



## Device description and purpose

The flame manikin (HENRY) is a male-shaped manikin of 1.85m height, equipped with 122 thermocouple-based heat flux sensors. A gas burner system consisting of 12 torches is used to produce  $84\text{kW/m}^2$  on the manikin surface to simulate a flash-over situation of defined intensity and duration.

The test setup corresponds to the requirements of ISO13506 (including EN469 Annex C) and ASTM F1930. The aim of these test procedures is to assess the thermal protection properties of heat and flame protective clothing systems when exposed to fire of a defined intensity. The heat flux data measured over time on the surface of the manikin will be used to predict burn risk using skin data defined in the standards.

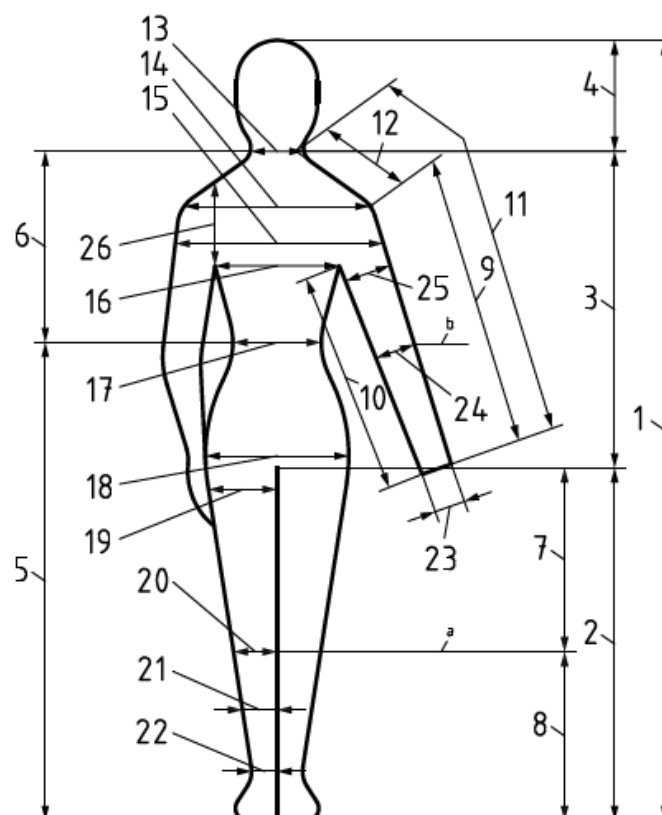
## Technical details

Chamber	The flame engulfment tests are performed in a specialized chamber. The chamber is connected to fume exhaust and a filtering system. A window allows supervision during the tests.
Manikin	Male-shaped manikin of 1.85m height with 122 heat flux sensors. The arms can be rotated to facilitate donning jackets.
Burner system	12 torches on 6 stands are used to generate a heat flux of $84\text{kW/m}^2$ ( $\pm 5\%$ ) on the manikin surface. Propane is used to fire the burners. Gas pressure is regulated to control flame intensity, and the gas supply is controlled using electrical valves. Electrical-controlled pilot flames are used to ignite the torches.
Sensors	122 epoxy-encapsulated thermocouple sensors are used to measure heat flux.
Results	<p>Heat flux and transferred energy over time per sensor</p> <p>Burn risk per sensor (1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> degree as well as pain level), per body part, and on a schematic manikin</p> <p>Cumulative burn risk over time</p> <p>Shrinkage of garment based on ease measurements</p> <p>After burn time</p> <p>Visual assessment of smoke production, burning, and melting, as well as color change or fabric destruction</p> <p>Pictures and video (optional)</p>

## Sample requirements

The typical clothing size and manikin dimensions for individual selection of the product size are given in the table below. Readymade garments of size L/54 usually fit the manikin.

No.	Description of male manikin (HENRY)	mm
1	Stature / total height	1865
2	Crotch height, from heel	890
3	Trunk	800
4	Head height, including neck	240
5	Waist height, from heel	1170
6	Collarbone to back waist	460
7	Crotch to knee	360
8	Knee height (standing)	560
9	Top of shoulder to wrist along arm	515
10	Arm inseam	430
11	Sleeve length, 3-point measurement from collarbone to wrist	760
12	Shoulder length	245
13	Neck circumference	450
14	Across shoulder	550
15	Across chest, (100mm down)	490
16	Chest circumference, at the armpits	1050
17	Waist circumference	860
18	Hip circumference, maximum	1030
19	Thigh circumference just below buttock	605
20	Knee circumference	405
21	Calf circumference	415
22	Ankle circumference	275
23	Wrist circumference	230
24	Elbow circumference	300
25	Upper arm circumference, at the mid-point	325
26	Shoulder circumference	400



The clothing samples are dressed from the bottom, pulling the shirt neckline over the legs (since the head is connected to the data collection system, and garments cannot be pulled over the head). This means that any clothing items covering the upper body that do not have sufficient neck opening will have to be cut from the neckline through one or both shoulder seams for ease of dressing and secured with security pins or staples for testing.

Three pre-treated specimens (according to standard) are tested. Single-layer garments are typically exposed for 4s, whereas multi-layer garments, such as firefighter turnout gear, will be exposed for 8s. Please, note that only non-burnable or FR treated materials will be tested.

## Methods and standards

The system was built according to ISO 13506, also compatible to ASTM F1930

ISO 13506-1 (2024)	Protective clothing against heat and flame - Part 1: Test method for complete garments - Measurement of transferred energy using an instrumented manikin
ISO 13506-2 (2024)	Protective clothing against heat and flame - Part 2: Skin burn injury prediction - Calculation requirements and test cases
ASTM F1930 (2020)	Standard Test Method for Evaluation of Flame Resistant Clothing for Protection Against Flash Fire Simulations Using an Instrumented Manikin
EN 469, Annex C (2020)	Protective clothing for firefighters - Performance requirements for protective clothing for firefighting activities

### Outcome and its practical meaning

---

- Comparing products (different prototypes, market screening, formal standardized values) for which standard methods and classification schemes are used
- Evaluating the performance of complete garments or protective clothing ensembles exposed to short-duration flame engulfment.
- Rating system to characterize the thermal protection provided by single-layer and multi-layer garments made of flame-resistant materials. The rating is based on the measured heat transfer (part 1) and burn risk (part 2) in response to a simulated flash-over simulation of defined intensity.

### 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.



[services-401@empa.ch](mailto:services-401@empa.ch)



Empa - Swiss Federal Laboratories for Materials Science and Technology  
Lab for Biomimetic Membranes and Textiles  
Lerchenfeldstrasse 5  
CH-9014 St. Gallen, Switzerland