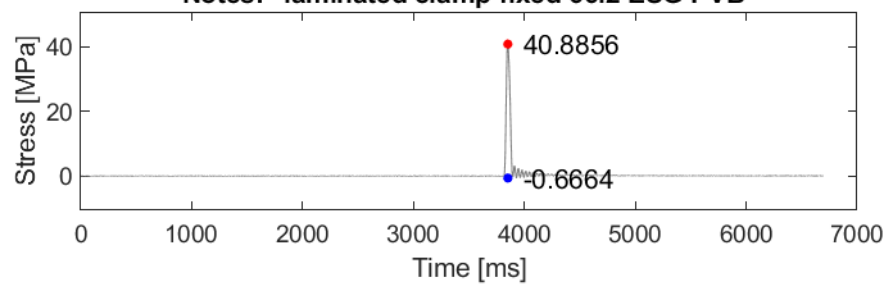
Data nr: 242
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 55.2 ESG SGP,cracked glass on pendulum side



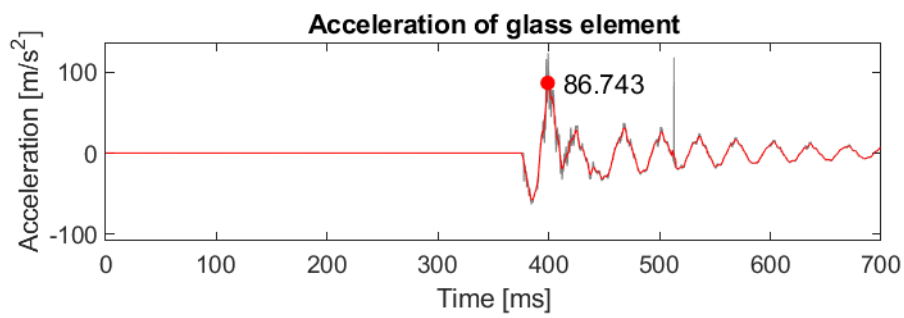
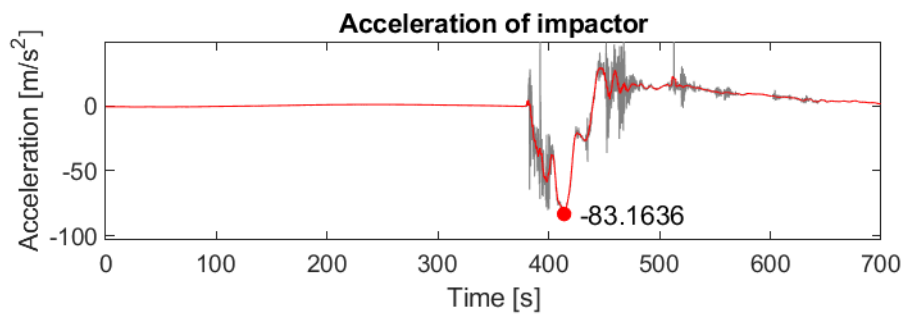
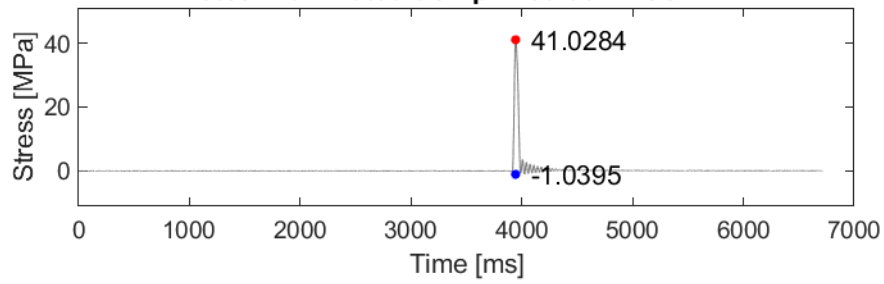
Data nr: 244
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



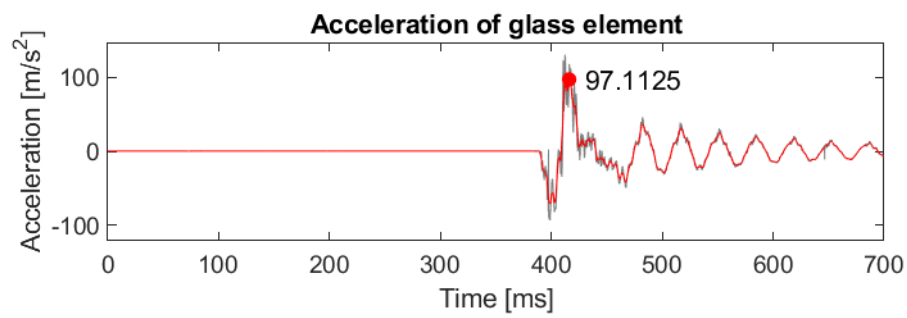
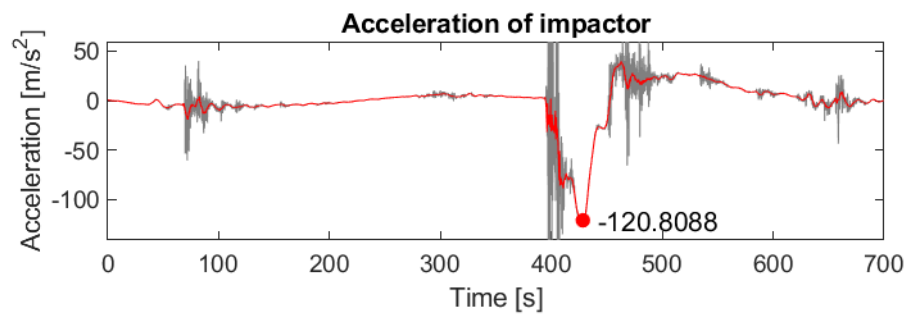
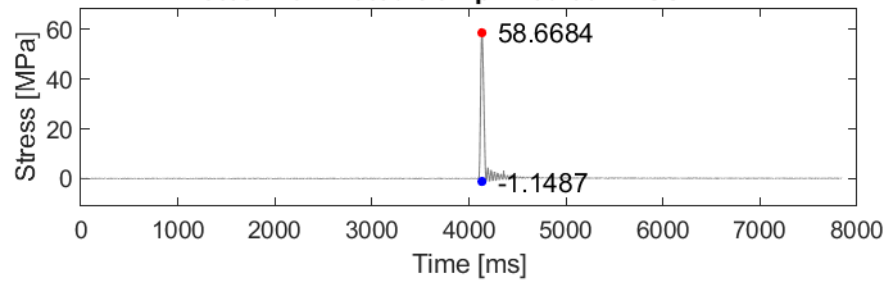
Data nr: 245
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



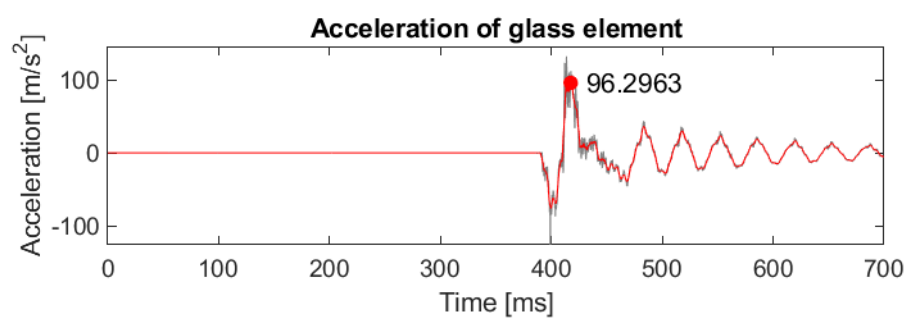
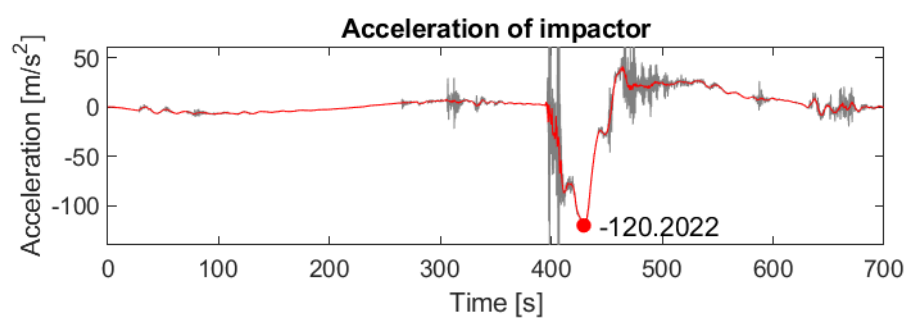
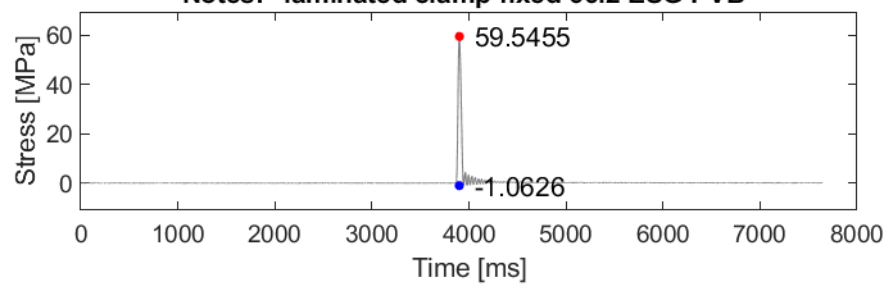
Data nr: 246
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



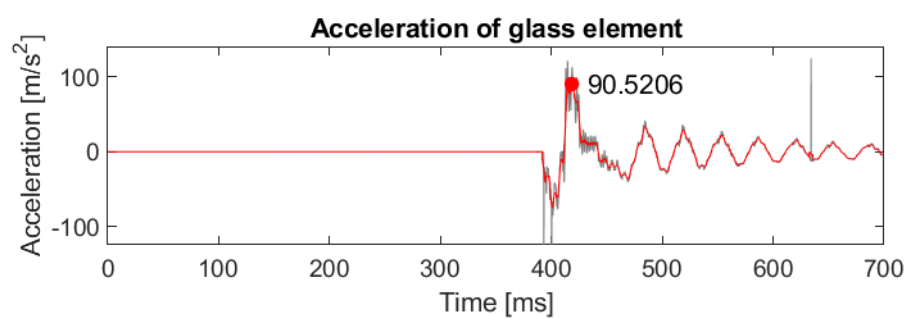
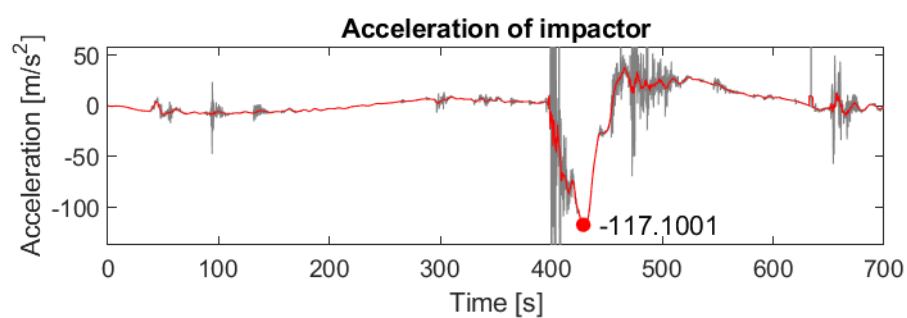
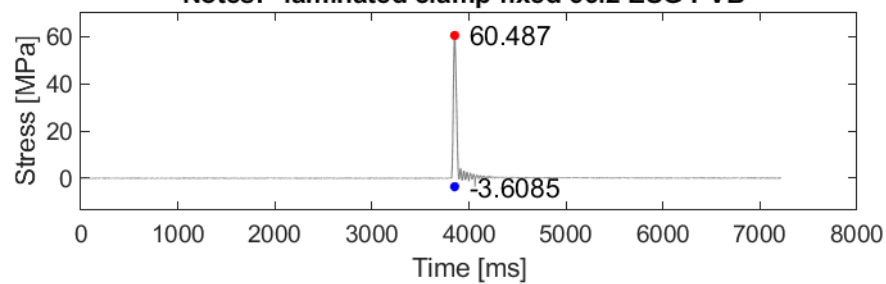
Data nr: 247
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



