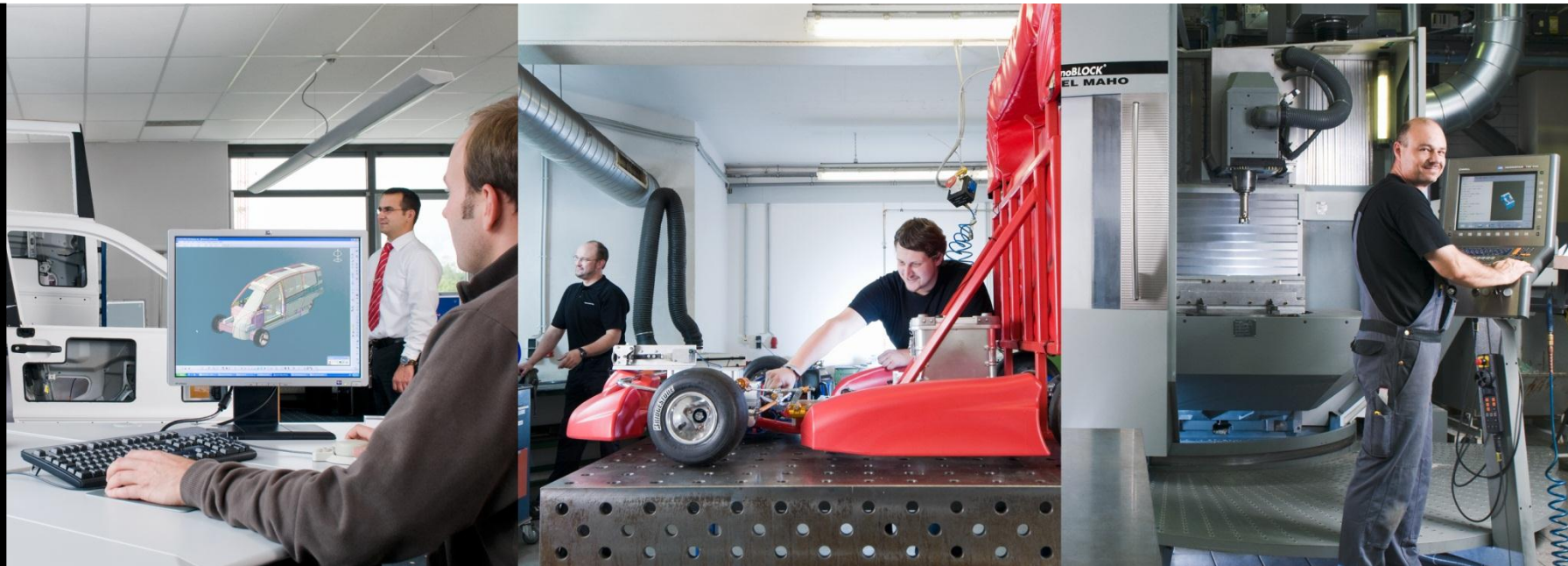


Durability Study SN03 at Bertrandt Laboratory Bertrandt Ingolstadt

Ingolstadt, 19. March 2013, J.C. Kolb



Agenda

1. Basic Information
2. Results of pendulum tests
3. Results of inverse tests
4. Summary

Agenda

- 1. Basic Information**

2. Results of pendulum tests

3. Results of inverse tests

4. Summary

Basic Information

- Start of analysing the Round Robin tests with the so called Masterlegs which were carried out from August 2012 to January 2013 world wide
- In this presentation only the tests performed by Bertrandt are analysed / included
- The objective is to show the behavior of the calibration results during 2 weeks testing

Database

- Schedule: 15.10.2012 – 26.10.2012
- Masterleg: SN03
- Calibration: Bertrandt
- Testing: Bertrandt, Audi
- Number of tests:
 - Pendulum: 12 tests
 - Inverse: 10 tests
 - Other tests: 32 tests

