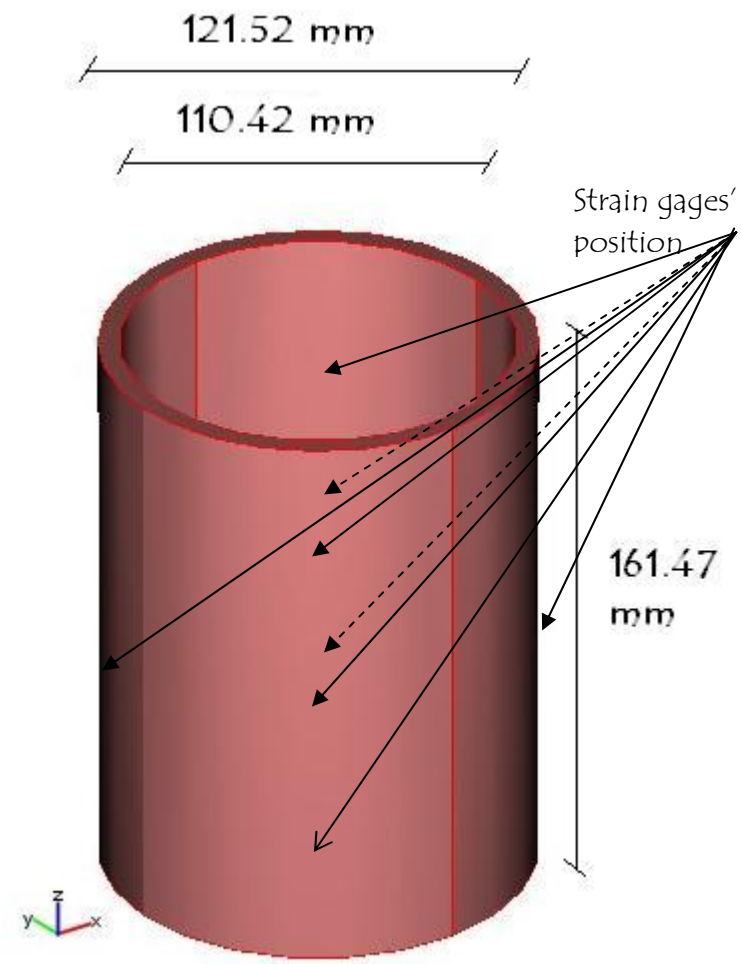
REPORT (part 1)

Target:

Understand stress distribution during the compression phase and its effect on coils.

Cylinder description:



- Material: aluminum

Coil material is not aluminum but in order to make this test we choose it with an intelligent thickness taking in consideration that young's modulus of cable is about 4 times inferior than Aluminum's one. So aluminum thickness has to be smaller than real coil thickness (as we have).

- Strain gauges' position:

To understand stress distribution we mounted sensors not only along the circumference (radial stress) but along cylinder's length too. This allow us to understand if it's better to use classical keys or smaller ones (the difference is in the number of blocks that are compressed at the same time!!!).

- Insulation layer:

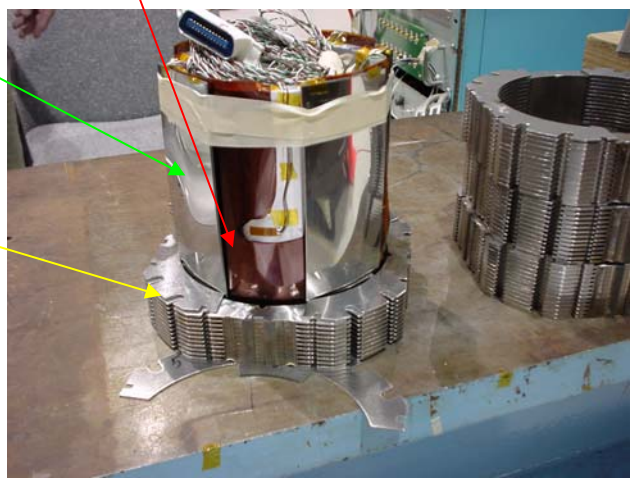
It's maiden by 4 kapton thin layers (0.125 mm each layer) and its thickness is about 0.5 mm.

- Aluminum foils:

We used 4 aluminum foils to protect structure from clamps during compression phase.

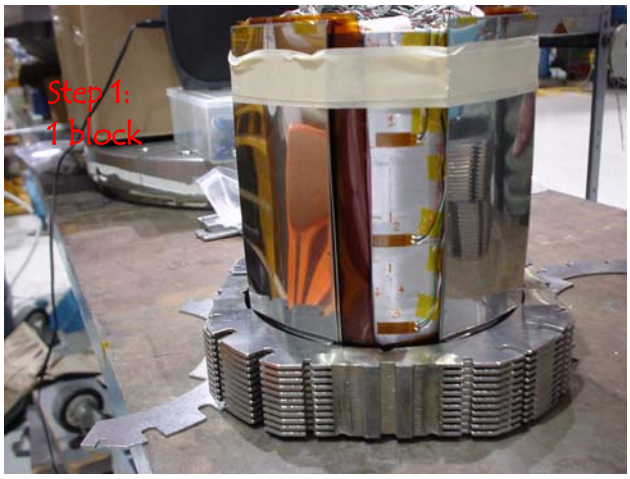
- Collars and keys:

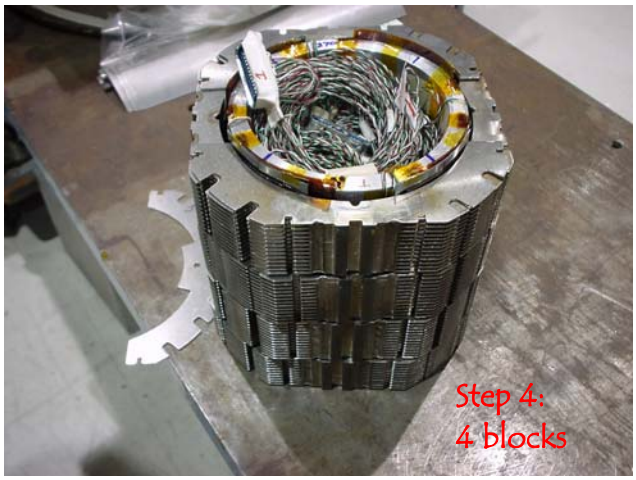
Our structure needs 4 collars and 32 small keys (or 16 big keys) to be compressed.



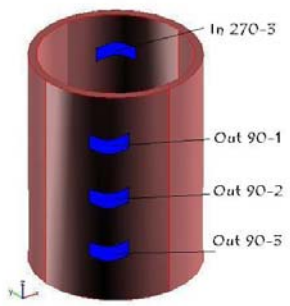
Test description:

1) We prepared 2 calibration files that contained nominal value of strain gauges' resistance at 300 K and at 77 K. These files are essential because we need a "zero" to measure the stress (reference value).
2) We read sensors' output compressing structure with big keys.
3) We did the same with the small ones, focusing our attention in the key travel and the block insertion (steps are shown in figures below).





Sensors Notation:



They are positioned inside (In) and Outside (Out) the cylinder at a different degree (0 – 90 – 180 – 270).

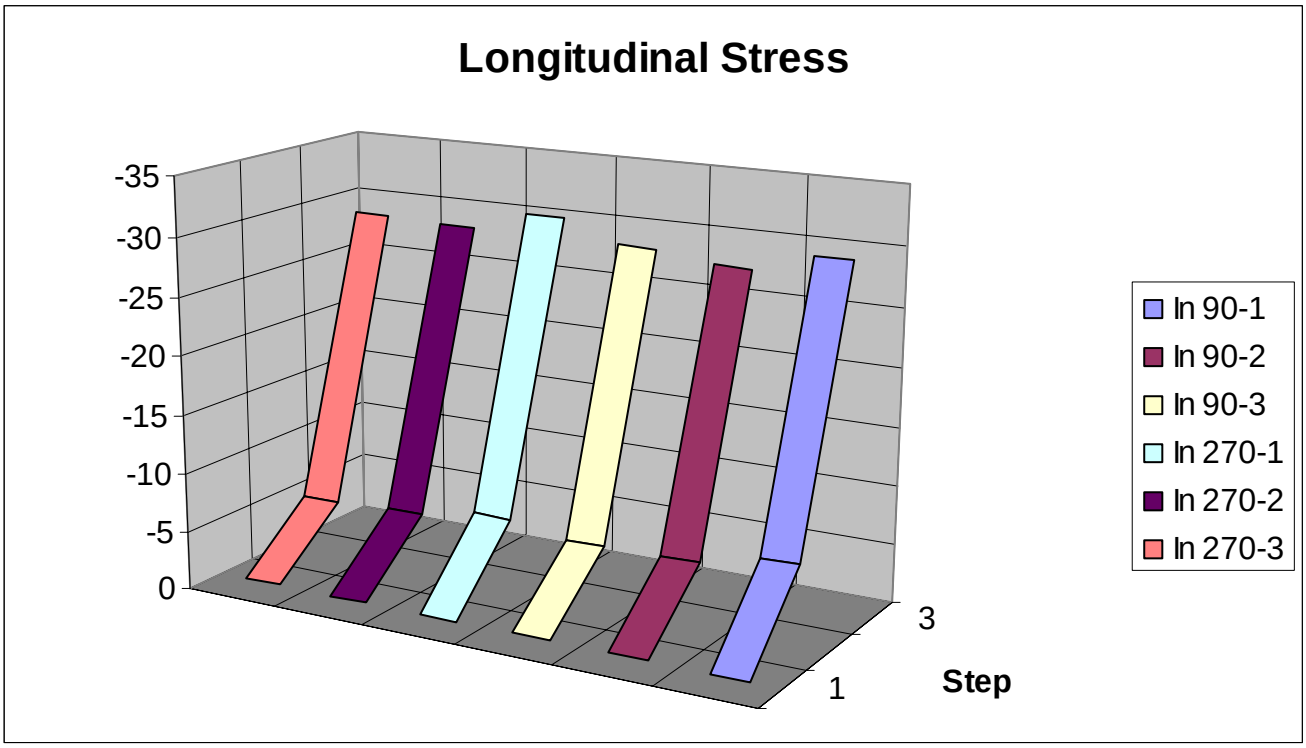
Calibration files:

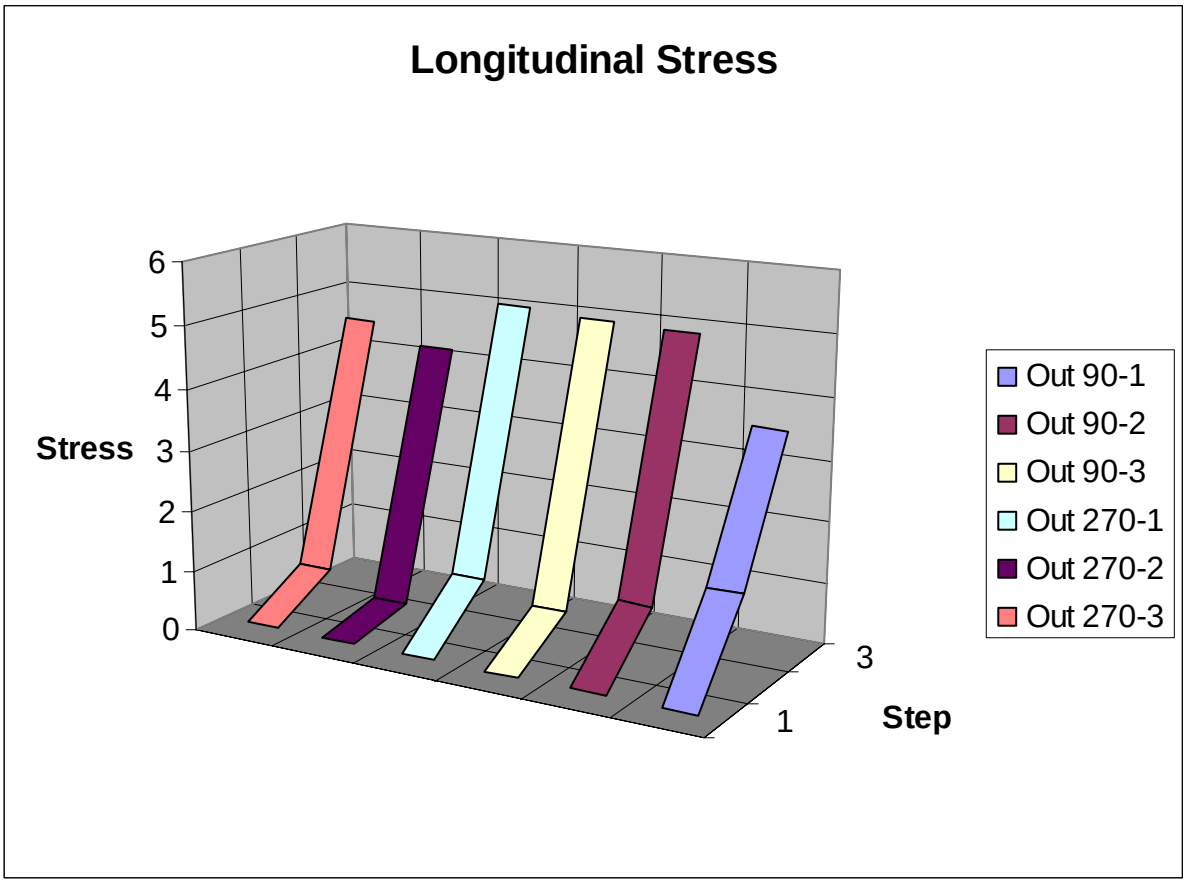
Gage factor: 2.07
Young's modulus: 7.00e+10

