

Tests Report

Client:	Sn Portugal, Lda.
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Proposal ID:	PSO160/2025
Report ID:	PSR0160/2025 – 3 rd version Cancels and replaces report PSR160/2025 – 2 nd version issued on 21/04/2025
Report issued date:	24/04/2025
Sample receipt date:	07/02/2025

Revision history			
Revision	Identification of the change	Reason for change	Date
0			17/04/2025
1		Comparison with results previously obtained with <i>StudioNeves</i> plates.	21/04/2025
2	Vertical line on the side	Magnification of the y and x-axes on graphs is presented in Figures 3 to 7, as requested by the client.	24/04/2025



1. Objectives

Determination of the multiaxial impact behavior of three plate samples provided by the client with the following references (Figure 1):



Comparison of the results with those obtained with *StudioNeves* stoneware plates and *Studioneves* bioplastic plates analysed in February 2025 (report PIEP PSR073/2025 issued on 26/02/2025).



Figure 1 – Plate samples provided by the client for analysis

2. Experimental procedure

The determination of the multiaxial impact behavior of three plate samples was carried out based on ISO 6603-2:2023 standard and under the test conditions presented in Table 1 (test conditions identical to those employed with the *StudioNeves* stoneware and bioplastic plates).

Table 1 – Experimental test conditions used to determine puncture impact resistance

Test method	ISO 6603-2:2023
Equipment	Ceast Fractovis Plus
Impactor	Hemispherical impactor with a diameter of 20 mm, non-lubricated (Figure 2)
Impact velocity	2,8 m/s
Mass applied	5,045 kg
Test temperature	(23±2) °C
Type of specimen used	Plates provided by the client (Figure 1)
Number of specimens tested	10 plates per sample
Specimen conditioning	More than 24 h at (23±2) °C and (50±10) % relative humidity
Date of the test	14/04/2025



Figure 2 – Test configuration to perform multi-axial impact tests on plates



3. Presentation and interpretation of results

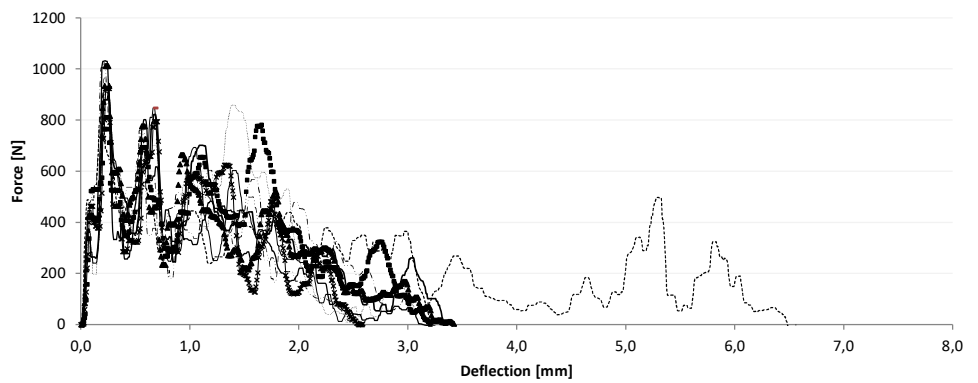
The force *versus* deflection curves recorded in multi-axial impact tests carried out on the plate samples [REDACTED] are shown in Figures 3 to 5. Figures 6 and 7 show the curves obtained with the *StudioNeves* stoneware and bioplastic plates, respectively.

The values of maximum force (F_M), deflection and energy at maximum force (I_M and E_M , respectively), puncture deflection (I_p) and puncture energy (E_p) determined from the aforementioned curves are presented in Tables 2 to 6.

