

FlexPLI - Round Robin Tests

Jan Christopher Kolb, Bertrandt

Daniel Folcini, Bertrandt

Thomas Kinsky, GM Europe/Opel (representing the ACEA Task Force Pedestrians)

Ingolstadt, 24.05.2012



Agenda

1. Test Series

2. Legforms

3. Inverse Certification Test Results

4. Pendulum Certification Test Results

5. Discussion

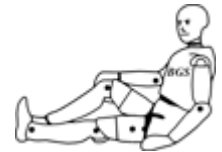
Test Series

- Test series sponsored by ACEA, the European Automobile Manufacturers' Association
- Tests conducted by Bertrandt in Ingolstadt and by BGS Boehme and Gehring in Bergisch Gladbach
- Both labs are considered to be well experienced with FlexPLI testing
- Serial production impactors were tested:
 - 3 inverse certification tests in each lab
 - 3 pendulum certification tests in each lab
- Test scenario according to the scenario proposed for inclusion into gtr No 9 (see document UNECE/TRANS/WP.29/GRSP/2011/13)
- Test results are intended to support the discussion on the possible need to modify the certification corridors proposed



European
Automobile
Manufacturers'
Association

bertrandt



Agenda

1. Test Series

2. Legforms

3. Inverse Certification Test Results

4. Pendulum Certification Test Results

5. Discussion

Legforms

- All legform impactors used for the test series are FlexPLI version GTR, manufactured by Humanetics
- Legforms are of different build levels:
 - Legform 1 assembled in June 2010 / major repair in May 2012;
 - Legform 2 assembled in Sept. 2010 / major repair in Jan. 2012;
 - Legform 3 assembled in March 2012
- Further tests with additional legforms are planned

Test schedule

- Tests conducted with the first three legforms

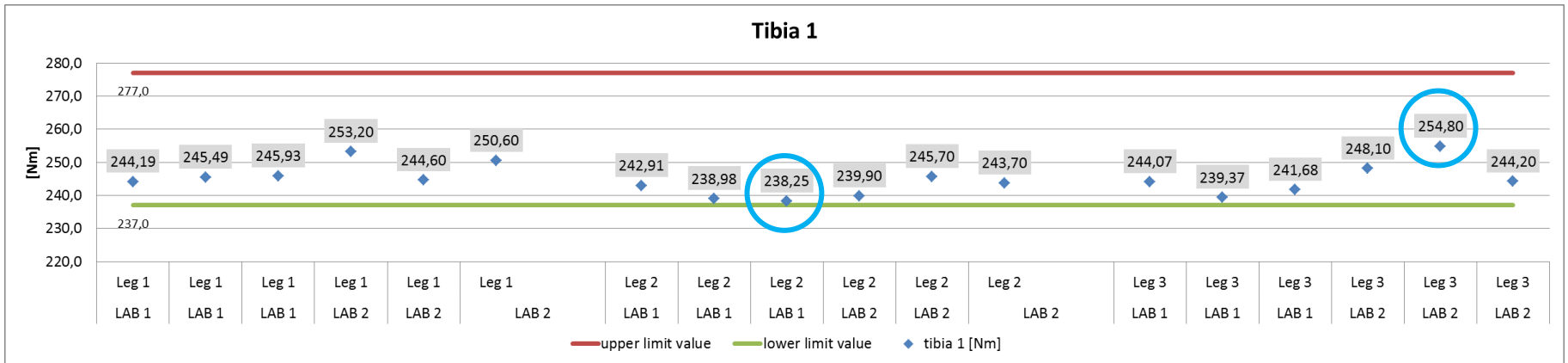
	LAB 1		LAB 2	
	Date	Test	Date	Test
Leg 1	14.03.2012	Pendulum	08.03.2012	Pendulum
Leg 1	14.03.2012	Inverse	08.03.2012	Inverse
Leg 2	15.03.2012	Pendulum	27.02.2012	Pendulum
Leg 2	15.03.2012	Inverse	24.02.2012	Inverse
Leg 3	05.04.2012	Pendulum	02.04.2012	Pendulum
Leg 3	04.04.2012	Inverse	30.03.2012	Inverse

Agenda

1. Test Series
2. Legforms
- 3. Inverse Certification Test Results**
4. Pendulum Certification Test Results
5. Discussion

