TILT TESTS ON RAL NOISE PROTOTYPE

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Version 01 – corrected for factor two error in optical lever calculation, and to include test 0.

1. AIMS

To explore the "residual tilt" effect observed on the LASTI noise prototype with the hope of finding a cause.

2. SETUP

We used the RAL noise prototype reaction chain. We positioned laser pointers to act as optical levers on the TM and PUM. In both cases the lever was amplified by the use of a mirror on the nearby wall, to bounce onto a screen (a flip-chart) on the opposite wall. See photos.

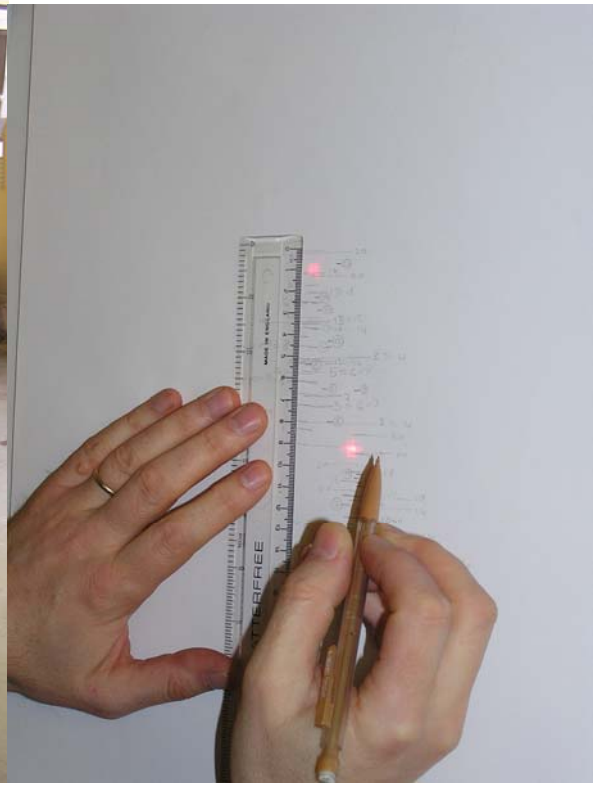
The location of the spots on the screen was marked with a pencil. Because it was impossible to completely eliminate residual motion of the masses, the procedure was to make two lines spanning the range of movement, then mark a point in between those two lines to act as the recorded spot location. The spot sizes were about 8mm (test mass) and 6mm (PUM); estimated accuracy of locating the spot was about 2 to 3mm.

Distance from masses to mirror on wall = 2.23

Distance from mirror to screen = 6.0

Total optical lever = 8.23m

2mm detectable output would thus correspond to about (2/8230/2) = 0.125 mRad.



3. TEST 0

As a trail, we tilted the whole chain without locking any masses. With an input tilt at the UIM of about 135mRad, we observed a permanent tilt at the TM of about 60mm spot movement (~3.5mRad) at the TM and 50mm (3 mRad) at the UIM.

4. TEST 1

The PUM was locked with its stops and the TM was forcibly tilted, then released. The any vertical spot motion observed. The tilt was such that the edges of the mass were displaced by about 25mm, so the forced tilt was about 25/150 = 170 mRad

	TM (mm)	PM (mm)	Tm (mRad)	
Start (1)	0	0		
CCW (2)	+5	0	+0.3	
CCW (3)	+5	0	+0.3	
CW (4)	0	0	0	
CW (5)	-1	0	-0.05	

5mm spot movement corresponds to ~0.3mRad.

5. TEST 2 – YAW

Test mass was forcibly yawed about 30mm over 150 (200mRad), then released and the effect on spot location horizontally was recorded.

	TM (mm)	PM (mm)	Tm (mRad)	
Start (1)	0	0		
CCW (2)	Small (<2mm)	0	<0.1	
CCW (3)	small	0		
CW (4)	Small	0		
CW (5)	Small	0		

6. TEST 3 – PU RELEASED

UIM was locked with stops from below, above and ends. The PU mass was released.

Procedure; tilt TM, record spot movement. Really hard to stabilise the spots!

	TM (mm)	PM (mm)	TM (mRad)	PM (mRad)
Start (1)	0	0		
CCW (2)	+50	+46	3.0	2.8
CCW (3)	+58	+53	3.5	3.2
CCW (4)	same	Same		
CW (5)	-8	-7	-0.5	-0.4
CW (6)	same	Same		

We seemed to be shifted back and forth between two limits.