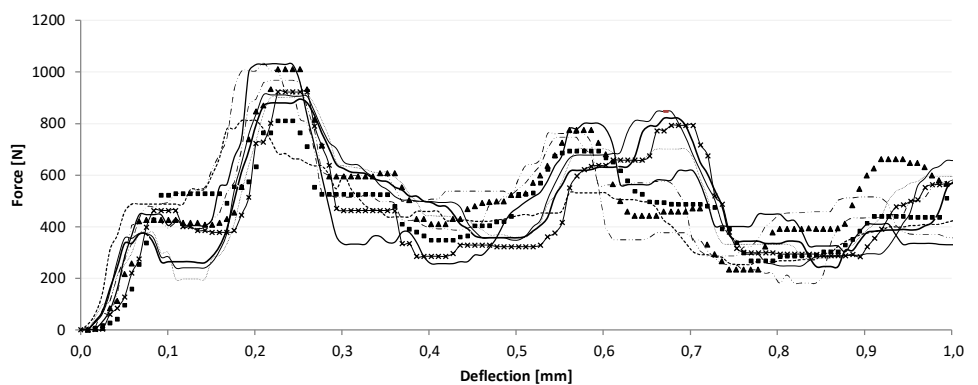
The *StudioNeves* stoneware plates exhibit the highest maximum impact force (F_M), which indicates the material's ability to resist initial puncture, followed in decreasing order of maximum impact force by [REDACTED] alumina stoneware (approximately 25 % lower), *Costa Nova* stoneware (approximately 47 % lower) [REDACTED] porcelain (approximately 69 % lower) and *StudioNeves* bioplastic plates (approximately 82 % lower), as shown in Figure 8.

Concerning impact energy, which reflects the material's ability to absorb energy (E_M) and resist crack propagation (E_p), *StudioNeves* bioplastic plates exhibit a notably higher value (Figures 9 and 10). The energy at maximum force (E_M) of the *StudioNeves* bioplastic plates is about 7 times greater than that of *StudioNeves* stoneware plates, 11 times greater than that of [REDACTED] stoneware plates, 24 times greater than that of *Steelite* alumina stoneware plates and 40 times greater than that of [REDACTED] porcelain plates.

The reduced ability to absorb and dissipate impact energy effectively makes *StudioNaves* stoneware, [REDACTED] porcelain plates more susceptible to cracking (once a crack is initiated, it can rapidly propagate through the material, leading to catastrophic failure), as shown in Figure 11.



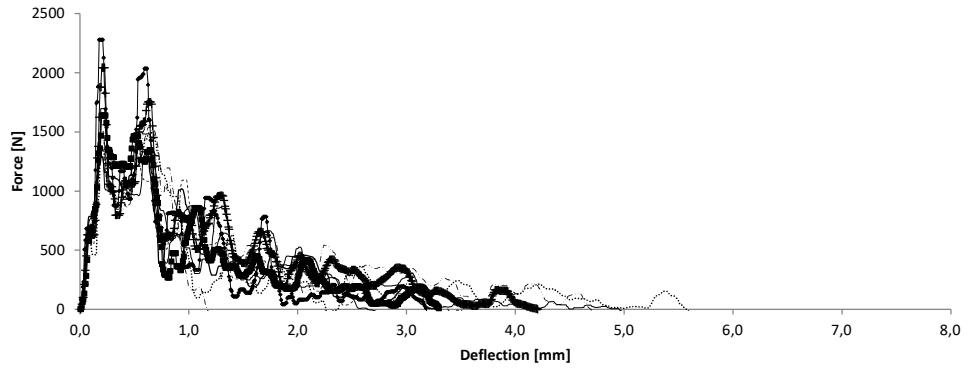
(a) Full-scale axis



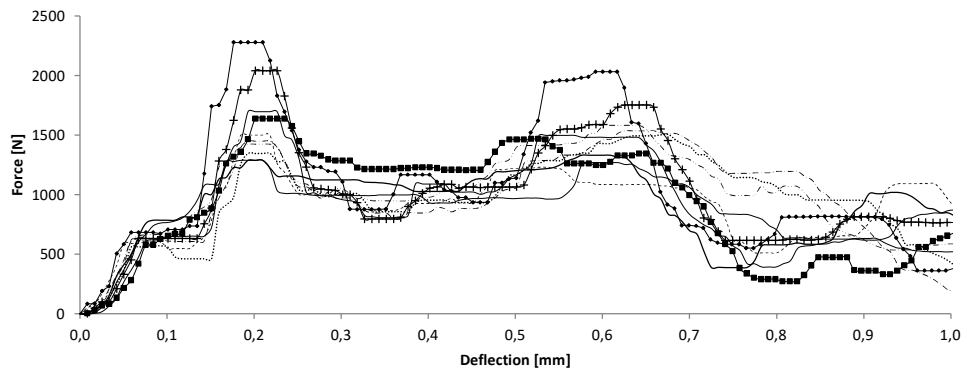
(b) Magnification on the x axis

Figure 3 - Curves of force versus deflection recorded in multi-axial impact tests carried out on [REDACTED] porcelain plates