Inverse Certification Test Results – Tibia 1

- All test results are in the lower half of the corridor proposed for gtr No 9



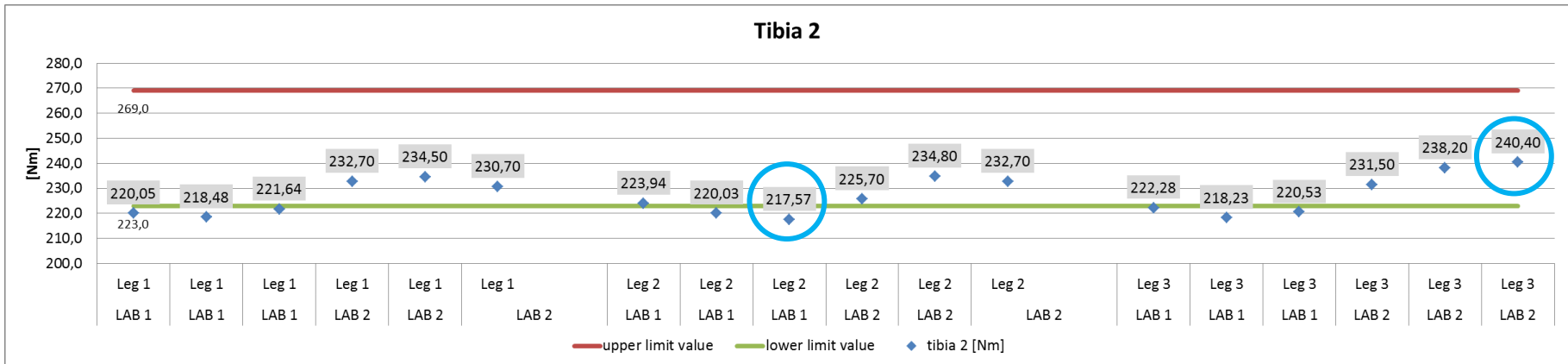
test bench	relevant limits	
LAB 1	min:	237
overall	max:	277
arithmetic mean	242,32	
standard deviation	2,72	
coefficient of variation	1,12%	
test bench	relevant limits	
LAB 2	min:	237
overall	max:	277
arithmetic mean	247,20	
standard deviation	4,59	
coefficient of variation	1,86%	

Tibia 1	relevant limits	
overall	min:	237
	max:	277
arithmetic mean	244,76	
standard deviation	4,50	
coefficient of variation	1,84%	

 highest and lowest value

Inverse Certification Test Results – Tibia 2

- In lab 1, most test results are below the lower limit value of the corridor
- In lab 2, test results meet the corridor but all are in the lower half of the corridor



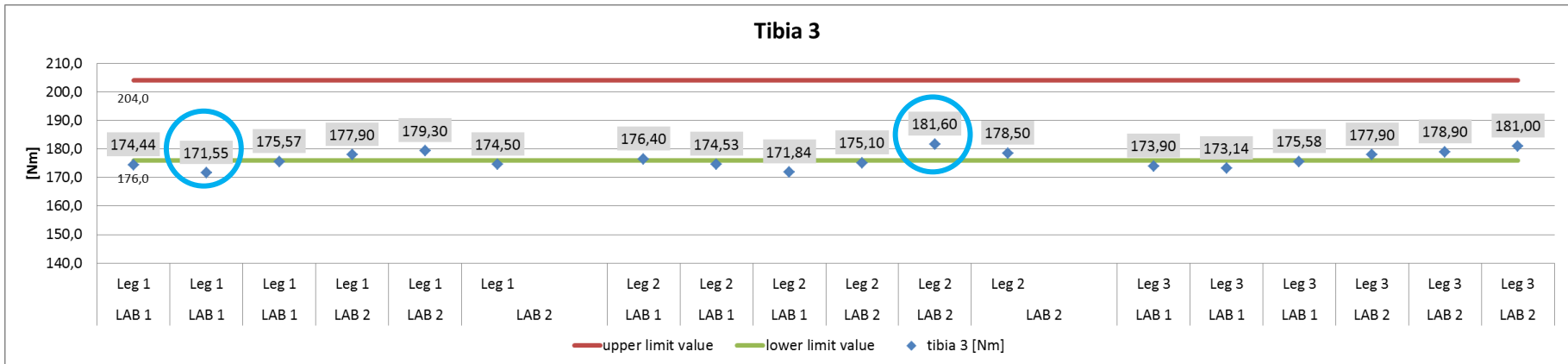
test bench	relevant limits	
LAB 1	min:	223
overall	max:	269
arithmetic mean	220,31	
standard deviation	1,95	
coefficient of variation	0,88%	
test bench	relevant limits	
LAB 2	min:	223
overall	max:	269
arithmetic mean	233,47	
standard deviation	4,03	
coefficient of variation	1,73%	

Tibia 2 overall	relevant limits	
	min:	223
	max:	269
arithmetic mean	226,89	
standard deviation	7,30	
coefficient of variation	3,22%	

○ highest and lowest value

Inverse Certification Test Results – Tibia 3

- All test results are around the lower limit value but regularly miss to meet the corridor



