

First Technology Safety Systems

FLEX-PLI-GTR Development

Review Dynamic Calibration Procedures

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BASt, Bergisch Gladbach, Germany

Content

- Review comments on GT procedure TEG-062
- Review GTR procedure
- Review Linear Guided Impactor proposal
- Comparison GTR Pendulum and Linear Guided Impactor proposal
- Recommendation
- Summary of pendulum procedure (for completeness)

Review TEG -062

TEG-062: ‘Test results are far out of a critical range and don’t mirror the real accident / injury scenario’

- **Tibia moment test <140Nm, tentative Injury threshold ~300Nm**
- **MCL test 12mm, tentative Injury threshold 18-20mm**
- **ACL test 4mm, tentative Injury threshold 11mm**
- **Valid concern! Is addressed in GTR procedure**
 - **Tibia moment test 240Nm, tentative Injury threshold ~300Nm**
 - **MCL test 22mm, tentative Injury threshold 18-20mm**
 - **ACL test 8mm, tentative Injury threshold 11mm**

GTR Calibration	Knee Acceleration	Femur Gage 1	Femur Gage 2	Femur Gage 3	Tibia Gage 1	Tibia Gage 2	Tibia Gage 3	Tibia Gage 4	Peak ACL	Peak MCL	Peak LCL	Peak PCL
Average	75.3	179	137	91.6	243	201	160	108	8.2	22.4	4.4	4.9
St.Dev	4.2	3.1	1.9	1.7	3.7	3.3	6.8	1.5	0.3	0.1	0.1	0.3
CV[%]	5.6	1.7	1.4	1.9	1.5	1.6	4.3	1.4	3.8	0.3	1.8	7.0

Review TEG - 062

TEG-62: 'Certification of the impactor without flesh and skin'

- **Valid concern! How to control the response of the skin?**
- **Quantify influence skin property on test results: study JARI: negligible difference between 30&45shoreA**
- **Linear guided procedure: if the test fails, how do you know the source: honeycomb, skin/flesh, or impactor?**
 - Linear guided impactor does not solve the problem
 - Linear guided impactor gives additional problem: honeycomb

Potential solution

- **Facultative skin-flesh performance test based on dynamic stopper block test procedure**

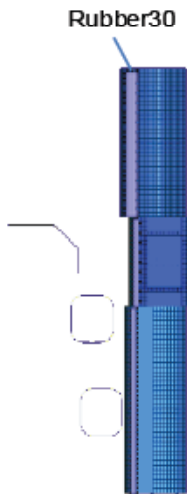
Flex-GT Rubber Stiffness

28 April 2008
JARI

Initial plan

Rubber30:

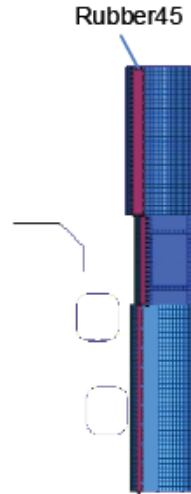
Flex-GT-prototype model,
H_i: Base + 50 mm