54 tests
- Calibration corridors: made up in Sept 2012, shown on following slide

Calibration corridors FlexPLI

INVERSE CORRIDORS							
Draft GTR9-PH2 since Sept. 2012	Tibia 1 (Nm)	Tibia 2 (Nm)	Tibia 3 (Nm)	Tibia 4 (Nm)	MCL (mm)	ACL (mm)	PCL (mm)
lower limit	272	252	192	108	21	10	6
upper limit	230	210	166	93	17	8	4

PENDULUM CORRIDORS							
Draft GTR9-PH2 since Sept. 2012	Tibia 1 (Nm)	Tibia 2 (Nm)	Tibia 3 (Nm)	Tibia 4 (Nm)	MCL (mm)	ACL (mm)	PCL (mm)
lower limit	272	219	166	111	24	10,5	5
upper limit	235	187	139	90	20,5	8	3,5

Testing schedule

- **First week: 15.10.2010 – 21.10.2012 (week 42/2012)**
 - **3 x Pendulum test**
 - **3 x Inverse test**
 - *9 x Flat wall*
 - **1x Pendulum**
 - *9 x Testrack / car tests*
 - **3 x Pendulum test**
 - **3 x Inverse tests**

- **Second week: 22.10.2012 – 26.10.2012 (week 43/2012)**
 - *6 x Flat wall*
 - **2 x Pendulum test**
 - **2 x Inverse Test**
 - **1 x Pendulum Test**
 - *8 x Testrack / car test*
 - **2 x Pendulum test**
 - **2 x Inverse Test**

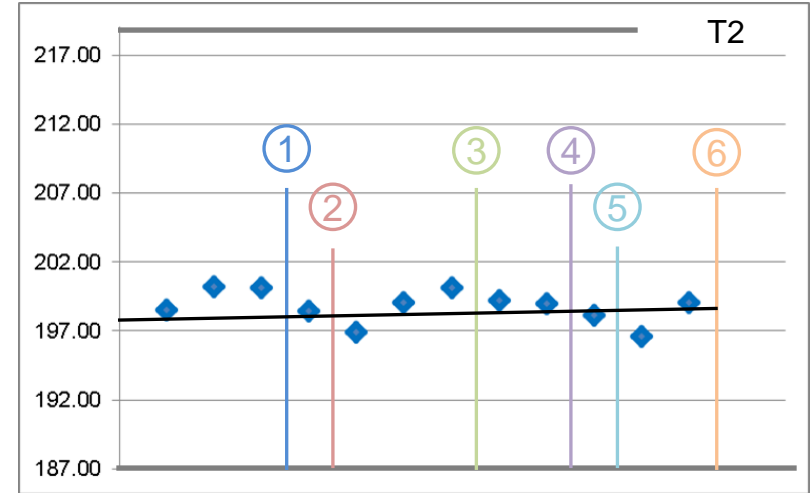
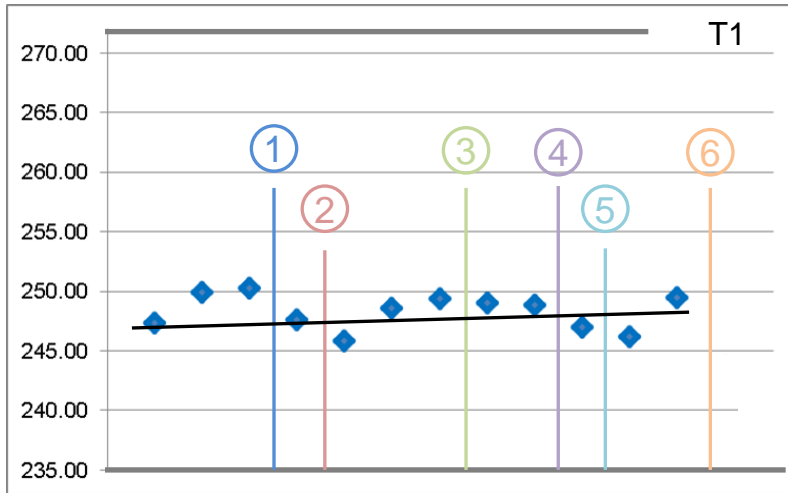
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- 2. Results of pendulum tests**
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Results pendulum tests