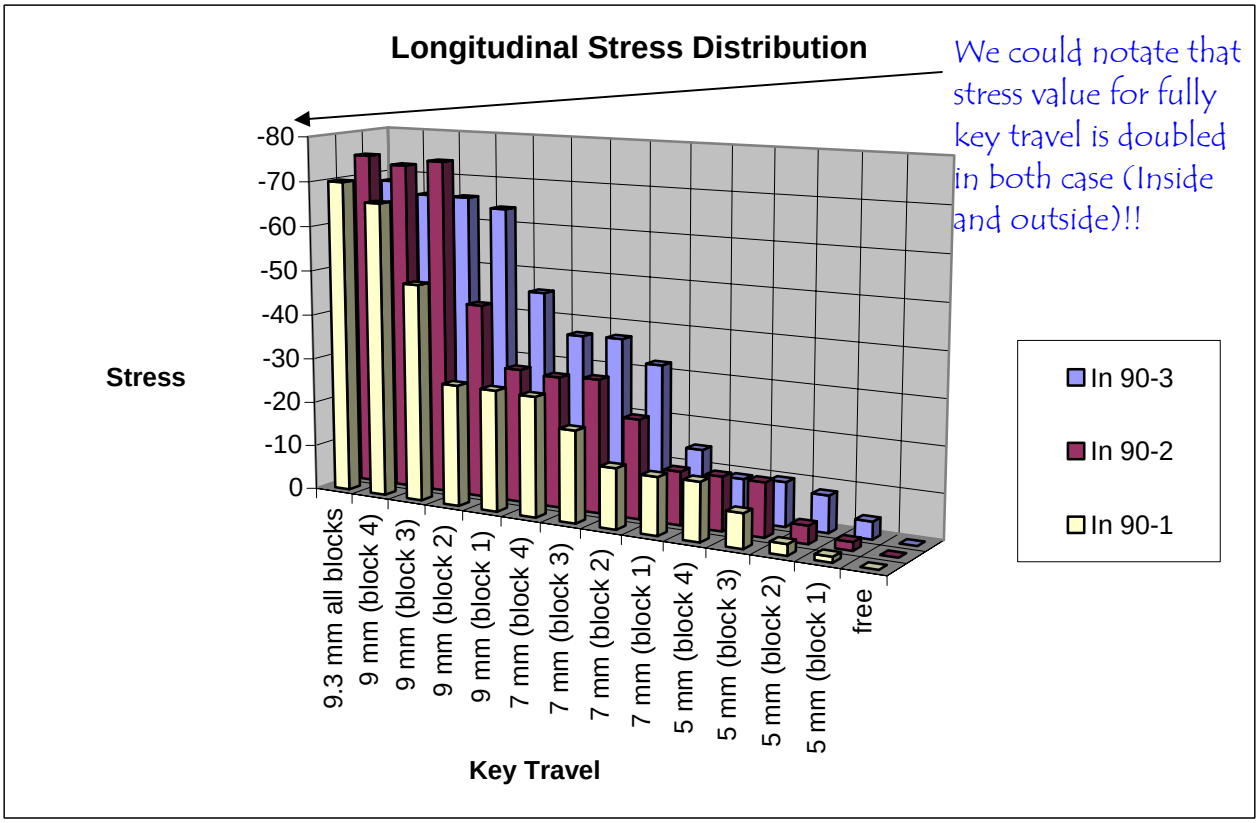
Strain gauges (300 k)	Resistance	Strain gauges (77 K)	Resistance
Inside 90 num 2	350,475	Inside 90 num 2	349,662
Inside 180	350,546	Inside 180	349,8
Inside 270 num 2	350,85	Inside 270 num 2	350,064
Inside 0	350,824	Inside 0	349,993
JUMPER	0	JUMPER	0
Outside 90 num 2	350,394	Outside 90 num 2	349,587
Outside 180	350,68	Outside 180	349,897
Outside 270 num 2	350,247	Outside 270 num 2	349,482
Outside 0	350,291	Outside 0	349,542
JUMPER	0	JUMPER	0
Inside 90 num 1	350,462	Inside 90 num 1	349,662
Inside 90 num 3	350,659	Inside 90 num 3	349,905
Inside 270 num 1	350,706	Inside 270 num 1	349,941
Inside 270 num 3	350,361	Inside 270 num 3	349,596
JUMPER	0	JUMPER	0
Outside 90 num 1	350,496	Outside 90 num 1	349,731
Outside 90 num 3	350,117	Outside 90 num 3	349,333
Outside 270 num 1	350,396	Outside 270 num 1	349,586
Outside 270 num 3	350,373	Outside 270 num 3	349,601
JUMPER	0	JUMPER	0

Readings (300 K):