Actual use

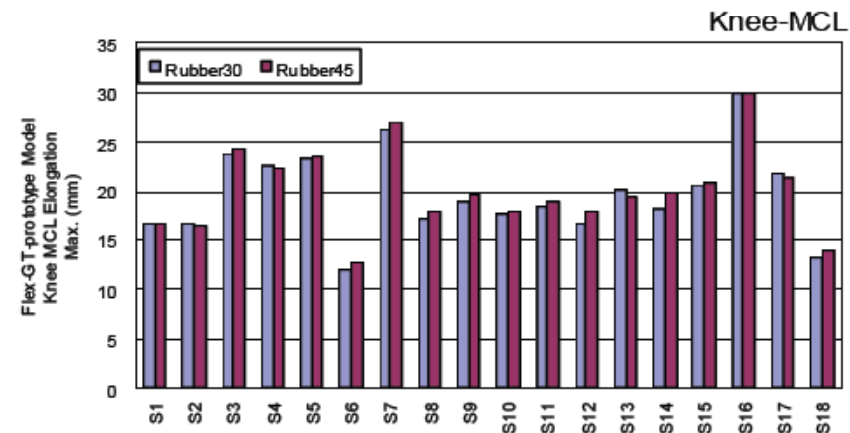
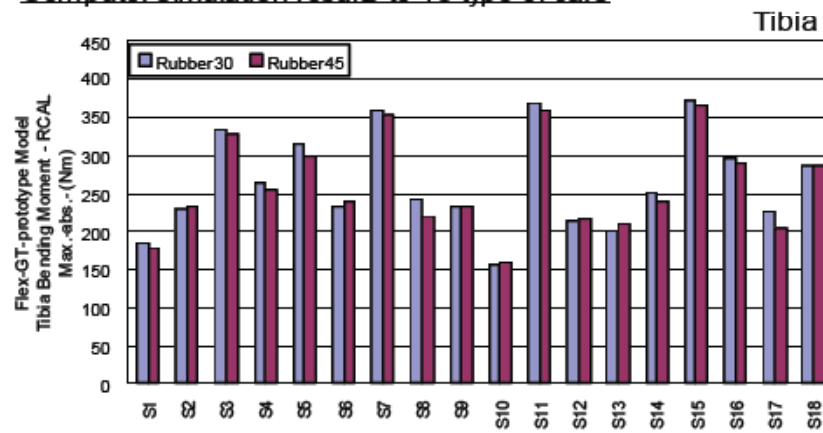
Rubber45:

Flex-GT-prototype model,
H_i: Base + 50 mm



Comparisons	Rubber 30	Rubber 45
Availability	Difficult to obtain (Special order is required)	Easy to obtain (Standard stiffness)
Price	Expensive (Special order)	Reasonable (Standard stiffness)
Productivity	Not easy (Relatively soft)	Easy (Standard stiffness)
Durability	Less durable (Relatively soft)	Durable (Standard stiffness)

Computer simulation results to 18 type of cars



Information of 18 type of cars.: 20th ESV, Paper No. 07-0178

Review TEG - 062

TEG-062 'Certification does not necessarily reveal existing defects / malfunctions'

TEG-062 'Certification does not ensure proper functionality of impactor'

- **Not valid. The pendulum test results are very repeatable, if there is problem the test would identify find it**
- **This is a generic problem. No certification procedure can provide 100% certainty in a single test.**

TEG-062 'Inverse certification test shows a higher scatter within test results'

- **Again, possible defects / malfunctions could become more obvious with inverse certification test**
- **Please explain this.**

Review TEG - 062

TEG-062 'Certification after each test necessary high effort needed'

- **Not valid. Frequency of test is not dependent from type of certification Linear Guided or Pendulum**

TEG-062 'Hard impact: neoprene / rubber sheets on steel beam are used as substitute for legform flesh'

- **test represents legform impact against rigid object.**
- **Not valid. The test condition is simplified to minimise variation of parameters**
- **Hard contact is generally accepted method to reduce variation**
 - **Examples dummy head drop, pendulum impacts chest, knee, etc.**

Review TEG - 062

TEG-062 'Influence of stopper and neoprene / rubber sheets on test results disproportionately high (independent from stopper material control)'

