Conductor Mechanical Testing – 05 September 2012

Update – 11 sept. 2012

Objectives:

New mechanical testing were performed on September 05th with the following procedure suggested during the design review held at Sigmaphi in July 2012:

- Conductor samples cut by EDM to avoid any distortion due to the cutting process. The samples were taken from a 25 turns dummy pancake wound with a 100 daN tension

- Conductors stack sides guided by a jig during the compression. Several boundaries conditions were tested:
  - -A) Clearance 0,2 mm similar to CEA testing procedure used for Iseult conductor
  - -B) sides blocked with no clearance against G10 sheet 0,2 mm thick
  - -C) sides blocked with no clearance against the jig steel block
  - -D) sides blocked with no clearance against the jig steel block pressed by a clamp

- Solid blocks of copper are also tested to validate the measurement procedure

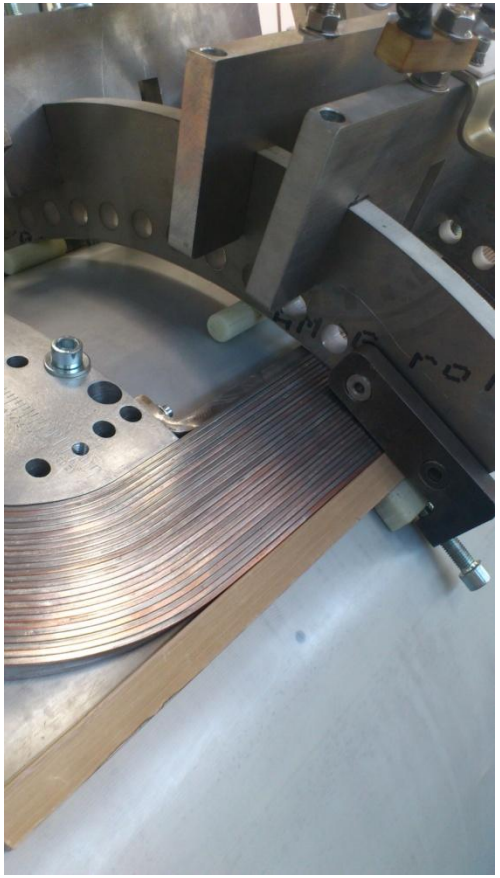
Results:

Results are identical to the previous testing made in April and June 2012. Guide the conductor stack sides, whatever the boundaries conditions, and cut the conductor by EDM do not change the mechanical measurement.

The first compression still exhibits a very low stiffness and plastic strain as already measured in April and June 2012. The measurement made on solid copper block validates the method with a pure elastic behavior for solid copper contrasting with the conductors stack large plastic behavior. These new measurement still confirm the conductor must be consolidated according to the analysis and proposal made during the design review held at Sigmaphi on 12 July 2012.

Sample reference	Description	Test
5.1	Samples length 40 mm, cut by EDM, took from the 25 turns dummy pancake wound with a 100 daN tension	Compression test with Aramis camera Guiding tool with 0,2 mm clearance
5.2	Idem 5.1	Compression test with Aramis camera Guiding tool with no clearance and G10 sheet 0,2 mm thick along the sides
5.3	Idem 5.1	Compression test with Aramis camera Guiding tool with no clearance
5.4	Idem 5.1	Compression test with Aramis camera Guiding tool with no clearance and sides pressed by a clamp
6.1	Solid block of copper	Compression test with Aramis camera Guiding tool with no clearance and G10 sheet 0,2 mm thick along the sides
6.2	Idem 6.1	Compression test with Aramis camera Guiding tool with no clearance and sides pressed by a clamp
6.3	Idem 6.1	Compression test with Aramis camera Guiding tool with 0,2 mm clearance

