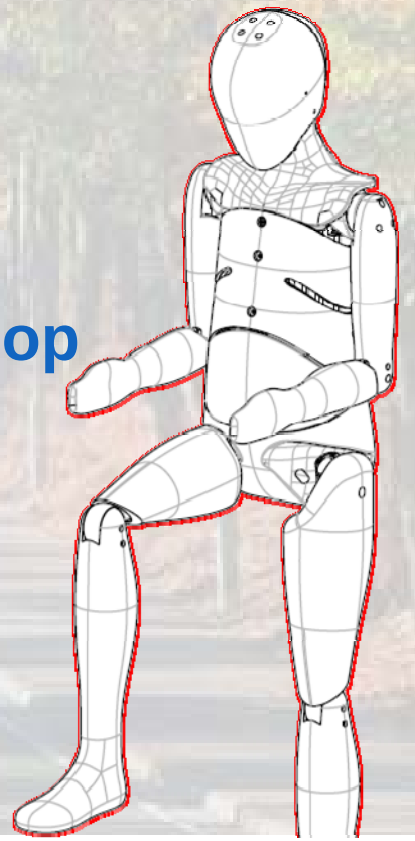
EPOCh – COVER – CASPER workshop
November 29 and 30, 2010

Q10 Biomechanical Requirements



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Introduction

This presentation aims to describe the biomechanical requirements of the Q10 dummy.

The size of the dummy is based on CANDAT (**C**hild **AN**thropometry **DAT**abase) for 10 yo children.

Biofidelity compliances are scaled with anthropometry and stiffness data, and are consistent with the Q dummy family. All these considerations were presented in different forums during the first half of the project.

The biomechanical performance of the Q10 will be covered in another presentation.

Content

1. Background

- The Q 10 dummy is the latest in the Q family, and testing with it has already started.
- Whereas the P family acted as loading devices with appropriate size and mass distributions, the Q dummies are specifically designed to have human like behaviour with regard to kinematics, humanetics and biomechanics.
- The entire Q family has been tested using EEVC reference values. For lateral impact; ISO references using the HYBRID III dummy family are also provided (although ultimately not used).
- Q dummies incorporate additional measurement capabilities, and new important injury criteria can be assessed in addition to those required by the ECE R44.

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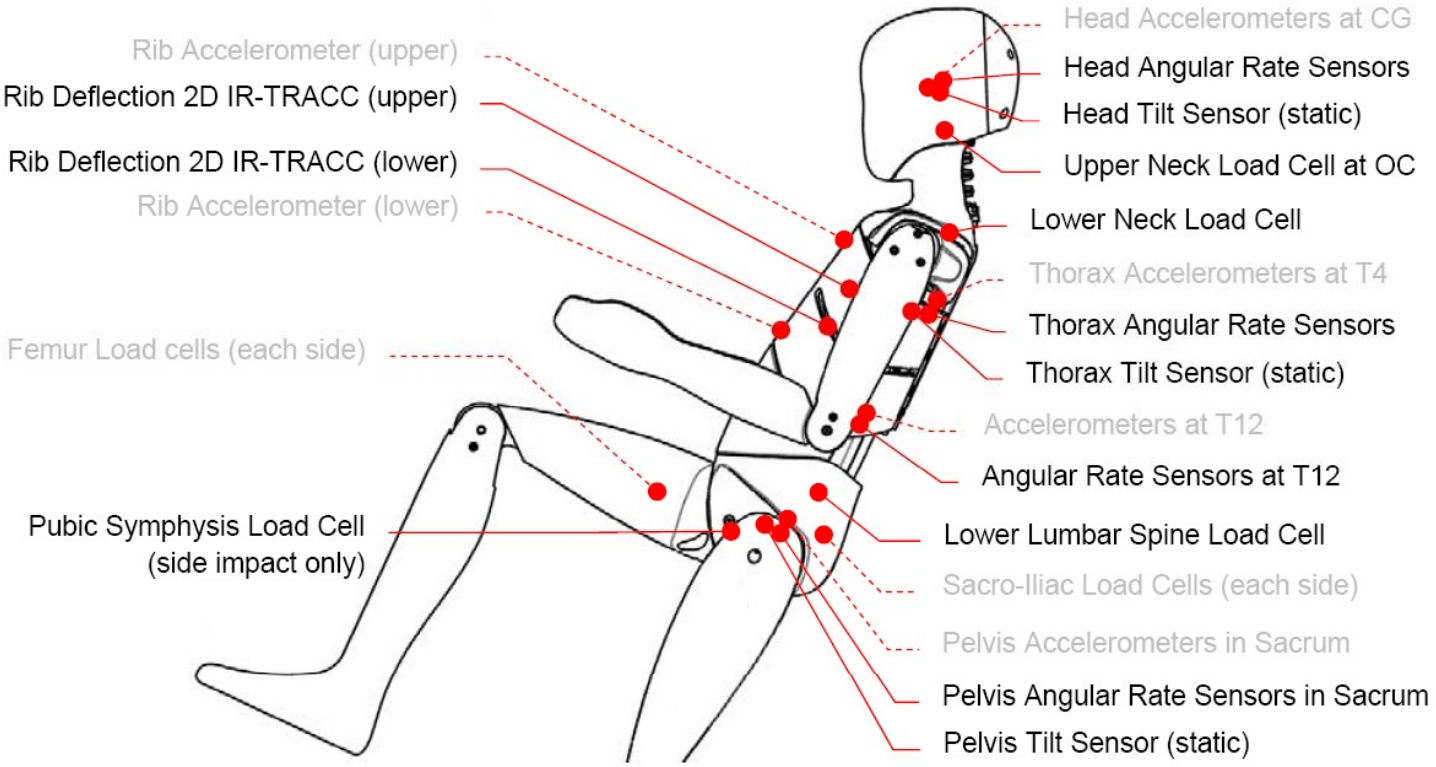
1. Background: Q10 dummy instrumentation overview