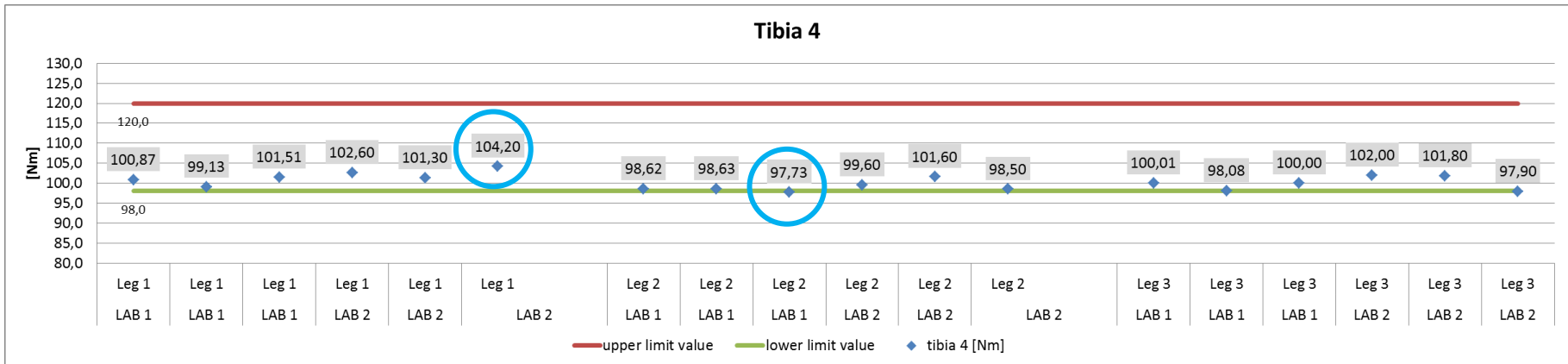
test bench	relevant limits	
LAB 1	min:	176
overall	max:	204
arithmetic mean	174,11	
standard deviation	1,58	
coefficient of variation	0,91%	
test bench	relevant limits	
LAB 2	min:	176
overall	max:	204
arithmetic mean	178,30	
standard deviation	2,23	
coefficient of variation	1,25%	

Tibia 3	relevant limits	
overall	min:	176
	max:	204
arithmetic mean	176,20	
standard deviation	2,85	
coefficient of variation	1,62%	

 highest and lowest value

Inverse Certification Test Results – Tibia 4

- Test results are around the lower limit value, nearly all results meet the corridor



test bench	relevant limits	
LAB 1	min:	98
overall	max:	120
arithmetic mean	99,40	
standard deviation	1,21	
coefficient of variation	1,22%	

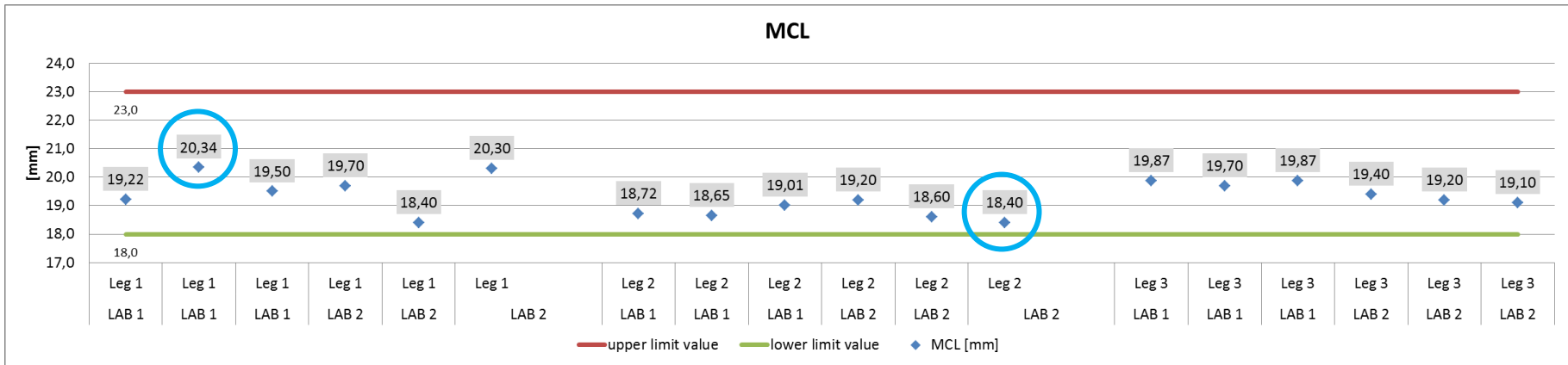
test bench	relevant limits	
LAB 2	min:	98
overall	max:	120
arithmetic mean	101,06	
standard deviation	1,91	
coefficient of variation	1,89%	

Tibia 4	relevant limits	
overall	min:	98
	max:	120
arithmetic mean	100,23	
standard deviation	1,80	
coefficient of variation	1,79%	

 highest and lowest value

Inverse Certification Test Results – MCL

- All test results meet the corridor
- For legform 1, test results significantly scatter



test bench	relevant limits	
LAB 1	min:	18
overall	max:	23
arithmetic mean	19,43	
standard deviation	0,54	
coefficient of variation	2,78%	