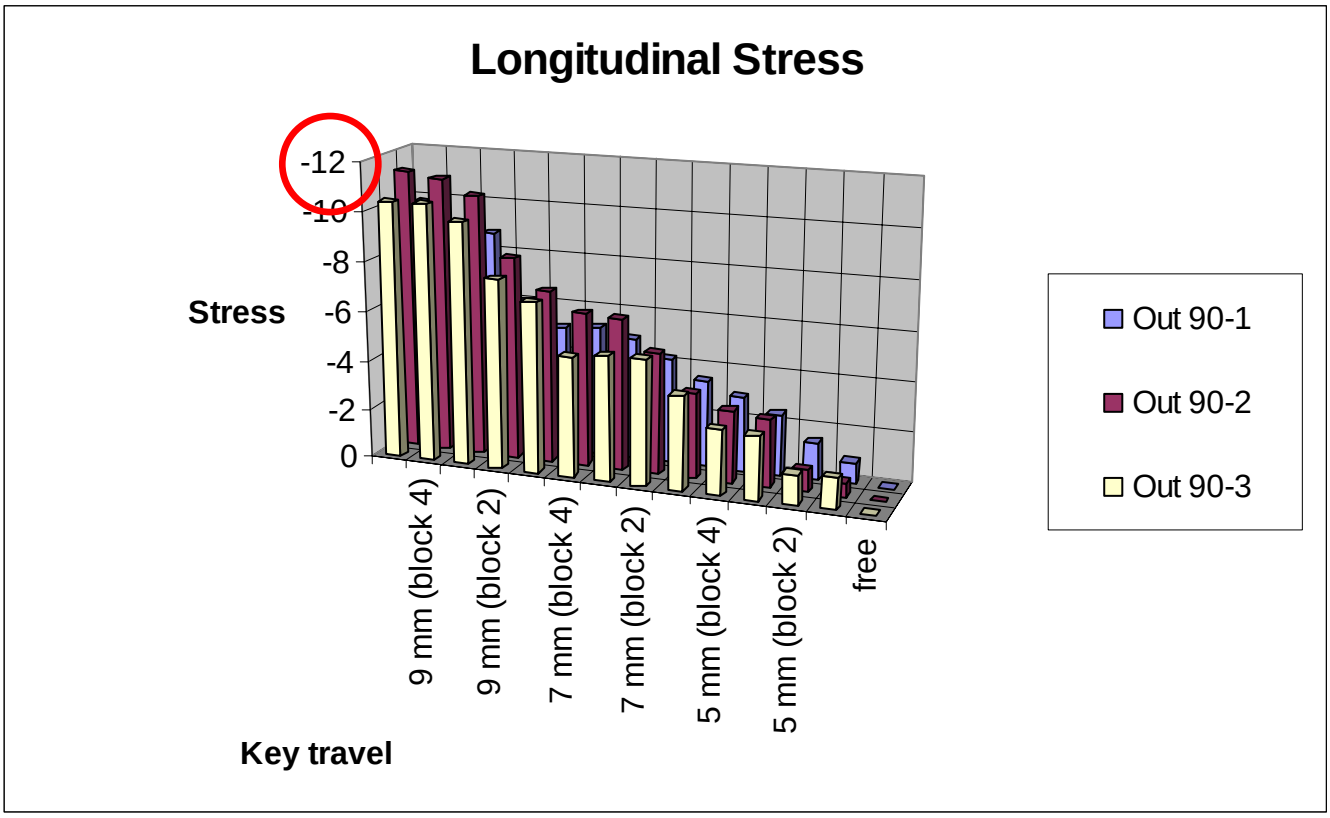
With big keys

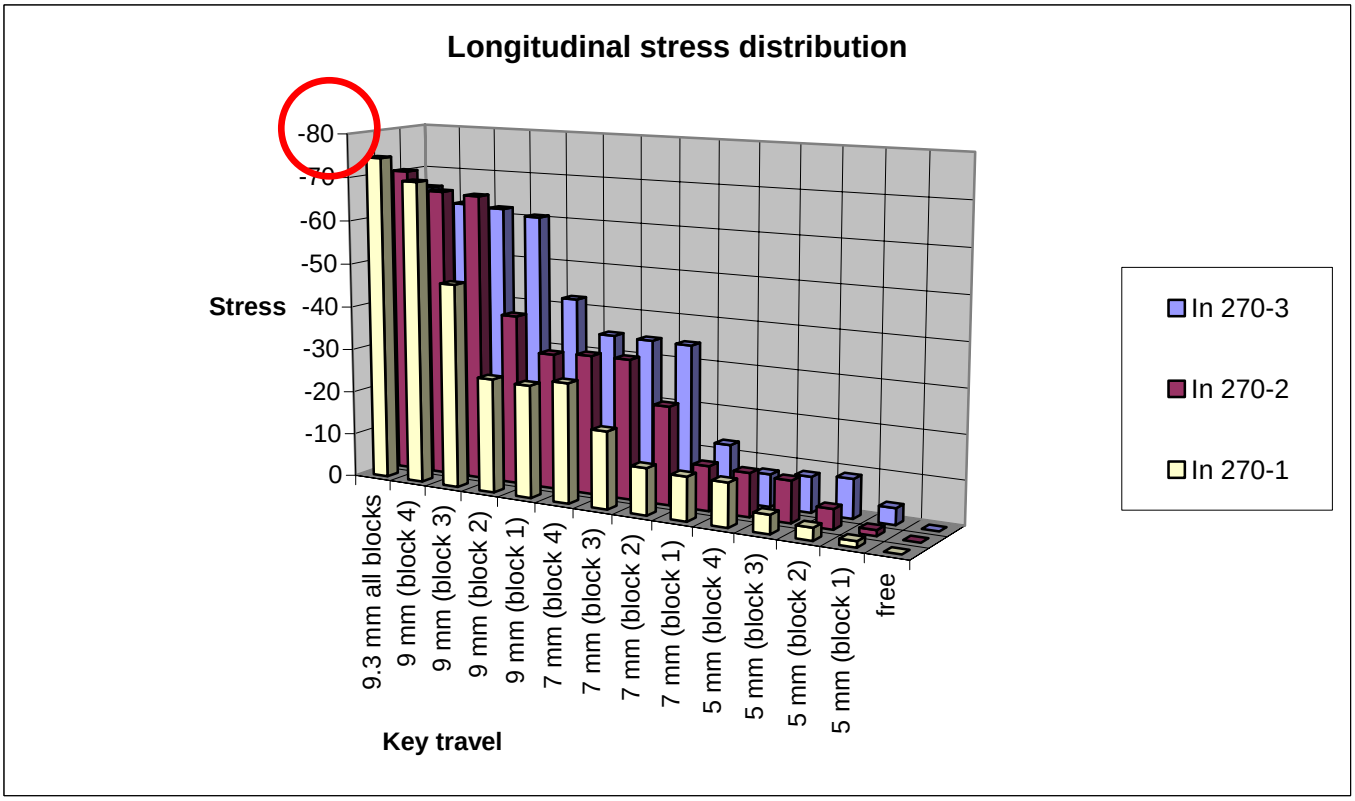


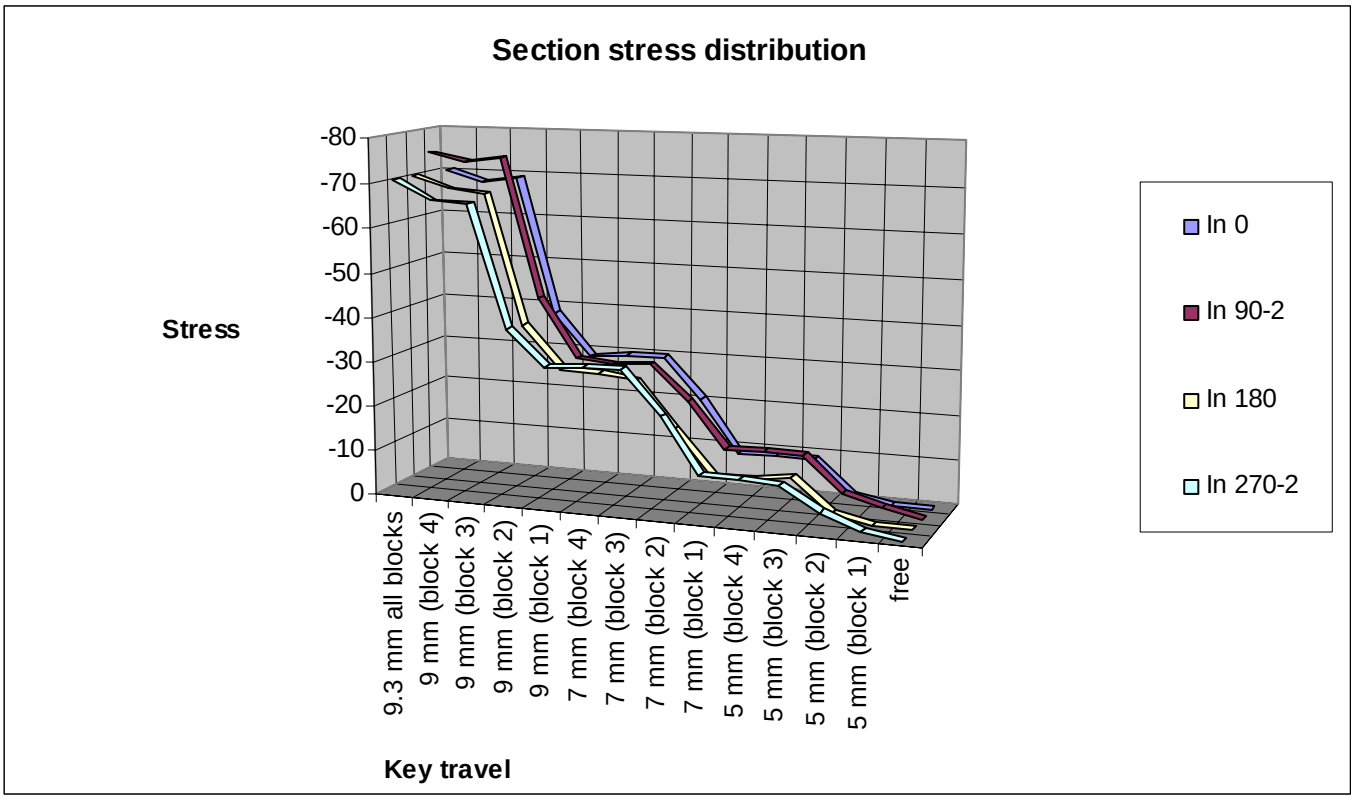


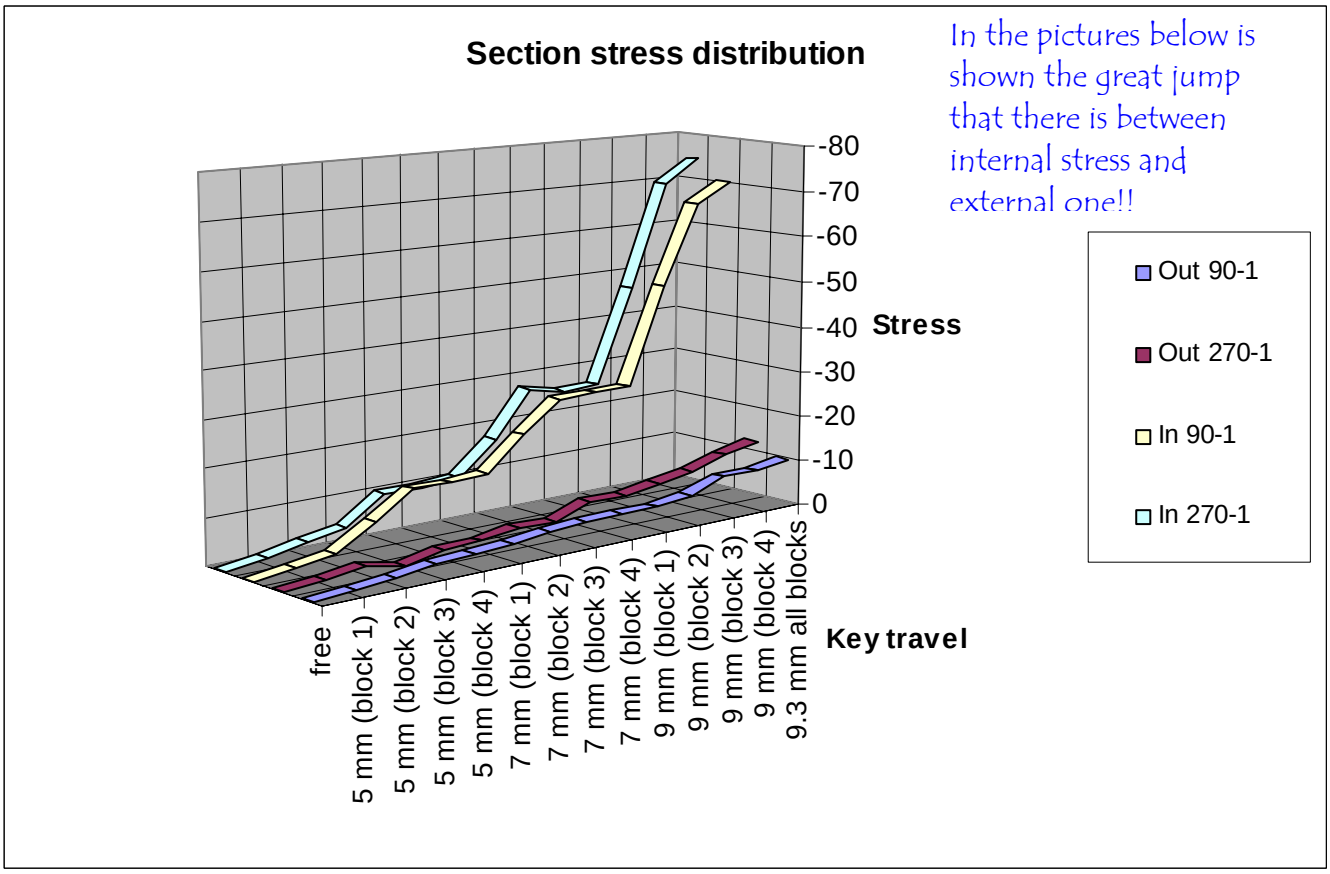


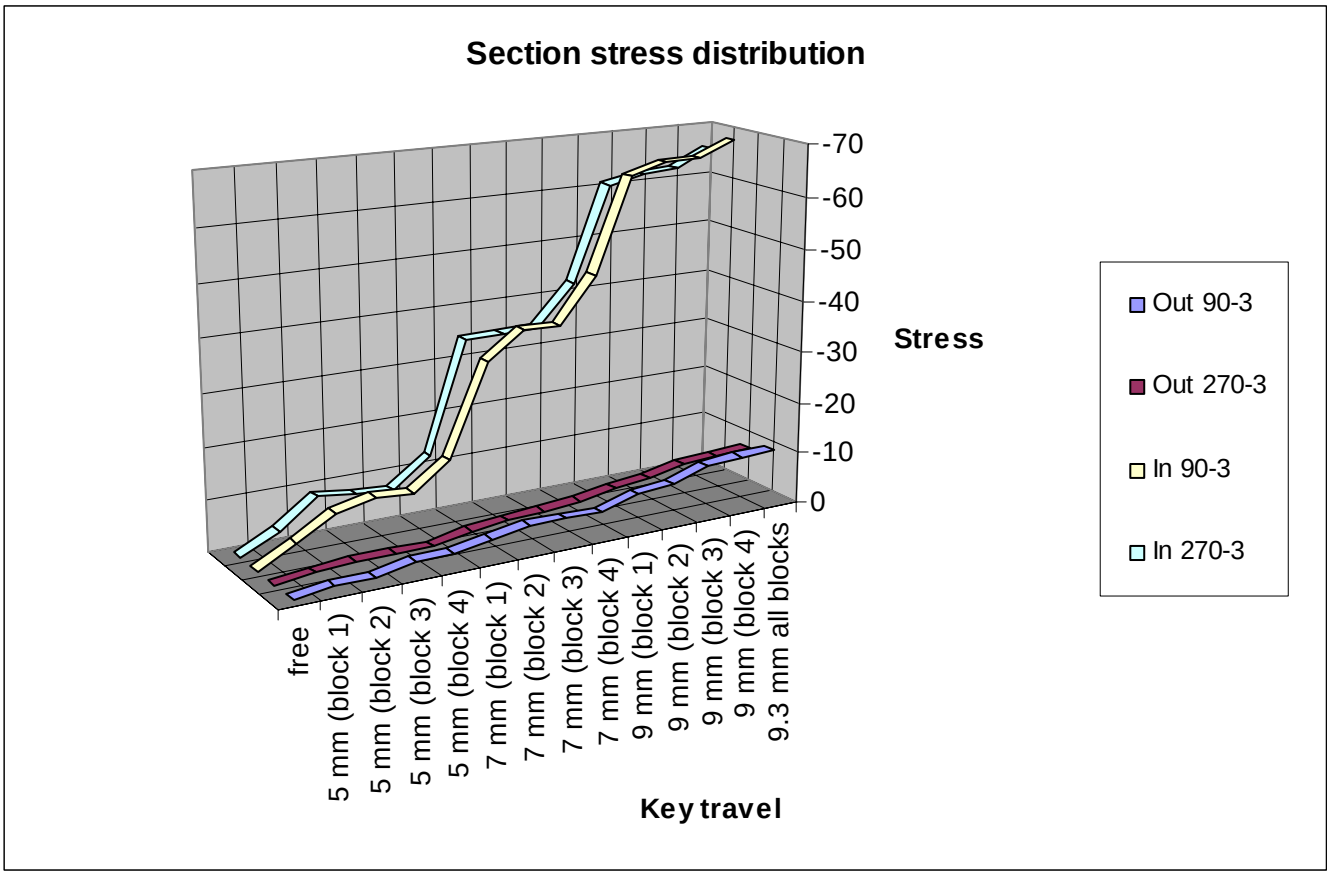
With small keys

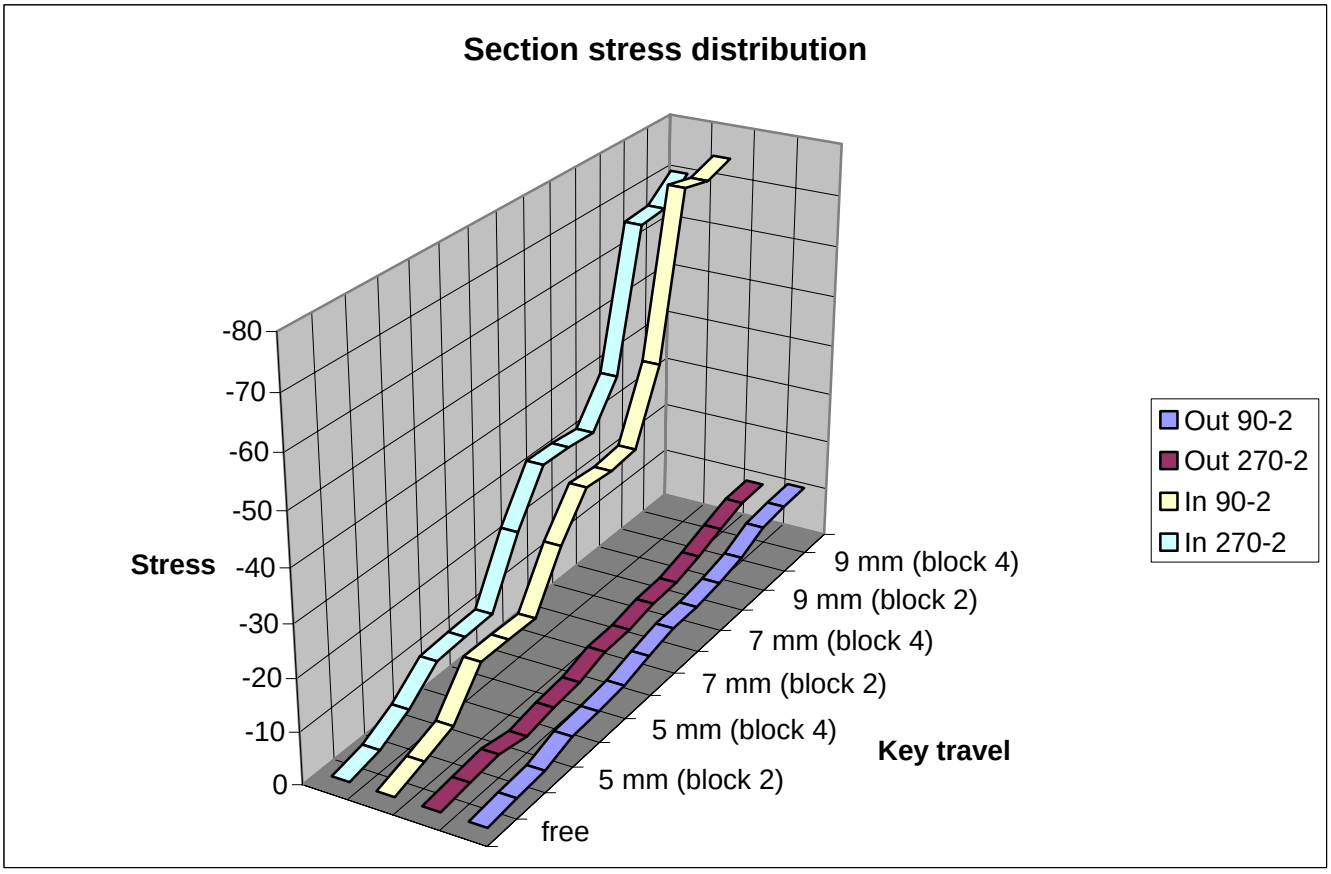

Longitudinal Stress
Stress
-12
-10
-8
-6
-4
-2
0
9 mm (block 4)
9 mm (block 2)
7 mm (block 4)
7 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Key travel
Out 90-1
Out 90-2
Out 90-3

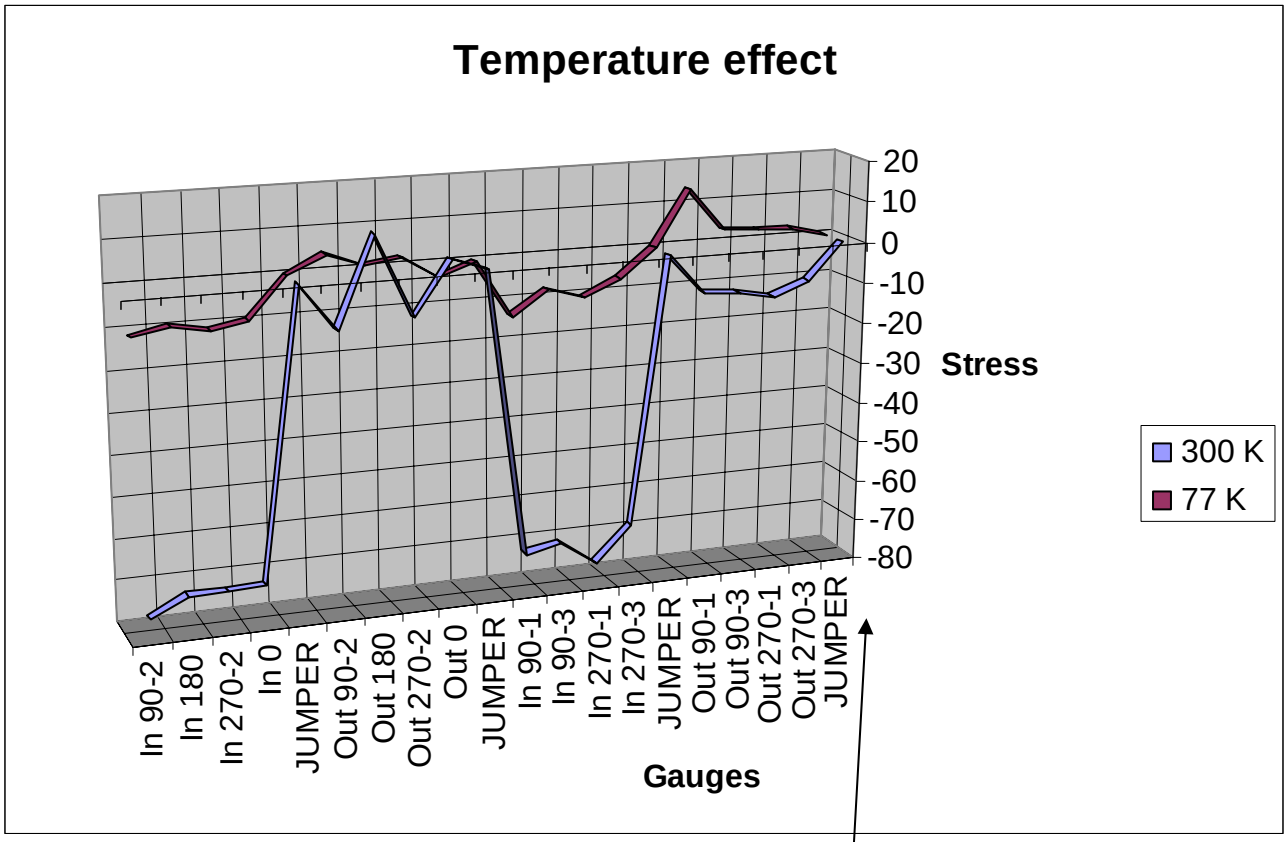

Longitudinal stress distribution
Stress
-80
-70
-60
-50
-40
-30
-20
-10
0
9.3 mm all blocks
9 mm (block 4)
9 mm (block 3)
9 mm (block 2)
9 mm (block 1)
7 mm (block 4)
7 mm (block 3)
7 mm (block 2)
7 mm (block 1)
5 mm (block 4)
5 mm (block 3)
5 mm (block 2)
5 mm (block 1)
free
Key travel
In 270-3
In 270-2
In 270-1


Section stress distribution
Stress
-80
-70
-60
-50
-40
-30
-20
-10
0
9.3 mm all blocks
9 mm (block 4)
9 mm (block 3)
9 mm (block 2)
9 mm (block 1)
7 mm (block 4)
7 mm (block 3)
7 mm (block 2)
7 mm (block 1)
5 mm (block 4)
5 mm (block 3)
5 mm (block 2)
5 mm (block 1)
free
Key travel
In 0
In 90-2
In 180
In 270-2


Section stress distribution
In the pictures below is shown the great jump that there is between internal stress and external one!!
-80
-70
-60
-50
-40
-30
-20
-10
0