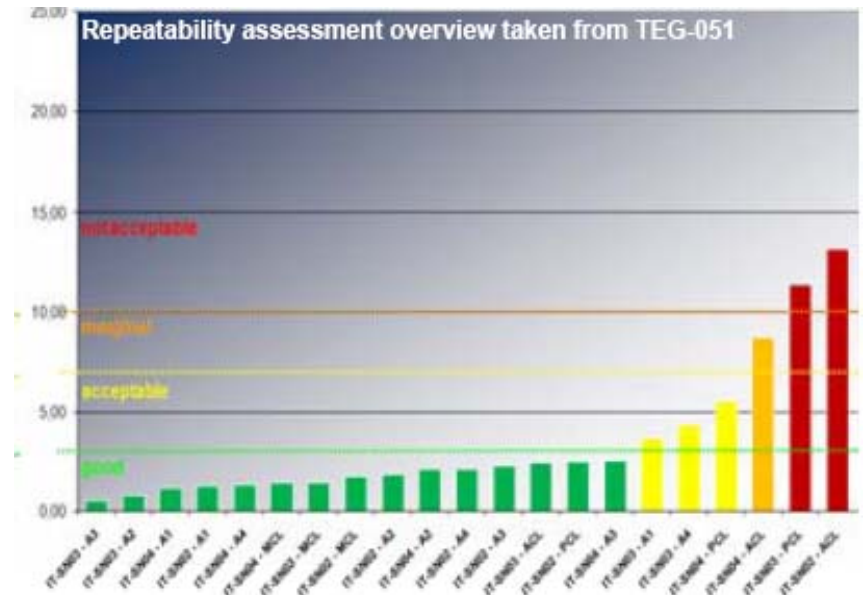
- **Concern is addressed by introduction of two counter measures to control impact pulse consistency:**
 - Knee-tibia accelerometer
 - Stopper block dynamic test
- **Not valid. The GTR dynamic calibration results are highly reproducible.**
 - 'Disproportionately high' is based on what data?

TEG-062 'Consistency test of stopper needed (see TEG-056)'

- Addressed in GTR pendulum procedure

Review Linear Guided Impactor proposal TEG-052 & TEG-062

- Use of complicated equipment
- Use of consumables each test (honeycomb)
- Introduction of variables
 - Honeycomb
 - Impact speed
 - Impact height
 - Different equipment between labs
- Additional wear and potential damage of skin by sharp honeycomb
- Reproducibility not as good as GTR pendulum test (by far)
- TEG-062 'Inverse test shows a higher scatter within test results'



GTR pendulum procedure

- + Results of 12 tests with three impactors given
- + Highly repeatable, Highly reproducible
- + Simple test
- + Simple equipment
- + Test results relevant for and close to injury criteria
- + Separate test for skin/flesh if necessary

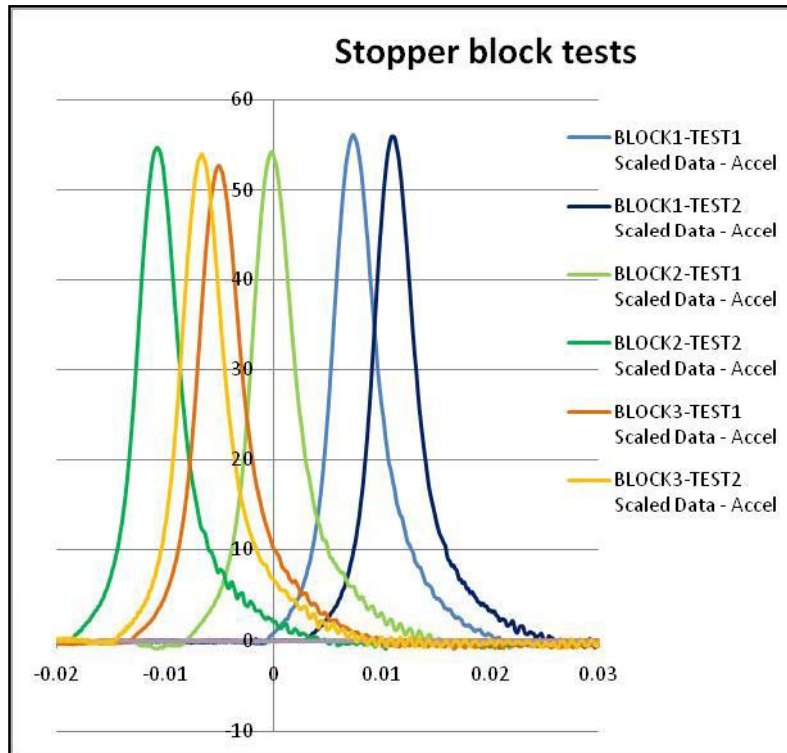
GTR Dynamic calibration results	Acceln. knee	Femur Gauge 1	Femur Gauge 2	Femur Gauge 3	Tibia Gauge 1	Tibia Gauge 2	Tibia Gauge 3	Tibia Gauge 4	Peak ACL	Peak MCL	Peak LCL	Peak PCL
Average	75.3	179.4	136.7	91.6	242.5	201.1	160.0	108.0	8.19	22.4	4.37	4.91
St.Dev	4.2	3.1	1.9	1.7	3.7	3.3	6.8	1.5	0.3	0.1	0.1	0.3
CV[%]	5.6	1.7	1.4	1.9	1.5	1.6	4.3	1.4	3.8	0.3	1.8	7.0
Criteria		300	300	300	300	300	300	300	11	20	20	11
St.Dev/ Criteria [%]		1.0	0.6	0.6	1.2	1.1	2.3	0.5	2.8	0.4	0.4	3.1