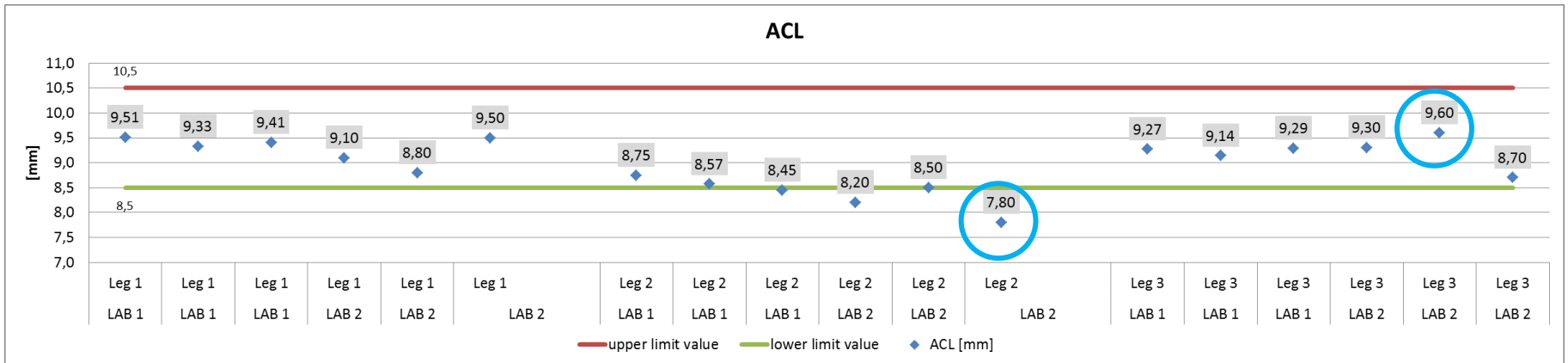
test bench	relevant limits	
LAB 2	min:	18
overall	max:	23
arithmetic mean	19,14	
standard deviation	0,59	
coefficient of variation	3,08%	

MCL	relevant limits	
overall	min:	18
	max:	23
arithmetic mean	14,03	
standard deviation	0,58	
coefficient of variation	4,16%	

 highest and lowest value

Inverse Certification Test Results – ACL

- For legforms 1 and 3, test results are in the middle of the corridor
- For legform 2, test results are around the lower limit value but do not all meet the corridor



test bench	relevant limits	
LAB 1	min:	8,5
overall	max:	10,5
arithmetic mean	9,08	
standard deviation	0,37	
coefficient of variation	4,03%	

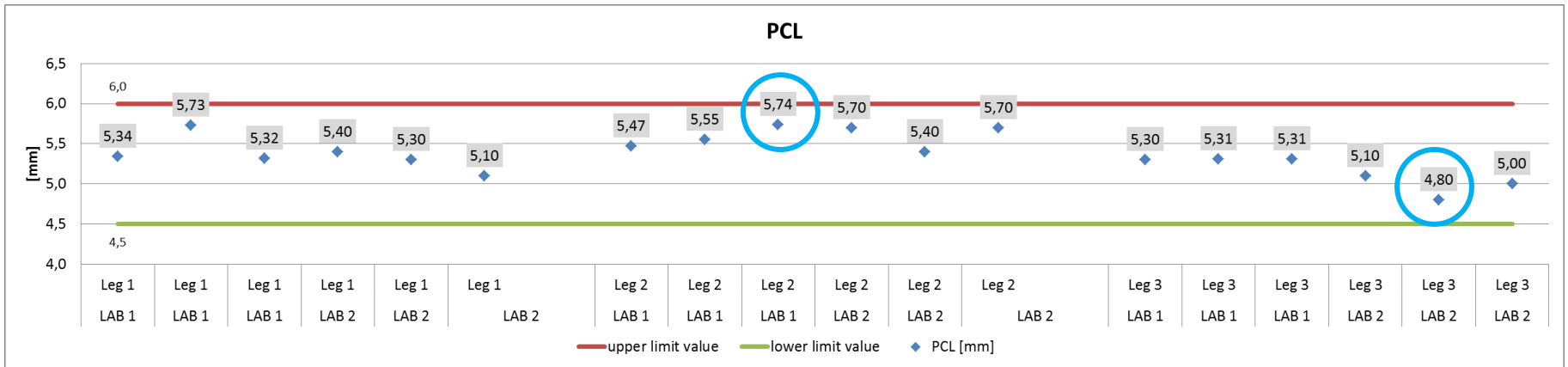
test bench	relevant limits	
LAB 2	min:	8,5
overall	max:	10,5
arithmetic mean	8,83	
standard deviation	0,57	
coefficient of variation	6,45%	

ACL	relevant limits	
overall	min:	8,5
	max:	10,5
arithmetic mean	8,96	
standard deviation	0,49	
coefficient of variation	5,52%	

○ highest and lowest value

Inverse Certification Test Results – PCL

- All test results are around the middle or in the upper half of the corridor



test bench	relevant limits	
LAB 1	min:	4,5
overall	max:	6
arithmetic mean	5,41	
standard deviation	0,18	
coefficient of variation	3,32%	

test bench	relevant limits	
LAB 2	min:	4,5
overall	max:	6
arithmetic mean	5,36	
standard deviation	0,29	
coefficient of variation	5,41%	