Stress
free
5 mm (block 1)
5 mm (block 2)
5 mm (block 3)
5 mm (block 4)
7 mm (block 1)
7 mm (block 2)
7 mm (block 3)
7 mm (block 4)
9 mm (block 1)
9 mm (block 2)
9 mm (block 3)
9 mm (block 4)
9.3 mm all blocks
Key travel
Out 90-1
Out 270-1
In 90-1
In 270-1


Section stress distribution
-70
-60
-50
-40
-30
-20
-10
0
Stress
free
5 mm (block 1)
5 mm (block 2)
5 mm (block 3)
5 mm (block 4)
7 mm (block 1)
7 mm (block 2)
7 mm (block 3)
7 mm (block 4)
9 mm (block 1)
9 mm (block 2)
9 mm (block 3)
9 mm (block 4)
9.3 mm all blocks
Key travel
Out 90-3
Out 270-3
In 90-3
In 270-3


Section stress distribution
-80
-70
-60
-50
-40
-30
-20
-10
0
Stress
9 mm (block 4)
9 mm (block 2)
7 mm (block 4)
7 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Key travel
Out 90-2
Out 270-2
In 90-2
In 270-2

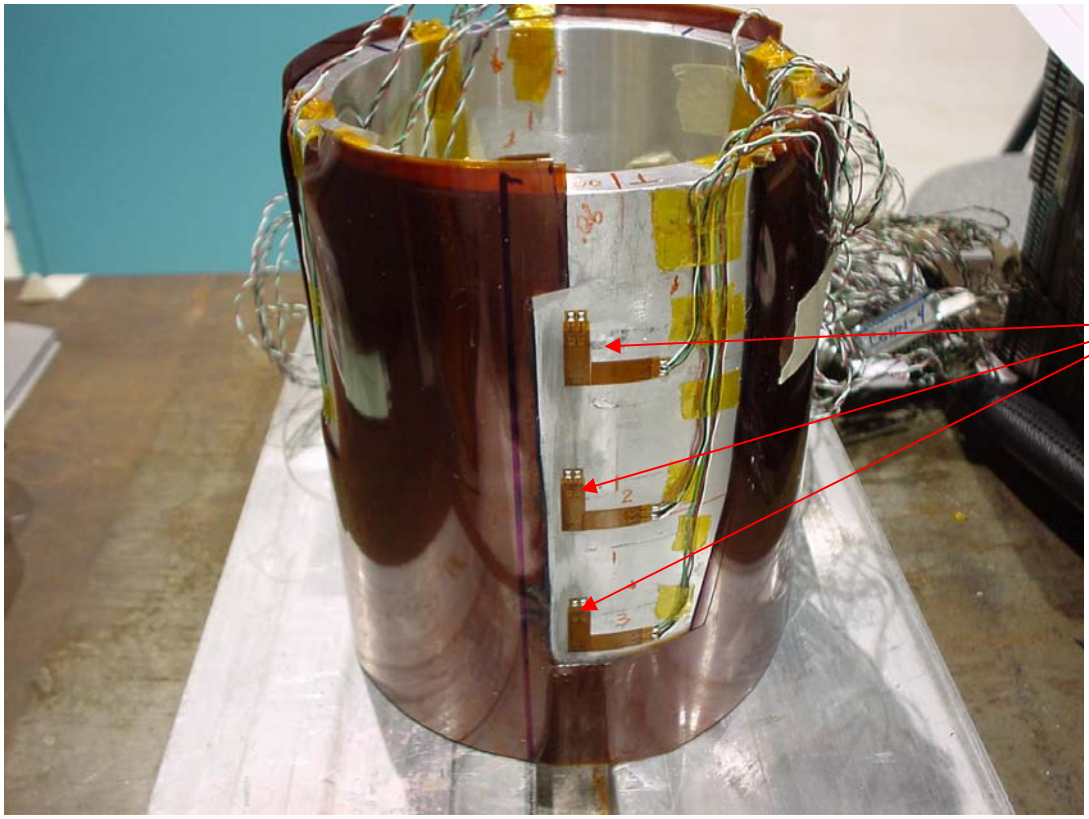


Temperature effect on stress when compression is maximum!!
Stress values are calculated considering for each plot the calibration values I mentioned before!! So 300K's plot and 77K's plot have 2 different zero!!

REPORT (part 2)

We now will analyze what happens to the same structure when we increase insulation layer!!!

This time we added 6 more gauges (at 90 degree, inside and outside) perpendicular to the ones we had already mounted! We could see them in the picture below!