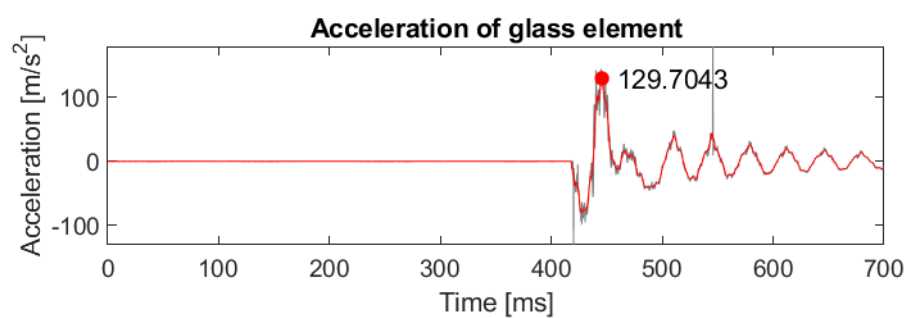
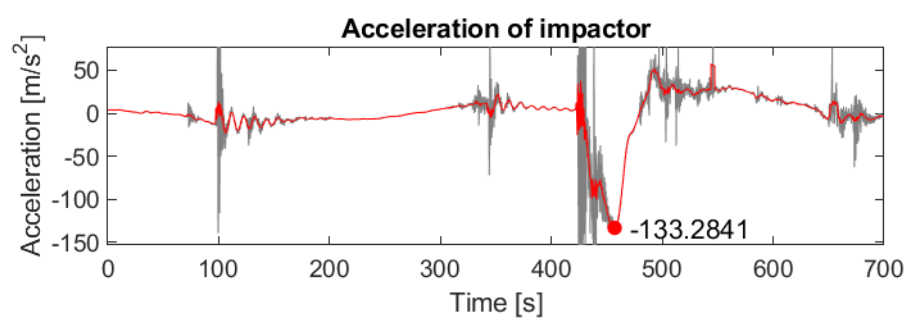
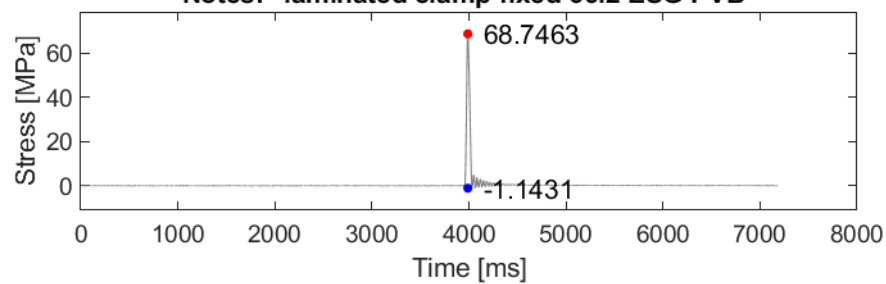
Data nr: 248
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



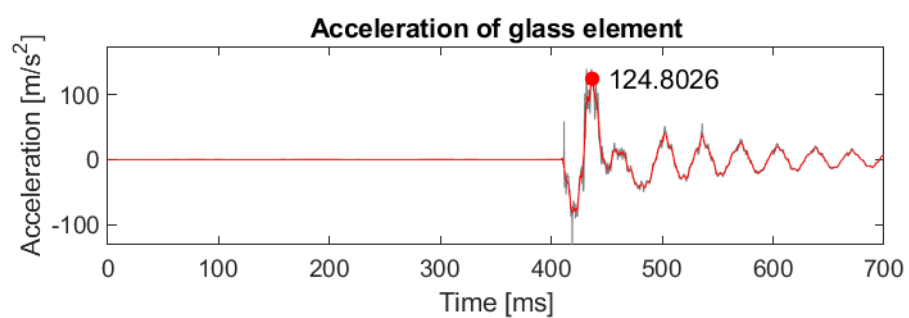
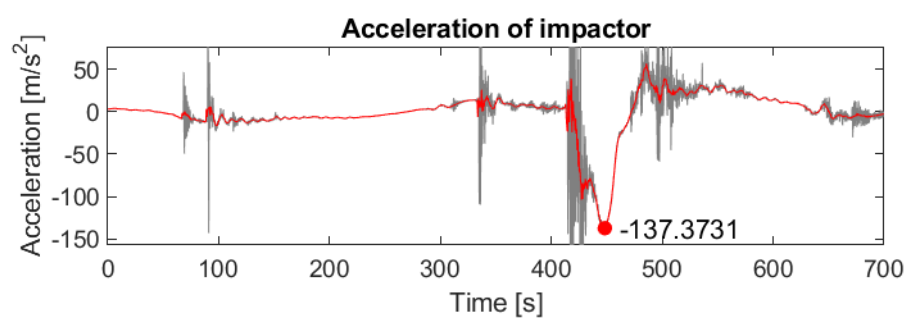
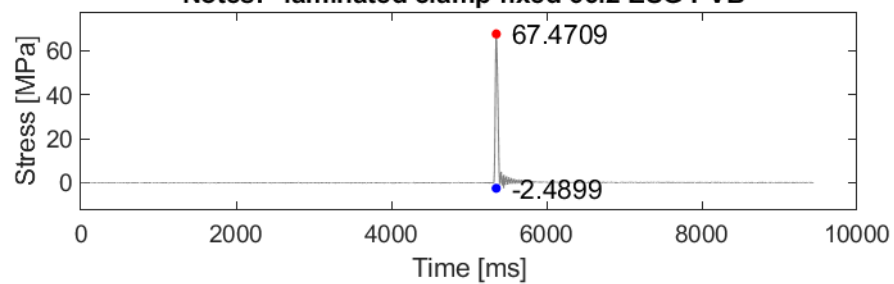
Data nr: 249
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



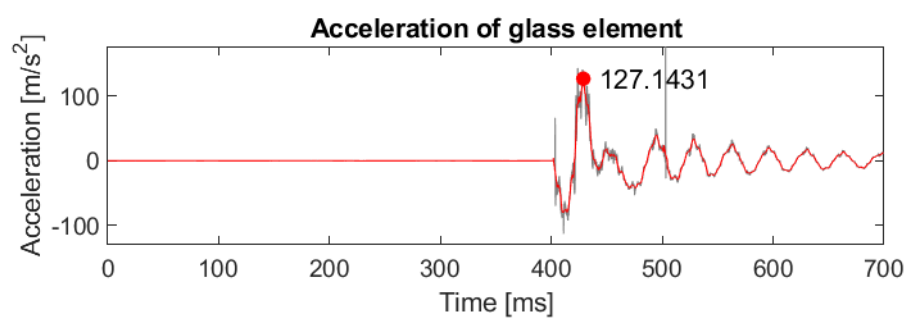
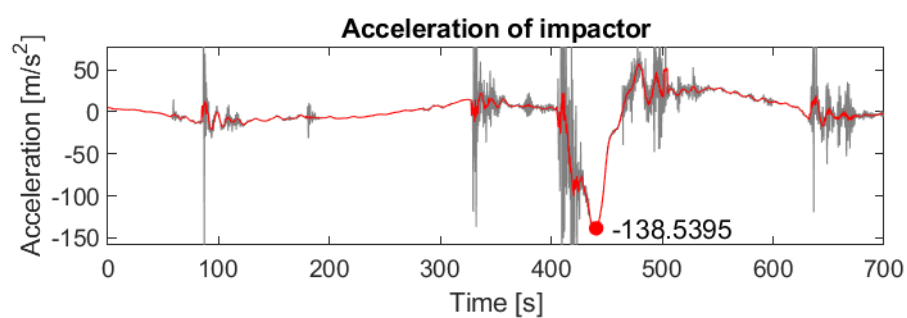
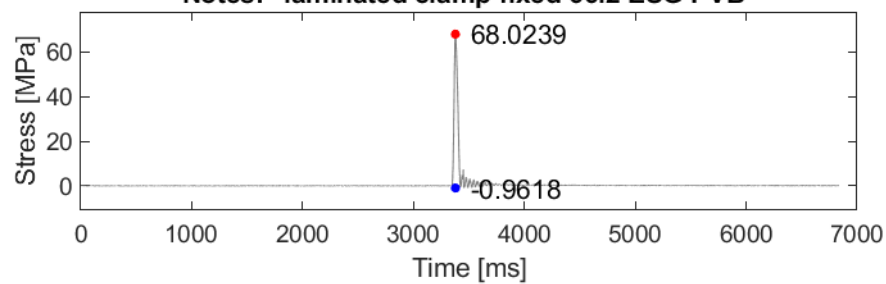
Data nr: 250
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



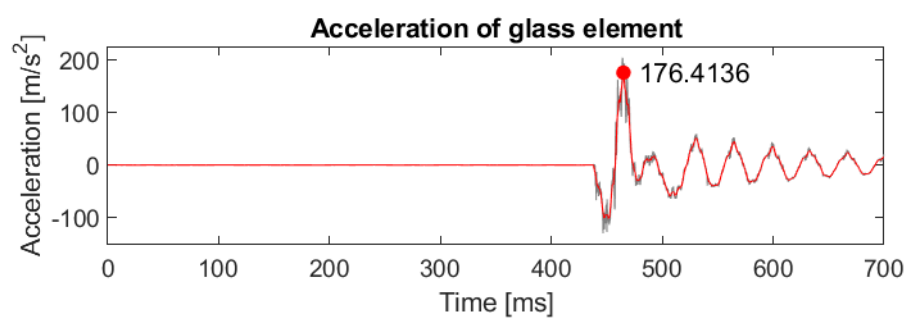
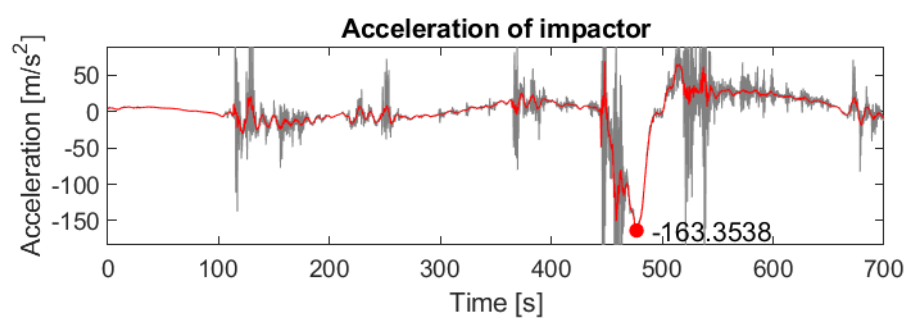
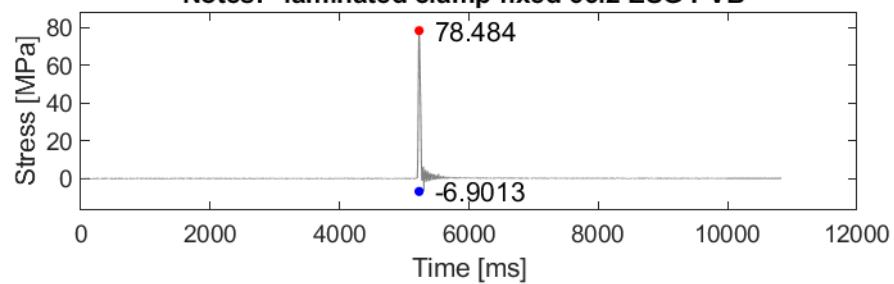
Data nr: 251
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"