7. TEST 4 – PU RELEASED

Look for proportionality of effect

7.1 Procedure.

Tilt the TM and record the movement of the spot from the PU at the first mirror (relatively short lever arm so can be used to record enforced mass tilts)

First test: input TM as in test above, PU spot moved 480 (=109 mRad or ~6 degrees)

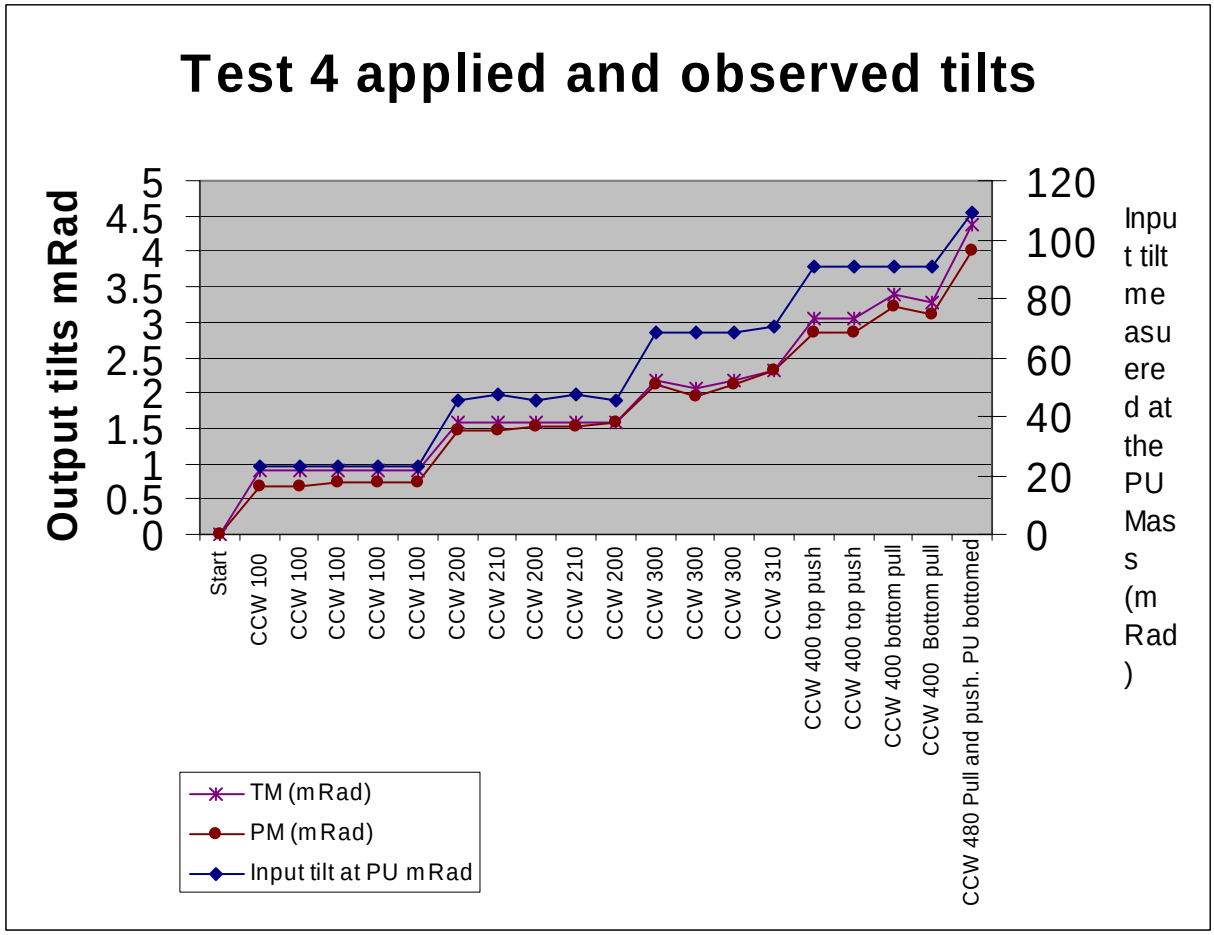
Then use a CW tilt to push us to the “CW limit” as seen above. (1)