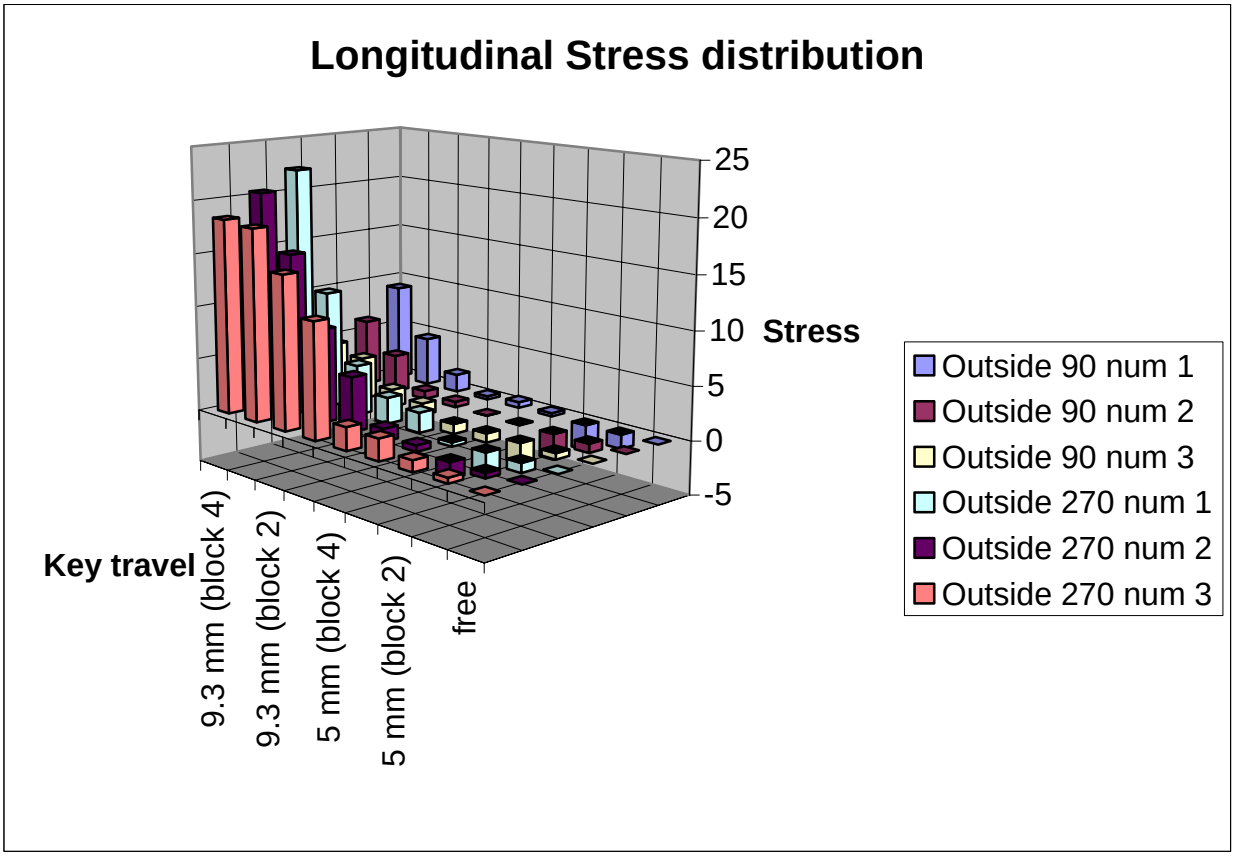


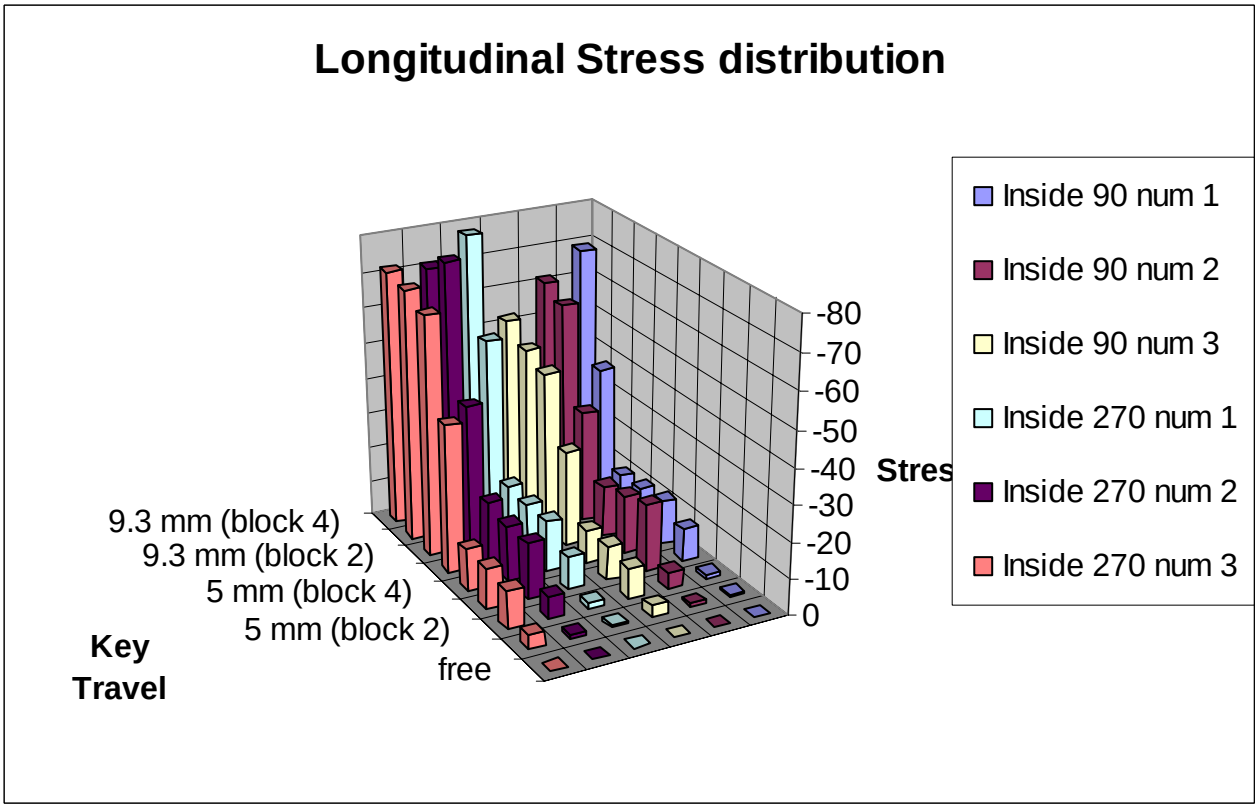
Calibration values:

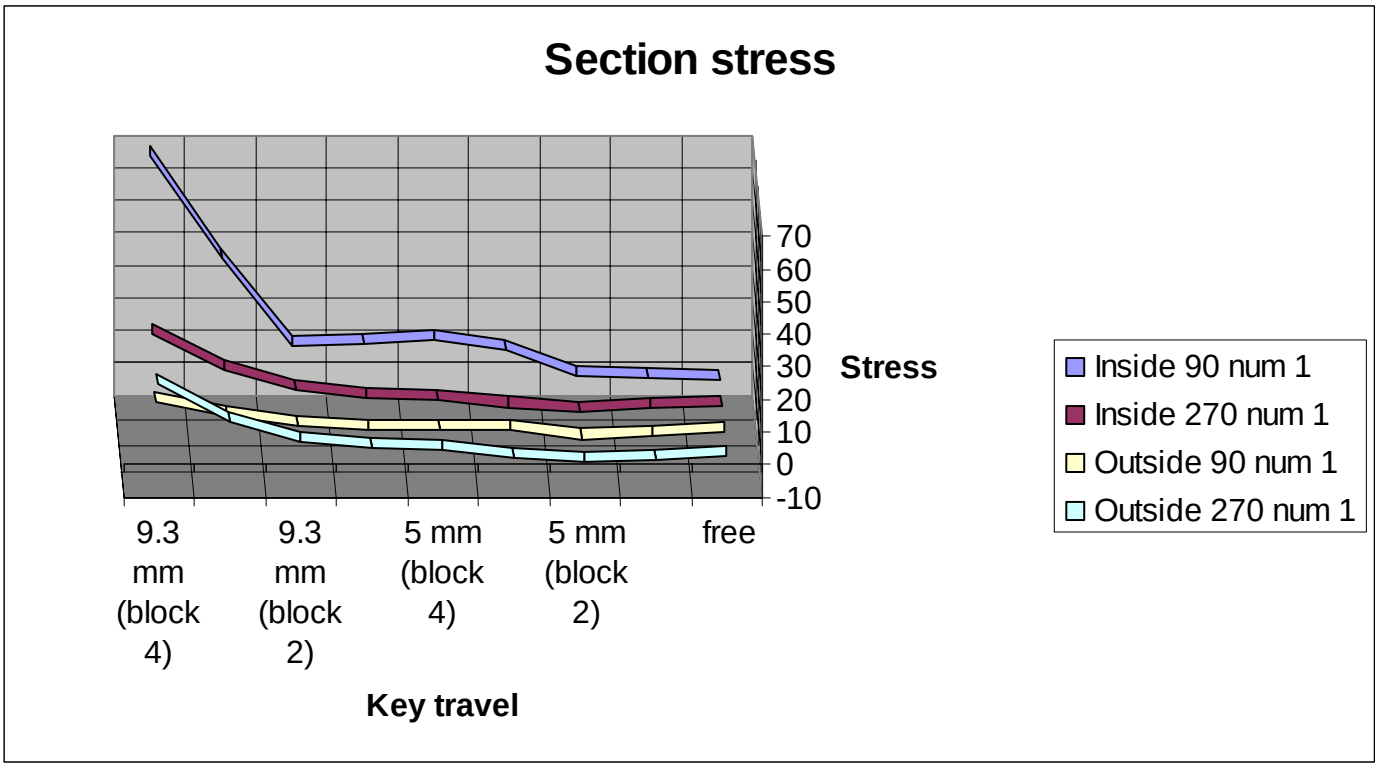
Strain gauges (300 k)	Resistance	Strain gauges (77 K)	Resistance
Inside 90 num 2	350,4736	Inside 90 num 2	349,6686
Inside 180	350,5533	Inside 180	349,7963
Inside 270 num 2	350,854	Inside 270 num 2	350,0638
Inside 0	350,8262	Inside 0	349,9925
Outside 90 num 2	350,3977	Outside 90 num 2	349,589
Outside 180	350,6855	Outside 180	349,8925
Outside 270 num 2	350,2463	Outside 270 num 2	349,4723
Outside 0	350,2459	Outside 0	349,4932
Inside 90 num 1	350,4593	Inside 90 num 1	349,6192
Inside 90 num 3	350,6574	Inside 90 num 3	349,8991
Inside 270 num 1	350,7022	Inside 270 num 1	349,9517
Inside 270 num 3	350,3601	Inside 270 num 3	349,5844
Outside 90 num 1	350,3096	Outside 90 num 1	349,5348
Outside 90 num 3	350,1141	Outside 90 num 3	349,3235
Outside 270 num 1	350,3949	Outside 270 num 1	349,5728
Outside 270 num 3	350,3162	Outside 270 num 3	349,5362
Inside P 90 num 1	350,647	Inside P 90 num 1	349,8425
Inside P 90 num 2	350,6118	Inside P 90 num 2	349,8558
Inside P 90 num 3	350,4346	Inside P 90 num 3	349,6473
Outside P 90 num 1	350,4625	Outside P 90 num 1	349,6477