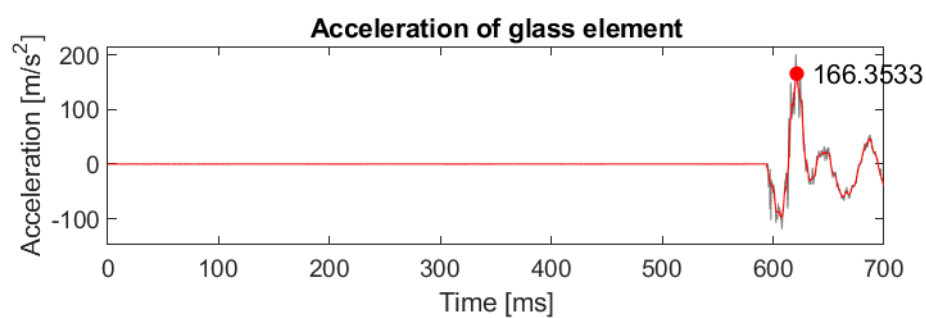
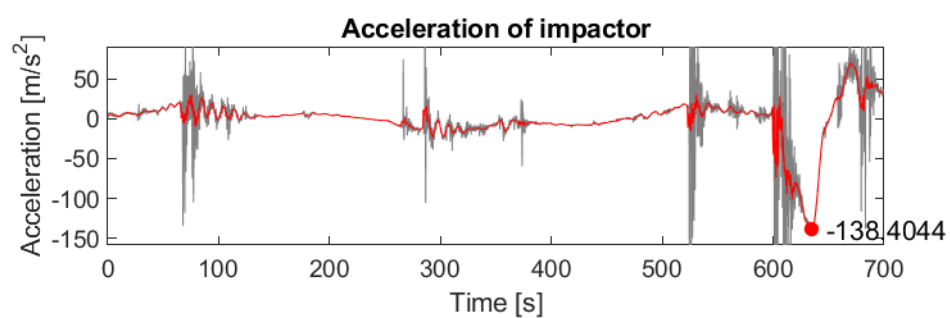
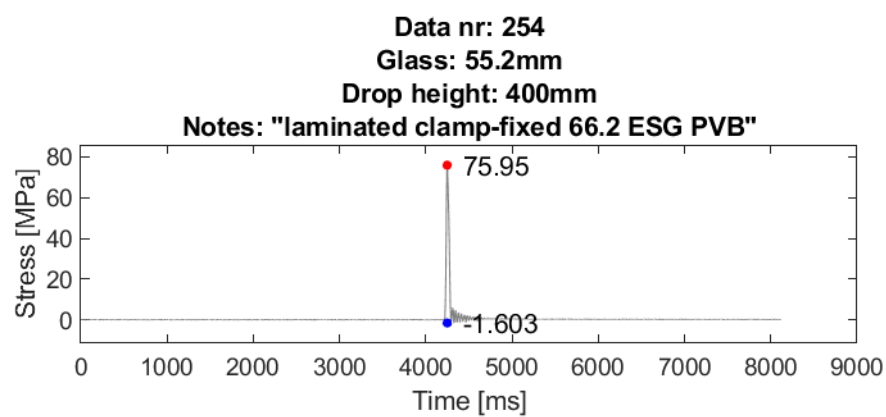


Data nr: 252
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"

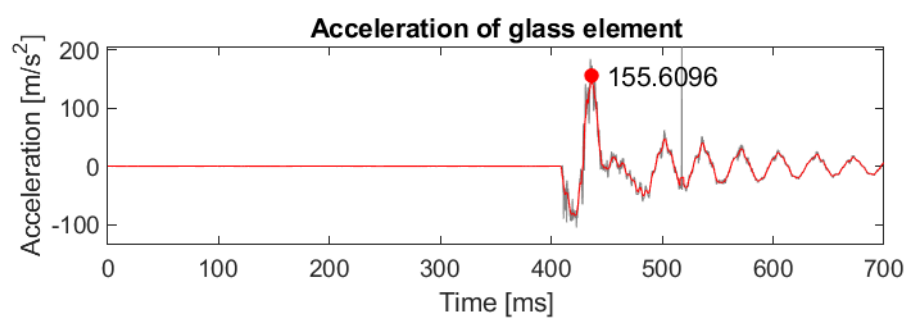
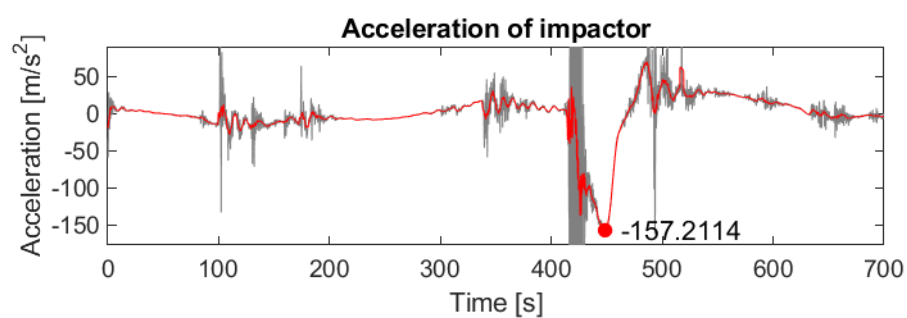
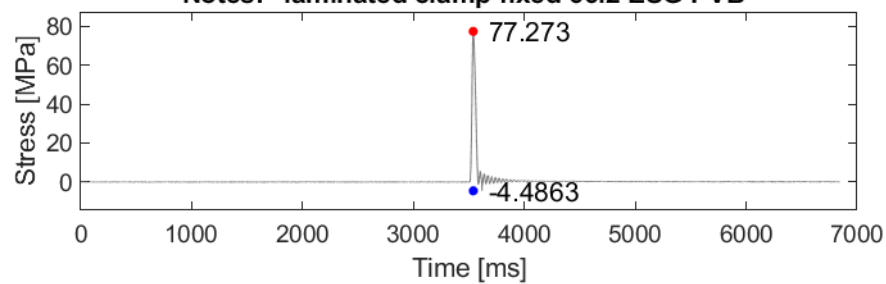


Data nr: 253
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"

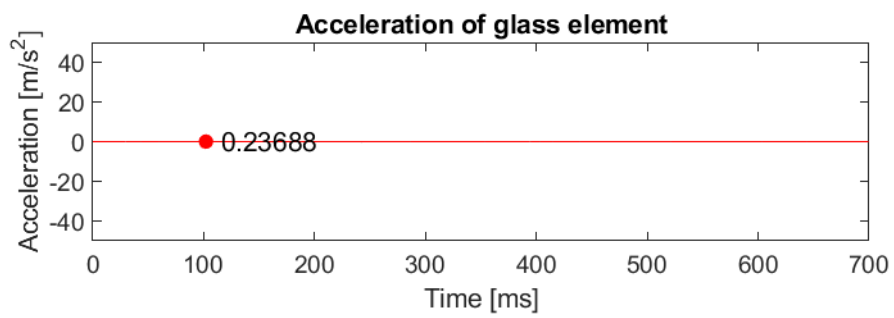
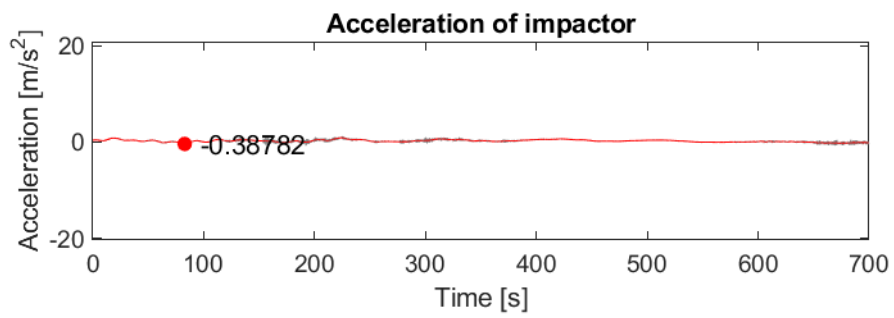
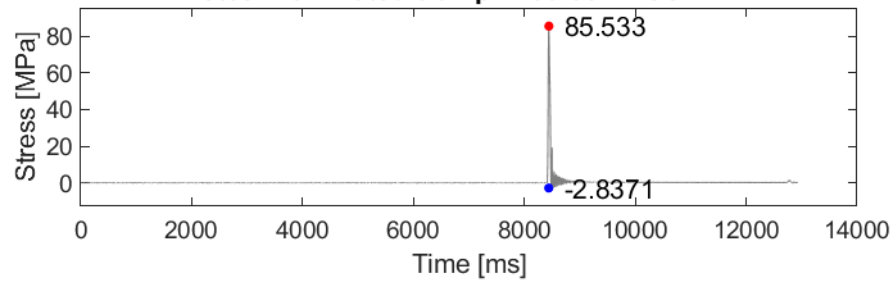


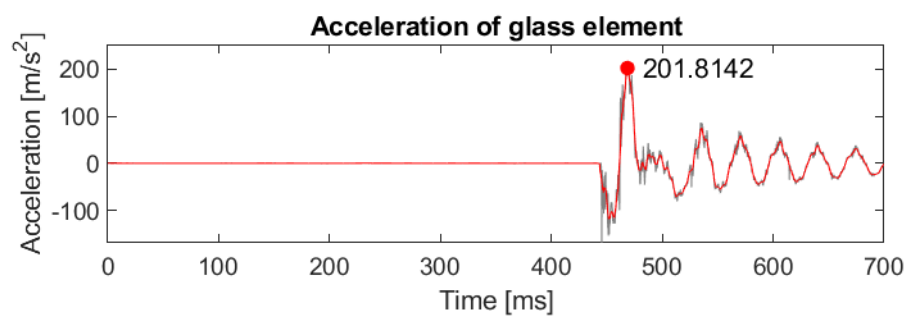
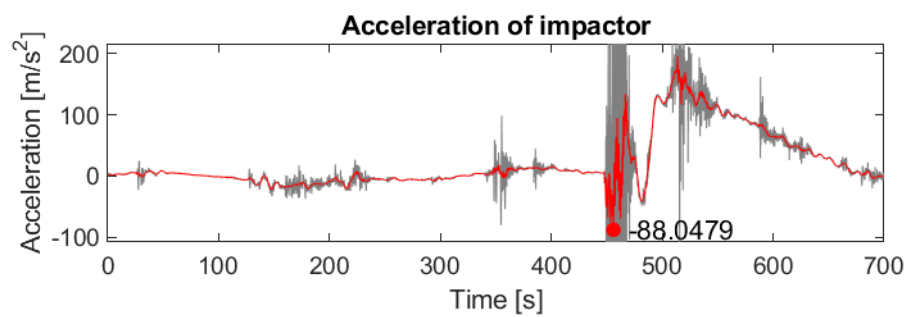
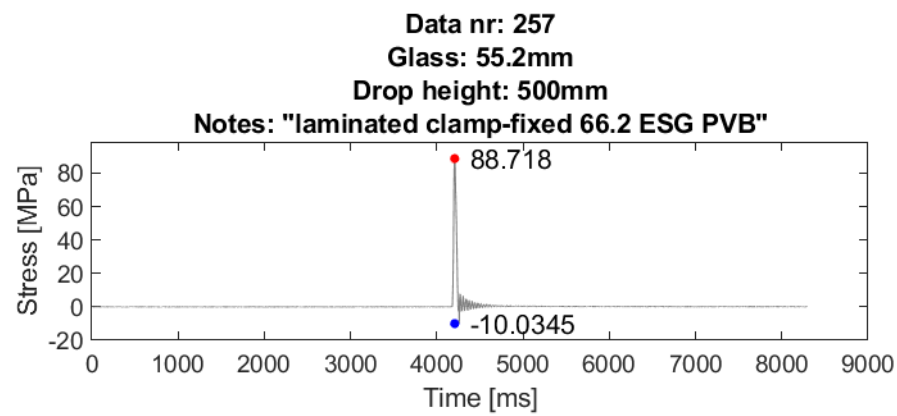


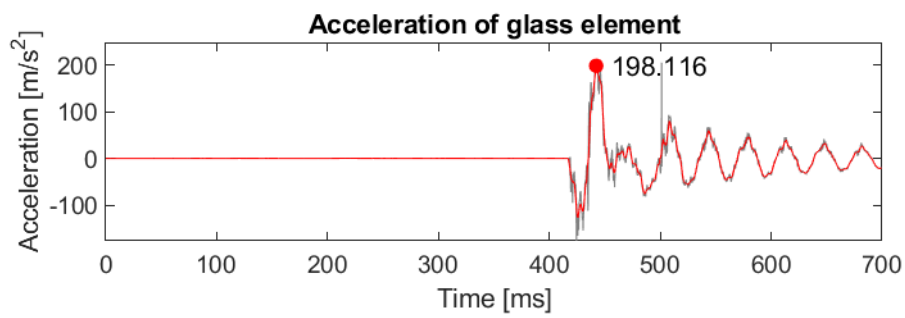
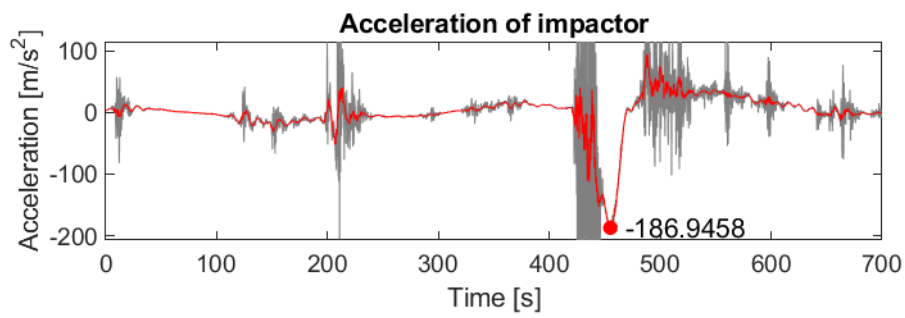
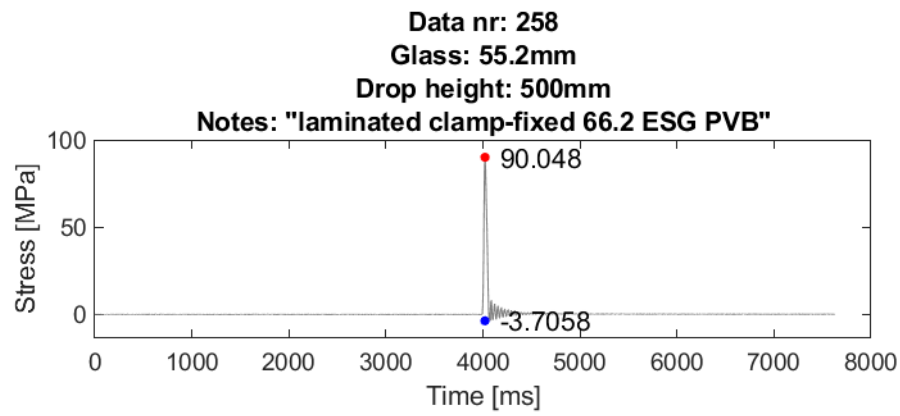
Data nr: 255
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



