Proposal for a Dynamic full assembly certification test procedure (inverse certification test)

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Content

Current certification test

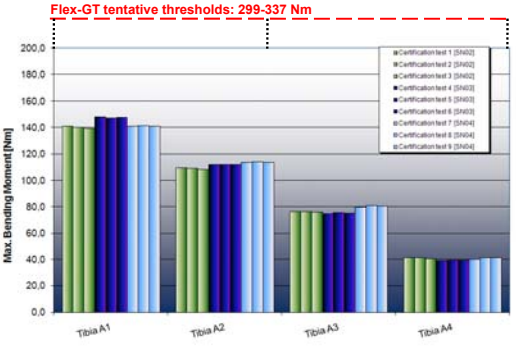
- The full calibration test procedures for the Flex-GTR (TEG-056) include a dynamic certification test
- The legform impactor is suspended upside down without flesh and skin over a pin joint from a fixed calibration rig with support arm and release magnet
- The impactor is lifted up to a (not yet) defined height and then released
- A stopper with several layers of neoprene and rubber sheets, mounted on a cross beam, is hit by the knee joint of the released impactor
- Measurement items / pass - fail parameters: string potentiometers (ACL, PCL, MCL and LCL), strain gauges (femur and tibia), tibia top accelerometer

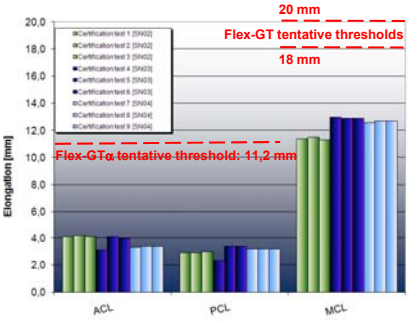
Flex-GTα certification

Flex-GTα knee detail

Current certification test

- Certification of the impactor without flesh and skin
- Certification test is just replacing a functional test of the strain gauges and string potentiometers ➔ could be replaced by a manual impactor bending
- Test results are far out of a critical range and don‘t mirror the real accident / injury scenario:





Certification test results taken from TEG-051

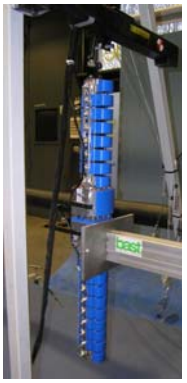
Current certification test

- **Hard impact: neoprene / rubber sheets on steel beam are used as substitute for legform flesh ➔ test represents legform impact against rigid object**
- **Influence of stopper and neoprene / rubber sheets on test results disproportionately high (independent from stopper material control)**
- **Consistency test of stopper needed (see TEG-056)**
- **Certification does not necessarily reveal existing defects / malfunctions**
- **Certification does not ensure proper functionality of impactor**
- **Certification after each test necessary ➔ high effort needed**

Content

Inverse certification test

- **Flex PLI is impacted by the upper edge of a linearly guided Al honeycomb impactor at a previously defined impact speed**
- **Impact location: upper edge of the honeycomb in line with the center of the knee**
- **Measurement items / pass - fail parameters:**
  three string potentiometers (ACL, PCL, MCL), four strain gauges (tibia)



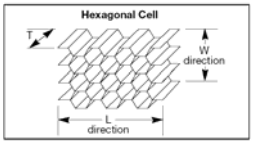
Flex-GT inverse testing

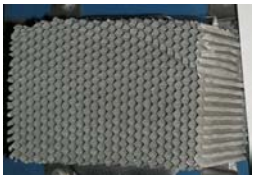
Inverse certification test

- **Test parameters:**
  - **Impact speed = 40 km/h**
  - **Mass of honeycomb impactor = 8,1 kg**
  - **Impact height: upper honeycomb edge in line with center of knee**

- **Aluminium honeycomb specifications:**

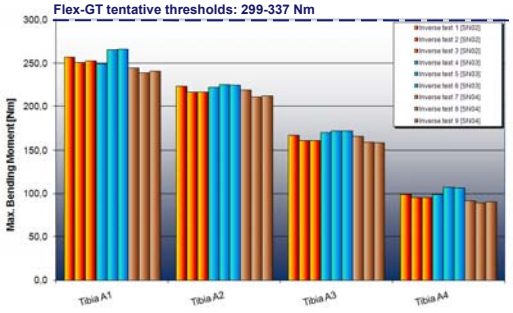
Specification	Data
Cell size	3/16
Alloy	5052
Foil gauge	.001
Density	3.1
Crush strength	75 PSI
Dimensions	250 * 160 * 60 mm

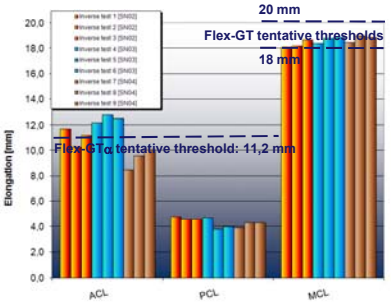




Inverse certification test

- Certification of the fully assembled impactor with flesh and skin
- Certification test checks the impactor functionality under real impact conditions
- Test results are within a more critical range and mirror the real accident / injury scenario:

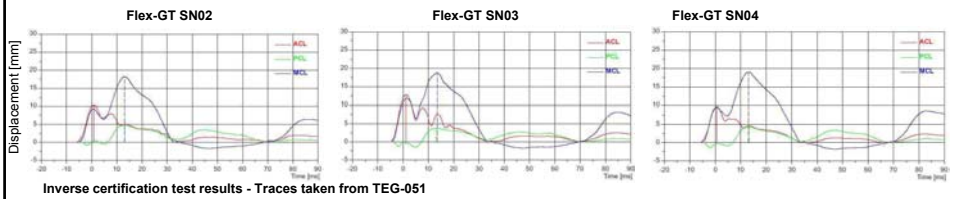




Inverse test results taken from TEG-051

Inverse certification test

- No consistency test of stopper needed
- No fixation of legform end needed
- „Soft“ impact due to deformable honeycomb material
- Certification after every 20 tests or each year ➔ lower effort needed
- Inverse certification test reveals existing defects / malfunctions better than previous procedure:



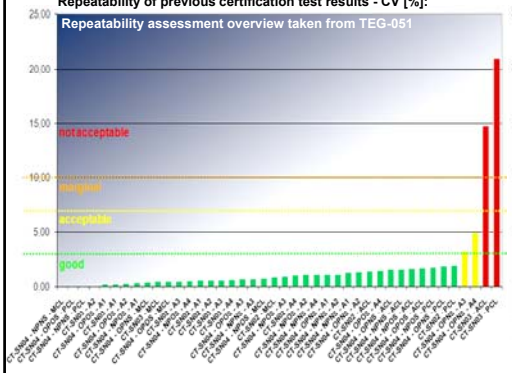
Inverse certification test results - Traces taken from TEG-051

Current certification test results

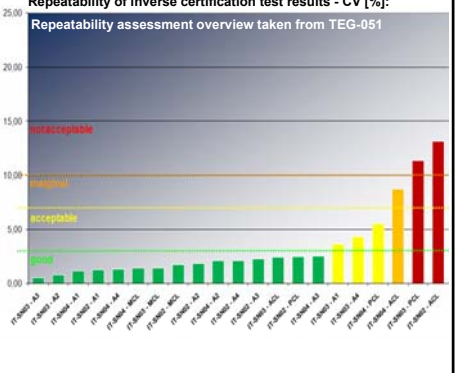
Inverse certification test

- Inverse certification test shows a higher scatter within test results
- Again, possible defects / malfunctions could become more obvious with inverse certification test:

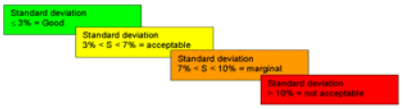
Repeatability of previous certification test results - CV [%]:



Repeatability of inverse certification test results - CV [%]:



Assessment of the standard deviation [CV] according to the requirements for dummies (best practice):



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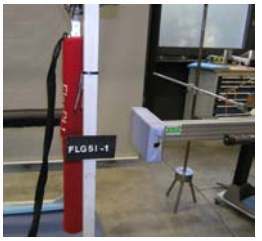
Summary

Criteria	Current certification test	Inverse certification test
Impactor assembly	w/o neoprene and rubber sheets (-)	full assembly with neoprene and rubber sheets (+)
Suspension	upside down; fixation of tibia end (-)	no fixation of legform end; in line with real car test (+)
Significance	functional test of strain gauges and string potentiometers only (-)	impactor functionality check under real impact conditions (+)
Certification results	not in the critical / injury relevant range (-)	within a more critical range reflecting the real injury scenario (+)
Additional tests	consistency test of stopper needed (-)	no additional test needed (+)
Efforts for single certification test	comparatively low (+)	comparatively high (-)
Frequency	after each test (-)	after 20 tests / each year (+)
Impact	„hard“ - legform impact against rigid object (neoprene / rubber sheets on steel beam are used as substitute for legform flesh) (-)	„soft“ due to honeycomb material (+)
Influence of flesh simulation on test results	too high weighting of stopper and neoprene / rubber sheets – hard impact material used (-)	balanced weighting - deformable impact material used(+)
Defects	not necessarily revealed (-)	revealed better because test conditions are reflecting better the real impact scenario (+)
Expendables	neoprene / rubber sheets for stopper	honeycombs
Others	measuring channels to assess the impactor functionality are partly not used for injury assessment	tendencies of current certification test can be stressed by inverse test

Content

Next steps

- **Inverse certification test results should mirror the critical values w.r.t. the Flex PLI injury criteria**
- **Definition of aluminium honeycomb specifications:**
  - **Cell size**
  - **Alloy**
  - **Foil gauge**
  - **Density**
  - **Crush strength**
  - **Honeycomb dimensions**
- **Definition of test parameters:**
  - **Impact speed**
  - **Mass of honeycomb impactor**
  - **Impact height**



- **Development of a certification test protocol (including specs, corridors etc.)**
- **Round robin evaluation tests (repeatability, reproducibility, applicability)**

Thank you!

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