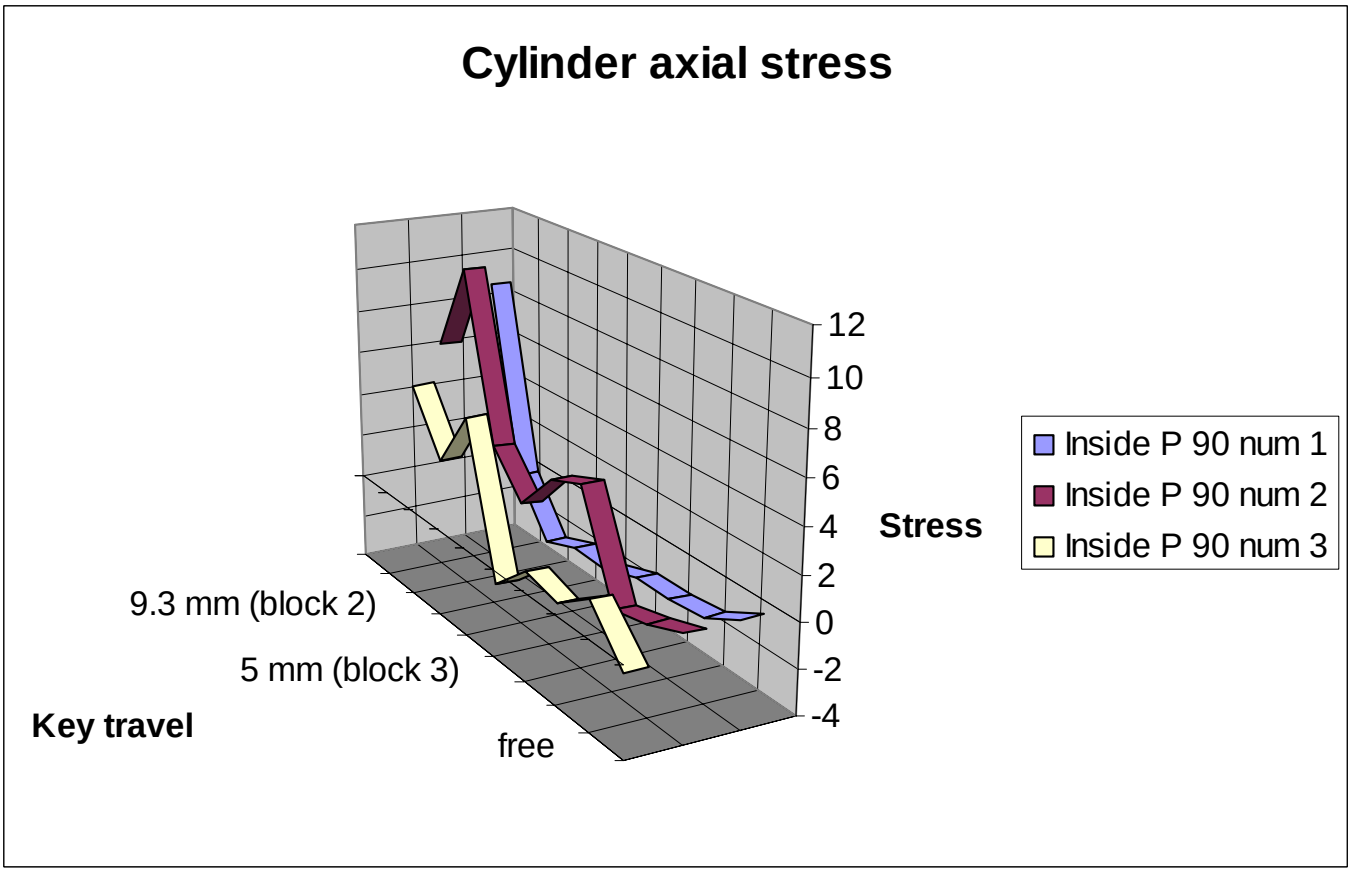
Outside P 90 num 2	350,4805	Outside P 90 num 2	349,6991
Outside P 90 num 3	350,5382	Outside P 90 num 3	349,775