PCL	relevant limits	
overall	min:	4,5
	max:	6
arithmetic mean	5,38	
standard deviation	0,28	
coefficient of variation	5,14%	

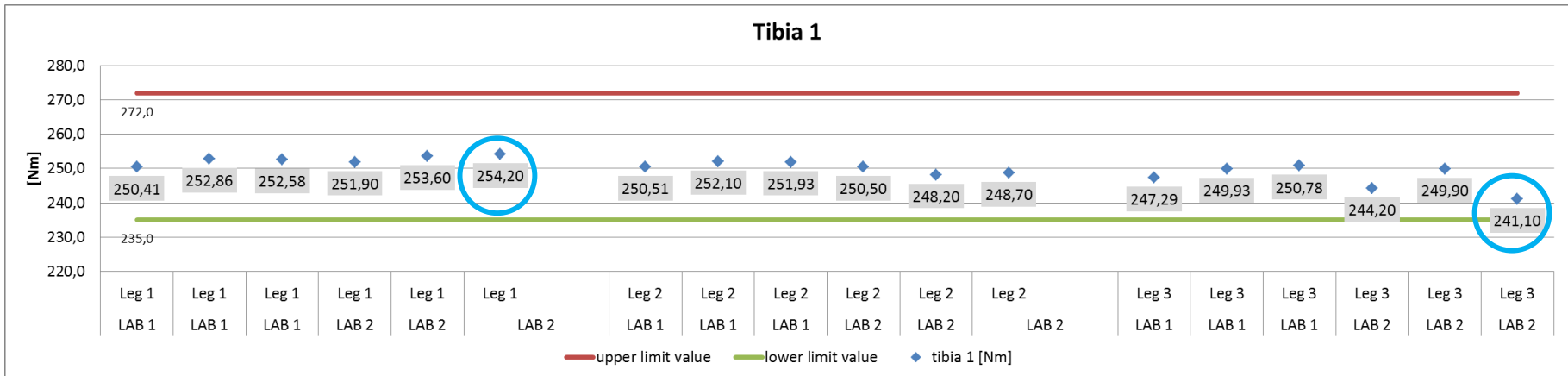
 highest and lowest value

Agenda

1. Test Series
2. Legforms
3. Inverse Certification Test Results
- 4. Pendulum Certification Test Results**
5. Discussion

Pendulum Certification Test Results – Tibia 1

- All test results meet the corridor, most test results are in the lower half
- For tests of legform 3 in lab 2, test results significantly scatter



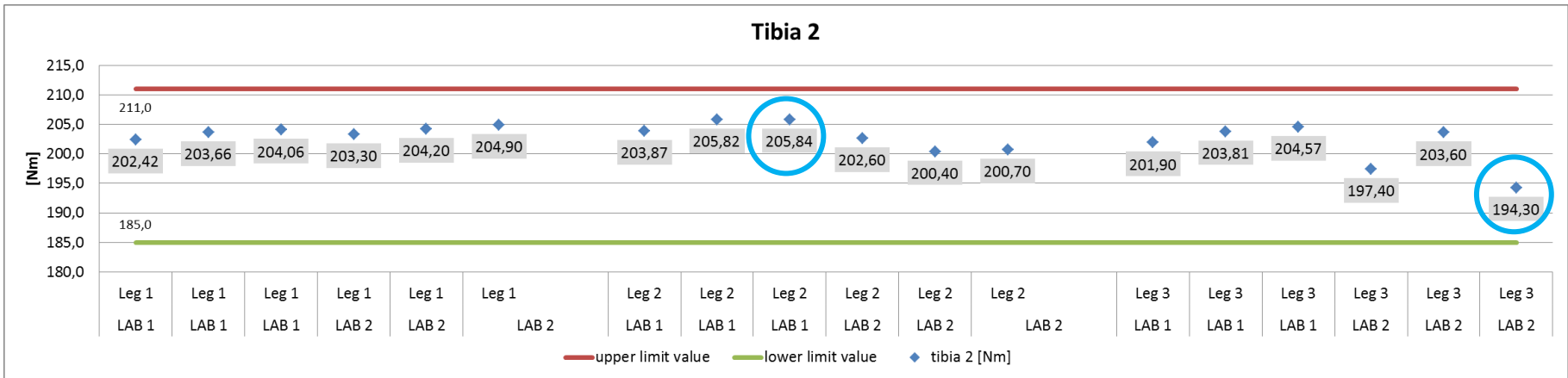
test bench	relevant limits	
LAB 1	min:	235
overall	max:	272
arithmetic mean	250,93	
standard deviation	1,62	
coefficient of variation	0,64%	
test bench	relevant limits	
LAB 2	min:	235
overall	max:	272
arithmetic mean	249,14	
standard deviation	4,02	
coefficient of variation	1,61%	

