MECHANICAL PROPERTIES OF SELF-SUPPORTING DOUBLE SKIN METAL FACED INSULATING PANELS

for

TP MA
Thermal Panel
Manufacturers Association

C/o AAAMSA Group

Precool
Flat Profile 100mm Thick
Expanded Polystyrene Panel

Tested in accordance with
EN 14509:2006
(DSS SANS 54509:2012)

Project number: TTL 12/031

Report date: 29 November 2012

THERMAL TEST LABORATORY CC.
(Reg. Nr. 2005/124190/23)

TTL
THERMAL TEST LABORATORY

Building 28,
CSIR campus
Meiring Naude Drive
Brummeria
PRETORIA 0184
(012) 349 1023

Part 1
Summary of Results

EN 14509:2006
(DSS SANS 54509:2012)

Expanded Polystyrene Wall/Ceiling Panels.

Reference: Precool EPS Panels.
Insulation: Expanded Polystyrene (EPS).
Panel Thickness: 100 mm. Panel Width: 1.135 m
Core Density: 16.5 kg/m^3. Panel Mass: 9.75 kg/m^2.
Facings: Steel; 0,55 mm external, 0,55 mm internal.
Coating: Chromodek (White).

Use: External and internal walls and roofs

Thermal Transmittance:	
RGHB (*System*)	0,755 W/m^2·K
FOX 314 (*Core*)	0,410 W/m^2·K
Thermal Conductivity:	
RGHB (System)	0,075 W/m·K
FOX 314 (*Core*)	0,037 W/m·K
Tensile strength:	
Initial Set	135,3x10^{-3} MPa
Repeated Loading	65,7x10^{-3} MPa
Durability (6 weeks)	60,2x10^{-3} MPa
Durability (24 weeks)	130,3x10^{-3} MPa
Compressive strength:	92,9x10^{-3} MPa
Shear modulus of core:	
Shear strength test	2,638 MPa
Bending Strength test	2,682 MPa
Bending moment capacity:	
Span	4,781 kNm/m
Internal support (downward load)	3,888 kNm/m
Internal support (uplift load)	2,993 kNm/m
Wrinkling Stress:	
Span	88,515 MPa
Internal support (downward load)	71,984 MPa
Internal support (uplift load)	55,417 MPa
Support reaction capacity:	1,108x10^4 N
Rain penetration:	300 Pa
Air permeability (*Total*)**:**	
40 Pa	2,08 m^3/m^{2}h
52 Pa	2,74 m^3/m^{2}h
68 Pa	3,67 m^3/m^{2}h
89 Pa	4,44 m^3/m^{2}h
117 Pa	6,01 m^3/m^{2}h
153 Pa	6,87 m^3/m^{2}h
200 Pa	8,75 m^3/m^{2}h
Resistance to point loads:	Class A

Thermal Test Laboratory
Facility Accreditation Number: T0409

Building 28, CSIR Campus,
Meiring Naude Road,
Brummeria, Pretoria,
Gauteng

PO Box 72169,
Lynnwood Ridge, Pretoria,
Gauteng
0040

Tel: +2712 349 2929
Fax: +2712 349 1519
E-mail: peet@firelab.co.za

Precool Manufacturing
(1969) (Pty) Ltd

429 Carl Street,
Pretoria West
Gauteng

PO Box 4053,
Pretoria,
Gauteng
0001

Tel: +2712 327 1291
Fax: +2712 327 1294
E-mail: info@precool.co.za

This page intentionally left blank

Contents

Page

1 Part 1: Summary of Results……..2

2 Contents…..……5

3 Normative References……...6

4 Symbols and abbreviations……...6
4.1 Effective use of the electronic report…… 8

5 Part 2: Test Results…… 9
5.1 Cross panel Tensile Strength and modulus of core material……...10
5.1.1 Initial Set……10
5.1.2 Repeated Loading……12
5.1.3 Durability Testing (DUR1)……...13
5.1.3.2 DUR1: 6 weeks……..……13
5.1.3.3 DUR1: 24 weeks……..…… 14
5.2 Compressive Strength and modulus of core material…….. 15
5.3 Shear Strength and modulus of core material……... 17
5.4 Bending Moment Capacity and stiffness of a simply supported panel…….. 20
5.5 Creep Deflection (1000 hours)…… 24
5.6 Interaction between bending moment and support force……24
5.7 Resistance to point loads……..28
5.8 Thermal transmittance……...29
5.9 Thermal conductivity……..31
5.10 Rain Penetration……32
5.11 Air permeability……... 34
5.12 Support reaction capacity at end of panel……..36

6 Part 3: Test Graphs and supplementary reports……..……39
Tensile Test: Initial Set……40
Tensile Test: Repeated Loading……47
Tensile Test: DUR1: 6 weeks…… 54
Tensile Test: DUR1: 24 weeks…….. 61
Compression Test……68
Shear Strength…….. 75
Bending moment capacity……... 82
Support force: Downward Load……... 89
Support force: Uplift Load…… 96
Thermal Transmittance (*Report*)……..103
Thermal Conductivity (*Report*)……..……107
Support reaction capacity……... 111

7 Conclusion……..……119

3 Normative References

The following standards were used and are required for full understanding of results reported within this document. Only the dated referenced standards apply to this document. Where no dates are specified the latest edition applies.

ASTM C518:2010, *Steady state thermal properties by means of the heat flow meter apparatus.*

ASTM C1363:2011, *Thermal performance of building materials and envelope assemblies by means of a hot box apparatus.*

EN 826:1996, *Thermal insulating products for building applications – Determination of compression behaviour.*

EN 1602:1997, *Thermal insulating products for building applications – Determination of apparent density.*

EN 1607:1997, *Thermal insulating products for building applications – Determination of tensile strength perpendicular to faces.*

EN 12114:2000, *Thermal performance of buildings – Air permeability of building components and building elements – Laboratory test method.*

EN 12865:2001, *Hygrothermal performance of building components and building elements – Determination of the resistance of external wall systems to driving rain under pulsating air pressure.*

EN 14509:2006 (DSS SANS 54509:2012), also referred to as ***the Standard***, *Self-supporting double skin metal faced insulating panels – Factory made products – Specifications.*

4 Symbols and abbreviations

For the purpose of this report the following symbols and abbreviations apply.

A cross-sectional area

B flexural rigidity, overall width of the panel/specimen, width of support

D overall depth of the panel

E modulus of elasticity

F force, load, support reaction, face

G shear modulus

I moment of inertia

L span, distance, load

M bending moment

R thermal resistance

U thermal transmittance

V volume

W *weight*

b width of test specimen, width of plate
c y-axis intersect
d depth of core
e distance between centroids of faces
f strength, reduction factor
h thickness
k parameter, thermal conductivity
l length
m mass, gradient of curve,
n number of tests, number of screws
t thickness of face sheet
w displacement
λ thermal conductivity
φ creep coefficient
σ stress, compressive stress
ρ density

Subscripts

C core
F face
G self-weight,
S system
c compression, core
lin linear
n nominal
s support
t tension, time
th thermal
u ultimate
v shear
0 basic value, unit width, time (e.g. $t = 0$), lower limit
1 external face, upper face, upper limit
2 internal face, lower face,

Abbreviations

ITT initial type testing
EPS expanded polystyrene

4.1 Effective use of the electronic report

This is a hyperactive report. The report is intended to be used in its electronic format to allow for easy navigation through the report's contents.

The following active links is available (access by a single left click):

- The entire ***Contents*** section is hyperactive and any part of the document can be accessed by clicking on the relevant heading.
- All ***headings*** and ***Cover Pages*** are hyperactive and clicking on a ***heading*** will return you to the ***Contents*** section***.***
- Where reference is made to a ***previous section*** of the report, clicking on the ***section number*** will navigate you to the referenced ***section***.
- Where ***standards*** are mentioned in the report, clicking on the ***standard*** will navigate you to the ***Nominative Reference*** section.
- You will be navigated to the ***Symbols and abbreviations*** section when clicking on any ***formula*** or ***equation***.
- Clicking on a ***specimen number*** in a ***Table*** will navigate you to the specimen's graph generated from the test data.
- In all ***Summary of Results Tables*** clicking on the ***Table heading*** will take you to the ***overlay graph*** or ***report*** evaluating all specimens in the test set.
- All the results given in ***Part 1: Summary of Results*** of the report are hyperactive and clicking on a result will take you to the relevant ***Summary of Results Table***.
- The Graphs given in ***Part 3: Test Graphs*** has easy navigation links on the top of the page giving you access to the ***Contents***, other ***Specimen Graphs*** and the ***Summary of Results Table*** pertaining to the test set.

Part 2
Test Results

5.1 Cross panel tensile test

5.1.1 Initial Set

5.1.1.1 Dimensions and densities

A full length panel was divided into three equal sections and 5 specimens of nominal 100 mm by 100 mm were extracted from these sections. Specimen 1 and 2 came from opposing quarters of the first section, specimen 3 from the centre section and specimen 4 and 5 from opposing quarters of the final section

The dimensions and densities of the initial set were determined according to EN 1602. The specimens were measured at 12 points, 4 for each linear dimension and the average thickness, length and width are given in Table 1. The specimens were weighed and the density calculated from the volume (V) and the mass (*m*) of each specimen:

$$\rho = \frac{m}{V}$$

Specimen number	Thickness mm	Length mm	Width mm	Mass g	Volume m^3	Density kg/m^3
1	99.0	101.2	100.8	100.45	0.001009	99.6
2	99.1	100.7	101.1	99.95	0.001008	99.2
3	99.0	101.0	101.2	100.90	0.001011	99.8
4	98.9	100.6	100.5	99.45	0.001000	99.5
5	98.9	100.5	101.0	100.40	0.001004	100.0

Table 1 – Dimensions and densities of the initial set specimens for the cross panel tensile test.

5.1.1.2 Calculations

The tests procedure of EN 1607 was followed and the results reported according to ***the Standard*** section A1. The inner and outer faces of the 100 mm by 100 mm specimens were adhered to timber squares secured to the tensile grips of the Hounsfield 5 kN tensile test bench (Figure 1). The grips are then separated at a speed of 10 mm per minute.

A load-deflection curve is generated from the results. The tensile strength of the core material (f_{Ct}) is determined by the ultimate load (F_u) from the test divided by the cross-sectional area (A) of the specimen.

$$f_{Ct} = \frac{F_u}{A}$$

The linear part of the curve is extended to intersect the ultimate load (F_u) line and the displacement at this point is used as the upper limit (w_{u1}) of the ideal displacement at ultimate load (w_u). The lower limit (w_{u0}) for the ideal displacement is the where the linear part of the curve intersect the deflection axis.

The tensile modulus of the core (E_{Ct}) is determined by the following equations:

$$w_u = w_{u1} - w_{u0}$$

$$E_{Ct} = \frac{F_u \cdot d_c}{w_u \cdot A}$$

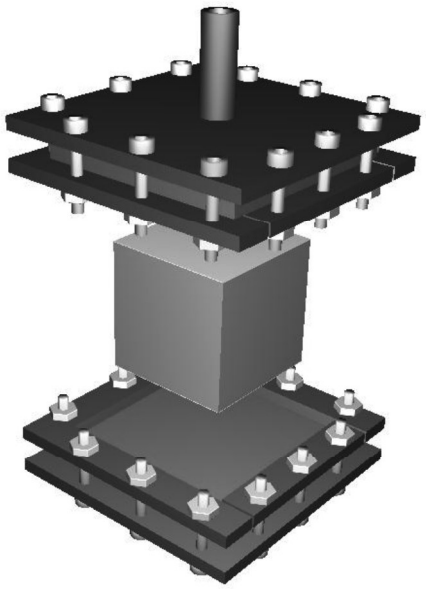


Figure 1 – Tensile grips used in tensile testing of 100 mm x 100 mm specimens

The values of the ultimate force during the test, tensile strength and tensile modulus of the core material for the 5 specimens are given in Table 2 and the summary of results in Table 3.

Specimen	F_u	f_{Ct}	w_{u0}	w_{u1}	w_u	E_{Ct}
number	**N**	**kPa**	**mm**	**mm**	**mm**	**MPa**
1	1500.0	147.0	0.00	2.08	2.08	6.999
2	1291.5	126.9	0.00	1.93	1.93	6.514
3	1366.5	133.7	0.02	2.01	1.99	6.651
4	1374.0	135.9	0.03	1.94	1.91	7.037
5	1350.0	133.0	0.05	2.03	1.98	6.643

Table 2 – Ultimate load, tensile strength and modulus of core material of the initial set specimens for the cross panel tensile test.

A1 Cross panel tensile test - Initial Set -	Number of test specimens		Qty	5
	Dimension and Density	Average Length	mm	100.8
		Average Width		100.9
		Average Thickness		99.0
		Density – Average	kg/m^3	99.6
		Density – Std dev.		0.3
	Ultimate Force F_u	Average	N	1376.4
		Maximum		1500.0
		Minimum		1291.5
		Standard Deviation		76.3
	Tensile Strength f_{Ct}	Average	kPa	135.3
		Maximum		147.0
		Minimum		126.9
		Standard Deviation		7.4
	Tensile modulus of core E_{Ct}	Average	MPa	6.769
		Maximum		7.037
		Minimum		6.514
		Standard Deviation		0.234

Table 3 – Summary of results of the initial set for the cross panel tensile test

5.1.2 Repeated Loading

This test is to determine the safety and serviceability of roof or ceiling panels with respect to a single person walking on the panel both during and after erection.

The tests were carried out according to ***the Standard*** section A9.2. Five specimens of 500 mm x nominal width x nominal thickness were cut from a full length panel. A square area of 100 mm x 100 mm was marked in the centre of each specimen. The Zwick 30 kN test bench was programmed to exert 40 cyclic loads of 600 N for 6 seconds with no load for 2 seconds through a square support plate of 100 mm x 100 mm.

After the cyclic loads were completed the marked square area was extracted, measured and weighed as stated in 5.1.1.1 and are reported in Table 4. Cross panel tensile tests were then conducted according to EN 1607 and the results calculated from the procedures described in 5.1.1.2 and are given in Table 5. A summary of the ultimate force, tensile strength and tensile modulus of the core are given in Table 6.

Specimen number	Thickness mm	Length mm	Width mm	Mass g	Volume m^3	Density kg/m^3
1	99.4	100.1	100.9	98.95	0.001003	98.7
2	99.0	100.6	101.0	98.55	0.001005	98.0
3	98.9	100.9	101.2	96.65	0.001009	95.8
4	99.0	101.1	101.3	99.45	0.001014	98.1
5	99.0	100.7	101.4	98.20	0.001010	97.2

Table 4 – Dimensions and densities of the repeated loading specimens for the cross panel tensile test.

Specimen number	F_u N	f_{Ct} kPa	w_{u0} mm	w_{u1} mm	w_u mm	E_{Ct} MPa
1	358.4	35.5	-0.01	0.48	0.49	7.198
2	300.4	29.6	-0.01	0.40	0.41	7.139
3	447.0	43.8	-0.01	0.78	0.79	5.480
4	1087.5	106.2	0.00	1.35	1.35	7.787
5	1156.3	113.2	0.00	1.54	1.54	7.280

Table 5 – Test results for the ultimate load, tensile strength and modulus of the core material of the repeated loading specimens.

A1 Cross panel tensile test - Repeated loading -	Number of test specimens			Qty	5
	Dimension and Density	Average Length		mm	100.7
		Average Width			101.2
		Average Thickness			99.1
		Density	Average	kg/m^3	97.5
			Std dev.		1.1
	Ultimate Force F_u	Average		N	669.9
		Maximum			1156.3
		Minimum			300.4
		Standard Deviation			416.6
	Tensile Strength f_{Ct}	Average		kPa	65.7
		Maximum			113.2
		Minimum			29.6
		Standard Deviation			40.6
	Tensile modulus of core E_{Ct}	Average		MPa	6.977
		Maximum			7.787
		Minimum			5.480
		Standard Deviation			0.875

Table 6 – Summary of results of the repeated loading specimens for the cross panel tensile test

5.1.3 Durability Testing (DUR1)

5.1.3.1 General

Heat is known to be the main cause of ageing on panels with polyurethane cores. The effect of ageing is then determined by the change in tensile strength after the specimens have been subjected to the durability cycles. The durability test is explained in ***the Standard*** section B1.

The test apparatus consists of an insulated chamber with a heater and fan in the vent that circulates the heated air in the chamber. The specimens are placed on grids within the chamber and the chamber sealed. The air temperature is held constant at 65°C for very light colours throughout the 24 week durability cycle.

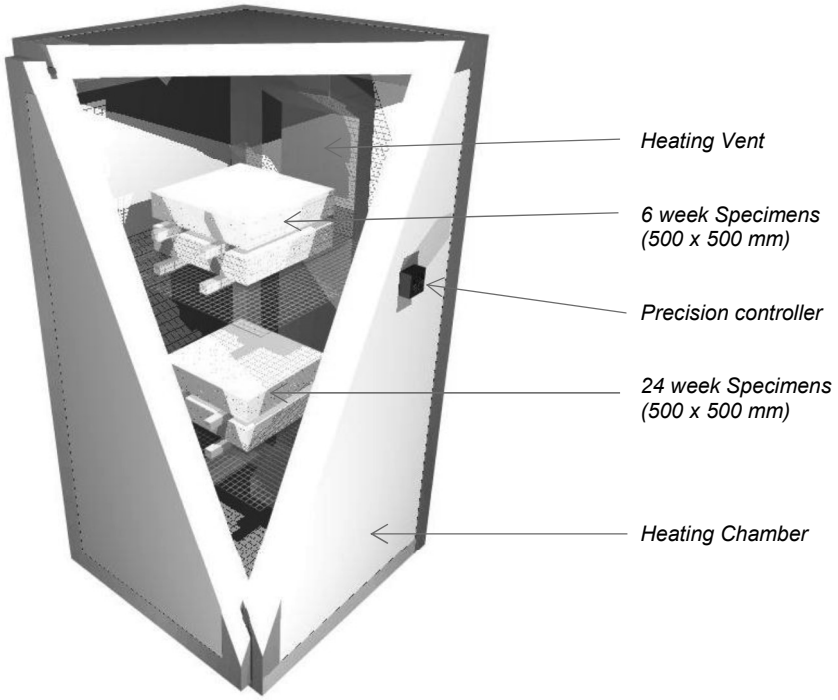


Figure 2 – Durability 1 Test Chamber with two sets of specimens

5.1.3.2 DUR1: 6 weeks

The first set was subjected to the durability conditions for 6 weeks. After the specimens were removed it was stored for 1 week under ambient laboratory and humidity conditions. The specimens were then measured and weighed according to the procedure described in 5.1.1.1 and the values are given in Table 7.

Specimen number	Thickness mm	Length mm	Width mm	Mass g	Volume m^3	Density kg/m^3
1	98.3	100.8	99.9	98.45	0.000989	99.5
2	98.2	100.3	101.7	98.65	0.001001	98.6
3	98.4	100.8	101.7	99.55	0.001008	98.8
4	98.5	101.8	101.5	100.10	0.001017	98.4
5	98.4	100.6	102.0	100.80	0.001009	99.9

Table 7 – Dimensions and densities for the cross panel tensile test of the durability specimens subjected to a 6 week cycle.

Tensile tests were performed according to EN 1607 as described in 5.1.1.2 and the individual specimen results are given in Table 8. A summary of the results of the ultimate load, tensile strength and tensile modulus of the core material obtained from the tests are given in Table 9.

Specimen	F_u	f_{Ct}	w_{u0}	w_{u1}	w_u	E_{Ct}
number	N	kPa	mm	mm	mm	MPa
1	200.3	19.9	-0.01	0.36	0.37	5.285
2	386.0	37.8	-0.01	0.62	0.63	5.898
3	726.8	70.9	0.00	1.00	1.00	6.976
4	958.0	92.7	0.01	1.15	1.14	8.011
5	815.0	79.4	0.00	1.05	1.05	7.443

Table 8 – Test results for the ultimate load, tensile strength and modulus of the core material of the DUR1: 6 weeks specimens

A1 Cross panel tensile test DUR1: 6 weeks	Number of test specimens			Qty	5
	Dimension and Density	Average Length		mm	100.9
		Average Width			101.4
		Average Thickness			98.4
		Density	Average	kg/m^3	99.0
			Std dev.		0.6
	Ultimate Force F_u	Average		N	617.2
		Maximum			958.0
		Minimum			200.3
		Standard Deviation			314.1
	Tensile Strength f_{Ct}	Average		kPa	60.2
		Maximum			92.7
		Minimum			19.9
		Standard Deviation			30.3
	Tensile modulus of core E_{Ct}	Average		MPa	6.723
		Maximum			8.011
		Minimum			5.285
		Standard Deviation			1.117

Table 9 – Summary of results of the DUR1: 6 weeks specimens for the cross panel tensile test.

5.1.4.3 DUR1: 24 weeks

The second set was subjected to the durability conditions for 24 weeks. After the specimens were removed it was stored for 1 week under ambient laboratory and humidity conditions. The specimens were then measured and weighed according to the procedure described in 5.1.1.1 and the values are given in Table 10.

Specimen	Thickness	Length	Width	Mass	Volume	Density
number	mm	mm	mm	g	m^3	kg/m^3
1	98.6	100.3	101.1	96.90	0.000999	97.0
2	98.5	101.0	99.9	96.65	0.000995	97.1
3	98.7	100.2	100.4	97.05	0.000992	97.8
4	98.5	101.1	100.5	96.90	0.001001	96.8
5	98.6	100.2	100.3	96.40	0.000991	97.3

Table 10 – Dimensions and densities for the cross panel tensile test of the durability specimens subjected to a 24 week cycle.

Tensile tests were performed according to EN 1607 as described in 5.1.1.2 and the individual specimen results are given in Table 11. A summary of the results of the ultimate load, tensile strength and tensile modulus of the core material obtained from the tests are given in Table 12.

Specimen	F_u	f_{Ct}	w_{u0}	w_{u1}	w_u	E_{Ct}
number	N	kPa	mm	mm	mm	MPa
1	1399.5	138.0	0.01	1.79	1.78	7.645
2	1347.0	133.5	0.02	1.87	1.85	7.108
3	1417.5	140.9	0.02	1.91	1.89	7.358
4	1022.5	100.6	0.02	1.43	1.41	7.030
5	1393.5	138.7	0.02	1.82	1.80	7.595

Table 11 – Test results for the ultimate load, tensile strength and modulus of the core material of the DUR1: 24 weeks specimens

A1 Cross panel tensile test DUR1: 24 weeks	Number of test specimens			Qty	5
	Dimension and Density	Average Length		mm	100.6
		Average Width			100.4
		Average Thickness			98.6
		Density	Average	kg/m^3	97.2
			Std dev.		0.4
	Ultimate Force F_u	Average		N	1316.0
		Maximum			1417.5
		Minimum			1022.5
		Standard Deviation			166.1
	Tensile Strength f_{Ct}	Average		kPa	130.3
		Maximum			140.9
		Minimum			100.6
		Standard Deviation			16.8
	Tensile modulus of core E_{Ct}	Average		MPa	7.347
		Maximum			7.645
		Minimum			7.030
		Standard Deviation			0.278

Table 12 – Summary of results of the DUR1: 24 weeks specimens for the cross panel tensile test.

5.2 Compressive strength and modulus of the core material

5.2.1 Dimensions and densities

Five specimens of nominal 100 mm by 100 mm were extracted from the same full length panel discussed in 5.1.1.1 from the three sections. Specimen 1 and 2 came from opposing quarters of the first section, specimen 3 from the centre section and specimen 4 and 5 from opposing quarters of the final section

The dimensions and densities of the specimens were determined according to EN 1602. The specimens were measure on 12 points, 4 for each linear dimension and the average thickness, length and width are given in Table 16. The specimens were weighed and the density calculated from the volume (V) and the mass (*m*) of each specimen:

$$\rho = \frac{m}{V}$$

Specimen number	Thickness mm	Length mm	Width mm	Mass g	Volume m^3	Density kg/m^3
1	98.7	99.6	100.4	97.75	0.000987	99.0
2	98.9	101.2	101.4	100.35	0.001015	98.9
3	99.0	100.9	100.8	100.10	0.001006	99.5
4	98.6	100.9	100.8	100.10	0.001003	99.8
5	98.9	102.1	102.1	100.30	0.001030	97.4

Table 16 – Dimensions and densities of the specimens for the compressive strength test.

5.2.2 Compressive strength and compressive modulus

The tests procedure of EN 826 was followed and the results reported according to ***the Standard*** section A2. The 100 mm by 100 mm specimens were placed centrally between the platens of the Hounsfield 5 kN tensile test bench (Figure 4). The platens compress the specimen at a speed of 10 mm per minute.

A load-deflection curve is generated from the results. The compressive strength of the core material (f_{Cc}) is determined by the ultimate load (F_u) from the test divided by the cross-sectional area (A) of the specimen.

$$f_{Cc} = \frac{F_u}{A}$$

The linear part of the curve is extended to intersect the ultimate load (F_u) line and the displacement at this point is used as the upper limit (w_{u1}) of the ideal displacement at ultimate load (w_u). The lower limit (w_{u0}) for the ideal displacement is the where the linear part of the curve intersect the deflection axis.

The compressive modulus of the core (E_{Cc}) is determined by the following equations:

$$w_u = w_{u1} - w_{u0}$$

$$E_{Cc} = \frac{F_u \cdot d_c}{w_u \cdot A}$$

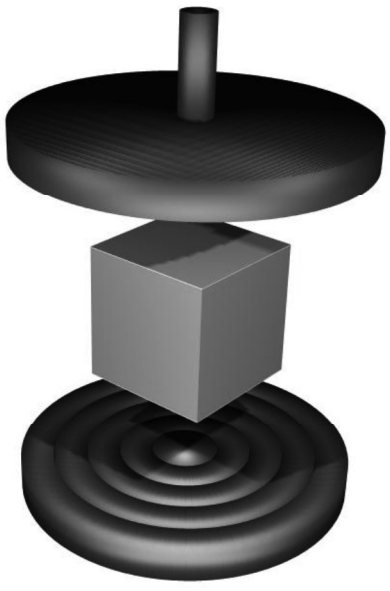


Figure 3 – Platens used in compression testing of 100 mm x 100 mm specimens

The values of the ultimate force during the test, compressive strength and compressive modulus of the core material for the 5 specimens are given in Table 17 and the summary of results in Table 18.

Specimen	F_u	f_{Cc}	w_{u0}	w_{u1}	w_u	E_{Cc}
number	N	kPa	mm	mm	mm	MPa
1	907.0	90.7	0.14	2.28	2.14	4.183
2	929.0	90.5	0.03	2.31	2.28	3.927
3	939.0	92.3	0.18	2.54	2.36	3.873
4	972.0	95.6	0.08	2.24	2.16	4.363
5	992.5	95.2	0.19	2.43	2.24	4.204

Table 17 – Ultimate load, compressive strength and modulus of core material of the specimens for the compression test.

A2 Compressive strength and modulus of the core material	Number of test specimens			Qty	5
	Dimension and Density	Average Length		mm	100.9
		Average Width			101.1
		Average Thickness			98.8
		Density	Average	kg/m^3	98.9
			Std dev.		0.9
	Ultimate Force F_u	Average		N	947.9
		Maximum			992.5
		Minimum			907.0
		Standard Deviation			34.2
	Compressive Strength f_{Cc}	Average		kPa	92.9
		Maximum			95.6
		Minimum			90.5
		Standard Deviation			2.4
	Compressive modulus of core E_{Cc}	Average		MPa	4.110
		Maximum			4.363
		Minimum			3.873
		Standard Deviation			0.205

Table 18 – Summary of results of the specimens for the compression test.

5.3 Shear strength and modulus of the core material

The test is conducted according to ***the Standard*** section A3. The purpose of the test is to determine the shear strength of the core (f_{Cv}) and the shear modulus of the core material (G_C).

5.3.1 Test Apparatus

The four point bending apparatus consist of two bottom supports and a two line loading bridge. The load is applied with a span between the loads of *L*/3. Steel load spreading plates of 10 mm thick by 100 mm wide are placed between the support rollers and the specimen of the Zwick 30 kN test bench to avoid local crushing of the core (see Figure 5).

Five specimens of nominal thickness x 100 mm x 800 mm were cut in the lengthwise direction from the full length of a panel. A loading rate of 10 mm per minute was used. Load-deflection curves were generated from the test results.

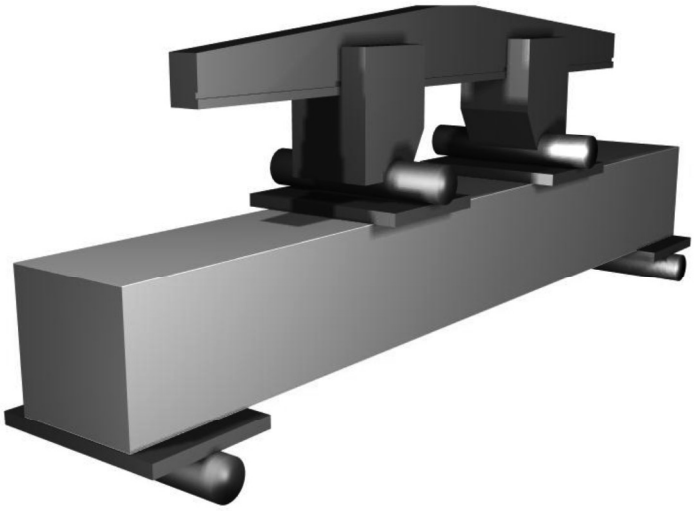


Figure 4 – Four point bending test arrangement with load spreading plates between the rollers and specimen.

5.3.2 Calculations

The shear strength of the core material (f_{Cv}) is determined by the ultimate load (F_u) from the test divided by the measured width (B) of the specimen multiplied by the depth between the centroids of the faces (e).

$$f_{Cv} = \frac{F_u}{2 \cdot B \cdot e}$$

The linear part of the curve is extended to intersect the ultimate load (F_u) line and the displacement at this point is used as the upper limit (w_{u1}) of the ideal displacement at ultimate load (w_u). The lower limit (w_{u0}) for the ideal displacement is the where the linear part of the curve intersect the deflection axis.

The shear modulus of the core (G_C) is determined in the following sequence of equations:

The flexural rigidity is determined from the area of the upper face (A_{F1}), lower face (A_{F2}), the respective modulus of elasticity (E) and the depth between the centroids of the faces (e):

$$B_s = \frac{E_{F1} \cdot A_{F1} \cdot E_{F2} \cdot A_{F2}}{E_{F1} \cdot A_{F1} + E_{F2} \cdot A_{F2}} \cdot e^2$$

From the flexural rigidity the bending deflection (Δw_B) can be calculated from the ultimate force (F_u) and specimen span (L):

$$\Delta w_B = \frac{F_u \cdot L^3}{56.34 \cdot B_s}$$

Shear deflection (Δw_s) is then determined from the ideal displacement at ultimate load (w_u) and the bending deflection (Δw_B) determined above:

$$\Delta w_s = w_u - \Delta w_B$$

Once the shear deflection (Δw_s) is determined the shear modulus of the core material (G_C) can be calculated from the ultimate force (F_u), specimen span (L), measured width of the specimen (B) and the thickness of the core material (d_c):

$$G_C = \frac{F_u \cdot L}{6 \cdot B \cdot d_c \cdot \Delta w_s}$$

5.3.3 Results

The individual results from the test and calculations for each specimen are given in Table 19 with the summary of the results given in Table 20. The following constants were used in calculating the results:

$E_{F1} = E_{F2} = 200\ GPa$

$A_{F1} = A_{F2} = 0.55 \cdot 100 = 55\ mm^2$

$e = 98.75 - 0.55 = 98.20\ mm$

Specimen number	F_u N	f_{cv} kPa	Δw_u mm	Δw_B mm	Δw_s mm	G_C MPa
1	1599.4	81.4	7.32	0.18	7.14	2.678
2	1610.0	82.0	7.46	0.18	7.28	2.644
3	1698.5	86.5	7.42	0.19	7.23	2.809
4	1679.8	85.5	7.77	0.19	7.58	2.649
5	1551.5	79.0	7.86	0.18	7.68	2.413

Table 19 – Results for the ultimate load, shear strength and shear modulus of the core material for the five specimens tested.

Shear strength and modulus of the core material	Number of tested specimens		Qty	5
	Span (L)		mm	700
	Loading Arrangement			L / 3
	Ultimate Force F_u	Average	N	1627.8
		Maximum		1698.5
		Minimum		1551.5
		Standard deviation		60.5
	Shear strength of core material f_{cv}	Average	kPa	82.9
		Maximum		86.5
		Minimum		79.0
		Standard deviation		3.1
	Shear modulus of core material G_C	Average	MPa	2.638
		Maximum		2.809
		Minimum		2.413
		Standard deviation		0.143

Table 20 – Summary of results for specimens of the shear test

5.4 Bending Moment Capacity and stiffness of a simply supported panel

The test is conducted according to ***the Standard*** section A5. The purpose of the test is to determine the bending strength of panels in which the span (*L*) is sufficiently large to ensure bending failure due to wrinkling, yielding or buckling of the faces. This test can also be used to determine a more reliable value for the shear modulus of the core material (G_C).

5.4.1 Test Apparatus

In order to achieve the simply supported support structure for the bending test two types of supports were required. Support structure 1 (*S1*) had to allow for rotational motion and support structure 2 (*S2*) for rotational as well as transverse motion. A full length panel of 6 m x 1.2 m x nominal thickness with a span (*L*) of 5.8 m between the two support structures was used for the bending test.

Uniform loading was achieved by subjecting the panel to a four line loading arrangement at positions *1*/8, *3*/8, *5*/8 and *7*/8. Face bricks were used as the loads. The bricks were weighed out in groups of 8 with an approximate mass of 25.6 kg ± 0.25 kg per group. The groups were loaded onto the panel by simultaneously placing 2 bricks at a time in an opposing scatter formation.

A dumpy level was used to measure the deflection of the panel at centre point by means of a steel ruler. Continues observation was done during the loading of the panel and recorded. Load-deflection curves were generated from the test results.

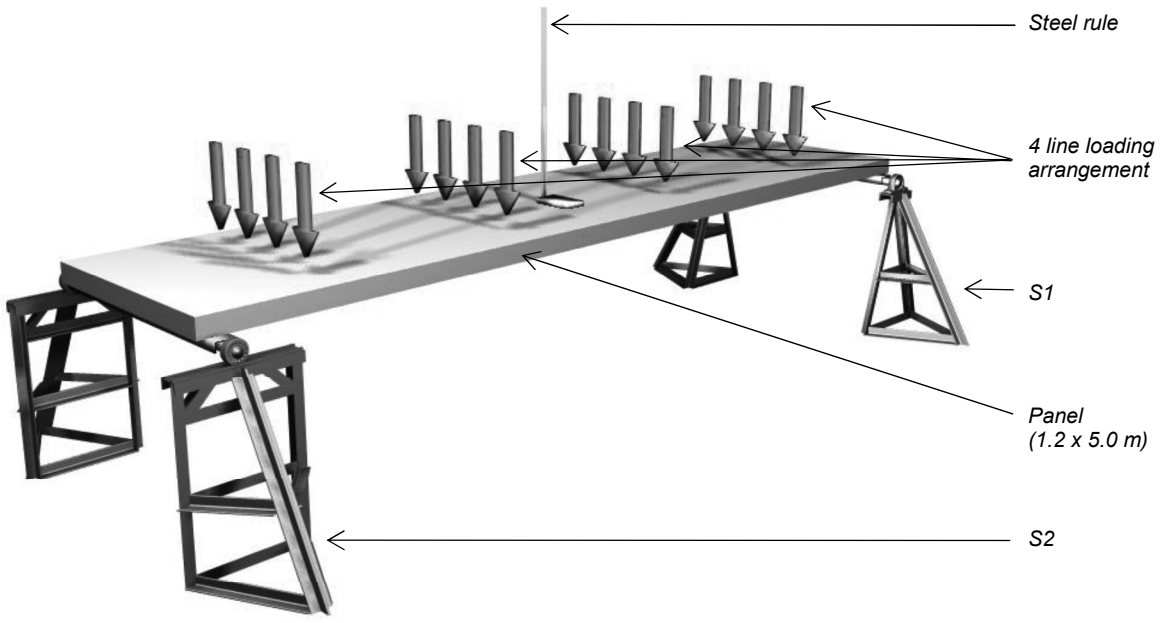


Figure 5 – Bending test apparatus. Arrows indicate loading arrangement with steel rule in centre for measuring deflection.

5.4.2 Calculations

5.4.2.1 Bending moment capacity (M_u)

The bending moment capacity (M_u) is determined by the span (L) and ultimate load (F_u) which is a combination of the load applied during the test (F_L) and the self-weight (F_G) of the panel.

$$W_G = \rho \cdot V = m \cdot A_{surface}$$

$$M_u = \frac{F_u \cdot L}{8}$$

5.4.2.2 Wrinkling stress (σ_w)

Wrinkling stress (σ_w) is only relevant to the top face in compression of panels with flat or lightly profiled faces. The wrinkling stress (σ_w) is calculated from the bending moment capacity (M_u), the depth between the centroids of the faces (e) and the cross-sectional area (A_1) of the face in compression.

$$\sigma_w = \frac{M_u}{e \cdot A}$$

5.4.2.3 Shear modulus of the core material (G_C)

A more reliable value for the shear modulus of the core material (G_C) can be determined from the bending moment capacity test from the following calculations:

The flexural rigidity is determined from the area of the upper face (A_{F1}), lower face (A_{F2}), the respective modulus of elasticity (E_{F1} *and* E_{F2}) and the depth between the centroids of the faces (e):

$$B_s = \frac{E_{F1} \cdot A_{F1} \cdot E_{F2} \cdot A_{F2}}{E_{F1} \cdot A_{F1} + E_{F2} \cdot A_{F2}} \cdot e^2$$

The following equation is used for the bending deflection due to the axial deformation in the faces (w_b) if the total load was applied as 4 equal line loads $F_L/4$ at positions 1/8, 3/8, 5/8, 7/8 of the span (L). From the bending deflection of the faces (w_b) and the deflection measured during the test (w) the deflection due to shear deformation of the core material can be determined.

$$w_b = \frac{41 \cdot F_L \cdot L^3}{3072 \cdot B_s}$$

$$w_v = w - w_b$$

The shear modulus (G_C) is then calculated using the deflection due to shear deformation in the core material (w_v).

$$G_C = \frac{F_L \cdot L}{8 \cdot A_C \cdot w_v} \qquad \text{with} \qquad A_C = B \cdot e$$

5.4.2.4 Results

The following constants were used in calculating the results:

$E_{F1} = E_{F2} = 200\ GPa$

$A_{F1} = A_{F2} = 0.55 \cdot 1135 = 624.25\ mm^2$

$e = 99.75 - 0.55 = 99.20\ mm$

Table 21 contains the results for the bending moment capacity (M_u) and wrinkling stress (σ_w) calculated from the ultimate load (F_u) which includes the effect of the self-weight (F_G) of the specimen.

Specimen	F_L	F_u	M_u	σ_w
number	N	N	N.m	MPa
1	6376.5	7025.1	5093.2	83.085
2	6759.1	7407.7	5370.6	87.610
3	7141.7	7790.3	5648.0	92.135
4	7269.2	7917.8	5740.4	93.643
5	6631.6	7280.2	5278.2	86.102

Table 21 – Results for bending moment capacity and wrinkling stress for the four specimens tested.

Table 22 contains the deflection measured at mid-span (w) at ultimate test load (F_L), deflection due to axial deformation in the faces (w_b) and the deflection due to shear deformation (w_v) which is used to determine the shear modulus of the core material (G_C).

Specimen	ω	ω_b	ω_v	G_C
number	m	m	m	MPa
1	0.0495	0.0304	0.0191	2.405
2	0.0490	0.0320	0.0170	2.858
3	0.0535	0.0337	0.0198	2.574
4	0.0535	0.0343	0.0192	2.691
5	0.0480	0.0315	0.0165	2.885

Table 22 – Ultimate test load, deflections of panel, faces and core material and shear modulus.

A summary of all the test results as well as the calculated results for the bending moment capacity (M_u), wrinkling stress for a 0.55 mm faces ($\sigma_{w,t1}$) and the shear modulus of the core material (G_C) determined by the bending test can be found in Table 23.

Bending moment capacity and stiffness of a simply supported panel	Number of tested specimens		Qty	5
	Span		m	5.8
	Loading Arrangement		1/8, 3/8, 5/8, 7/8	
	Load (F_L)	Average	N	6835.6
		Maximum		7269.2
		Minimum		6376.5
		Standard deviation		367.4
	Load and self-weight (F_u)	Average	N	7484.2
		Maximum		7917.8
		Minimum		7025.1
		Standard deviation		367.4
	Bending Moment Capacity (M_u)	Average	Nm	5426.1
		Maximum		5740.4
		Minimum		5093.2
		Standard deviation		266.4
	Wrinkling Stress 0.55 mm facing ($\sigma_{w,t1}$)	Average	MPa	88.515
		Maximum		93.643
		Minimum		83.085
		Standard deviation		4.345
	Shear modulus of core material (G_C)	Average	MPa	2.682
		Maximum		2.885
		Minimum		2.405
		Standard deviation		0.201

Table 23 – Summary of bending test result and calculations.

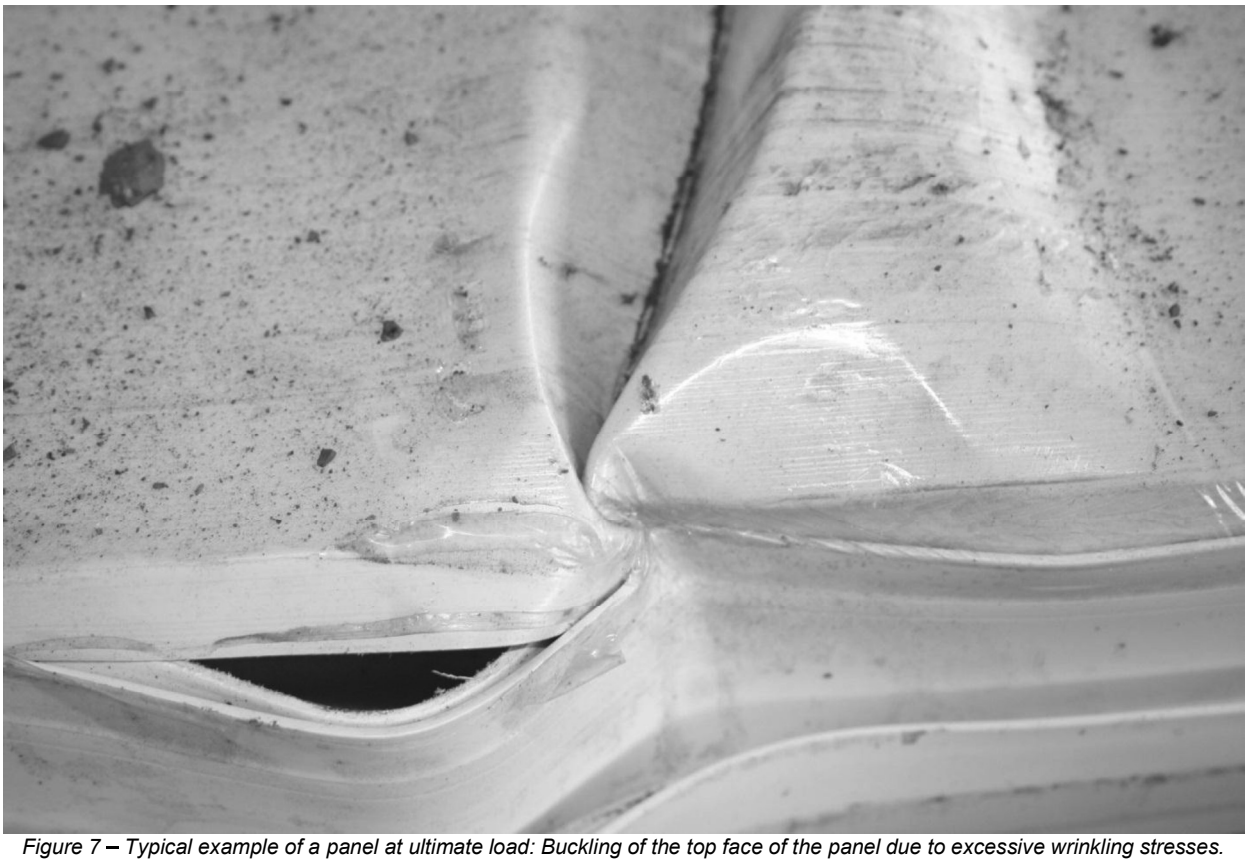


Figure 7 – Typical example of a panel at ultimate load: Buckling of the top face of the panel due to excessive wrinkling stresses.

