C-NCAP MANAGEMENT REGULATION

(EDITION 2027)

TR04

Chinese 50th Percentile Male Physical Dummy Technical Requirements

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1 Introduction

1.1 Definitions

The 50th percentile male physical dummy (with Chinese anthropometry) (hereinafter referred to as the physical dummy with Chinese anthropometry), as used in this document, refers to a physical dummy prototype with a complete structure, including skeleton, skin, rubber components, and other structural elements. The physical dummy with Chinese anthropometry shall comply with all requirements specified in this document; if it fails to meet any of the specified criteria, it shall not be used for relevant testing activities.

1.2 Overall process

The physical dummy with Chinese anthropometry shall meet all certification conditions in this document, mainly including three aspects. First, the critical dimensions of the dummy prototype shall meet the specified requirements given in this document; second, the quality of each segment assembly of the dummy prototype shall meet the specified requirements given in this document; third, the performance of the key test parts of the dummy prototype shall meet the specified requirements given in this document.

2 Certification process for the physical dummy with Chinese anthropometry

2.1 Dummy prototype dimension requirements

This certification procedure specifies the dimensional testing process for the dummy prototype, as follows:

a. Remove the abdominal padding and chest skin of the dummy.

b. Place the dummy on a flat, rigid, smooth, clean, and dry measurement seat that meets the following requirements:

b.1 The seat surface shall be horizontal and must be at least 406 mm wide and 406 mm deep, with a vertical backrest section attached to the rear of the seat mounting fixture that is at least 406 mm wide and 914 mm high.

b.2 The dummy's midsagittal plane shall remain vertical and be positioned at the center of the measurement surface.

c. Remove the four socket bolts connecting the lumbar and thoracic vertebrae. Screw the nut on the lumbar cable to 1.1 N·m to 1.4 N·m.

Note: At this time, check the chest for damage. If necessary, remove the chest displacement sensor for calibration. Special care shall be taken to avoid damage to the sensor wire.

d. Reassemble the lumbar and thoracic spine together.

e. Fix the dummy onto the test fixture such that the posterior surfaces of the upper thorax and the posterior surfaces of the buttocks (the posterior surface of the upper part of the buttocks that contacts the

lumbar) are tangent (or as close to tangent as possible) to the rear vertical surface of the measurement device. The median sagittal plane of the dummy shall remain vertical.

f. It is recommended to first use the dummy's H-point rod to locate the H-point position, then adjust the dummy so that both left and right sides meet the requirements of Items C and D, with the difference between the left and right side measurements kept within 2.5 mm.

g. Secure the dummy's head and thoracic spine using ratchet straps, extend the neck to position the dummy such that the distance from the posterior surface of the head to the back of the measurement seat is approximately 43.2 mm ±2.5 mm, and then fix the head in this position.

h. Align the thighs and lower legs parallel to the midsagittal plane, ensuring that the posterior surfaces of the thighs are in close contact with the surface of the measurement seat, and orient the line connecting the knee joint pivot and the bolt joining the ankle joint to the lower tibia vertically.

i. Position the feet parallel to the dummy's midsagittal plane, with the soles of the feet horizontal and parallel to the seat surface.

j. Position the upper arms vertically such that the centerline between the dummy's shoulder joint and elbow joint is parallel to the rear vertical surface of the measurement seat.

k. Position the forearms horizontally so that the centerline between the dummy's elbow joint and wrist joint is parallel to the surface of the measurement seat.

l. Record the following external dimensions, as illustrated in Figure 1.

A. Overall seated height: measured from the seat surface to the highest point of the dummy's head.

B. Shoulder pivot height: measured from the centerline of the shoulder pivot bolt to the seat surface.

C. H-point height (reference distance): measured from the seat surface (reference surface).

D. Distance from point H to the back of the seat (reference distance): measured from the rear vertical surface of the seat (reference surface).

E. Distance from the shoulder pivot to the back of the seat: from the middle surface of the shoulder joint skeleton to the rear vertical surface of the seat.

F. Thigh Thickness: measured from the seat surface (when the posterior surface of the thigh is in close contact with the seat surface) to the highest point of the proximal femur.

G. Elbow-to-wrist pivot distance: measured from the center of the elbow pivot bolt to the center of the wrist pivot bolt.

H. Rear head-to-seat back distance (reference distance): measured from the rearmost point of the head to the rear vertical surface of the seat.

I. Shoulder-to-elbow pivot distance: measured from the highest point of the shoulder joint

skeleton to the center of the elbow pivot bolt.

J. Elbow pivot height: the vertical distance from the center of the elbow pivot bolt to the seat surface.

K. Distance from the anterior edge of the knee to the seat back: measured from the most anterior surface of the knee (i.e., the front surface of the knee musculature) to the rear vertical surface of the seat.

L. Distance from seat surface to sole of foot: the vertical distance from the seat surface to the horizontal plane of the foot sole.

M. Knee pivot height: the vertical distance from the knee pivot to the horizontal plane of the sole of the foot.

N. Distance from the posterior edge of the lower leg to the seat back: measured from the rearmost edge of the dummy's lower leg skin to the rear vertical surface of the seat.

O. Chest depth (excluding chest skin): measured approximately at the midpoint between the third and fourth ribs.

P. Foot length: measured from the tip of the toes to the rear of the heel.

R. Distance from knee pivot to back of seat: the distance from the centerline of knee pivot to the vertical surface behind the seat.