Tibia 1 overall	relevant limits	
	min:	235
	max:	272
arithmetic mean	250,04	
standard deviation	3,19	
coefficient of variation	1,28%	

○ highest and lowest value

Pendulum Certification Test Results – Tibia 2

- All test results meet the corridor, most test results are in the upper half
- Again, for legform 3 test results significantly scatter during tests in lab 2



test bench	relevant limits	
LAB 1	min:	185
overall	max:	211
arithmetic mean	203,99	
standard deviation	1,25	
coefficient of variation	0,61%	

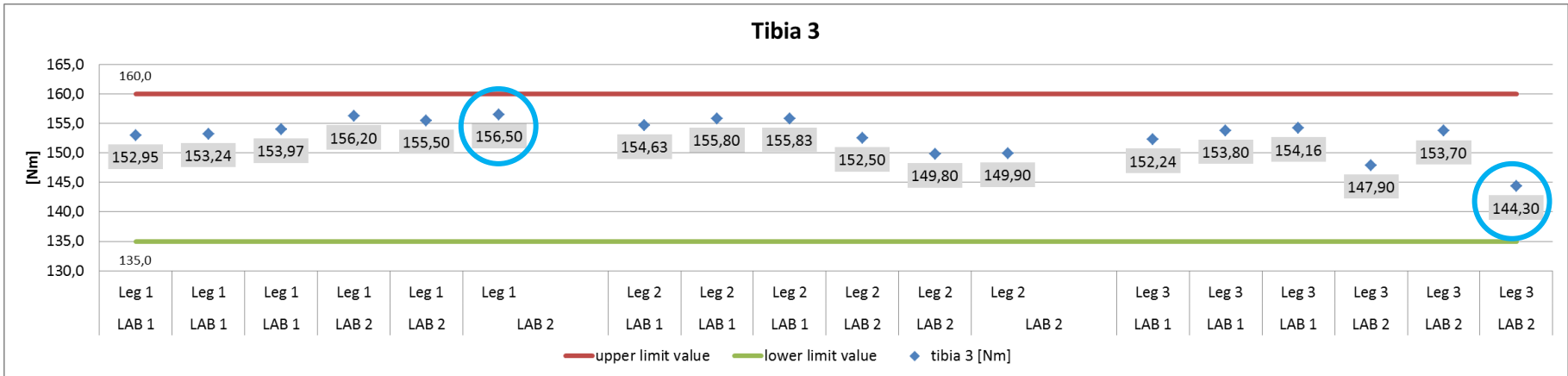
test bench	relevant limits	
LAB 2	min:	185
overall	max:	211
arithmetic mean	201,27	
standard deviation	3,30	
coefficient of variation	1,64%	

Tibia 2 overall	relevant limits	
	min:	185
	max:	211
arithmetic mean	202,63	
standard deviation	2,84	
coefficient of variation	1,40%	

highest and lowest value

Pendulum Certification Test Results – Tibia 3

- Most test results are in the upper half of the corridor
- Again, for legform 3 test results significantly scatter during tests in lab 2



test bench	relevant limits	
LAB 1	min:	135
overall	max:	160
arithmetic mean	154,07	
standard deviation	1,14	
coefficient of variation	0,74%	

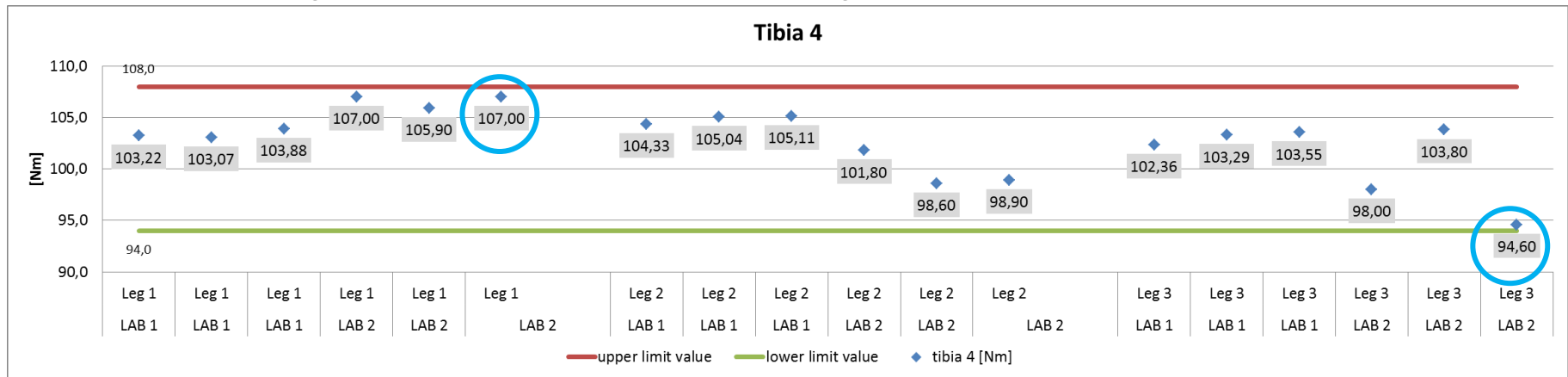
test bench	relevant limits	
LAB 2	min:	135
overall	max:	160
arithmetic mean	151,81	
standard deviation	3,92	
coefficient of variation	2,58%	