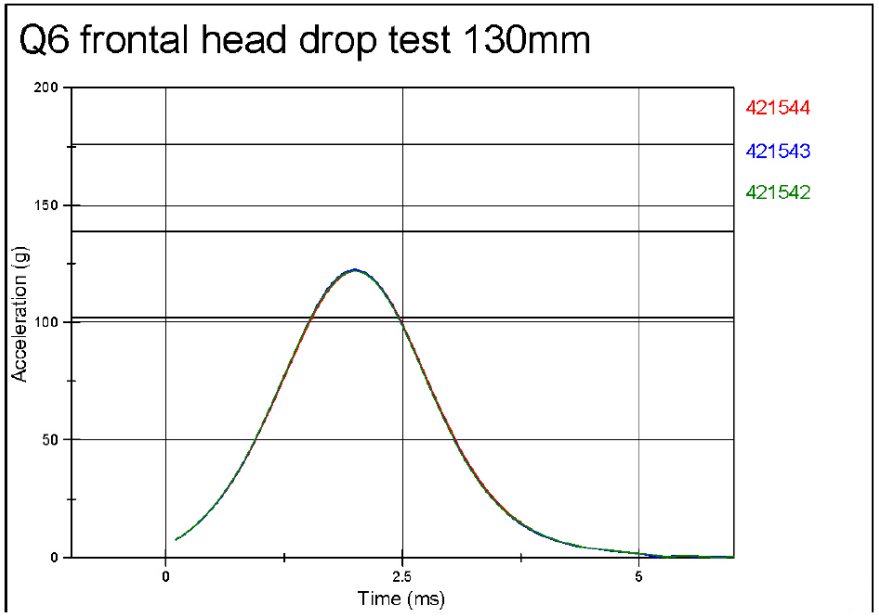


2. Frontal Impact: targets

- The Q10 focuses mainly on the frontal impact performance.
- Biofidelity impact response set up for head, neck, thorax, abdomen and lower extremities.
- Biofidelity is based on the scaling of adult performance targets with geometrical and material property scaling factors. This scaling is based on CANDAT.

2.1 - Head: Performance target in frontal impact test

Description Age in years	CANDAT code	Q6 6.0	Q10 10.5
Head peak acceleration between			
Upper limit in [G]		176	**194.2**
Lower limit in [G]		102	**113.1**

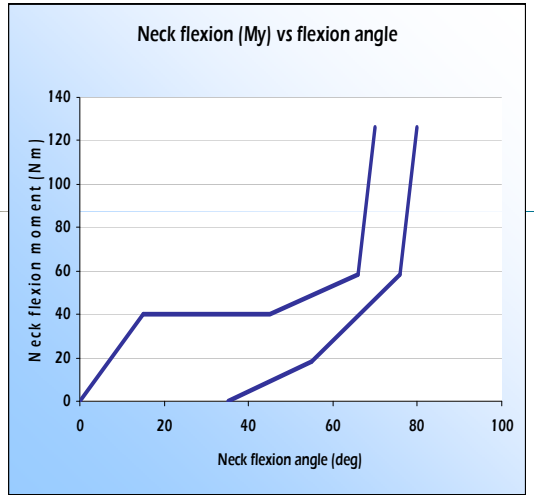


e.g. Q6 corridor

- Biofidelity performance needs to comply with a standard drop table impact test setup (EEVC).
- Drop height is set at 130mm.
- Corridors:
  - Lower limit (g) : 113,1
  - Upper limit (g) : 194,2