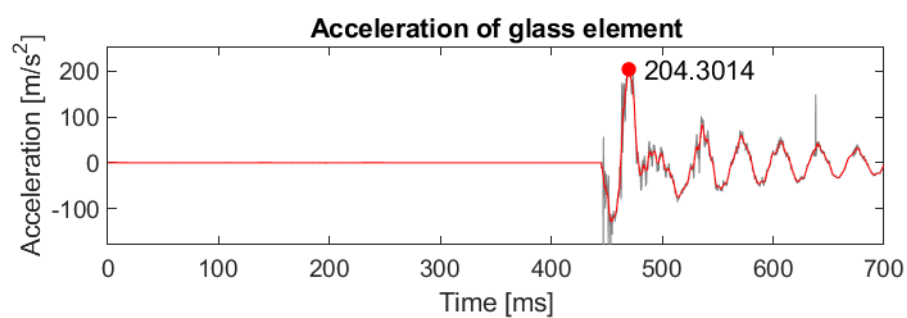
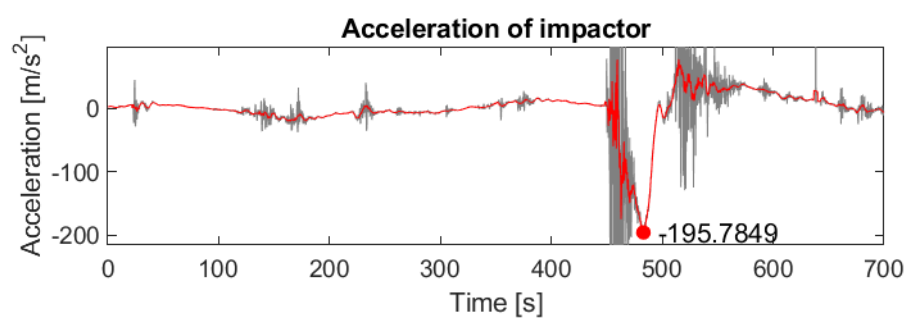
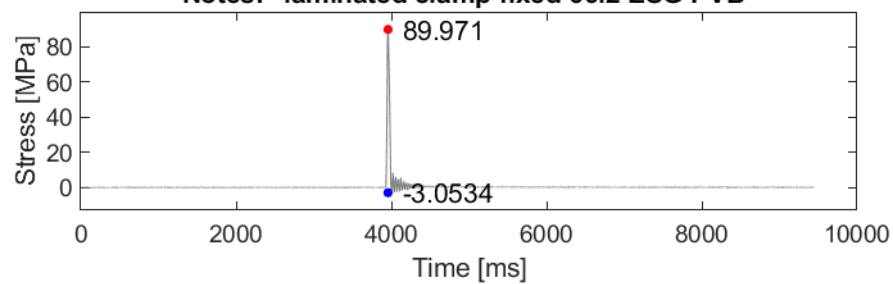
Data nr: 256
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



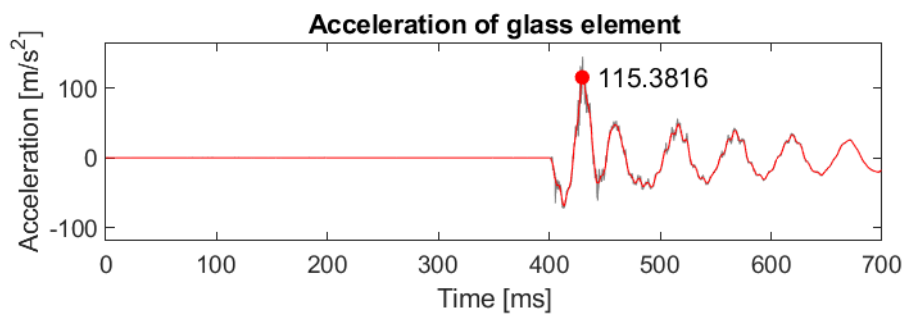
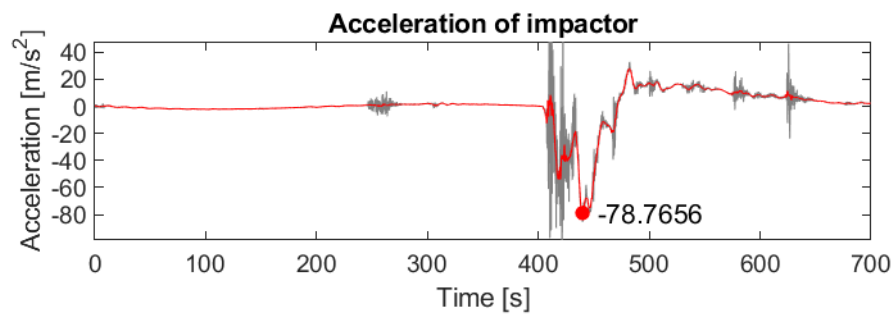
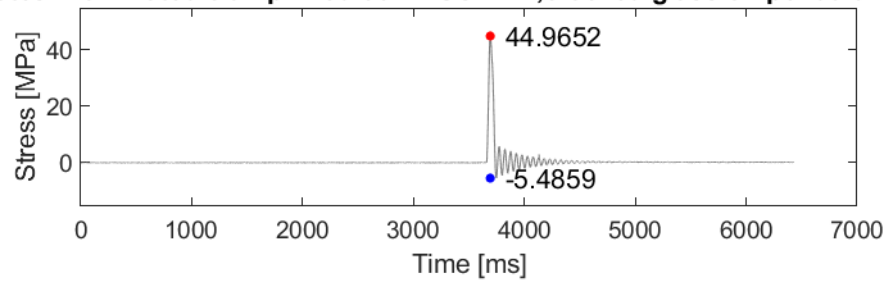




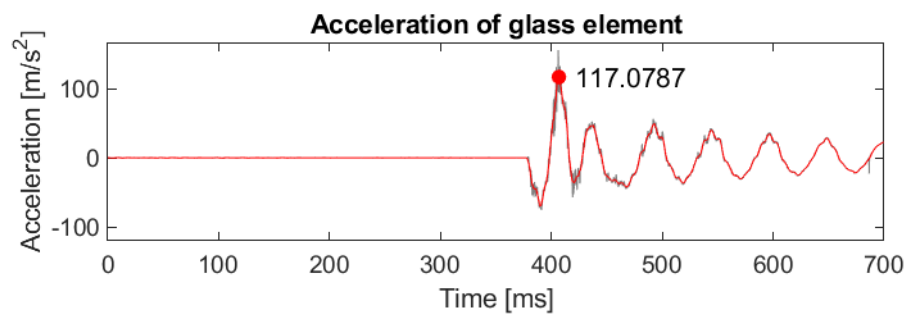
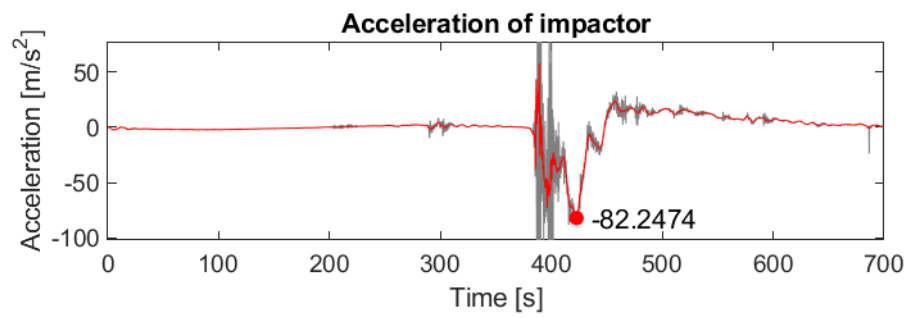
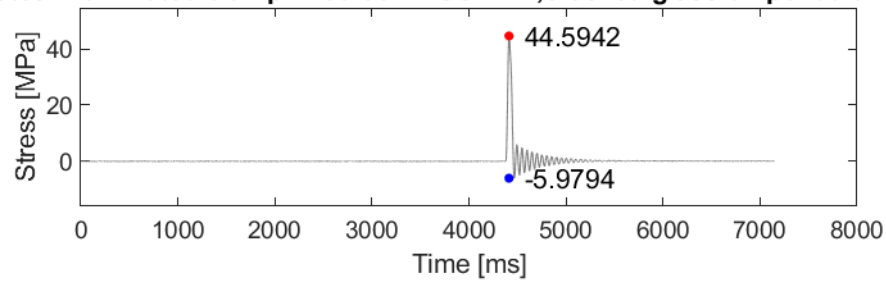
Data nr: 259
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 66.2 ESG PVB"



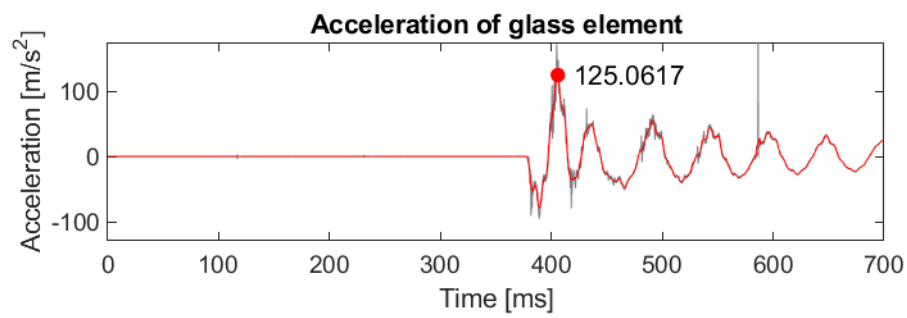
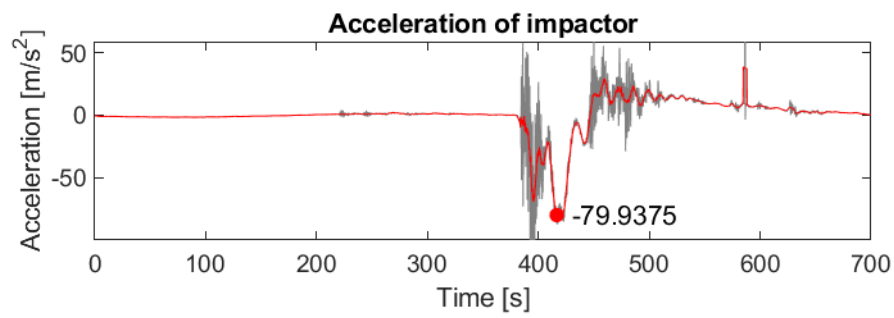
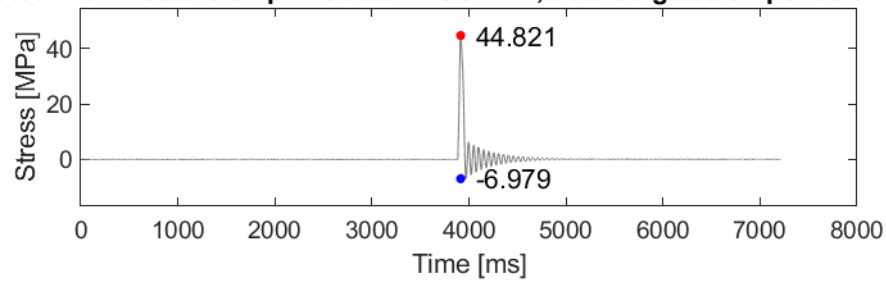
Data nr: 261
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB,cracked glass on pendulum side