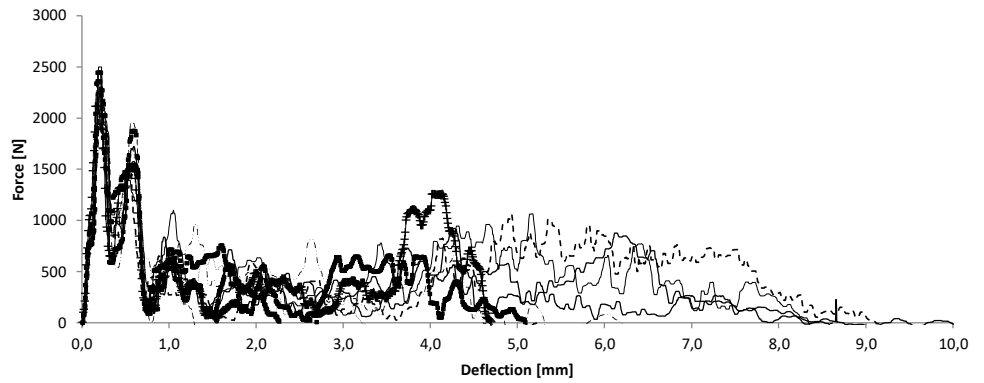


(a) Full-scale axis

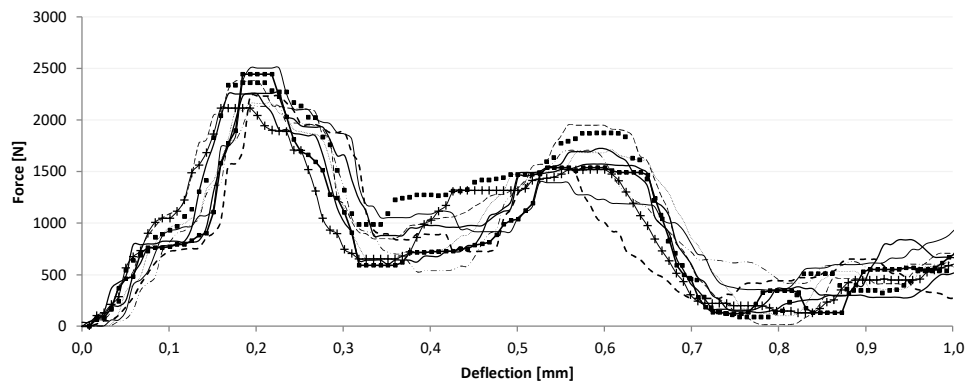


(b) Magnification on the x axis

Figure 4 - Curves of force versus deflection recorded in multiaxial impact tests carried out on [redacted] stoneware plates