Recommendation

- Adopt GTR pendulum procedure
 - Updated GT procedure
 - Addition of 5kg mass
 - Addition of knee accelerometer
 - Inclined stopper block
 - Stopper block dynamic test
- Consider facultative dynamic stopper drop test for skin/flesh
- Agree on frequency of the tests

Dynamic stopper block test

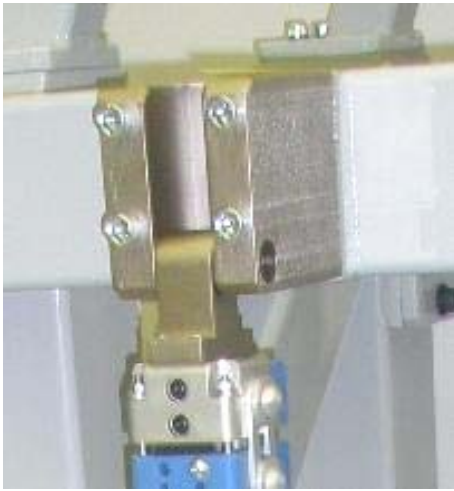
- Drop test 200mm, 2m/s
- Drop mass 7.00kg steel bar, Ø50mm, rounded edge
- Record drop mass acceleration
- Stopper block as used in dynamic calibration test
 - 3 layers of Chloroprene rubber, 2 layers of Neoprene



block #1	56.2
	55.8
block #2	54.5
	54.2
block #3	52.7
	54.0
Average	54.6
St.Dev.	1.2
CV [%]	2.1