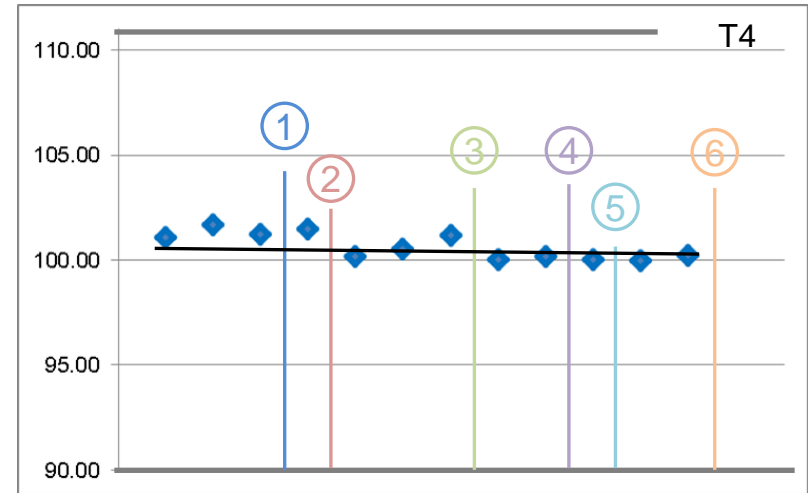
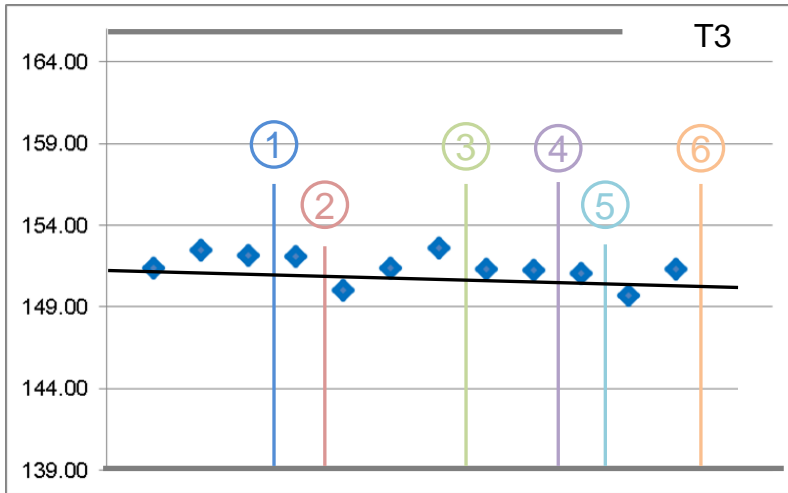
KW	Impaktor	Art des Tests	Tibia 1 [Nm]	Tibia 2 [Nm]	Tibia 3 [Nm]	Tibia 4 [Nm]	ACL [mm]	PCL [mm]	MCL [mm]
KW 42/2012	Masterleg	Kalibrierung Pendel	247,32	198,48	151,32	101,07	9,86	4,10	22,75
KW 42/2012	Masterleg	Kalibrierung Pendel	249,84	200,19	152,45	101,66	10,13	3,86	22,98
KW 42/2012	Masterleg	Kalibrierung Pendel	250,20	200,1	152,12	101,23	10,12	3,94	23,05
3 x Inverse, 9 x Flat wall									
KW 42/2012	Masterleg	Kalibrierung Pendel	247,53	198,41	152,05	101,48	9,43	4,57	22,86
9 x Testrack / car testing									
KW 42/2012	Masterleg	Kalibrierung Pendel	245,77	196,89	149,99	100,13	10,22	3,79	22,81
KW 42/2012	Masterleg	Kalibrierung Pendel	248,52	199,06	151,36	100,52	10,14	3,92	22,89
KW 42/2012	Masterleg	Kalibrierung Pendel	249,36	200,08	152,58	101,17	10,13	3,94	22,94
3 x Inverse, 6 x Flat wall									
KW 43/2012	Masterleg	Kalibrierung Pendel	248,98	199,15	151,26	100,01	10,09	3,99	23,00
KW 43/2012	Masterleg	Kalibrierung Pendel	248,84	198,92	151,22	100,17	10,10	3,96	22,95
2 x Inverse									
KW 43/2012	Masterleg	Kalibrierung Pendel	246,98	198,07	151,01	100,01	9,69	4,35	22,90
8 x Testrack / car testing									
KW 43/2012	Masterleg	Kalibrierung Pendel	246,18	196,58	149,64	99,94	9,90	4,11	22,73
KW 43/2012	Masterleg	Kalibrierung Pendel	249,40	199,01	151,26	100,21	10,17	3,95	22,96
2 x Inverse									
Arithmetic mean			248,58	199,34	151,89	101,37	10,00	3,98	22,87
Standard deviation			1,45	1,16	0,89	0,64	0,24	0,22	0,10
Coefficient of variation			0,59%	0,58%	0,59%	0,63%	2,36%	5,52%	0,43%