DUMMY PANCAKE 25 TURNS



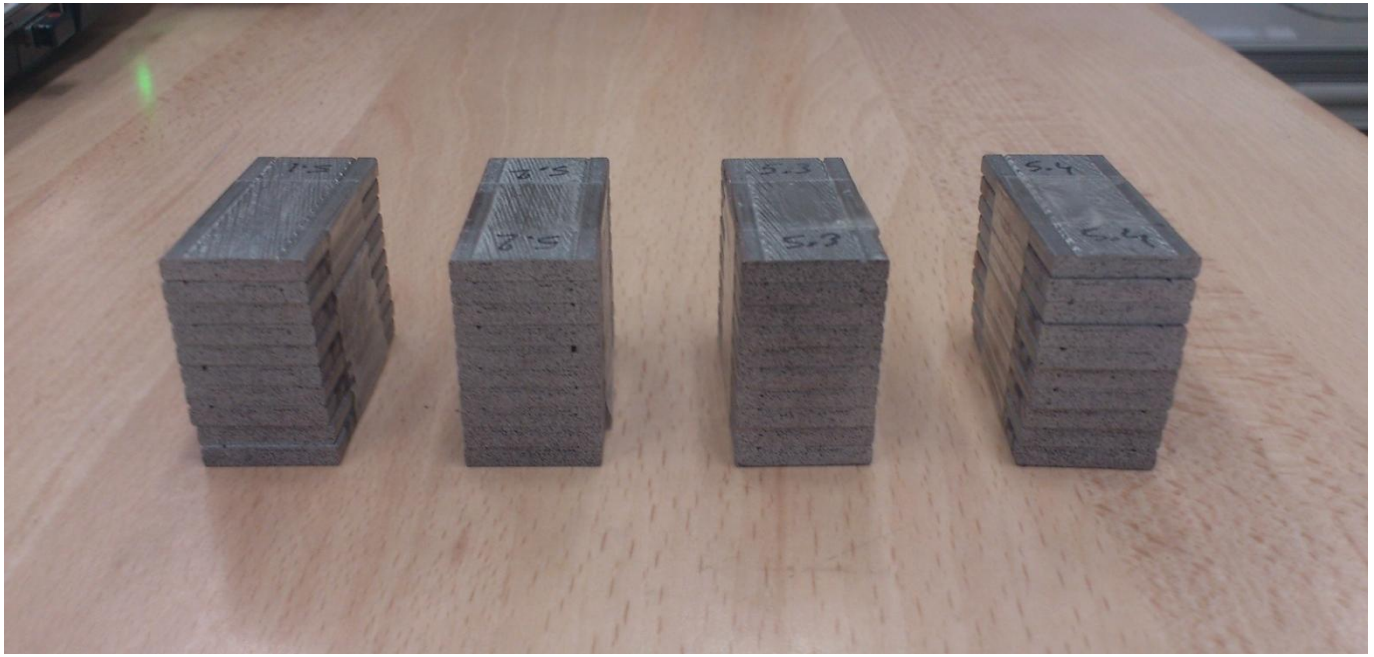
Winding tension: 100 daN

EDM CUTTING

EDM cutting machine

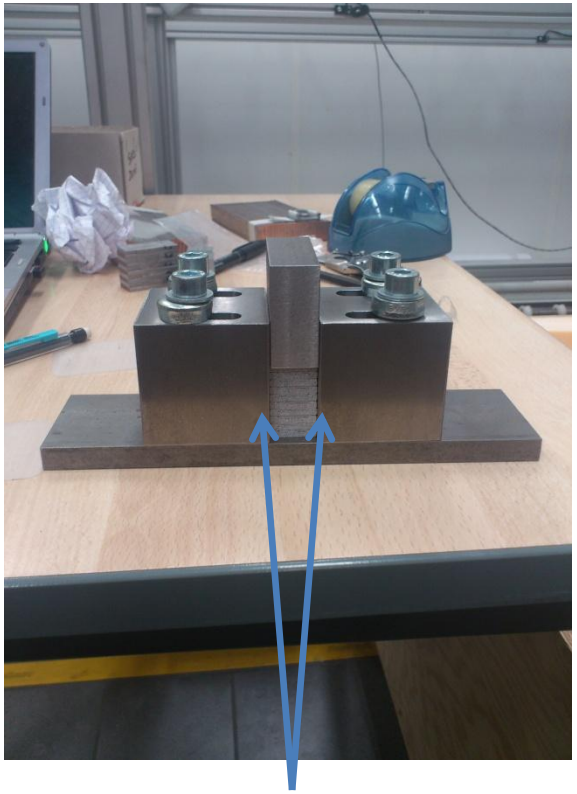
Dummy pancake cross section

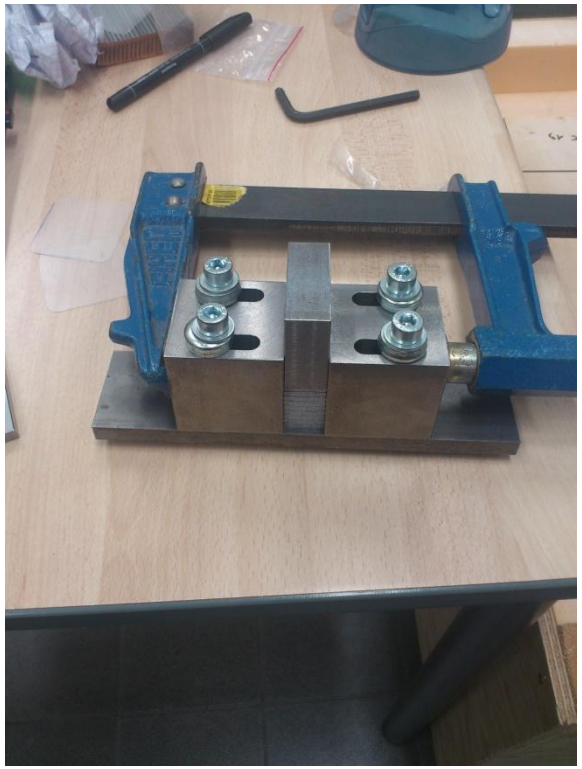
CONDUCTOR SAMPLES



SOLID COPPER SAMPLES

GUIDING TOOL

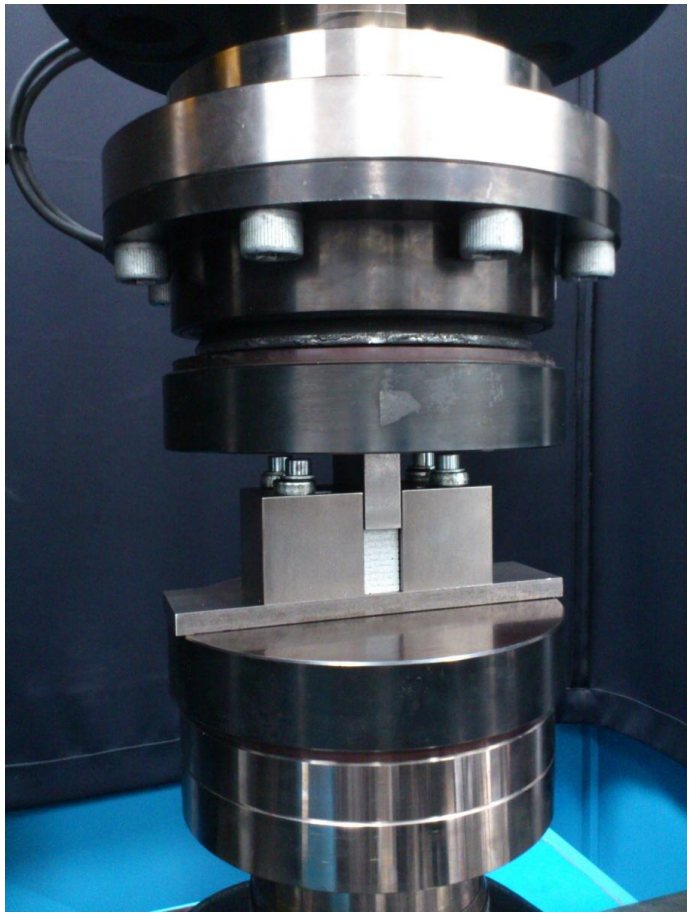


