

Flame Resistant fabrics, garments and test methods

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Agenda

- What is flame resistance
- Fabric tests for flame resistance
 - Flame tests
 - Heat transfer
- Garment test methods
 - What do the results mean
- Summary & Question

What is flame resistance

Flame Resistant?



Not flame resistant



Flammability tests for Immersion suits

ETSO 2C 502 & 503

The outer fabric used in the construction of the suit shall be of low flammability. It shall not have a burn rate greater than 100mm/min (4in/min) when tested in accordance with the horizontal test of CS-25 Book 1 (JAR) Appendix F Part 1 or other approved equivalent method.

- It can burn but not too fast

ISO 15027 constant wear immersion suits

- When tested in accordance with ISO 15027-3:2012, 3.5, the constant wear suit material shall neither be consumed nor sustain burning nor continue melting 6 s after being removed from the flames.
- Sample must not easily ignite,
 - But does not need to be a flame retardant material

ETSO

CS-25 Book 1 Appendix F Part 1 (b)(5)

- Test is done in a draft free cabinet
- Cabinet has a limited air volume
 - Hence limited oxygen to support burning
- Outer fabric is face down
- Bunsen burner applied to fabric for 15 seconds then extinguished
- Designed for aircraft cabin materials not garments
- Must burn at less than 100mm/min

Video of Test



ISO 15027 Immersion suit

Flammability Test method

- Suit placed over hanger lowest point 250mm above pan
- Transported at 0,29 m/s through the flames for 2 s
- Over a pan of burning petrol or n-heptane
- Start finish 2m away
- Pan size 300mm x 350mm x 65mm
- Material shall neither be consumed nor sustain burning nor continue melting 6 s after being removed from the flames.

Results

- Nylon suits can pass the test
- They do not readily ignite
- But once ignited will burn
- Gore would **not** consider standard nylon laminate suits that pass this test flame retardant

Flame tests

ISO 15025 - A

- Common flame test to assess fabrics
- Horizontal Flame Duration 10 seconds
- Flame length 25 mm +/- 2mm
- Look for hole >5mm
- After flame or after glow >2 seconds
- Flaming Debris
- Flame spread



Flame tests

Edge burn test ISO 15025 -B

- Similar to horizontal flame but Flame impinges on bottom edge of fabric
- Burner angle at 30° to Vertical
- Higher variability seen in results
- Not typically used in fire fighting specifications due variable results

Gore Testing

- From extensive testing of vertical flame ASTM D6413 testing Gore has seen no correlation to a thermal manikin test
- Materials that perform well in a vertical flame test can perform poorly in a thermal manikin test
- Materials that perform poorly in a vertical flame test can perform well in a thermal manikin test

ISO 17493 Oven test

Method

- Vertical sample
- Test looks for sample shrinkage
- Sample size can vary
 - This could influence result
- Changes of the material
- Melting, dripping
- Dimensional changes
- Results not specified