Tibia 3 overall	relevant limits	
	min:	135
	max:	160
arithmetic mean	152,94	
standard deviation	3,10	
coefficient of variation	2,03%	

○ highest and lowest value

Pendulum Certification Test Results – Tibia 4

- For all legforms, significant scatter of the test results can be noted
- For tests of legforms 2 and 3 in lab 2, test results significantly scatter



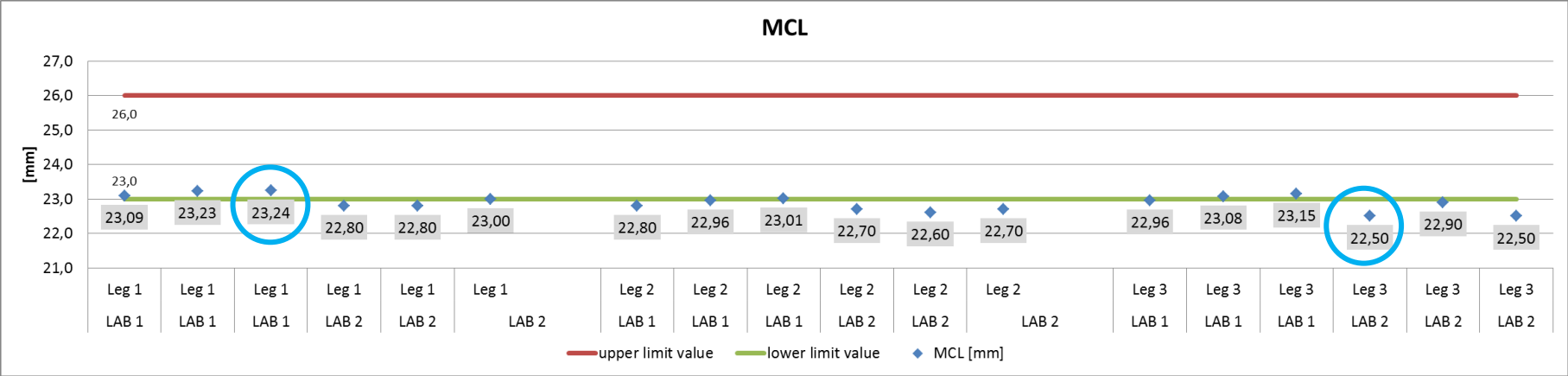
test bench	relevant limits	
LAB 1	min:	94
overall	max:	108
arithmetic mean	103,76	
standard deviation	0,87	
coefficient of variation	0,84%	
test bench	relevant limits	
LAB 2	min:	94
overall	max:	108
arithmetic mean	101,73	
standard deviation	4,21	
coefficient of variation	4,14%	

Tibia 4 overall	relevant limits	
	min:	94
	max:	108
arithmetic mean	102,75	
standard deviation	3,21	
coefficient of variation	3,12%	

highest and lowest value


Pendulum Certification Test Results – MCL

- All test results are around the lower limit value but regularly miss to meet the corridor



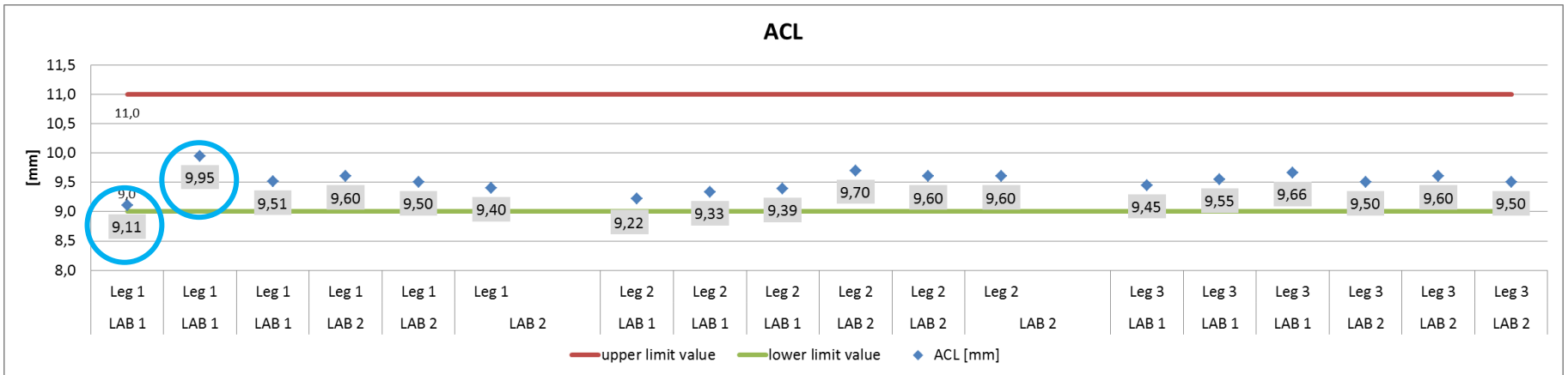
test bench	relevant limits	
LAB 1	min:	23
overall	max:	26
arithmetic mean	23,06	
standard deviation	0,13	
coefficient of variation	0,58%	
test bench	relevant limits	
LAB 2	min:	23
overall	max:	26
arithmetic mean	22,72	
standard deviation	0,16	
coefficient of variation	0,71%	