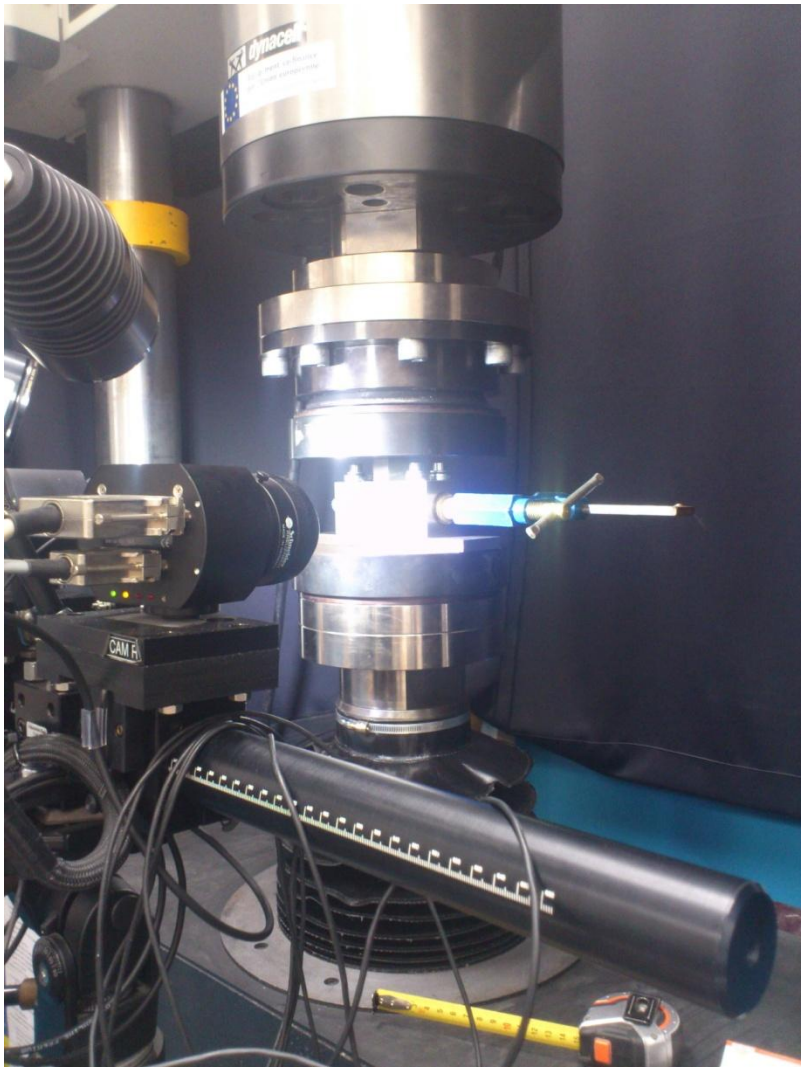


Conductors are alternated within a stack to offset the copper keystonning

Side boundary conditions:
0,2 mm clearance (samples 5.1 and 6.3)
OR
G10 sheet 0,2 mm thick (samples 5.2 and 6.1)
OR
Contact, no clearance (sample 5.3)
OR
Contact, no clearance + clamp (samples 5.4, 6.2)