2.3 - Neck performance target in frontal impact test

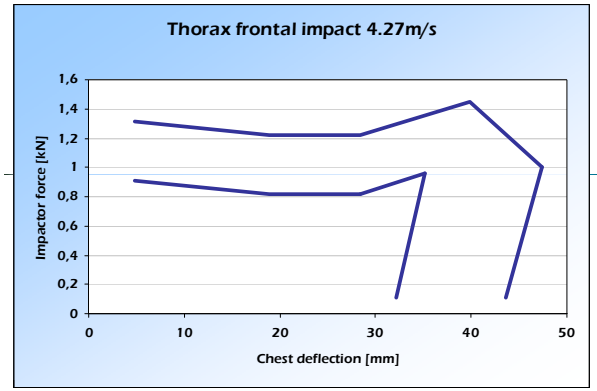
Description Age in years	CANDAT code	Q6 6.0		Q10 10.5	
		Degr.	Nm	degr.	Nm
Upper limit		0	0.00	0	0.00
		15	30.3	15	40.4
		45	30.3	45	40.4
		66	43.7	66	58.3
		70	94.3	70	125.8
Lower limit		35	0.0	35	0.0
		55	13.4	55	17.9
		76	43.7	76	58.3
		80	94.3	80	125.8

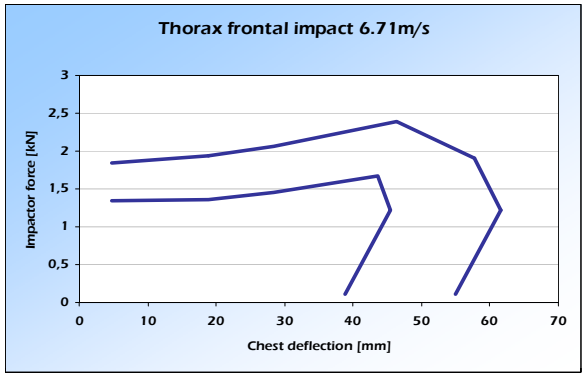


- EEVC Reference values
- Impactor weights different for each test.

2.3 Thorax performance target in frontal impact test

Description	CANDAT code	Q6		Q10	
Age in years		6.0		10.5	
4.27 m/s impact		[mm]	[dN]	[mm]	[dN]]
Upper limit		4.4	0.87	4.8	1.31
		17.3	0.81	18.9	1.22
		25.9	0.81	28.4	1.22
		36.3	0.96	39.8	1.45
		43.2	0.66	47.4	1.00
		39.7	0.07	43.6	0.11
Lower limit		4.4	0.60	4.8	0.91
		17.3	0.54	18.9	0.82
		25.9	0.54	28.4	0.82
		32.0	0.63	35.1	0.96
		29.4	0.07	32.2	0.11
6.71 m/s impact		[mm]	[dN]	[mm]	[dN]]
Upper limit		4.4	1.22	4.8	1.85
		17.3	1.28	18.9	1.94
		25.9	1.37	28.4	2.07
		42.3	1.58	46.4	2.39
		52.7	1.25	57.8	1.90
		56.2	0.81	61.6	1.22
		50.1	0.07	55.0	0.11
Lower limit		4.4	0.89	4.8	1.35
		17.3	0.90	18.9	1.36
		25.9	0.96	28.4	1.45
		39.7	1.10	43.6	1.67
		41.5	0.81	45.5	1.22
		35.4	0.07	38.9	0.11





- EEVC Reference values
- Full body pendulum impactor tests at 4.27 and 6.71 m/s.
- Impactor weights different for each test.