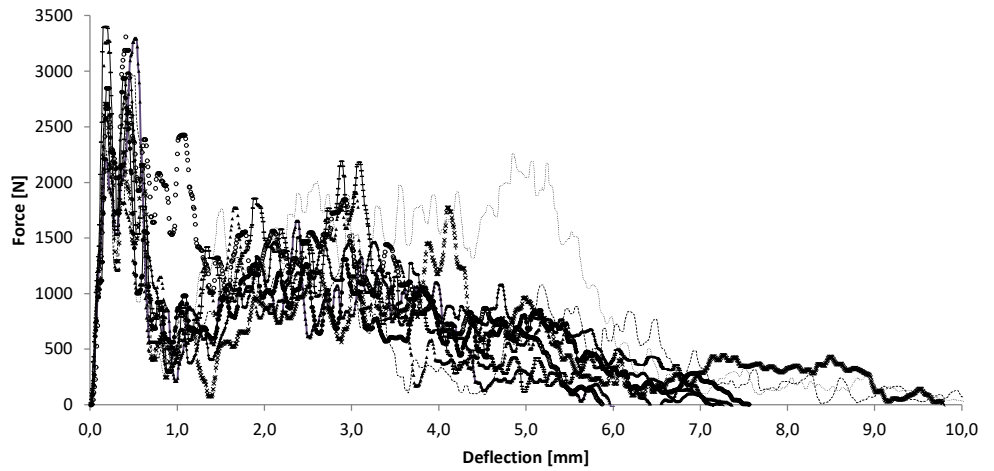


(a) Full-scale axis

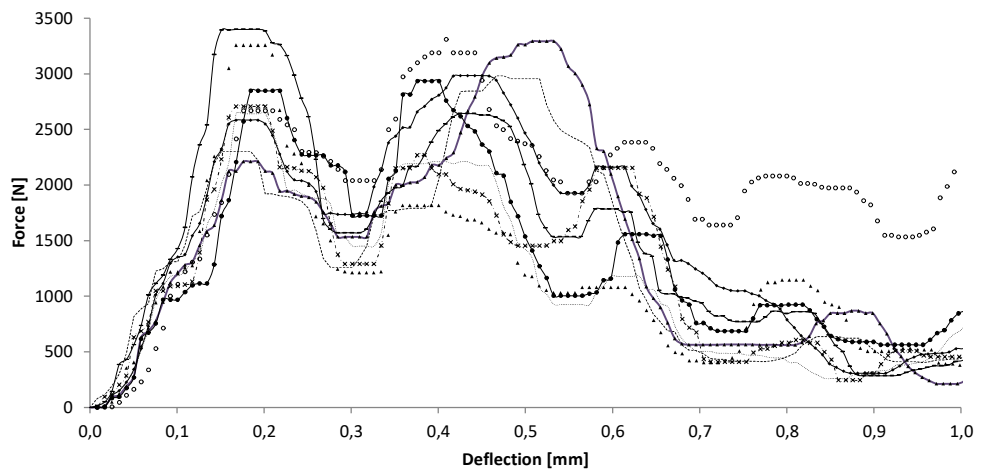


(b) Magnification on the x axis

Figure 5 - Curves of force versus deflection recorded in multiaxial impact tests carried out on ██████████ alumina stoneware plates