COMPRESSION MACHINE

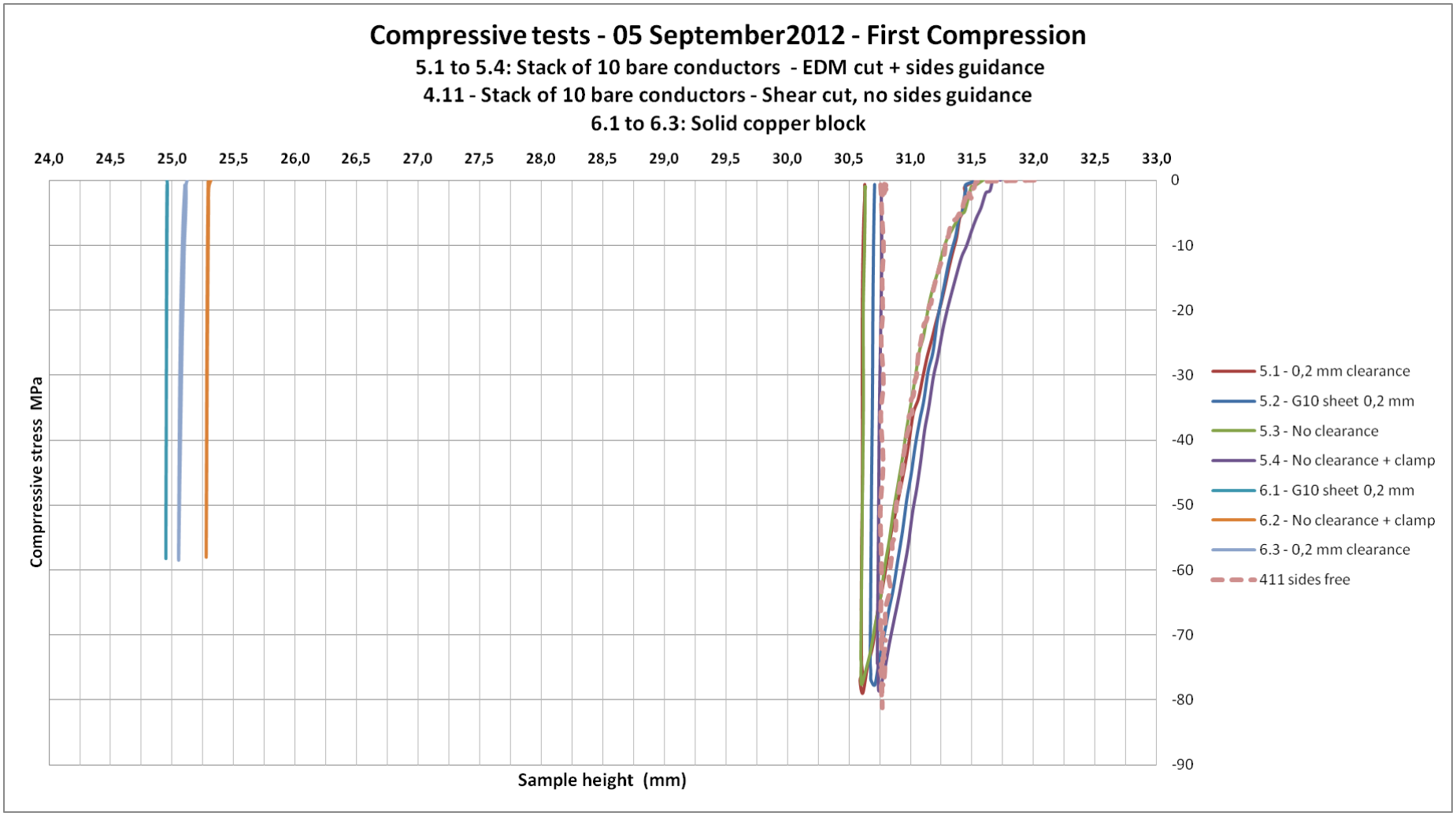




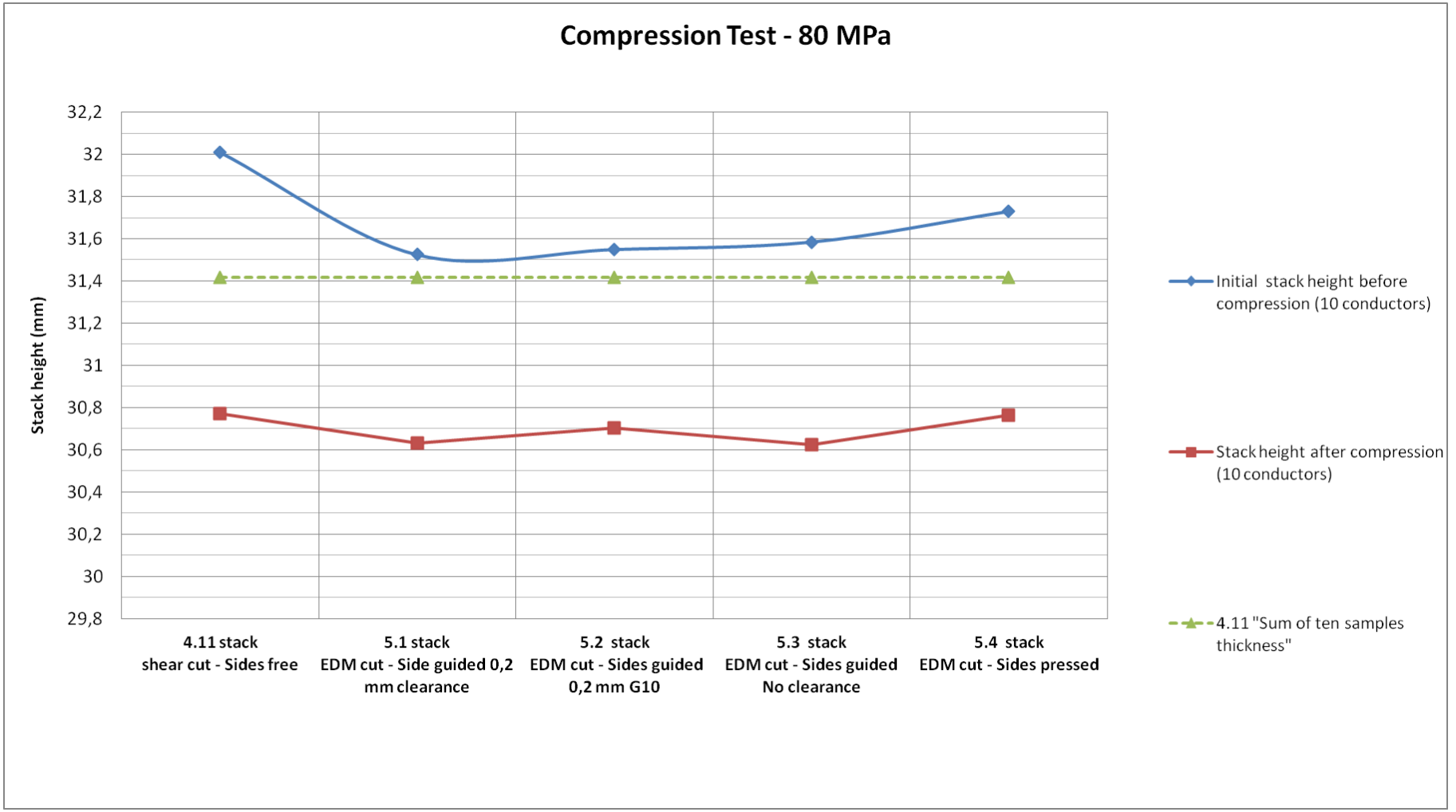
- Ball pivot press is used for the compression
- Speed rate 0,01 mm / second
- Stack is preloaded at 1kN to set up 0% strain
- Final load is 60 kN