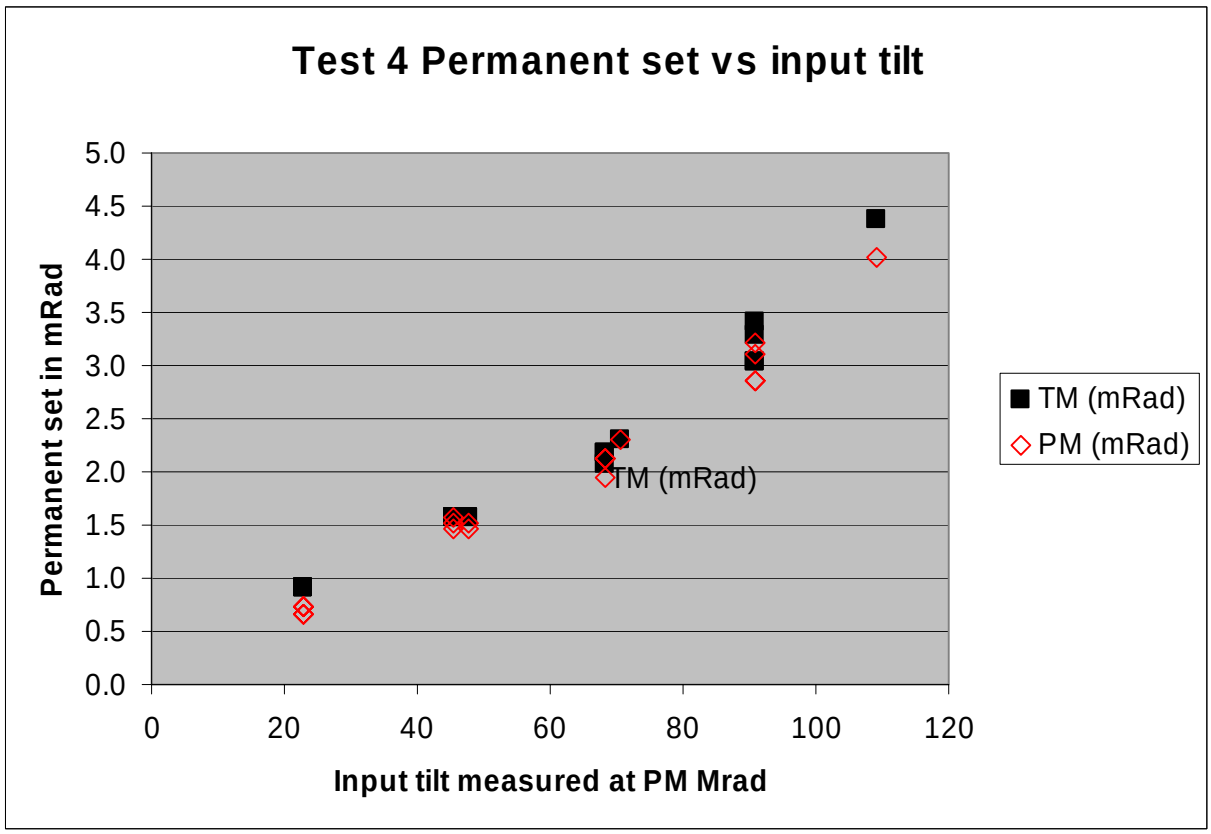
Repeat large CW to check (2) – little/no movement at screen. Call this zero.

Now inject controlled tilt at the TM, by observing the position of the spot from the PUM at the mirror on the wall.

Towards the end of this test we began to suspect that there was some influence of the way the Tm was tilted (by the bias between push and the top and pull at the bottom) – but when we tried some variants we did not see any effect.

	Input tilt at PU mRad	Result set	TM (mm)	PM (mm)	TM (mRad)	PM (mRad)
Start		2	0	0		
CCW 100	23	3	15	11	0.9	0.7
CCW 100	23	4	15	11	0.9	0.7
CCW 100	23	5	15	12	0.9	0.7
CCW 100	23	6	15	12	0.9	0.7
CCW 100	23	7	15	12	0.9	0.7
CCW 200	45	8	26	24	1.6	1.5
CCW 210	48	9	26	24	1.6	1.5
CCW 200	45	10	26	25	1.6	1.5
CCW 210	48	11	26	25	1.6	1.5
CCW 200	45	12	26	26	1.6	1.6
CCW 300	68	13	36	35	2.2	2.1
CCW 300	68	14	34	32	2.1	1.9
CCW 300	68	15	36	35	2.2	2.1
CCW 310	70	16	38	38	2.3	2.3
CCW 400 top push	91	17	50	47	3.0	2.9
CCW 400 top push	91	18	50	47	3.0	2.9
CCW 400 bottom pull	91	19	56	53	3.4	3.2
CCW 400 Bottom pull	91	20	54	51	3.3	3.1
CCW 480 Pull and push. PU bottomed	109	21	72	66	4.4	4.0