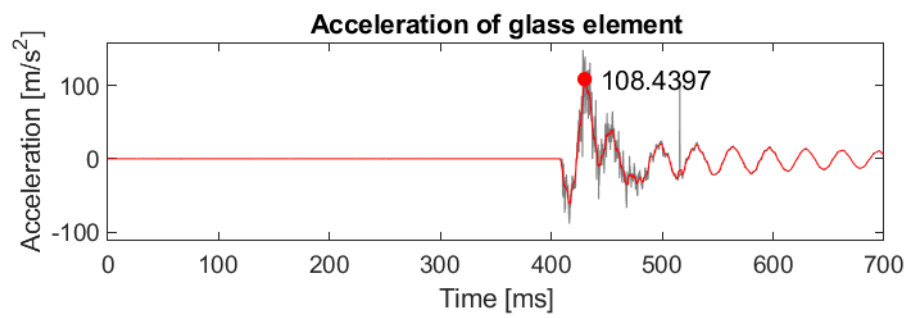
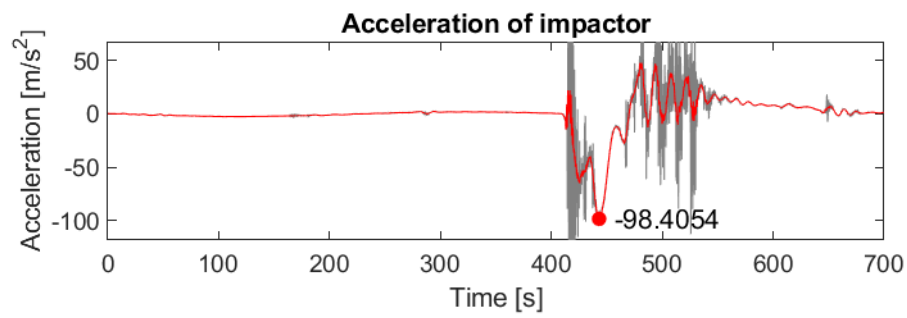
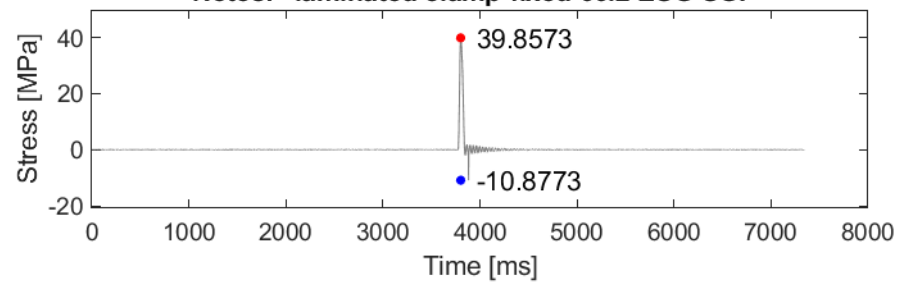
Data nr: 262
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB,cracked glass on pendulum side

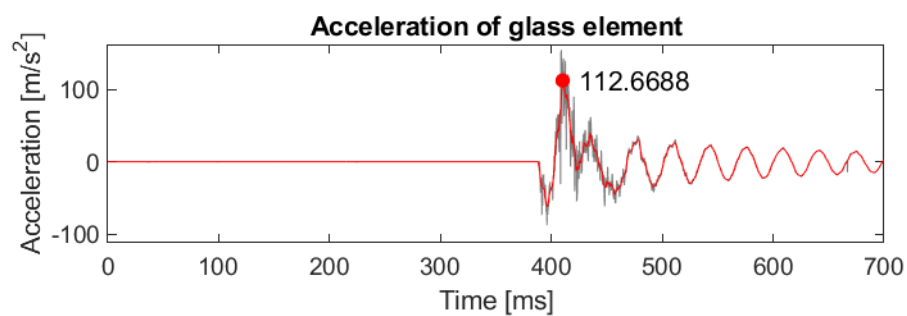
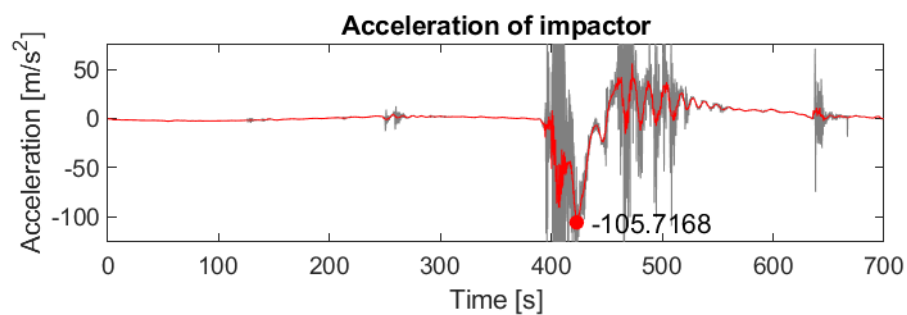
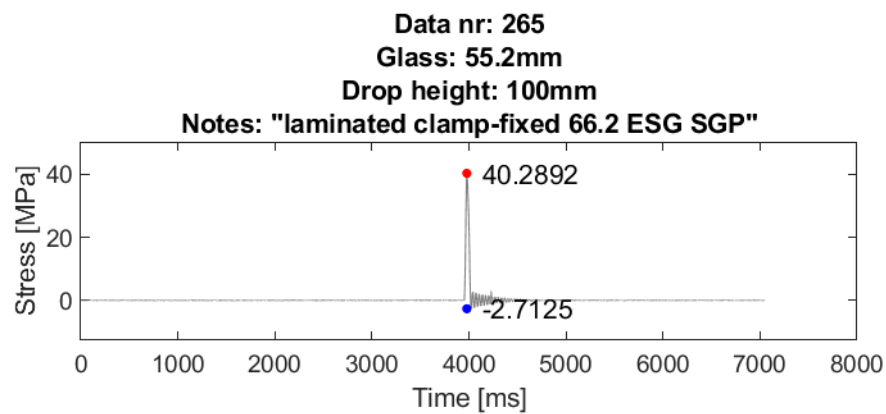


Data nr: 263
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG PVB,cracked glass on pendulum side

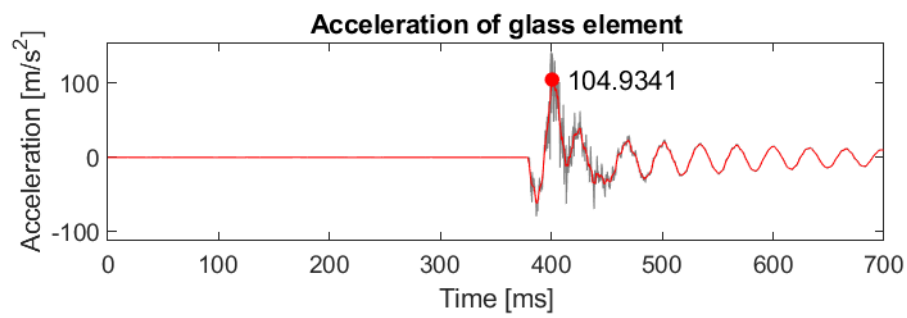
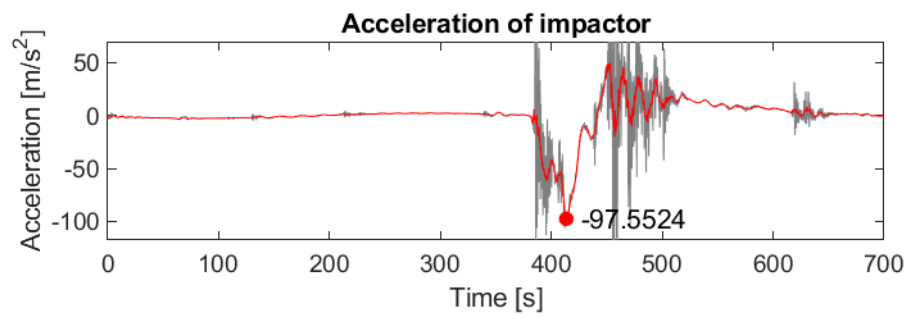
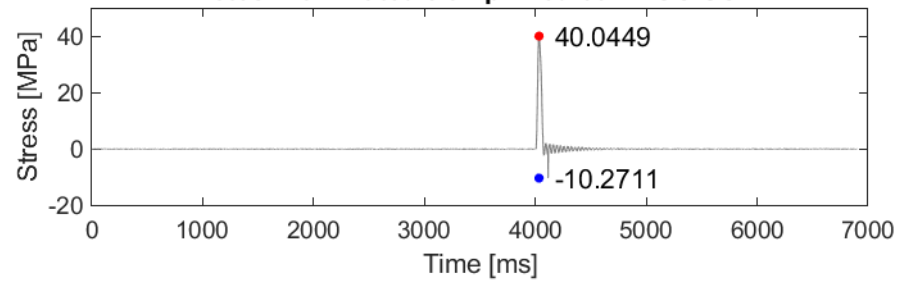


Data nr: 264
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

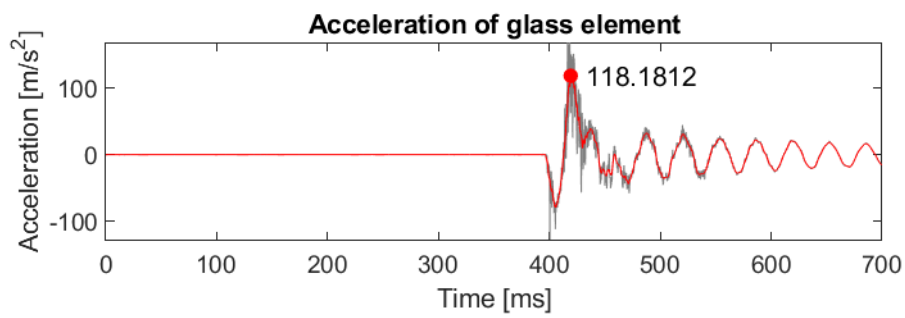
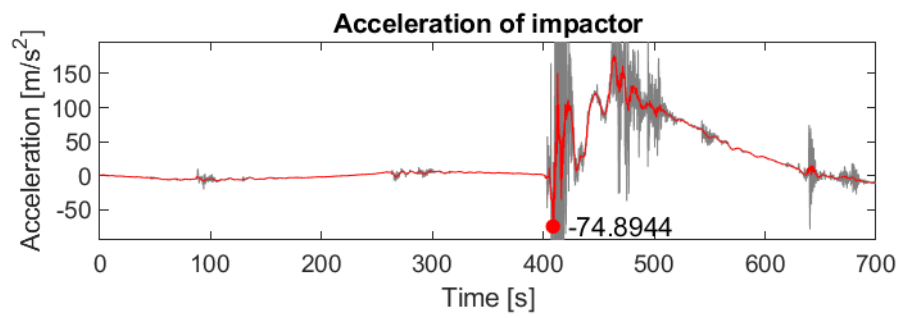
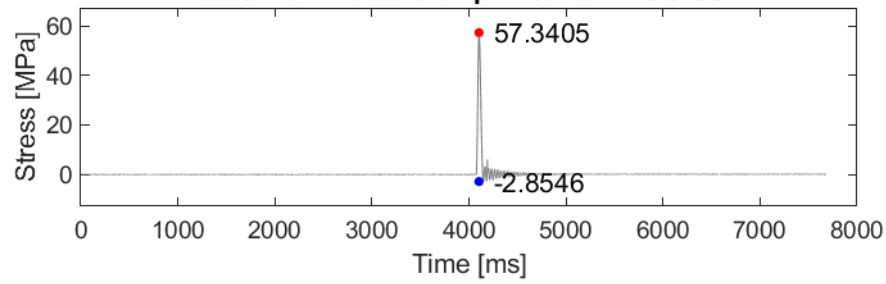