5.5 Creep deflection (1000 hour)

Creep is only of interest in design of ceiling or roof panels. Creep is a time-dependant, permanent deformation of the panel when subjected to a constant load.

5.5.1 Test Apparatus

The same apparatus shown in Figure 6 is used as and is described in 5.4.1. The load is between 30% to 40% of the ultimate load determined in the test of 5.4 Bending moment capacity.

The Test is conducted according to ***the Standard*** section A6. The load is uniformly applied and the deflection measured daily over the test period of a 1000 hours.

5.5.2 Test Resluts

Table 24 gives the initial deflection (*t*=*i*) due to the load applied followed by time periods of interest with the corresponding measured deflections.

Time interval	Deflection
hour	min
i	39.0
200	43.0
500	45.0
800	45.5
1000	45.5

Table 24: Initial and creep deflections

5.6 Interaction between bending moment and support force

This test is also referred to as the simulated central support test and is used to determine the bending strength at an internal support of a panel which is continues over two or more spans. The test is conducted according to ***the Standard*** section A7.

Six specimens of 4.2 m x nominal thickness x nominal width were cut from panels for completing the two sets of tests. The span (*L*) of the bottom supports for the two tests were set at 4.0 m.

5.6.1 Test Apparatus

5.6.1.1 Downward load

The test arrangement for the simulated central support test with a downward force consists of a single upper support exerting a line load in the centre of the span (*L/2*) between the Zwick 30 kN test bench's bottom supports. 60 mm wide load spreading plates of are placed between the upper and bottom supports to avoid local crushing of the core material (see Figure 8).

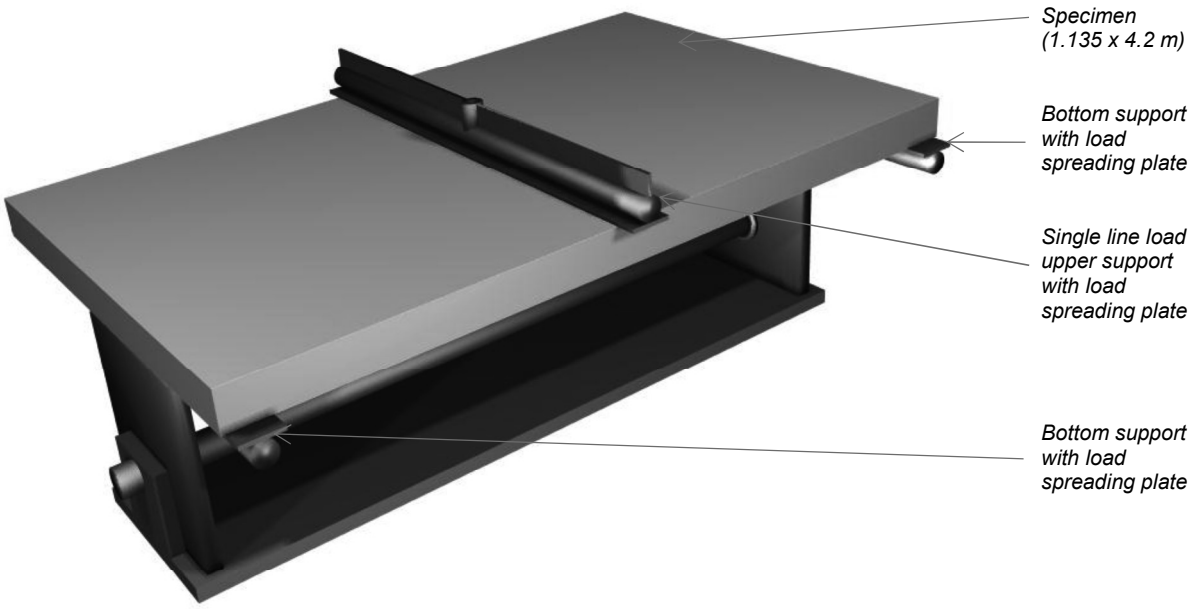


Figure 8 – Test arrangement for the simulated central support test with a downward load.

5.6.1.1 Uplift load

The simulated central support test with an uplift load consists of a purlin fastened to the bottom of the full width specimen by means of 2 screws and washers as would be done in practice. The upper support of the Zwick 30 kN test bench is connected to the exposed sides of the purlin through the purlin support brackets (see Figure 9).

The combination of the two tests ensures that all modes of failure (wrinkling of the face, compressive failure of the core and tensile failure of the connections) are designed for approximately the same equal levels of safety.

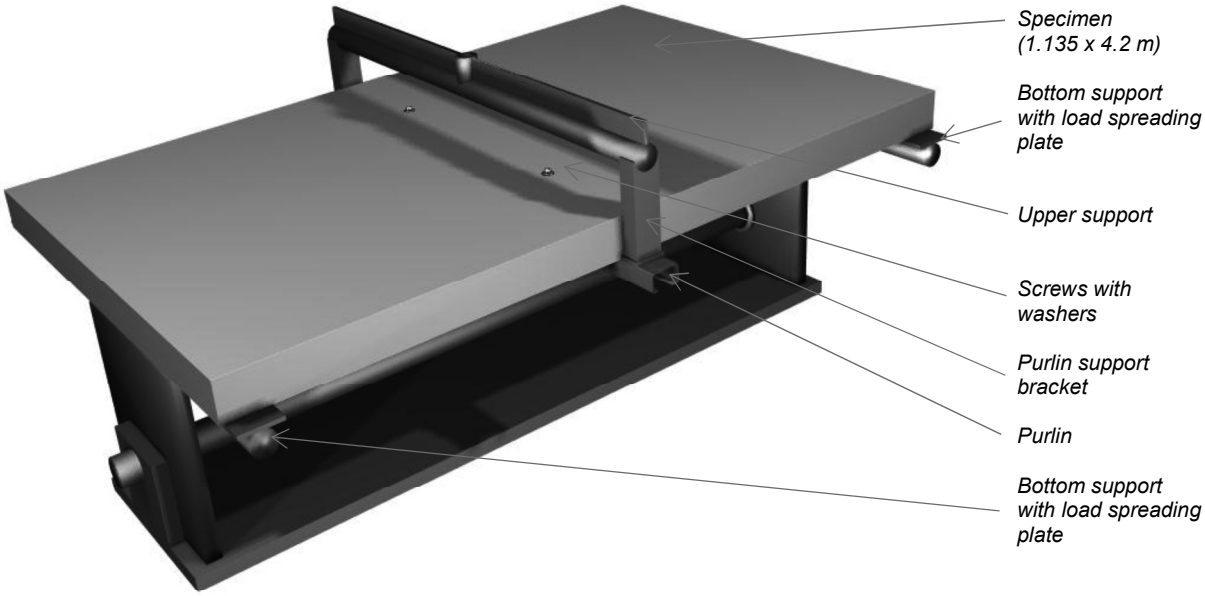


Figure 9 – Test arrangement for the simulated central support test with an uplift load.

5.6.2 Calculations

The bending moment capacity (M_u) is determined by the following equation with the ultimate load (F_u) which consists of the test load (F_L) and the weight of the loading system (F_{LS}), the self-weight of the specimen (F_G) and the span (L) between the bottom supports.

$$M_u = \frac{F_u \cdot L}{4} + \frac{F_G \cdot L}{8}$$

Wrinkling stress (σ_w) is only relevant to the face in compression of panels with flat or lightly profiled faces. The wrinkling stress (σ_w) is calculated from the bending moment capacity (M_u), the depth between the centroids of the faces (e) and the cross-sectional area (A) of the face in compression.

$$\sigma_w = \frac{M_u}{e \cdot A}$$

5.6.3 Results

The results for the simulated central support with a downward load is given in Table 24 and contains the test load (F_L), ultimate load (F_u) which includes the weight of the loading system (F_{LS}), bending moment capacity (M_u) and the wrinkling stress (σ_w), for the face in compression. A summary of the results is given in Table 25. The constants used for calculating the results for both the downward load (DL) and uplift load (UL) are:

$F_{LS,DL}$ = 65.2 N

$F_{LS,UL}$ = 84.1 N

F_G = 432.4 N

$A_{F1} = A_{F2} = 0.55 \cdot 1135 = 624.25\ mm^2$

$e = 98.75 - 0.55 = 98.20\ mm$

Specimen number	F_L N	F_u N	M_u N.m	σ_w MPa
1	3643.5	3711.7	3927.9	64.076
2	4932.7	4997.9	5214.1	85.058
3	3830.9	3896.1	4112.3	67.084
4	4230.0	4295.2	4511.4	73.595
5	4016.4	4081.6	4297.8	70.110

Table 24 – Results for the simulated central support test with a downward load.

Simulated central support test - Downward load -	Number of tested specimens		Qty	5
	Span		m	4.0
	Loading direction			Downward
	Force (F_u)	Average	N	4196.5
		Maximum		4997.9
		Minimum		3711.7
		Standard deviation		497.6
	Bending Moment Capacity (M_u)	Average	N.m	4412.7
		Maximum		5214.1
		Minimum		3927.9
		Standard deviation		497.6
	Wrinkling Stress (σ_w)	Average	MPa	71.984
		Maximum		85.058
		Minimum		64.076
		Standard deviation		8.117

Table 25 – Summary of results

The results for the simulated central support with an uplift load is given in Table 26 and contains the test load (F_L), ultimate load (F_u) which includes the weight of the loading system (F_{LS}), bending moment capacity (M_u) and the wrinkling stress (σ_w), for the face in compression. A summary of the results is given in Table 27.

Specimen number	F_L **N**	F_u **N**	M_u **N.m**	σ_w **MPa**
1	2783.2	2867.3	3083.5	50.300
2	3123.6	3207.7	3423.9	55.853
3	3710.2	3794.3	4010.5	65.422
4	2918.6	3002.7	3218.9	52.509
5	2948.8	3032.9	3249.1	53.002

Table 26 – Results for the simulated central support test with an uplift load.

Simulated central support test - Uplift load -	Number of tested specimens		Qty	5
	Span		m	4.0
	Loading direction			Uplift load
	Force (F_u)	Average	N	3181.0
		Maximum		3794.3
		Minimum		2867.3
		Standard deviation		363.7
	Bending Moment Capacity (M_u)	Average	N.m	3397.2
		Maximum		4010.5
		Minimum		3083.5
		Standard deviation		363.7
	Wrinkling Stress (σ_w)	Average	MPa	55.417
		Maximum		65.422
		Minimum		50.300
		Standard deviation		5.932

Table 27 – Summary of results

5.7 Resistance to point loads

This test is to determine the safety and serviceability of roof or ceiling panels with respect to a single person walking on the panel both during and after erection. The tests were carried out according to ***the Standard*** section A9.1

If the panel carries the load without any visible damage (Class A) there will be no restrictions to access the roof or ceiling either during or after erection.

Should the specimen supports the load but with visible permanent damage (Class B) measures shall be taken to restrict access to the ceiling panels and the use of walking boards is compulsory during the erection to avoid damage to the panels. After the building work is complete there shall be no provision for access to the roof or ceiling panels.

If the panel fails to support the load (Class C) it will only be used as ceilings or roof panels where no walking access is possible or permitted. This limitation must be clearly marked on the panel or elsewhere.

5.7.1 Test apparatus

The central support of the Zwick 30 kN test bench is used to exert the off centre load of 1.2 kN to the edge at mid-span of the test specimen (see Figure 10). The Zwick's load cell was verified by means of a calibrated scale to determine the corresponding off centre load versus the crosshead load before the tests were conducted.

The span (*L*) of the bottom supports was set at 1.880 m for the resistance to point load test.

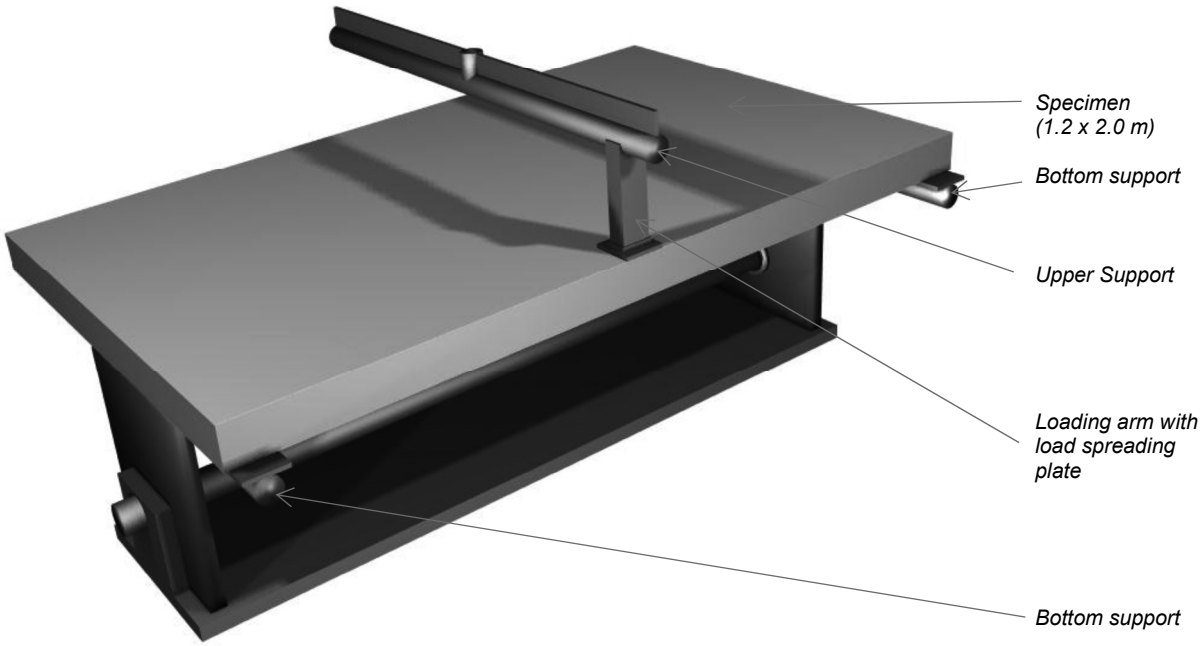


Figure 10 – Loading arrangement for the resistance to point test.

5.7.2 Results

The tests were conducted on three specimens of 2.0 m x nominal thickness x nominal width. All samples resisted the point load with no visible damage to the edge. The panels have no restrictions to access during or after erection (Class A).

5.8 Thermal transmittance

A deviation was made to ***the Standard*** section A10 in determining the thermal transmittance of a panel. The panel was built into a system and was tested according to ASTM C1363:2011 in a Rotateable Guarded Hot Box (RGHB). The system includes a purlin to which the panel with a joint detail is fastened by screws as would be done in practice (see Figure 11).

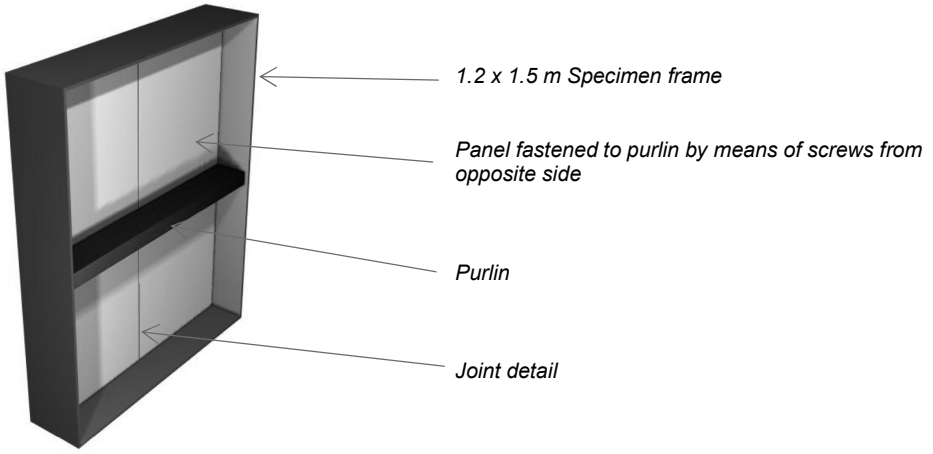


Figure 11 – Specimen representative of a panel assembly for testing in the RGHB according to ASTM C1363:2011

5.8.1 Test Apparatus

The RGHB is an apparatus designed to evaluate actual conditions within a controlled environment. The apparatus consists of two chambers, one to simulate climate conditions with forced convection, the other room conditions with natural convection.

The heat flow through the specimen is monitored for steady state conditions by means of 258 temperature probes. Once steady state is achieved the thermal performance can be determined either from air-to-air or surface-to-surface data captured during the test cycle.



Figure 12 – RGHB with climate chamber left, surround panel with specimen middle and room chamber with metering box right.

The absence of building elements such as purlins, joints and fasteners which cause heat bridging in actual applications are neglected when testing in small scale steady state heat flow instruments for determining thermal conductivity of e.g. core materials. Due to the ability of the RGHB to physically determine the thermal resistance of complete building envelope assemblies it is the preferred method for testing a complex system.

5.8.2 Results

The following RGHB data was sampled every second, averaged and recorded every minute:

- The temperature histories for the specimen for each test
- The air flow rates in the metering box and the climate side
- The area-weighted temperatures of both sides of the surround panel
- The spatial temperature distribution of the baffle surface in the metering box
- The spatial temperature distribution of the metering box air
- The output of the thermopile measuring the heat flow through the metering box walls
- The temperature increase of the metering box cooling loop and its flow rate
- The surface and internal temperatures of the specimen

The RGHB test data was analysed to determine the surface-to-surface thermal resistance values of the specimen. This analyses took account of the power input into the metering box (for controlling the air and baffle surface temperatures), the net thermopile gain/loss, the heat gain/loss through the surround panel and all other losses (or gains) such as flanking losses for which the RGHB has been calibrated in accordance with the requirements of both the National Fenestration Rating Council (NFRC) and the South African National Accreditation System (SANAS).

Parameters	Units	Results
Time rate of net heat input to the metering box, Q_{WM}	W	48.00
Time rate of heat flow through the surround panel, Q_{SP}	W	9.60
Time rate of heat flow from the metering box to the guard chamber through the metering box walls, Q_{MB}	W	-0.20
Time rate of heat flow due to flanking losses of the Metering Box, $Q_{MB,FL}$	W	3.69
Time rate of heat flow through specimen frame, Q_{SF}	W	1.03
Time rate of heat flow through metered specimen, Q_S	W	33.47
Average air velocity, room side, $V_{air,r}$	m/s	0.272
Space average air temperature, room side, $T_{a,r}$	°C	20.93
Space average air temperature, climate side, $T_{a,c}$	°C	-5.05
Area weighted average temperature of specimen hot surface, $T_{r,s}$	°C	20.48
Area weighted average temperature of specimen cold surface, $T_{c,s}$	°C	-5.17
Surface to surface thermal resistance, $R_{th,Sys}$	m^2·K/W	1.324
Thermal transmittance of specimen, U_{Sys}	W/m^2·K	0.755

Table 28 – Summary of results from RGHB testing according to ASTM C1363

5.9 Thermal conductivity

Thermal conductivity (k) is the ability of a material to conduct heat and is expressed in W/m·K. Ideal insulation materials have a low thermal conductivity. If the thermal conductivity (k) is known for a material one can divide the thermal conductivity by the thickness (d_C) in order to determine the thermal transmittance (U) of the material which is also the reciprocal of thermal resistance (R_{th}).

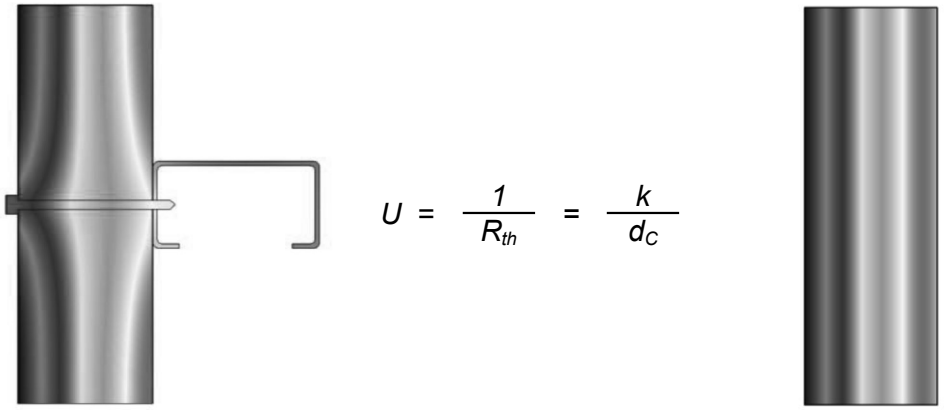


Figure 13 – The effect of thermal bridging on the thermal conductivity can be seen in the thermal images of a panel system (left) against only the panel (right).

The Laser Comp Fox 314 heat flow meter instrument was used to determine the thermal conductivity (k) of a specimen of 76.9 mm x 300 mm x 300 mm.

5.9.1 Test Apparatus

The Fox 314 has been designed to comply with ASTM C518, ISO8301, EN12667, EN1946-1 and EN1946-3, and is provided with a built-in calibration according to the NIST 1450b standard.

It has 0.6µV resolution on the integral high output heat flux transducers and 0.01ºC temperature control and resolution, based on its 24 bit ADC. The thickness of the sample is measured on all four corners of the specimen providing an accuracy of ±0.025mm thickness measurement. The instrument therefore has a repeatability of 99.8% and an accuracy of 99%.

5.9.2 Results

Thermal conductivity and resistance	Instrument measured thickness (d_C)			mm	76.9
	Density as tested (ρ)			kg/m^3	17.2
	Mean temperature	Test set point	1	°C	-5
			2		15
			3		35
	Temperature difference across specimen	Test set point	1	°C	20
			2		30
			3		30
	Thermal Conductivity (k_{Panel})	Test set point	1	W/m·K	0.034
			2		0.037
			3		0.039
		Mean values			0.037
	Thermal Resistance ($R_{th,Panel}$)	Test set point	1	m^2·K/W	2.25
			2		2.09
			3		2.97
		Mean values			2.44

Table 29 – Summary of results for specimen tested according to ASTM C518.

5.10 Rain Penetration

Rain penetration is often the cause of building damage due to the penetration of wind driven rain through external wall elements. The amount of rain penetration is dependant on the rainfall and wind speed occurring simultaneously.

5.10.1 Test Apparatus

The AAAMSA Performance Test Rig (APT) consists of a pressure chamber with a 3 m x 3 m opening. The APT is equipped with a centrifugal fan capable of generating positive and negative pressure differentials up to 4 kPa. The rig is fitted with a water spray system with 16 water jets capable of covering the entire 9 m^2 opening (maximum specimen size) with a constant film of water.

Interchangeable specimen plugs allows for different sized specimens to be installed into the opening of the chamber. The standard specimen sizes catered for is 3 x 3 m, 2.4 x 2.1 m, 1.2 x 1.5 m and 1.2 x 1.2 m.

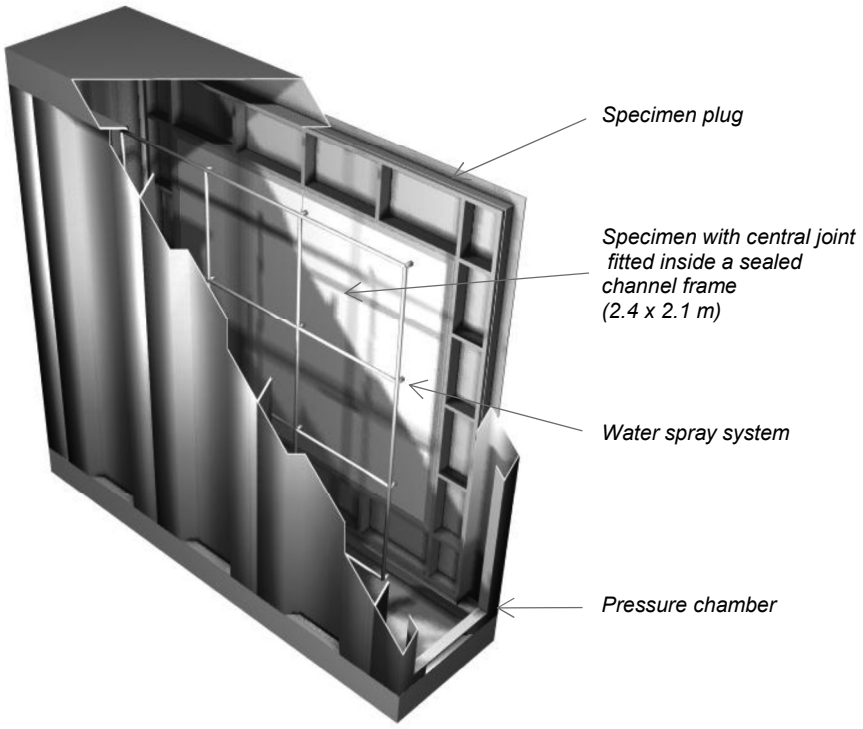


Figure 14 – AAAMSA Performance Test Rig with specimen installed into specimen plug. Water spray system is also visible.

5.10.2 Procedure

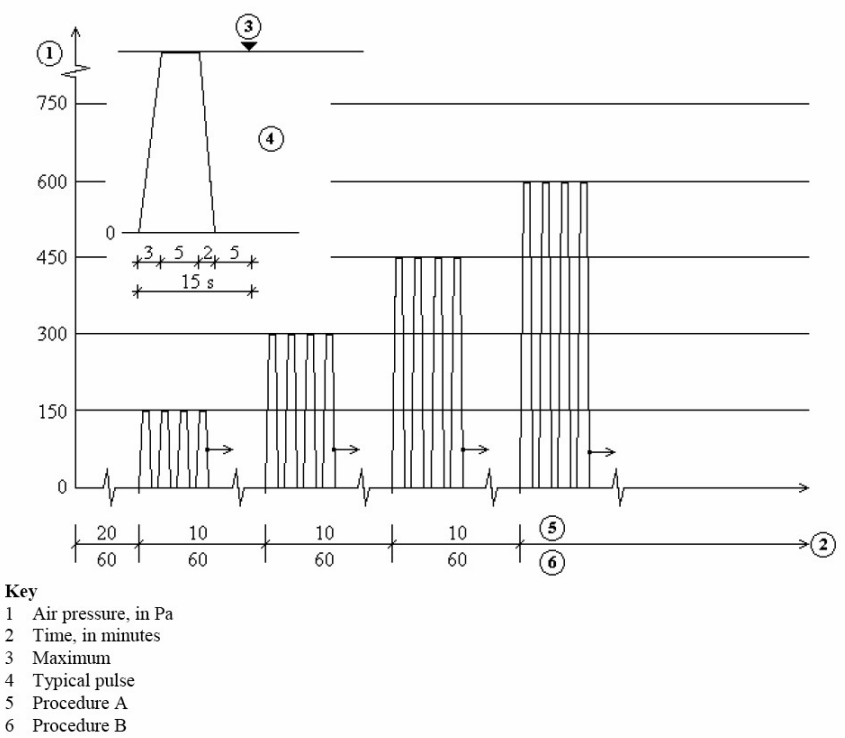
The specimen of 2.4 x 2.1 m consisted of two panels of nominal width joined with the vertical joint in the centre. The channel on the outer perimeter was sealed as per manufacturer's specifications. The joint was not sealed as would be done in practice.

The test was conducted according to EN 12865 with an applied amount of water of 10.44 lpm for the duration of the test cycle. The specimen is initially sprayed for 20 minutes with no pressure difference. After the 20 minutes have lapsed pulsating air pressure is applied according to the time intervals shown in Table 30. The procedure is also shown graphically in Figure 14.

Each pressure pulse consists of four stages: a rising pressure stage of 3 seconds, a maximum pressure stage of 5 seconds, a falling pressure stage of 2 seconds and a zero pressure stage of 5 seconds. The total duration of a pulse shall be 15 seconds.

Pressure difference	Time interval	Total time at end of steps
Pa	min	min
0	20	20
0 to 150	10	30
0 to 300	10	40
0 to 450	10	50
0 to 600	10	60

Table 30 – Pulsating pressure test procedure



Key
1 Air pressure, in Pa
2 Time, in minutes
3 Maximum
4 Typical pulse
5 Procedure A
6 Procedure B

Figure 15 – Schematic of test procedure (from EN 12865).

5.10.2 Results

Water penetration occurred through the joint during the 42nd minute at a pressure of 450 Pa thus failing the cycle. The specimen is water tight up to pressures not exceeding 300 Pa.

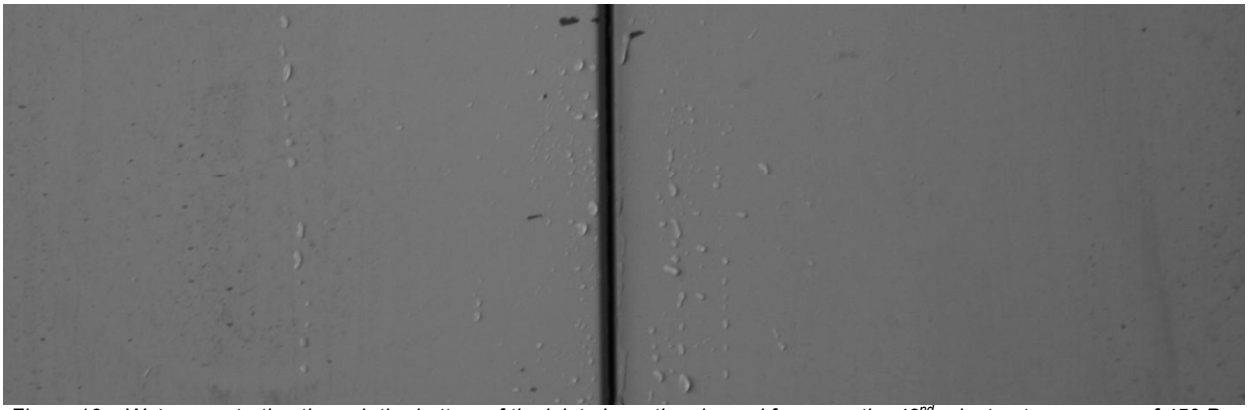


Figure 16 – Water penetration through the bottom of the joint above the channel frame on the 42nd minute at a pressure of 450 Pa.

5.11 Air permeability

Air permeability is an important criterion especially in insulating products where excessive air leakage can lead to poor insulating performance. The test is conducted according to EN 12114.

5.11.1 Test apparatus

The AAAMSA Performance Test Rig (APT rig) as described in 5.9.1 was used in determining the air permeability of the same 2.4 x 2.1 m specimen prior to the rain penetration test. The APT is equipped with 3 rotameters measuring the volume flow rate with the ranges of 60 m^3/h, 18.0 m^3/h and 4.00 m^3/h. The rotameters are used in conjunction with an inclined manometer allowing for precise air pressure control.

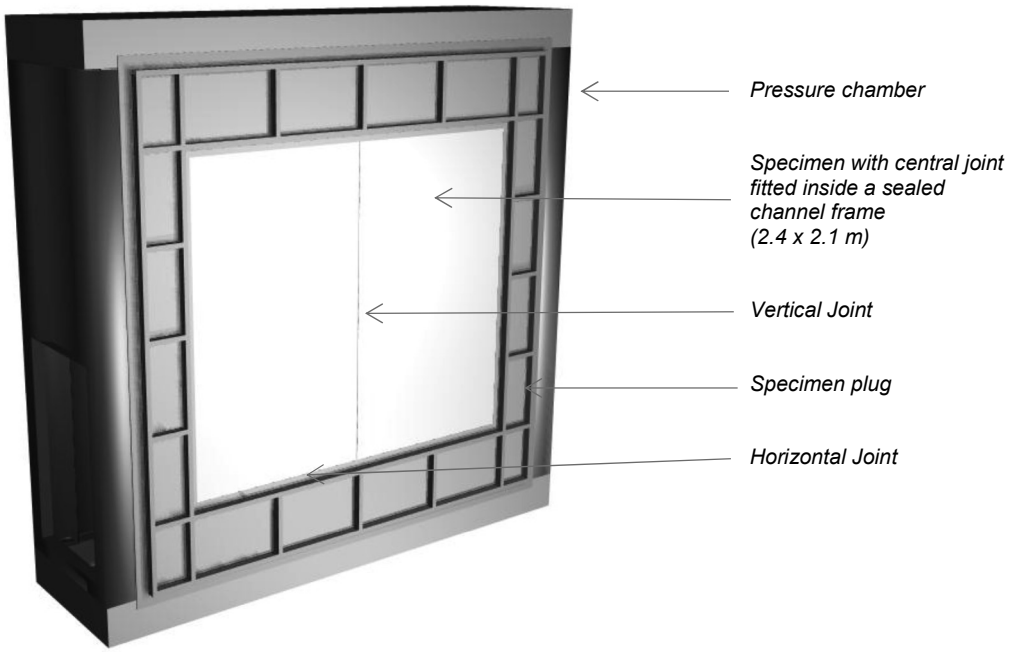


Figure 17 – AAAMSA Performance Test Rig seen from front with a specimen with central joint installed into specimen plug.

5.11.2 Procedure

The specimen was sealed on both side channels and the top channel during construction allowing for air leakage to be measured on the bottom channel as a representative horizontal joint and the vertical joint between the two panels.

The air leakage of the vertical and horizontal joints were measured at the following pressure differentials determined by the equations given below for a minimum pressure (Δp_{min}) of 40 Pa and a maximum pressure (Δp_{max}) of 200 Pa for 6 pressure steps (N):

$$\Delta p_i = 10^{\,i\frac{\log \Delta p_{\max} - \log \Delta p_{\min}}{N} + \log \Delta p_{\min}}$$

$$\Delta p_i = \exp\left(i\frac{\ln(\Delta p_{\max}) - \ln(\Delta p_{\min})}{N} + \ln(\Delta p_{\min}) \right)$$

The pressures to be used from the equations were an initial pressure of 40 Pa, increased to 52 Pa, 68 Pa, 89 Pa, 117 Pa, 153 Pa and reaching the maximum pressure of 200 Pa on the 6th step. The test procedure for the pressure increase is shown graphically in Figure 17.

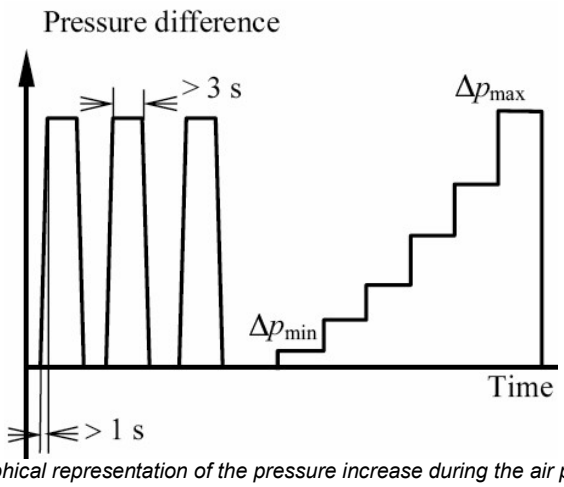


Figure 18 – Graphical representation of the pressure increase during the air permeability test.

Before the test is commenced the horizontal and vertical joints were sealed by means of tape and silicone. The Air permeability test was repeated three times through all pressure ranges. Test 1 to determine the residual leakage of the APT rig itself, test 2 to determine the leakage through the vertical joint and test 3 to determine the leakage through the horizontal joint.

5.11.3 Results

The residual leakage of the rig was determined with both the horizontal and vertical joints sealed. The leakage of the vertical joint was measured with the vertical joint seal removed. The horizontal joint was measured with both the horizontal and vertical joints' seals removed.

During the three test sequences for the residual, horizontal and vertical joints the required volume flow rate measured by the three rotameters were documented.

In order to determine the leakage of the vertical joint the residual leakage determined in test 1 is subtracted from the total leakage measured during test 2. The leakage of the horizontal joint is determined by subtracting the total leakage determined in test 2 from the total leakage determined in test 3.

Table 31 contains the air leakage measured in volume flow rate (m^3/h) during the tests and the results for the air permeability ($m^3/h \cdot m^2$) of the individual joints and specimen.

	Air leakage			**Air permeability**		
Pressure	**Test 1**	**Test 2**	**Test 3**	**Vertical Joint**	**Horizontal joint**	**Specimen** (*Total*)
Pa	m^3/h	m^3/h	m^3/h	$m^3/h \cdot m^2$	$m^3/h \cdot m^2$	$m^3/h \cdot m^2$
40	5.00	13.70	15.50	1.73	0.36	2.08
52	5.30	16.60	19.10	2.24	0.50	2.74
68	6.20	21.00	24.70	2.94	0.73	3.67
89	7.30	26.10	29.70	3.73	0.71	4.44
117	8.50	32.10	38.80	4.68	1.33	6.01
153	9.80	38.20	44.40	5.63	1.23	6.87
200	11.10	46.70	55.20	7.06	1.69	8.75

Table 31 – Summary of the volume flow rates measured during the Air permeability test.

5.12 Support reaction capacity at end of panel

The test determines the reaction capacity at the end of the lightly profiled panel and is an alternative to calculation for design purposes. The test is conducted according to ***the Standard*** section A15.

5.12.1 Test Apparatus

The Zwick 30 kN test bench was adapted in order to perform the test. The right hand support had to hold a 10 mm thick steel plate at an incline of 1:20. The distance between the top edge of the inclined support and the centre of the loading platen was 150 mm. The left hand support which allowed for rotational motion of the specimen was a distance of 1.85 m from the centre of the loading platen.

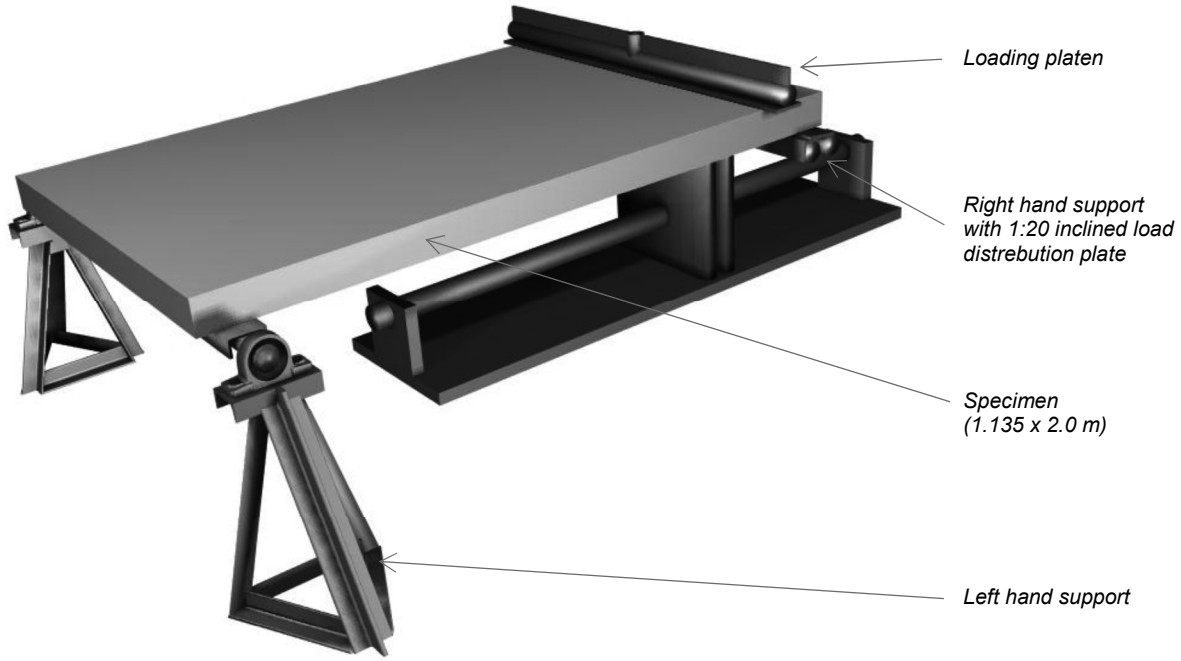


Figure 19 – Test arrangement for the support reaction capacity test.

The inclined support was achieved by combining the Zwick bottom supports and placing a 5 x 60 mm equal leg angle over the front support and clamping the 10 x 100 mm wide load spreading plate onto both the angle and back support (see figure 19). The left hand support was placed 1.85 m from the top edge of the inclined support.



Figure 20 – Right hand support with inclined load spreading plate.

5.12.2 Calculations

The load was measured at the loading platen. The reaction capacity (F_{R1}) is calculated by the maximum load (F_u) measured during the test, the distance between the inclined support and loading platen (L_1) and the distance between the loading platen and the left hand support (L_2).

$$F_{R1} = \frac{L_2}{L_1 + L_2} \cdot F_u$$

The distribution parameter (k) is determined by the following equation from the width of the specimen (B), width of the support (L_s), distance between the centroids of the faces (e) and compressive strength of the core (f_{Cc}) following initial type testing.

$$F_{R1} = B \cdot (L_s + 0.5 \cdot k \cdot e) \cdot f_{Cc}$$

rearranging gives

$$k = \frac{2 \cdot F_{R1} - f_{Cc} \cdot B \cdot L_s}{f_{Cc} \cdot B \cdot e}$$

The results from the test and calculations are given in Table 32 with the summary in Table 33. The constants used in the calculations are as follow:

$B = 1.135\ m$

$L_s = 100\ mm$

$e = 98.75 - 0.55 = 98.20\ mm$

$f_{Cc} = 92.867\ kPa$

Specimen number	F_u N	F_{R1} N	k
1	12005.9	11050.0	0.098
2	13718.0	12625.8	0.403
3	10832.8	9970.3	0.110
4	10665.9	9816.7	0.140
5	12287.7	11309.3	0.149
6	12716.2	11703.7	0.225

Table 32 – Test results, support reaction capacity and distribution parameter k.