Conductor dimensions before and after testing

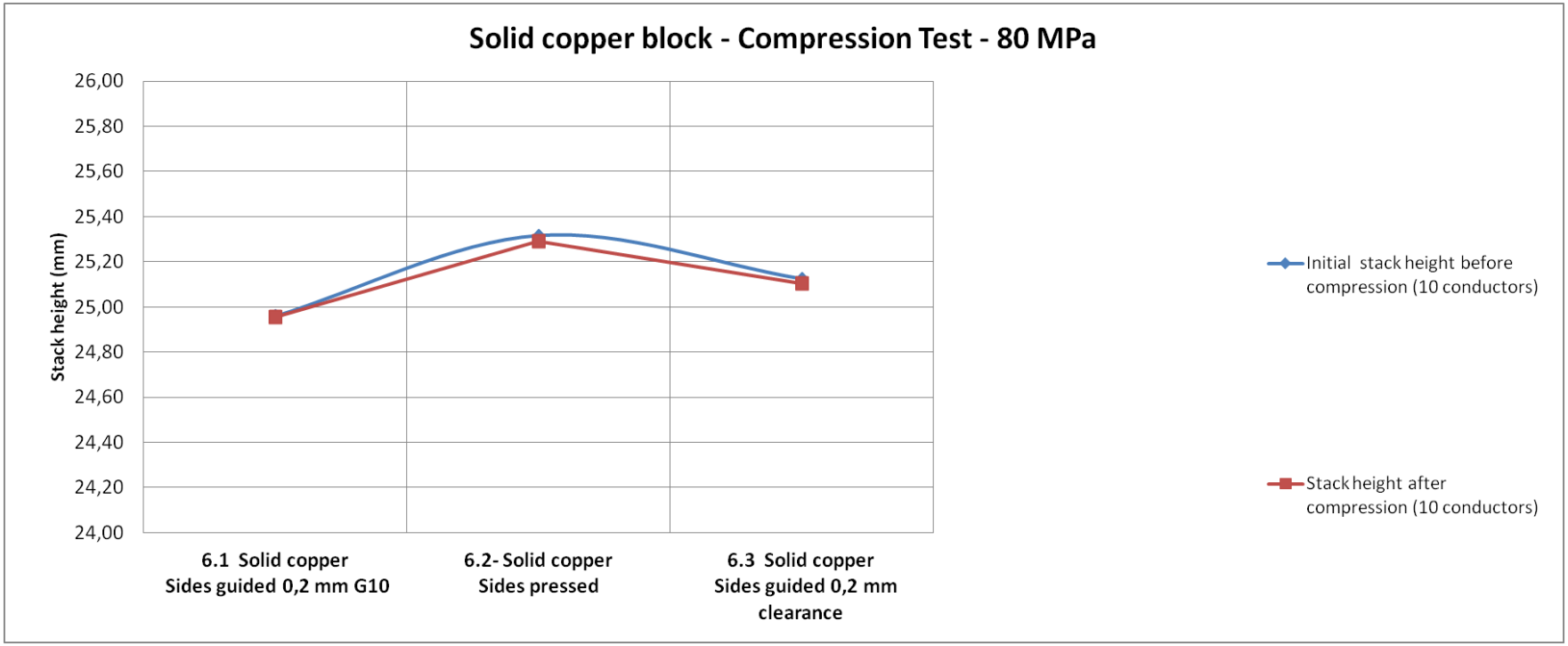
Sample		Equivalent conductor thickness before testing	Width before testing	Equivalent conductor thickness after testing	Width after testing	Initial stack height before compression (10 conductors)	Stack height after compression (10 conductors)	Remanent strain after compression - Geometric measurement (0% strain at 0 preload)	Remanent strain after compression - Aramis camera measurement (0% strain at 1 kN	4.11 "Sum of ten samples thickness"
4.11 stack shear cut - Sides free	Stack 10 conductors - shear cut	3,20	18,72	3,08	18,84	32,01	30,77	3,87%	2,42%	31,416
5.1 stack EDM cut - Side guided 0,2 mm clearance	Stack 10 conductors - EDM cut	3,15	18,7	3,06	18,79	31,53	30,63	2,84%	2,58%	31,416
5.2 stack EDM cut - Sides	Stack 10 conductors - EDM cut	3,16	18,695	3,07	18,87	31,55	30,71	2,68%	2,35%	31,416
5.3 stack EDM cut - Sides	Stack 10 conductors - EDM cut	3,16	18,69	3,06	18,865	31,59	30,63	3,04%	2,79%	31,416
5.4 stack EDM cut - Sides	Stack 10 conductors - EDM cut	3,17	18,72	3,08	18,745	31,73	30,77	3,04%	2,86%	31,416
6.1 Solid copper Sides guided 0,2 mm	Solid copper block		20,125		20,12	24,96	24,96	0,02%	0,02%	
6.2- Solid copper Sides pressed	Solid copper block		20,18		20,145	25,315	25,29	0,10%	0,03%	
6.3 Solid copper Sides guided 0,2 mm	Solid copper block		20,05		20,075	25,125	25,105	0,08%	0,04%	