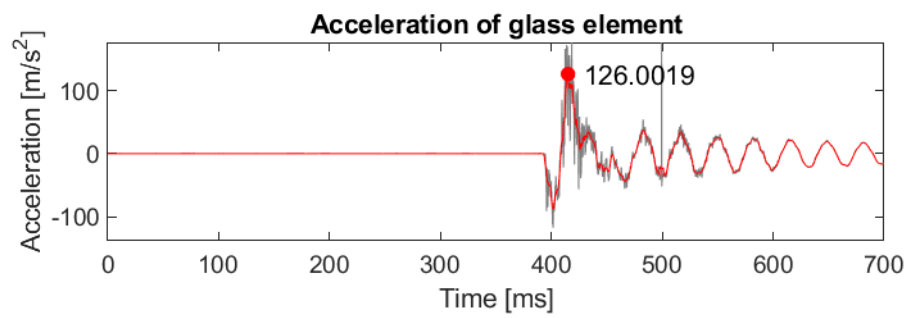
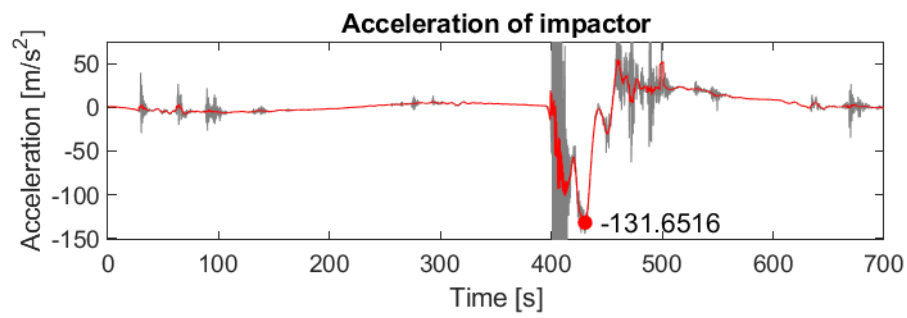
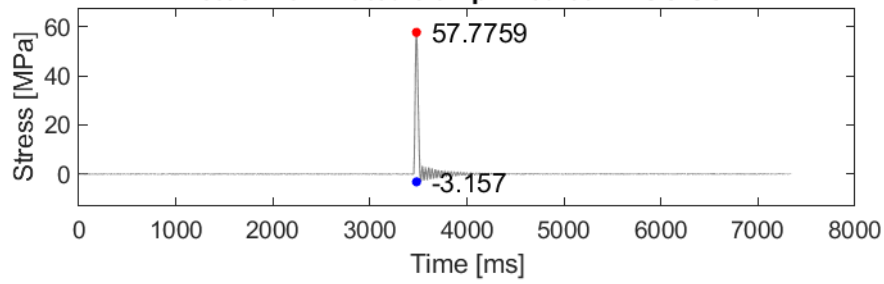
Data nr: 266
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"



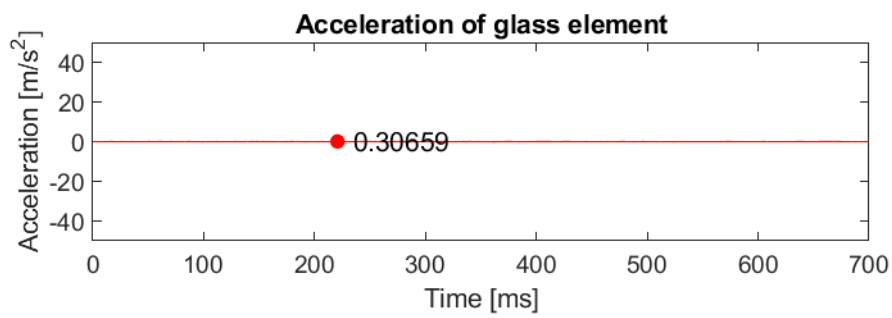
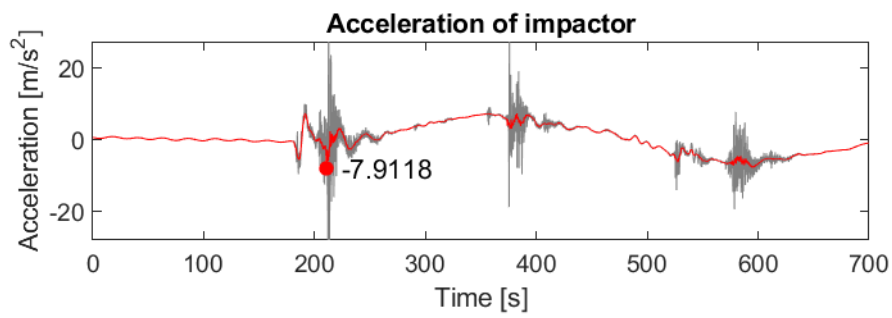
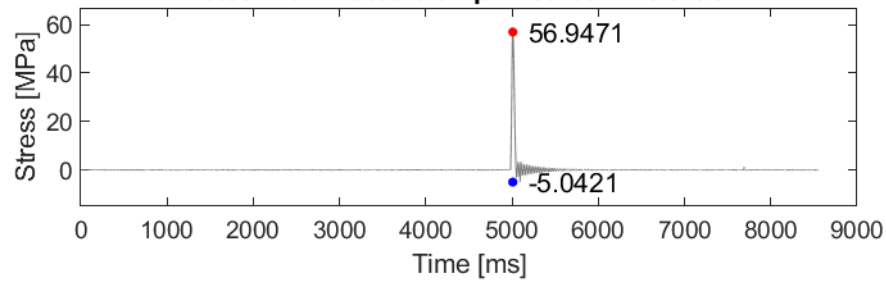
Data nr: 267
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

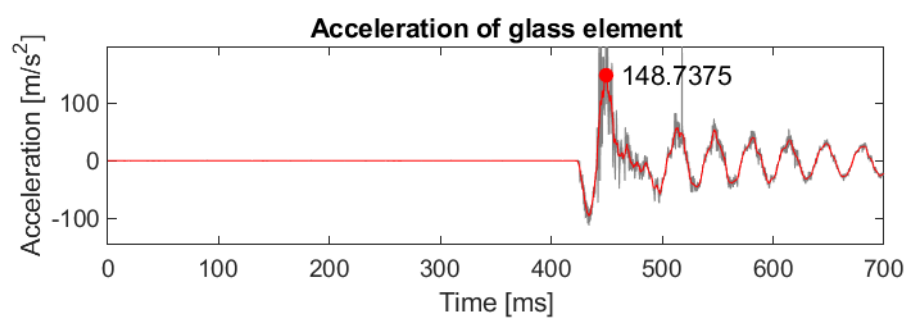
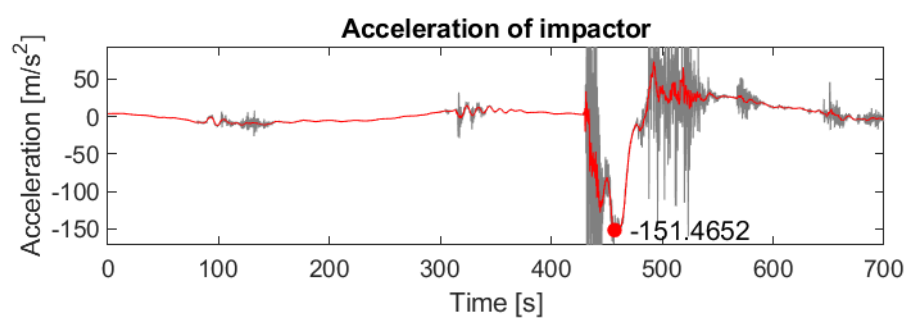
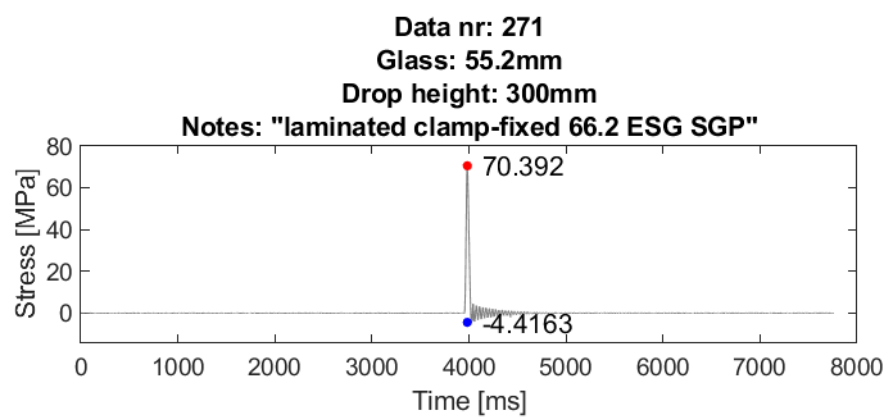


Data nr: 268
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

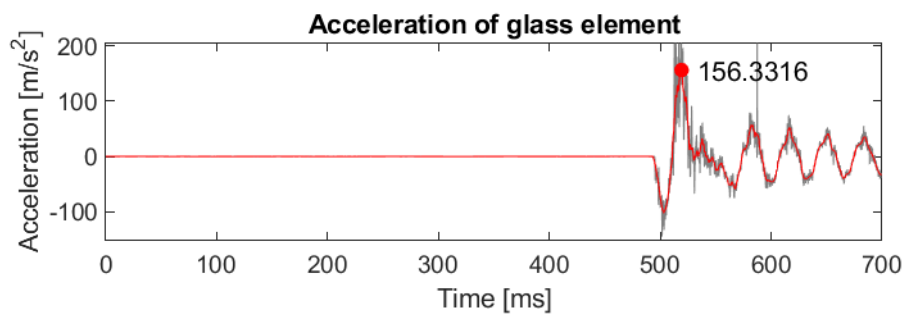
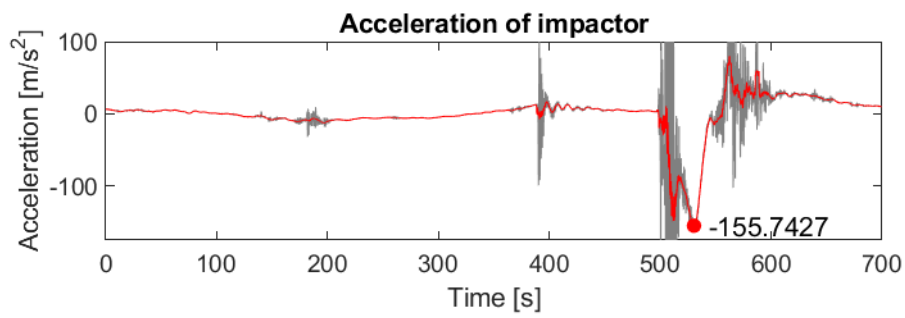
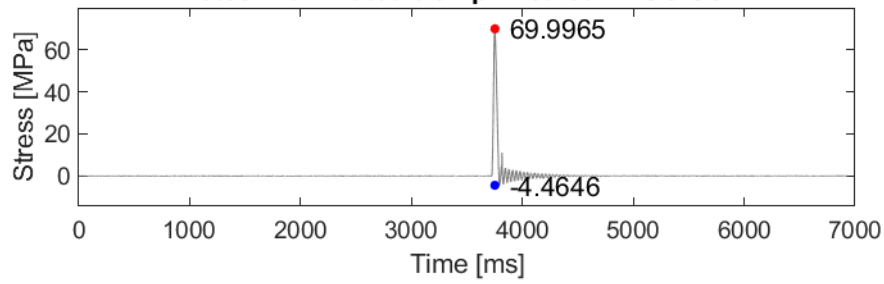


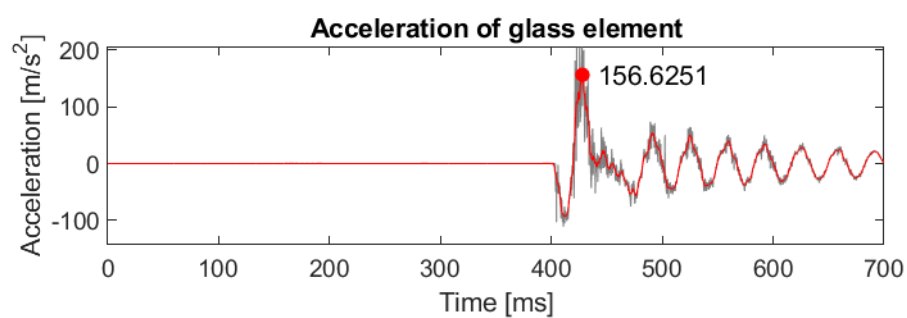
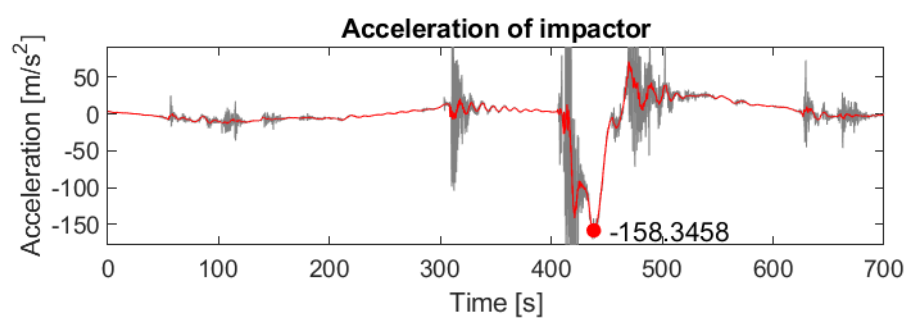
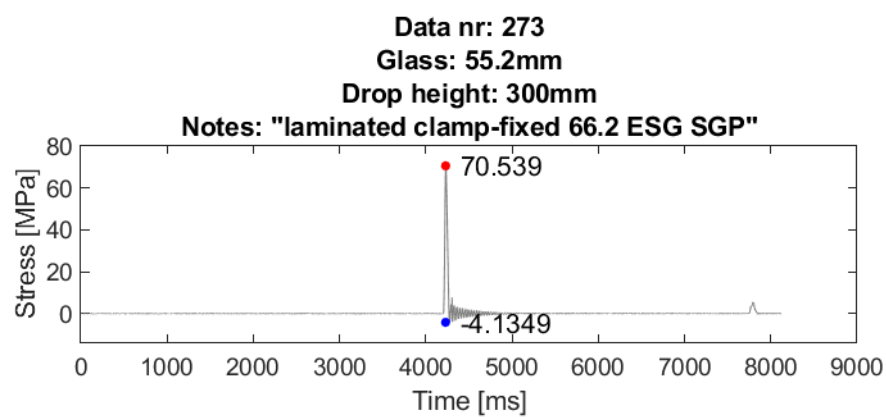
Data nr: 269
Glass: 55.2mm
Drop height: 200mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"



