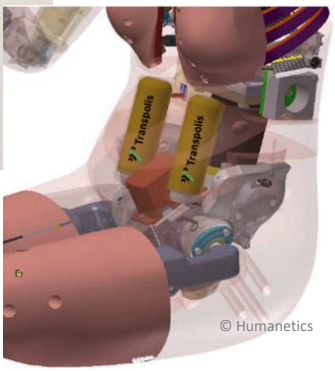
APTS USER MANUAL



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IMPORTANT SAFETY INSTRUCTIONS

1. This product is not intended for use by persons with reduced sensory or mental capacities, or lack of experience and knowledge, unless they have been given supervision or instructions concerning use of the product by a person responsible for their safety
2. Read these instructions carefully before using the product
3. Keep these instructions safe
4. Take notice of all warnings
5. Follow all instructions
6. Do not store or use this product near a heat source such as radiators, heaters, ovens, or other apparatus that produces heat
7. Clean only with a dry cloth
8. Do not dismantle the plug wiring
9. Do not remove the Lemo plug from the cable
10. Never open the sensor head containing the electronics and wiring
11. Never remove the bladder from the sensor head
12. Do not use sharp or cutting tools
13. Do not immerse the unit in water or any another liquid
14. Protect the cable and the plug from being walked on or pinched, particularly at plugs, convenience receptacles, and the point where they exit from the apparatus
15. Only use plugs or accessories specified by the manufacturer

EU COMPLIANCE INFORMATION

This product is compliant to RoHS 3 directive (2015/863/CE) and RoHS 2 directive (2011/65/CE) by the EU and Advisory Council concerning the restriction of the use of certain hazardous substances in electric and electronic equipment.
This product is also compliant to 2014/30/EU Electromagnetic Compatibility (EMC) Directive.

WEEE NOTICE

This appliance is labeled in accordance with European Directive 2012/19/EU concerning waste of electrical and electronic equipment (WEEE). This label indicates that this product should not be disposed of with household waste. It should be deposited at an appropriate facility to enable recovery and recycling.

Q-SERIES DUMMIES IN SAFETY TESTING

Q-Series of child dummies were developed in 1993 as successors to the P-Series in hopes of giving engineers the information they needed to design greater impact protection for children in cars. This new generation of dummies has much better anthropometry, biomechanics and kinematics, all key to better evaluating the risk of injury to varying ages and sizes of child passengers. The Q-Series can be used in frontal or side impact testing, and the instrumentation is interchangeable within the dummy series.
It is listed below the Q dummy configurations for Child Restraint System (UNECE R129) regulation and NCAP consumer ratings with indication of APTS specification.

Q type	ADAC 2020		UNECE R129	
	Frontal impact	Side impact	Frontal impact	Side impact
Q1/Q1.5	Yes	No	Yes + APTS	No
Q3	Yes + APTS	Yes + APTS	Yes + APTS	Yes + APTS
Q6	Yes + APTS	Yes + APTS	Yes + APTS	Yes + APTS
Q10	Yes	No	Yes + APTS	Yes + APTS

Q type	Euro NCAP 2020		Korean NCAP 2020	
	Frontal impact	Side impact	Frontal impact	Side impact
Q1/Q1.5	No	No	No	No
Q3	No	No	No	No
Q6	Yes	Yes	Yes	Yes
Q10	yes	No	Yes	Yes

Q type	Asian NCAP 2020		American NCAP 2020	
	Frontal impact	Side impact	Frontal impact	Side impact
Q1/Q1.5	Yes	Yes	No	No
Q3	Yes	Yes	No	No
Q6	No	No	Yes	Yes
Q10	No	No	Yes	Yes

Q type	China NCAP 2022	
	Frontal impact	Side impact
Q1.5	No	No
Q3	Yes	No
Q6	No	No
Q10	Yes + APTS	No

THOR DUMMIES IN SAFETY TESTING

THOR series represent the future of crash-technology— the most sophisticated ATDs for assessing whole-body trauma in a variety of occupant restraint environments. They are available for use today, and THOR-50M is currently being validated by NHTSA and Euro NCAP for certified use in frontal impact tests. We expect validation of THOR-5F to follow.
THOR-50M and THOR-5F special abdomen with APTS are currently being validated by NHTSA and Euro NCAP for certified use in frontal impact tests.

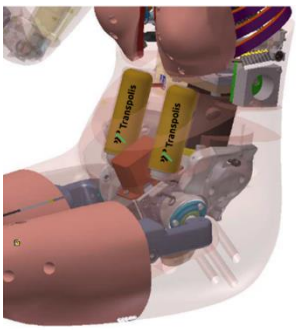
GENERAL DESCRIPTION

The APTS sensors have been designed to measure the abdomen pressure inside the dummy to certify child restraint systems during crash tests and to crash safety assessment of vehicles.
Each sensor is made of a soft and robust cylindrical elastomer bladder, filled with a specific liquid, and sealed with a mechanical cover. The sensor head includes a miniature pressure cell and signal conditioning electronics. The key design of the fluid-elastomer assembly enables a very high biofidelity with the real stiffness of abdominal tissues. The ability of the restraint system to meet injury regulatory criteria is assessed by recording the pressure inside the abdomen during the crash impact.
For impact testing, the sensors are inserted vertically by pair in the abdomen. Both Q and THOR APTS units are standard compliant with ISO 6487and SAE J2570 and EC directives.

APTS Q-D30/D40/D50 DESCRIPTION

Since 2016, Transpolis has been manufacturing Abdominal Pressure Twin Sensors (patented by IFSTTAR) for the Q-series infant to child dummies used for crash tests (front and side impact testing). APTS sensors are an essential tool for in-depth assessment of child restraint systems. This is a unique sensor to evaluate abdominal injury risk and submarining for occupant safety prediction.
The use of APTS has been specified in UNECE R129 regulation in replacement of the UNECE R44 (i.e Size regulation for Child Restraint Systems). Moreover, of most NCAP programs worldwide use Q dummies in their injury assessment capabilities (passive safety). Each sensor is made of a soft and robust cylindrical elastomer bladder, filled with a specific liquid, and sealed with a mechanical head. The sensor head includes a miniature pressure cell and signal conditioning electronics. The key design of the fluid-elastomer assembly enables a very high biofidelity with the real stiffness of abdominal tissues.
The ability of the restraint system to meet injury regulatory criteria is assessed by recording the pressure inside the abdomen during the crash impact. The sensors are inserted vertically by pair in the abdomen. They are available in 3 variants:

- APTS Q-D30 for Q1 and Q1.5 child dummies
- APTS Q-D40 for Q3 and Q6 child dummies
- APTS Q-D50 for Q10 child dummies



APTS THOR-5F/50M DESCRIPTION

Transpolis has been committed to the ABISUP project aiming at developing a new abdomen to improve injury prediction on crash test dummies and extending the use of APTS sensors to adult ATDs. In place of IR-TRACCs, Abdomen Pressure Twin Sensors (APTS) are utilized in the upper and lower abdomen as an alternative way to predict abdomen injury and submarining.

Each sensor is made of a soft and robust cylindrical elastomer bladder, filled with a specific liquid, and sealed with a mechanical head. The sensor head includes a miniature pressure cell and signal conditioning electronics. The key design of the fluid-elastomer assembly enables a very high biofidelity with the real stiffness of abdominal tissues. The ability of the restraint system to meet injury regulatory criteria is assessed by recording the pressure inside the abdomen during the crash impact.

They are available in 2 variants:

- APTS THOR-5F for female ATD dummies and female AV ATD dummies
- APTS THOR-50M for male ATD dummies and male AV ATD dummies

SENSOR UNIT TECHNICAL SPECIFICATIONS

APTS Q-D30/D40/D50

Performance, environmental and electrical characteristics

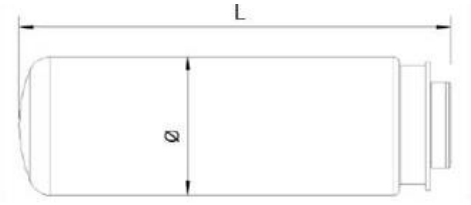
Range (bar / psi / kPa)	5 / 73 / 500	Safe temperature (°C)	-20 to 70
Safe overload	150%	Compensated temperature (°C)	0 to 50
Rated output (mV/bar) (1)	0.42 ±20%	Temperature effect on zero (%RO/°C) and output (%/°C)	±1% and ±0.3%
Nominal range excitation (VDC)	5 to 15	Non linearity (%RO)	±1.5% max.
Bridge excitation (VDC) (2)	2.048	Hysteresis (%RO)	±1% max.
Cable	Length 9m, black polyurethane coated, 32AWG copper wire, outer diameter 2.6 mm	Bridge resistance (Ω)	350 ±10%
Plug	Lemo FGG.00.306.CLAD35Z	Compliance EC directives	RoHS 3 directive (2015/863/EU) EMC directive (2014/30/EU)
TEDS (IEEE P1451.4)	DS2431 1024-bit EEPROM chip		

(1) With an excitation voltage from 5 VDC to 15 VDC (2) Constant and regulated voltage (conditioning electronics in sensor head)

Mechanical characteristics

Sensor reference P/N	APTS Q-D30	APTS Q-D40	APTS Q-D50
Dimensions L × ØD (mm)	105 × 30	125 × 40	141 × 50
Weight (g) (3)	81±2%	160±2%	272±2%
Special abdomen P/N (Humanetics / *Cellbond*)	Q1/1.5 : 036-5005	Q3 : 020-5005 / *140968* Q6 : 033-5005 / *149827*	Q10 : 010-4309 / *141578*
Biofidelity static response (bar/mm) (4)	1.01/10.81 ±10%	0.67/16.51 ±10%	0.60/15.81 ±10%

(3) Cable not included (4) Data obtained after static compression test with a belt: measurement of the pressure (bar) and the deflection (mm) with 250 N load.



NOTA 1. – APTS sensors are provided with a calibration and conformance certificate (pressure and bio fidelity) – see calibration service policy

NOTA 2. – APTS sensors are designed to support severe impact when used in standard conditions (see user manual).

NOTA 3. – Service maintenance and warranty conditions upon request

NOTA 4. – User manual, options list, safety datasheet, CE certificate upon request

APTS THOR-5F/50M

Performance, environmental and electrical characteristics

Range (bar / psi / kPa)	5 / 73 / 500	Safe temperature (°C)	-20 to 70
Safe overload	150%	Compensated temperature (°C)	0 to 50
Rated output (mV/bar) (1)	0.42 ±20%	Temperature effect on zero (%RO/°C) and output (%/°C)	±1% and ±0.3%
Bridge excitation (VDC) (2)	2.048	Non linearity (%RO)	±1.5% max.
Nominal range excitation (VDC)	5 to 15	Hysteresis (%RO)	±1% max.
Cable	Length 9m, black polyurethane coated, 32AWG copper wire, outer diameter 2.6 mm	Bridge resistance (Ω)	350 ±10%
Plug	Lemo FGG.00.306.CLAD35Z	Compliance EC directives	RoHS 3 directive (2015/863/EU) EMC directive (2014/30/EU)
TEDS (IEEE P1451.4)	DS2431 1024-bit EEPROM chip		

(1) With an excitation voltage from 5 VDC to 15 VDC (2) Constant and regulated voltage (conditioning electronics in sensor head)

Mechanical characteristics

Sensor reference P/N		APTS THOR-5F	APTS THOR-AV-5F	APTS THOR-AV-50M	APTS THOR-50M-Abisup
Dimensions L × ØD (mm)		125 × 40	125 × 40	141 x 50	121 x 50
Weight (g) (3)		160±2%	160±2%	272x±2%	236x±2%
Special abdomen P/N	*Humanetics*	474-4306	474-4306	478-4400	
	Cellbond	147600			
Bio-fidelity static response (bar/mm) (4)		0.67/16.51 ±10%	0.67/16.51 ±10%	0.60/15.81 ±10%	0.65/15.32 ±10%

(3) Cable not included (4) Data obtained after static compression test with a belt: measurement of the pressure (bar) and deflection (mm) with 250 N load.

SPECIAL ABDOMEN PART NUMBER

The APTS are mounted inside special dummy abdomen. These abdomen assemblies are designed by Humanetics Innovation Solutions or Cellbond featuring two blind holes parallel to the lumbar spine. The APTS must be inserted in the abdomen with the sensor head downwards and the sensor cables coming out of the abdomen through small holes. To reduce the friction with the skin inside the hole, each APTS sensor shall be inserted in a thin Lycra socket. To prevent unwanted slippage during testing, the sock should be attached to the bottom of the hole.

Manufacturer	Q type Q1/1.5	Q3	Q6	Q10
Humanetics	036-5005	020-5005	033-5005	010-4309
Cellbond	N/A	140968	149827	141578

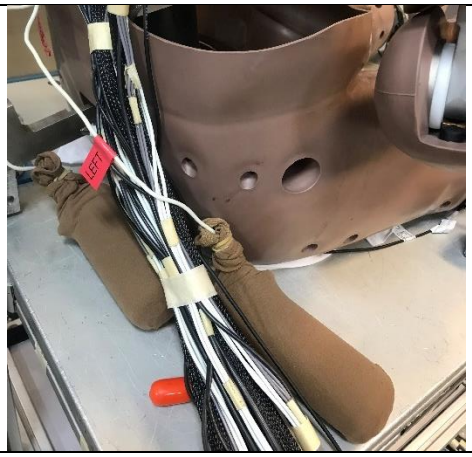
Manufacturer	THOR Type APTS THOR-5F	APTS THOR-AV-5F	APTS THOR-AV-50M
Humanetics	474-4306	474-4306	478-4400
Cellbond	147600		

GENERAL RECOMMENDATIONS

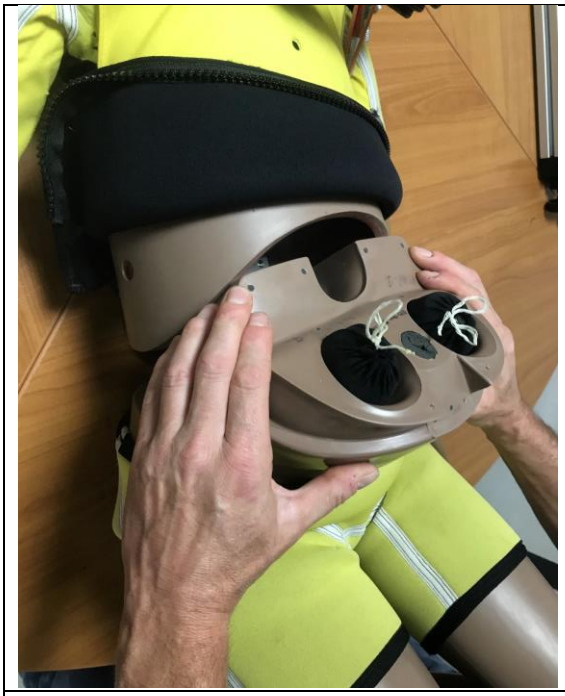
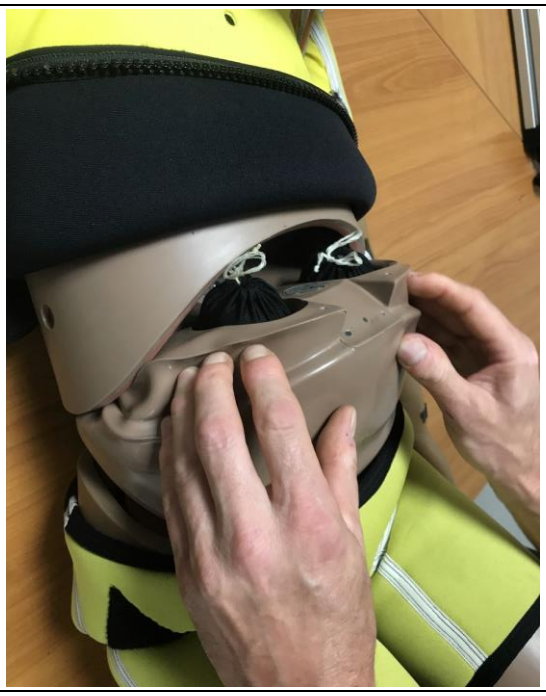
Listed below are the general requirements to operate the APTS sensor with maximum safety and quality of measurement results.

- The APTS should be stored in a temperature-controlled room (around 20°C/68°F) and away from water
- Before a test, the APTS should be kept in the test environment for at least 4 hours
- Using a lycra socket over the APTS sensor is recommended because lower friction coefficient with the abdomen is obtained
- After each test, verify that the APTS are still in place: check the upper bladder position with respect to the abdomen. If the APTS have moved upwards (typically 2 cm or more) then the test results may not be valid and the APTS must be checked for damage (cable, etc.)
- For data processing, pressure signals should be filtered using a CFC 180 filter.
- Before the test, the signal pressure offset should be cancelled or the pressure value just prior to the test shall be recorded (with the dummy in final test position).
- The maximum pressure criterion is the maximum of the left and right pressure (low passed filtered and offset removed)
- A time interval of at least 15 minutes should be observed between two tests on the same APTS

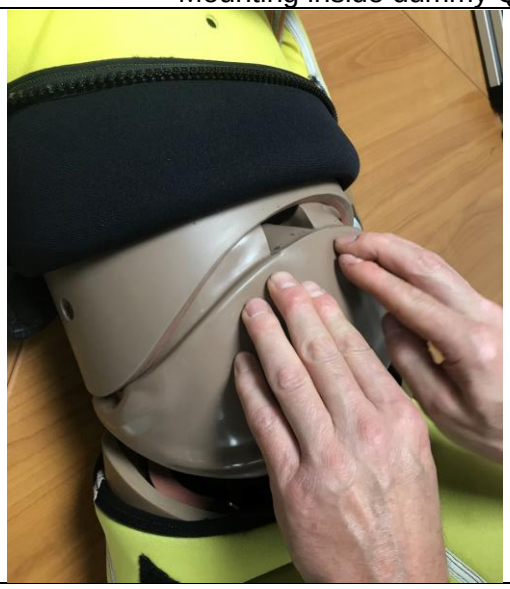
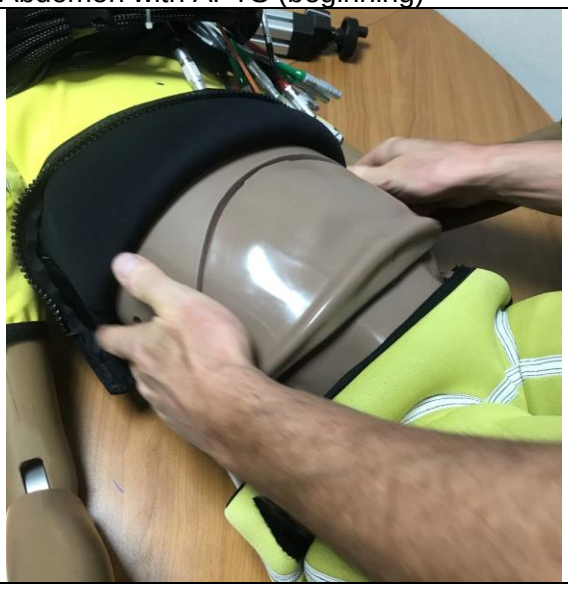
Handling APTS inside dummy abdomen



View of lycra socket introduced over APTS

Mounting inside dummy Q6 Abdomen with APTS (beginning)

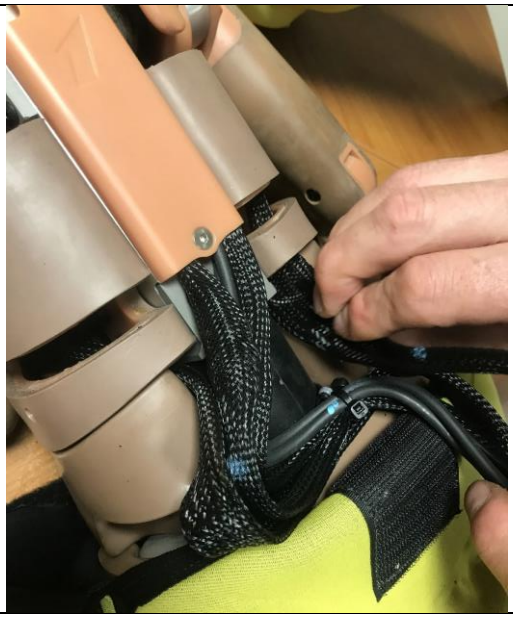
Mounting inside dummy Q6 Abdomen with APTS (end)

CABLE ROUTING AND PROTECTION

The dummy transducers have been designed and selected for use with small cross-section cables. These cables do not need much space and ensure minimum interference with the kinematics of the dummy.
In the design of the dummy, paths for the transducer cables have been defined. The general guideline is that all cables should be routed towards the thoracic spine of the dummy.
Cables should run from the top to the base of the thoracic spine. The abdomen has been formed to allow the routing of the cables in such a way that they lie recessed between the rib cage and the pelvis skin.

	
View of abdomen outside Q6 dummy	Preparation of APTS cable routing inside Q6 abdomen
	
Introduction of APTS inside abdomen (sensor head downward)	View of APTS pair inside abdomen with cable output along the sensor (not recommended)

View of APTS cable output at the abdomen bottom (recommended)



Routing the instrumentation cables above the pelvis and along the spine. Be careful about the curvature radius of the cables

View of the final routing of the sensors harness at the bottom of the spine

MAINTENANCE

After sales services performed by TRANSPOLIS SAS about repair and maintenance are limited to:

- Plug rework or change
- Cable rework or change
- Control, verification, and calibration

CALIBRATION

To guarantee high quality standard of the measurements, it is highly recommended to perform an official pressure calibration of the APTS at least once a year. The calibration must be done in the Transpolis laboratory or in a laboratory accredited by Transpolis (please ask Transpolis for technical support). During the calibration, the APTS biofidelity conformance is also verified.
The calibration is performed with a pressure test bench developed by Transpolis. The calibration is performed by direct comparison of the pressure signal of the APTS sensor with the pressure reference sensor.

The summary of the calibration procedure is:

- The sensors are placed four at a time in a pressure vessel.
- After offset adjustment, the air pressure inside the vessel is applied and increased slowly from 0 bar to 4 bar within about 30 seconds, then decreased from 4 bar to 0 bar within about 30 seconds.
- The pressure signals of the reference sensor and the APTS sensors are recorded with the data acquisition system.

The measurement results are delivered in a table including:

- Applied pressure Pr (Pressure measured by the reference sensor).
- Output signal, given by the APTS sensor.
- Modelling pressure, calculated with column 1 & 2 (linearization of the measurement curve).
- Non-linearity, which is the max value of deviation of the positive slope, given in percentage of the full scale (%FS).
- The sensitivity is the positive slope of the modelling curve, considering the excitation voltage.
- The sensitivity uncertainty is the standard deviation of the sensitivity taking into account 95% confidence interval
- Hysteresis is the maximum difference between increasing and decreasing values of the pressure, given in % of the FS.

Results table				
Applied pressure Pr (bar)	**Output signal (mV)**	**Modelling pressure Pm (bar)**	**Deviation Pr-Pm (bar)**	**Non-linearity (%FS)**
0,000	0,001	0,005	-0,005	0,1%
0,400	0,162	0,409	-0,009	0,2%
0,800	0,318	0,799	0,001	0,0%
1,200	0,478	1,202	-0,002	0,0%
1,600	0,636	1,596	0,004	0,1%
2,000	0,799	2,005	-0,005	0,1%
2,400	0,955	2,396	0,004	0,1%
2,800	1,115	2,797	0,003	0,1%
3,200	1,276	3,200	0,000	0,0%
3,600	1,439	3,610	-0,010	0,2%
4,000	1,597	4,005	-0,005	0,1%
3,600	1,438	3,607	-0,007	0,2%
3,200	1,277	3,202	-0,002	0,1%
2,800	1,117	2,802	-0,002	0,1%
2,400	0,960	2,408	-0,008	0,2%
2,000	0,798	2,003	-0,003	0,1%
1,600	0,639	1,605	-0,005	0,1%
1,200	0,479	1,203	-0,003	0,1%
0,800	0,319	0,803	-0,003	0,1%
0,400	0,162	0,408	-0,008	0,2%
0,027	0,016	0,042	-0,015	0,4%

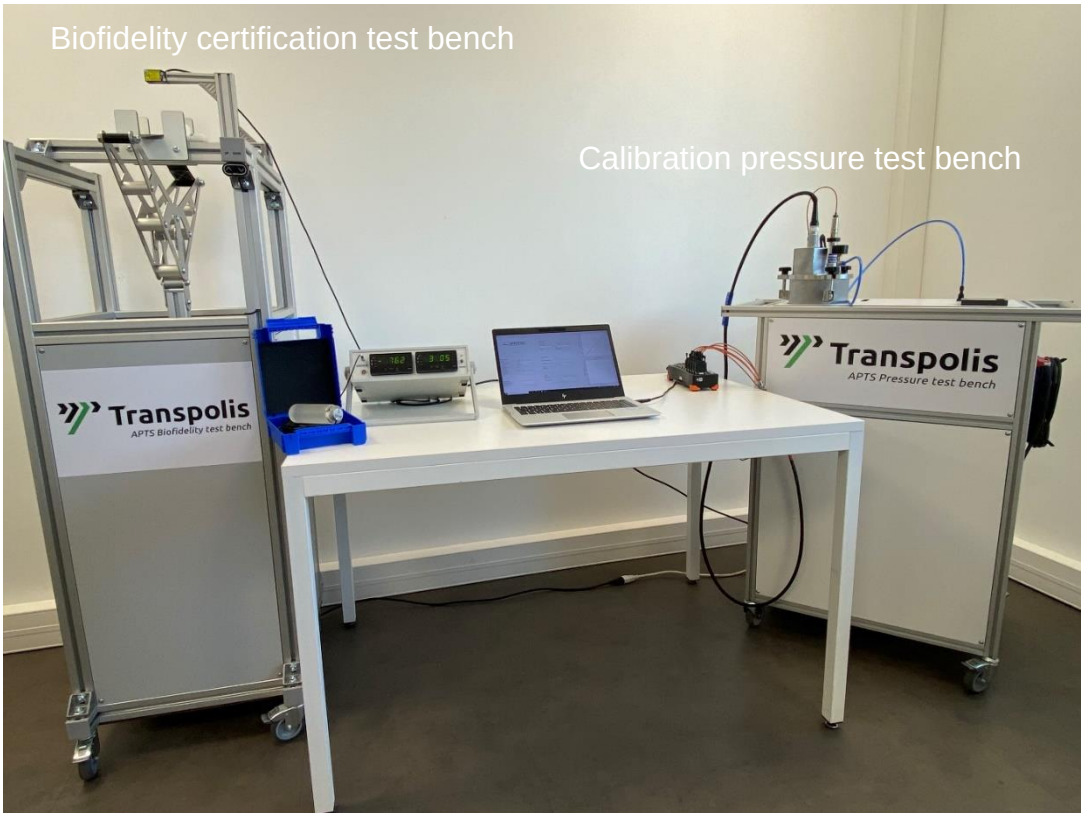
APTS Calibration Data	
Sensitivity (mV/bar)	**0,399**
Offset (mV)	**-0,001**
Sensitivity uncertainty U at k=2	0,6%
Non-linearity (%FS)	0,2%
Hysteresis (%FS)	0,1%

CERTIFICATION

Besides the inspections to be performed before each test, the dummy abdomen and the APTS should be regularly certified to check its performance. It is advised to certify the APTS sensor at each calibration and at least once a year. When doubts on obtained measurements arise, when parts are replaced and when injury criteria are significantly exceeded, it is recommended to do again the certification test.

Biofidelity certification data are obtained after static compression test with a belt: measurement of the pressure P (bar) and the deflection D (mm) with a 250 N load. If the P/D values are between the +/-10% margin of the criteria, the APTS passes the test.

APTS Certification Data : Biofidelity Static Response			
Sensor specifications		**Test data**	
Delta Pressure (bar)	Deflection (mm)	Delta Pressure (bar)	Deflection (mm)
0,67 +/-10%	16,51 +/-10%	0,68	17,76
Test result		**Passed**	



ACKNOWLEDGMENTS

Pictures and data of ATDs reproduced by courtesy of Humanetics, Cellbond and TeamTex.