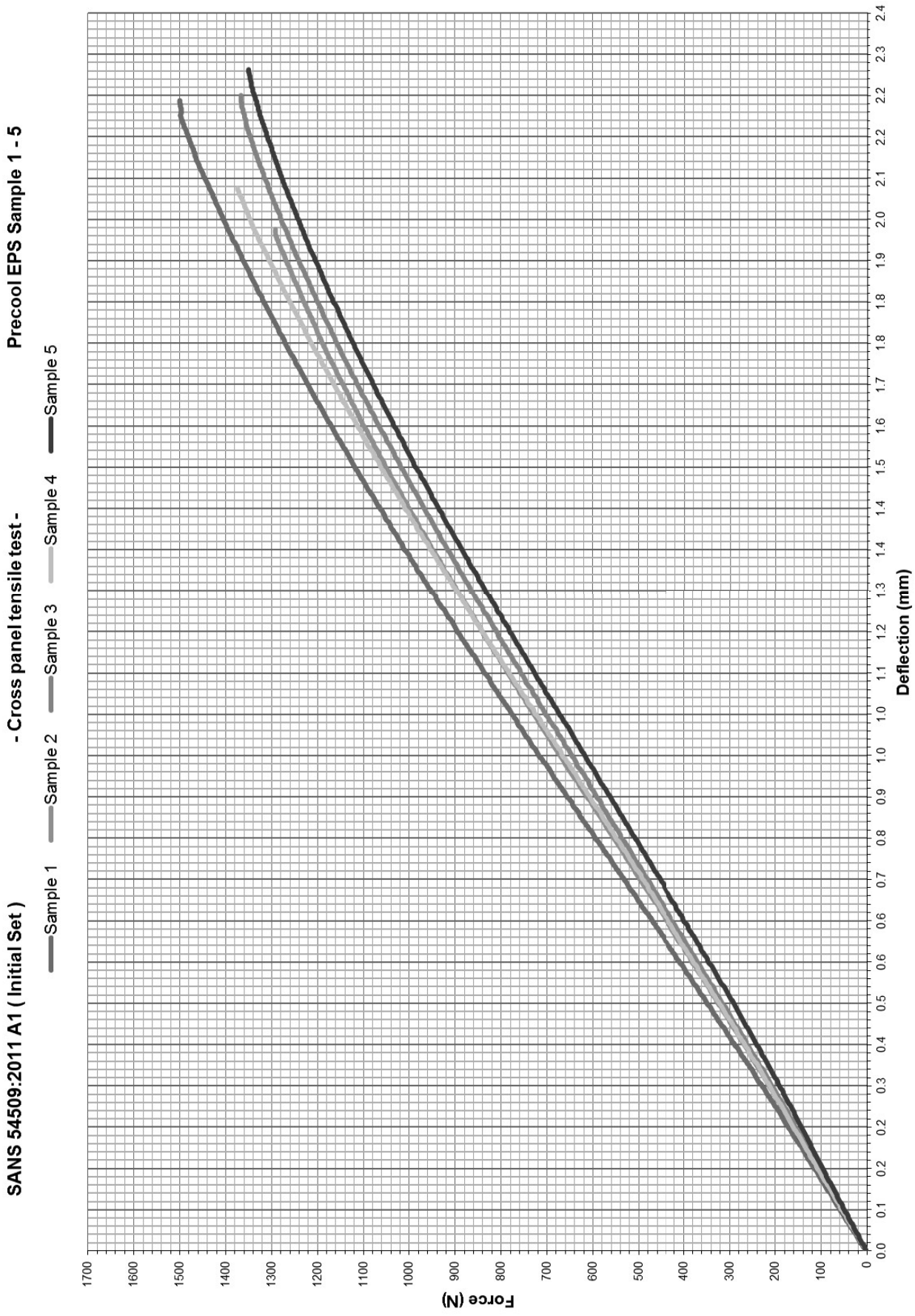
Support reaction capacity	Number of tested specimens		Qty	6
	Span		m	1.850
	Force (F_u)	Average	N	12037.8
		Maximum		13718.0
		Minimum		10665.9
		Standard deviation		1155.9
	Support reaction capacity (F_{R1})	Average	N	11079.3
		Maximum		12625.8
		Minimum		9816.7
		Standard deviation		1063.9
	Distribution parameter (k)	Average		0.187
		Maximum		0.403
		Minimum		0.098
		Standard deviation		0.114

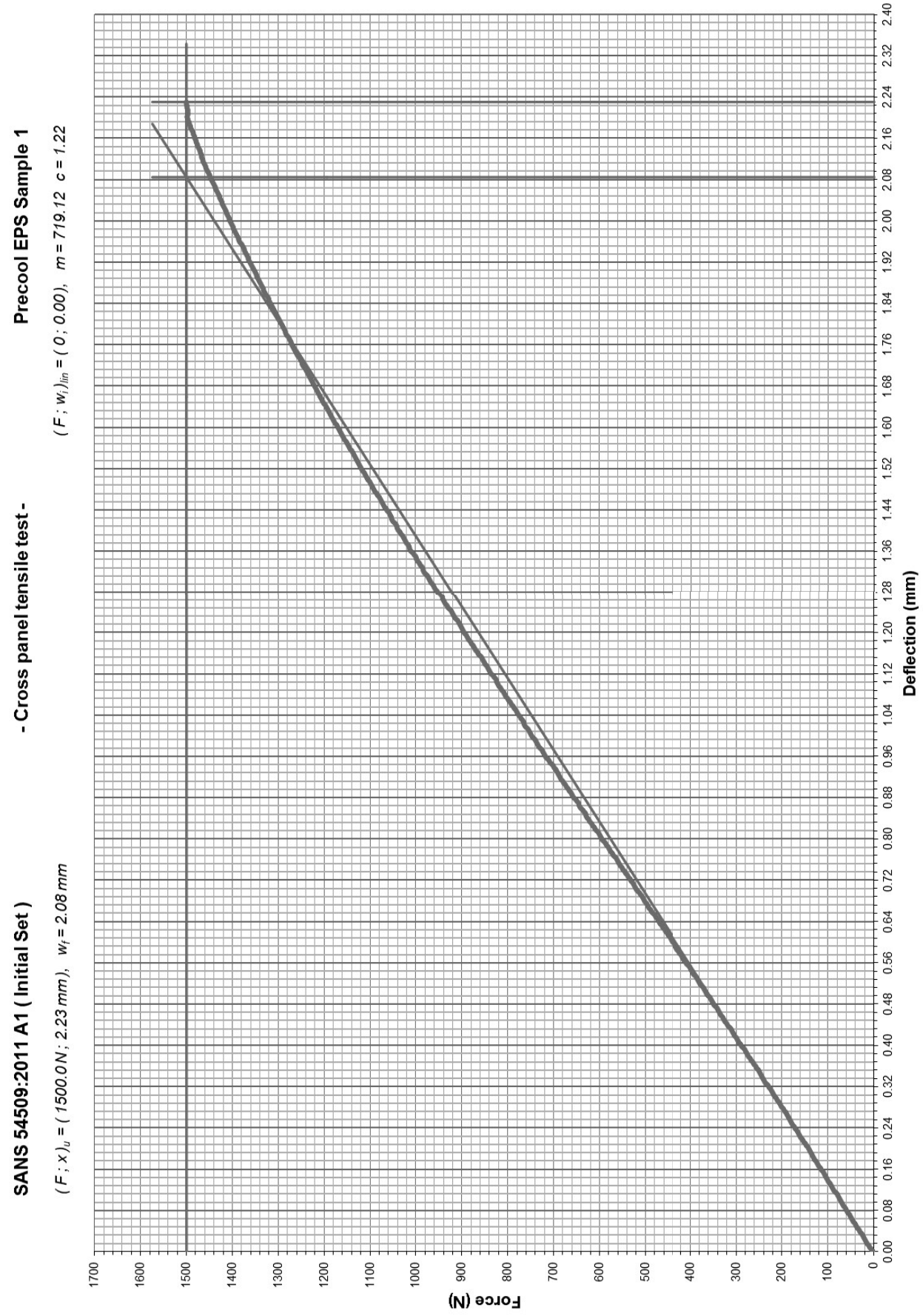
Table 33 – Summary of test results for the support reaction capacity test.

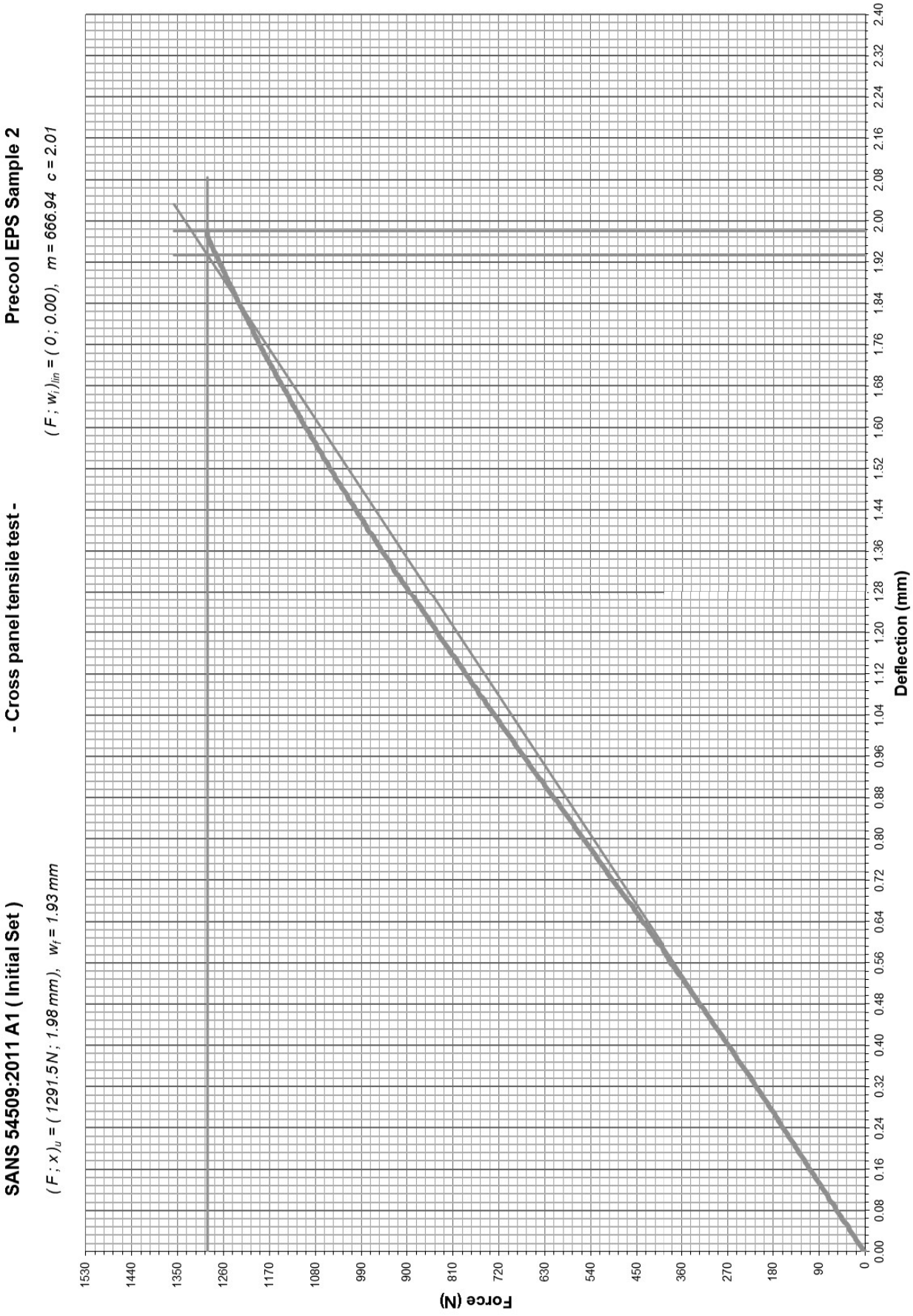
The first three specimens tested had the end caps of the complete panel intact with the last three open ended as may be found when panels are modified during construction.

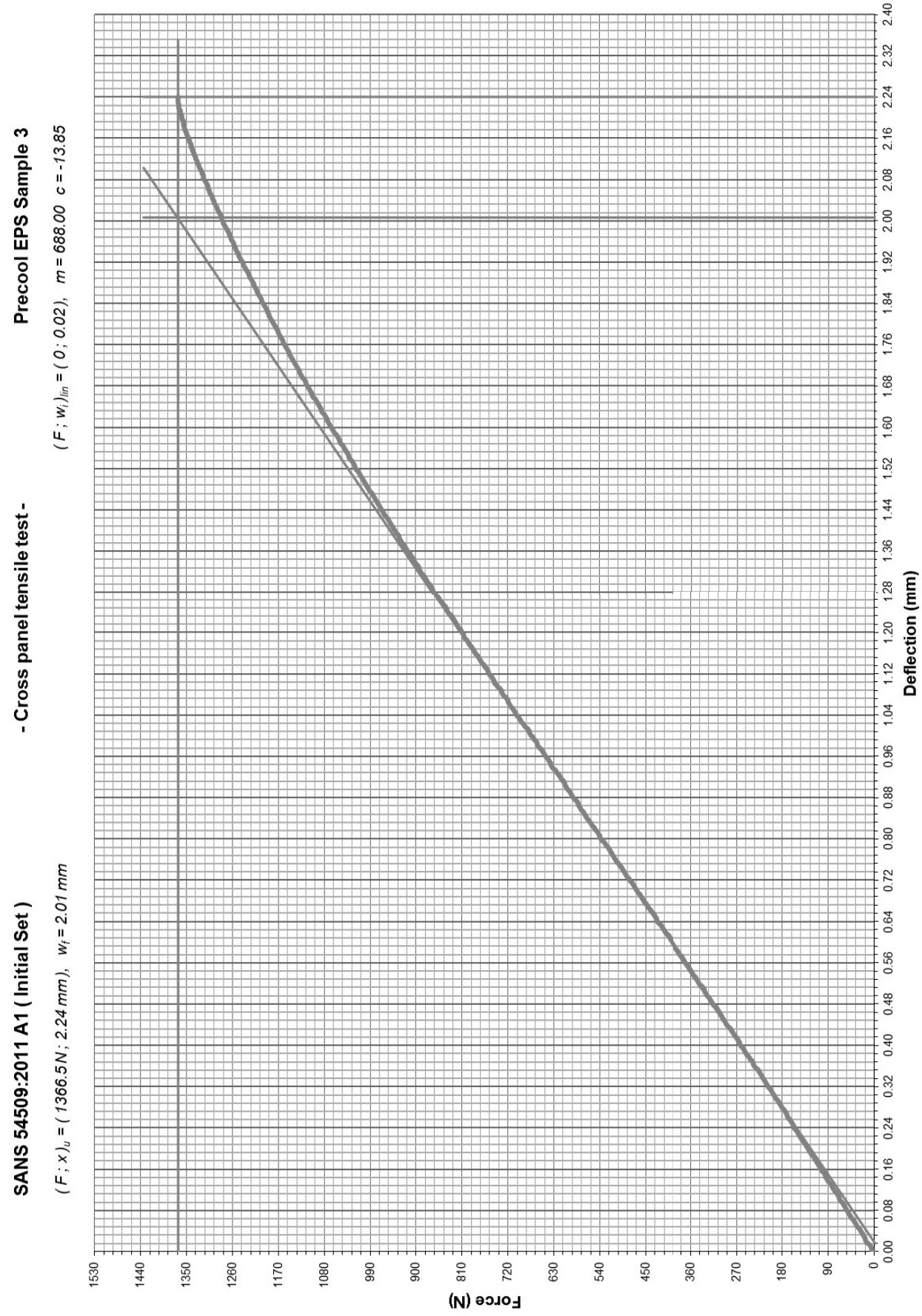
Part 3
Test Graphs and supplementary reports

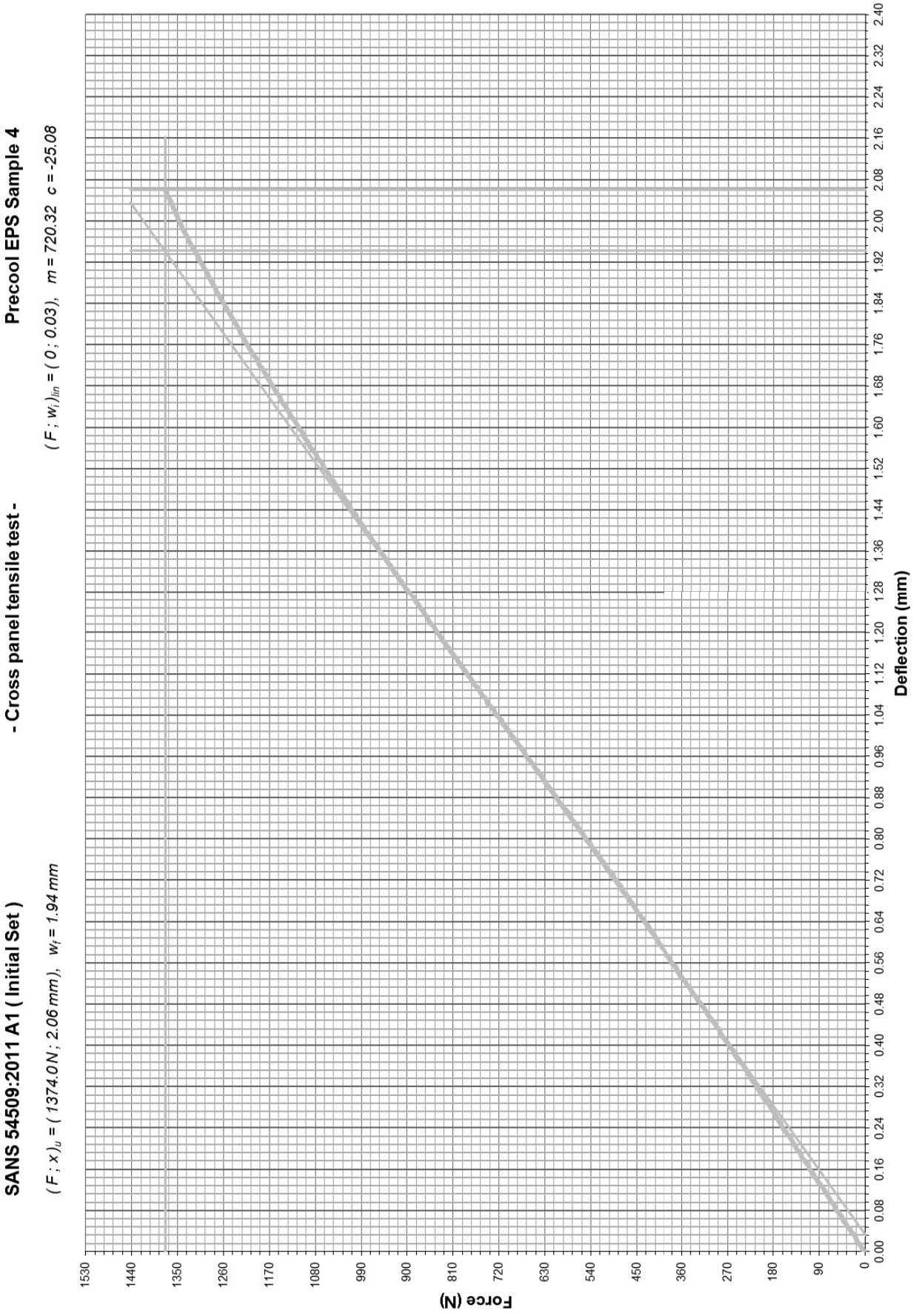
Tensile Test
EN 14509:2006
(DSS SANS 54509:2012)
A1
Initial Set

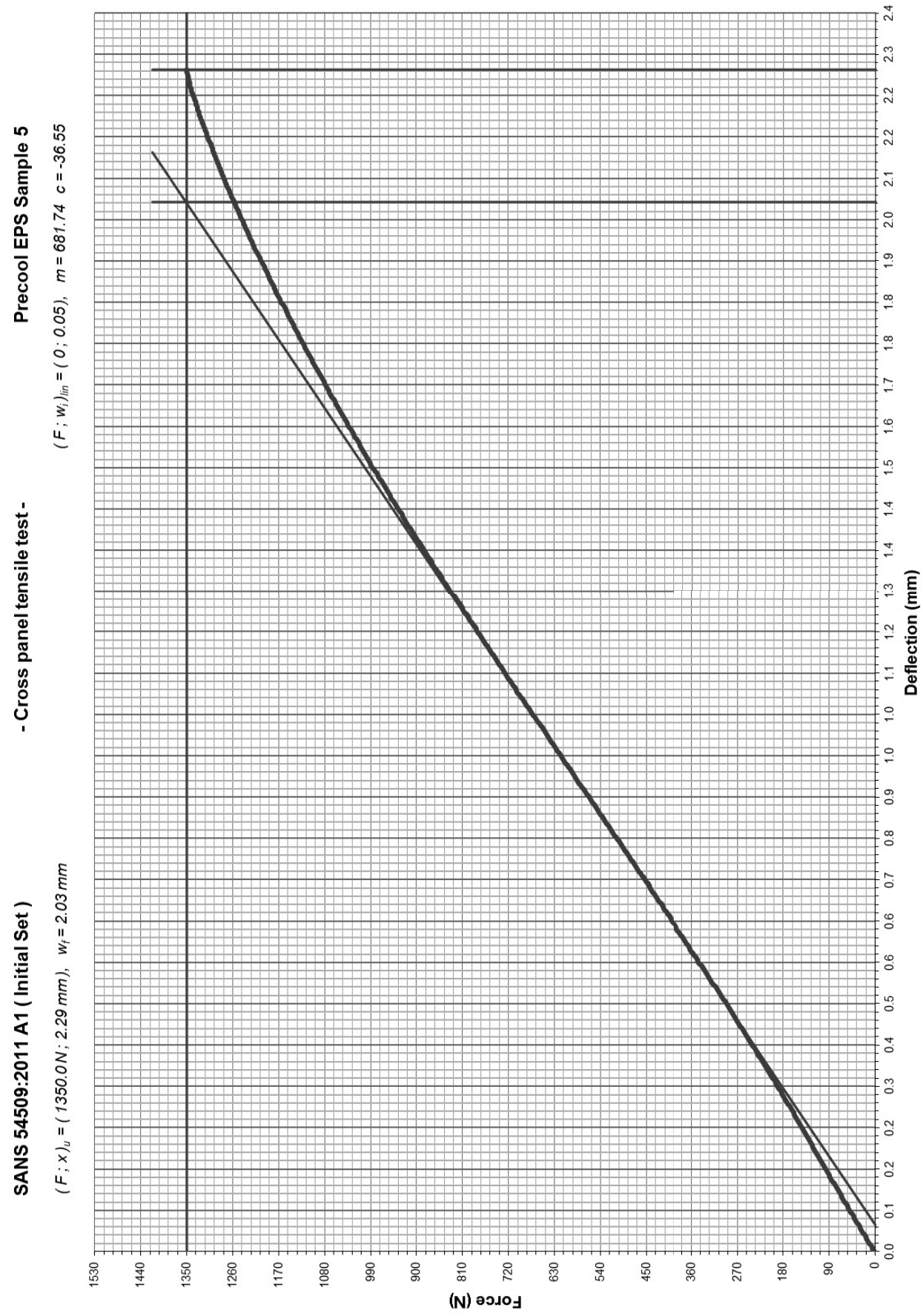

SANS 54509:2011 A1 (Initial Set)
- Cross panel tensile test -
Precool EPS Sample 1 - 5
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
Deflection (mm)


Precool EPS Sample 1
- Cross panel tensile test -
SANS 54509:2011 A1 (Initial Set)
(F ; w_i)_lin = (0 ; 0.00), m = 719.12 c = 1.22
(F ; x)_u = (1500.0 N ; 2.23 mm), w_f = 2.08 mm
Force (N)
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

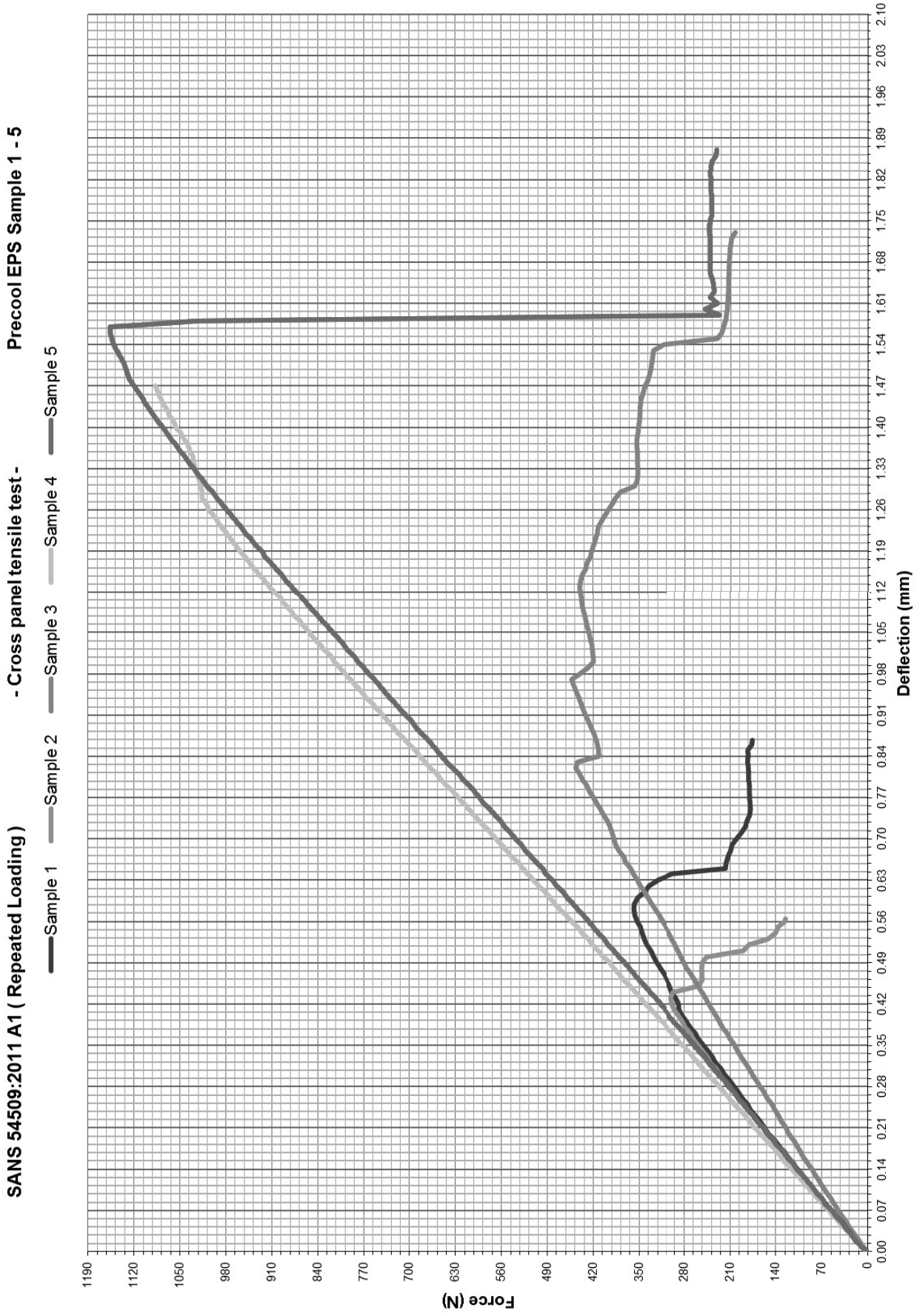

Precool EPS Sample 2
- Cross panel tensile test -
SANS 54509:2011 A1 (Initial Set)
$(F; w_i)_{lin} = (0; 0.00)$, $m = 666.94$ $c = 2.01$
$(F; x)_u = (1291.5N; 1.98\ mm)$, $w_f = 1.93\ mm$
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

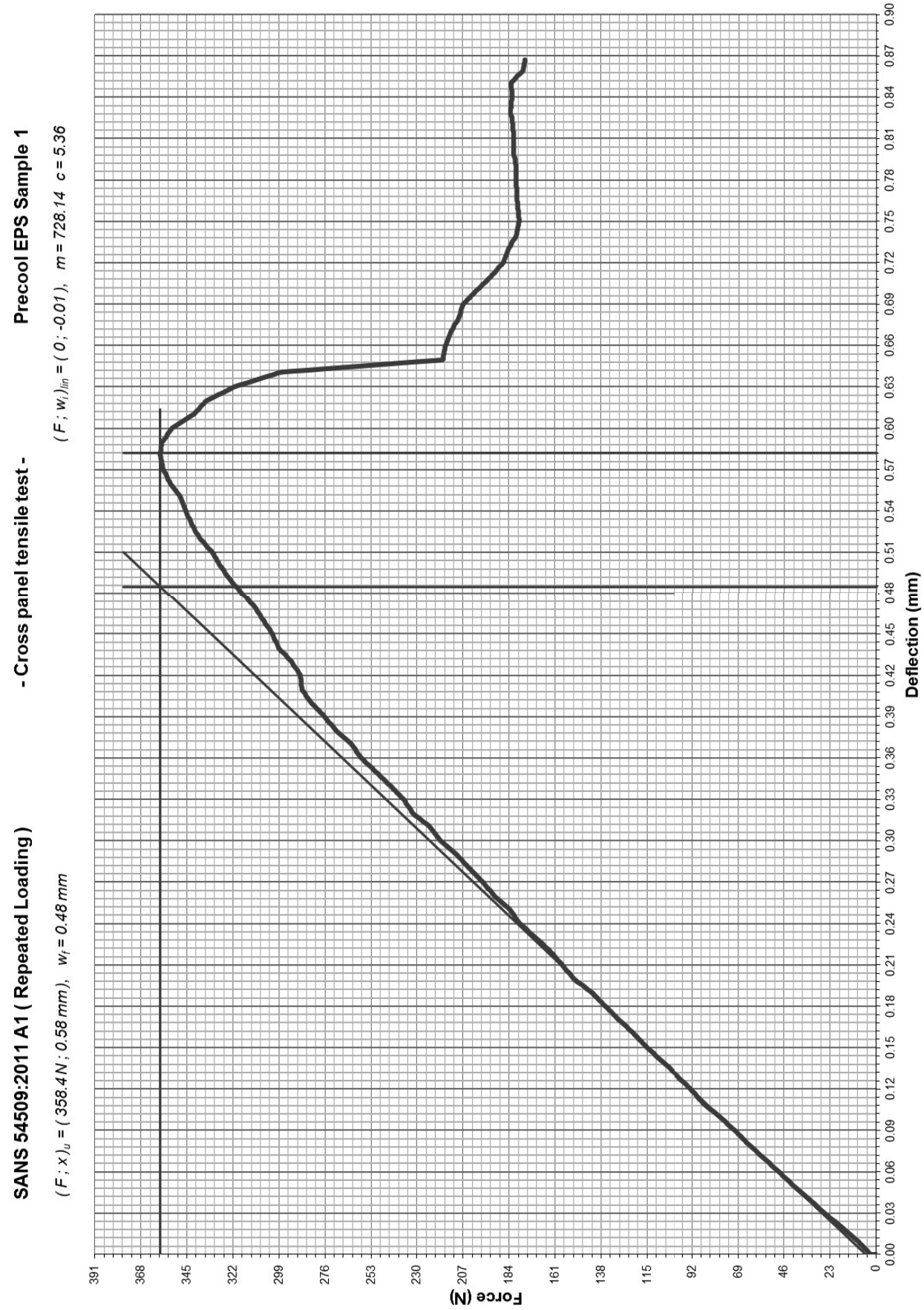

Precool EPS Sample 3
- Cross panel tensile test -
SANS 54509:2011 A1 (Initial Set)
(F ; w_i)_lin = (0 ; 0.02), m = 688.00 c = -13.85
(F ; x)_u = (1366.5 N ; 2.24 mm), w_i = 2.01 mm
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

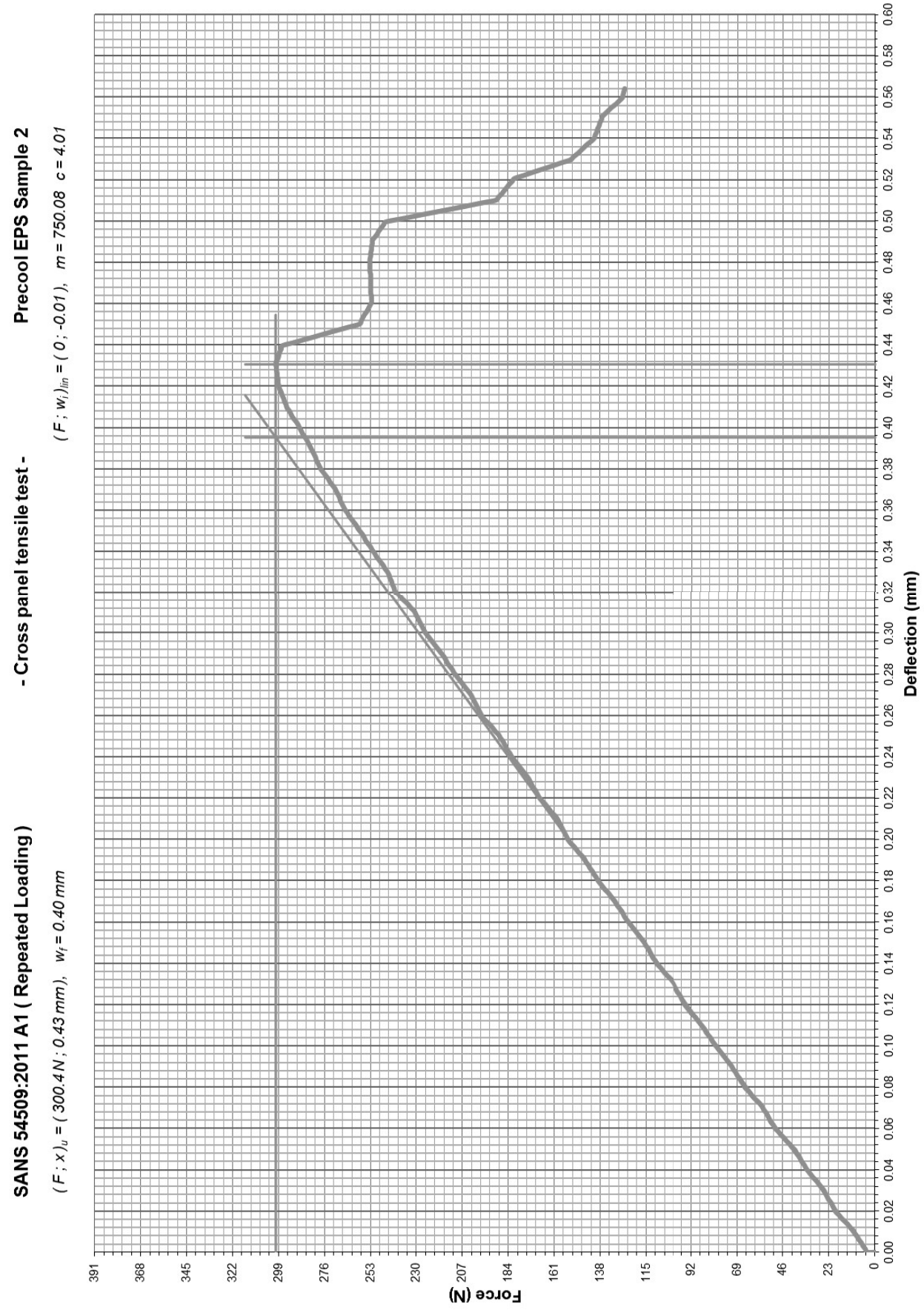

Precool EPS Sample 4
- Cross panel tensile test -
SANS 54509:2011 A1 (Initial Set)
$(F; w_i)_{lin}$ = (0 ; 0.03), m = 720.32 c = -25.08
$(F; x)_u$ = (1374.0 N ; 2.06 mm), w_i = 1.94 mm
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

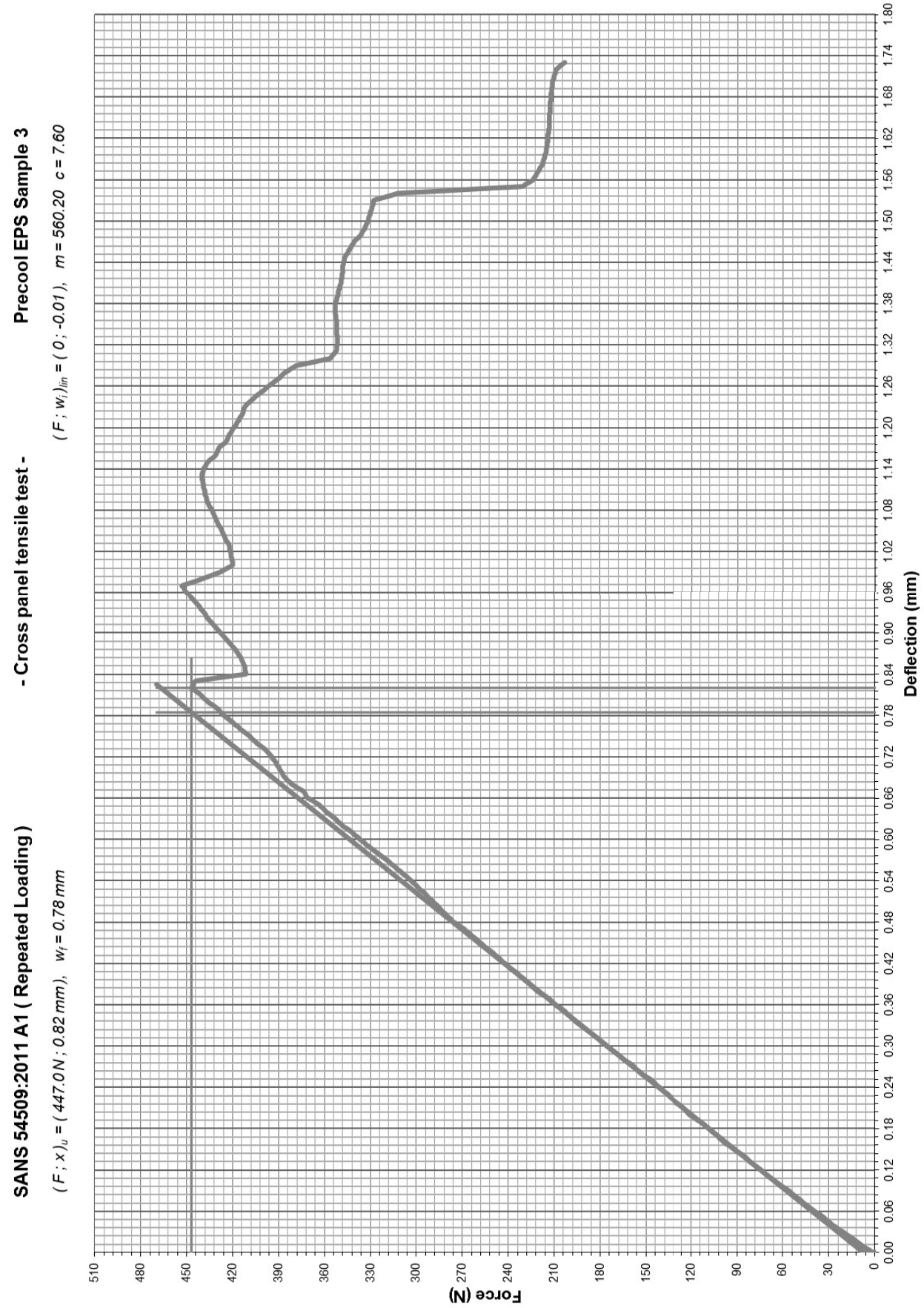

Precool EPS Sample 5
- Cross panel tensile test -
SANS 54509:2011 A1 (Initial Set)
$(F ; w_i)_{lin}$ = (0 ; 0.05), m = 681.74 c = -36.55
$(F ; x)_u$ = (1350.0 N ; 2.29 mm), w_i = 2.03 mm
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.0
0.1
0.2
0.2
0.3
0.4
0.5
0.6
0.6
0.7
0.8
0.9
1.0
1.0
1.1
1.2
1.3
1.4
1.4
1.5
1.6
1.7
1.8
1.8
1.9
2.0
2.1
2.2
2.2
2.3
2.4

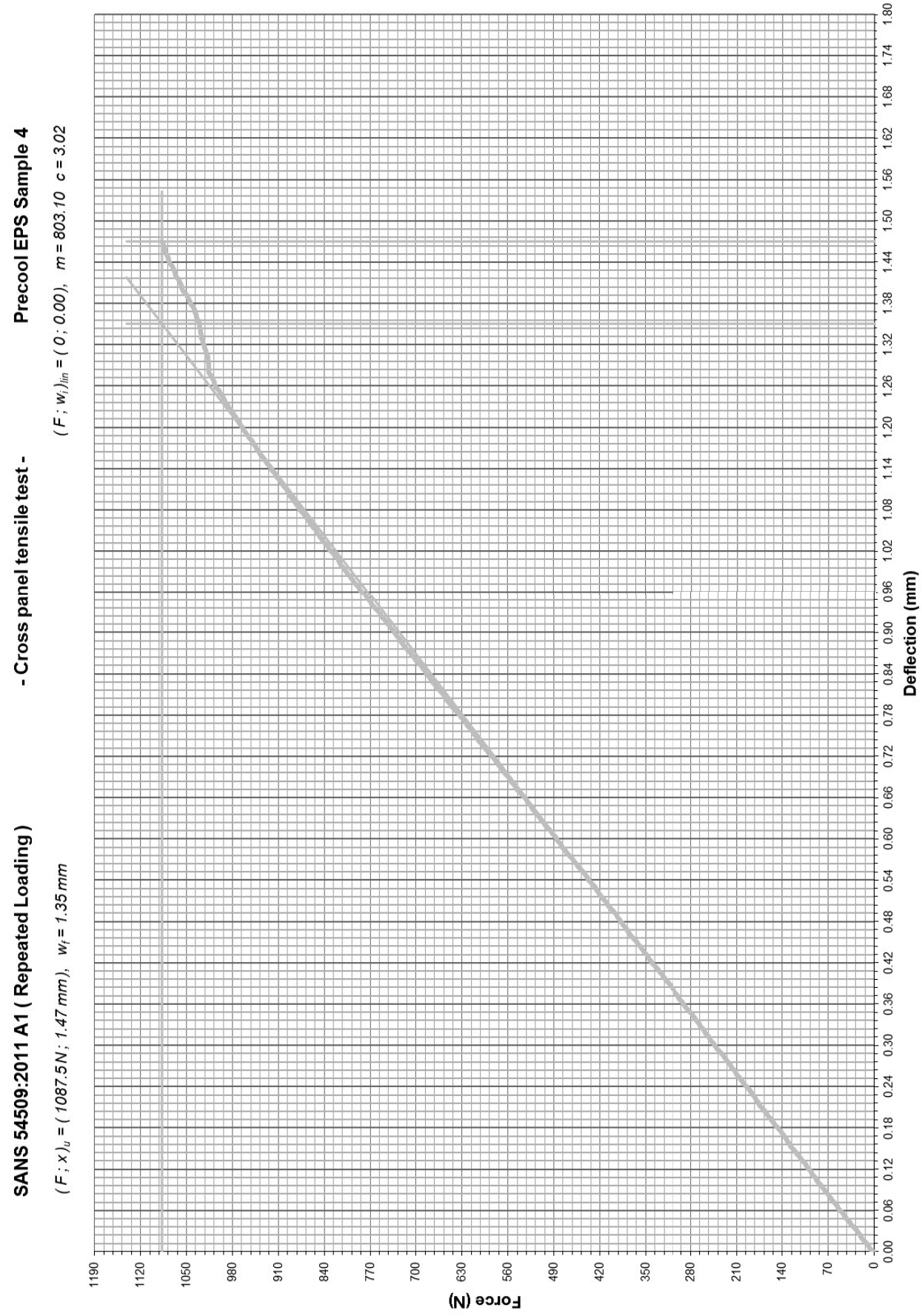
Tensile Test
EN 14509:2006
(DSS SANS 54509:2012)
A1
Repeated Loading

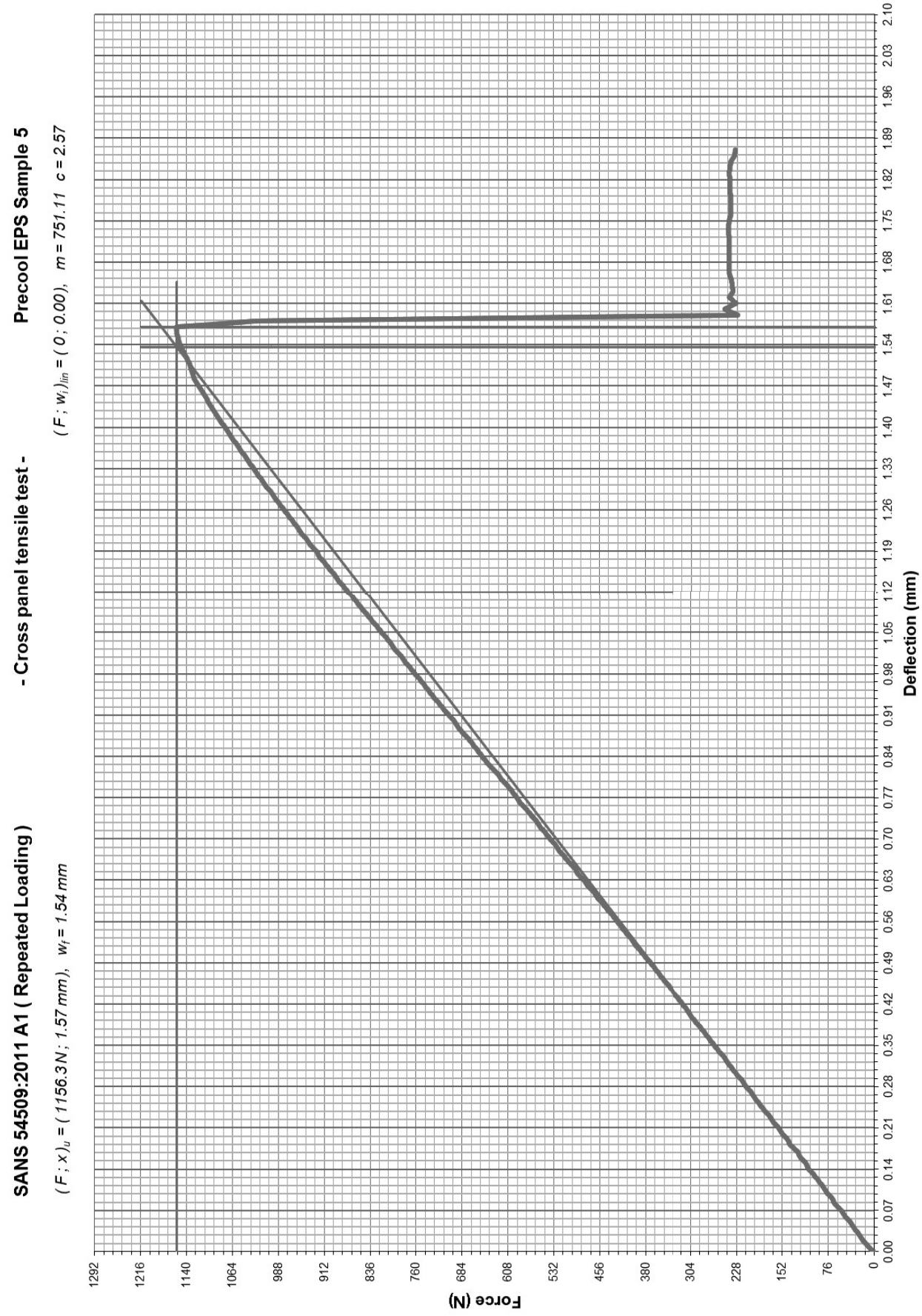

Precool EPS Sample 1 - 5
- Cross panel tensile test -
SANS 54509:2011 A1 (Repeated Loading)
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
1190
1120
1050
980
910
840
770
700
630
560
490
420
350
280
210
140
70
0
Deflection (mm)
0.00
0.07
0.14
0.21
0.28
0.35
0.42
0.49
0.56
0.63
0.70
0.77
0.84
0.91
0.98
1.05
1.12
1.19
1.26
1.33
1.40
1.47
1.54
1.61
1.68
1.75
1.82
1.89
1.96
2.03
2.10