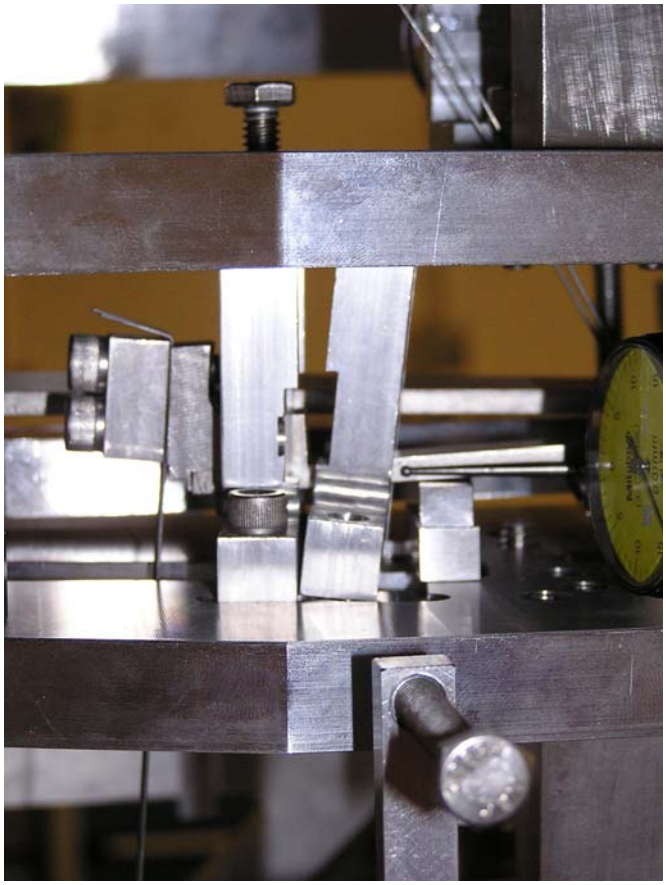

Test 4 applied and observed tilts
Output tilts mRad
Input tilt measured at the PU Mass (mRad)
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
20
40
60
80
100
120
Start
CCW 100
CCW 100
CCW 100
CCW 100
CCW 100
CCW 200
CCW 210
CCW 200
CCW 210
CCW 200
CCW 300
CCW 300
CCW 300
CCW 310
CCW 400 top push
CCW 400 top push
CCW 400 bottom pull
CCW 400 Bottom pull
CCW 480 Pull and push. PU bottomed
TM (mRad)
PM (mRad)
Input tilt at PU mRad


Test 4 Permanent set vs input tilt
Permanent set in mRad
Input tilt measured at PM Mrad
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
0
20
40
60
80
100
120
TM (mRad)
TM (mRad)
PM (mRad)