Compressive tests - 05 September2012 - First Compression
5.1 to 5.4: Stack of 10 bare conductors - EDM cut + sides guidance
4.11 - Stack of 10 bare conductors - Shear cut, no sides guidance
6.1 to 6.3: Solid copper block
24,0
24,5
25,0
25,5
26,0
26,5
27,0
27,5
28,0
28,5
29,0
29,5
30,0
30,5
31,0
31,5
32,0
32,5
33,0
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
Comprressive stress MPa
Sample height (mm)
5.1 - 0,2 mm clearance
5.2 - G10 sheet 0,2 mm
5.3 - No clearance
5.4 - No clearance + clamp
6.1 - G10 sheet 0,2 mm
6.2 - No clearance + clamp
6.3 - 0,2 mm clearance
411 sides free

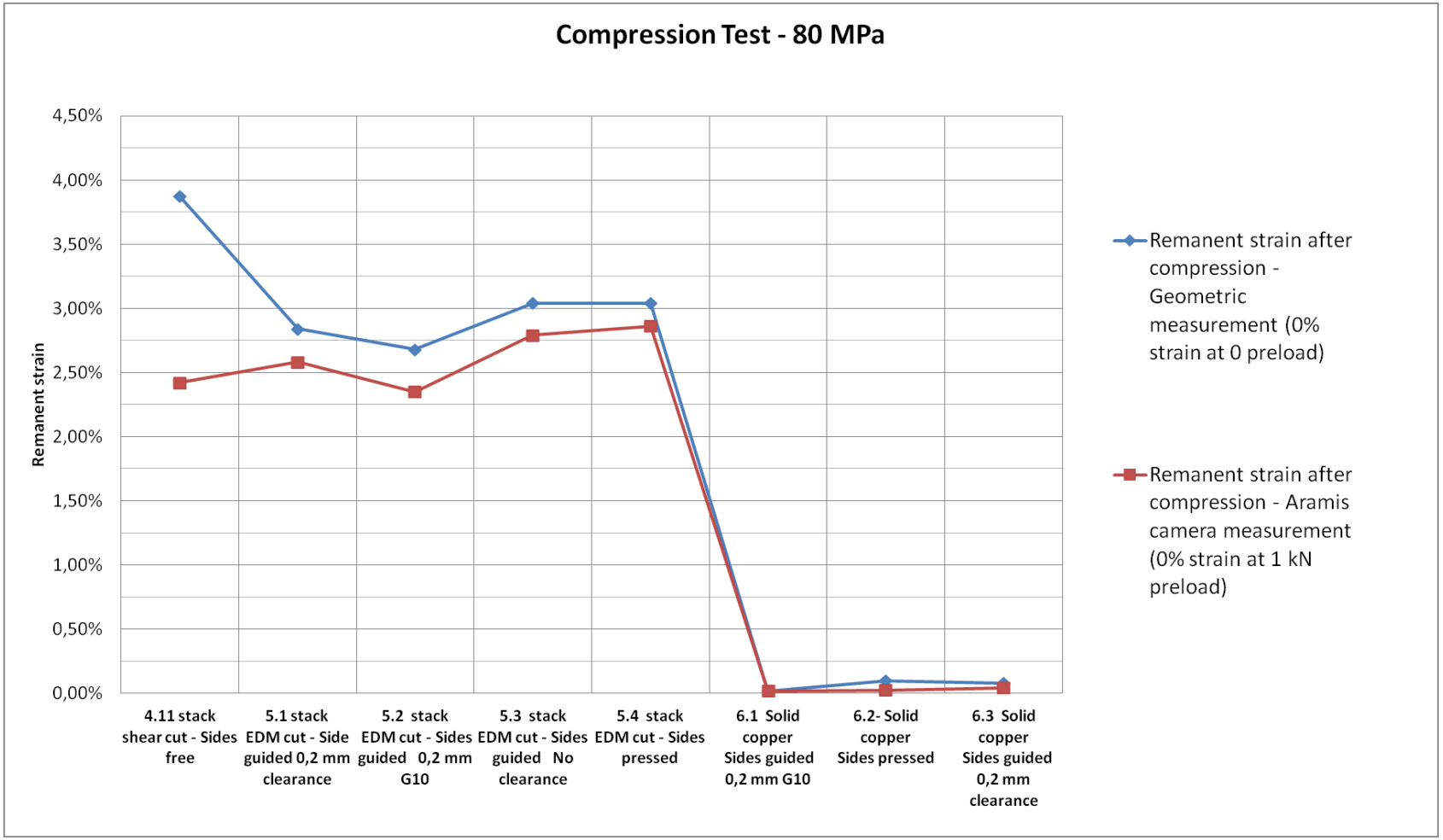
Stack height before and after compression