Results pendulum tests



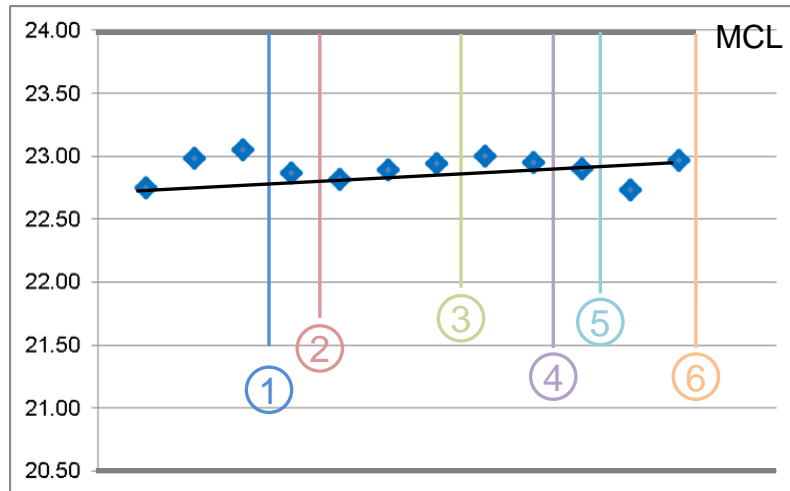
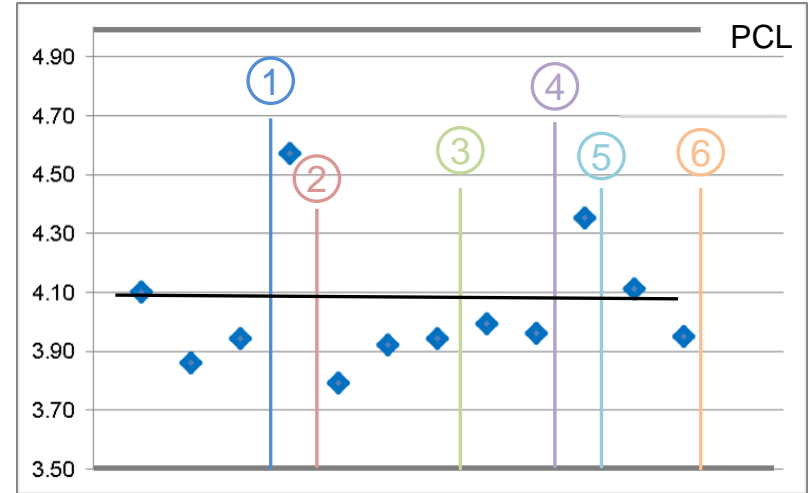
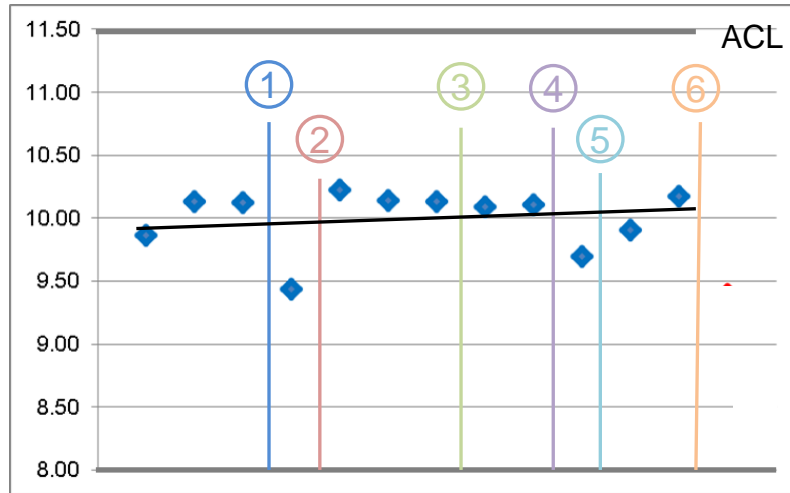
- Key:
- ① 3 x Inverse, 9 x Flat wall
 - ② 9 x Testrack / Car testing
 - ③ 3 x Inverse, 6 x Flat wall
 - ④ 2 x Inverse
 - ⑤ 8 x Testrack / car testing
 - ⑥ 2 x Inverse