Precool EPS Sample 1
- Cross panel tensile test -
SANS 54509:2011 A1 (Repeated Loading)
(F ; w_i)_lin = (0 ; -0.01), m = 728.14 c = 5.36
(F ; x)_u = (358.4 N ; 0.58 mm), w_f = 0.48 mm
Force (N)
391
368
345
322
299
276
253
230
207
184
161
138
115
92
69
46
23
0
Deflection (mm)
0.00
0.03
0.06
0.09
0.12
0.15
0.18
0.21
0.24
0.27
0.30
0.33
0.36
0.39
0.42
0.45
0.48
0.51
0.54
0.57
0.60
0.63
0.66
0.69
0.72
0.75
0.78
0.81
0.84
0.87
0.90

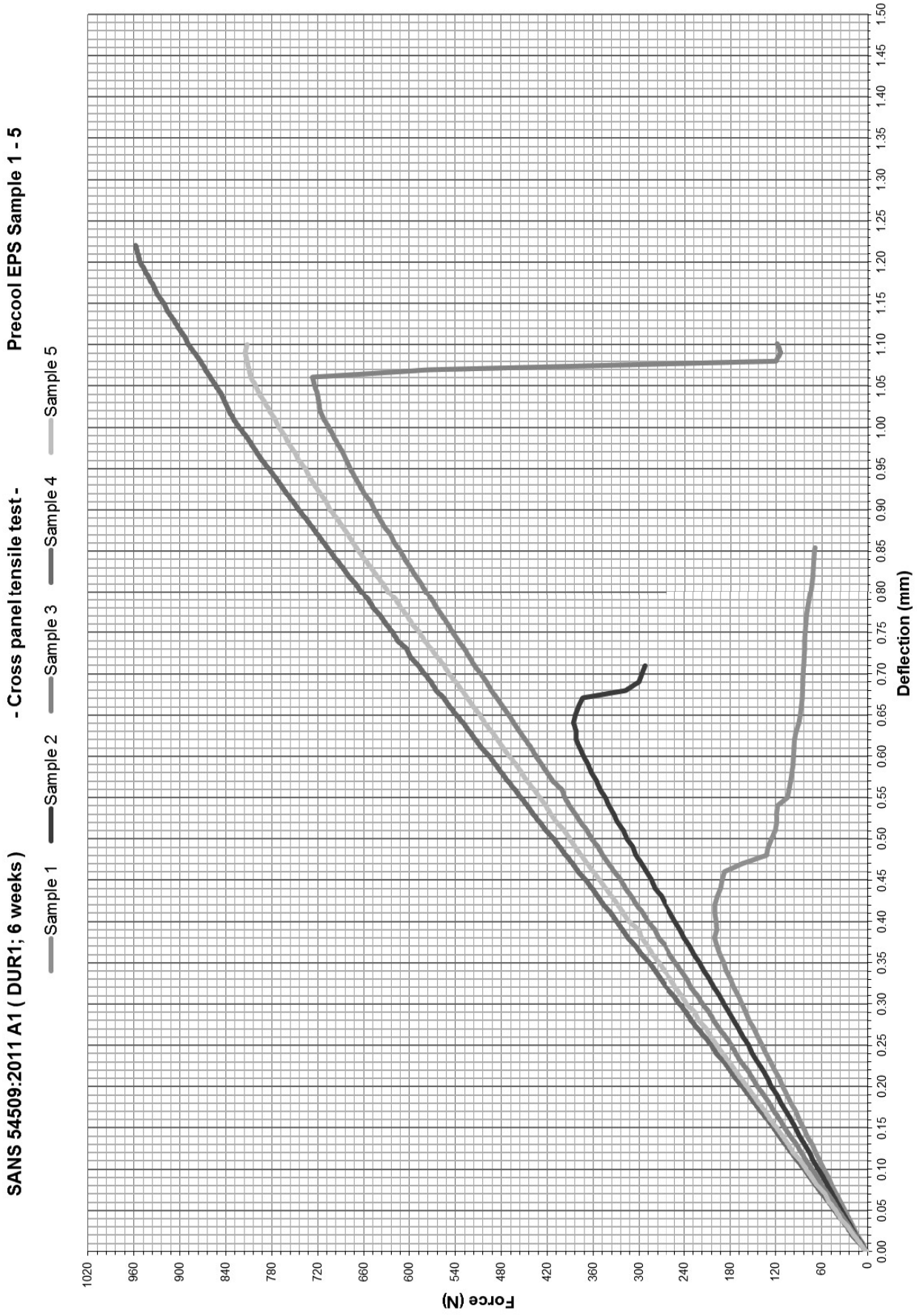

SANS 54509:2011 A1 (Repeated Loading)
(F ; x)u = (300.4 N ; 0.43 mm), wf = 0.40 mm
- Cross panel tensile test -
Precool EPS Sample 2
(F ; wi)lin = (0 ; -0.01), m = 750.08 c = 4.01
Force (N)
391
368
345
322
299
276
253
230
207
184
161
138
115
92
69
46
23
0
Deflection (mm)
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
0.16
0.18
0.20
0.22
0.24
0.26
0.28
0.30
0.32
0.34
0.36
0.38
0.40
0.42
0.44
0.46
0.48
0.50
0.52
0.54
0.56
0.58
0.60

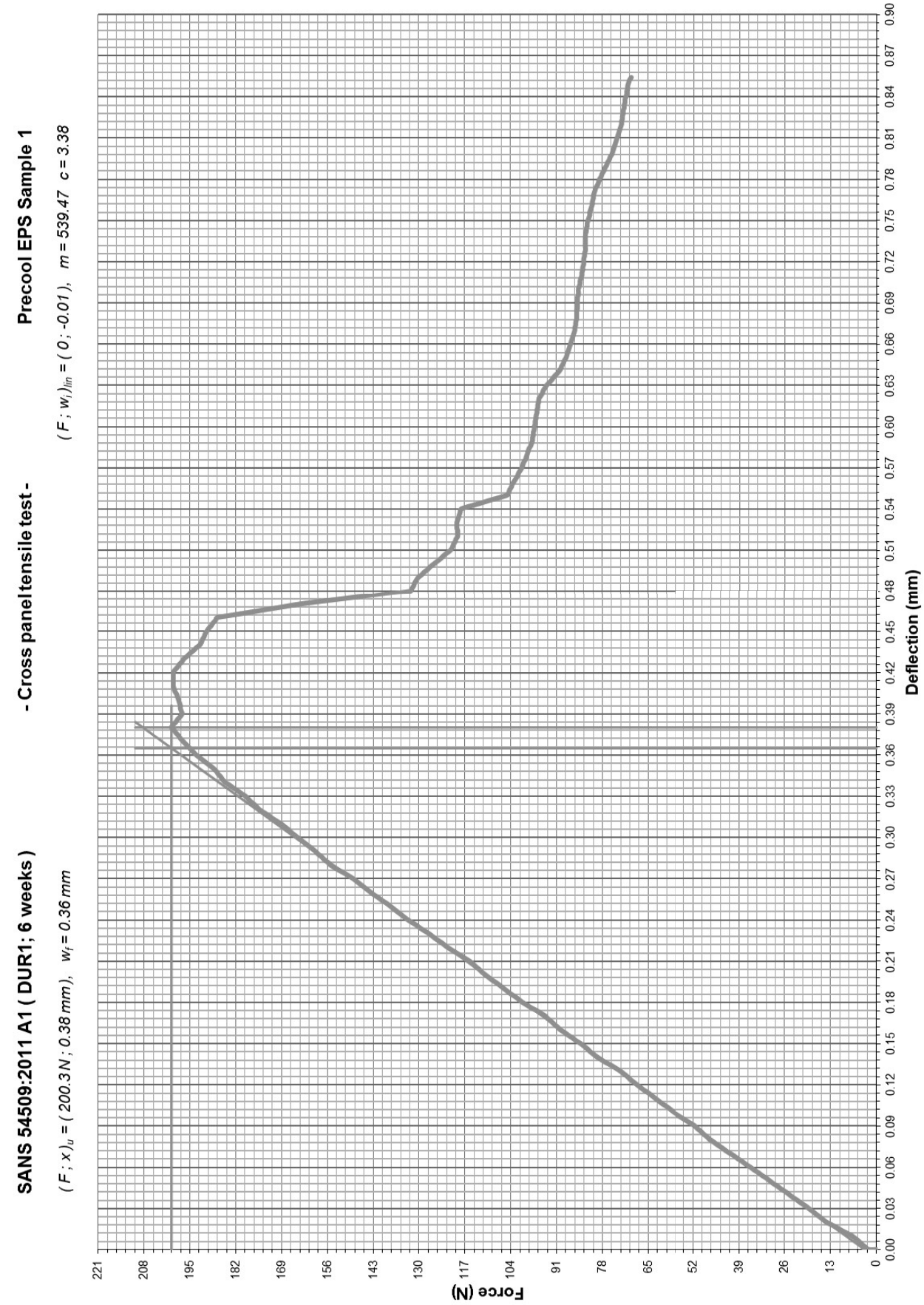

SANS 54509:2011 A1 (Repeated Loading)
(F ; x)u = (447.0 N ; 0.82 mm), wf = 0.78 mm
- Cross panel tensile test -
Precool EPS Sample 3
(F ; wi)lin = (0 ; -0.01), m = 560.20 c = 7.60
Force (N)
510 480 450 420 390 360 330 300 270 240 210 180 150 120 90 60 30 0
Deflection (mm)
0.00 0.06 0.12 0.18 0.24 0.30 0.36 0.42 0.48 0.54 0.60 0.66 0.72 0.78 0.84 0.90 0.96 1.02 1.08 1.14 1.20 1.26 1.32 1.38 1.44 1.50 1.56 1.62 1.68 1.74 1.80

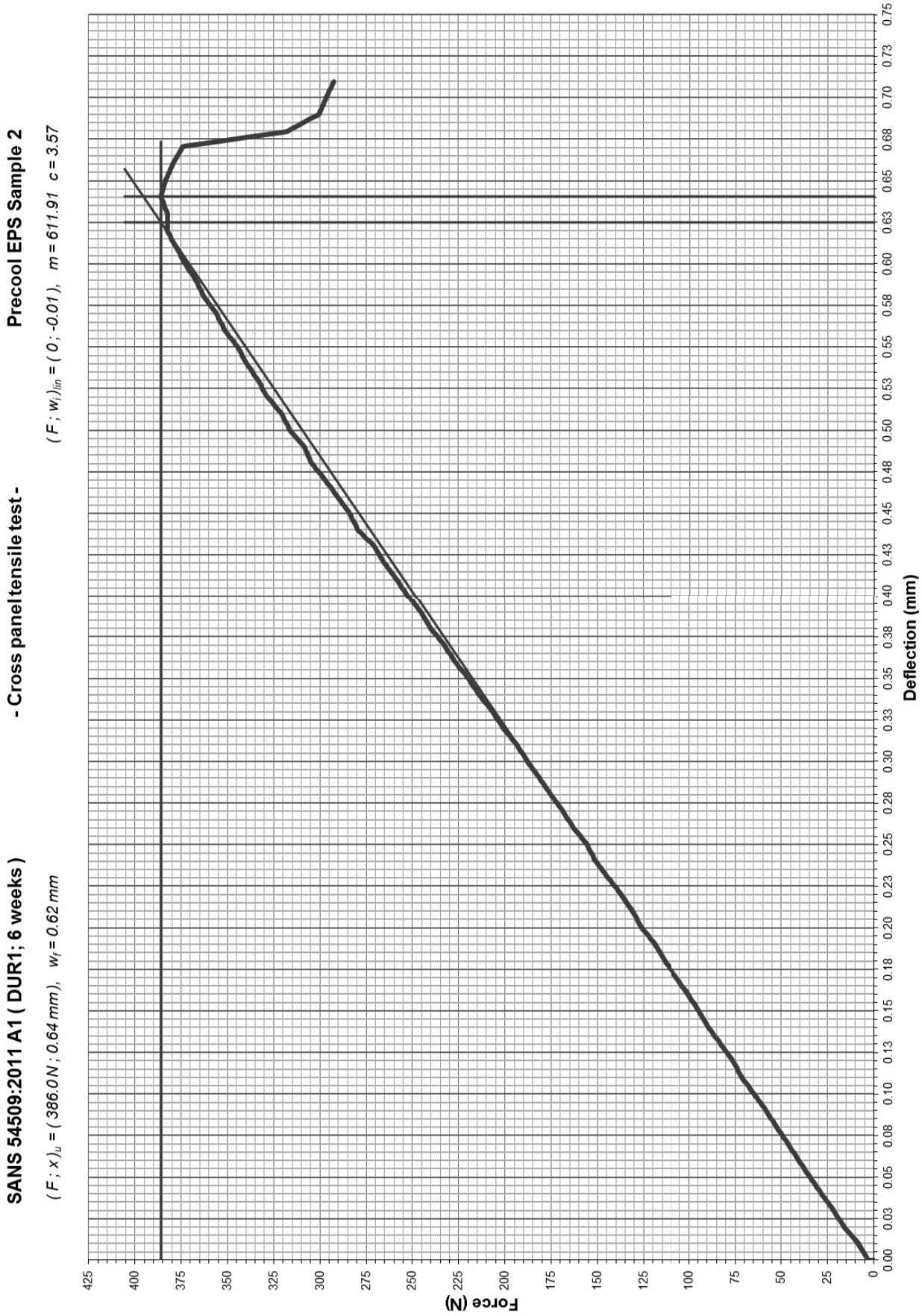

SANS 54509:2011 A1 (Repeated Loading)
- Cross panel tensile test -
Precool EPS Sample 4
$(F ; x)_u$ = (1087.5 N ; 1.47 mm), w_f = 1.35 mm
$(F ; w_i)_{lin}$ = (0 ; 0.00), m = 803.10 c = 3.02
Force (N)
1190
1120
1050
980
910
840
770
700
630
560
490
420
350
280
210
140
70
0
Deflection (mm)
0.00
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.60
0.66
0.72
0.78
0.84
0.90
0.96
1.02
1.08
1.14
1.20
1.26
1.32
1.38
1.44
1.50
1.56
1.62
1.68
1.74
1.80

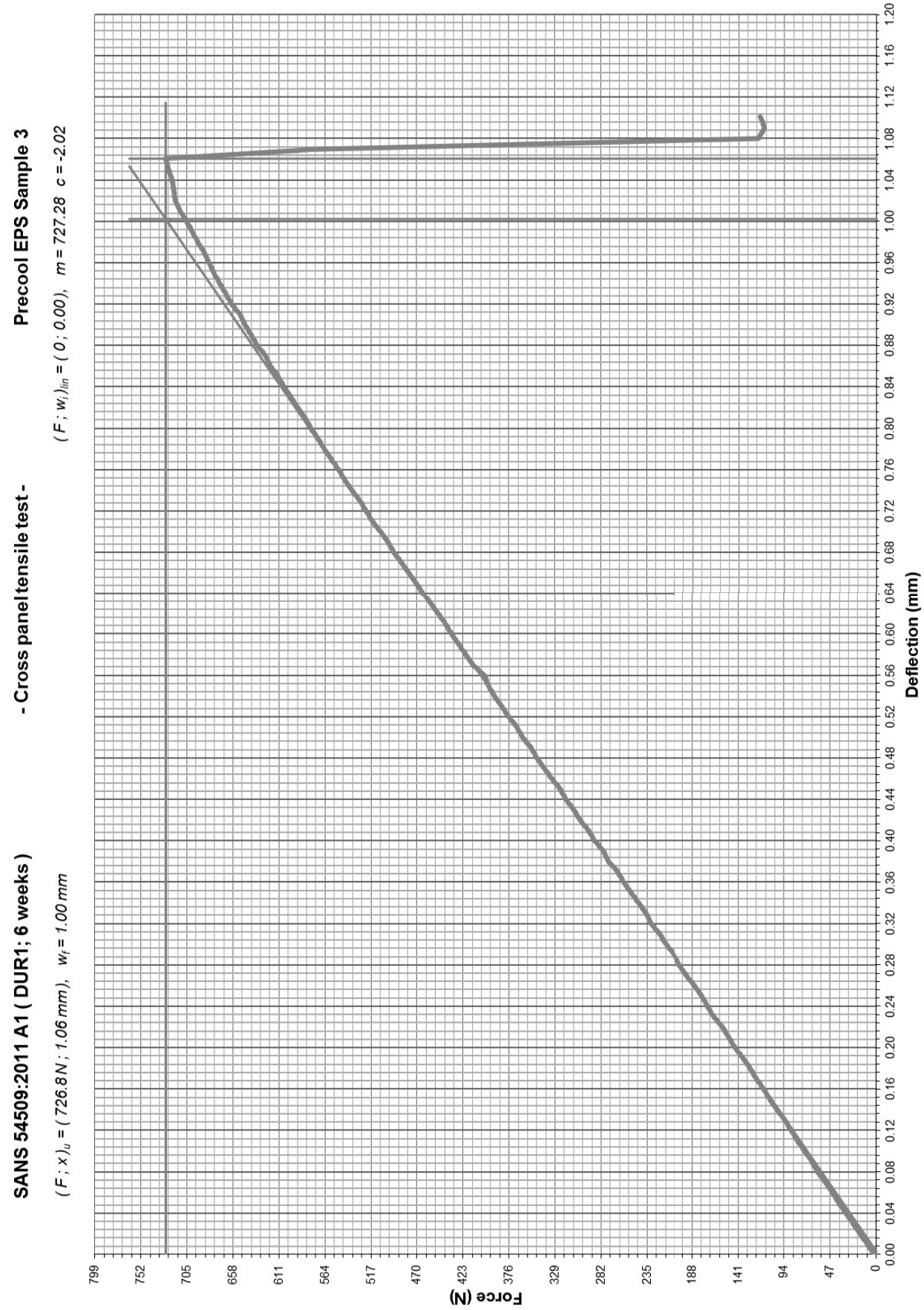

Precool EPS Sample 5
- Cross panel tensile test -
SANS 54509:2011 A1 (Repeated Loading)
(F ; w_i)_lin = (0 ; 0.00), m = 751.11 c = 2.57
(F ; x)_u = (1156.3 N ; 1.57 mm), w_f = 1.54 mm
Force (N)
1292
1216
1140
1064
988
912
836
760
684
608
532
456
380
304
228
152
76
0
Deflection (mm)
0.00
0.07
0.14
0.21
0.28
0.35
0.42
0.49
0.56
0.63
0.70
0.77
0.84
0.91
0.98
1.05
1.12
1.19
1.26
1.33
1.40
1.47
1.54
1.61
1.68
1.75
1.82
1.89
1.96
2.03
2.10

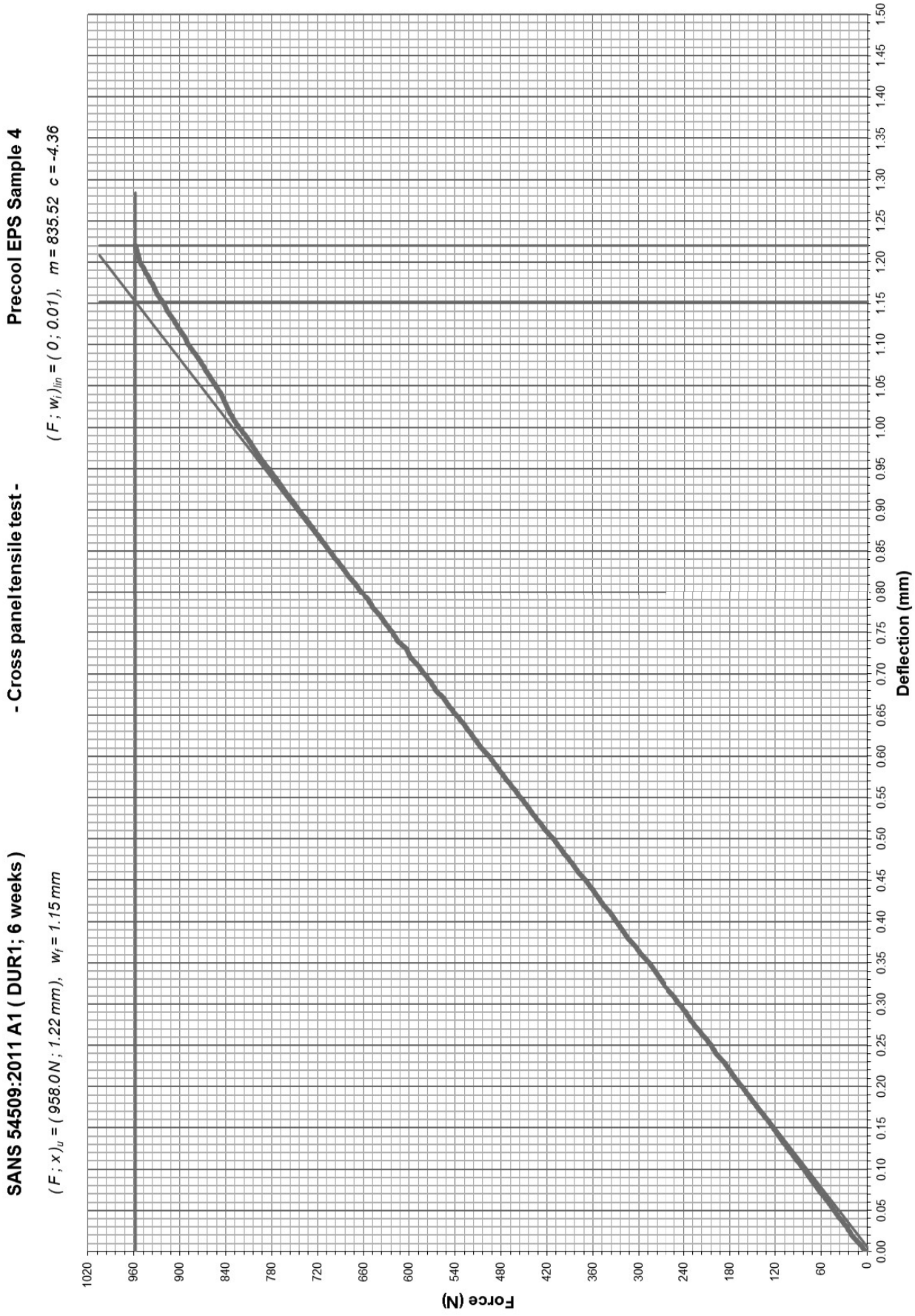
Tensile Test
EN 14509:2006
(DSS SANS 54509:2012)
A1
Durability Testing
6 weeks

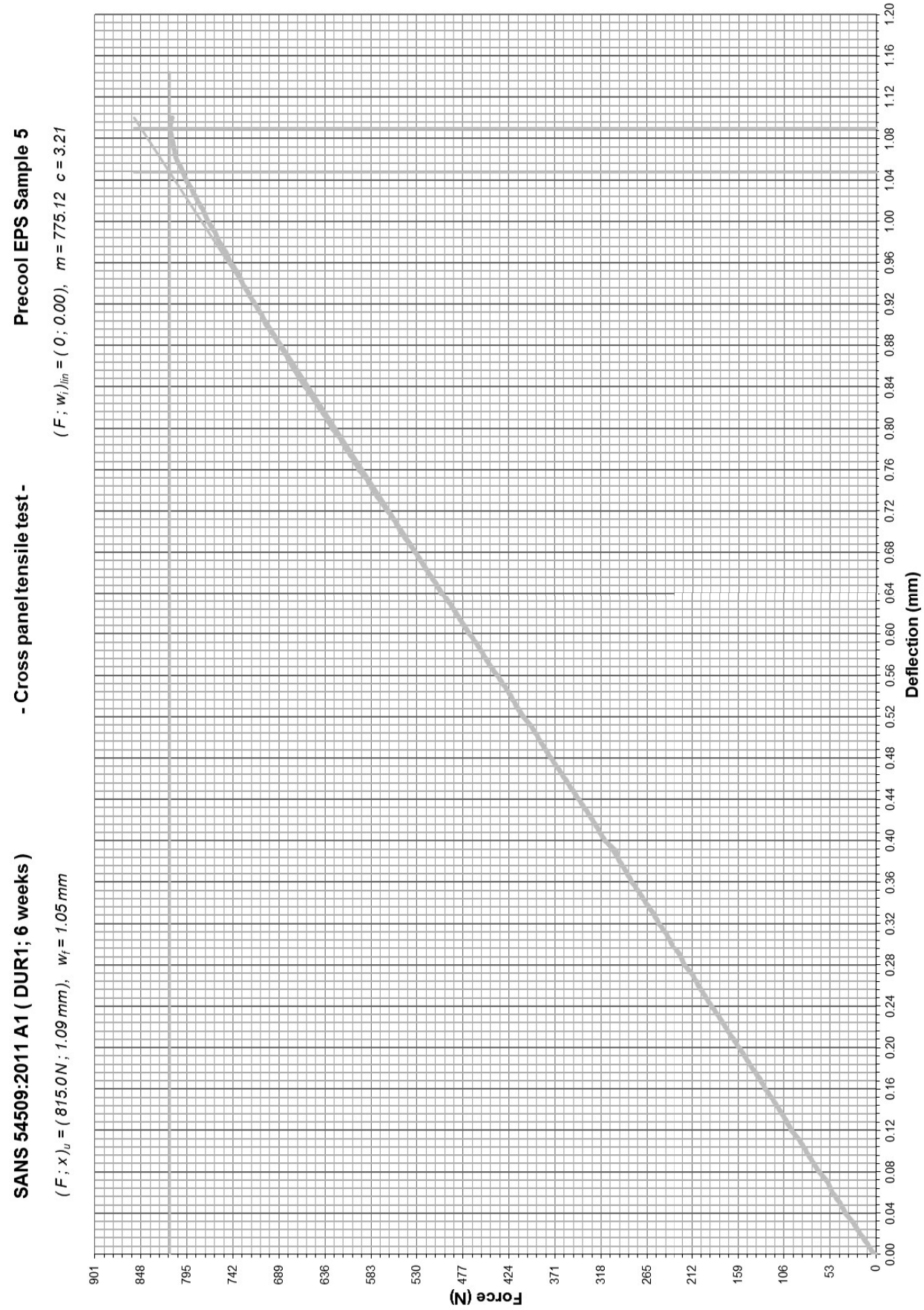

SANS 54509:2011 A1 (DUR1; 6 weeks)
- Cross panel tensile test -
Precool EPS Sample 1 - 5
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
Deflection (mm)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.35
1.40
1.45
1.50


Precool EPS Sample 1
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 6 weeks)
(F ; w_i)_lin = (0 ; -0.01), m = 539.47 c = 3.38
(F ; x)_u = (200.3 N ; 0.38 mm), w_f = 0.36 mm
Force (N)
221
208
195
182
169
156
143
130
117
104
91
78
65
52
39
26
13
0
Deflection (mm)
0.00
0.03
0.06
0.09
0.12
0.15
0.18
0.21
0.24
0.27
0.30
0.33
0.36
0.39
0.42
0.45
0.48
0.51
0.54
0.57
0.60
0.63
0.66
0.69
0.72
0.75
0.78
0.81
0.84
0.87
0.90

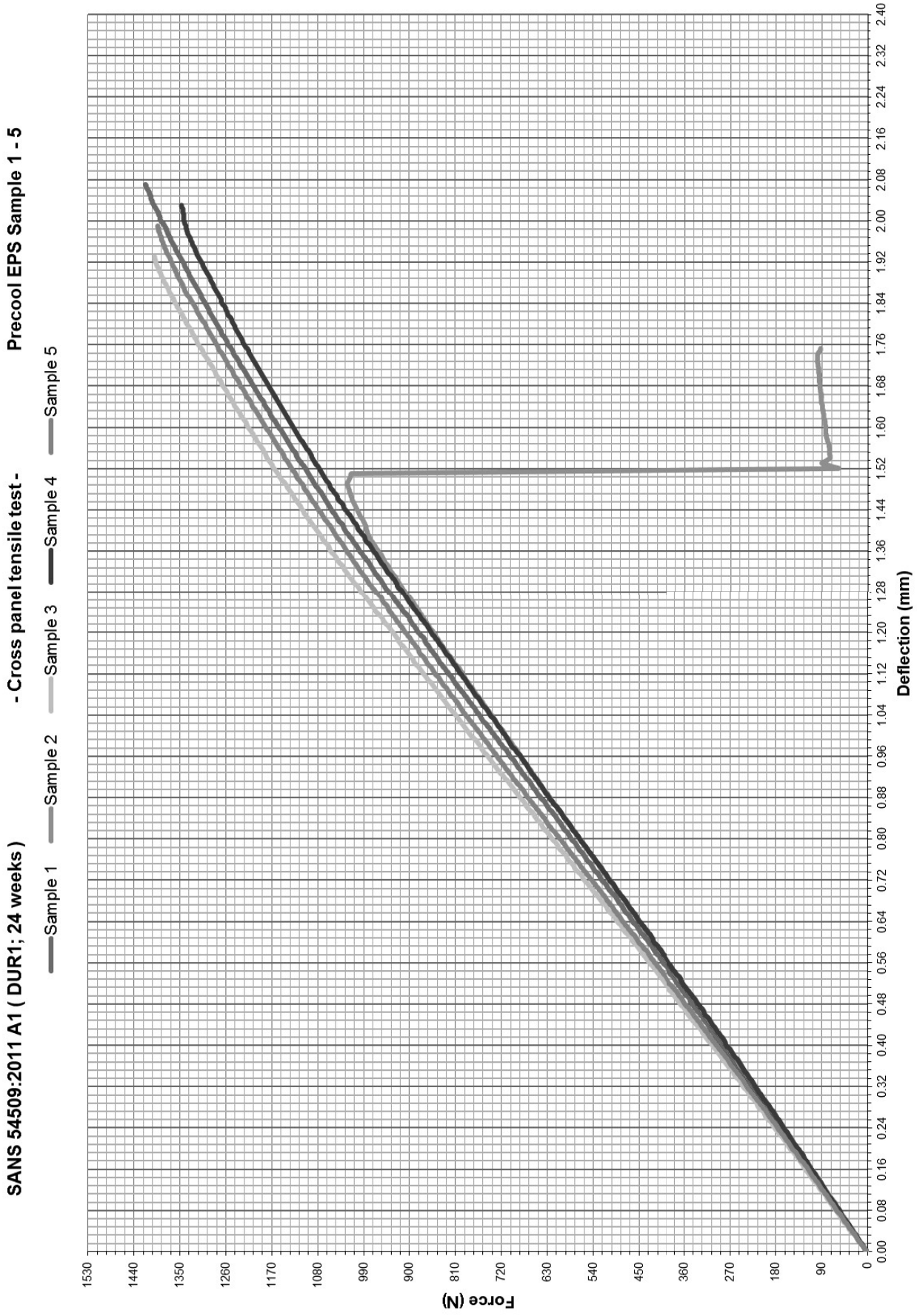

Precool EPS Sample 2
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 6 weeks)
(F ; w_i)_lin = (0 ; -0.01), m = 611.91 c = 3.57
(F ; x)_u = (386.0 N ; 0.64 mm), w_f = 0.62 mm
Force (N)
425 400 375 350 325 300 275 250 225 200 175 150 125 100 75 50 25 0
Deflection (mm)
0.00 0.03 0.05 0.08 0.10 0.13 0.15 0.18 0.20 0.23 0.25 0.28 0.30 0.33 0.35 0.38 0.40 0.43 0.45 0.48 0.50 0.53 0.55 0.58 0.60 0.63 0.65 0.68 0.70 0.73 0.75

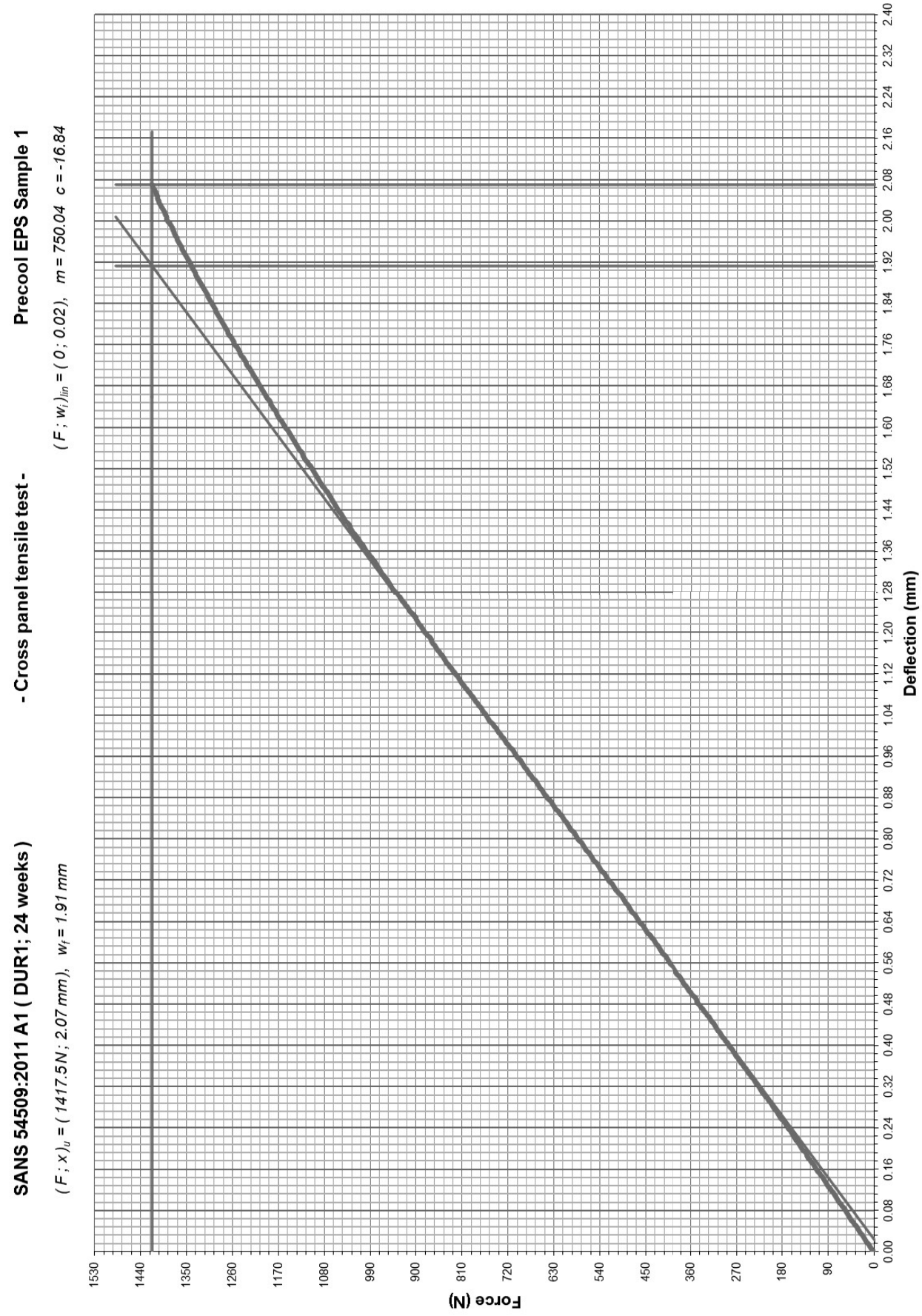

Precool EPS Sample 3
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 6 weeks)
(F ; w_i)_lin = (0 ; 0.00), m = 727.28 c = -2.02
(F ; x)_u = (726.8 N ; 1.06 mm), w_f = 1.00 mm
Force (N)
799
752
705
658
611
564
517
470
423
376
329
282
235
188
141
94
47
0
Deflection (mm)
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
0.76
0.80
0.84
0.88
0.92
0.96
1.00
1.04
1.08
1.12
1.16
1.20

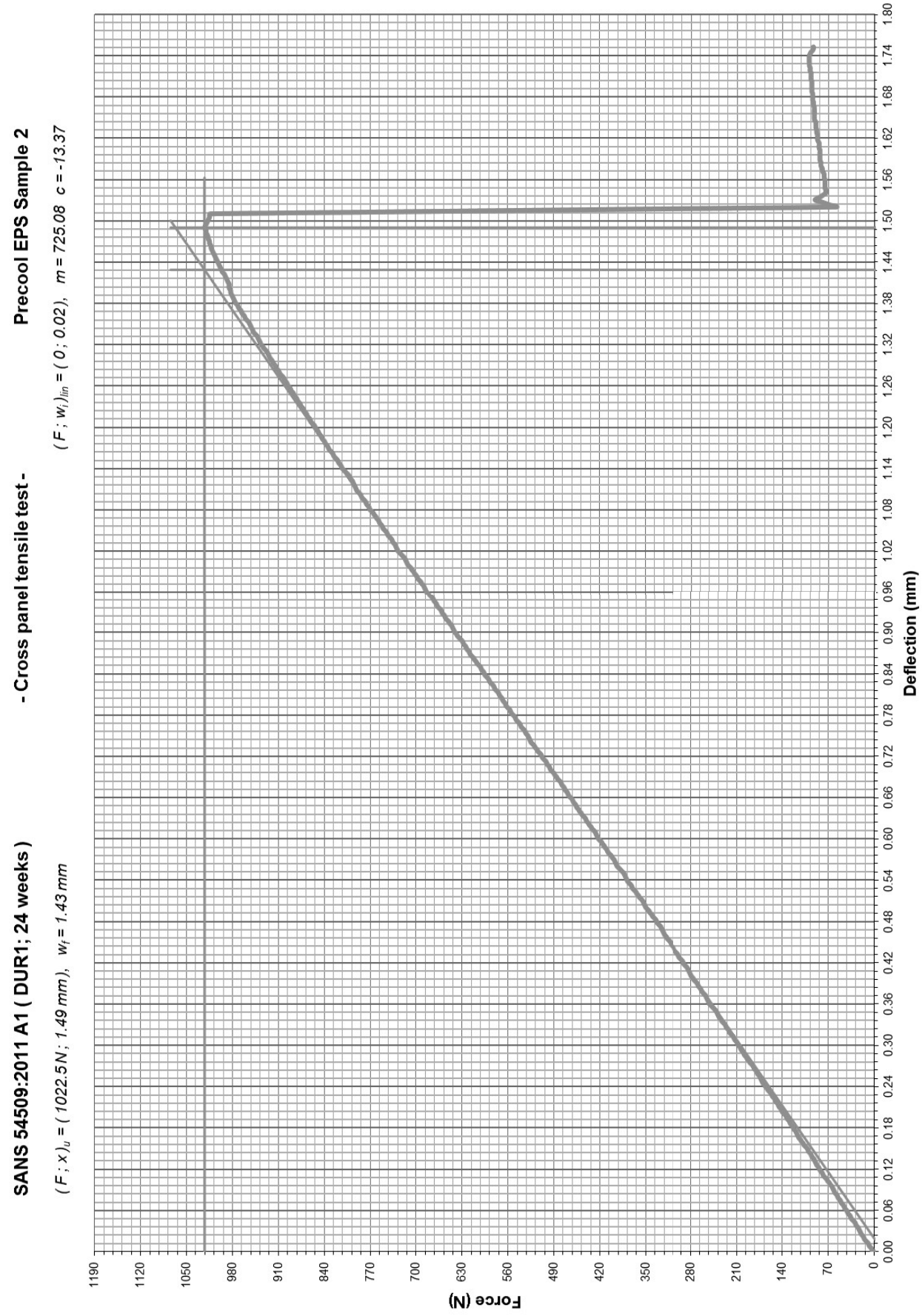

Precool EPS Sample 4
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 6 weeks)
(F ; w_i)_lim = (0 ; 0.01), m = 835.52 c = -4.36
(F ; x)_u = (958.0 N ; 1.22 mm), w_f = 1.15 mm
Force (N)
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
Deflection (mm)
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00
1.05
1.10
1.15
1.20
1.25
1.30
1.35
1.40
1.45
1.50

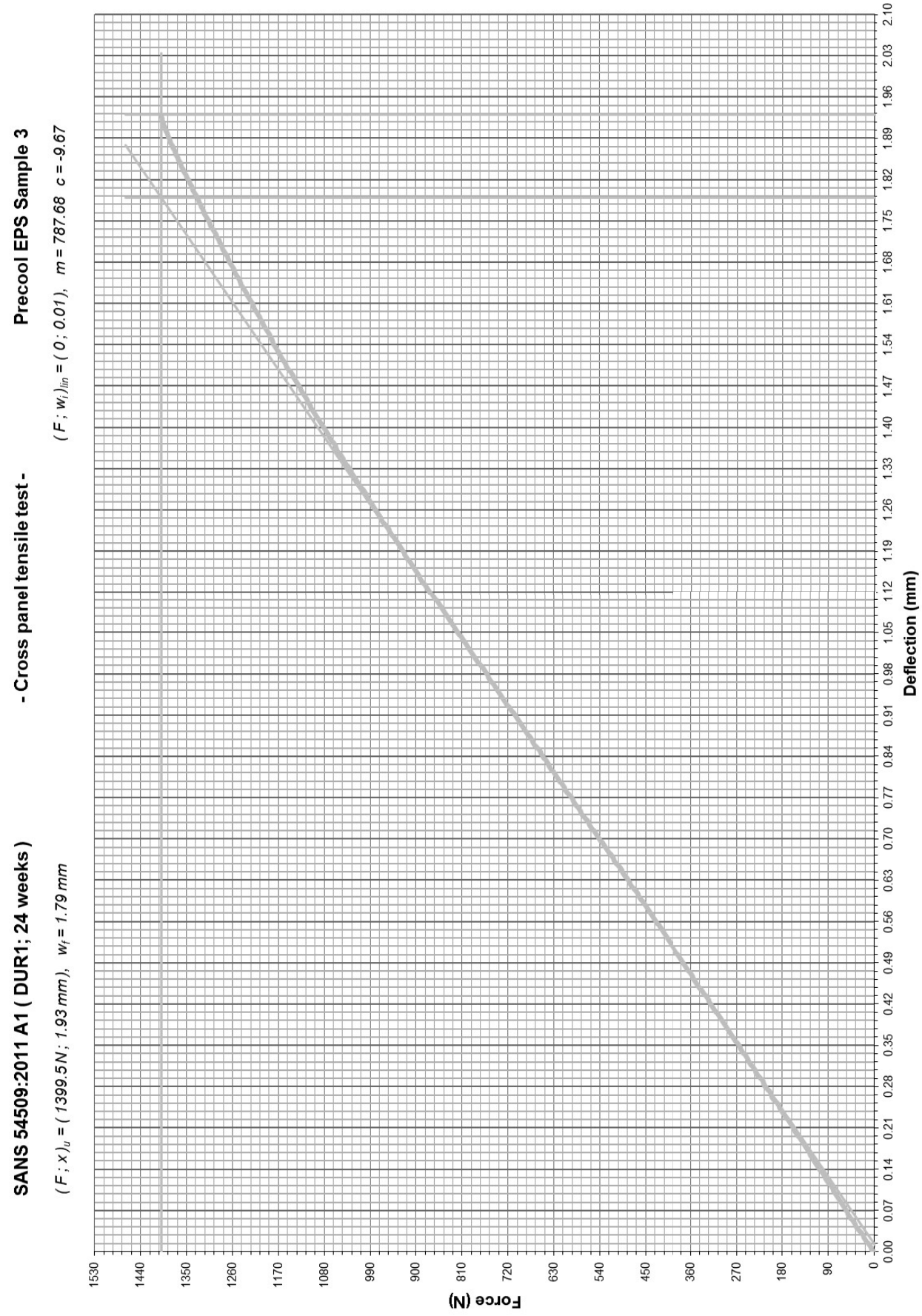

Precool EPS Sample 5
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 6 weeks)
(F ; w_i)_lin = (0 ; 0.00), m = 775.12 c = 3.21
(F ; x)_u = (815.0 N ; 1.09 mm), w_f = 1.05 mm
Force (N)
901
848
795
742
689
636
583
530
477
424
371
318
265
212
159
106
53
0
Deflection (mm)
0.00
0.04
0.08
0.12
0.16
0.20
0.24
0.28
0.32
0.36
0.40
0.44
0.48
0.52
0.56
0.60
0.64
0.68
0.72
0.76
0.80
0.84
0.88
0.92
0.96
1.00
1.04
1.08
1.12
1.16
1.20

