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
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?