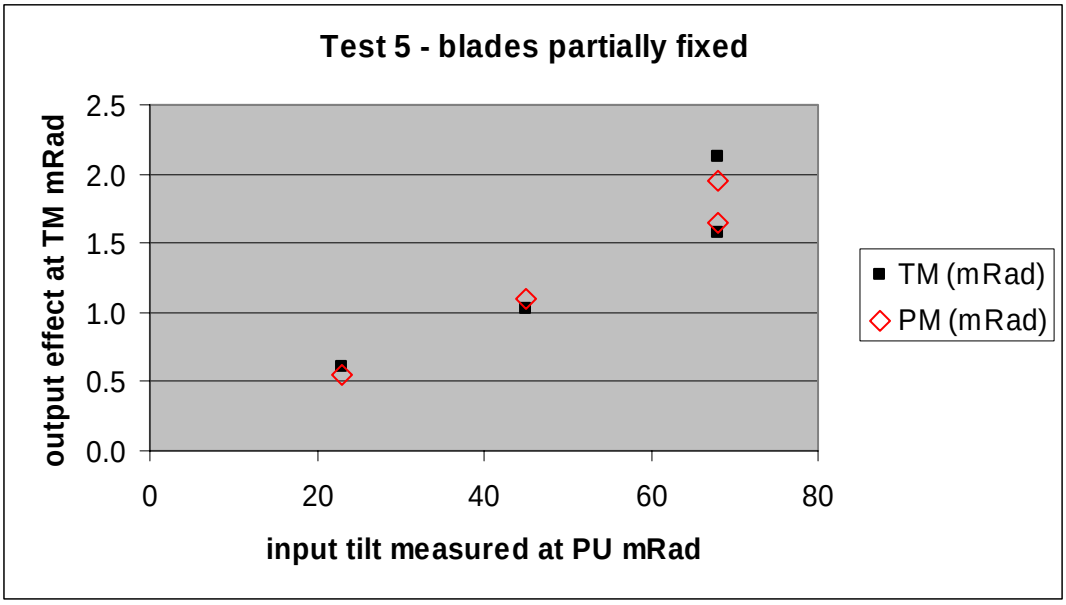
8. BLADES LOCKED

For this test we locked the blades in the UIM by inserting a bar under the blade near the tip and winding the blade stop screw down hard (see picture).

As before we started with a full CW tilt, repeated to ensure that the spots did not move. Then we moved in steps of 45 mRad CCW movement as before.



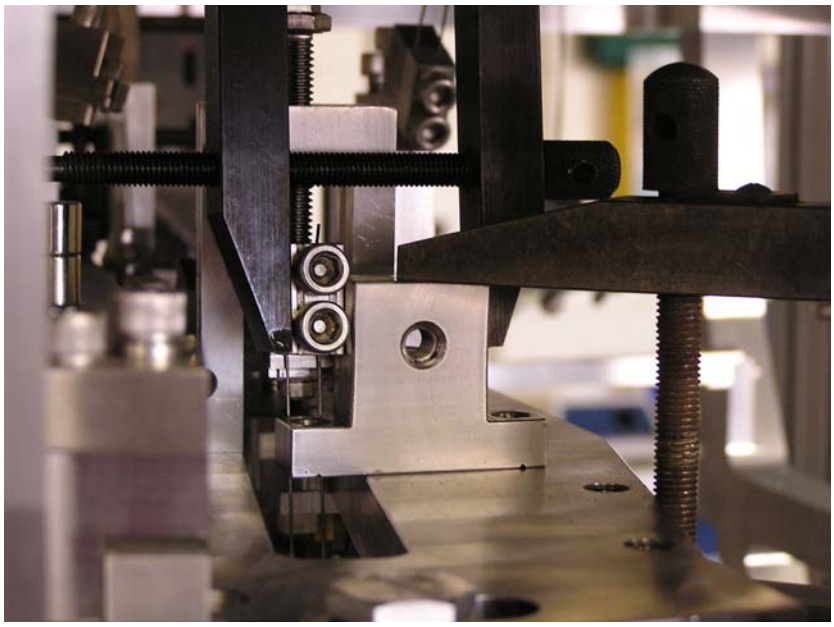
	Input tilt at PU mRad	Result set	TM (mm)	PM (mm)	TM (mRad)	PM (mRad)
Start	23	2	10	9	0.6	0.5
CCW 100	45	3	17	18	1.0	1.1
CCW 200	68	4	26	27	1.6	1.6
CCW 300	68	5	35	32	2.1	1.9
CCW 300, hit stops + OL wires	23	2	10	9	0.6	0.5



9. TEST 6 – BLADES MORE FULLY LOCKED

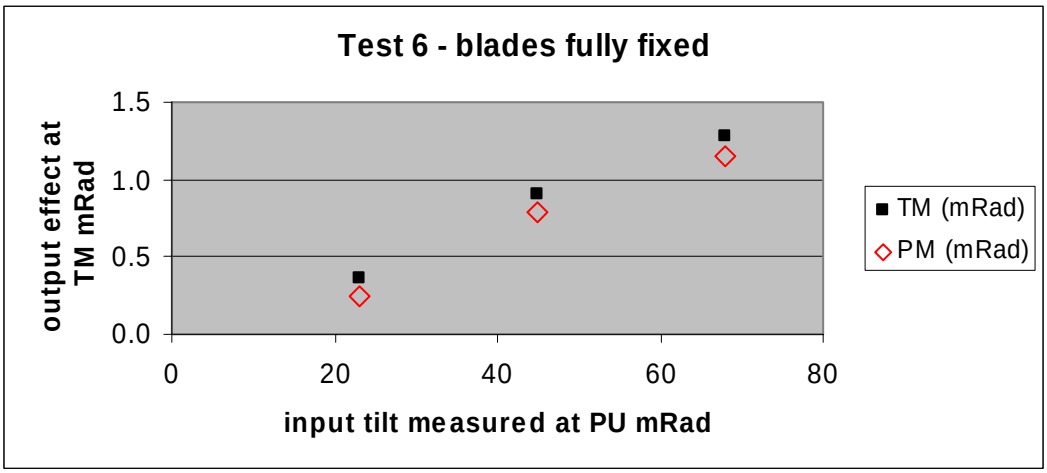
We put a clock on the side of one of the wire clamps at the end of the UI blades. When we tilted the mass some movement (of order 10 micron) was visible suggesting that the clamping of the blade tips was not preventing twist.