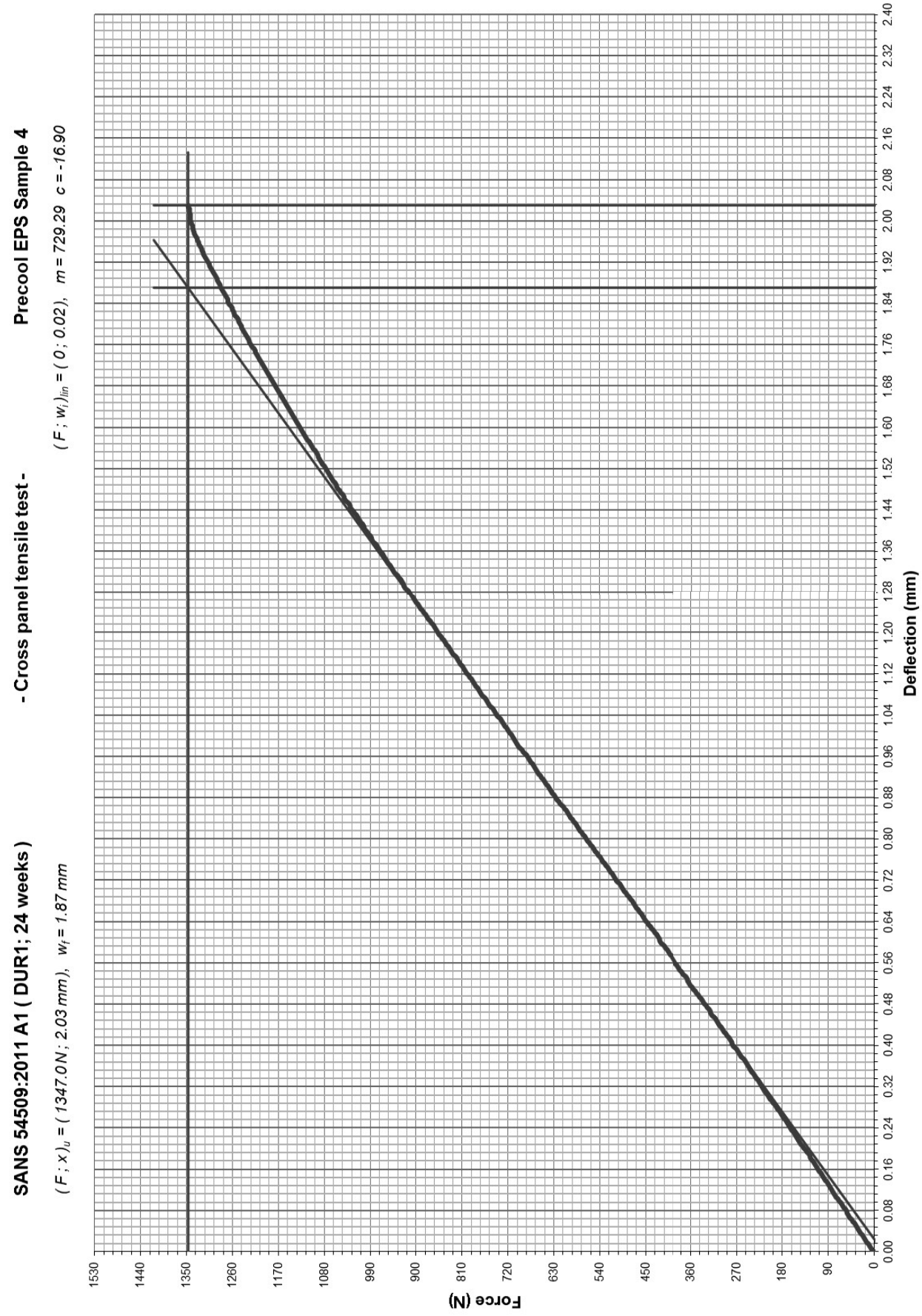
Tensile Test
DSS SANS 54509:2012 A1
Durability Testing
24 weeks

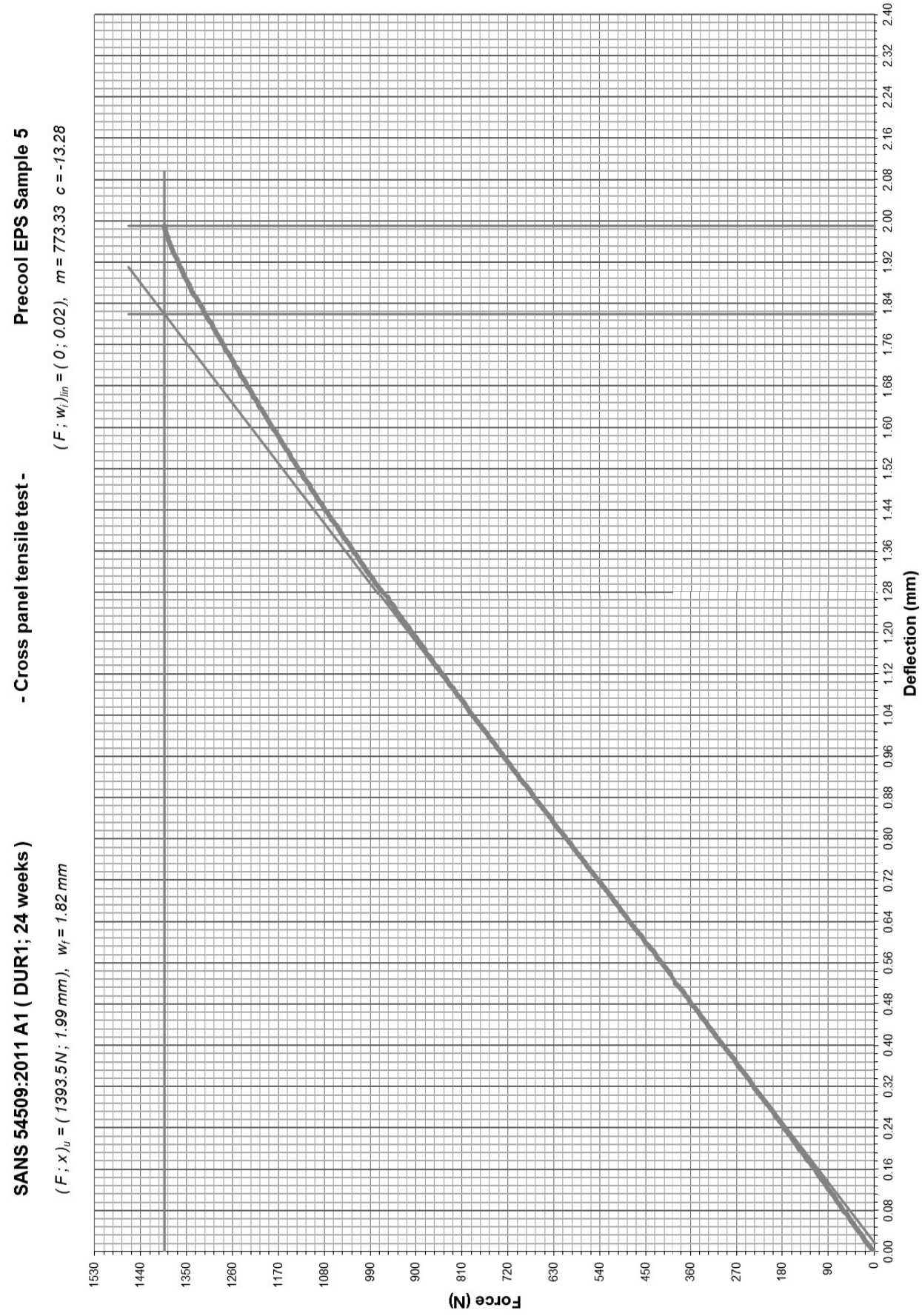

SANS 54509:2011 A1 (DUR1; 24 weeks)
- Cross panel tensile test -
Precool EPS Sample 1 - 5
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40


Precool EPS Sample 1
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 24 weeks)
(F ; x)u = (1417.5 N ; 2.07 mm), wf = 1.91 mm
(F ; wi)lin = (0 ; 0.02), m = 750.04 c = -16.84
Force (N)
Deflection (mm)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

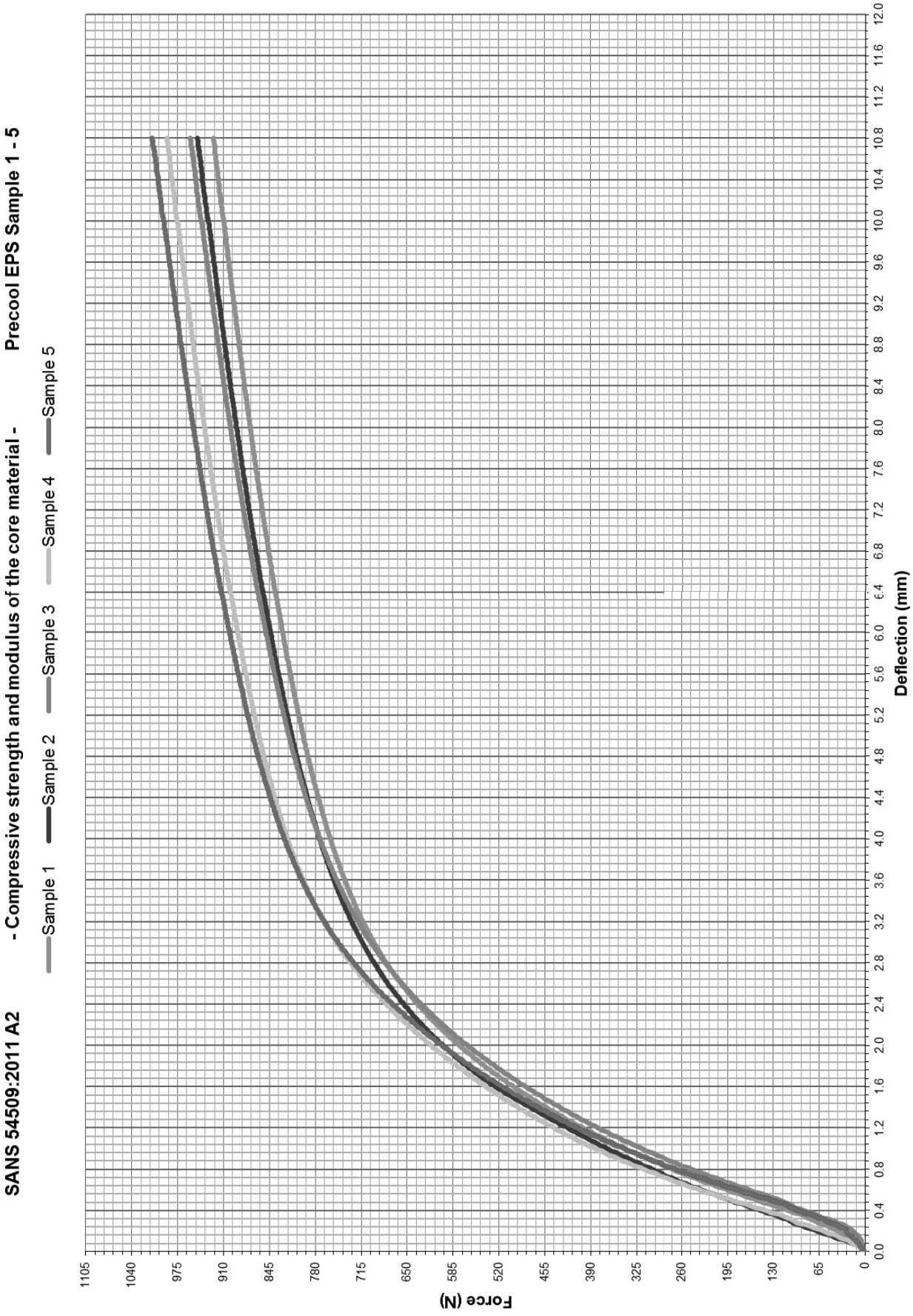

Precool EPS Sample 2
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 24 weeks)
(F ; x)u = (1022.5 N ; 1.49 mm), wf = 1.43 mm
(F ; wi)lin = (0 ; 0.02), m = 725.08 c = -13.37
Force (N)
1190
1120
1050
980
910
840
770
700
630
560
490
420
350
280
210
140
70
0
Deflection (mm)
0.00
0.06
0.12
0.18
0.24
0.30
0.36
0.42
0.48
0.54
0.60
0.66
0.72
0.78
0.84
0.90
0.96
1.02
1.08
1.14
1.20
1.26
1.32
1.38
1.44
1.50
1.56
1.62
1.68
1.74
1.80

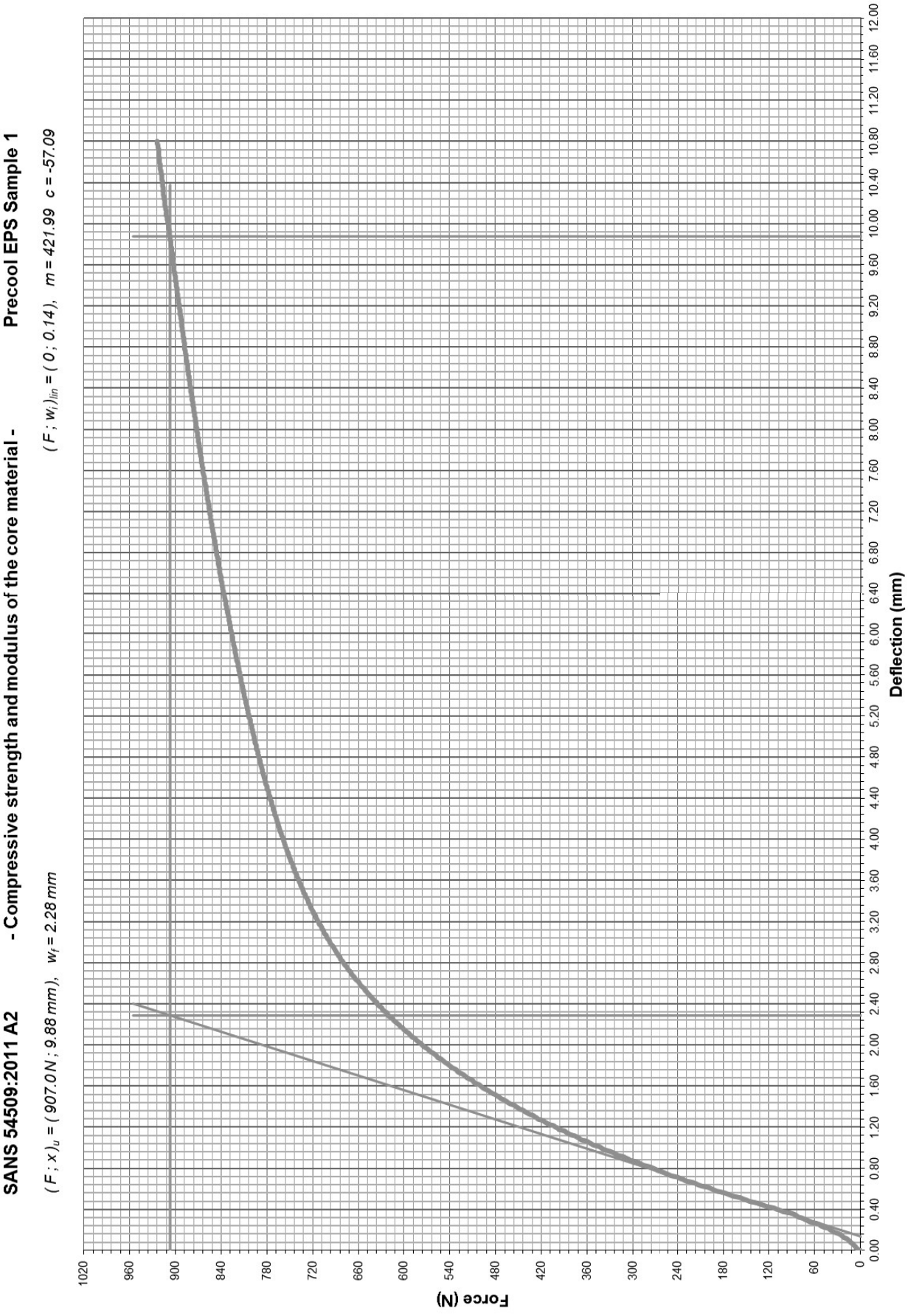

SANS 54509:2011 A1 (DUR1; 24 weeks)
- Cross panel tensile test -
Precool EPS Sample 3
(F ; x)u = (1399.5 N ; 1.93 mm), wf = 1.79 mm
(F ; wi)lin = (0 ; 0.01), m = 787.68 c = -9.67
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.07
0.14
0.21
0.28
0.35
0.42
0.49
0.56
0.63
0.70
0.77
0.84
0.91
0.98
1.05
1.12
1.19
1.26
1.33
1.40
1.47
1.54
1.61
1.68
1.75
1.82
1.89
1.96
2.03
2.10

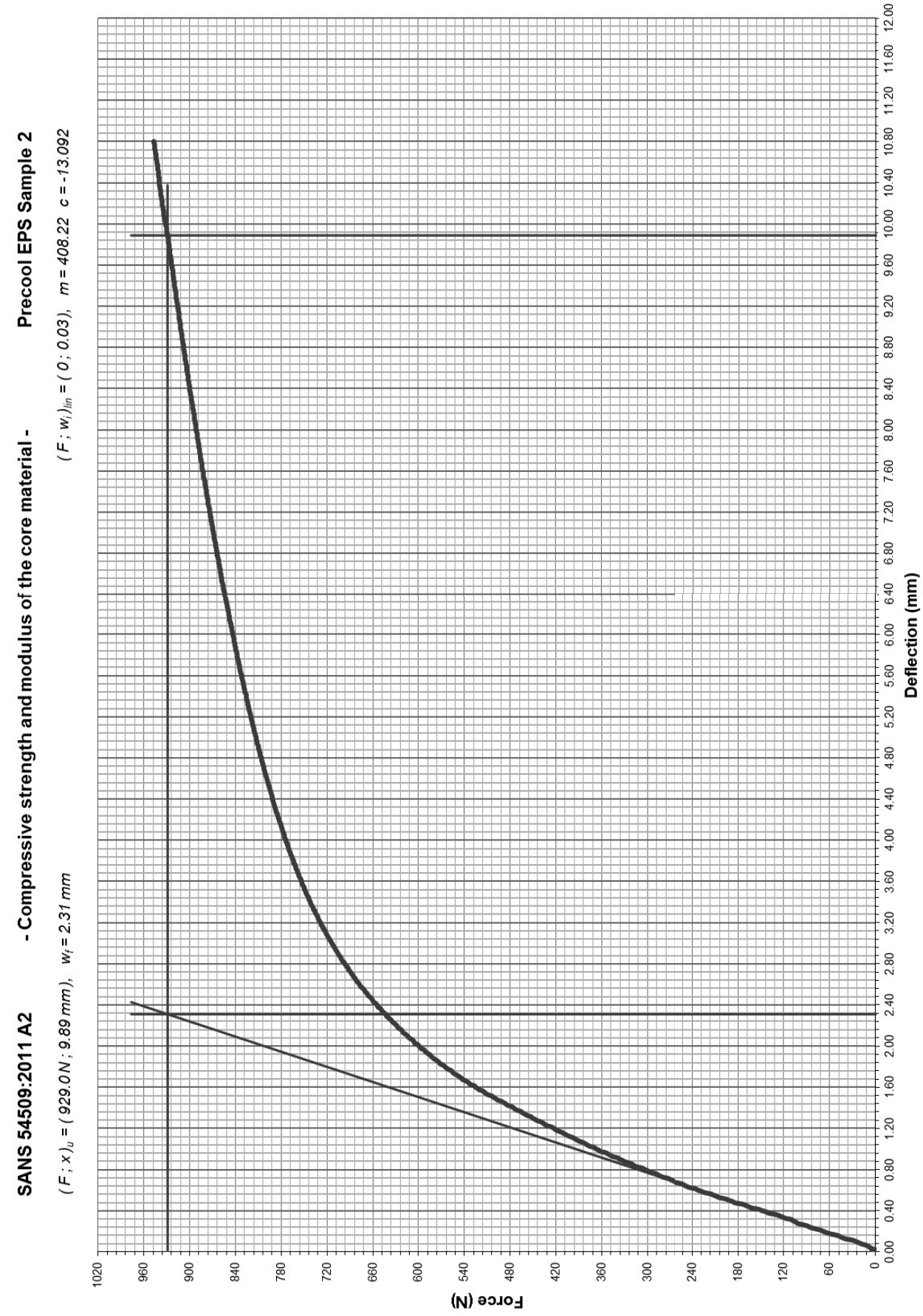

Precool EPS Sample 4
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 24 weeks)
$(F; w_i)_{lin}$ = (0 ; 0.02), m = 729.29 c = -16.90
$(F; x)_u$ = (1347.0 N ; 2.03 mm), w_f = 1.87 mm
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

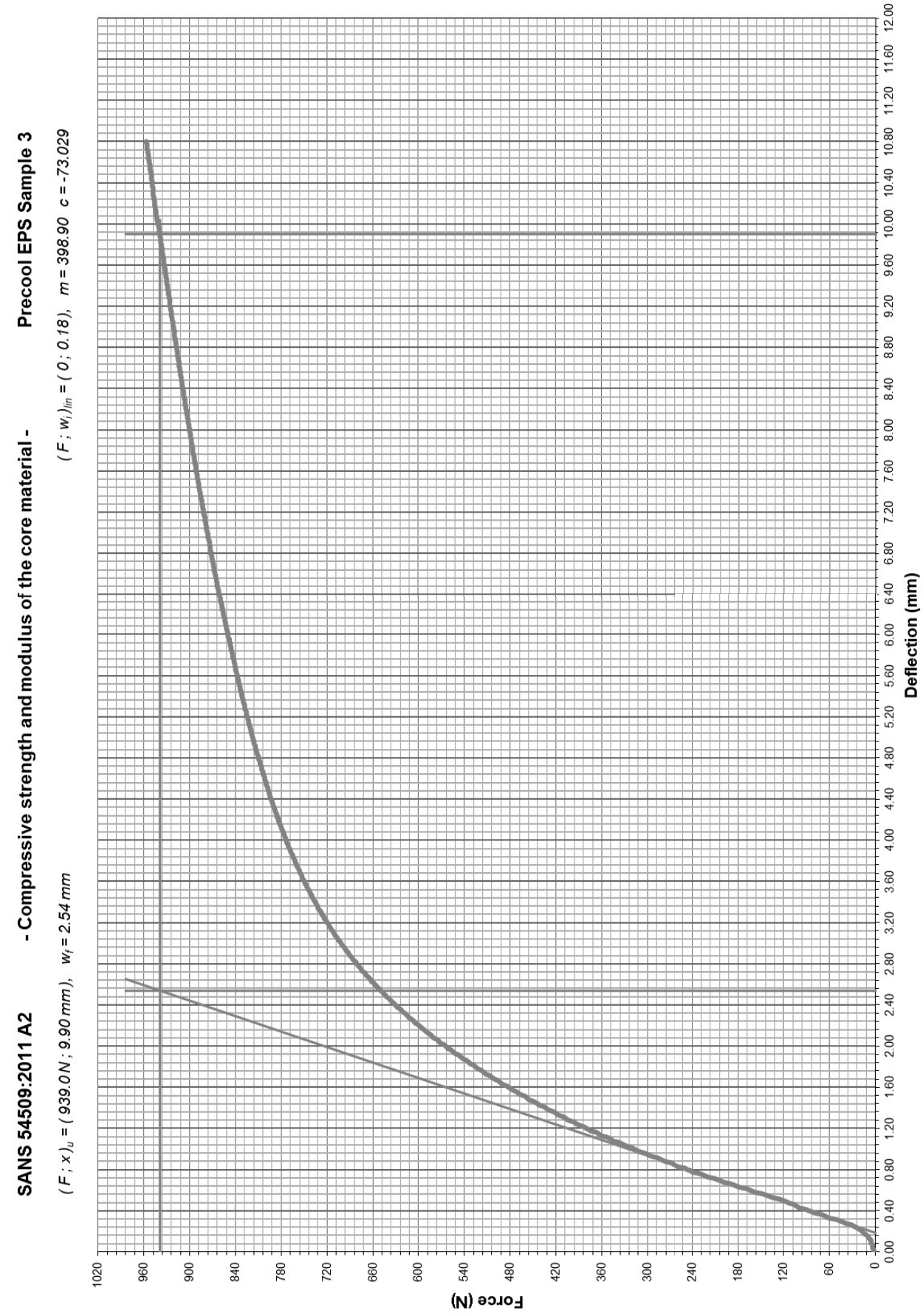

Precool EPS Sample 5
- Cross panel tensile test -
SANS 54509:2011 A1 (DUR1; 24 weeks)
(F ; w_i)_lin = (0 ; 0.02), m = 773.33 c = -13.28
(F ; x)_u = (1393.5 N ; 1.99 mm), w_f = 1.82 mm
Force (N)
1530
1440
1350
1260
1170
1080
990
900
810
720
630
540
450
360
270
180
90
0
Deflection (mm)
0.00
0.08
0.16
0.24
0.32
0.40
0.48
0.56
0.64
0.72
0.80
0.88
0.96
1.04
1.12
1.20
1.28
1.36
1.44
1.52
1.60
1.68
1.76
1.84
1.92
2.00
2.08
2.16
2.24
2.32
2.40

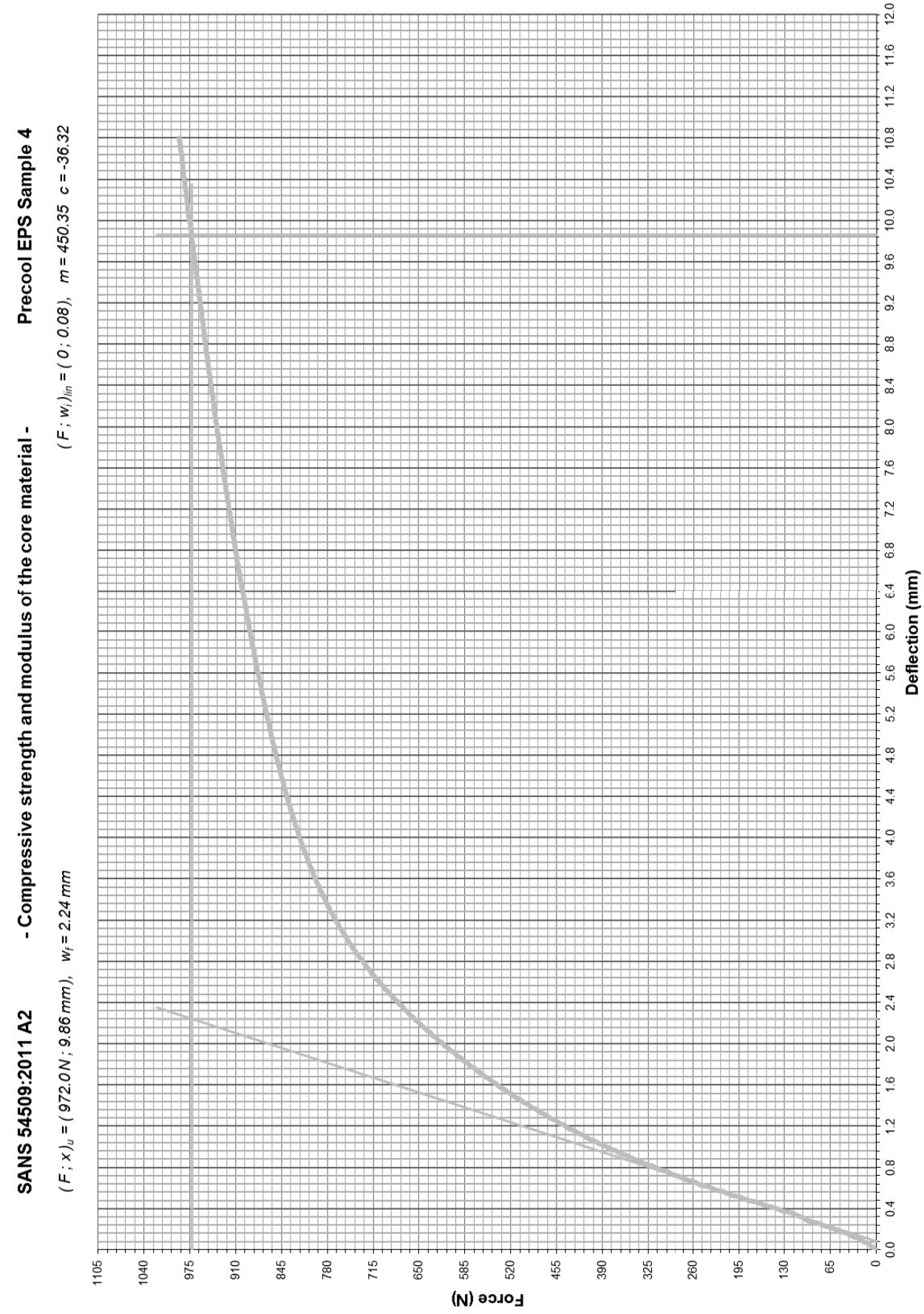
Compression Test
EN 14509:2006
(DSS SANS 54509:2012)
A2

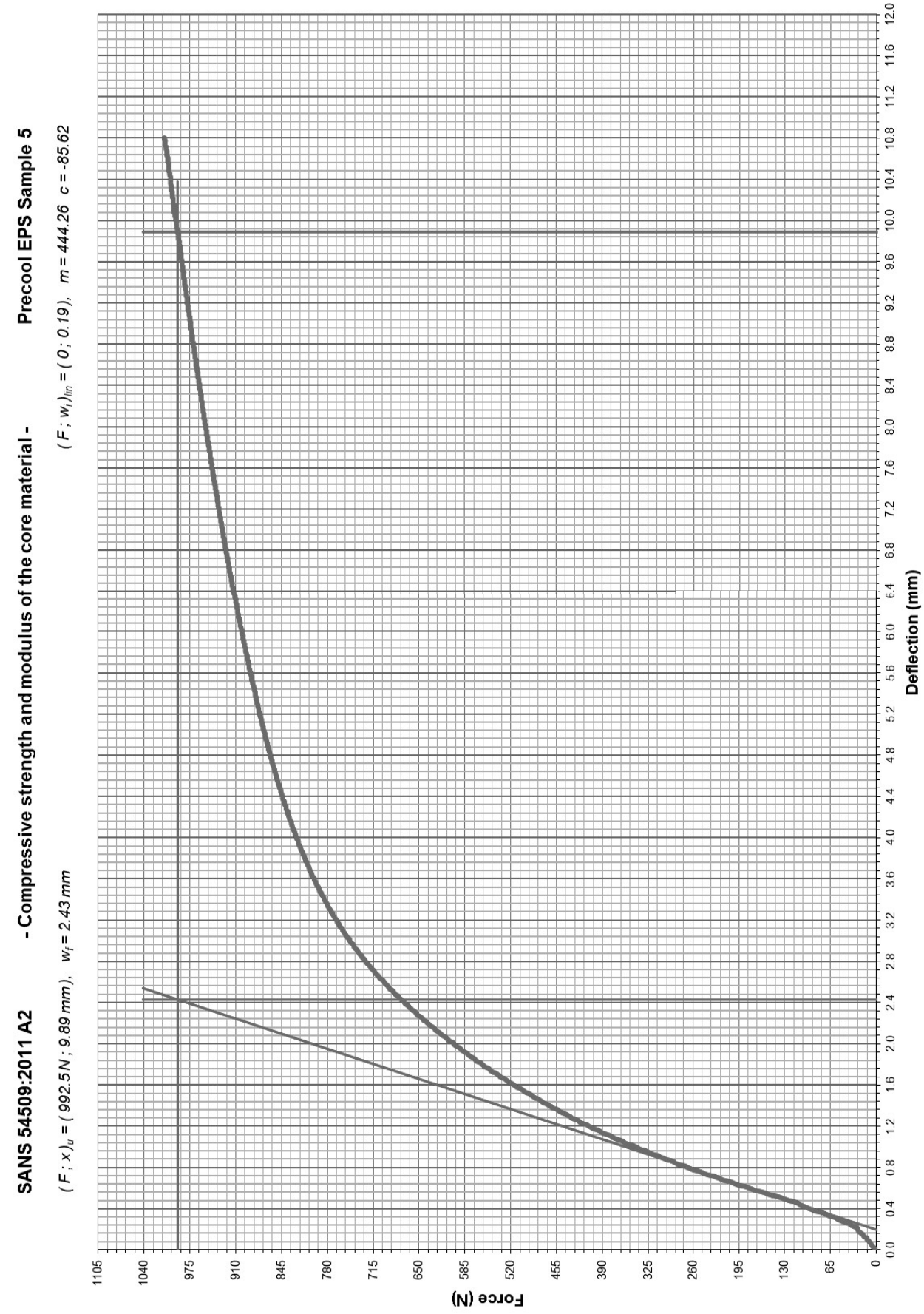

SANS 54509:2011 A2
- Compressive strength and modulus of the core material -
Precool EPS Sample 1 - 5
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
1105
1040
975
910
845
780
715
650
585
520
455
390
325
260
195
130
65
0
Deflection (mm)
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
6.4
6.8
7.2
7.6
8.0
8.4
8.8
9.2
9.6
10.0
10.4
10.8
11.2
11.6
12.0


SANS 54509:2011 A2 - Compressive strength and modulus of the core material - Precool EPS Sample 1
(F ; x)u = (907.0 N ; 9.88 mm), wf = 2.28 mm
(F ; wi)lin = (0 ; 0.14), m = 421.99 c = -57.09
Force (N)
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
Deflection (mm)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
4.40
4.80
5.20
5.60
6.00
6.40
6.80
7.20
7.60
8.00
8.40
8.80
9.20
9.60
10.00
10.40
10.80
11.20
11.60
12.00

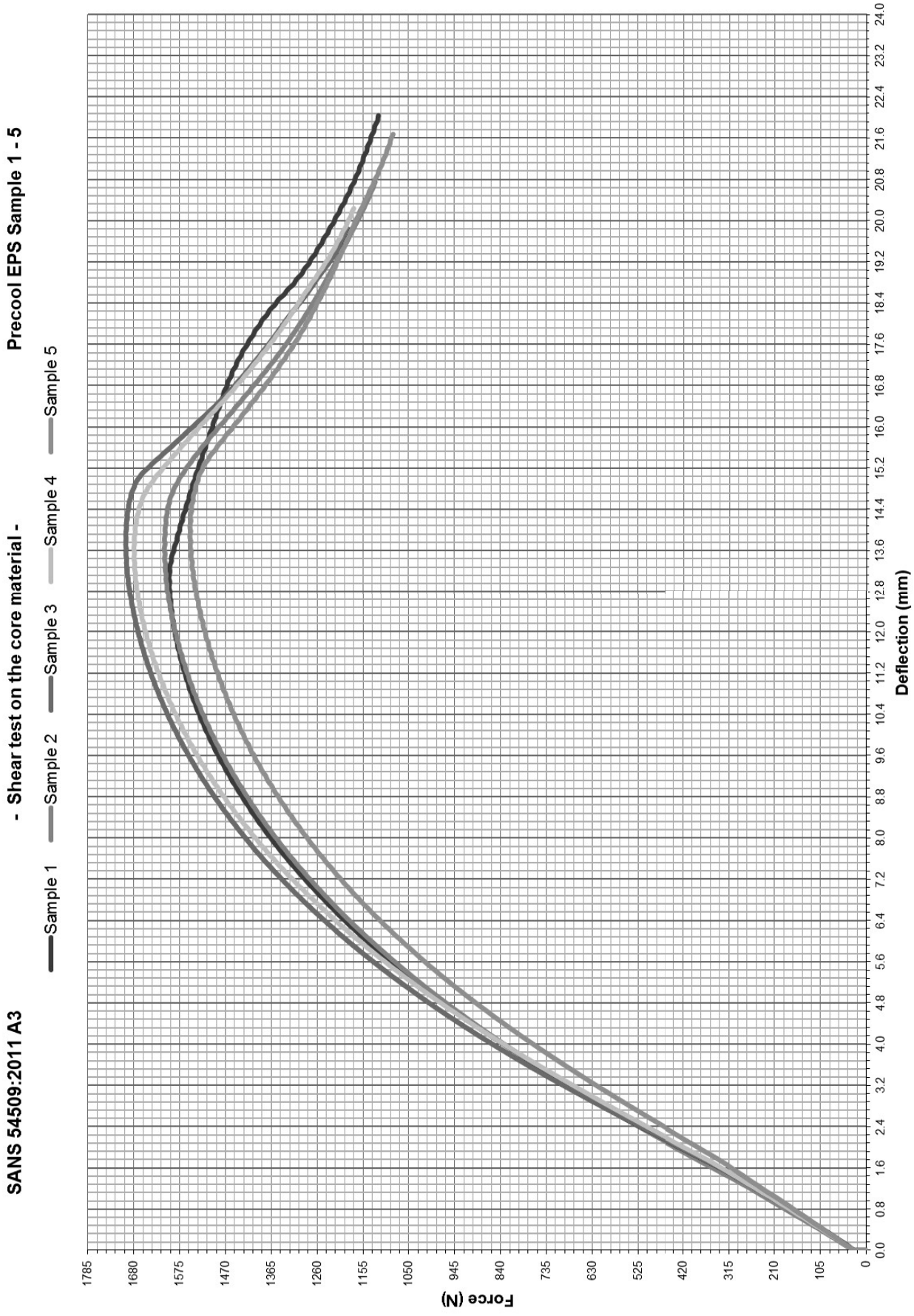

SANS 54509:2011 A2 - Compressive strength and modulus of the core material - Precool EPS Sample 2
(F ; x)u = (929.0 N ; 9.89 mm), wf = 2.31 mm
(F ; wi)lin = (0 ; 0.03), m = 408.22 c = -13.092
Force (N)
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
Deflection (mm)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
4.40
4.80
5.20
5.60
6.00
6.40
6.80
7.20
7.60
8.00
8.40
8.80
9.20
9.60
10.00
10.40
10.80
11.20
11.60
12.00

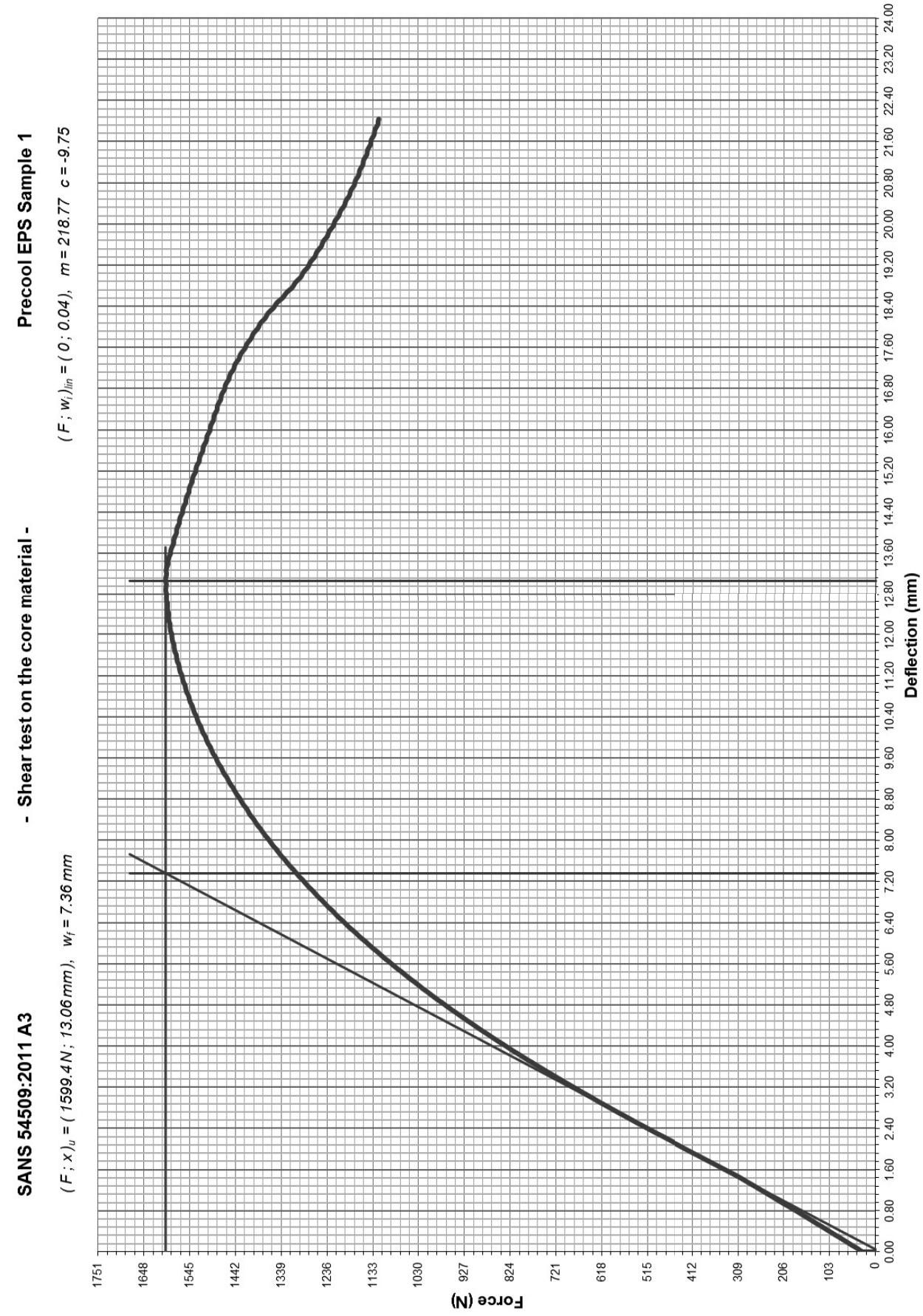

SANS 54509:2011 A2 - Compressive strength and modulus of the core material - Precool EPS Sample 3
(F ; x)u = (939.0 N ; 9.90 mm), wf = 2.54 mm
(F ; wi)lin = (0 ; 0.18), m = 398.90 c = -73.029
Force (N)
1020
960
900
840
780
720
660
600
540
480
420
360
300
240
180
120
60
0
Deflection (mm)
0.00
0.40
0.80
1.20
1.60
2.00
2.40
2.80
3.20
3.60
4.00
4.40
4.80
5.20
5.60
6.00
6.40
6.80
7.20
7.60
8.00
8.40
8.80
9.20
9.60
10.00
10.40
10.80
11.20
11.60
12.00

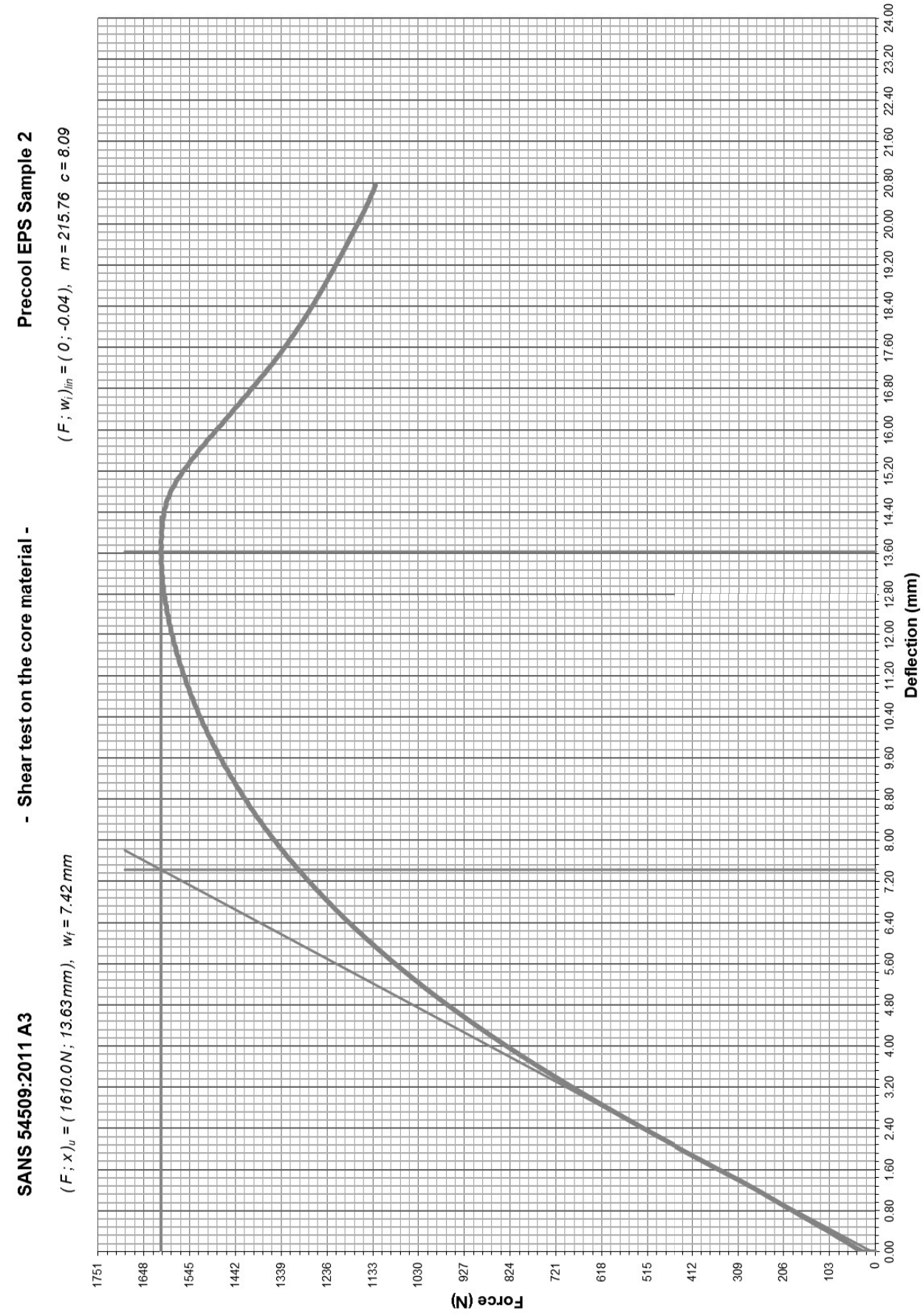

SANS 54509:2011 A2 - Compressive strength and modulus of the core material - Precool EPS Sample 4
$(F ; x)_u = (972.0\,N ; 9.86\,mm)$, $w_f = 2.24\,mm$
$(F ; w_i)_{lin} = (0 ; 0.08)$, $m = 450.35$ $c = -36.32$
Force (N)
1105
1040
975
910
845
780
715
650
585
520
455
390
325
260
195
130
65
0
Deflection (mm)
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
6.4
6.8
7.2
7.6
8.0
8.4
8.8
9.2
9.6
10.0
10.4
10.8
11.2
11.6
12.0