FLEX-PLI-GTR dynamic calibration set-up



Disassembly for transport
Top bar and release mechanism

Top pivot minimum play

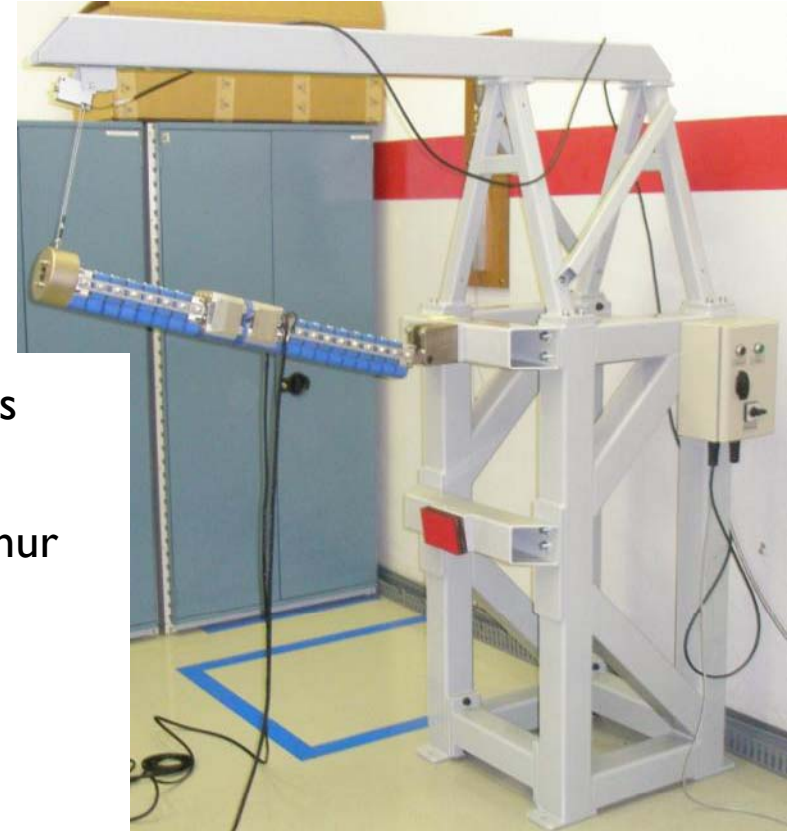
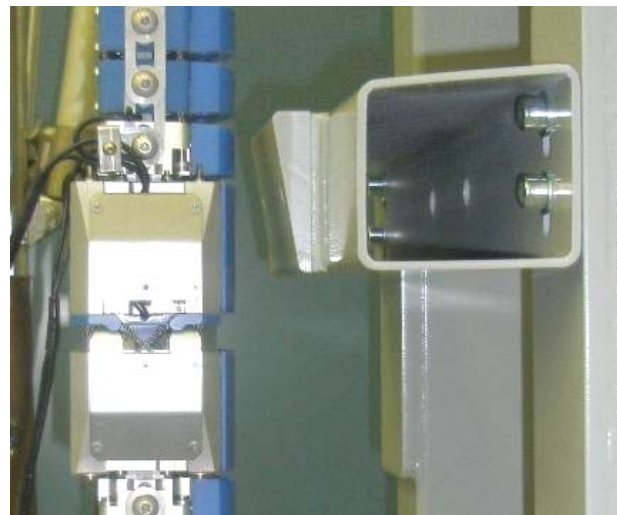
Accurate shoulder bolt

Top pivot on tibia

Hinged brackets off board cables

10 deg inclined stopper bar

5kg calibration mass bottom femur



Summary dynamic calibration

TEST #1 Leg #1	75.1	177	135	90	246	201	160	108	8.03	22.4	4.29	4.99
TEST #2 Leg #1	82.9	181	138	92	247	201	160	109	8.59	22.5	4.33	4.41
TEST #3 Leg #1, block #1	82.2	179	136	91	245	200	159	108	8.61	22.4	4.30	4.37
TEST #4 Leg #1, block #1	78.7	175	135	90	241	195	156	106	8.64	22.5	4.24	4.38
TEST #1 Leg #2, block #2	74.0	175	134	90	235	197	152	106	8.16	22.2	4.30	4.85
TEST #2 Leg #2, block #1	69.2	177	135	92	241	199	153	107	7.79	22.4	4.42	5.26
TEST #3 Leg #2, block #2	71.6	181	137	94	245	204	158	111	7.89	22.4	4.46	5.25
TEST #4 Leg #2, block #1	72.1	176	135	92	241	199	153	107	7.84	22.4	4.44	5.22
TEST #5 Leg #2, block #1	73.3	183	140	96	248	205	158	110	7.87	22.5	4.48	5.18
TEST #1 Leg #3, block #1	77.2	183	138	91	239	204	170	107	8.34	22.3	4.34	4.90
TEST #2 Leg #3, block #2	75.3	183	138	91	241	205	171	108	8.30	22.4	4.40	4.95
TEST #4 Leg #3, block #1	71.8	183	138	91	242	204	171	109	8.17	22.4	4.43	5.12
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Thanks!