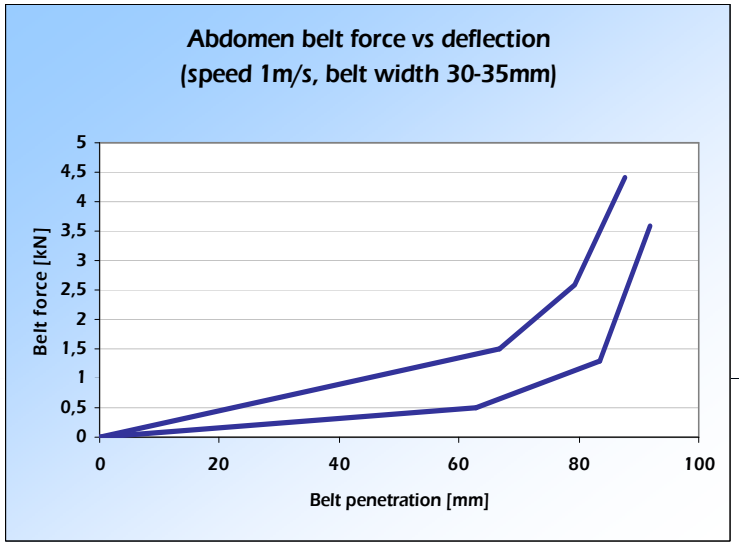
2.4 Lumbar spine in frontal impact test

Assuming the spinal cord development during the growth of a child is consistent over its entire length, the scaling method used is based on the geometrical data of the human neck

- Target for lateral bending stiffness: 137,1 Nm/rad

Description	Q6	Q10
Age in years	6.75	10.5
Lateral bending stiffness in [Nm/rad]	102.8	**137.1**

2.5 Abdominal targets in frontal impact test



Description		Q6		Q10	
Age in years		6.0		10.5	
Belt force		0.375		**0.515**	
Belt penetration		0.700		**0.836**	
		mm	kN	**mm**	**kN**
Upper limit		0.0 56.0 66.5 73.7	0.0 1.1 1.9 3.2	0.0 66.8 79.4 87.7	0.0 1.5 2.6 4.4
Lower limit		0.0 52.4 70.0 77.2	0.0 0.4 0.9 2.6	0.0 62.7 83.6 91.9	0.0 0.5 1.3 3.6

Tests

- Rouhana test: uses a seat belt with width of 30-35mm to penetrate into the abdomen at the L4 vertebrae, speed of 1m/s up to a deflection of 50% of the torso depth at waist.
- Static flat plate intrusion test: deflection/depth ratio will give a stiffness percentage, from which it can be determined whether a softer or stiffer abdomen is needed.

3.0 Lateral impact: targets

- Several provisions will be introduced where possible to allow for side impact testing, however frontal impact is prioritised.
- Biofidelity impact response set up for head, neck, thorax, abdomen shoulder and pelvis.
- Side impact biofidelity is based on the scaling of adult performance targets with geometrical and material property scaling factors. This scaling is based on CANDAT.
- ISO tests are based on the Hybrid III dummies (10yo for the following comparisons)

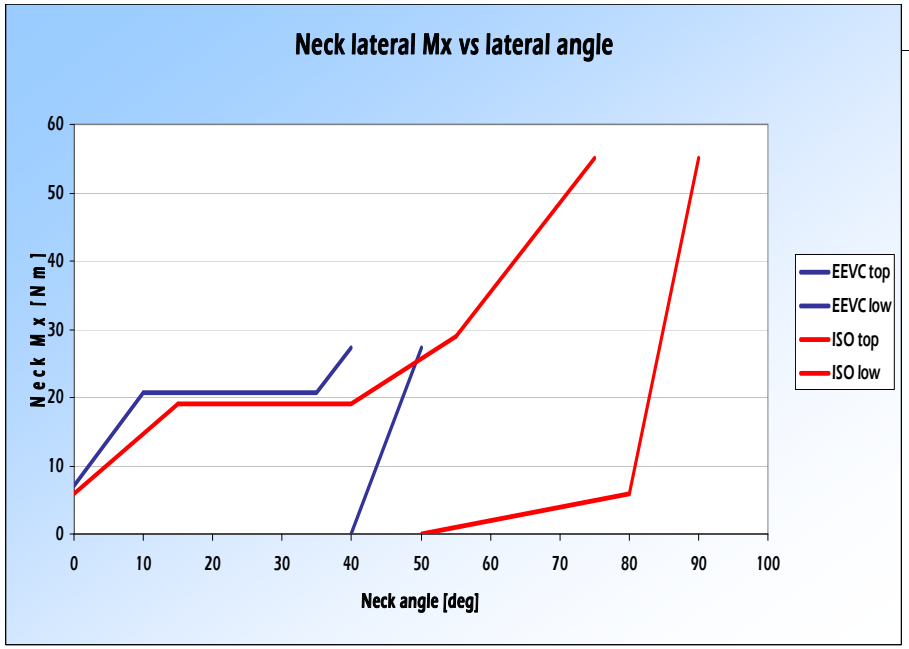
3.1 Head in lateral impact test

EEVC and ISO methods.