Results pendulum tests



- Key:
- ① 3 x Inverse, 9 x Flat wall
 - ② 9 x Testrack / Car testing
 - ③ 3 x Inverse, 6 x Flat wall
 - ④ 2 x Inverse
 - ⑤ 8 x Testrack / car testing
 - ⑥ 2 x Inverse

Results pendulum tests



- Key:
- ① 3 x Inverse, 9 x Flat wall
 - ② 9 x Testrack / Car testing
 - ③ 3 x Inverse, 6 x Flat wall
 - ④ 2 x Inverse
 - ⑤ 8 x Testrack / car testing
 - ⑥ 2 x Inverse

Summary pendulum tests

- Absolut variations of single tests:
 - Tibia moments: < 5 Nm
 - Elongations: < 1 mm
- Result: very little variation
all values within corridors
- Comparison with other round robins

	Laboratory	Type of leg	Number of legs	Number of tests	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	PCL	MCL
CoD on hand tests (Masterleg SN03)	Bertrandt	SN03	1	12	0,59%	0,58%	0,59%	0,63%	2,36%	5,52%	0,43%
CoD Masterleg SN03 in particular from Calibration Round Robin	Bertrandt	SN03	1	3	0,32%	0,38%	0,34%	0,35%	1,76%	1,67%	0,73%
Masterleg Calibration Round Robin, mean CoD of 3 Masterlegs (IG GTR9-PH2)	Bertrandt	SN01 SN03 E-Leg	3	9	0,42%	0,42%	0,31%	0,19%	1,59%	2,06%	0,64%
ACEA-Round Robin, mean CoD of 5 Industrial Legs (detailed results shown in doc. GTR9-5-05r2)	Bertrandt	Industrial leg	5	15	0,36%	0,43%	0,45%	0,61%	1,40%	2,04%	0,35%