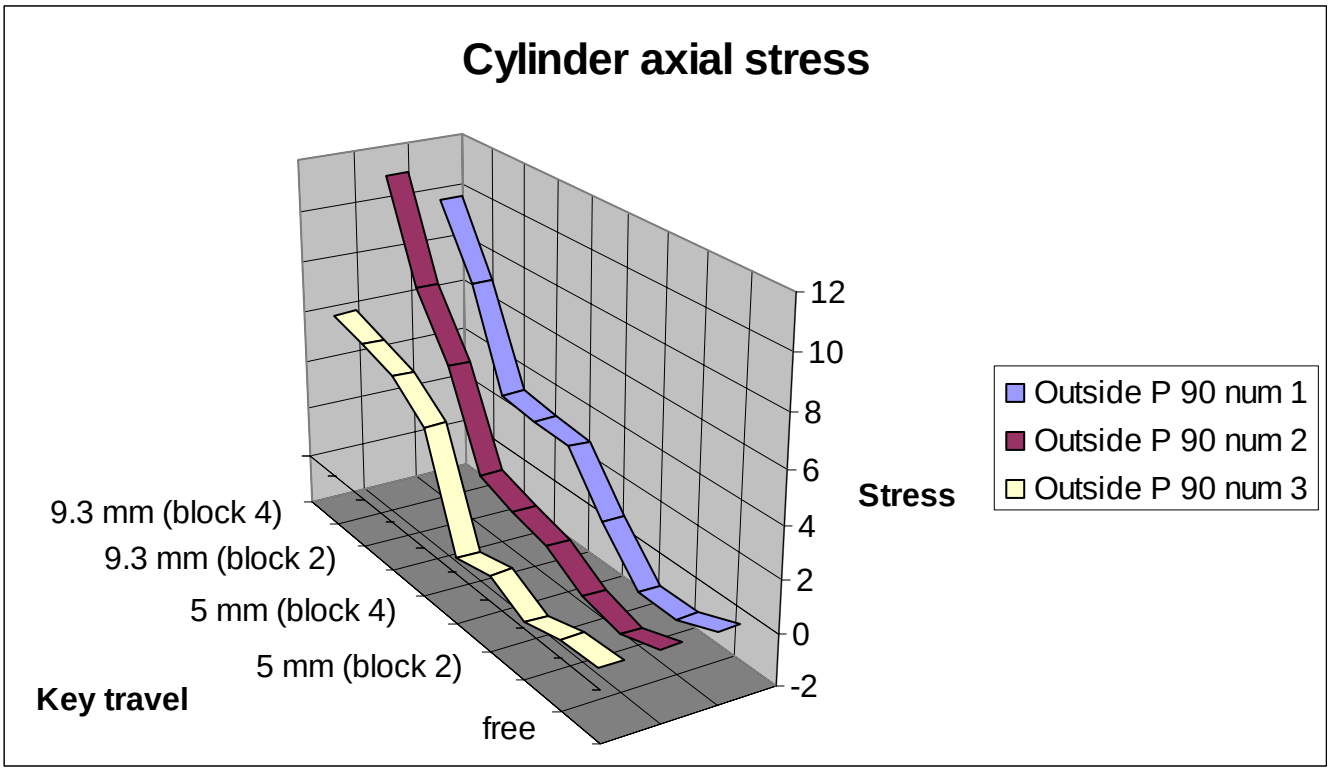
1 LAYER more

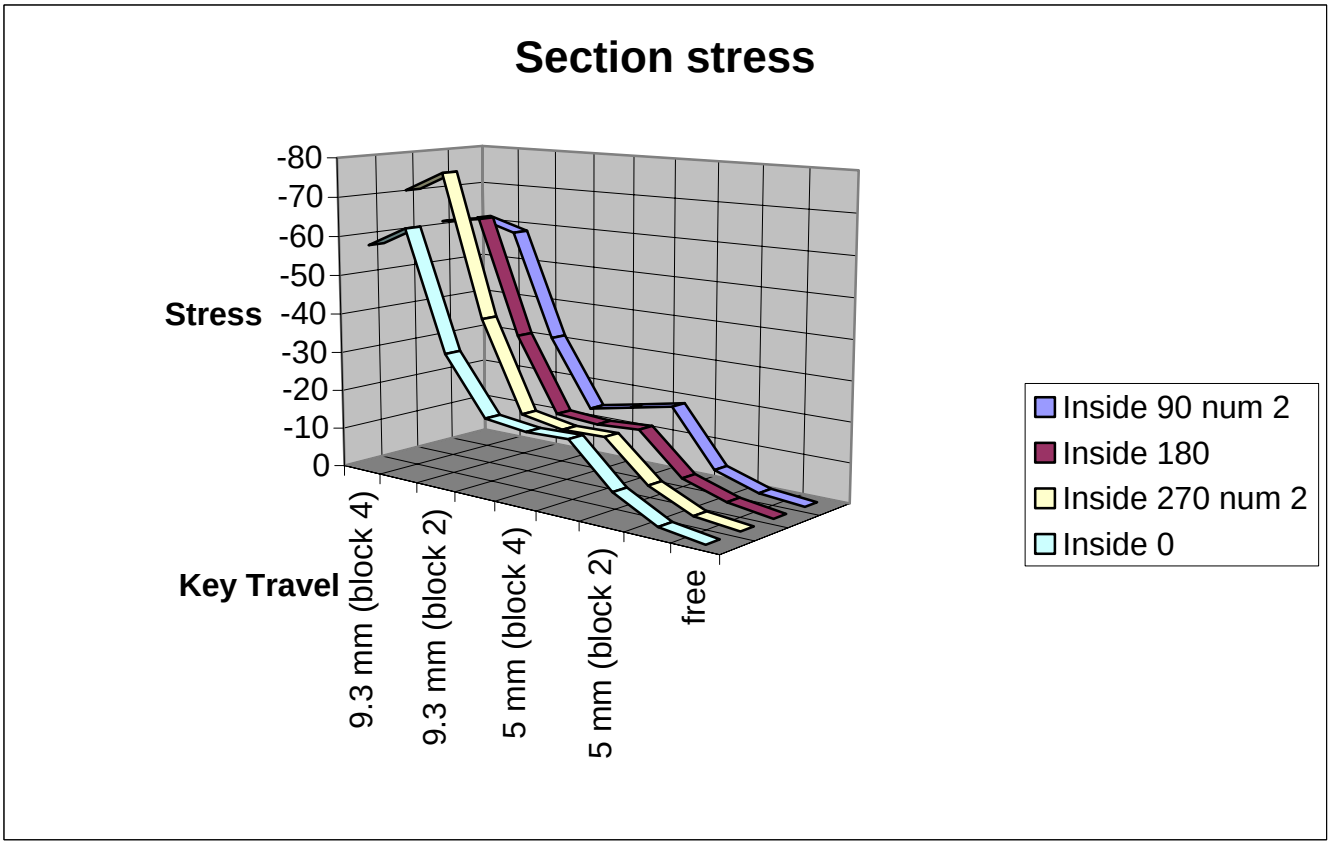


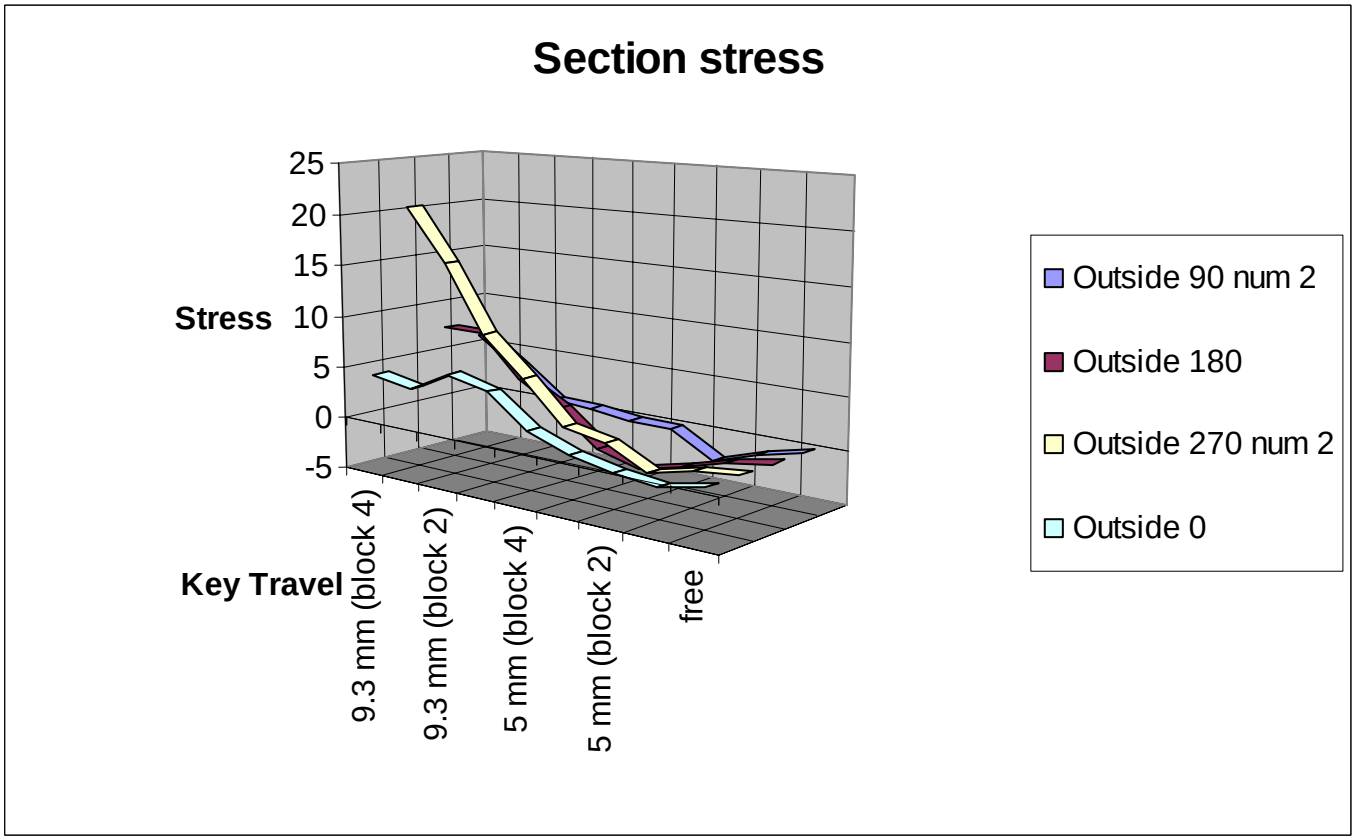


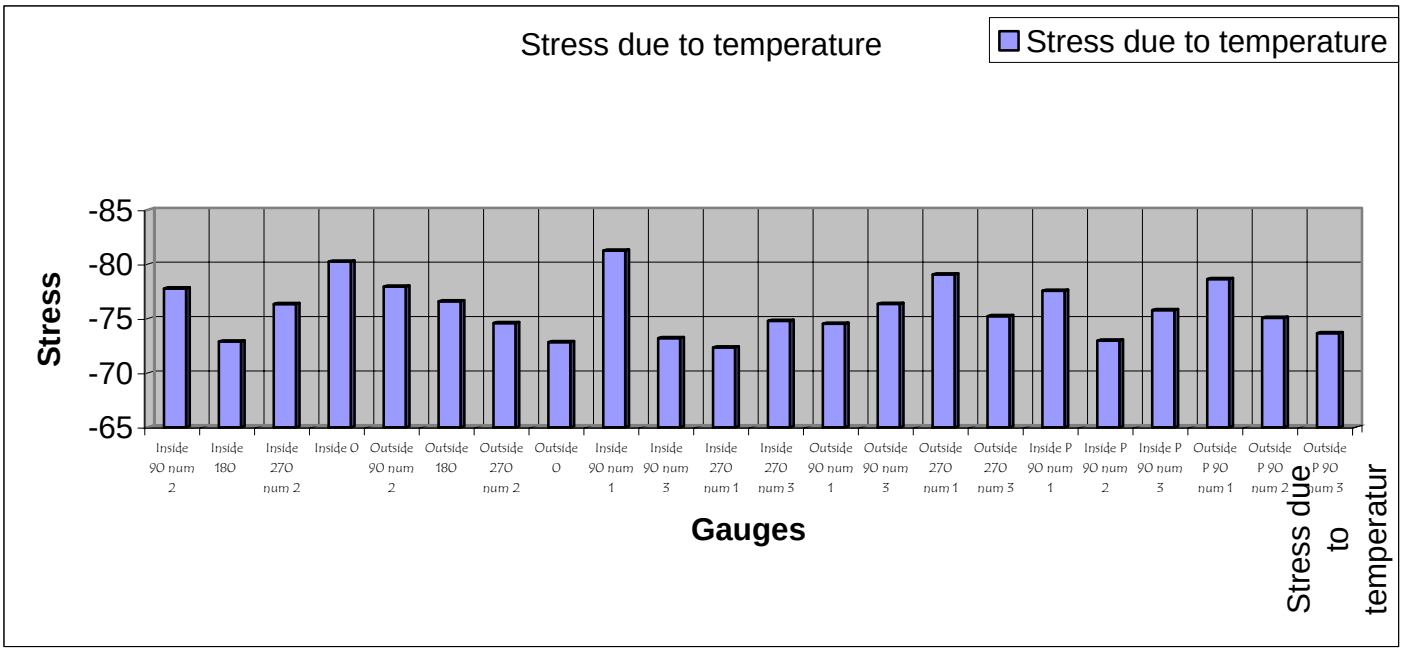

Section stress
70
60
50
40
30
20
10
0
-10
Stress
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Key travel
Inside 90 num 1
Inside 270 num 1
Outside 90 num 1
Outside 270 num 1


Cylinder axial stress
12
10
8
6
4
2
0
-2
-4
Stress
9.3 mm (block 2)
5 mm (block 3)
free
Key travel
Inside P 90 num 1
Inside P 90 num 2
Inside P 90 num 3

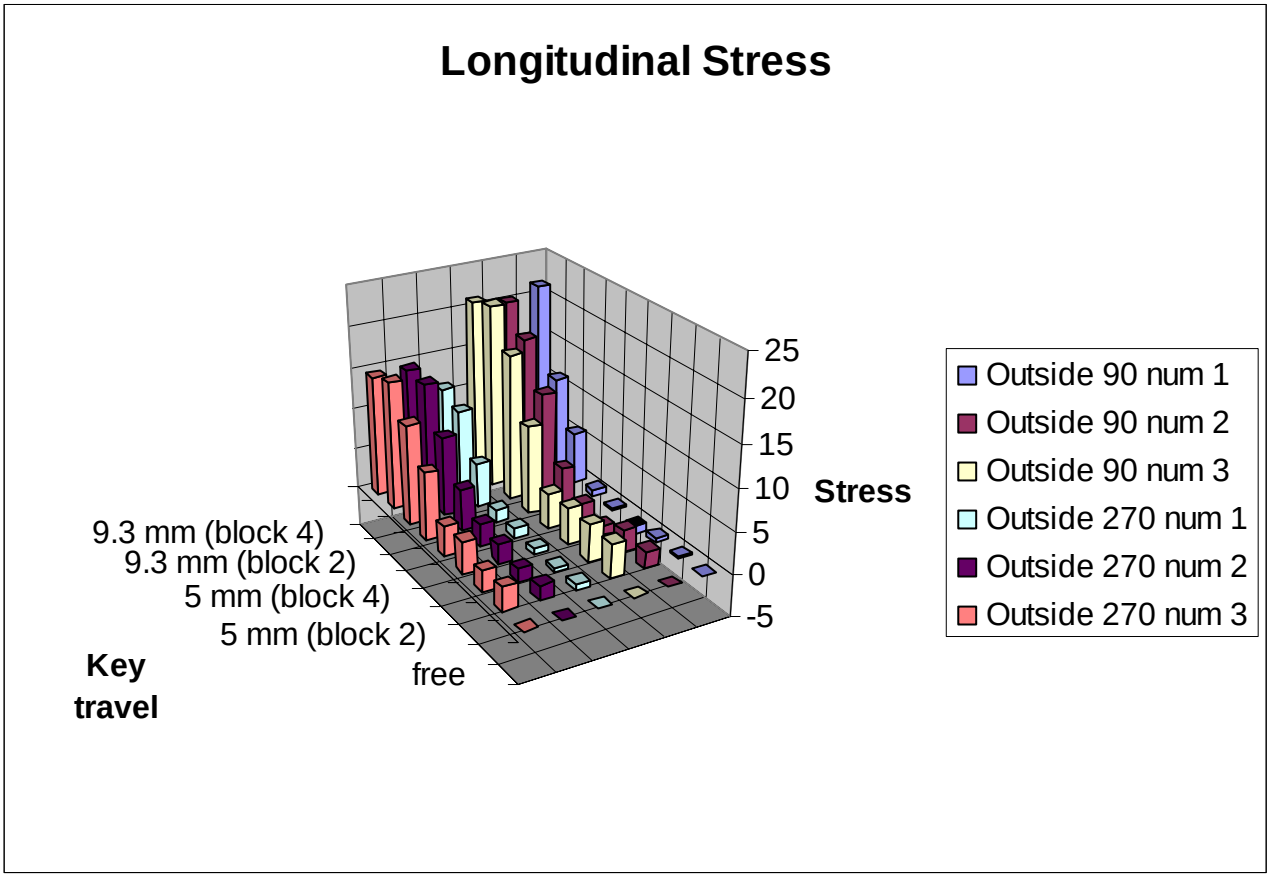

Cylinder axial stress
12
10
8
6
4
2
0
-2
Stress
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Key travel
Outside P 90 num 1
Outside P 90 num 2
Outside P 90 num 3

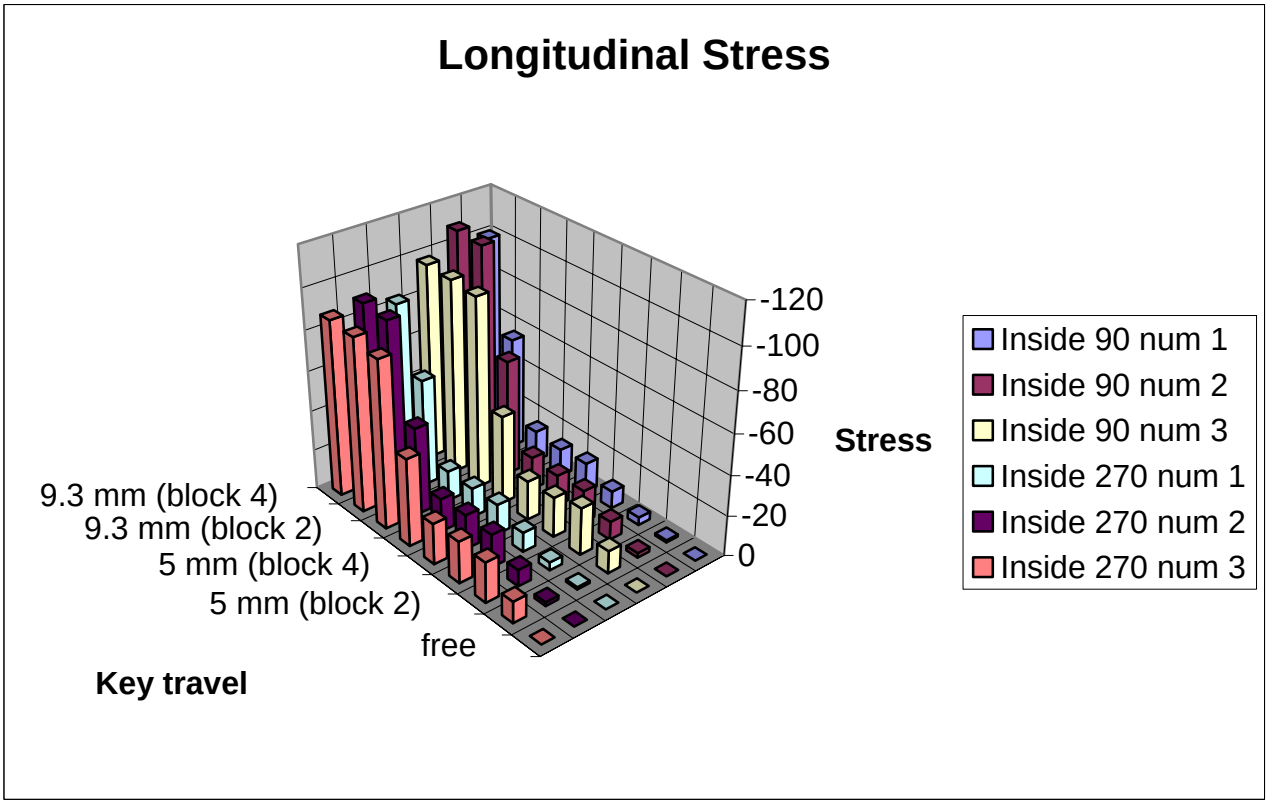

Section stress
-80
-70
-60
-50
-40
-30
-20
-10
0
Stress
Key Travel
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Inside 90 num 2
Inside 180
Inside 270 num 2
Inside 0