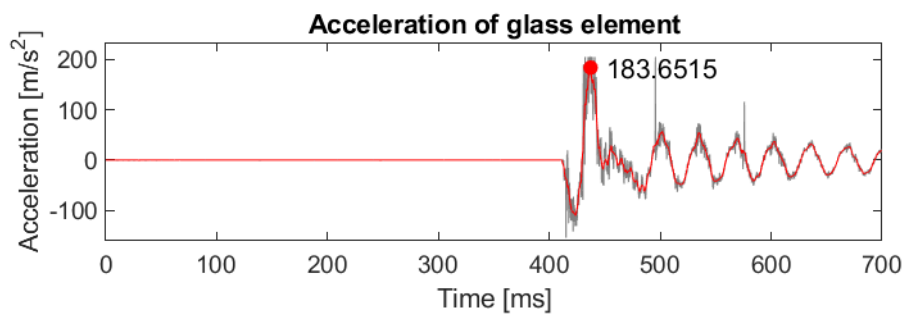
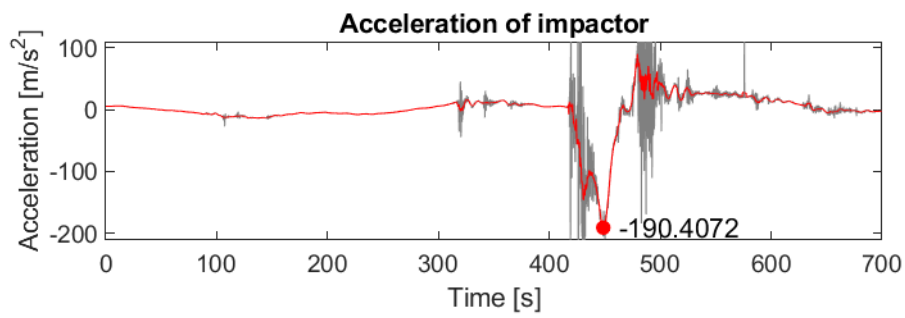
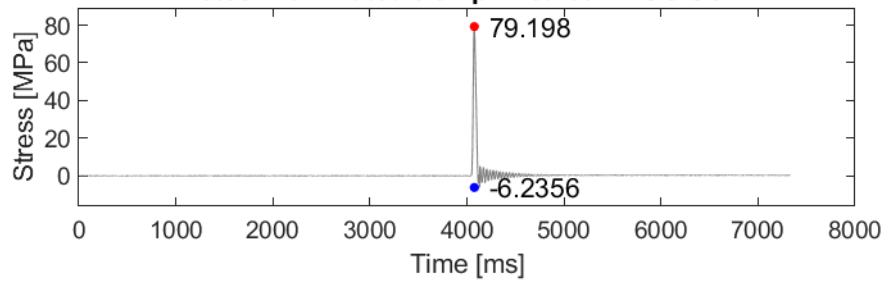


Data nr: 272
Glass: 55.2mm
Drop height: 300mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

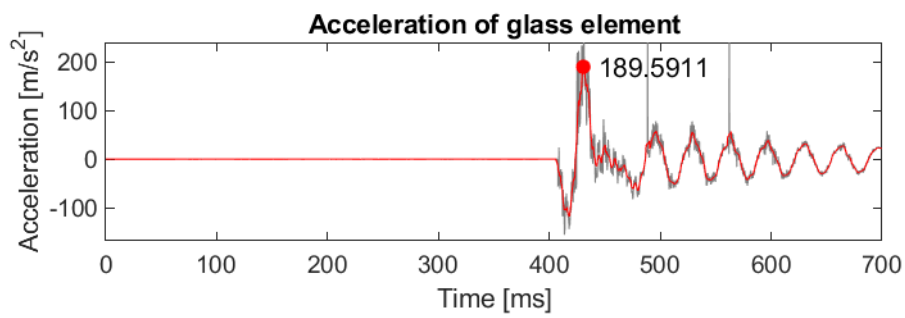
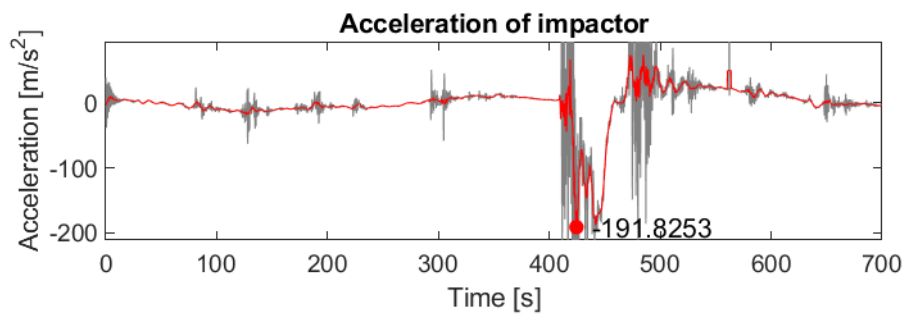
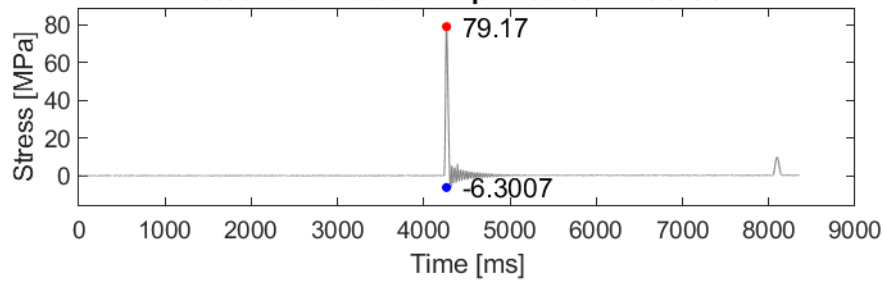




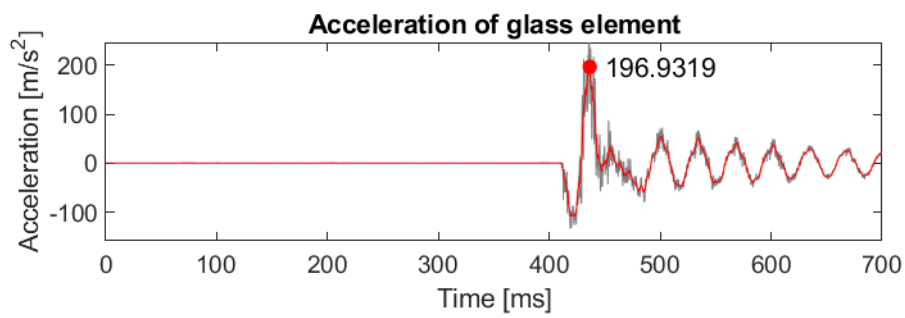
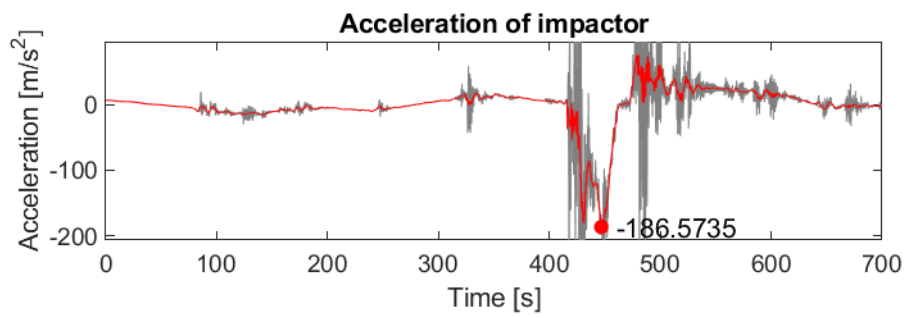
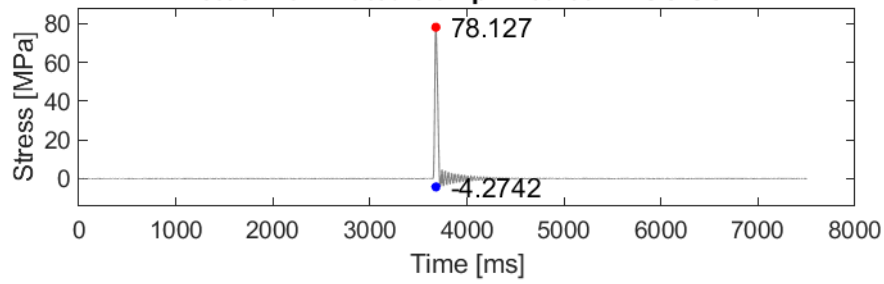
Data nr: 274
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"



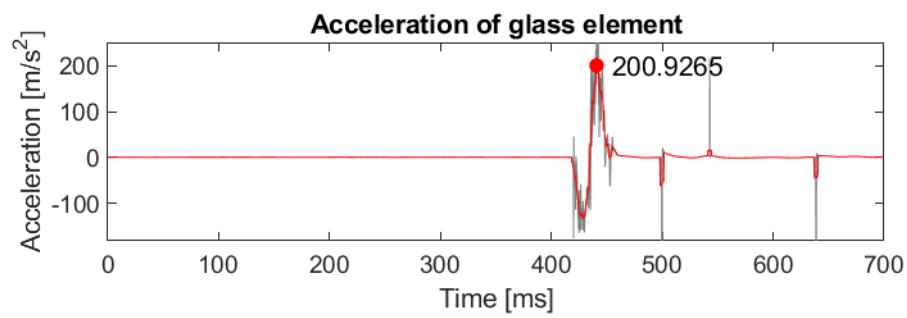
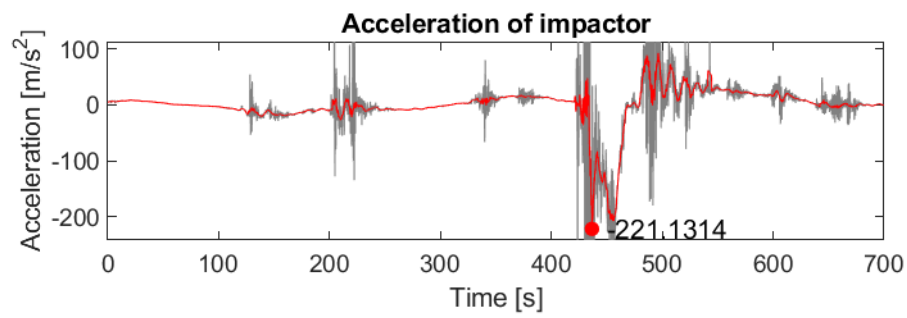
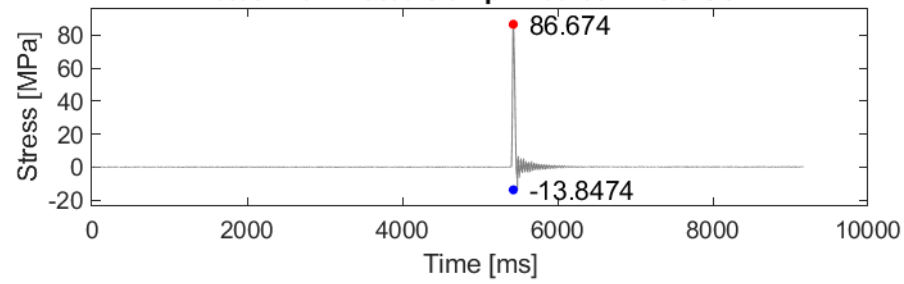
Data nr: 275
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"