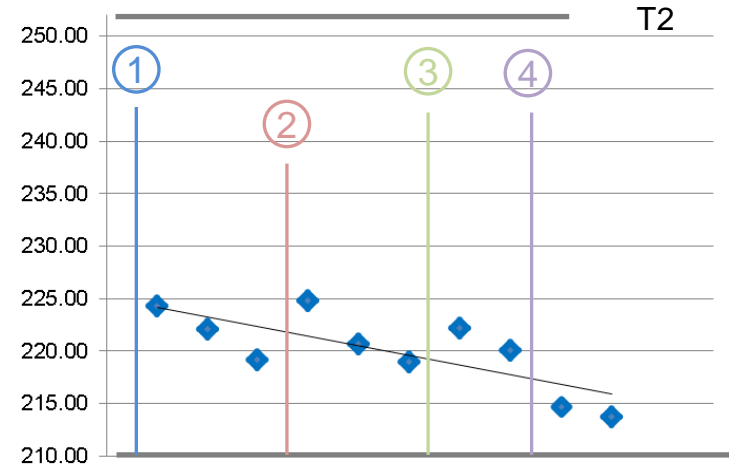
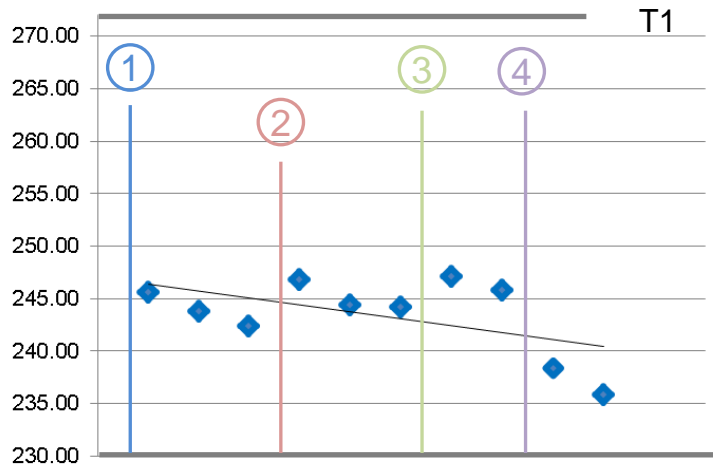
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Results inverse tests