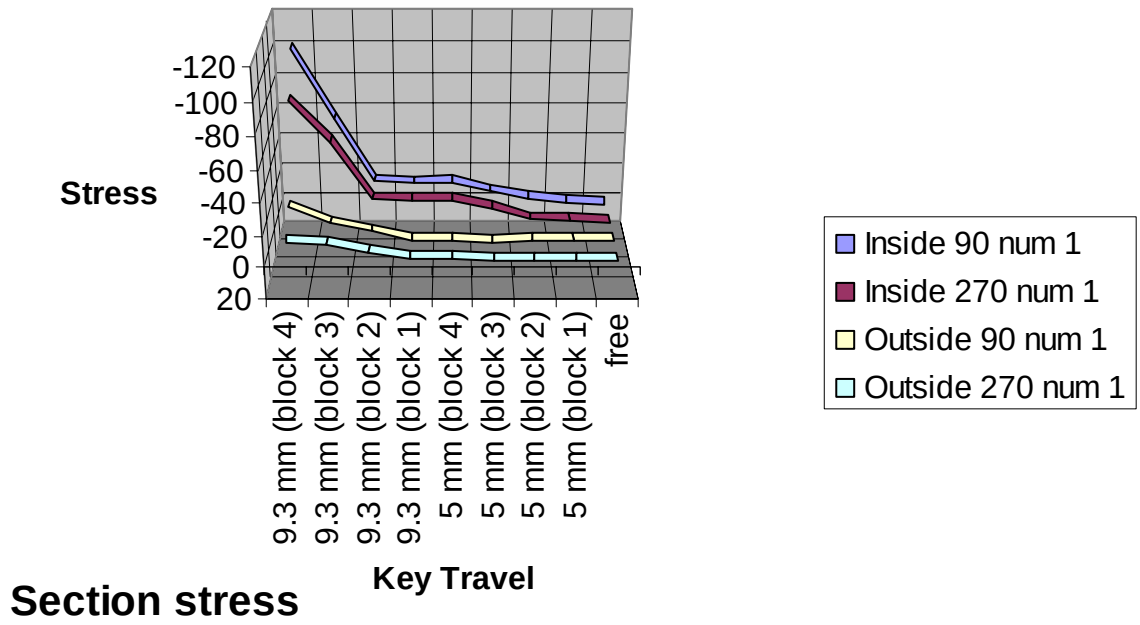

Section stress
Stress
25
20
15
10
5
0
-5
Key Travel
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Outside 90 num 2
Outside 180
Outside 270 num 2
Outside 0


Stress due to temperature
Stress due to temperature
Stress
-85
-80
-75
-70
-65
Inside 90 num 2
Inside 180
Inside 270 num 2
Inside 0
Outside 90 num 2
Outside 180
Outside 270 num 2
Outside 0
Inside 90 num 1
Inside 90 num 3
Inside 270 num 1
Inside 270 num 3
Outside 90 num 1
Outside 90 num 3
Outside 270 num 1
Outside 270 num 3
Inside P 90 num 1
Inside P 90 num 2
Inside P 90 num 3
Outside P 90 num 1
Outside P 90 num 2
Outside P 90 num 3
Gauges
Stress due to temperatur

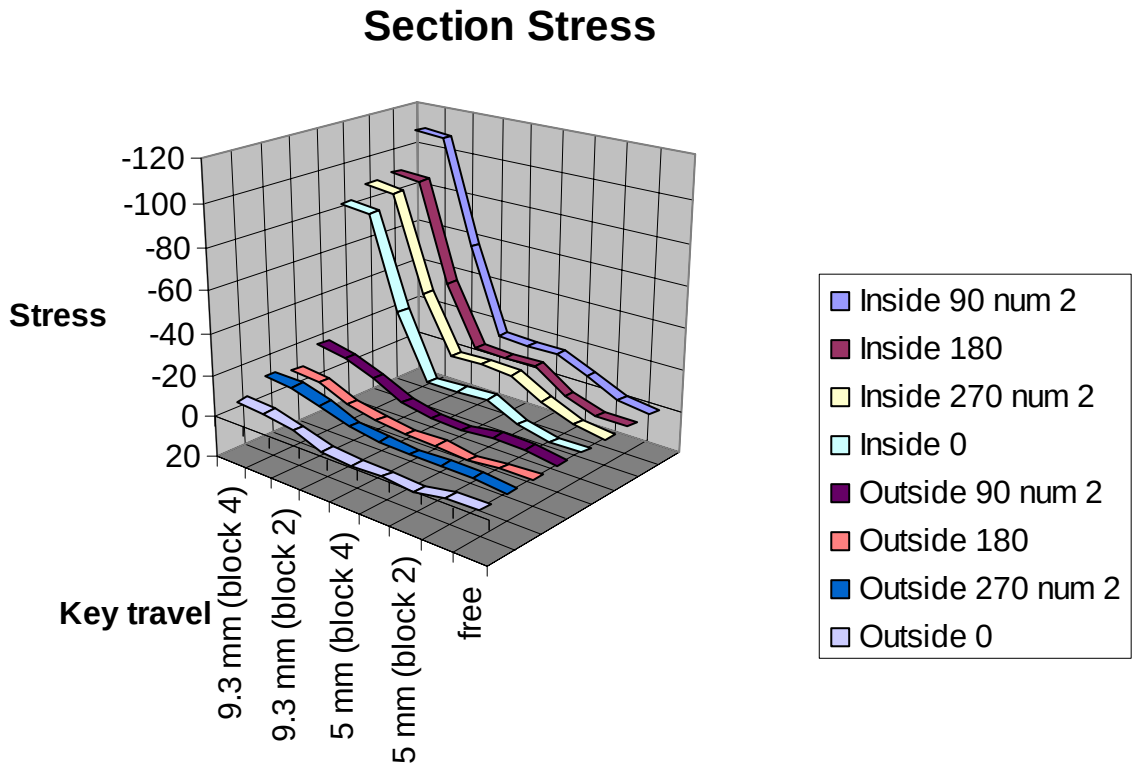
2 LAYERS more

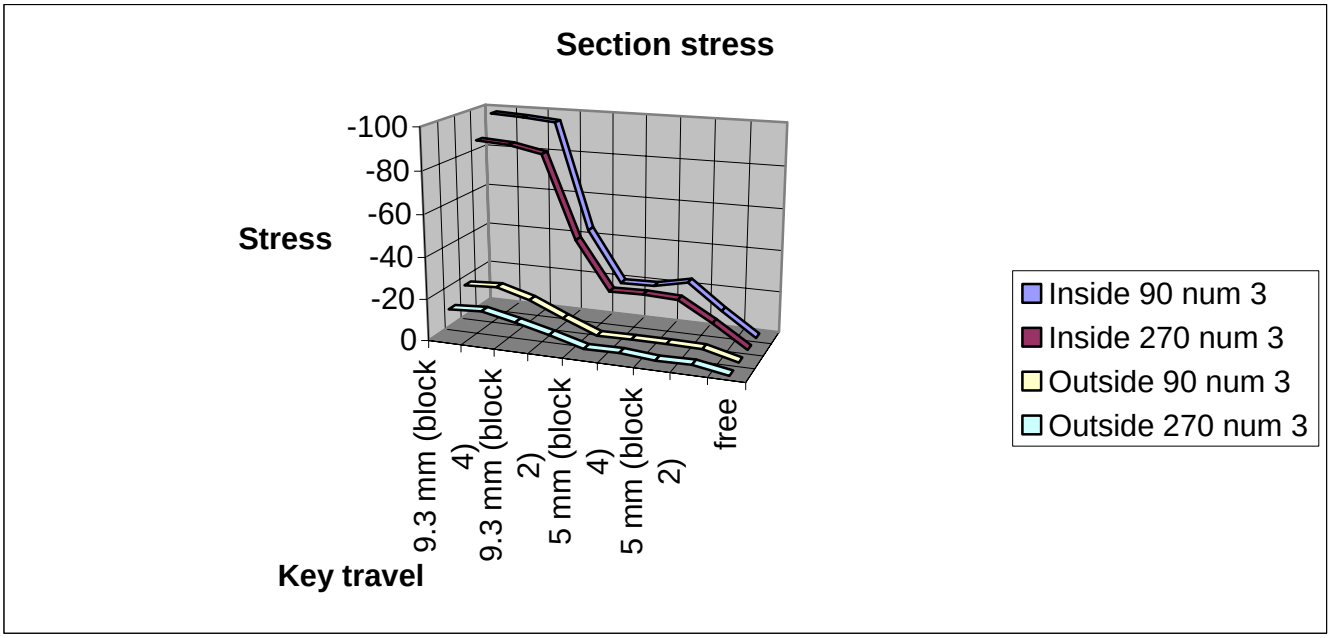


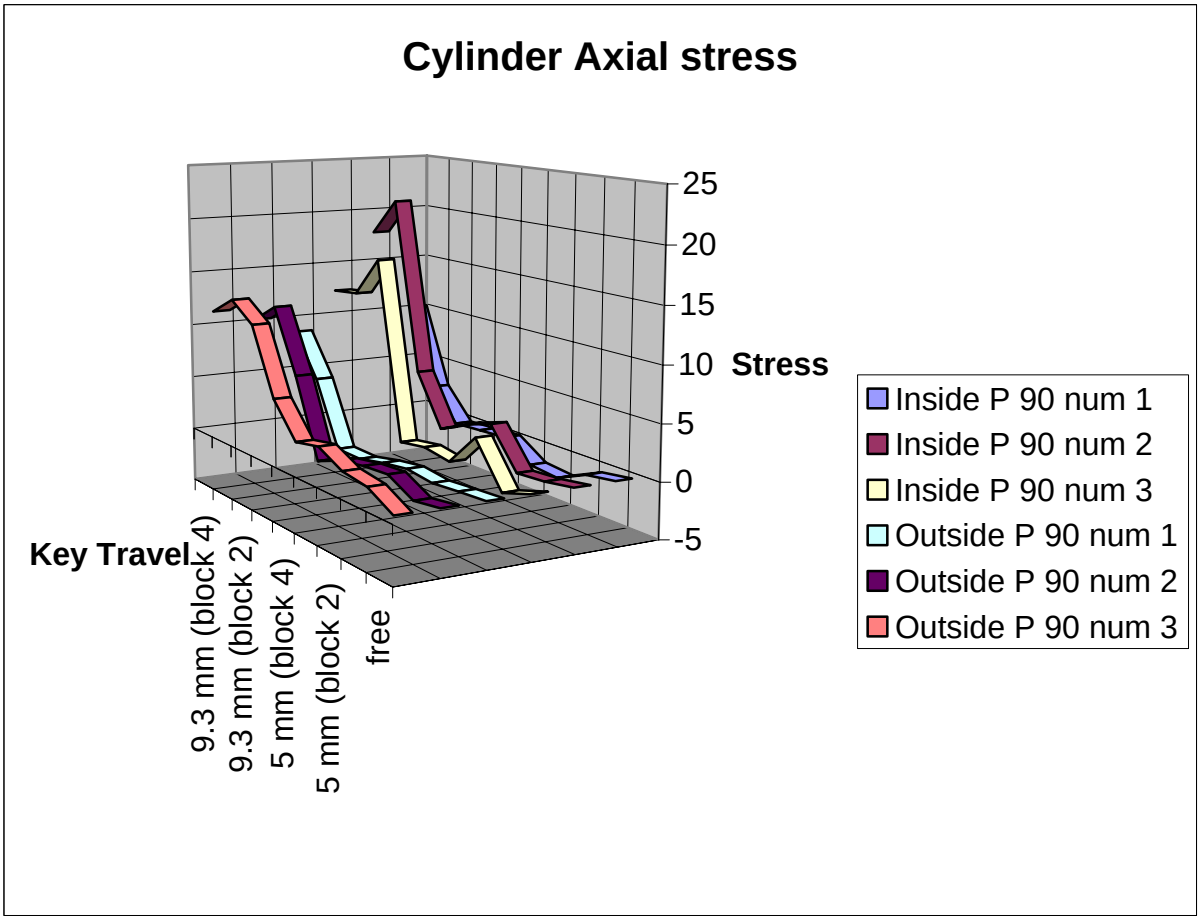




Section stress




Section stress
Stress
-100
-80
-60
-40
-20
0
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Key travel
Inside 90 num 3
Inside 270 num 3
Outside 90 num 3
Outside 270 num 3


Cylinder Axial stress
25
20
15
10
5
0
-5
Stress
Key Travel
9.3 mm (block 4)
9.3 mm (block 2)
5 mm (block 4)
5 mm (block 2)
free
Inside P 90 num 1
Inside P 90 num 2
Inside P 90 num 3
Outside P 90 num 1
Outside P 90 num 2
Outside P 90 num 3