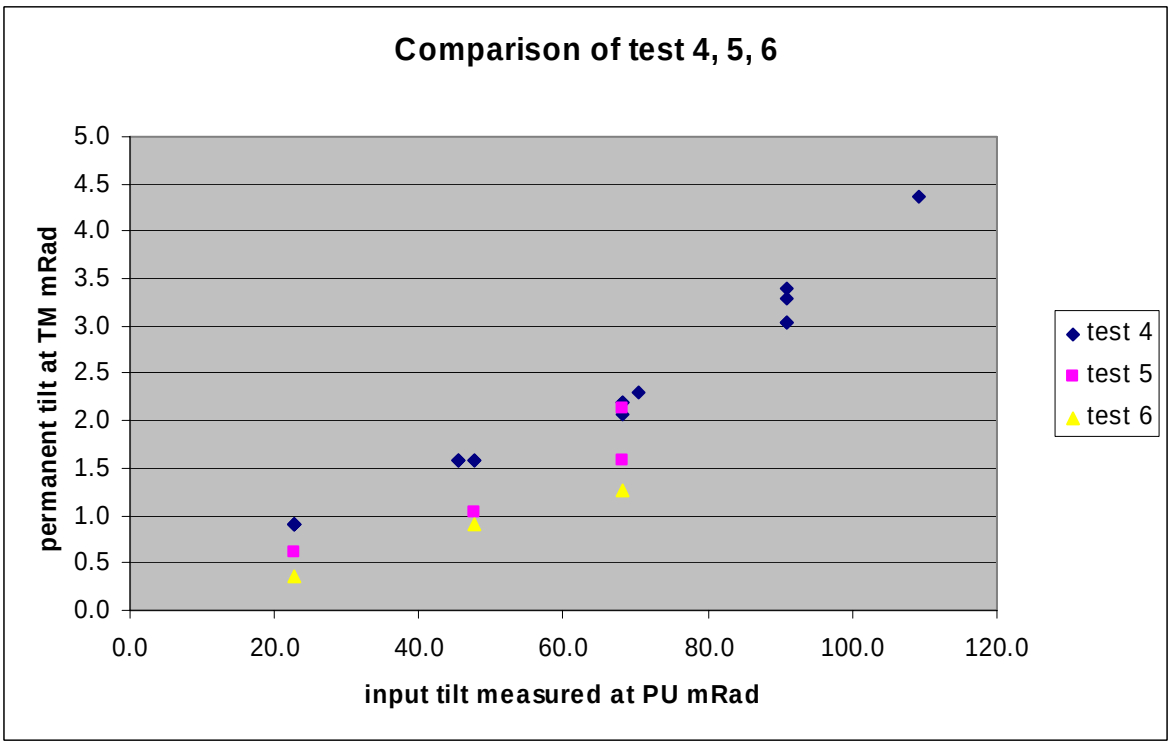
We clamped the blade tips with a bricolage of clamps (se picture) and checked with the clock that they did not seem to be moving. Then procedure as at Test 5.



	Input tilt at PU mRad	Result set	TM (mm)	PM (mm)	TM (mRad)	PM (mRad)

Start		1	0	0		
CCW 100	23	2	6	4	0.4	0.2
CCW 200	45	3	15	13	0.9	0.8
CCW 300	68	4	21	19	1.3	1.2





The effect is of the order of 0.02 mRad output per mRad input. An interesting observation is that, if this efffect is linear down to small levels, an output tilt of 100 microRad would be produced by an input tilt of 5 mRad.

10. CONCLUSIONS

1. Even with the PU locked, we find that a tilt at the TM produces a permanent set. A tilt of ~170mRad produced a set of ~0.3mRad.

2. With the UIM locked, the same effect is visible. A tilt of the TM sufficient to tip the UIM by 50mRad, produces a permanent set at the TM of ~1mRad and the effect is roughly linear between ~20mRad and ~100mRad input tilt.