V. Shoulder width: the distance between the outermost edges of the left and right shoulder joint skeletons.

W. Foot width: the width of the foot at its widest point.

m. Install the dummy's abdominal filler and chest skin and reposition the dummy.

n. Mark and record the locations for chest circumference and waist circumference measurements.

Y. Chest circumference (with chest skin): the circumference measured at a height of 430.0 mm ±5.0 mm above the seat surface.

Z. Waist circumference (with chest skin): the waist circumference measured at 245.0 mm ±5.0 mm above the seat surface.

AA. Reference height for chest circumference measurement: The reference height at which the chest circumference is measured.

BB. Reference height for waist circumference measurement: the reference height at which the waist circumference is measured.

This certification procedure specifies 23 external anthropometric parameter requirements for the dummy, along with their corresponding tolerance ranges. The reference dimensional standards provided in accordance with the measurement procedure described above are listed in Table 1.

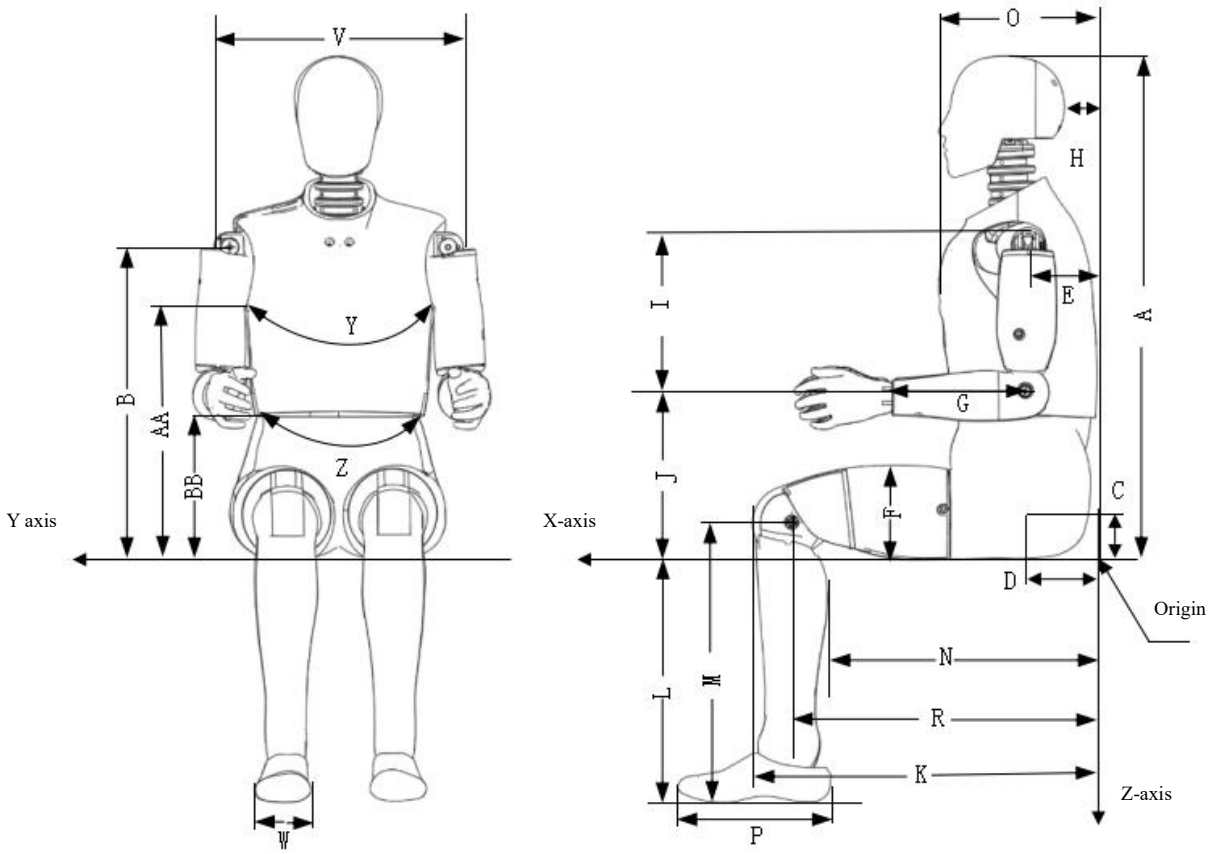


Figure 1 Schematic diagram of dummy size measurement

Table 1 External anthropometric parameter requirements for the physical dummy with Chinese anthropometry

No.	Identification	Measurement items	Value and tolerance (mm)
1	A	Overall seated height	885.7±10.0
2	B	Shoulder pivot height	509.5±7.5
3	C	H point height (reference distance)	93.5±2.5
4	D	Distance from the H-point to the seat back (reference distance)	135.5±2.5
5	E	Distance from the shoulder pivot to the seat back	84.0±5.0
6	F	Thigh thickness	150.0±7.5
7	G	Distance from elbow to wrist	229.0±7.5
8	H	Distance from back of head to seat back (reference distance)	43.2±2.5
9	I	Distance from shoulder to elbow pivot	285.0±8.0
10	J	Elbow pivot height	264.5±10.0

11	K	Distance from the anterior edge of the knee to the seat back	568.0±13.0
12	L	Distance from the seat surface to the sole of the foot	400.0±12.0
13	M	Knee pivot height	453.0±12.0
14	N	Distance from the posterior edge to the seat back	453.0±12.0
15	O	Chest depth (excluding chest skin)	211.0±9.0
16	P	Foot length	250.0±7.5
17	R	Distance from the knee pivot to the seat back	513.3±13.0
18	V	Shoulder width	400.0±7.5
19	W	Foot width	96.0±7.5
20	Y	Chest circumference (with chest skin)	935.0±15.0
21	Z	Waist circumference (with chest skin)	847.3±15.0
22	AA	Reference height for chest circumference measurement	430.0±5.0
23	BB	Reference height for waist circumference measurement	245.0±5.0

2.2 Mass requirements for dummy prototype

The mass requirements for each segmented assembly of the dummy prototype are specified in Table 2.

Table 2 Mass parameter requirements for the physical dummy with Chinese anthropometry

No.	Segment assembly name	Value and tolerance (kg)
1	Head assembly	4.38±0.05
2	Neck assembly	1.49±0.05
3	Upper torso assembly	15.06±0.14
4	Lower torso assembly	19.55±0.14
5	Left thigh assembly	5.58±0.09
6	Right thigh assembly	5.58±0.09
7	Left lower leg assembly	4.01±0.07
8	Right lower leg assembly	4.01±0.07

9	Left foot assembly	1.06±0.07
10	Right foot assembly	1.06±0.07
11	Left upper arm assembly	1.91±0.08
12	Right upper arm assembly	1.91±0.08
13	Left forearm assembly	1.54±0.05
14	Right forearm assembly	1.54±0.05
15	Left hand assembly	0.46±0.05
16	Right hand assembly	0.46±0.05
17	Total mass of dummy	69.60±1.20

2.3 Dummy calibration test requirements

The prototype calibration tests for the physical dummy with Chinese anthropometry involve 5 key body regions, including head, neck, chest, knee, and feet, with a total of 11 calibration test conditions. The performance criteria that the dummy must meet under each calibration test condition are provided in Table 3. Additionally, the dummy calibration tests shall be conducted in accordance with the specified test environment, test setup, filtering settings, and other requirements outlined in the document.

For the physical dummy with Chinese anthropometry, it shall be re-calibrated every 4 impact tests. Its knee joint sliding displacement shall be calibrated according to the low-speed impact calibration test as described in Section 2.3.7 after every 4 test, and it shall also be calibrated according to the high-speed impact calibration test as described in Section 2.3.8 after every 10 test.

If a part of the dummy is damaged during tests, that part shall be replaced.

All calibration data of dummies shall be retained and made available for inspection.

Table 3 Performance indicator requirements for calibration tests of key dummy components

No.	Calibration condition	Indicator type	Indicator requirements	Remarks
1	Head drop test condition	Peak head resultant acceleration	230 g–280 g	
		Peak lateral acceleration	-15 g–15 g	
		Secondary amplitude ratio	0–10%	
2	Neck-bending condition	Initial collision velocity	6.89 m/s–7.13 m/s	
		Pendulum pulse @ 10 ms	2.1 m/s–2.5 m/s	
		Pendulum pulse @ 20 ms	4.0 m/s–5.0 m/s	
		Pendulum pulse @ 30 ms	5.8 m/s–7.0 m/s	
		Maximum D-plane rotation angle	66 deg–80 deg	
		Maximum occipital condyle moment	81.5 N·m–101.5 N·m	
		Time at which the occipital condyle moment crosses 10 N·m	79 ms–99 ms	

3	Neck extension condition	Initial collision velocity	5.95 m/s–6.19 m/s	
		Pendulum pulse @ 10 ms	1.5 m/s–1.9 m/s	
		Pendulum pulse @ 20 ms	3.2 m/s–4.0 m/s	
		Pendulum pulse @ 30 ms	4.7 m/s–5.7 m/s	
		Maximum D-plane rotation angle	85 deg–112 deg	
		Maximum occipital condyle moment	-72 N·m–-53 N·m	
		Time at which the occipital condyle moment crosses -10 N·m	97 ms–117 mm	
4	Low speed impact to the chest	Peak chest displacement	-25.2 mm–20.3 mm	The pendulum mass shall be 19.78 kg ±0.02 kg.
		Peak impact force	-2.67 kN–2.36 kN	
		Hysteresis rate	60%–75%	
5	High speed impact to the chest	Peak chest displacement	-68.6 mm–-60.0 mm	
		Peak impact force	-5.75 kN–-5.10 kN	
		Hysteresis rate	69%–85%	
6	Knee impact condition	Peak impact force	-5.78 kN–-4.72 kN	
7	Low speed impact of knee slider	Peak of displacement	9.6 mm–13.0 mm	
8	High speed impact of knee slider	Peak thigh force at knee displacement @ 10.50 mm	-1.67 kN–-1.22 kN	
		Peak thigh force at knee displacement @ 18.32 mm	-3.01 kN–-2.21 kN	
9	Upper foot (without shoes) impact	Peak My bending moment of the lower tibia	91 N·m–139 N·m	
10	Lower foot (without shoes) impact	Peak pendulum acceleration	255 g–355 g	
11	Lower foot (with shoes) impact	Peak lower tibial axial force Fz	2.9 kN–3.9 kN	

The detailed procedures and requirements for the above 11 calibration test conditions are as follows:

2.3.1 Head drop test conditions

Test environment: the temperature is 18.9°C–25.6°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Visually check the surface of the head skin for cracks, cuts, or abrasions. If wear or cuts in the forehead area of the head skin have penetrated beyond the outer layer thickness, the head skin shall be replaced or repaired.

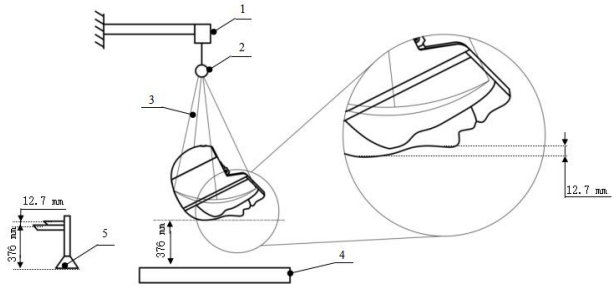
（2）Install the accelerometers such that the sensitive axes of the three accelerometers intersect at the head's center of mass. Tighten the head sensor base mounting bolts to a torque of 7.5 N·m, and torque the skull rear cover mounting bolts to 18 N·m.

（3）Ensure that all sensors are properly installed and calibrated.

（4）Prior to testing, the impact surface of the skin and the test bench surface may be cleaned with isopropyl alcohol or an equivalent cleaning agent. The impact surface and the skin must be kept clean and dry.

（5）Suspend the head assembly in the manner shown in the following figure. When the head's midsagittal plane is vertical, the lowest point of the forehead shall be located 12.7 mm ±1 mm below the lowest point of the dummy's nose. Drop the head assembly from a height of 376 mm ±1 mm, ensuring that it falls smoothly and without obstruction onto the surface of the test bench.

（6）For consecutive tests on the same head assembly, a minimum interval of 2 hours is required.



Explanation of the indexing sequence number:
1 – Quick release device;
2 – Spiral adjustment device;
3 – Head hanging rope;
4 – Horizontal steel plate;
5 – Optional measuring tools.

Figure 2 Schematic diagram of the head drop test

Data processing: accelerometer signals shall be processed according to the CFC 1000 filter class.

2.3.2 Neck bending test conditions

Test environment: the temperature is 20.6°C–22.2°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the neck for cracks, cuts, and any separation between the rubber and metal components.

（2）Check the nodding block for damage and replace it if necessary. If the height of the head block is less than 80% of the original height, it needs to be replaced. Ensure that the nodding block is properly installed.

（3）Check the head-neck pivot thrust washer for proper interference fit, and adjust or replace it if necessary.

（4）Before testing, tighten the nut on the neck cable to 1.36 N·m ±0.27 N·m. Install the head-neck assembly on the swing arm in the manner shown in Figure 3, ensuring that the midsagittal plane of the head remains vertical.

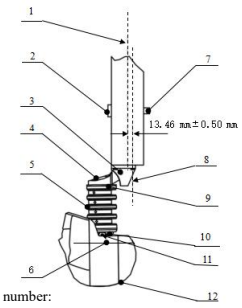
（5）Install an angular sensor to measure the relative rotation angle of the “D” plane.

（6）Honeycomb aluminum or an equivalent substitute shall be prepared to meet the swing arm velocity requirements during the test. Prior to the test, the honeycomb aluminum or its equivalent substitute shall be pre-compressed so that 90% to 100% of its surface is in contact with the swing arm impact face.

（7）When the swing arm is resting against the honeycomb aluminum, ensure that the perpendicularity deviation between the dummy’s head “D” plane and the swing arm centerline does not exceed ±1°.

（8）A minimum waiting period of 30 minutes is required between consecutive tests on the same neck.

During the swing arm’s motion, the following conditions shall be met: impact velocity shall be between 6.89 m/s and 7.13 m/s; swing arm pulse velocity at 10 ms shall be between 2.1 m/s and 2.5 m/s; swing arm pulse velocity at 20 ms shall be between 4.0 m/s and 5.0 m/s; swing arm pulse velocity at 30 ms shall be between 5.8 m/s and 7.0 m/s.



Explanation of the indexing sequence number:
1 – Swing arm centerline;
2 – Swing arm impact plane;
3 – Neck bracket;
4 – Neck angle adjustment block;
5 – Neck assembly;
6 – Head "D" plane;
7 – Acceleration sensor;
8 – Mounting bolt location;
9 – Neck calibration pad;
10 – neck force sensor;
11 – Head pivot;
12 – Head assembly.

Fig. 3 Schematic diagram of neck bending test

Data processing: 1) The angular sensor signal shall be processed according to the CFC 60 filter class;

2）The swing arm acceleration sensor signal shall be processed according to the CFC 180 filter class;

3）The force signals from the load cell shall be processed according to the CFC 1000 filter class;

4）The moment signals from the load cell shall be processed according to the CFC

600 filter class.

2.3.3 Neck extension test conditions

Test environment: the temperature is 20.6°C–22.2°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the neck for cracks, cuts, and any separation between the rubber and metal components.

（2）Check the nodding block for damage and replace it if necessary. If the height of the head block is less than 80% of the original height, it needs to be replaced. Ensure that the nodding block is properly installed.

（3）Check the head-neck pivot thrust washer for proper interference fit, and adjust or replace it if necessary.

（4）Before testing, tighten the nut on the neck cable to 1.36 N·m ±0.27 N·m. Install the head-neck assembly on the swing arm in the manner shown in Figure 4, ensuring that the midsagittal plane of the head remains vertical.

（5）Install an angular sensor to measure the relative rotation angle of the “D” plane.

（6）Honeycomb aluminum or an equivalent substitute shall be prepared to meet the swing arm velocity requirements during the test. Prior to the test, the honeycomb aluminum or its equivalent substitute shall be pre-compressed so that 90% to 100% of its surface is in contact with the swing arm impact face.

Note: The neck extension test and the neck flexion test shall use honeycomb aluminum (or its equivalent substitute) of different sizes.

（7）When the swing arm is resting against the honeycomb aluminum, ensure that the perpendicularity deviation between the dummy’s head “D” plane and the swing arm centerline does not exceed ±1°.

（8）A minimum waiting period of 30 minutes is required between consecutive tests on the same neck.

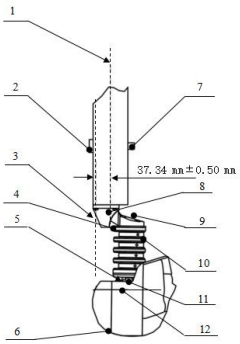
During the swing arm’s motion, the following conditions shall be met: impact velocity shall be between 5.95 m/s and 6.19 m/s; swing arm pulse velocity at 10 ms shall be between 1.5 m/s and 1.9 m/s; swing arm pulse velocity at 20 ms shall be between 3.2 m/s and 4.0 m/s; swing arm pulse velocity at 30 ms shall be between 4.7 m/s and 5.7 m/s.

Data processing: 1) The angular sensor signal shall be processed according to the CFC 60 filter class;

2）The swing arm acceleration sensor signal shall be processed according to the CFC 180 filter class;

3）The force signals from the load cell shall be processed according to the CFC 1000 filter class;

4）The moment signals from the load cell shall be processed according to the CFC 600 filter class.



Explanation of the indexing sequence number:
1 – Swing arm centerline;
2 – Swing arm impact plane;
3 – Mounting bolt location;
4 – Neck calibration pad;
5 – Head pivot;
6 – Head assembly;
7 – Acceleration sensor;
8 – Neck bracket;
9 – Neck angle adjustment block;
10 – Neck assembly;
11 – neck force sensor;
12 – Head "D" plane.

Figure 4 Schematic diagram of neck extension test

2.3 4 Chest low speed impact test conditions

Test environment: the temperature is 20.6°C–22.2°C, relative humidity is 10%–70%. Prior to the test, the entire dummy shall be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours, until the rib temperature reaches the test environmental temperature. This conditioning period shall not include the time required for the dummy to achieve thermal equilibrium with the environment.

Test settings:

（1）Remove the dummy's chest skin and visually inspect the chest assembly for cracks, cuts, or damage, paying particular attention to the rib dampers, chest deflection sensors, and the rear rib mounting plates for any signs of damage.

（2）Screw the nut on the lumbar cable to 1.1 N·m to 1.4 N·m.

（3）Check all sensors to ensure they are properly installed, oriented, and calibrated.

（4）Align the positioning marks on the dummy's neck angle adjustment block and neck bracket with the zero-degree mark.

（5）Place the dummy (without the chest skin, but wearing pants) on the chest calibration bench surface, which should be long enough to support the pelvis and extended legs, as shown in Figure 5.

（6）The mass of the pendulum used for chest impact shall be 19.78 kg ±0.02 kg, including the mass of the sensor, rigid attachments, and the lower 1/3 portion of the suspension cables.

（7）Ensure that the dummy's arms are positioned horizontally and parallel to the dummy's midsagittal plane, with a horizontal angle tolerance of less than ±2°. Adjust the rib plane so that its angular deviation from the horizontal plane is within ±0.5°. Use an H-point rod and an angle-measuring device to adjust the pelvis angle to 13° ±2°, and ensure that the dummy's midsagittal plane is within ±1° of the vertical orientation.

（8）Position the pendulum's longitudinal centerline within ±±1 mm of a point 12.7 mm below the horizontal centerline of the dummy's 3rd rib, and align it such that the angular deviation from the dummy's midsagittal plane is less than 0.5°. Additionally, the lateral offset between the pendulum's longitudinal centerline and the dummy's midsagittal plane shall be controlled within 3 mm.

（9）After completing the initial setup, record reference measurements of the positions of components such as the posterior surface of the thoracic spine and the neck bracket. These reference measurements are primarily used for subsequent positional calibration after the dummy's chest skin has been reinstalled.

（10）Install the chest skin and dress the dummy in an upper garment. Then, using the previously recorded reference measurements, reposition the dummy in accordance with the aforementioned requirements. Note: After installing the chest skin, the reference locations must remain accessible. Therefore, it may be necessary to unzip the rear zipper of the chest skin before verifying compliance with the reference measurements, and then re-zip it after the verification is complete.

（11）Considering the thickness of the chest skin, the dummy shall be shifted slightly in the direction of the pendulum impact to ensure that the pendulum still strikes the dummy's chest at the lowest point of its travel.

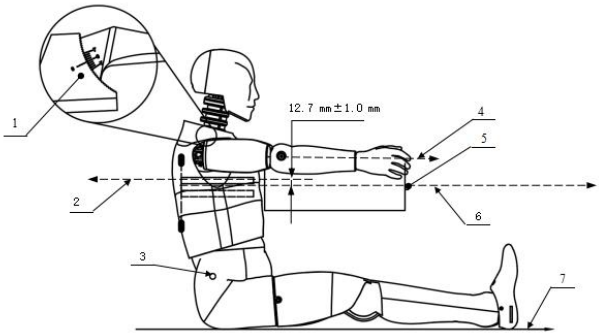
（12）At the moment of impact, the angle between the pendulum's longitudinal centerline and the horizontal line within the dummy's midsagittal plane shall be within ±2°.

（13）Guide the pendulum to ensure it does not undergo significant lateral, vertical, or rotational motion during impact; the pendulum velocity at impact shall be between 2.94 m/s and 3.06 m/s.

（14）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy's chest.

Data processing: 1) The pendulum acceleration sensor channel shall be processed according to the CFC 180 filter class.

2) The displacement sensor channel shall be processed according to the CFC 180 filter class.



Explanation of the indexing sequence number:
1 – Neck mounting location;
2 – Horizontal centerline of the third rib;
3 – H-point rod insertion hole location;
4 – Arm horizontal centerline;
5 – Acceleration sensor;
6 – Pendulum centerline;
7 – Test bench surface.

Figure 5 Schematic diagram of chest impact test

2.3.5 Chest high-speed impact test conditions

Test environment: Same as the chest low-speed impact test.

Test settings: The test settings are similar to the chest low-speed impact test. The difference is that, at the moment of impact, the pendulum velocity shall be between 6.59 m/s and 6.83 m/s.

Data processing: 1) The pendulum acceleration sensor channel shall be processed according to the CFC 180 filter class.

2）The displacement sensor channel shall be processed according to the CFC 180 filter class.

2.3.6 Knee impact test conditions

Test environment: the temperature is 18.9°C–25.6°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the knee assembly and knee pad for damage such as cracks or cuts, and replace the affected components if any such damage is found.

（2）As shown in Figure 6, install the knee/lower leg assembly onto the test fixture using the femur load cell or its substitute block. Tighten the mounting bolts of the femur load cell or its substitute block to 40.7 N·m. When using the lower leg assembly, adjust the lower leg so that its axis forms an angle of 24°±1° rearward from the vertical direction.

（3）The pendulum used for knee impact testing of the China-specific anthropomorphic test device (ATD) is identical to that used for the Hybrid III 50th percentile dummy knee impact test.

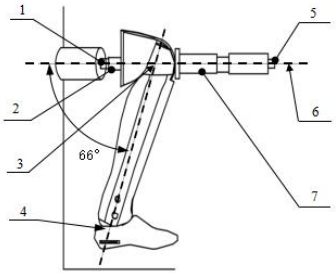
（4）Adjust the pendulum's longitudinal centerline so that it aligns with the longitudinal centerline of the femur load cell or its substitute block during impact, with an angular tolerance of ±2°, and ensure the horizontal angle of the pendulum's longitudinal centerline is within ±0.5°.

（5）Guide the pendulum to ensure that no significant lateral, vertical, or rotational motion occurs at the initial moment of contact between the pendulum and the knee.

（6）The pendulum impact velocity at the moment of striking the knee shall be between 2.07 m/s and 2.13 m/s.

（7）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy's knee.

Data processing: the acceleration sensor channel shall be processed according to the CFC 600 filter class.



Explanation of the indexing sequence number:
1 – Leg bracket;
2 – Thigh force sensor or its substitute block;
3 – Knee pivot axis;
4 – Lower leg axis;
5 – Acceleration sensor;
6 – Pendulum centerline;
7 – Pendulum.

Figure 6 Schematic diagram of knee impact test

2.3.7 Knee slider low-speed impact test conditions

Test environment: the temperature is 20.6°C–22.2°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the knee assembly for damage. Particular attention should be paid to the knee slider assembly, ensuring that the sliding rails are intact and clean. Install the knee displacement sensor, ensuring its shaft can slide freely.

（2）Check all sensors to ensure they are properly installed, oriented, and calibrated.

（3）Connect the two ends of the femur load cell to the knee and the knee test fixture, respectively,

and tighten the mounting bolts to 40.7 N·m.

（4）Attach the knee slider load transfer bracket to the slider assembly so that the knee slider can experience a dynamic response upon impact by the pendulum.

（5）The pendulum used for knee slider impact testing of the China-specific anthropomorphic test device (ATD) is identical to that used for the Hybrid III 50th percentile dummy knee slider impact test.

（6）As shown in Figure 7, adjust the pendulum so that the angle between the pendulum's longitudinal centerline and the centerline of the femur load cell is within 0°±2°, and the horizontal angle of the pendulum's longitudinal centerline is within ±0.5°.

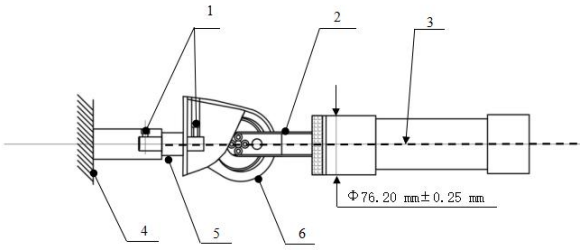
（7）Guide the pendulum to ensure that no significant lateral, vertical, or rotational motion occurs when the pendulum contacts the knee slider load transfer bracket.

（8）The pendulum impact velocity shall be between 1.53 m/s and 1.57 m/s.

（9）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy's knee slider.

Data processing: 1) The force sensor channel shall be processed according to the CFC 600 filter class;

2) The displacement sensor channel shall be processed according to the CFC 180 filter class.



Explanation of the indexing sequence number:
1 – Mounting bolts;
2 – Knee slider load transfer bracket;
3 – Pendulum centerline;
4 – Fixing device;
5 – Thigh force sensor;
6 – Knee assembly.

Figure 7 Schematic diagram of knee slider impact test

2.3.8 Knee slider high-speed impact test conditions

Test environment: the temperature is 18.9°C–25.6°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings: Similar to the knee slider low-speed impact test settings. The difference is that the pendulum impact velocity shall be between 2.7 m/s and 2.8 m/s.

Data processing: 1) The force sensor channel shall be processed according to the CFC 600 filter class;

2) The displacement sensor channel shall be processed according to the CFC 180 filter class.

2.3.9 Upper foot (without shoes) impact test condition

Test environment: the temperature is 19.0°C–25.0°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the test components for damage, and repair or replace the affected parts if any damage is found.

（2）The sensitive axis of the pendulum acceleration sensor shall be parallel to the direction of impact on the foot.

（3）Clean the surface of the foot skin and the pendulum surface with isopropyl alcohol or an equivalent, and then apply talcum powder.

（4）The pendulum used for foot impact test of the dummy with Chinese anthropometry has the same specifications as that used for the Hybrid III 50th percentile dummy foot impact test.

（5）As shown in Figure 8, install the foot without shoes together with the lower leg and knee assembly onto a rigidly fixed test fixture to prevent movement during impact. The centerline of the thigh force sensor replacement block should be kept vertical with an error of ±0.5°.

（6）Place the dummy’s heel on a flat, low-friction PTFE sheet and adjust the mounting position so that the bolt at the knee flexion joint and the bolt at the ankle joint are at the same height, with an angular tolerance of ±3°.

（7）Adjust the ankle joint so that the plane passing through the sole of the foot is vertical and perpendicular to the impact direction, with a tolerance of ±3°. Adjust the ankle joint to a free state first, then tighten it sufficiently to ensure the foot remains stably positioned on the PTFE sheet.

（8）Adjust the knee joint to a torque level equivalent to 1.5 g±0.5 g (where the "1.5 g±0.5 g" setting refers to the degree of tightening torque applied to the dummy’s joints, determined by the criterion that any body segment of the dummy can remain stationary or descend slowly and steadily at any joint position).

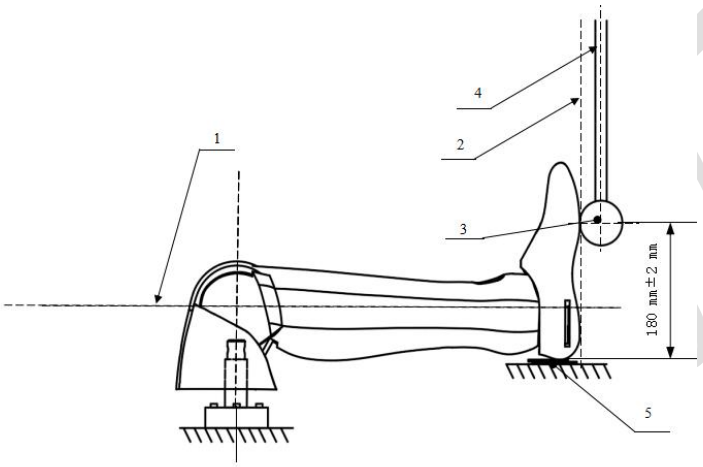
（9）The centerline of the pendulum shall be horizontal and perpendicular to the direction of impact. The swing arm shall impact the sole of the foot at a vertical distance of 180 mm ±2 mm from the rearmost point of the dummy’s heel skin surface (i.e., the upper surface of the PTFE sheet on which the dummy’s

heel is placed). At the moment of impact, the longitudinal centerline of the swing arm shall lie within ±1° of the vertical direction.

（10）The pendulum should be properly guided to prevent significant lateral, vertical, or rotational motion.

（11）The pendulum impact velocity shall be between 6.6 m/s and 6.8 m/s.

（12）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy’s foot.



Explanation of the indexing sequence number:
1 – Horizontal line passing through the knee and ankle joints;
2 – Vertical plane;
3 – Pendulum;
4 – Swing arm;
5 – Polytetrafluoroethylene sheet.

Figure 8 Schematic diagram of upper foot (without shoes) impact test

Data processing: The moment signals from the load cell shall be processed according to the CFC 600 filter class.

2.3.10 Lower foot (without shoes) impact test condition

Test environment: the temperature is 19.0°C–25.0°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the test components for damage, and repair or replace the affected parts if any damage is found; also check the energy-absorbing pad at the heel for damage and replace it if necessary.

（2）The sensitive axis of the pendulum acceleration sensor shall be parallel to the direction of impact on the foot.

（3）Clean the surface of the foot skin and the pendulum surface with isopropyl alcohol or an

equivalent, and then apply talcum powder.

（4）The pendulum used for foot impact test of the dummy with Chinese anthropometry has the same specifications as that used for the Hybrid III 50th percentile dummy foot impact test.

（5）As shown in Figure 9, install the foot without shoes together with the lower leg and knee assembly onto a rigidly fixed test fixture to prevent movement during impact. The centerline of the thigh force sensor replacement block should be kept vertical with an error of ±0.5°.

（6）Place the dummy's heel on a flat, low-friction PTFE sheet and adjust the mounting position so that the bolt at the knee flexion joint and the bolt at the ankle joint are at the same height, with an angular tolerance of ±3°.

（7）Adjust the ankle joint so that the plane passing through the sole of the foot is vertical and perpendicular to the impact direction, with a tolerance of ±3°. Adjust the ankle joint to a free state first, then tighten it sufficiently to ensure the foot remains stably positioned on the PTFE sheet.

（8）Adjust the knee joint to a torque level equivalent to 1.5 g±0.5 g.

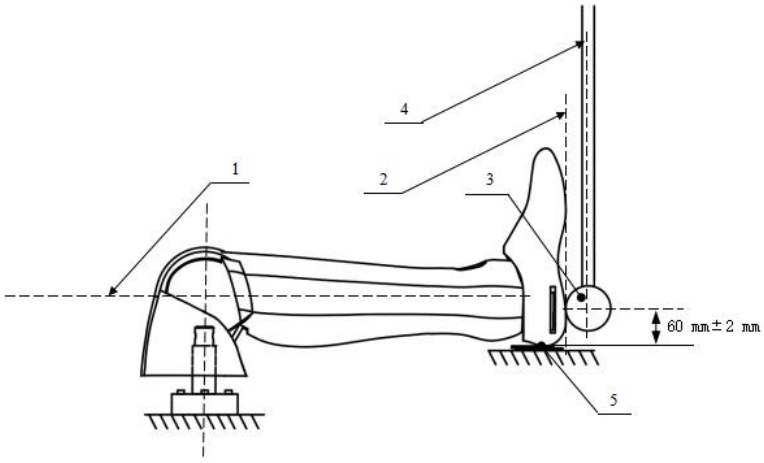
（9）The centerline of the pendulum shall be horizontal and perpendicular to the direction of impact. The swing arm shall impact the sole of the foot at a vertical distance of 60 mm ±2 mm from the rearmost point of the dummy's heel skin surface (i.e., the upper surface of the PTFE sheet on which the dummy's heel is placed). At the moment of impact, the longitudinal centerline of the swing arm shall lie within ±1° of the vertical direction.

（10）The pendulum should be properly guided to prevent significant lateral, vertical, or rotational motion.

（11）The pendulum impact velocity shall be between 4.3 m/s and 4.5 m/s.

（12）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy's foot.

Data processing: the acceleration sensor channel shall be processed according to the CFC 600 filter class.



Explanation of the indexing sequence number:
1 – Horizontal line passing through the knee and ankle joints;
2 – Vertical plane;
3 – Pendulum;
4 – Swing arm;
5 – Polytetrafluoroethylene sheet.

Figure 9 Schematic diagram of lower foot (without shoes) impact test

2.3.11 Lower foot (with shoes) impact test condition

Test environment: the temperature is 19.0°C–25.0°C, relative humidity is 10%–70%. Prior to testing, the test components must be preconditioned by being left undisturbed in the aforementioned temperature and humidity environment for at least 4 hours. This conditioning period shall not include the time required for the components to reach thermal equilibrium with the environment.

Test settings:

（1）Check the test components for damage, and repair or replace the affected parts if any damage is found; also check the energy-absorbing pad at the heel for damage and replace it if necessary.

（2）The sensitive axis of the pendulum acceleration sensor shall be parallel to the direction of impact on the foot.

（3）The dummy's foot shall be fitted with footwear that complies with the specified requirements. Prior to testing, wipe the sole of the shoe with a clean cloth and clean the pendulum surface with isopropyl alcohol or an equivalent cleaner.

（4）The pendulum used for foot impact test of the dummy with Chinese anthropometry has the same specifications as that used for the Hybrid III 50th percentile dummy foot impact test.

（5）As shown in Figure 10, install the foot with shoes together with the lower leg and knee assembly onto a rigidly fixed test fixture to prevent movement during impact. The centerline of the thigh force sensor replacement block should be kept vertical with an error of ±0.5°.

（6）Place the dummy's shoe heel on a flat, low-friction PTFE sheet and adjust the mounting position so that the bolt at the knee flexion joint and the bolt at the ankle joint are as close as possible to the same

height.

（7）Adjust the ankle joint so that the plane passing through the sole of the shoe is vertical and perpendicular to the impact direction, with a tolerance of ±3°. Adjust the ankle joint to a free state first, then tighten it sufficiently to ensure the foot remains stably positioned on the PTFE sheet.

（8）Adjust the knee joint to a torque level equivalent to 1.5 g±0.5 g.

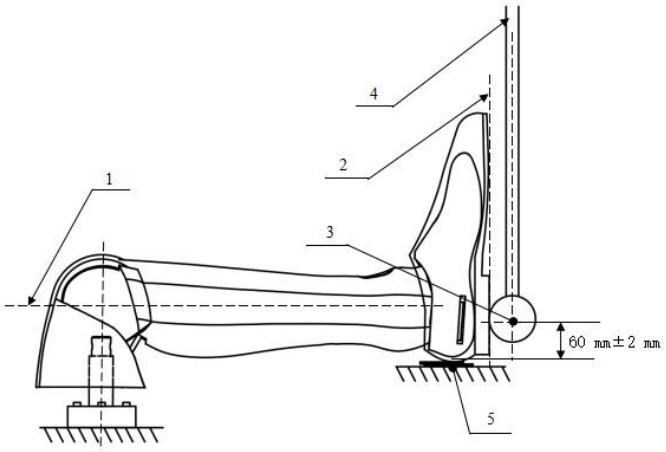
（9）The centerline of the pendulum shall be horizontal and perpendicular to the direction of impact. The swing arm shall impact the sole of the foot at a vertical distance of 60 mm ±2 mm from the rearmost point of the dummy's heel skin surface. At the moment of impact, the longitudinal centerline of the swing arm shall lie within ±1° of the vertical direction.

（10）The pendulum should be properly guided to prevent significant lateral, vertical, or rotational motion.

（11）The pendulum impact velocity shall be between 6.6 m/s and 6.8 m/s.

（12）A minimum waiting period of 30 minutes is required between consecutive tests on the same dummy's foot.

Data processing: The force signal from the load cell shall be processed according to the CFC 600 filter class.



Explanation of the indexing sequence number:
1 – Horizontal line passing through the knee and ankle joints;
2 – Vertical plane;
3 – Pendulum;
4 – Swing arm;
5 – Polytetrafluoroethylene sheet.

Figure 10 Schematic diagram of lower foot (with shoes) impact test