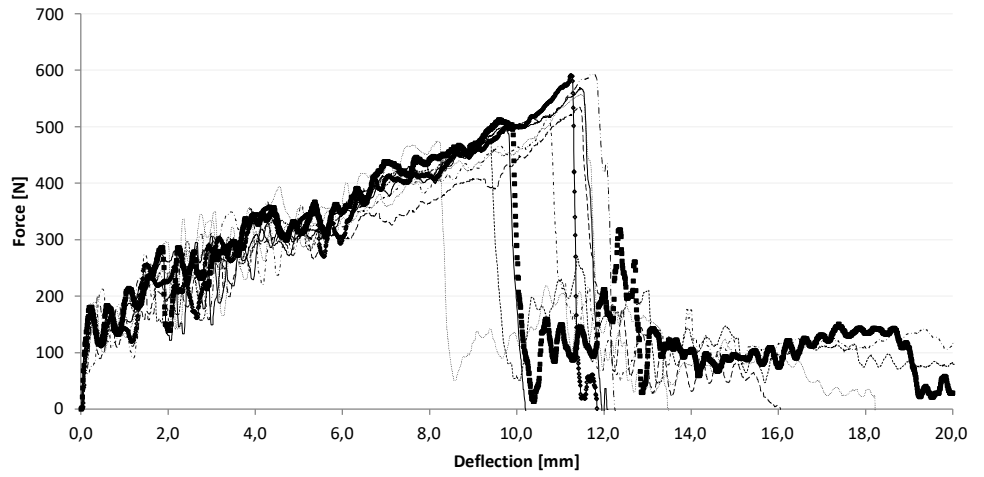


(a) Full-scale axis

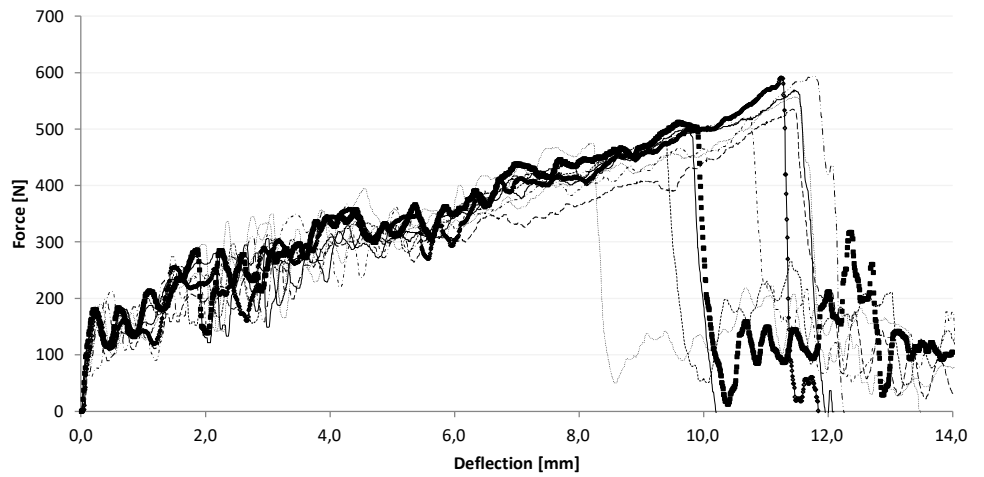


(b) Magnification on the x axis

Figure 6 - Curves of force versus deflection recorded in multiaxial impact tests carried out on *StudioNeves* stoneware plates



(a) Full-scale axis



(b) Magnification on the x axis

Figure 7 - Curves of force versus deflection recorded in multi-axial impact tests carried out on *StudioNeves* bioplastic plates

Table 2 – Puncture impact behaviour [ISO 6603-2:2023] of the [redacted] porcelain plates

Specimen	F _M (N)	l _M (mm)	E _M (J)	l _p (mm)	E _p (J)
1	911	0,21	0,06	0,44	0,22
2	896	0,25	0,10	0,44	0,21
3	812	0,18	0,08	0,68	0,34
4	811	0,23	0,09	0,38	0,18
5	1034	0,21	0,10	0,29	0,17
6	923	0,23	0,07	0,37	0,17
7	914	0,25	0,09	0,39	0,19
8	1011	0,23	0,09	0,38	0,20
9	1032	0,22	0,09	0,29	0,15
10	969	0,22	0,08	0,60	0,33
Average	931	0,22	0,09	0,43	0,22
Standard deviation	81	0,02	0,01	0,13	0,07



Table 3 – Puncture impact behaviour [ISO 6603-2:2023] of the [redacted] stoneware plates

Specimen	F _M (N)	l _M (mm)	E _M (J)	l _p (mm)	E _p (J)
1	1289	0,18	0,12	0,81	0,76
2	1582	0,60	0,62	0,86	0,93
3	1536	0,63	0,58	0,90	0,93
4	1500	0,18	0,10	0,75	0,71
5	1331	0,58	0,57	0,71	0,72
6	1636	0,20	0,13	0,72	0,81
7	1503	0,67	0,63	0,93	0,93
8	2041	0,20	0,15	0,30	0,30
9	1695	0,19	0,12	0,33	0,28
10	2041	0,18	0,12	0,30	0,34
Average	1615	0,36	0,31	0,66	0,67
Standard deviation	256	0,22	0,25	0,25	0,26

Table 4 – Puncture impact behaviour [ISO 6603-2:2023] of the [REDACTED] alumina stoneware plates

Specimen	F _M (N)	l _M (mm)	E _M (J)	l _p (mm)	E _p (J)
1	2501	0,19	0,16	0,33	0,44
2	2233	0,19	0,13	0,33	0,39
3	2133	0,19	0,13	0,31	0,36
4	2161	0,19	0,15	0,31	0,37
5	2259	0,19	0,13	0,67	0,81
6	2116	0,16	0,12	0,65	0,78
7	2376	0,18	0,18	0,67	0,94
8	2361	0,18	0,18	0,66	0,95
9	2250	0,17	0,12	0,66	0,79
10	2444	0,18	0,13	0,30	0,36
Average	2283	0,18	0,14	0,49	0,62
Standard deviation	133	0,01	0,02	0,18	0,26



Table 5 – Puncture impact behaviour [ISO 6603-2:2023] of the *StudioNeves* stoneware plates