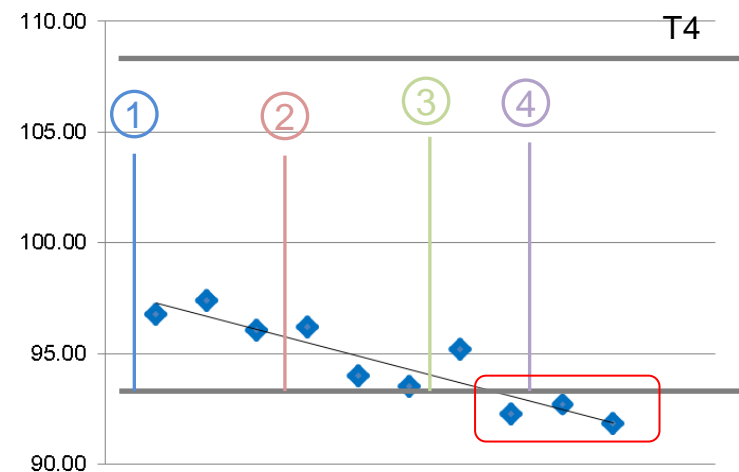
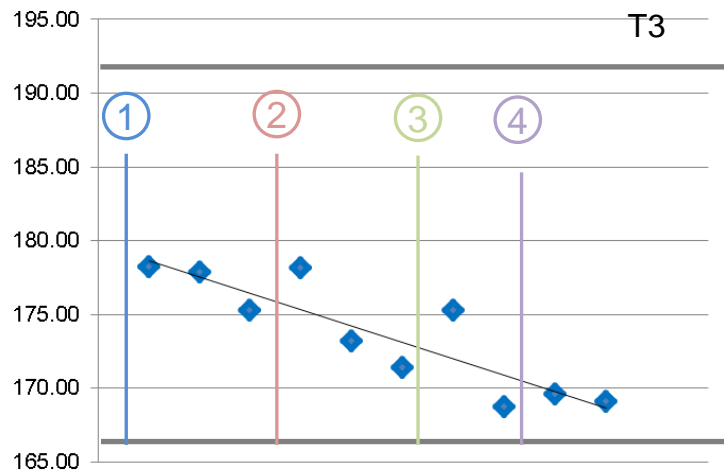
KW	Impaktor	Art des Tests	Tibia 1 [Nm]	Tibia 2 [Nm]	Tibia 3 [Nm]	Tibia 4 [Nm]	ACL [mm]	PCL [mm]	MCL [mm]
3 x Pendulum									
KW 42/2012	Masterleg	Kalibrierung Inverse	245,58	224,28	178,23	96,76	10,64	4,60	19,24
KW 42/2012	Masterleg	Kalibrierung Inverse	243,80	222,07	177,82	97,35	9,92	4,87	19,15
KW 42/2012	Masterleg	Kalibrierung Inverse	242,35	219,10	175,27	96,04	9,71	5,06	19,08
9 x Flat wall, 1 x Pendulum, 9 x Tetrack / car testing, 3 x Pendulum									
KW 42/2012	Masterleg	Kalibrierung Inverse	246,78	224,81	178,14	96,18	10,54	4,39	18,52
KW 42/2012	Masterleg	Kalibrierung Inverse	244,37	220,66	173,21	93,97	9,91	5,16	19,20
KW 42/2012	Masterleg	Kalibrierung Inverse	244,15	218,96	171,41	93,48	10,06	5,19	19,31
6 x Flat wall, 2 x Pendulum									
KW 43/2012	Masterleg	Kalibrierung Inverse	247,12	222,13	175,30	95,19	20,61	4,53	19,19
KW 43/2012	Masterleg	Kalibrierung Inverse	245,83	220,01	168,73	92,24	19,64	5,16	20,14
1 x Pendulum, 8 x Tetrack / car testing, 2 x Pendulum									
KW 43/2012	Masterleg	Kalibrierung Inverse	238,39	214,70	169,58	92,70	10,49	4,39	18,44
KW 43/2012	Masterleg	Kalibrierung Inverse	235,85	213,68	169,06	91,81	9,79	4,68	18,06
Arithmetic mean			243,42	220,04	173,68	94,57	10,13	4,80	19,03
Standard deviation			3,66	3,66	3,81	1,99	0,37	0,32	0,57
Coefficient of deviation			1,50%	1,66%	2,20%	2,11%	3,63%	6,75%	3,02%