MCL overall	relevant limits	
	min:	23
	max:	26
arithmetic mean	22,89	
standard deviation	0,22	
coefficient of variation	0,98%	

 highest and lowest value

Pendulum Certification Test Results – ACL

- All test results are in the lower half of the corridor



test bench	relevant limits	
LAB 1	min:	9
overall	max:	11
arithmetic mean	9,46	
standard deviation	0,23	
coefficient of variation	2,47%	

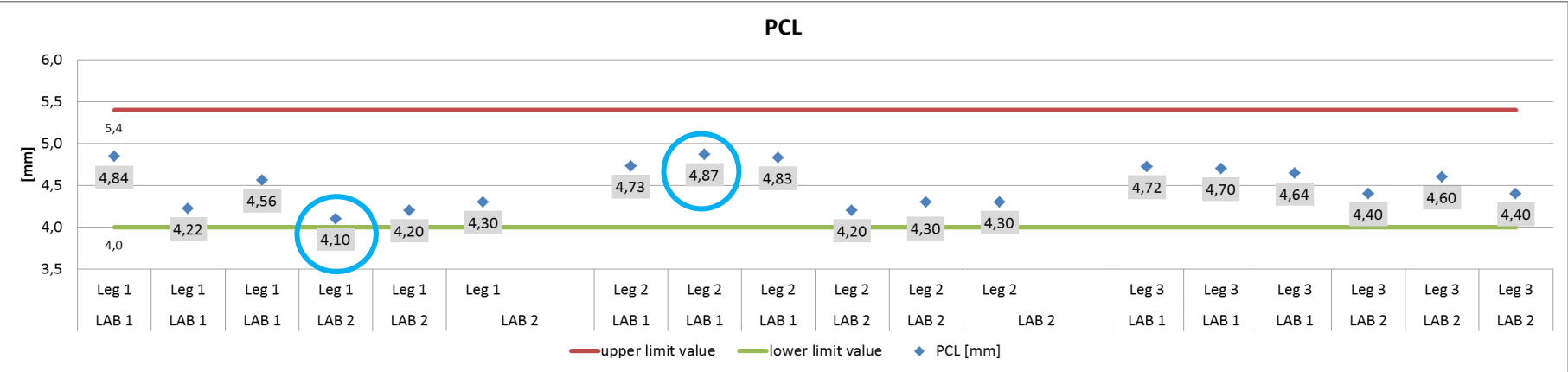
test bench	relevant limits	
LAB 2	min:	9
overall	max:	11
arithmetic mean	9,56	
standard deviation	0,08	
coefficient of variation	0,87%	

ACL overall	relevant limits	
	min:	9
	max:	11
arithmetic mean	9,51	
standard deviation	0,18	
coefficient of variation	1,91%	

highest and lowest value

Pendulum Certification Test Results – PCL

- All test results are in the corridor but show significant scatter



test bench	relevant limits	
LAB 1	min:	4
overall	max:	5,4
arithmetic mean	4,68	
standard deviation	0,19	
coefficient of variation	4,01%	
test bench	relevant limits	
LAB 2	min:	4
overall	max:	5,4
arithmetic mean	4,31	
standard deviation	0,14	
coefficient of variation	3,18%	

PCL overall	relevant limits	
	min:	4
	max:	5,4
arithmetic mean	4,50	
standard deviation	0,25	
coefficient of variation	5,48%	

highest and lowest value

Agenda

1. Test Series
2. Legforms
3. Inverse Certification Test Results
4. Pendulum Certification Test Results
- 5. Discussion**

Discussion

- Test results generally are very promising: Meeting the corridors for both certification tests, the inverse as well as the pendulum test, with one single impactor is in principle possible
- In addition, in most cases scatter of the test results is acceptable
- However, test results also indicate that there may be a need to slightly shift the corridors to allow serial production legforms reliably meeting the corridors that were defined using prototype legforms
- Further testing seems necessary to assess whether test results can be generally confirmed
- Further testing seems also necessary to assess the long time performance of the legforms
- The root causes for the scatter noted with different legforms and in between the two labs should be investigated
- It remains unclear what can be done if a legform constantly fails meeting the corridors
- Measures seem necessary that would allow a fine tuning of the respective legforms

Thanks.