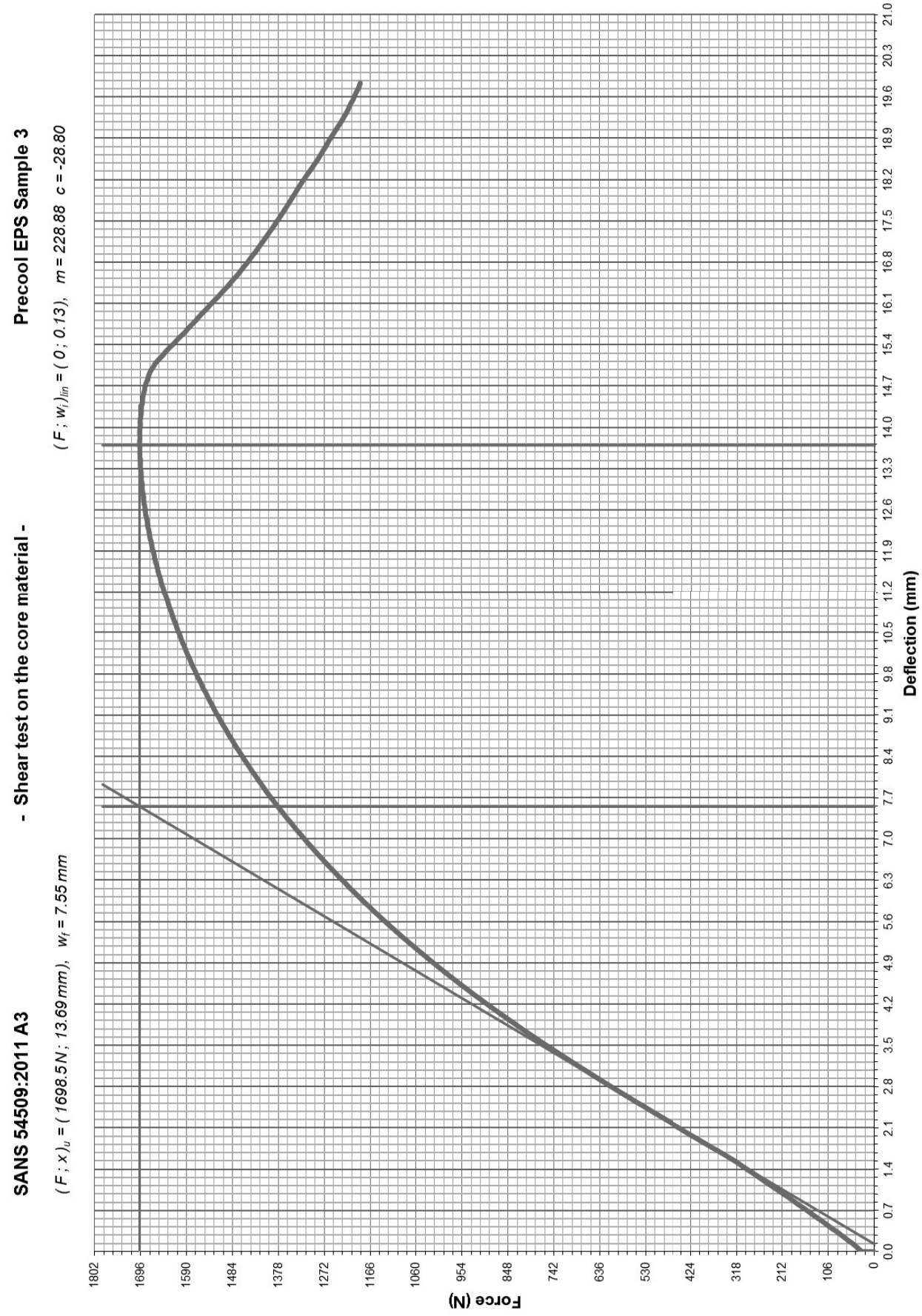

SANS 54509:2011 A2 - Compressive strength and modulus of the core material - Precool EPS Sample 5
$(F ; x)_u = (992.5N ; 9.89\ mm)$, $w_f = 2.43\ mm$
$(F ; w_i)_{lin} = (0 ; 0.19)$, $m = 444.26$ $c = -85.62$
Force (N)
Deflection (mm)
1105
1040
975
910
845
780
715
650
585
520
455
390
325
260
195
130
65
0
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
6.0
6.4
6.8
7.2
7.6
8.0
8.4
8.8
9.2
9.6
10.0
10.4
10.8
11.2
11.6
12.0

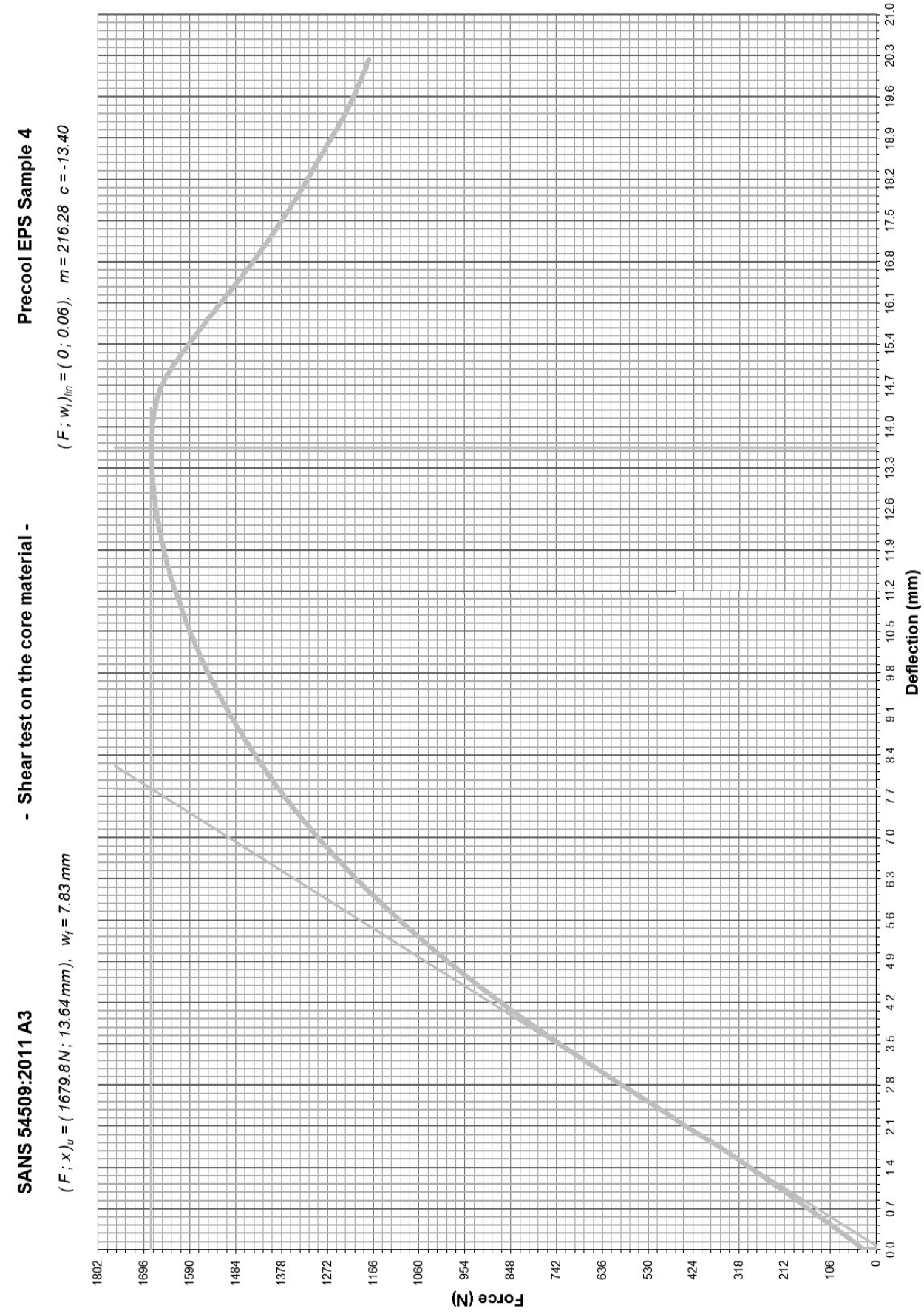
Shear Strength
EN 14509:2006
(DSS SANS 54509:2012)
A3

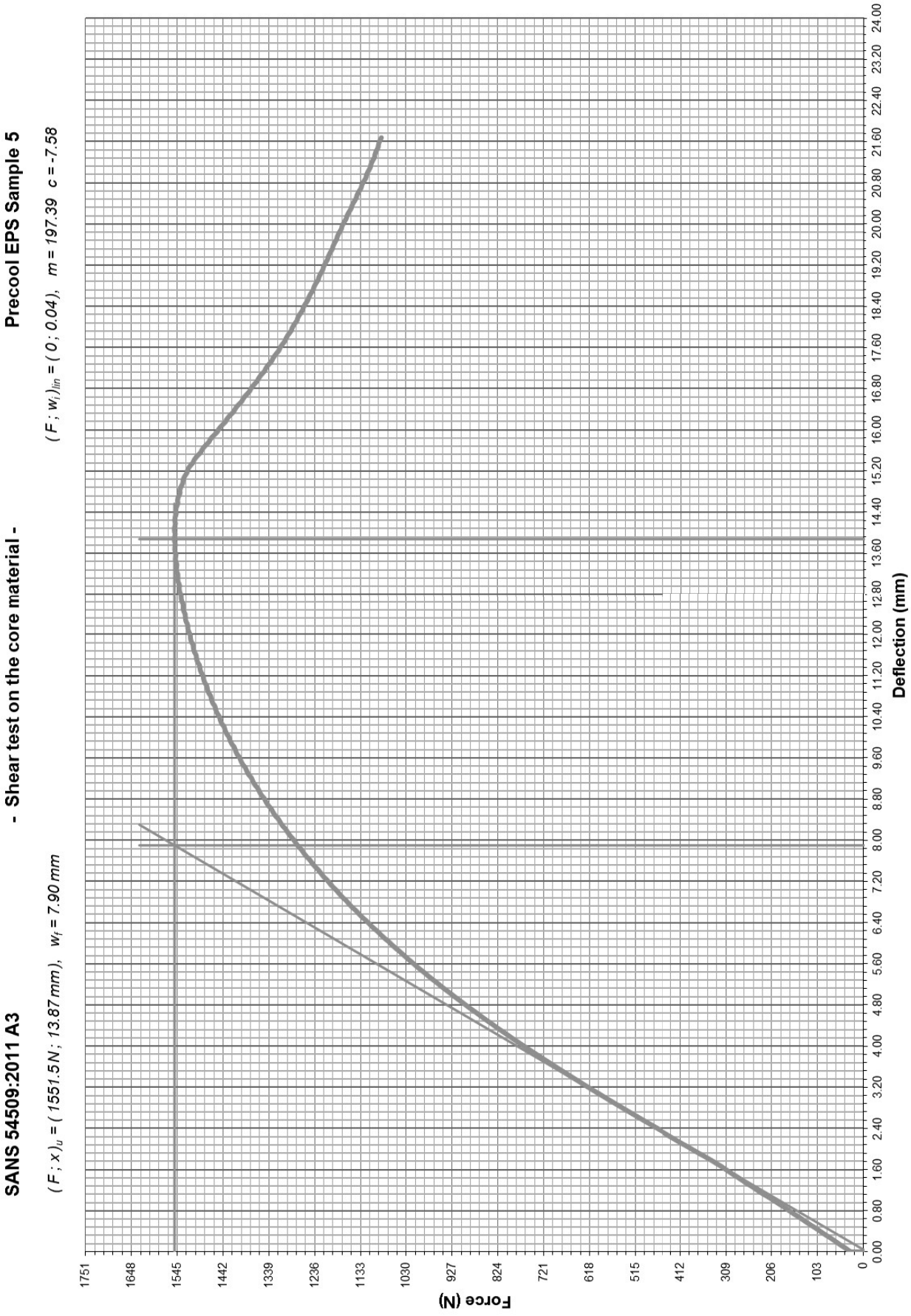

Precool EPS Sample 1 - 5
- Shear test on the core material -
SANS 54509:2011 A3
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
1785
1680
1575
1470
1365
1260
1155
1050
945
840
735
630
525
420
315
210
105
0
Deflection (mm)
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
8.8
9.6
10.4
11.2
12.0
12.8
13.6
14.4
15.2
16.0
16.8
17.6
18.4
19.2
20.0
20.8
21.6
22.4
23.2
24.0


Precool EPS Sample 1
- Shear test on the core material -
SANS 54509:2011 A3
(F ; w_i)_lim = (0 ; 0.04), m = 218.77 c = -9.75
(F ; x)_u = (1599.4 N ; 13.06 mm), w_f = 7.36 mm
Force (N)
1751
1648
1545
1442
1339
1236
1133
1030
927
824
721
618
515
412
309
206
103
0
Deflection (mm)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
8.00
8.80
9.60
10.40
11.20
12.00
12.80
13.60
14.40
15.20
16.00
16.80
17.60
18.40
19.20
20.00
20.80
21.60
22.40
23.20
24.00

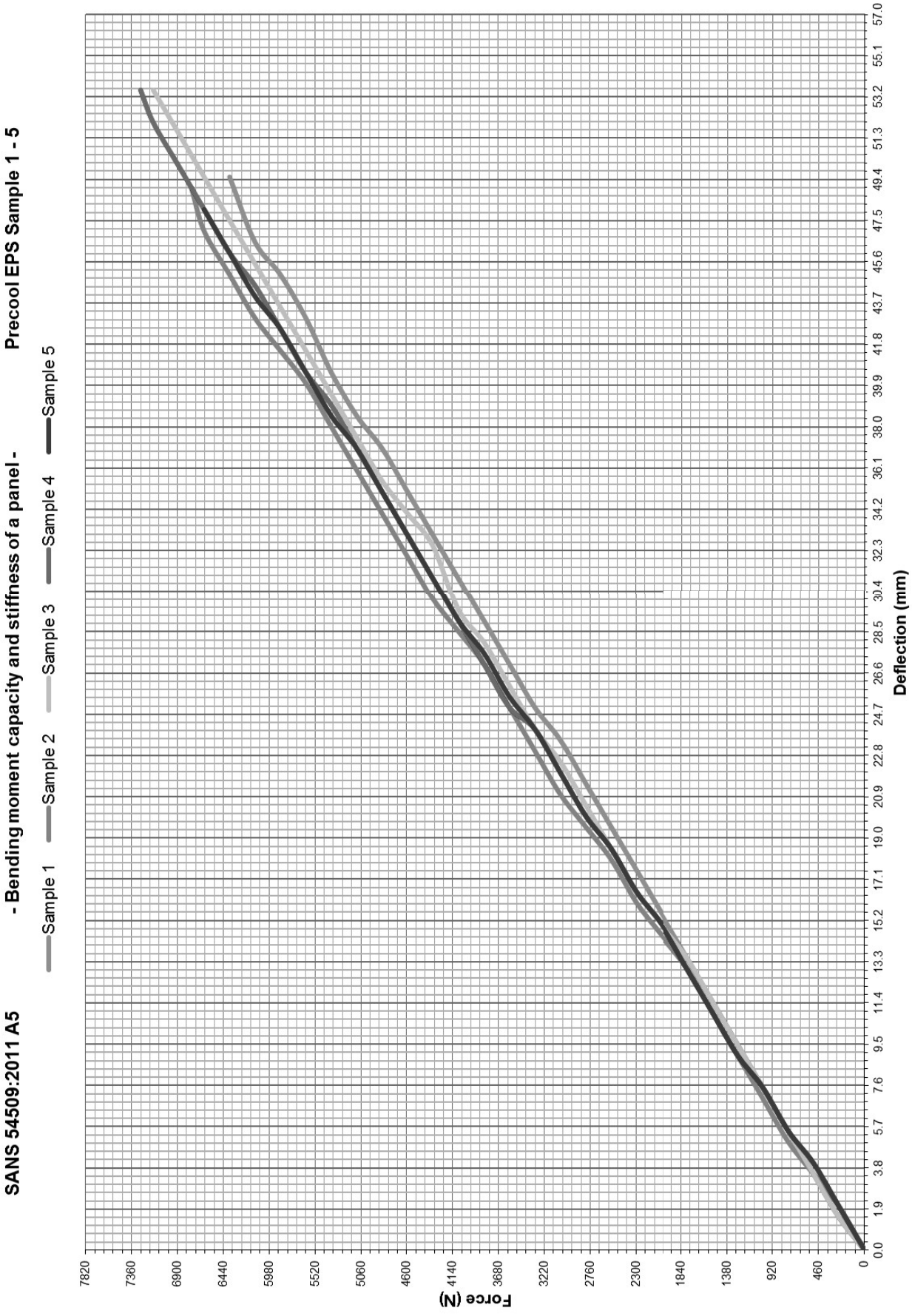

Precool EPS Sample 2
- Shear test on the core material -
SANS 54509:2011 A3
(F ; w_i)_lin = (0 ; -0.04), m = 215.76 c = 8.09
(F ; x)_u = (1610.0 N ; 13.63 mm), w_i = 7.42 mm
Force (N)
1751
1648
1545
1442
1339
1236
1133
1030
927
824
721
618
515
412
309
206
103
0
Deflection (mm)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
8.00
8.80
9.60
10.40
11.20
12.00
12.80
13.60
14.40
15.20
16.00
16.80
17.60
18.40
19.20
20.00
20.80
21.60
22.40
23.20
24.00

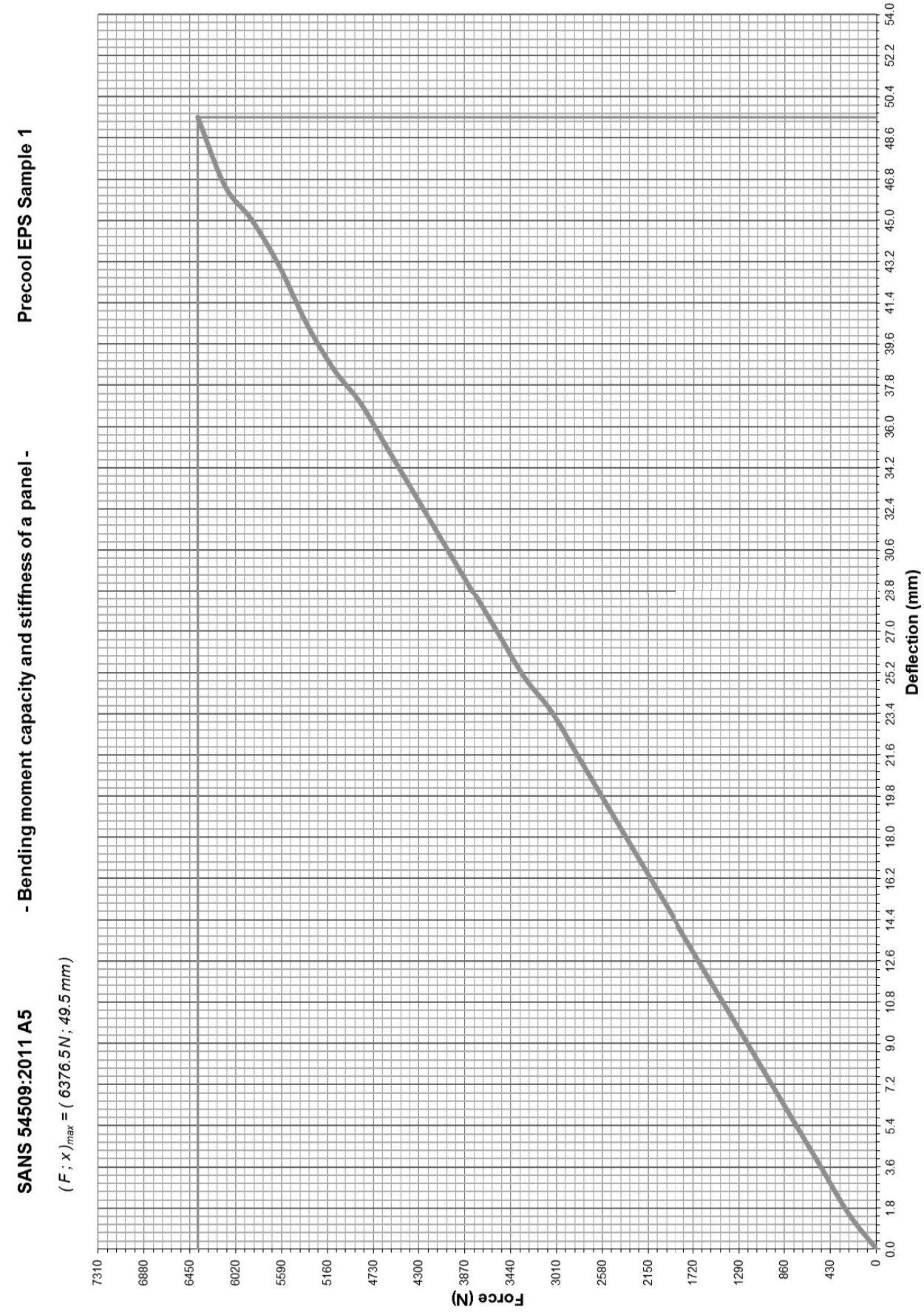

Precool EPS Sample 3
- Shear test on the core material -
SANS 54509:2011 A3
(F ; w_i)_lin = (0 ; 0.13), m = 228.88 c = -28.80
(F ; x)_u = (1698.5 N ; 13.69 mm), w_i = 7.55 mm
Force (N)
1802
1696
1590
1484
1378
1272
1166
1060
954
848
742
636
530
424
318
212
106
0
Deflection (mm)
0.0
0.7
1.4
2.1
2.8
3.5
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
11.2
11.9
12.6
13.3
14.0
14.7
15.4
16.1
16.8
17.5
18.2
18.9
19.6
20.3
21.0

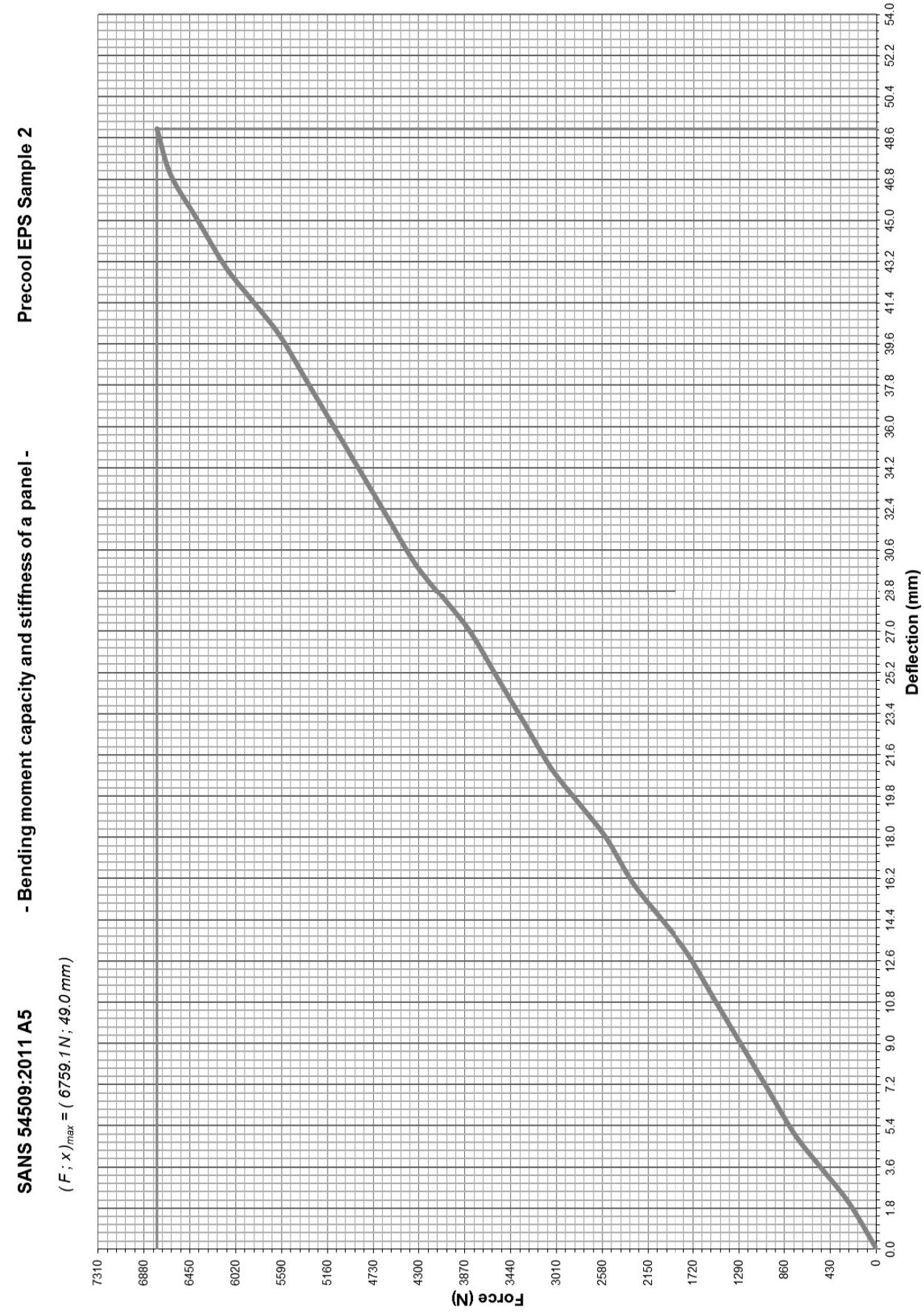

Precool EPS Sample 4
- Shear test on the core material -
SANS 54509:2011 A3
(F ; w_i)_lin = (0 ; 0.06), m = 216.28 c = -13.40
(F ; x)_u = (1679.8 N ; 13.64 mm), w_i = 7.83 mm
Force (N)
1802
1696
1590
1484
1378
1272
1166
1060
954
848
742
636
530
424
318
212
106
0
Deflection (mm)
0.0
0.7
1.4
2.1
2.8
3.5
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
11.2
11.9
12.6
13.3
14.0
14.7
15.4
16.1
16.8
17.5
18.2
18.9
19.6
20.3
21.0


Precool EPS Sample 5
- Shear test on the core material -
SANS 54509:2011 A3
(F ; w_i)_lim = (0 ; 0.04), m = 197.39 c = -7.58
(F ; x)_u = (1551.5 N ; 13.87 mm), w_f = 7.90 mm
Force (N)
1751
1648
1545
1442
1339
1236
1133
1030
927
824
721
618
515
412
309
206
103
0
Deflection (mm)
0.00
0.80
1.60
2.40
3.20
4.00
4.80
5.60
6.40
7.20
8.00
8.80
9.60
10.40
11.20
12.00
12.80
13.60
14.40
15.20
16.00
16.80
17.60
18.40
19.20
20.00
20.80
21.60
22.40
23.20
24.00

Bending Moment Capacity
EN 14509:2006
(DSS SANS 54509:2012)
A5


SANS 54509:2011 A5
- Bending moment capacity and stiffness of a panel -
Precool EPS Sample 1 - 5
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Force (N)
7820
7360
6900
6440
5980
5520
5060
4600
4140
3680
3220
2760
2300
1840
1380
920
460
0
Deflection (mm)
0.0
1.9
3.8
5.7
7.6
9.5
11.4
13.3
15.2
17.1
19.0
20.9
22.8
24.7
26.6
28.5
30.4
32.3
34.2
36.1
38.0
39.9
41.8
43.7
45.6
47.5
49.4
51.3
53.2
55.1
57.0


Precool EPS Sample 1
- Bending moment capacity and stiffness of a panel -
SANS 54509:2011 A5
$(F;x)_{max}$ = (6376.5 N ; 49.5 mm)
Force (N)
7310
6880
6450
6020
5590
5160
4730
4300
3870
3440
3010
2580
2150
1720
1290
860
430
0
Deflection (mm)
0.0
1.8
3.6
5.4
7.2
9.0
10.8
12.6
14.4
16.2
18.0
19.8
21.6
23.4
25.2
27.0
23.8
30.6
32.4
34.2
36.0
37.8
39.6
41.4
43.2
45.0
46.8
48.6
50.4
52.2
54.0

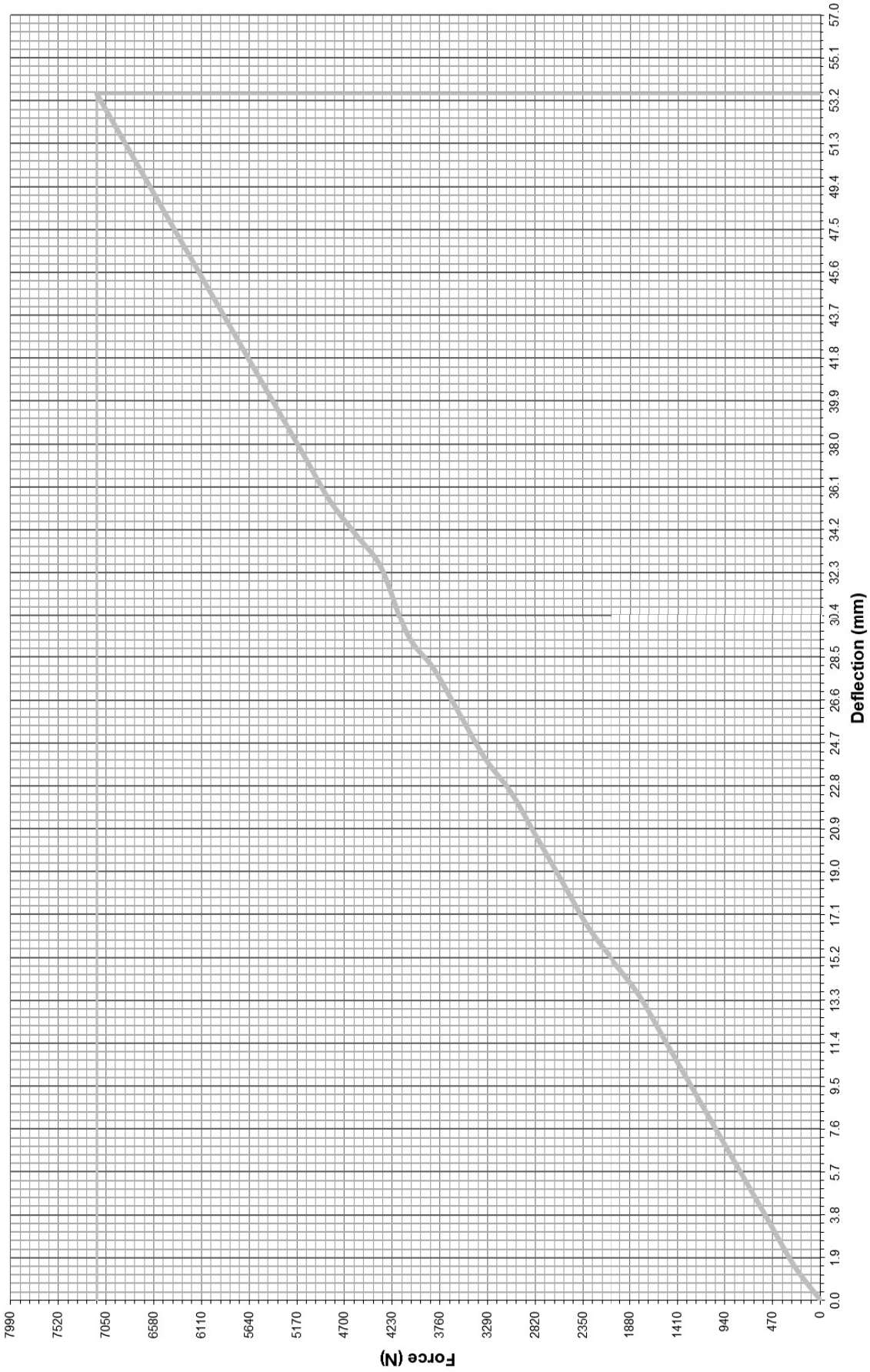

Precool EPS Sample 2
- Bending moment capacity and stiffness of a panel -
SANS 54509:2011 A5
(F ; x)max = (6759.1 N ; 49.0 mm)
Force (N)
7310
6880
6450
6020
5590
5160
4730
4300
3870
3440
3010
2580
2150
1720
1290
860
430
0
Deflection (mm)
0.0
1.8
3.6
5.4
7.2
9.0
10.8
12.6
14.4
16.2
18.0
19.8
21.6
23.4
25.2
27.0
23.8
30.6
32.4
34.2
36.0
37.8
39.6
41.4
43.2
45.0
46.8
48.6
50.4
52.2
54.0

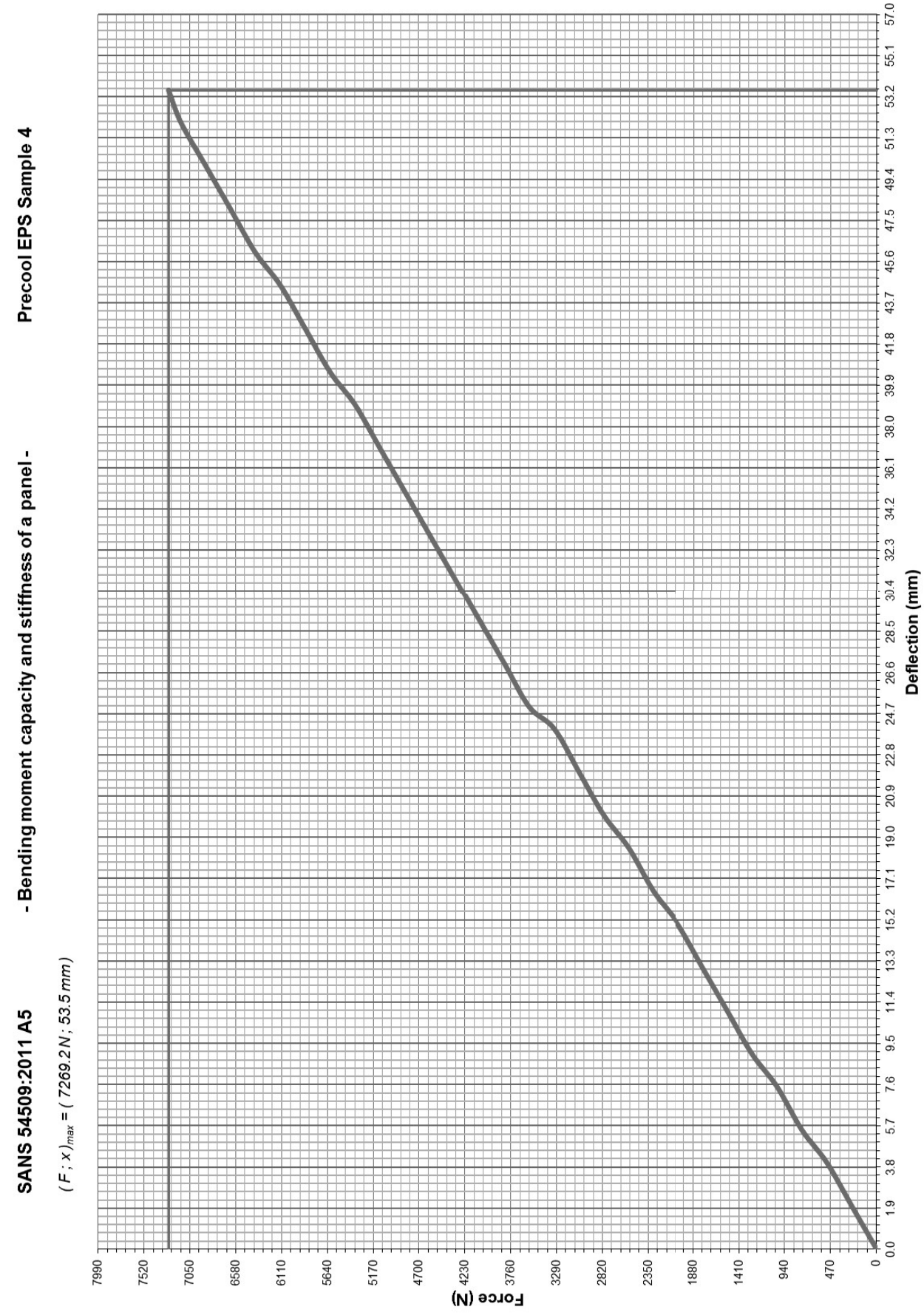
Precool EPS Sample 3

- Bending moment capacity and stiffness of a panel -

SANS 54509:2011 A5

$(F ; x)_{max} = (7141.7 N ; 53.5 mm)$



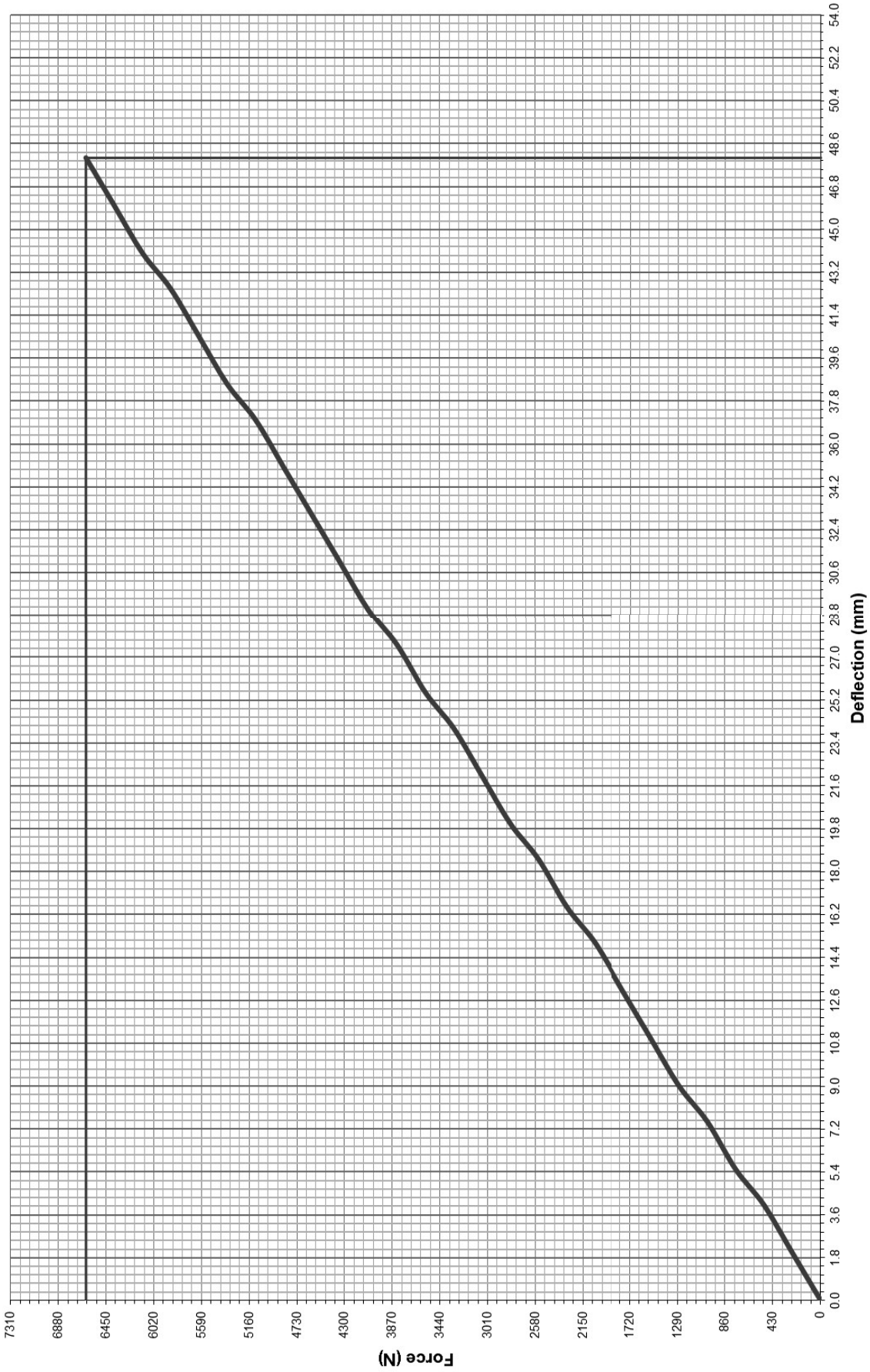

Precool EPS Sample 4
- Bending moment capacity and stiffness of a panel -
SANS 54509:2011 A5
(F ; x)max = (7269.2 N ; 53.5 mm)
Force (N)
7990
7520
7050
6580
6110
5640
5170
4700
4230
3760
3290
2820
2350
1880
1410
940
470
0
Deflection (mm)
0.0
1.9
3.8
5.7
7.6
9.5
11.4
13.3
15.2
17.1
19.0
20.9
22.8
24.7
26.6
28.5
30.4
32.3
34.2
36.1
38.0
39.9
41.8
43.7
45.6
47.5
49.4
51.3
53.2
55.1
57.0

Precool EPS Sample 5

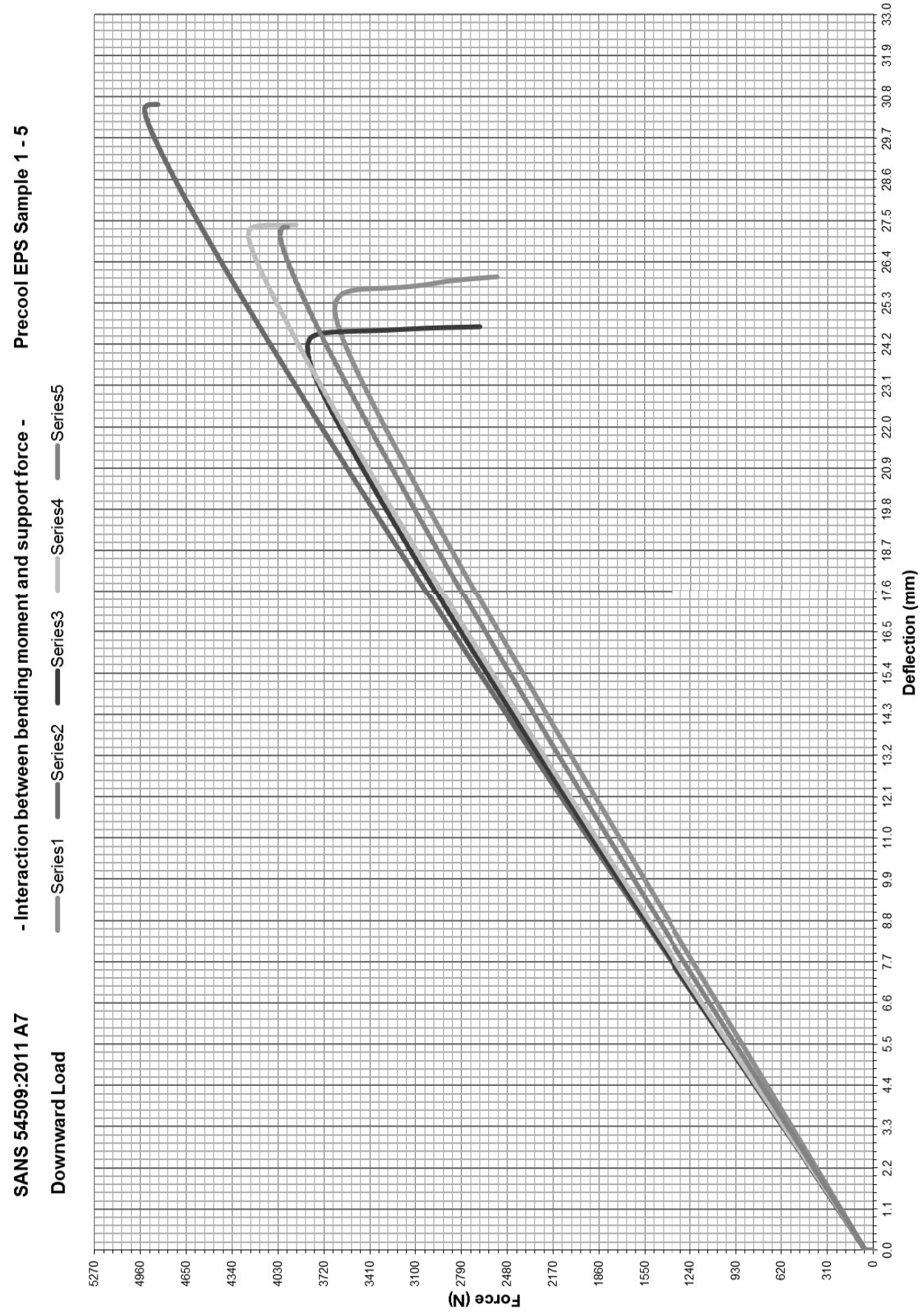
- Bending moment capacity and stiffness of a panel -