Different corridors:	Comparison

▪ EEVC (Q series) methodology
  ▪ 116.4-200G
  ▪ Drop height: 130mm
▪ ISO TR9790 methodology
  ▪ 107-161G
  ▪ Drop height: 200mm
OR
  ▪ 220-297G
  ▪ Drop height (on padded surface): 1200mm
	▪ European approach excludes skull fracture cases because the dummies should then operate under low severity level below skull fracture.
	▪ ISO targets are based on fracture and non-fracture head drop tests.
	▪ Consequently, cannot harmonise the two methods.
	▪ It is recommended to use the European method for side impact head performance evaluation.

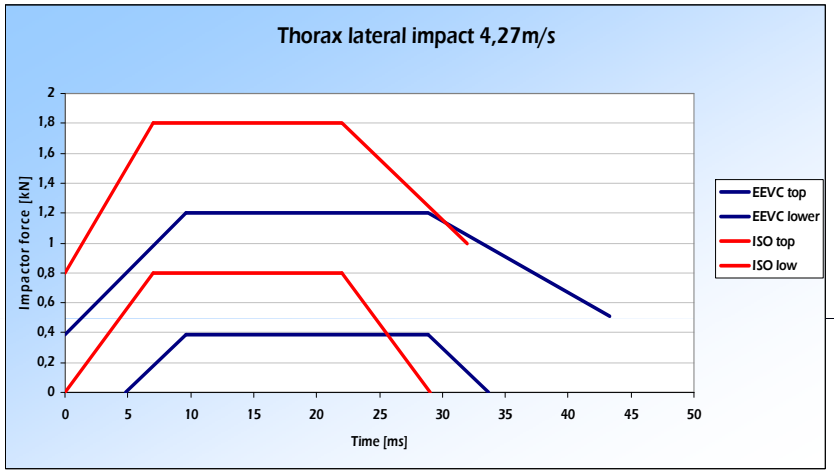
3.2 Neck: EEVC & ISO corridor comparison in lateral impact test.

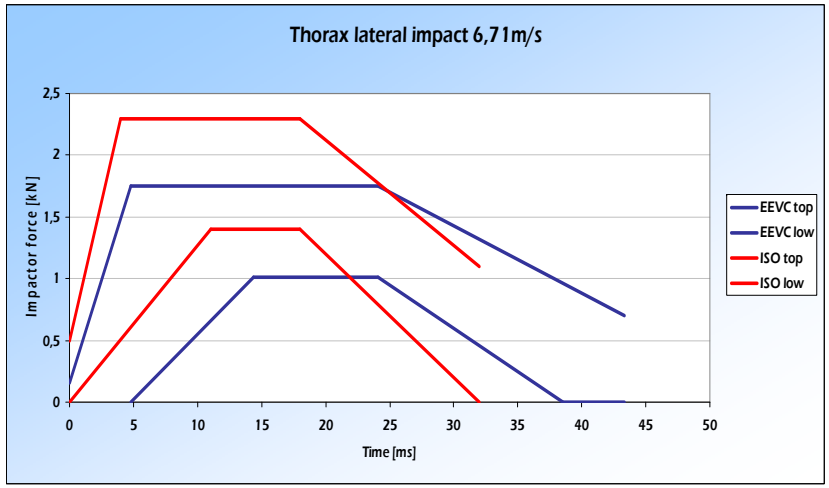


Comparison

- European requirement based on low severity volunteer test, where as ISO test use older cadaver test data in more severe tests.
- Requirements are not compatible.
- It is recommended to use the European methodology for side impact neck performance evaluation.
- These graphs are supported by analogous tables seen in the frontal impact (ISO references on HYBRID III dummies).

3.3 Thorax: EEVC & ISO corridor comparison in lateral impact test.





Comparison

- The difference is due to the difference in mass of the impactors (6,9kg for HYBRID and 8,8kg for Q10). This alone doesn't justify the entire difference.
- The HIII 10yo corridor is higher with regards to impactor force and shorter in terms of time.
- European methodology proposed in line with evaluation performed for the other Q series.
- These graphs are supported by analogous tables seen in the frontal impact (ISO references on HYBRID III dummies).

3.4 Lumbar spine in lateral impact test

- Same as for frontal impact.
- Target specified is scaled from the Hybrid III.
- The scaling method is based on the geometrical data of the neck, assuming that the spinal cord development is consistent through the growth of the child and across its entire length.
- Target for lateral bending stiffness: 142.8 Nm/rad

Description	Q6	Q10
Age in years	6.75	10.5
Lateral bending stiffness in [Nm/rad]	104.2	142.8

3.5 Abdomen and pelvis in lateral impact test

- Abdomen and pelvis are not critical for the design. Extrapolation of current designs is not anticipated to give any problems.
- The targets for the abdomen and the pelvis will be investigated when the spine is determined.

Thank you very much for your kind attention.

For more information

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