Results inverse tests



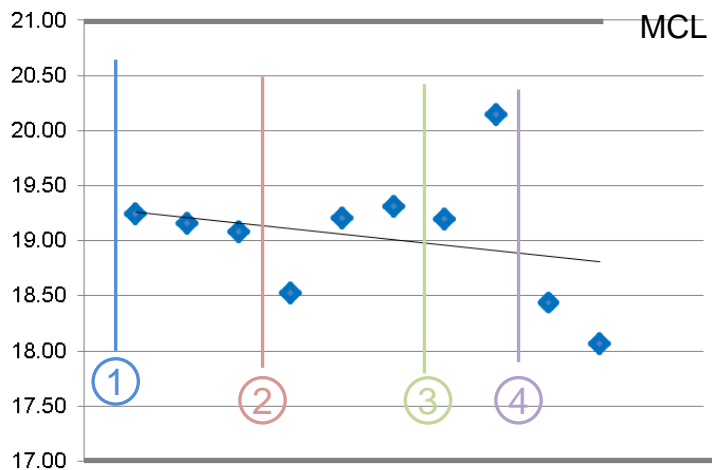
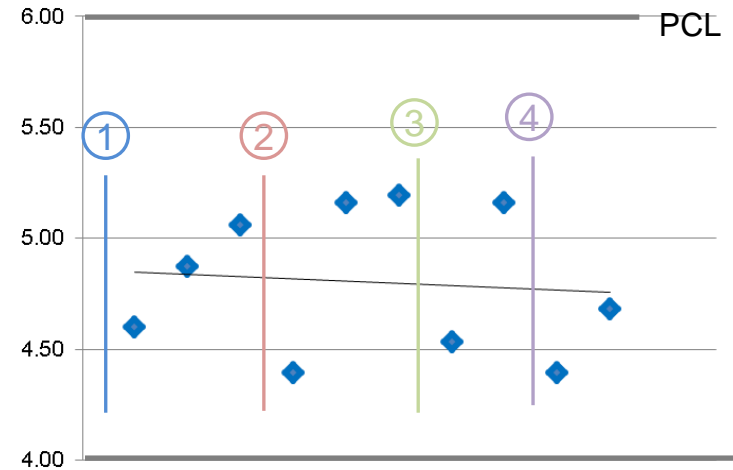
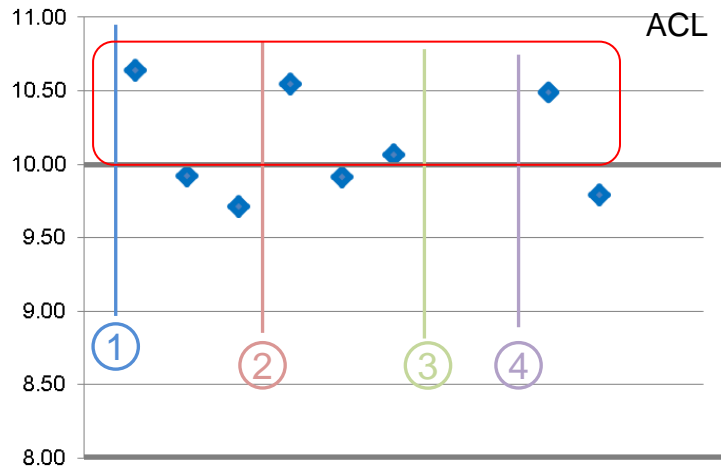
- Key:
- ① 3 x Pendulum
 - ② 9 x Flat wall, 1 x Pendulum, 9 x Testrack / car testing, 3 x Pendulum
 - ③ 6 x Flatwall, 2 x Pendulum
 - ④ 1 x Pendulum, 8 x Testrack / car testing, 2 x Pendulum

Results inverse tests



- Key:
- ① 3 x Pendulum
 - ② 9 x Flat wall, 1 x Pendulum, 9 x Testrack / car testing, 3 x Pendulum
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Results inverse tests



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 - ② 9 x Flat wall, 1 x Pendulum, 9 x Testrack / car testing, 3 x Pendulum
 - ③ 6 x Flatwall, 2 x Pendulum
 - ④ 1 x Pendulum, 8 x Testrack / car testing, 2 x Pendulum

Summary inverse tests

- Absolut variations of single tests:
 - Tibia moments: < 20 Nm
 - Elongations: < 1,5 mm , except 1 result at MCL
- Result: considerable variations
7 out of 48 values out of corridors
3 x Tibia 4 below range, 4 x ACL above range
- Comparison with other round robins

	Laboratory	Type of leg	Number of legs	Number of tests	Tibia 1	Tibia 2	Tibia 3	Tibia 4	ACL	PCL	MCL
CoD on hand tests (Masterleg SN03)	Bertrandt	SN03	1	10	1,50%	1,66%	2,20%	2,11%	3,63%	6,75%	3,02%
CoD Masterleg SN03 in particular from Calibration Round Robin	Bertrandt	SN03	1	3	0,58%	0,31%	0,49%	0,99%	3,54%	3,55%	0,84%
Masterleg Calibration Round Robin, mean CoD of 3 Masterlegs (IG GTR9-PH2)	Bertrandt	SN01 SN03 E-Leg	3	9	0,45%	0,51%	0,71%	1,10%	23,60%	3,21%	0,48%
ACEA-Round Robin, mean CoD of 5 Industrial Legs (detailed results shown in doc. GTR9-5-05r2)	Bertrandt	Industrial leg	5	15	0,59%	1,11%	0,80%	0,73%	0,79%	1,66%	1,08%

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Summary

- ??

Thank you for your attention.