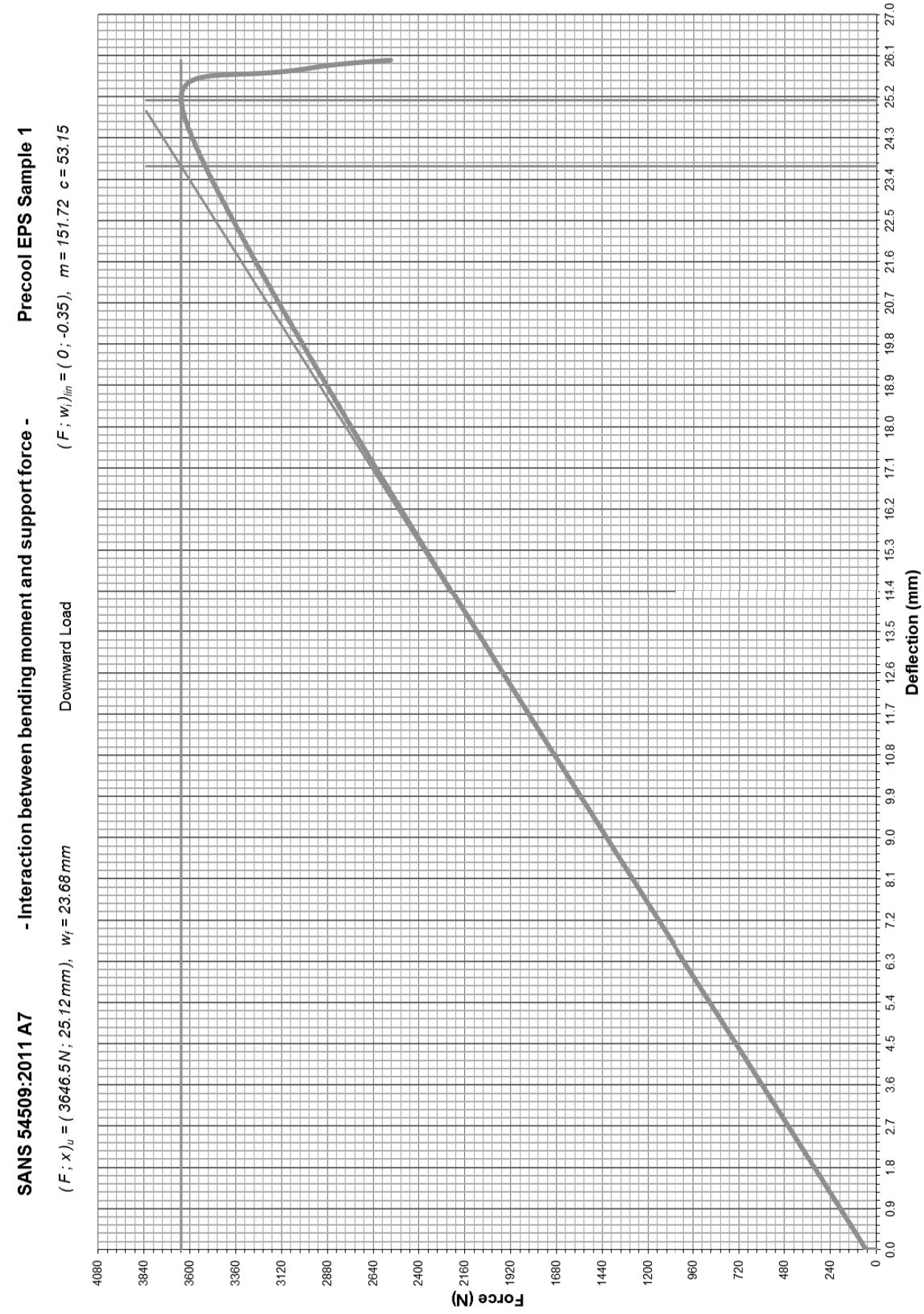
SANS 54509:2011 A5

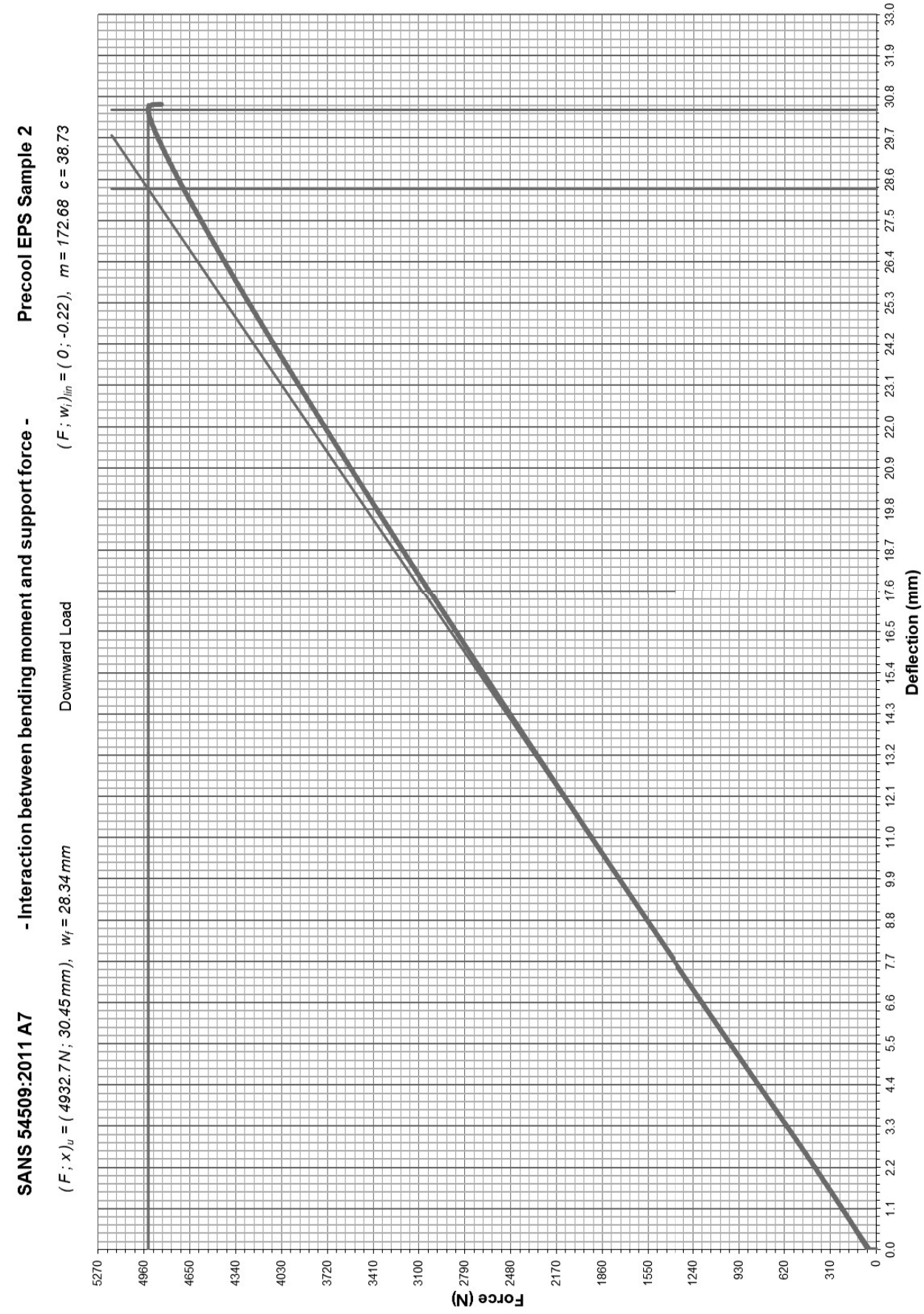
$(F ; x)_{max} = (6631.6\,N ; 48.0\,mm)$

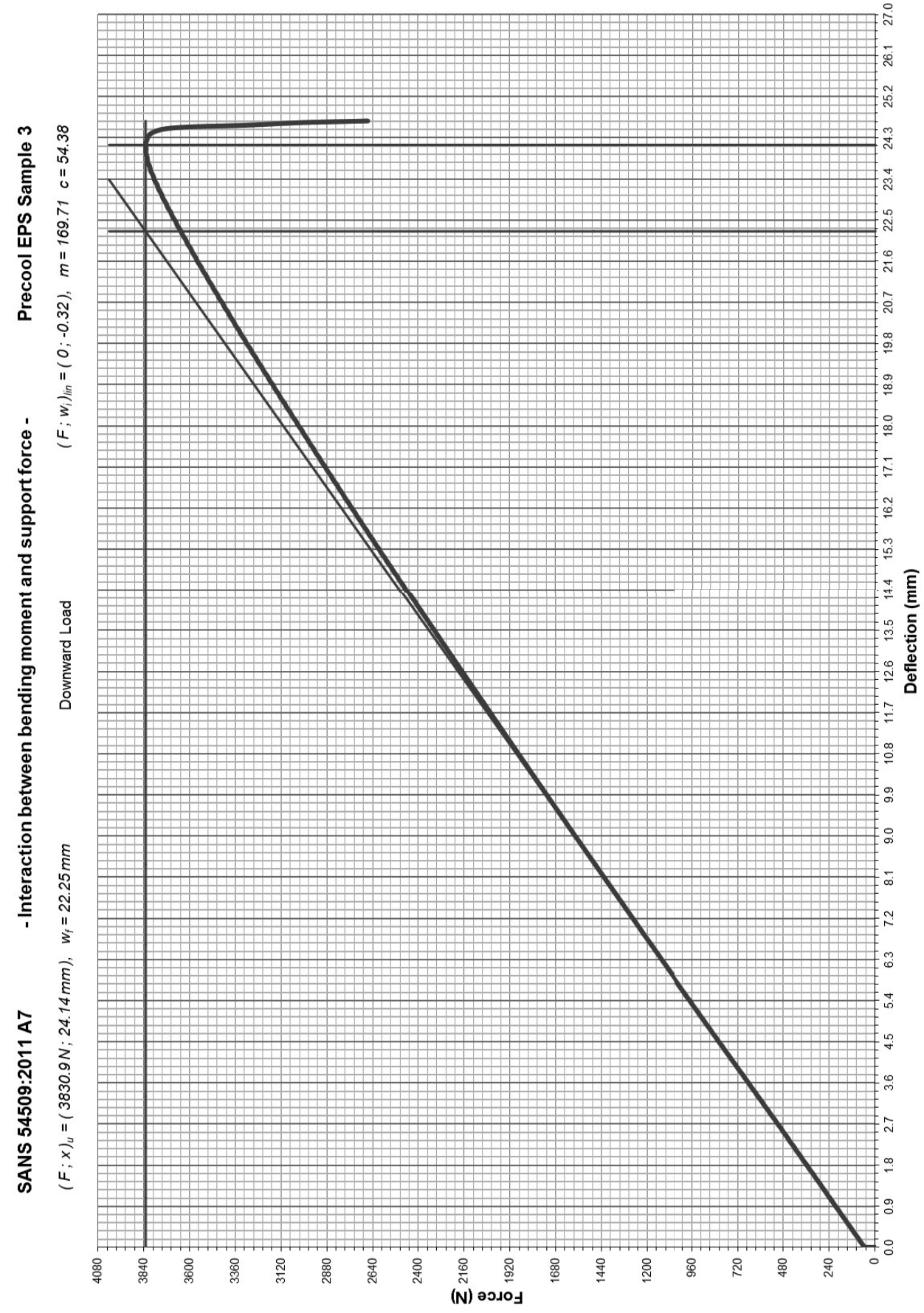


Simulated Central Support Test
EN 14509:2006
(DSS SANS 54509:2012)
A7
Downward Load


SANS 54509:2011 A7
Downward Load
- Interaction between bending moment and support force -
Precool EPS Sample 1 - 5
Series1
Series2
Series3
Series4
Series5
Force (N)
5270
4960
4650
4340
4030
3720
3410
3100
2790
2480
2170
1860
1550
1240
930
620
310
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0

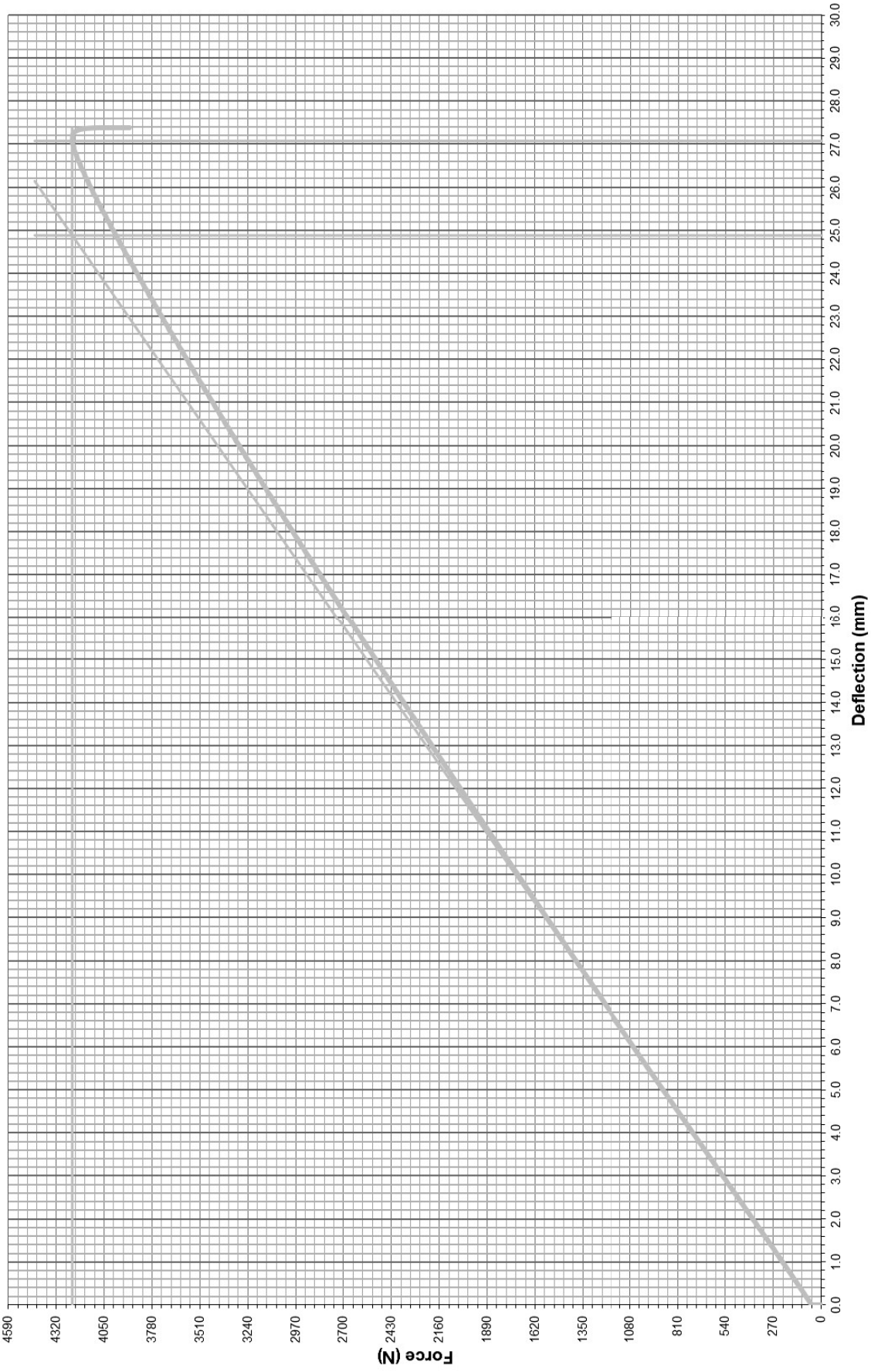

SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 1
$(F;x)_u = (3646.5\,N;25.12\,mm)$, $w_f = 23.68\,mm$
Downward Load
$(F;w_i)_{lin} = (0;-0.35)$, $m = 151.72$ $c = 53.15$
Force (N)
4080
3840
3600
3360
3120
2880
2640
2400
2160
1920
1680
1440
1200
960
720
480
240
0
Deflection (mm)
0.0
0.9
1.8
2.7
3.6
4.5
5.4
6.3
7.2
8.1
9.0
9.9
10.8
11.7
12.6
13.5
14.4
15.3
16.2
17.1
18.0
18.9
19.8
20.7
21.6
22.5
23.4
24.3
25.2
26.1
27.0

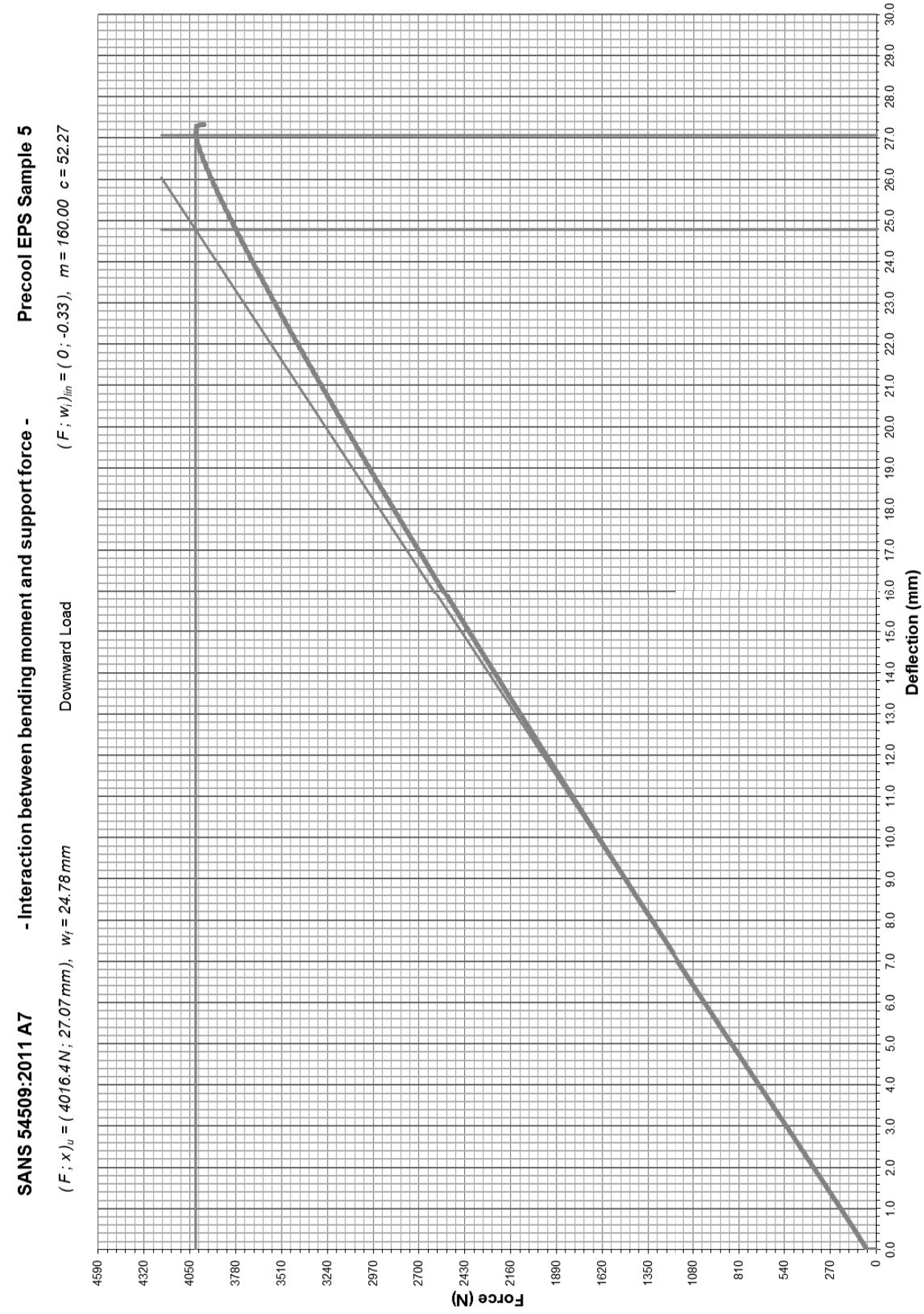

SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 2
$(F;x)_u = (4932.7\,N;\ 30.45\,mm)$, $w_f = 28.34\,mm$
Downward Load
$(F;w_i)_{lin} = (0;\ -0.22)$, $m = 172.68$ $c = 38.73$
Force (N)
5270
4960
4650
4340
4030
3720
3410
3100
2790
2480
2170
1860
1550
1240
930
620
310
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0


Precool EPS Sample 3
- Interaction between bending moment and support force -
SANS 54509:2011 A7
$(F; w_i)_{lin} = (0; -0.32)$, $m = 169.71$ $c = 54.38$
$(F; x)_u = (3830.9\,N; 24.14\,mm)$, $w_i = 22.25\,mm$
Downward Load
Force (N)
Deflection (mm)
4080 3840 3600 3360 3120 2880 2640 2400 2160 1920 1680 1440 1200 960 720 480 240 0
0.0 0.9 1.8 2.7 3.6 4.5 5.4 6.3 7.2 8.1 9.0 9.9 10.8 11.7 12.6 13.5 14.4 15.3 16.2 17.1 18.0 18.9 19.8 20.7 21.6 22.5 23.4 24.3 25.2 26.1 27.0

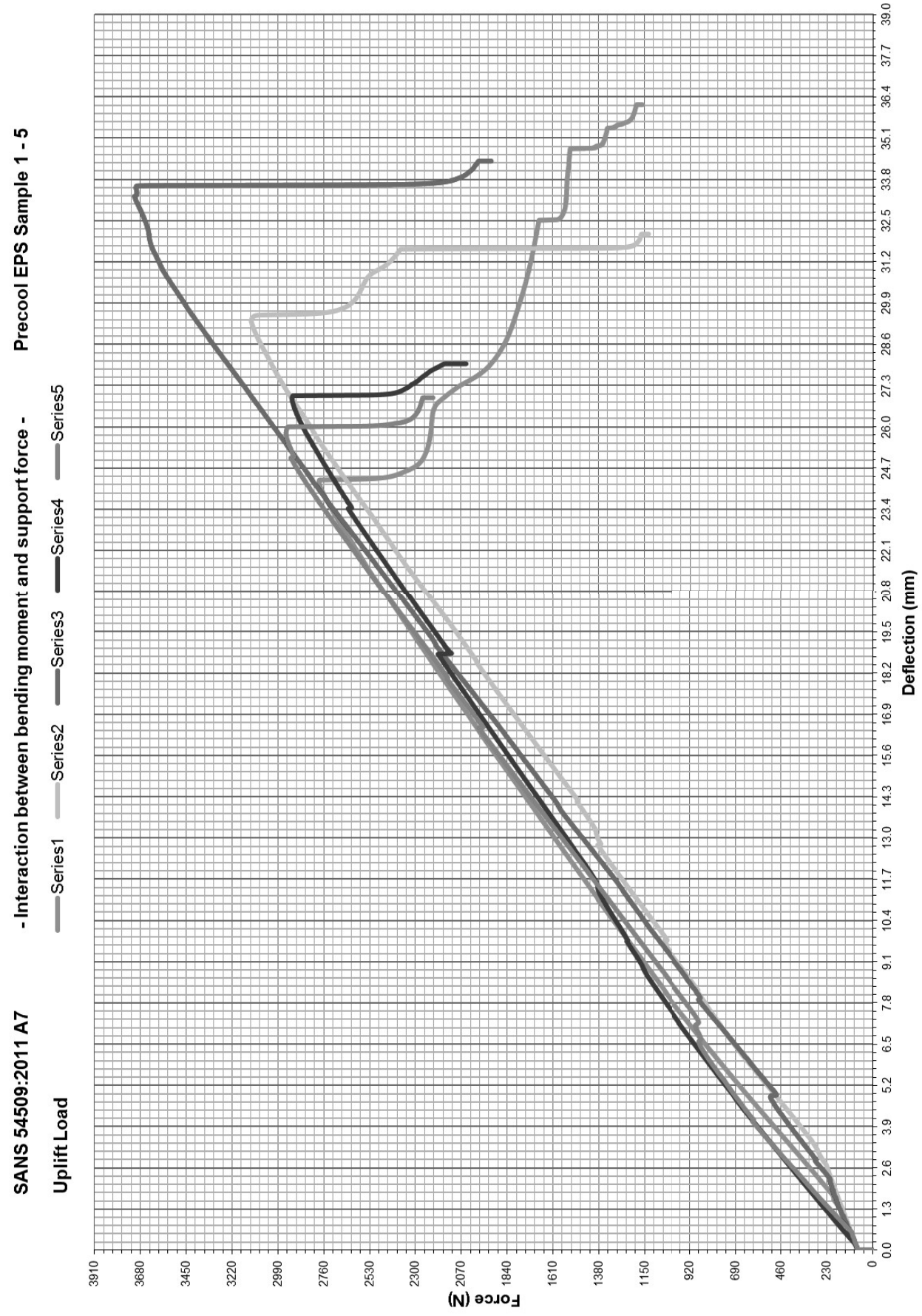
SANS 54509:2011 A7 **- Interaction between bending moment and support force -** **Precool EPS Sample 4**

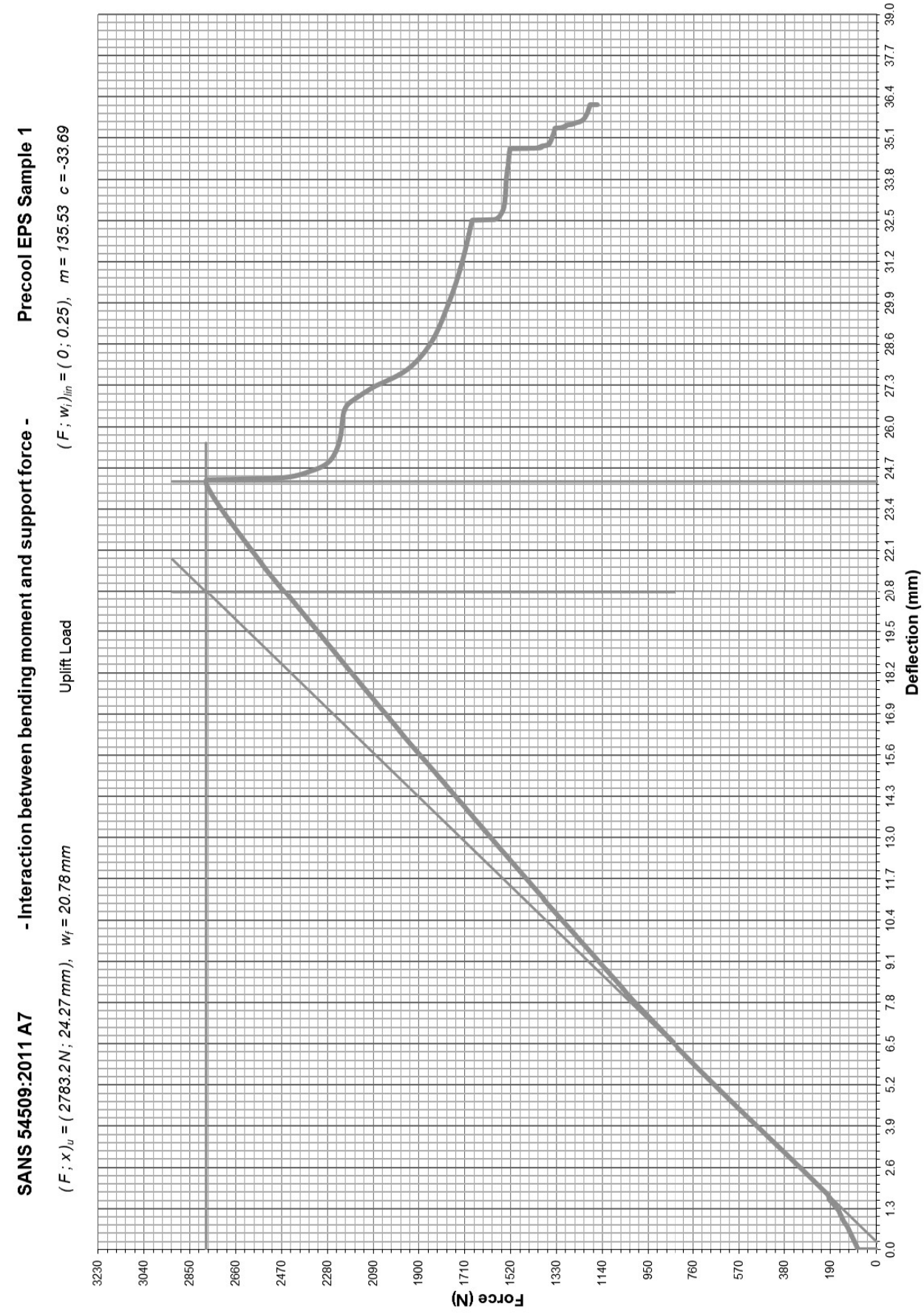
$(F ; x)_u = (4230.0\,N ; 27.07\,mm)$, $w_f = 24.88\,mm$ Downward Load $(F ; w_i)_{lin} = (0 ; -0.31)$, $m = 167.91$ $c = 52.73$




SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 5
$(F;x)_u = (4016.4\,N;\ 27.07\,mm)$, $w_i = 24.78\,mm$
Downward Load
$(F;w_i)_{lin} = (0;\ -0.33)$, $m = 160.00$ $c = 52.27$
Force (N)
4590
4320
4050
3780
3510
3240
2970
2700
2430
2160
1890
1620
1350
1080
810
540
270
0
Deflection (mm)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0

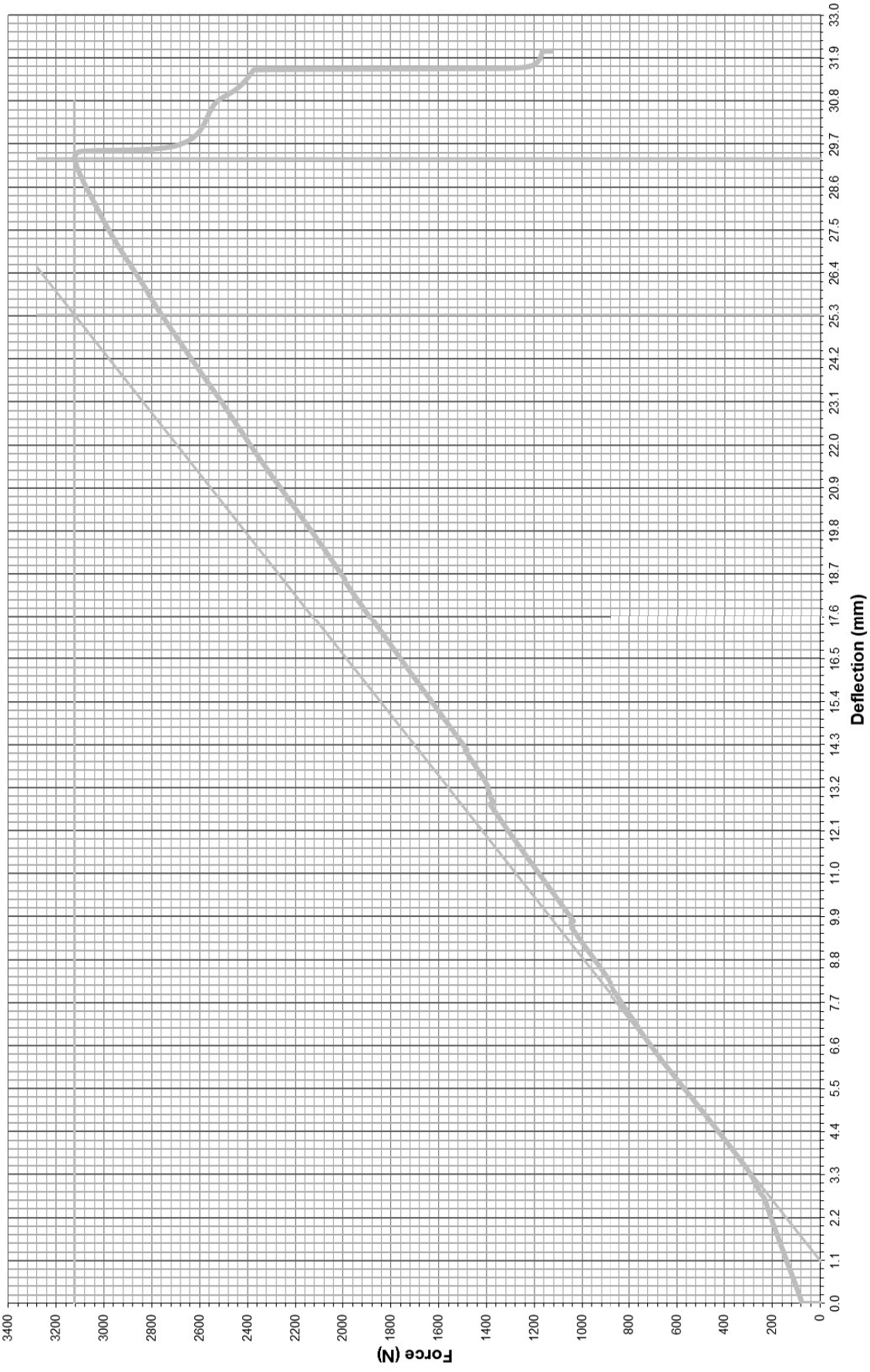
Simulated Central Support Test
EN 14509:2006
(DSS SANS 54509:2012)
A7
Uplift Load

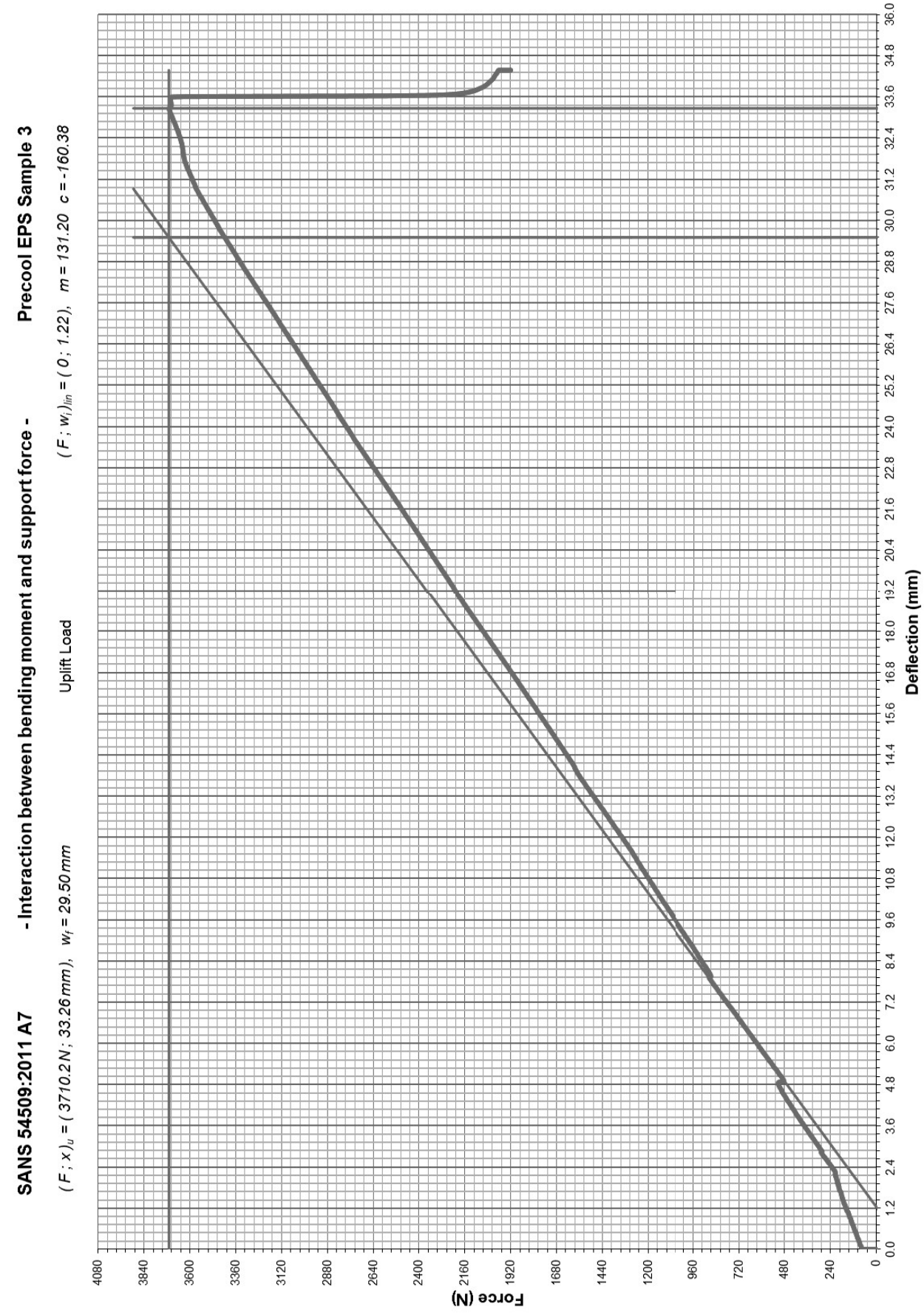

SANS 54509:2011 A7
Uplift Load
- Interaction between bending moment and support force -
Precool EPS Sample 1 - 5
Series1
Series2
Series3
Series4
Series5
Force (N)
3910
3680
3450
3220
2990
2760
2530
2300
2070
1840
1610
1380
1150
920
690
460
230
0
Deflection (mm)
0.0
1.3
2.6
3.9
5.2
6.5
7.8
9.1
10.4
11.7
13.0
14.3
15.6
16.9
18.2
19.5
20.8
22.1
23.4
24.7
26.0
27.3
28.6
29.9
31.2
32.5
33.8
35.1
36.4
37.7
39.0

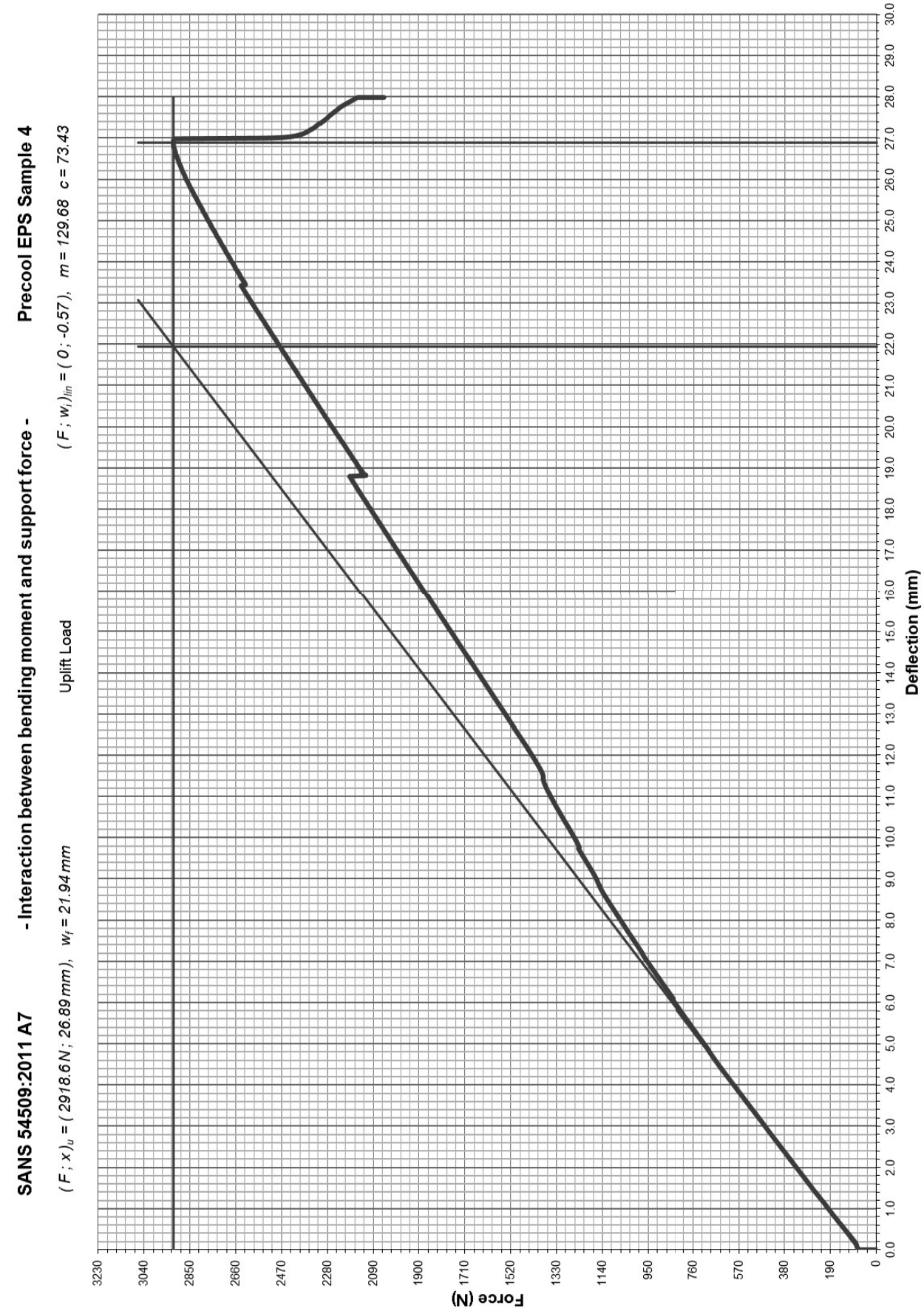

SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 1
$(F ; x)_u = (2783.2\,N ; 24.27\,mm)$, $w_f = 20.78\,mm$
Uplift Load
$(F ; w_i)_{lin} = (0 ; 0.25)$, $m = 135.53$ $c = -33.69$
Force (N)
3230
3040
2850
2660
2470
2280
2090
1900
1710
1520
1330
1140
950
760
570
380
190
0
Deflection (mm)
0.0
1.3
2.6
3.9
5.2
6.5
7.8
9.1
10.4
11.7
13.0
14.3
15.6
16.9
18.2
19.5
20.8
22.1
23.4
24.7
26.0
27.3
28.6
29.9
31.2
32.5
33.8
35.1
36.4
37.7
39.0

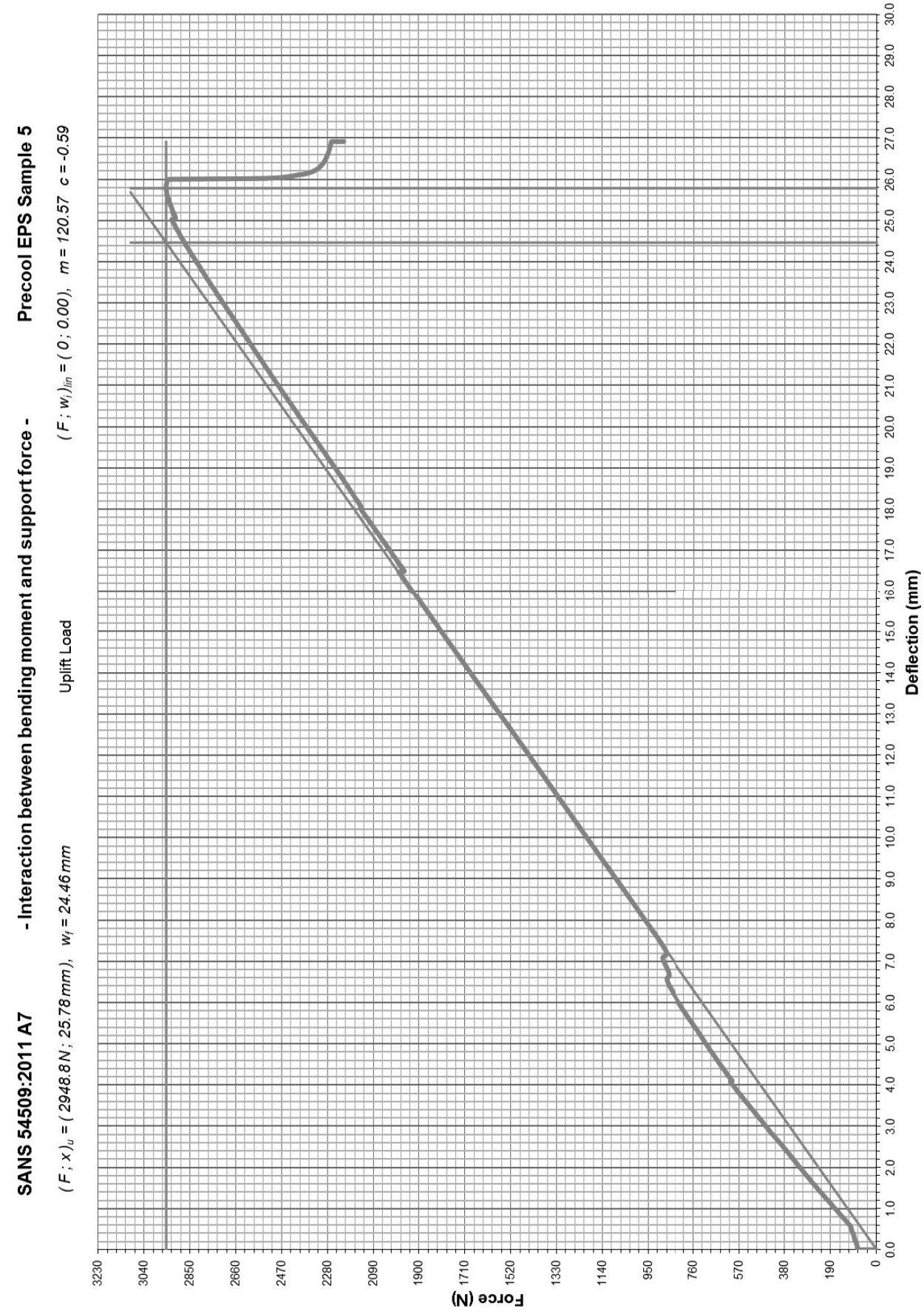
SANS 54509:2011 A7 - Interaction between bending moment and support force - Precool EPS Sample 2

$(F; x)_u = (3123.6\,N; 29.33\,mm)$, $w_f = 25.33\,mm$ Uplift Load $(F; w_i)_{lin} = (0; 1.08)$, $m = 128.84$ $c = -139.29$




SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 3
(F ; x)u = (3710.2 N ; 33.26 mm), wf = 29.50 mm
Uplift Load
(F ; wi)lin = (0 ; 1.22), m = 131.20 c = -160.38
Force (N)
4080
3840
3600
3360
3120
2880
2640
2400
2160
1920
1680
1440
1200
960
720
480
240
0
Deflection (mm)
0.0
1.2
2.4
3.6
4.8
6.0
7.2
8.4
9.6
10.8
12.0
13.2
14.4
15.6
16.8
18.0
19.2
20.4
21.6
22.8
24.0
25.2
26.4
27.6
28.8
30.0
31.2
32.4
33.6
34.8
36.0


SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 4
$(F;x)_u = (2918.6\,N;\ 26.89\,mm)$, $w_i = 21.94\,mm$
Uplift Load
$(F;w_i)_{lin} = (0;\ -0.57)$, $m = 129.68$ $c = 73.43$
Force (N)
3230
3040
2850
2660
2470
2280
2090
1900
1710
1520
1330
1140
950
760
570
380
190
0
Deflection (mm)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0


SANS 54509:2011 A7
- Interaction between bending moment and support force -
Precool EPS Sample 5
(F ; x)u = (2948.8 N ; 25.78 mm), wf = 24.46 mm
Uplift Load
(F ; wi)lin = (0 ; 0.00), m = 120.57 c = -0.59
Force (N)
3230
3040
2850
2660
2470
2280
2090
1900
1710
1520
1330
1140
950
760
570
380
190
0
Deflection (mm)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
19.0
20.0
21.0
22.0
23.0
24.0
25.0
26.0
27.0
28.0
29.0
30.0

Thermal Transmittance
ASTM C1363:2011
(*Report*)

SYSTEM THERMAL RESISTANCE TEST REPORT

OF A TPMA THERMAL PANEL

Determination of the Thermal Resistance of Thermally Insulated Wall Systems in accordance with ASTM C 1363-11: *Standard Test Method for Thermal Performance of Building Materials and Envelope Assemblies by Means of a Hot Box Apparatus.*

TEST APPLICANT: Thermal Panel Manufacturers Association (TPMA)

INTRODUCTION

Thermal Test Laboratory CC has been retained by The AAAMSA Group to test and determine the Thermal Resistance of a TPMA panel, with an expanded polystyrene, by means of the Rotatable Guarded Hot Box (RGHB) and in accordance with ASTM C 1363-11.