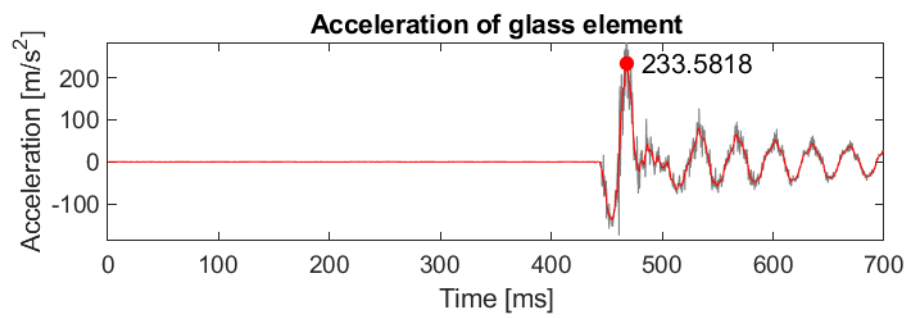
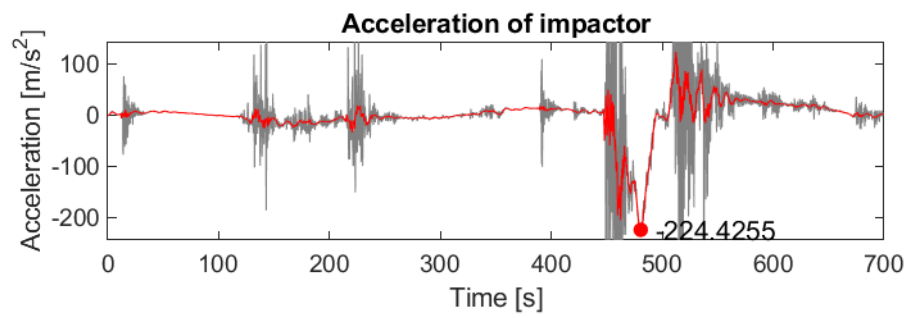
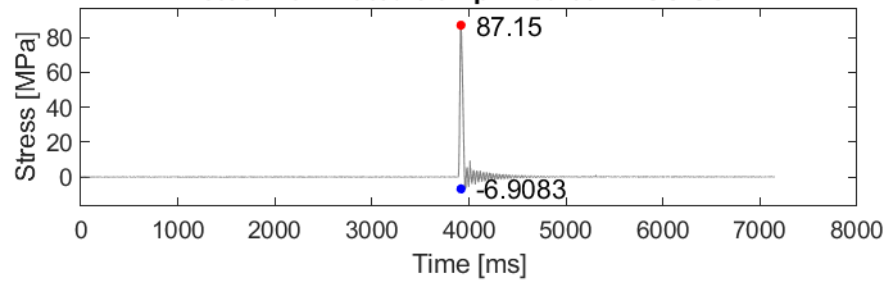
Data nr: 276
Glass: 55.2mm
Drop height: 400mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

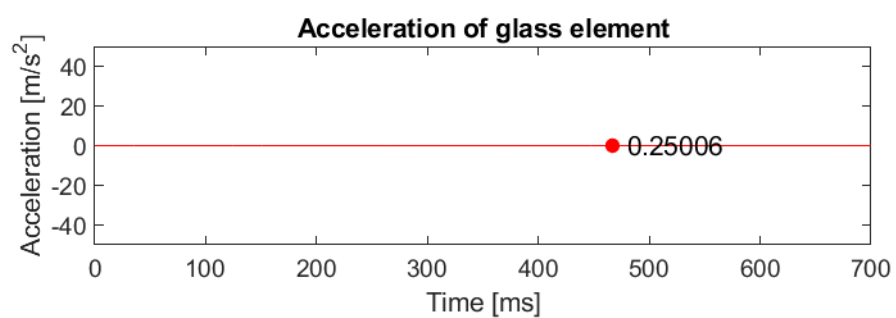
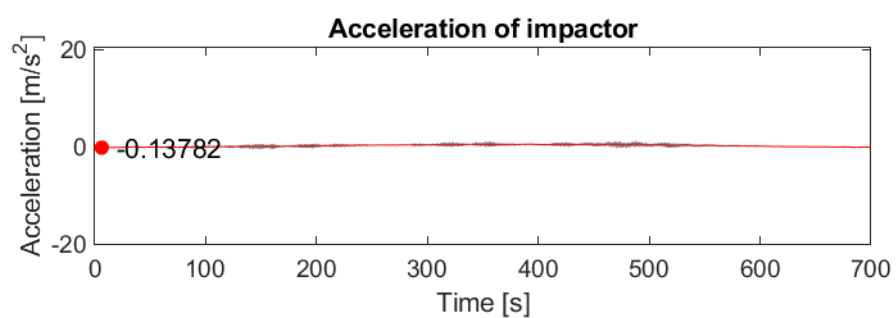
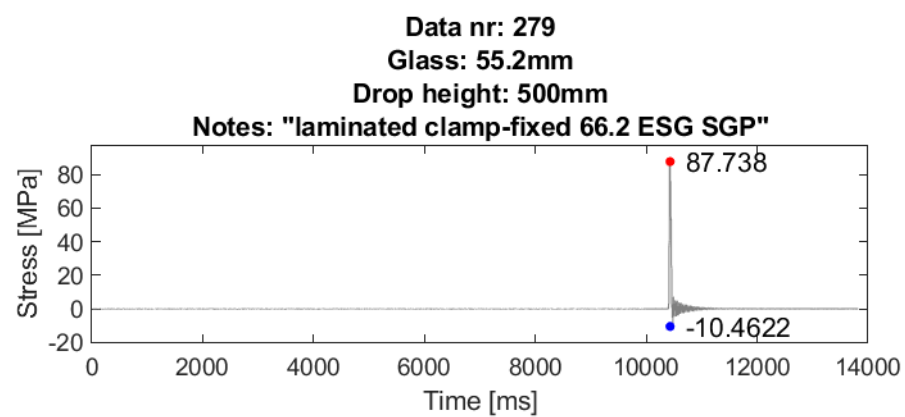


Data nr: 277
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

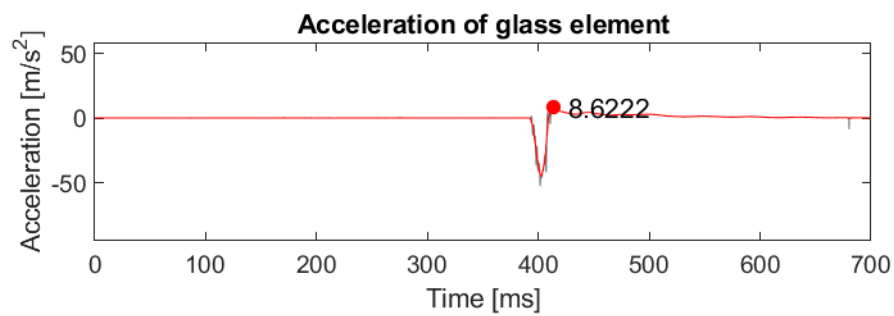
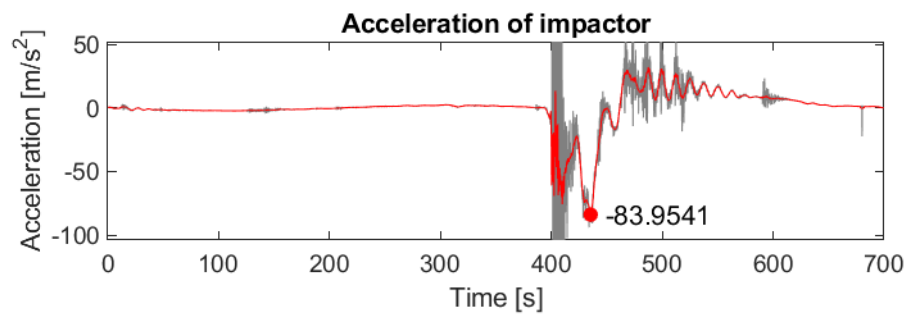
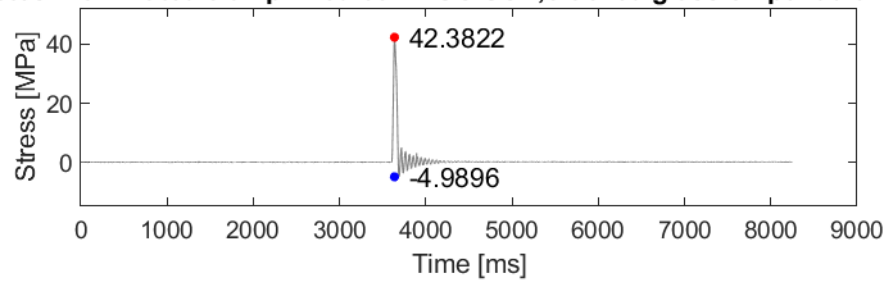


Data nr: 278
Glass: 55.2mm
Drop height: 500mm
Notes: "laminated clamp-fixed 66.2 ESG SGP"

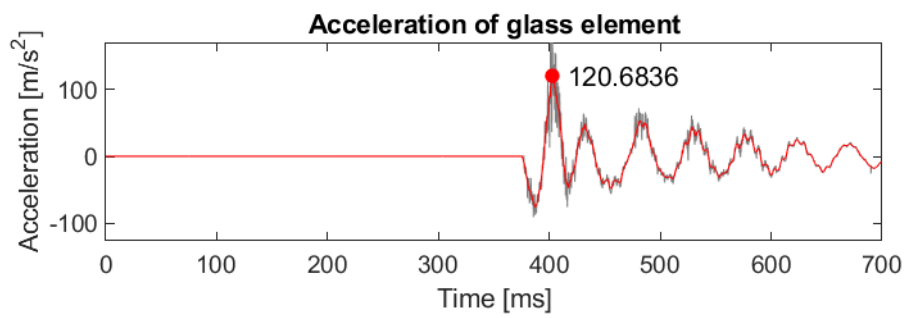
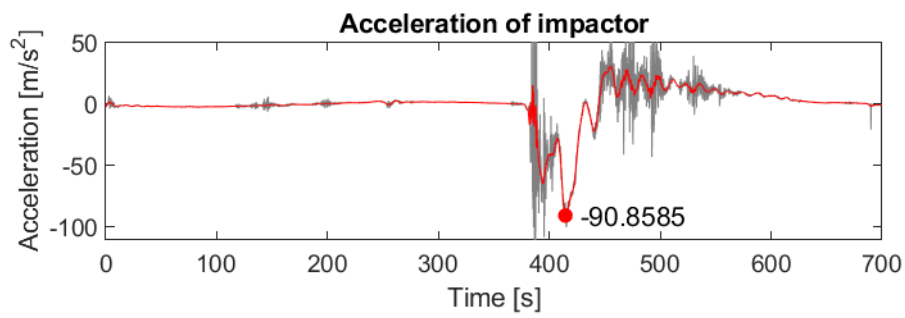
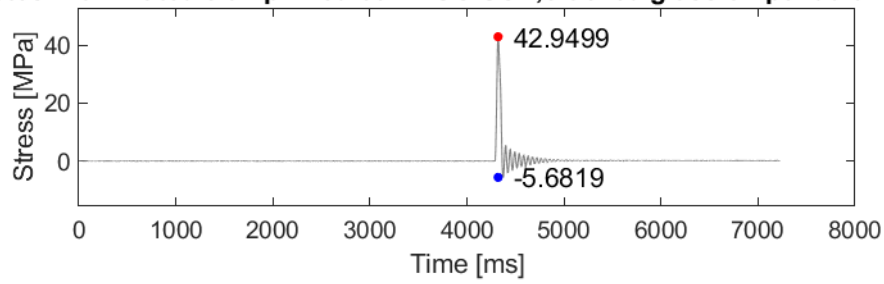




Data nr: 282
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG SGP,cracked glass on pendulum side



Data nr: 283
 Glass: 55.2mm
 Drop height: 100mm
 Notes: "laminated clamp-fixed 66.2 ESG SGP,cracked glass on pendulum side



Data nr: 284
Glass: 55.2mm
Drop height: 100mm
Notes: "laminated clamp-fixed 66.2 ESG SGP,cracked glass on pendulum side