Specimen	F _M (N)	l _M (mm)	E _M (J)	l _p (mm)	E _p (J)
1	2827	0,43	0,74	0,62	1,17
2	2981	0,47	0,76	0,62	1,16
3	2640	0,17	0,14	0,52	0,84
4	3293	0,51	0,90	0,62	1,21
5	3310	0,41	0,75	0,71	1,45
6	3257	0,17	0,19	0,46	0,75
7	2934	0,38	0,60	0,51	0,92
8	2983	0,43	0,75	0,66	1,30
9	3399	0,17	0,21	0,63	1,25
10	2706	0,17	0,15	0,66	1,10
Average	3033	0,33	0,52	0,60	1,12
Standard deviation	268	0,14	0,31	0,08	0,22

Table 6 – Puncture impact behaviour [ISO 6603-2:2023] of the *StudioNeves* bioplastic plates

Specimen	F_M (N)	l_M (mm)	E_M (J)	l_p (mm)	E_p (J)
1	501	9,69	3,01	9,93	3,12
2	535	11,42	3,52	11,74	3,65
3	482	9,23	2,80	9,56	2,95
4	512	9,59	3,11	10,02	3,32
5	569	11,44	3,88	11,74	4,03
6	590	11,23	3,83	11,35	3,90
7	475	8,15	2,54	8,35	2,63
8	557	11,46	3,80	11,78	3,96
9	594	11,75	4,14	12,14	4,34
10	519	10,71	3,38	10,93	3,48
Average	533	10,47	3,40	10,76	3,54
Standard deviation	43	1,22	0,52	1,23	0,54