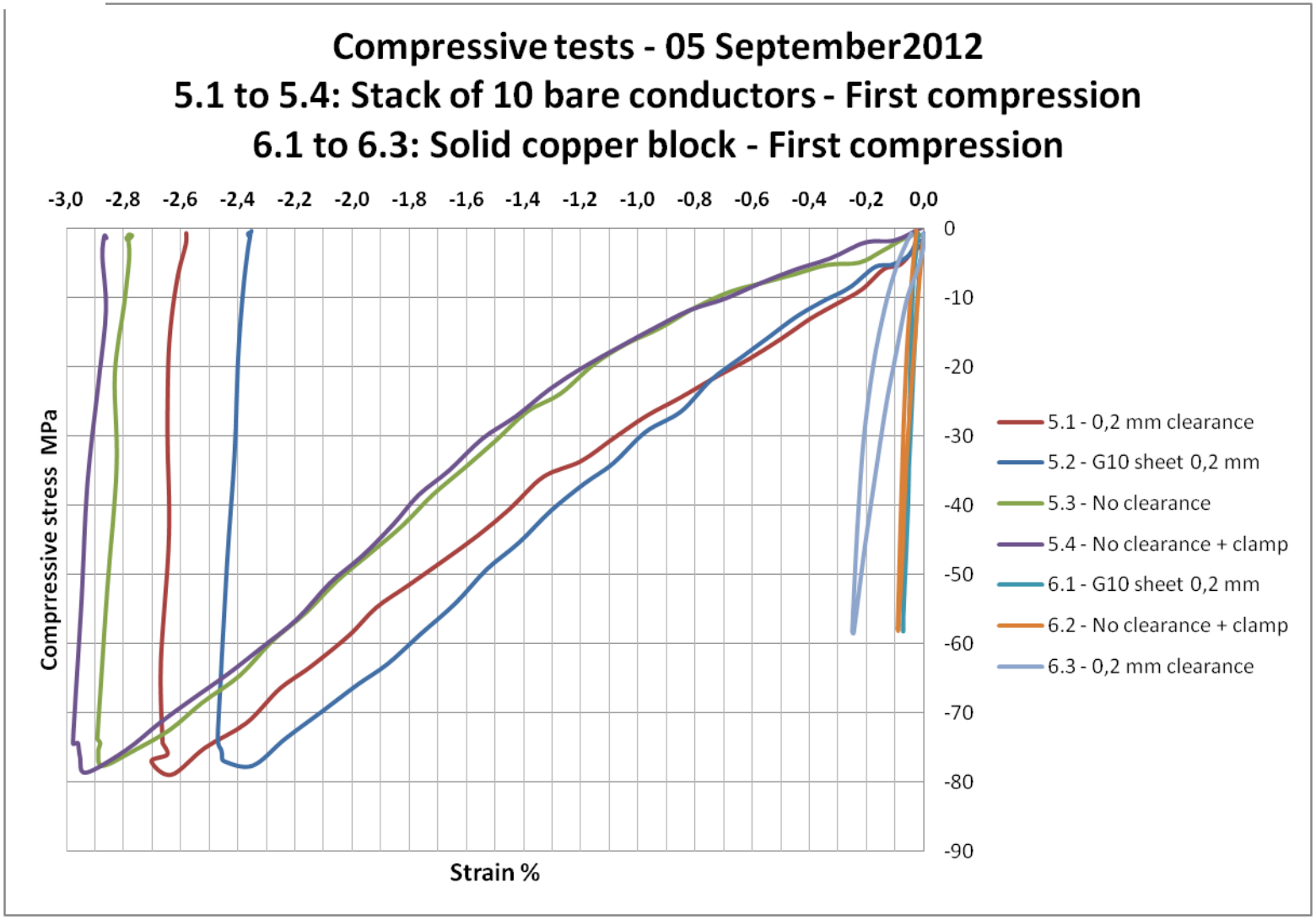


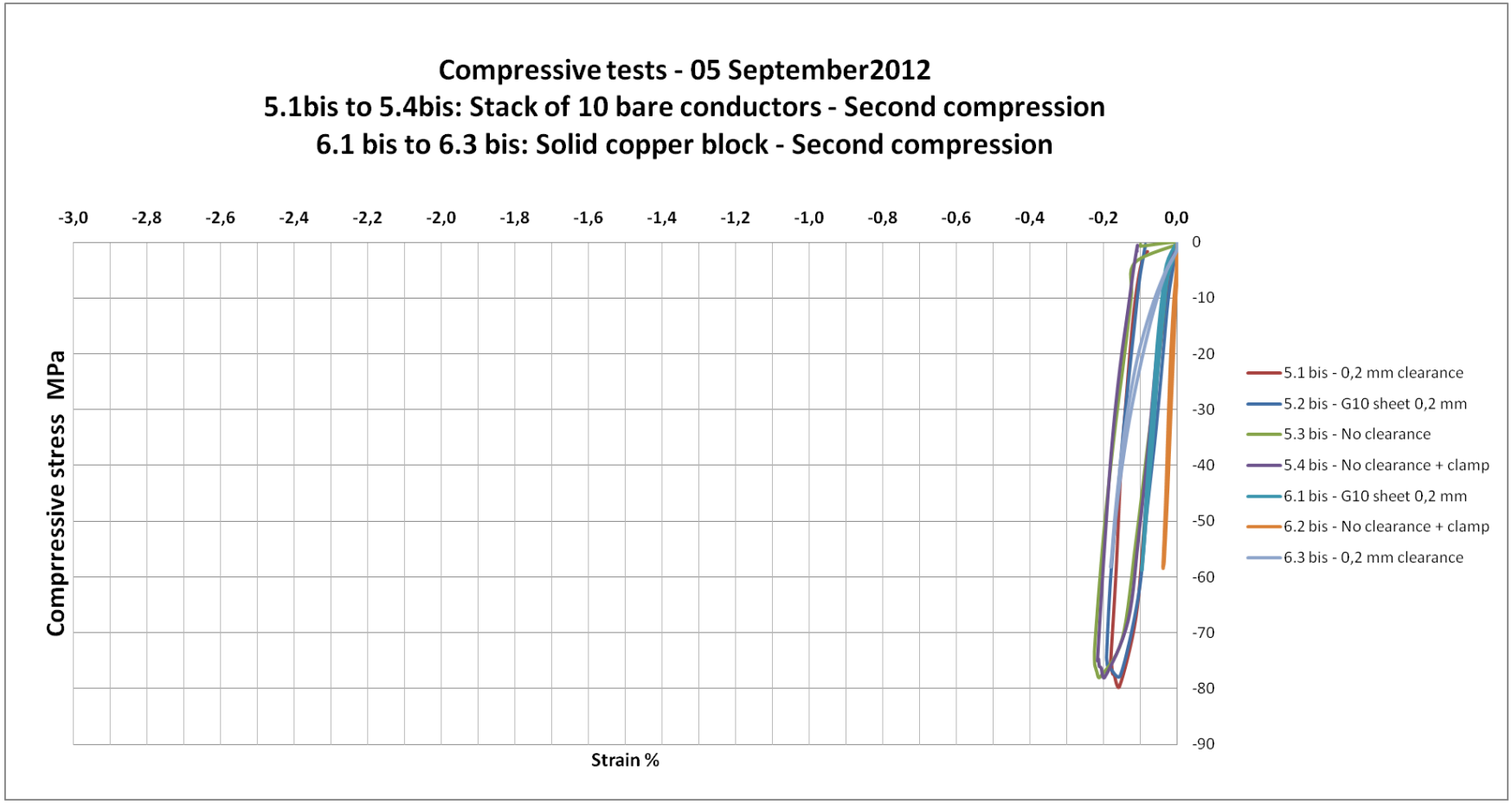
Solid copper block dimensions before and after testing



Stack permanent strain after compression




Compressive tests - 05 September2012
5.1 to 5.4: Stack of 10 bare conductors - First compression
6.1 to 6.3: Solid copper block - First compression
-3,0 -2,8 -2,6 -2,4 -2,2 -2,0 -1,8 -1,6 -1,4 -1,2 -1,0 -0,8 -0,6 -0,4 -0,2 0,0
0 -10 -20 -30 -40 -50 -60 -70 -80 -90
Comprressive stress MPa
Strain %
5.1 - 0,2 mm clearance
5.2 - G10 sheet 0,2 mm
5.3 - No clearance
5.4 - No clearance + clamp
6.1 - G10 sheet 0,2 mm
6.2 - No clearance + clamp
6.3 - 0,2 mm clearance


Compressive tests - 05 September2012
5.1bis to 5.4bis: Stack of 10 bare conductors - Second compression
6.1 bis to 6.3 bis: Solid copper block - Second compression
Comprressive stress MPa
Strain %
-3,0
-2,8
-2,6
-2,4
-2,2
-2,0
-1,8
-1,6
-1,4
-1,2
-1,0
-0,8
-0,6
-0,4
-0,2
0,0
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
5.1 bis - 0,2 mm clearance
5.2 bis - G10 sheet 0,2 mm
5.3 bis - No clearance
5.4 bis - No clearance + clamp
6.1 bis - G10 sheet 0,2 mm
6.2 bis - No clearance + clamp
6.3 bis - 0,2 mm clearance