STANDARD TEST CONDITIONS

The standard test conditions for the RGHB tests were selected based on the requirements of ASTM C1058 - 03(2008): *Standard Practice for Selecting Temperatures for Evaluating and Reporting Thermal Properties of Thermal Insulation*. The standard test conditions used for these tests are as follows:

Room side (metering box)

Air temperature:	21 ºC (Cold climatic conditions)
Flow velocity:	0.3 m/s downward

Climate side:

Air temperature:	- 5.0 ºC (Cold climatic conditions)
Flow velocity:	5.5 m/s upward

Mean temperature of specimens for cold climatic conditions: 8.0 °C

TEST APPARATUS AND TEST SPECIMENS

The system thermal resistances of the two specimens were determined by using a rotatable guarded hot box (RGHB). Details on the RGHB are available in an internal TTL report (RGHB Testing Equipment Manual).

The specimen tested were a thermal panel with an expanded polystyrene core. The test specimen of nominally 1.5 m (h) x 1.2 m (w) was prepared. The specimen was installed in a Supawood frame.

In preparation for testing, the test specimen was mounted in the aperture of the surround panel in a vertical position. It was then instrumented with approximately 24 calibrated thermocouples mounted at selected positions on both surfaces of the specimen. After setting the test parameters, the cooling system was started and the system was allowed to saturate and reach stable conditions where it had to stay for a period of at least four hours while key test parameters were monitored within tight tolerances. The thermal resistance and thermal transmittance of the test specimen were then determined by analysing the recorded test data.

TEST RESULTS

The following RGHB data was sampled every second, averaged and recorded every minute:

- The temperature histories for the specimen for each test
- The air flow rates in the metering box and the climate side
- The area-weighted temperatures of both sides of the surround panel
- The spatial temperature distribution of the baffle surface in the metering box
- The spatial temperature distribution of the metering box air
- The output of the thermopile measuring the heat flow through the metering box walls
- The temperature increase of the metering box cooling loop and its flow rate
- The surface and internal temperatures of the specimen

The RGHB test data was analysed to determine the surface-to-surface thermal resistance values of the specimen. This analyses took account of the power input into the metering box (for controlling the air and baffle surface temperatures), the net thermopile gain/loss, the heat gain/loss through the surround panel and all other losses (or gains) such as flanking losses for which the RGHB has been calibrated in accordance with the requirements of both the National Fenestration Rating Council (NFRC) and the South African National Accreditation System (SANAS).

Parameters	Units	EPS Core
Time rate of net heat input to the metering box, Q_{WM}	W	48.00
Time rate of heat flow through the surround panel, Q_{SP}	W	9.60
Time rate of heat flow from the metering box to the guard chamber through the metering box walls, Q_{MB}	W	-0.20
Time rate of heat flow due to flanking losses of Metering Box, $Q_{MB,FL}$	W	3.69
Time rate of heat flow through specimen frame, Q_{SF}	W	1.03
Time rate of heat flow through metered specimen, Q_S	W	33.47
Average air velocity, room side, $V_{air,r}$	m/s	0.272
Space averaged air temperature, room side, $T_{a,r}$	ºC	20.93
Space averaged air temperature, climate side, $T_{a,c}$	ºC	-5.05
Area weighted average temperature of specimen hot surface, $T_{r,s}$	ºC	20.48
Area weighted average temperature of specimen cold surface, $T_{c,s}$	ºC	-5.17
Surface to surface thermal resistance, R_w	m^2•K/W	1.324

CONCLUSSION

In summary, the measured surface-to-surface thermal resistances for the specimen are as follows:

	EPS Core
SURFACE-TO-SURFACE THERMAL RESISTANCE (m^2·K/W)	**1.324**

ADDITIONAL INFORMATION*:*

Sample Conditioning: *The test specimens were maintained at ambient conditions prior to testing.*

Test Procedure*: Please refer to TTL document, RGHB/SOP/01 2009: RGHB Operating Procedures. For the RGHB testing the thermal resistance of the insulation system is determined from surface stream to surface. The airflow condition in the climate side is selected to simulate a 20 km/hr warm or cold wind.*

Deviations (if any) from ASTM C 1363-11: *No deviations*

SIGNATORIES

Test Officer*:*	*Name:*	Dr Gerrit Genis
	Date:	29 November 2011
	Signature:	

Thermal Conductivity
ASTM C518:2010
(*Report*)

TEST REPORT ASTM C 518 – 10
Steady-State Thermal Transmission Properties

Date Received: 24/05/2012	Order no.: DS/1020/12		Test Officer: Arno van der Walt
Test Sponsor :	AAAMSA GROUP 2nd Road HALFWAY HOUSE 1685	Test Applicant:	Precool 429 Carl Street Pretoria West 0001
Tel no: Email address: Cell no: AAAMSA Affiliation	012 327 1291 info@precool.co.za - TPMA		Date test was completed : 08/10/2012

SAMPLE DESCRIPTION

Product name :	Unknown
Type/s of product :	100 mm thick EPS core insulation Panel.
Manufacturer:	Precool.
Physical description of samples/specimens :	One 300 mm by 300 mm sample was extracted from a full size 100mm thick thermal insulation panel.
Description of specimen/s and relationship to sample/s if known:	The bonded steel skins and some EPS of the abovementioned sample were then removed leaving a ±77mm thick core material test specimen.
Sample/specimen conditioning:	The sample was conditioned in accordance with the relevant standard.

Specimen no :	Instrument measured thickness (mm) :	Dimensions (mm) :	Mass as tested (kg) :	Density as tested :	
				(kg/m³)	(kg/m²)
1	76.9	300mm x 300mm	0.1192	17.2	1.32
In the event that more than 3 (three) specimens were tested the information shall be listed in an Annexure					

METHOD OF TESTING	
Heat flow direction:	Upwards
Orientation of specimen:	Horizontal

Notes:

The test specimen system was tested at three mean temperatures.

The test specimen system filled the entire test chamber and the top and bottom plates of the test machine had good contact with the upper and lower plates of the tested specimen during testing.

The upper and lower surfaces of the tested specimen were identical in colour and composition; hence the orientation of the specimen with regards to the test plates is immaterial.

INSTRUMENT DESCRIPTION AND ACCURACY

TTL uses a Laser Comp Fox 314 heat flow meter instrument for measuring thermal conductivity. The Fox 314 has been designed to comply with ASTM C518,ISO8301,EN12667,EN1946-1 and EN1946-3, and is provided with a built-in calibration according to the NIST 1450b standard. It has 0.6µV resolution on the integral high output heat flux transducers and 0.01ºC temperature control and resolution, based on its 24 bit ADC. The thickness of the sample is measured on all four corners of the specimen providing an accuracy of ±0.025mm thickness measurement. The instrument therefore has a repeatability of 99.8% and an accuracy of 99%

TEST CRITERIA

Test temperature set point :	Mean temperature (°C) :	Temperature difference across specimen (°C) :
1	-5	20
2	15	30
3	35	30
Date of last calibration of instrument :	The machine is verified annually by means of a comparative test using a calibration transfer standard specimen.	

In the event that more than 3 (three) set points were used the information shall be listed in an Annexure

TEST RESULTS

Specimen no :	Test set point :	Thermal Conductivity W/(m·K) :	Thermal resistance (m²·K)/W :	Test period (min) :	Mass loss/gain during test (%) :
SP 1	1.	0.034	2.25	40	0
	2.	0.037	2.09	48	0
	3.	0.039	2.97	49	0
	Mean values :	**0.037**	**2.44**	-	-

In the event that more than 3 (three) set points were used or specimens tested, all the information in the table above can be found in Annexure-C

Environmental conditions during test:	Temperature (°C) :	Relative humidity (% Rh) :
	23.1	44

Factors which may have affected the results and deviations from ASTM C 518 - 10 :
No deviations were made.

CONCLUSION

The average **thermal conductivity** for the tested specimen is **0.037 W/(m·K)**

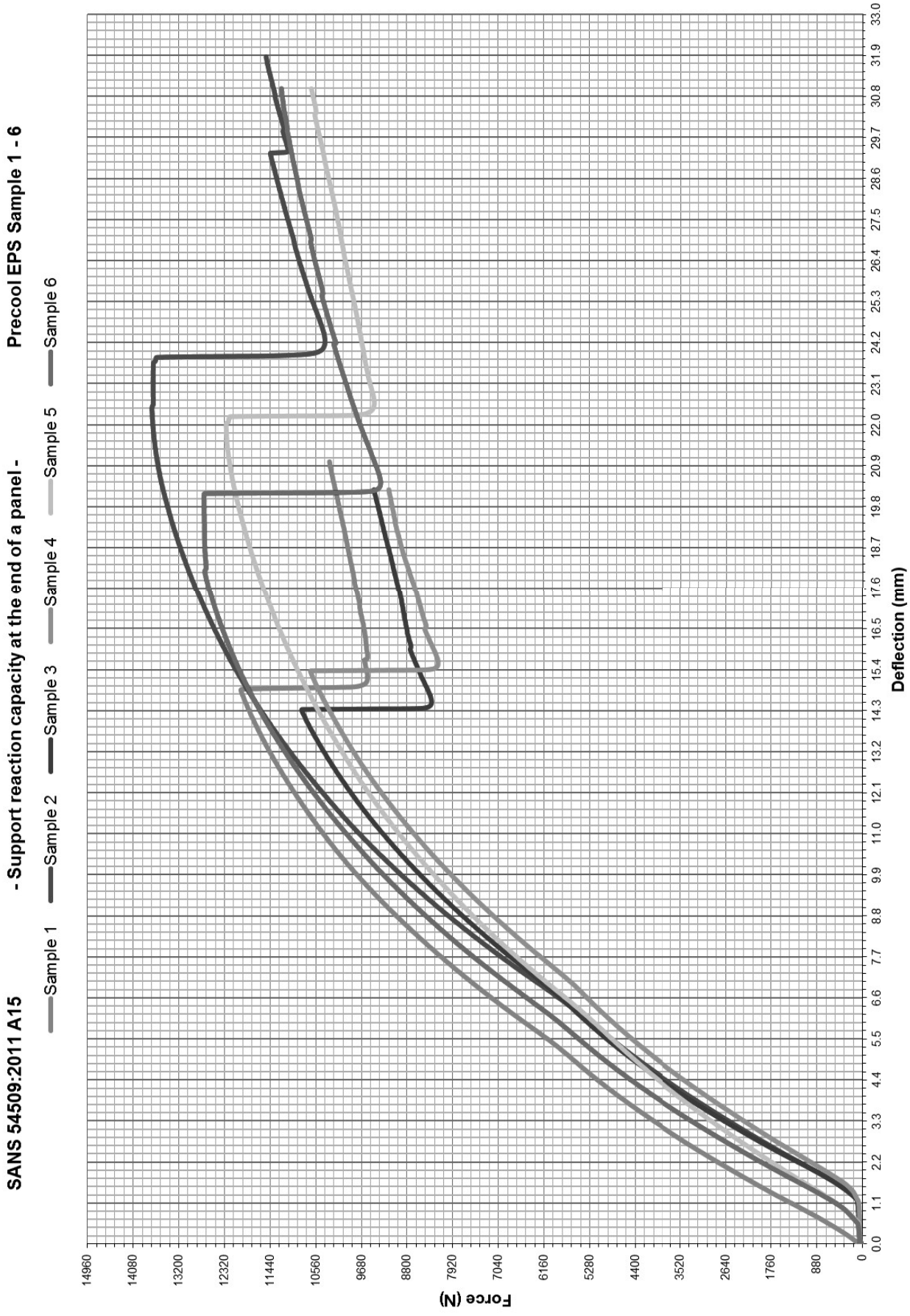
The average **thermal resistance** for the specimen as tested is **2.44 (m²·K)/W**

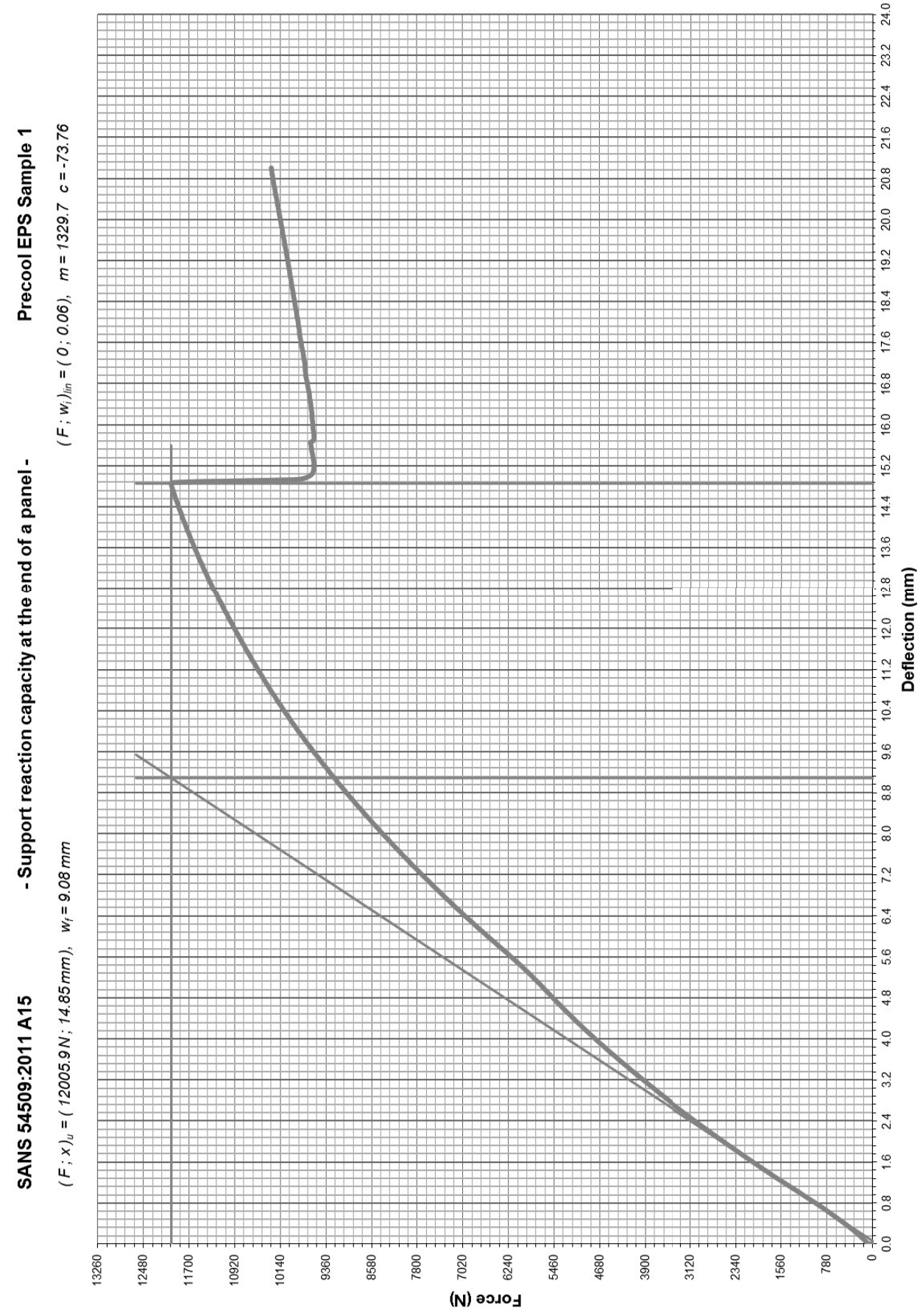
Notes: The thermal conductivity of a material is a function of its mean temperature, and the thermal resistance is a function of thermal conductivity and material thickness.

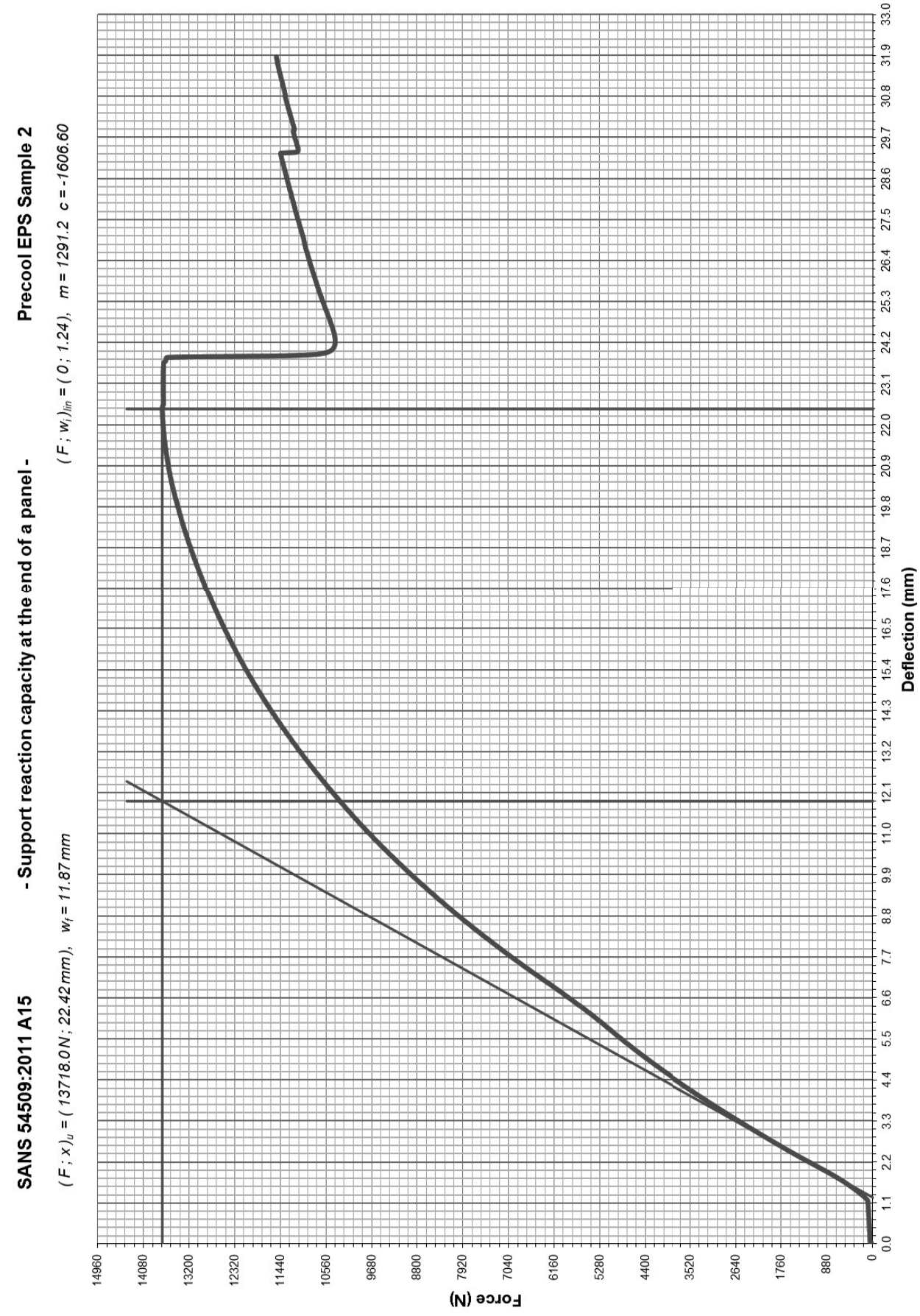
Test officer: A P J van der Walt	Results verified by: K Strydom
Date: 09/10/2012	Date: 09/10/2012
Technical Signatory:	Manager Signatory:

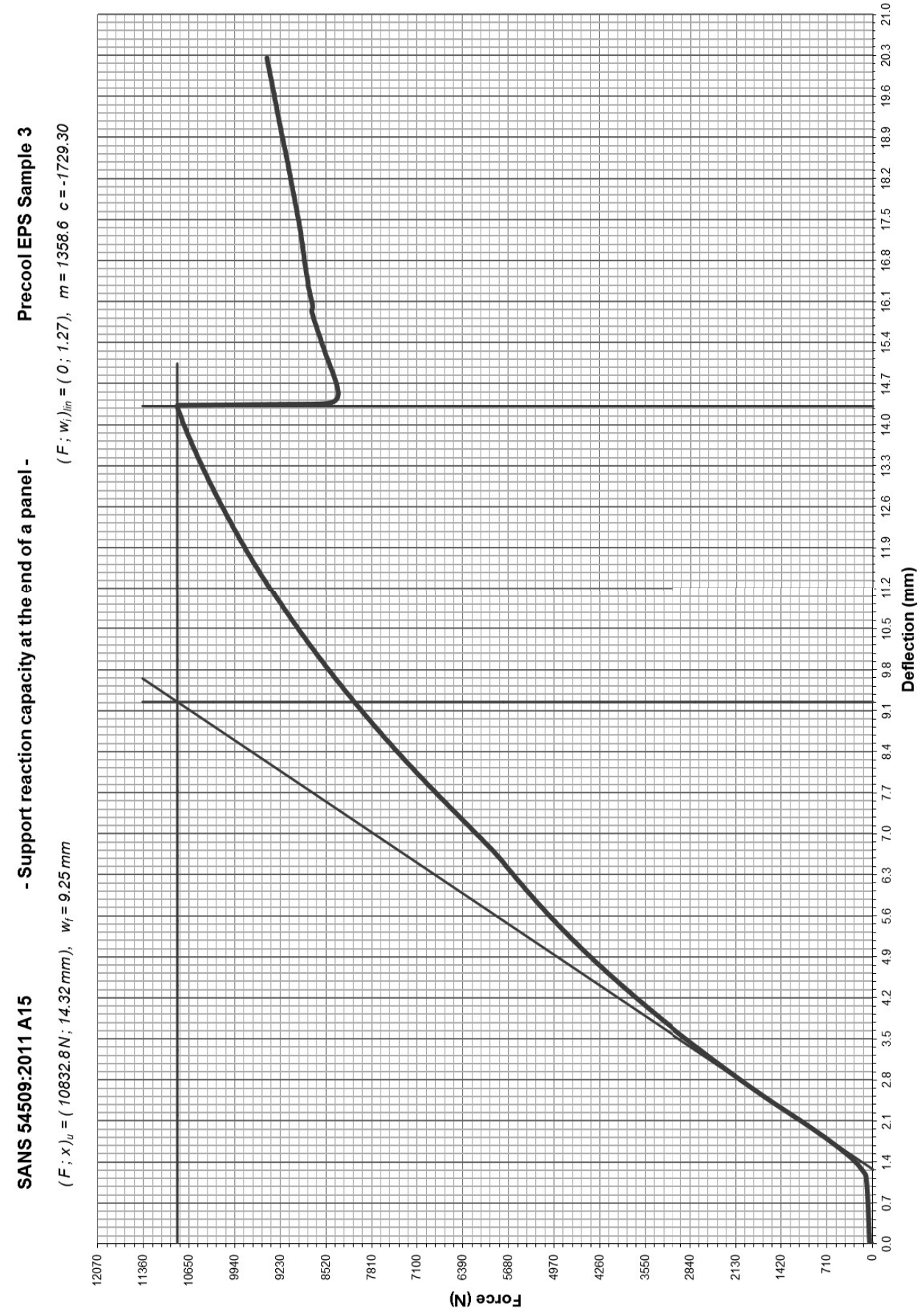
***** END OF REPORT *****

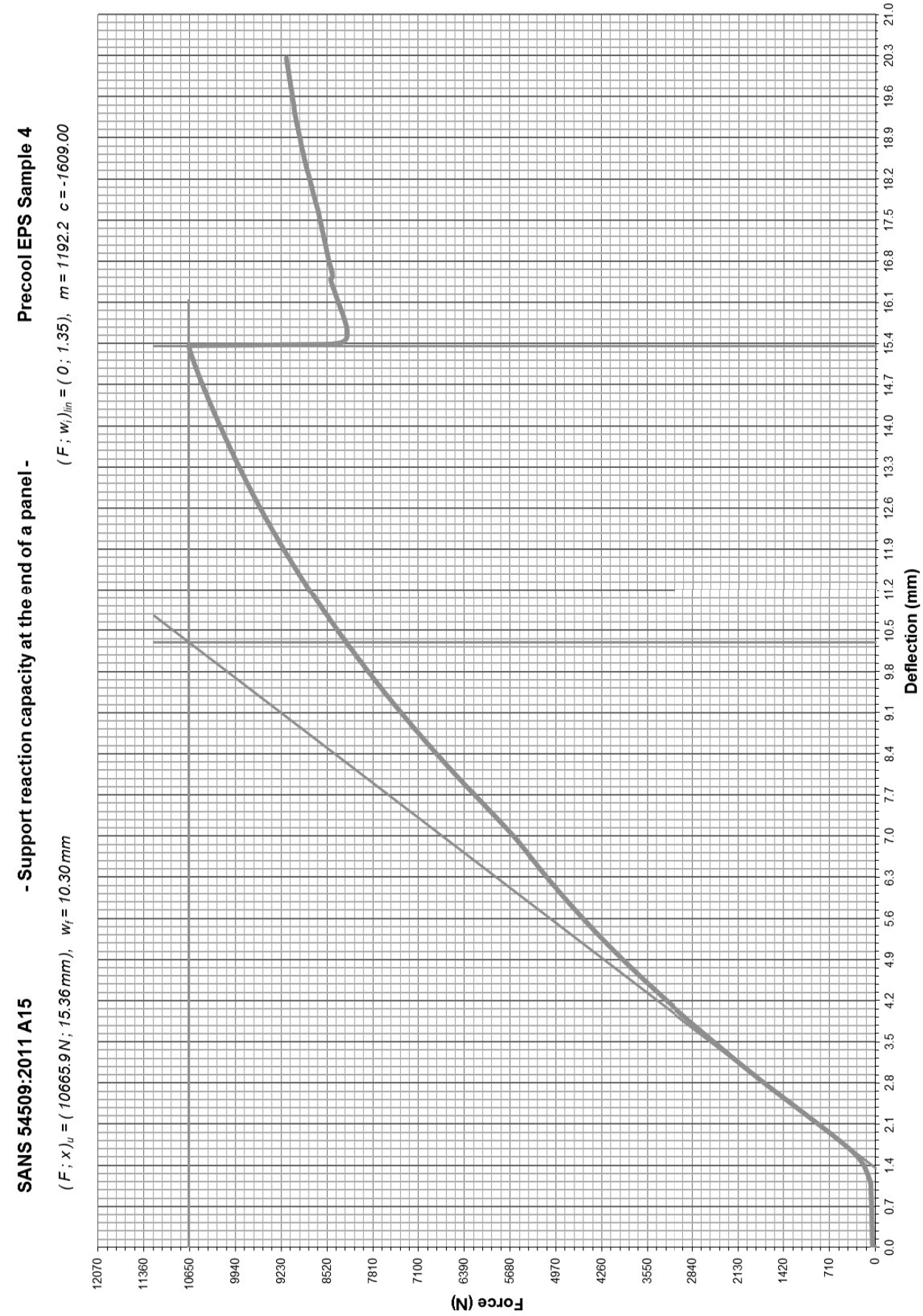
Support Reaction Capacity
EN 14509:2006
(DSS SANS 54509:2012)
A15

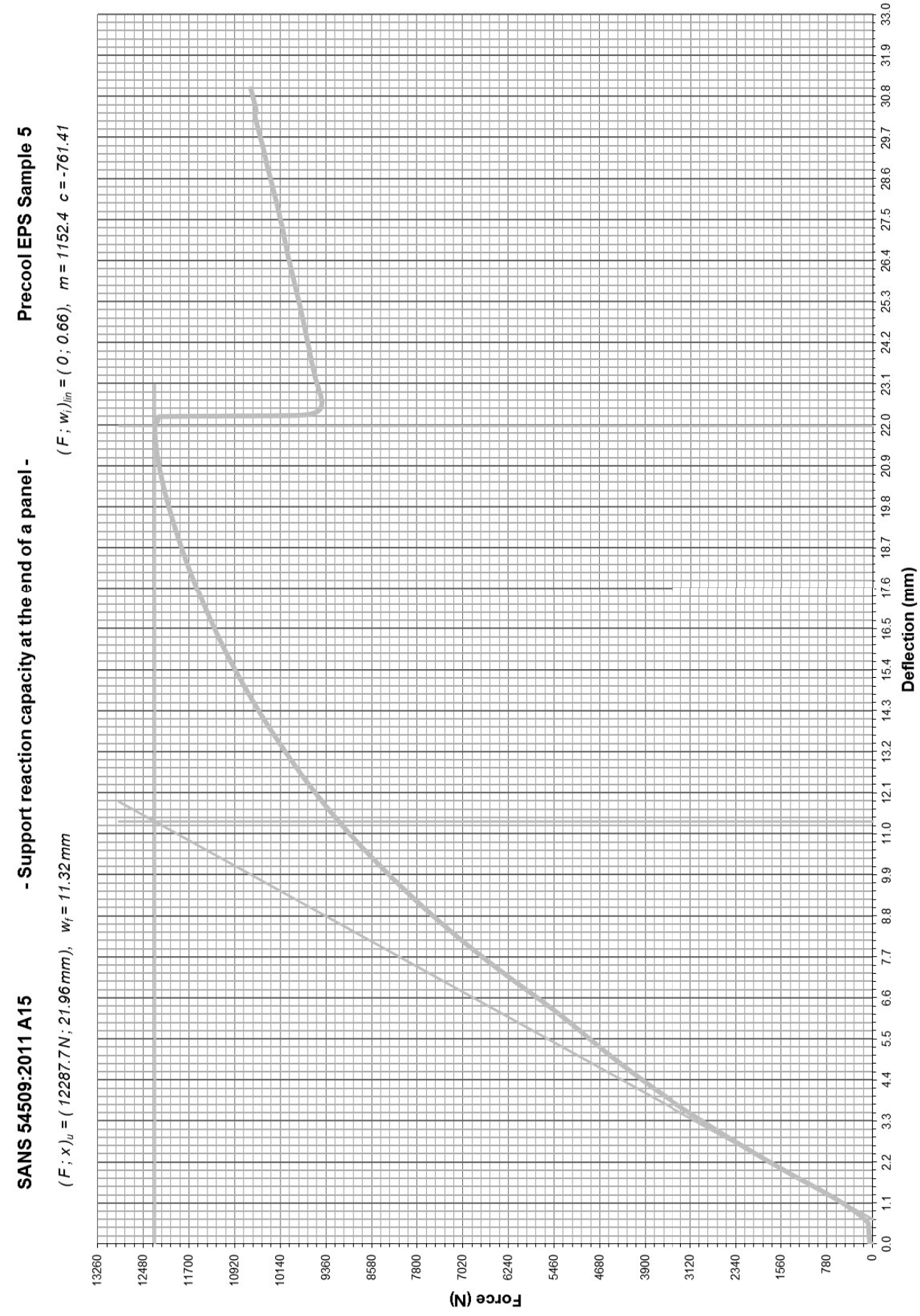

SANS 54509:2011 A15
- Support reaction capacity at the end of a panel -
Precool EPS Sample 1 - 6
Sample 1
Sample 2
Sample 3
Sample 4
Sample 5
Sample 6
Force (N)
14960
14080
13200
12320
11440
10560
9680
8800
7920
7040
6160
5280
4400
3520
2640
1760
880
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0

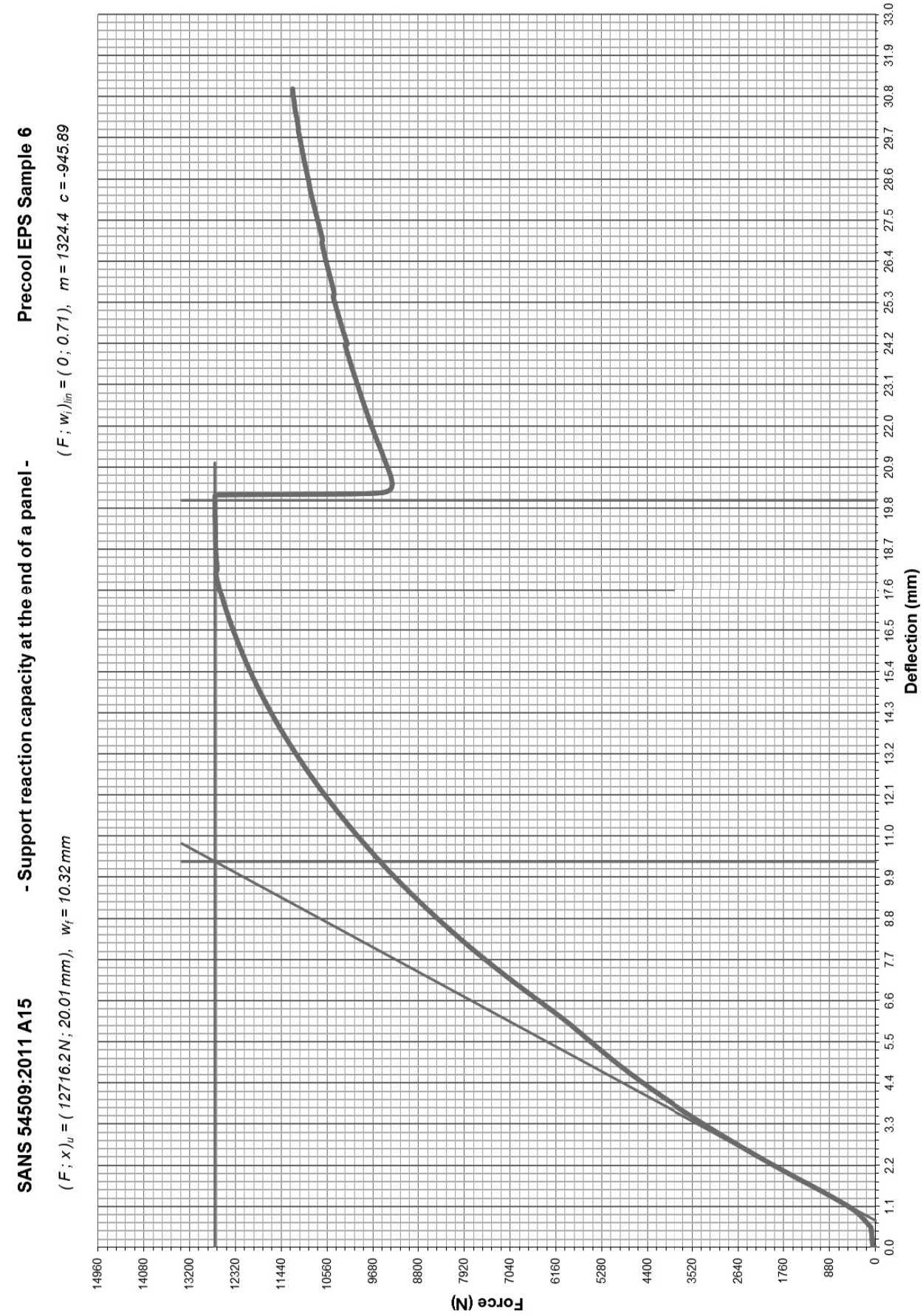

Precool EPS Sample 1
$(F ; w_i)_{lin} = (0 ; 0.06)$, $m = 1329.7$ $c = -73.76$
SANS 54509:2011 A15 - Support reaction capacity at the end of a panel -
$(F ; x)_u = (12005.9\,N ; 14.85\,mm)$, $w_f = 9.08\,mm$
Force (N)
13260
12480
11700
10920
10140
9360
8580
7800
7020
6240
5460
4680
3900
3120
2340
1560
780
0
Deflection (mm)
0.0
0.8
1.6
2.4
3.2
4.0
4.8
5.6
6.4
7.2
8.0
8.8
9.6
10.4
11.2
12.0
12.8
13.6
14.4
15.2
16.0
16.8
17.6
18.4
19.2
20.0
20.8
21.6
22.4
23.2
24.0


Precool EPS Sample 2
- Support reaction capacity at the end of a panel -
SANS 54509:2011 A15
$(F; w_i)_{lin} = (0; 1.24)$, $m = 1291.2$ $c = -1606.60$
$(F; x)_u = (13718.0\,N; 22.42\,mm)$, $w_f = 11.87\,mm$
Force (N)
14960
14080
13200
12320
11440
10560
9680
8800
7920
7040
6160
5280
4400
3520
2640
1760
880
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0


SANS 54509:2011 A15
- Support reaction capacity at the end of a panel -
Precool EPS Sample 3
(F ; x)u = (10832.8 N ; 14.32 mm), wf = 9.25 mm
(F ; wi)lin = (0 ; 1.27), m = 1358.6 c = -1729.30
Force (N)
12070
11360
10650
9940
9230
8520
7810
7100
6390
5680
4970
4260
3550
2840
2130
1420
710
0
Deflection (mm)
0.0
0.7
1.4
2.1
2.8
3.5
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
11.2
11.9
12.6
13.3
14.0
14.7
15.4
16.1
16.8
17.5
18.2
18.9
19.6
20.3
21.0


Precool EPS Sample 4
- Support reaction capacity at the end of a panel -
SANS 54509:2011 A15
$(F; x)_u = (10665.9\,N; 15.36\,mm)$, $w_f = 10.30\,mm$
$(F; w_i)_{lin} = (0; 1.35)$, $m = 1192.2$ $c = -1609.00$
Force (N)
12070
11360
10650
9940
9230
8520
7810
7100
6390
5680
4970
4260
3550
2840
2130
1420
710
0
Deflection (mm)
0.0
0.7
1.4
2.1
2.8
3.5
4.2
4.9
5.6
6.3
7.0
7.7
8.4
9.1
9.8
10.5
11.2
11.9
12.6
13.3
14.0
14.7
15.4
16.1
16.8
17.5
18.2
18.9
19.6
20.3
21.0


SANS 54509:2011 A15
- Support reaction capacity at the end of a panel -
Precool EPS Sample 5
$(F; x)_u = (12287.7\,N; 21.96\,mm)$, $w_f = 11.32\,mm$
$(F; w_i)_{lin} = (0; 0.66)$, $m = 1152.4$ $c = -761.41$
Force (N)
13260
12480
11700
10920
10140
9360
8580
7800
7020
6240
5460
4680
3900
3120
2340
1560
780
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0


Precool EPS Sample 6
- Support reaction capacity at the end of a panel -
SANS 54509:2011 A15
$(F;w_i)_{lin} = (0;0.71),\ m = 1324.4\ \ c = -945.89$
$(F;x)_u = (12716.2\,N;20.01\,mm),\ \ w_f = 10.32\,mm$
Force (N)
14960
14080
13200
12320
11440
10560
9680
8800
7920
7040
6160
5280
4400
3520
2640
1760
880
0
Deflection (mm)
0.0
1.1
2.2
3.3
4.4
5.5
6.6
7.7
8.8
9.9
11.0
12.1
13.2
14.3
15.4
16.5
17.6
18.7
19.8
20.9
22.0
23.1
24.2
25.3
26.4
27.5
28.6
29.7
30.8
31.9
33.0

7. Conclusion

Adhesion between the faces or skins and the core material was satisfactory.

Adhesion between broken core segments was satisfactory and in some cases increased the strength of the panels containing such joints.

End of Report		
Report compiled by:	P Strydom (SANAS Accredited Testing Officer)	
Date of report:	29 November 2012	Signature:

Results verified by:	K Strydom (Manager TTL)	
Date of report:	29 November 2012	Signature: