# Sweating thermal cylinder Torso


## Device description and purpose

Heated sweating cylinder named 'Torso' is used to measure the environmental heat exchange through the fabric assembly of a clothing system. It consists of a multi-layered cylinder and two heated aluminum guards, which help to minimize lateral heat losses. The climatic chamber allows for the simulation of variety of conditions including hot, cold or windy outdoor conditions.

Torso can be used to determine thermal and evaporative properties of the single and multilayer fabric assemblies according to dedicated standards to compare the sample to predeceasing prototypes, other products on the market or against required values given in standards. In addition customizable real-life scenarios can be simulated to evaluate fabric assembly performance at its actual conditions of use.

## Technical details

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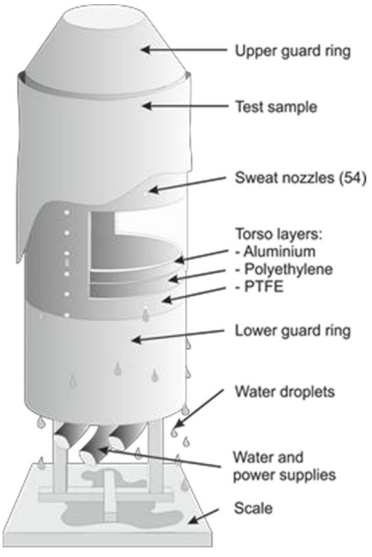
| Construction | The main cylinder of Torso has a diameter of 30 cm and a height of 46 cm, which approximates the size of the adult male trunk. The aluminum cylinder is heated on its inner surface, and is coated on the outer side with a 7 mm thick polyethylene layer and Teflon outer layer protecting surface temperature sensors. |
| Heating | Torso is a single-segment system heated homogenously on its entire surface. The mean temperature of the main cylinder is measured at its outer surface using nickel resistance wire deployed evenly over the cylinder. The heating system of Torso consists of heating foils placed on the inner surface of the main cylinder and along the edges of the guards neighboring with the main cylinder. The power supply delivers electrical power in pulse-width modulation, of which length is adjusted every second. Such a system provides a precise determination of the power delivered (sum of the pulses width during a given period of time) and it allows immediate adjustment of supplied power for better accuracy of the entire system. The maximal power output of the main cylinder of Torso approximates 360W/m2. |



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Sweating

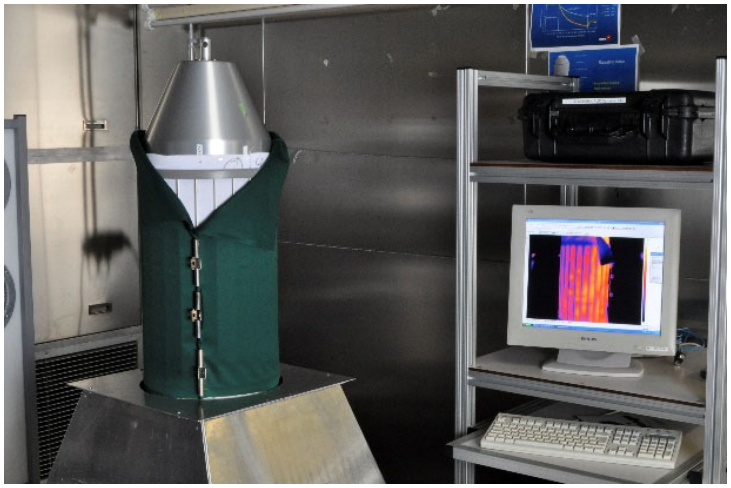
Torso is equipped with 54 sweat outlets distributed evenly over the surface of the main cylinder, which are connected to internal, separately controlled valves. These outlets and a tight-fitting textile 'skin' distribute water, which is used to simulate sweating over the surface of the main cylinder. An external water tank, which supplies the sweat outlets with water, is positioned on a precision balance to determine the mass of the liquid sweated. The sweat rate can be varied from 20 milliliters to up to 1 litre per hour to simulate all possible activities and conditions. Precision scale allows observing the weight change of the entire system including the sample and provides the information about evaporation or drying rate of the sample. Torso system encompasses also water catching system collecting the drip off water that can be weighed at the end of the measurement.

Chamber

A climatic chamber has an important input to the precision of the thermal device. The chamber, where Torso is placed, maintains the air temperature within ±1 °C and relative humidity within ±5 % in the range of -10 °C and 40 °C and 35-95%, respectively. Additional structures to the climatic chamber help to circulate the air in a quasi-piston flow system, which gives a homogenous velocity field and low turbulence level. The wind tunnel placed in front of the manikin is used to simulate relative air movement, for example to simulate walking and wind speeds up to 3.0 m/s.

## Additional equipment

Additional air gap spacers are available to produce homogenous air gaps between sample layers of 0.5, 1, 3 and 5cm. Temperature and humidity sensors can be placed between fabric layers or wherever required to record local conditions across the layers. Infrared camera can be also placed in the climatic chamber to record overall thermal signature of the outer surface of fabric assembly.



## Sample requirements

To produce 3 samples for Torso measurements 2 running meter of the fabric with minimal width of 1.2m is needed. If working with air gap spacers more fabric might be needed for the samples. Elastic samples are often sewn into a tube with pre-set stretch level, whereas non-stretch samples are fixed on the main cylinder with clamps.

## Methods and standards

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| ISO 18640-1 | Protective clothing for firefighters - Physiological impact - Part 1: Measurement of coupled heat and mass transfer with the sweating TORSO |
| ISO 15831 (2004) | Clothing - Physiological effects - Measurement of thermal insulation by means of a thermal manikin |

## Outcome and its practical meaning

- Comparing products (different prototypes, market screening, formal standardized values) for which standard methods and classification schemes are used
- Creating protocols resembling real life use conditions of clothing by setting climatic chamber conditions, surface temperatures, activity levels (constant heat supply), and wind conditions to observe effects inside the fabric assembly, for example, temperature development, moisture accumulation, ventilation effect.
- Connection to modelling tools to extend data interpretation where our thermo-physiological, clothing and thermal comfort models can be used to simulate virtually various scenarios of use based on basic clothing

parameters measured according to standard methods to obtain physiological and comfort profiles of the user. This information can be used to determine theoretical conditions of use, effects on the wearer, e.g. safe working time, dehydration, thermal sensation.

## Contact

If you have any queries regarding the suitability, cost or time frames associated with this testing, please, do not hesitate to contact us. Please, also check on our website (link) the possible formats of collaboration with our team.

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