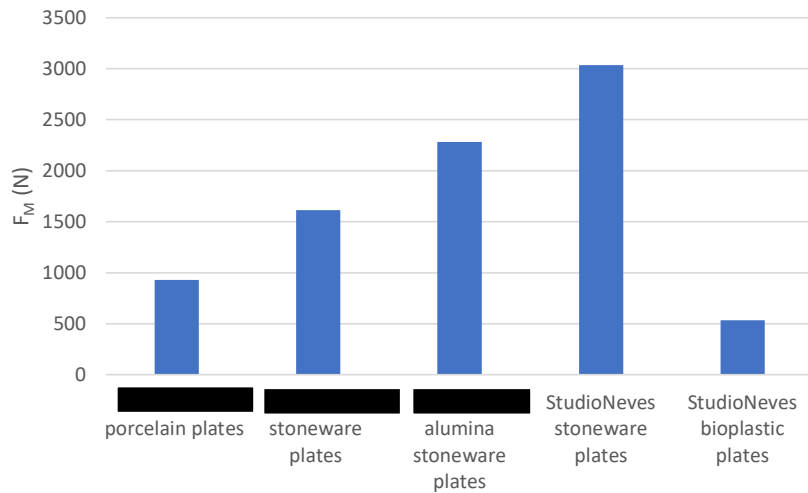


Figure 8 - Maximum impact force (F_M) obtained for samples analysed

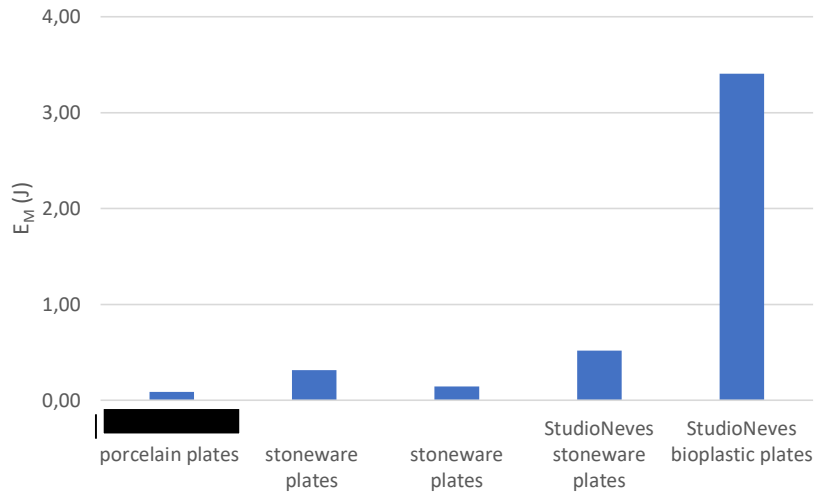


Figure 9 – Energy at maximum impact force (E_M) obtained for samples analysed

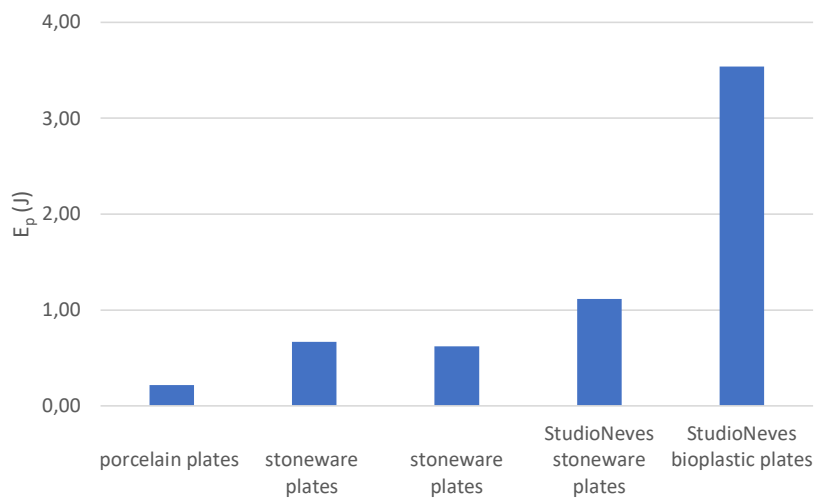


Figure 10 – Puncture energy (E_P) obtained for samples analysed

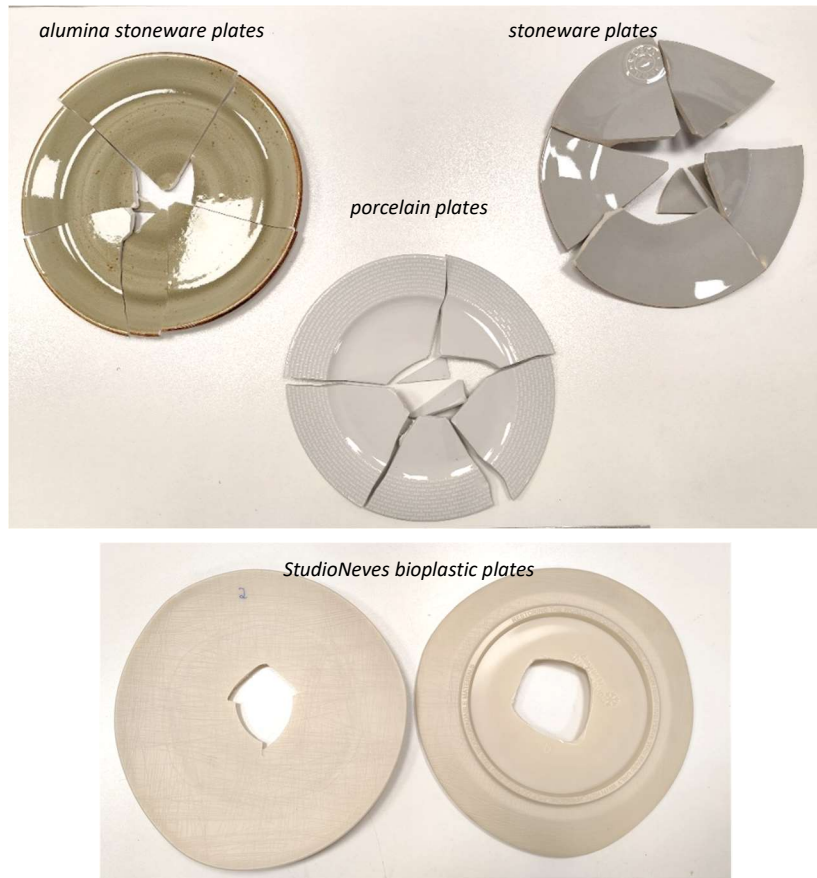


Figure 11 - Failure mode observed in plate samples subjected to multi-axial impact tests

Report approved by:



Paula Peixoto

Tests and Failure Analysis | Coordinator