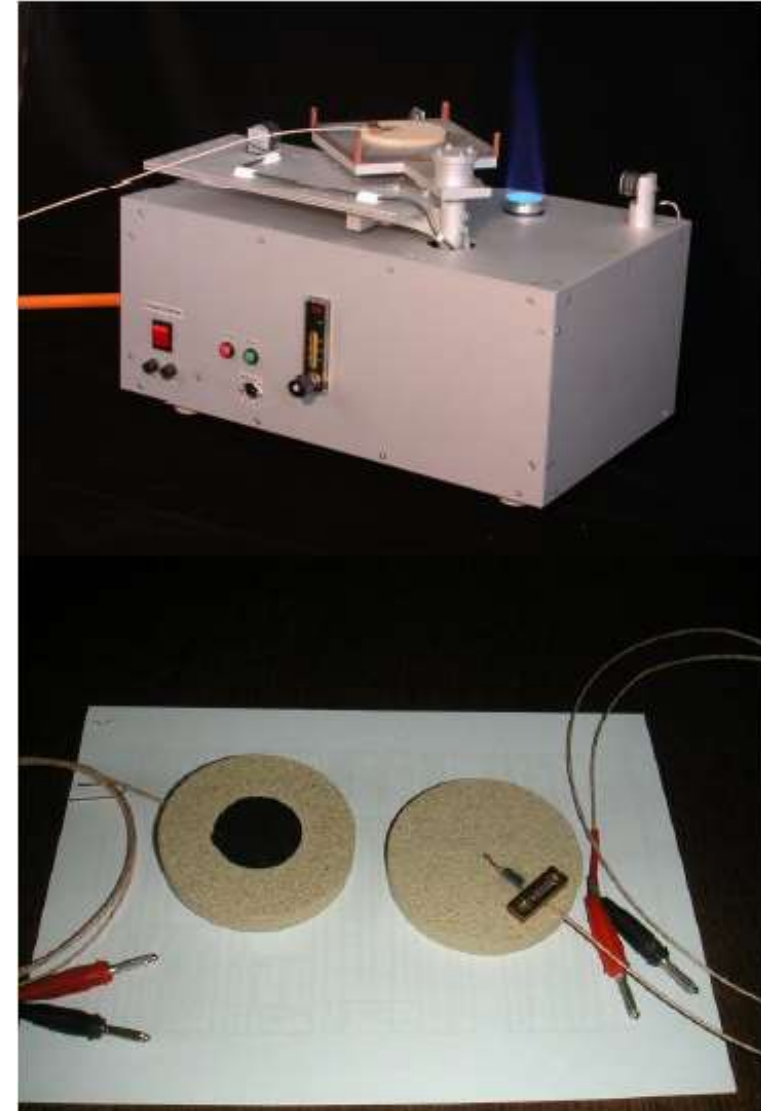
Use related

- ISO 11612
 - 5min exposure, at 180°C,
 - Normal
 - Shrinkage max 5%
 - 5min exposure at 260°C
 - Higher temperature optional except for next to skin layers
 - Shrinkage max 10%
 - Meet normal procedure
 - Closure can be opened 5 min after test

ISO 9151 heat transmission on exposure to flame

Convective heat test

- Measure temperature rise from flame through fabric assembly
- Measure 12 & 24°C rise
 - Time in seconds to 0.1 second
- Energy 80kW/m²
- Indications
 - 12°C temperature rise indication of pain
 - 24°C temperature rise indication of 2nd degree burn
 - Difference 12 – 24°C is escape time



ISO 6942 (Radiation heat test)

- Method A
 - 3 minutes
 - Note any changes separately for each layer
 - E.g shrinkage, melting, charring, etc
- Method B
 - Look for time for increase in temperature rise of 12°C & 24°C
- Energy levels
 - Low 5 kW/m² or 10 kW/m²
 - Medium 20 kW/m² or 40 kW/m²
 - High 80 kW/m²

Test Equipment



ISO 14116

Aim

- Reduce risk of clothing burning in brief contact with small flames
- Index 1,2 or 3 depending on performance
- 1 or multiple layers
 - Test fabric and seams
- If protection against heat hazards is needed, & protection against flame,
 - Standard is not appropriate
 - Use ISO 11612

Index after ISO 15025 –A horizontal flame

- Index 1
 - No flame boundary lower edge or hole upper or vertical edge.
 - No flaming or molten debris
 - Afterglow time shall be ≤ 2 s.
- Index 2 (+index 1)
 - No hole formation of >5 mm
- Index 3 (+ index 1 & 2)
 - After flame time shall be ≤ 2 s.
- All tests initial & after washing

ISO 11612

Aim

- Protective clothing against heat and/or flame
- Covers materials made from flexible materials for the body except hands
- For garments not covered by other standards
- Materials tested pre & post washing
- Risk assessment is done by employer or user

Key Tests for heat & flame

- Heat resistance oven test 180°C
 - ISO 17493, 260°C optional
- Flame test ISO 15025 A (A1)
 - Similar to Index 3 ISO 14116
 - B hemmed edge (A2) index 3 except hole clause
- Convective heat ,B
 - ISO 9151, index depends on time to 24°C
- Radiant heat, C
 - ISO 6942 index depends on time to 24°C
- Optional thermal manikin test ISO 13506

ISO 13506 Thermal Manikin Test Prediction of burn injury using an instrumented manikin

Test Method

- Manikin is clothed in full clothing system to analyse
 - Underwear
 - Mid layer(s)
 - Outer layer
- 8 -12 burners, 84 kW/m²
- Test can be done for different times e.g 4, 8 seconds
- Need to do minimum of 3 tests
- Different manikins give different results

Key Report Details

- Number of 2nd & 3rd Degree Burns
 - after 60s single layer
 - After 120s multi layer
- After flame, after glow
- Clothing system
- Pain, 1st degree burns
- Pretreatment(s)
- Burn time seconds
- Video
- Other observations

Fuel air explosion

- Testing carried out by University of Alberta
- Did 60 experiments of igniting propane gas cloud
- Wide variety of wind conditions, different days and conditions
- Different amounts of fuel
- 360° sensors
- All sensors registered fire for less than 3 seconds
- Heat flux within & across exposures consistent @ 84kW/m²

What does this mean

What is the threat

- What do you want to protect against
 - What is realistic
- Is the test a good indicator of performance & risk
- Are the results comparable
- Is flame threat as well as heat transfer covered?

Most realistic tests

- Thermal manikin ISO 13506
 - But would the person be still in real life?
 - Expensive
- For regular heat & flame testing
 - ISO 14116 limited flame spread
 - ISO 16112 protective clothing against heat & flame
 - Or key elements of standards

Summary

- Many tests for heat & flame resistant fabrics
- Most realistic test is thermal manikin ISO 13506
- Can use other tests at fabric level
 - E.g. horizontal flame test ISO 15027
 - Heat transfer convective ISO 9151
 - Heat transfer radiant ISO 6942
 - Garment certification tests ISO 14116 & ISO 11612
- Understand the risk use appropriate tests

Questions?

