



Protect Your People®



EN 11612

EN 14116

NFPA 2112

NFPA 2113

## USA and European Standards for Clothing to Protect against Heat and Flame Hazards



North America and Europe have their own standards for clothing to protect against heat and flames.

But how do they differ? And which is better for assessing garment effectiveness?

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HPFR

**“As a Safety Manager in a Global Industry, you want to be sure your people have the best protection.. So which standards are the best and which should you apply?”**

The generally accepted default position of specifiers of PPE only applying one standard, the choice often based simply on geography , is limiting. Different standards often contain unique and useful tools for assessing PPE performance.

So, given an objective to protect workers as well as they can be protected, rather than considering only one standard, understanding and using the best from different standards can be a more effective strategy.

This document compares the main USA and European standards for flame and heat protective garments.

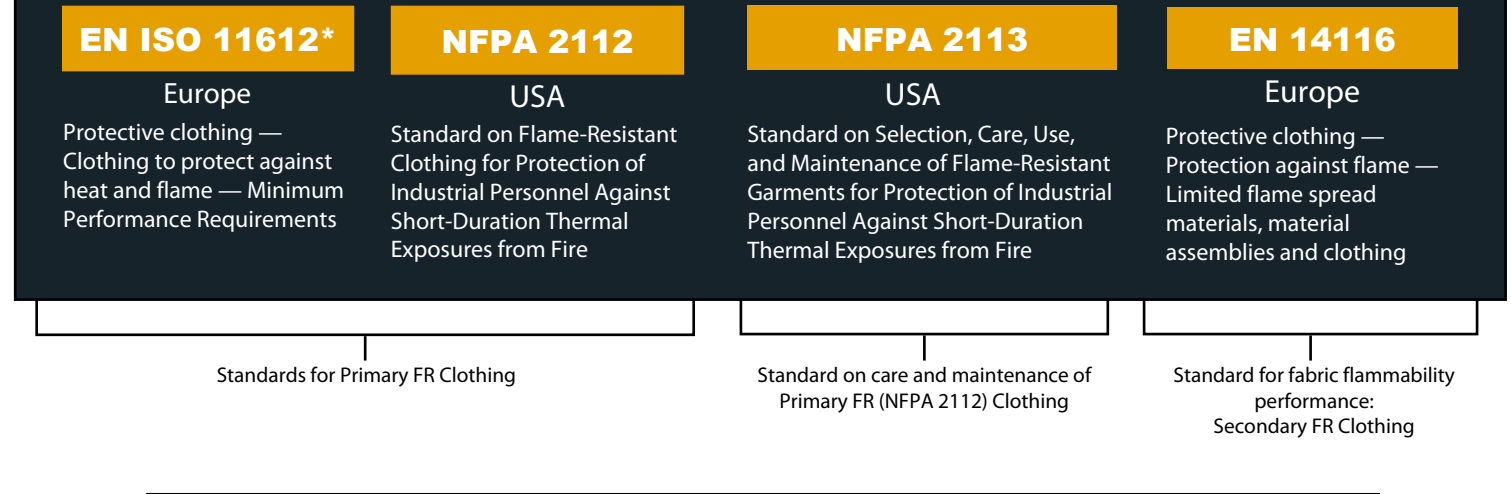
In general, both contain similar test requirements, but with some key differences.

This page contains an outline summary. Read on for a more detailed analysis

\* Note: there is also a specific European standard for welding apparel, EN 11611. It is similar to EN 11612 with some additional requirements and is not covered in this document. There is no equivalent North American standard for welding clothing

sales@lakeland.com

## Comparison of Standards - General Summary



### Thermal Resistance Tests

- Both EN 11612 and NFPA 2112 standards contain a vertical flammability test with minor differences but similar requirements, the NFPA version can be said to be marginally more demanding
- Both standards contain tests assessing heat energy transfer resistance. However
  - The US standard contains only 1 test (convective/radiant heat) with a simple minimum performance requirement
  - The EN test contains 5 optional (at least one must be conducted) tests against different types of heat energy transfer and as well as minimum performance for each provides classification of results so allowing garment performance comparison.

Thus, the EN test provides more useful information for users

### Thermal Mannequin Test?

- Both standards include a thermal mannequin test, in which a test garment is subjected o a simulated flash fire under specific conditions, and likely body burn percentage, location and depth are predicted
- However: -
  - The US test is mandatory and includes minimum performance requirements
  - The EN test is optional and contains no minimum performance requirements

Thus, the US test is more demanding and provides mandatory information and minimum performance in a real-world flash-fire simulation

### Conclusions

- The US NFPA 2112 standard generally requires higher performance levels overall than the EN 11612 test – especially in the case of the mandated thermal mannequin test
- The European EN 11612 standard features more useful testing and information in its range of heat energy resistance tests against different types of heat energy, but lacks a mandatory thermal mannequin test.



## The Following pages feature a more detailed comparison of the standards , focussing on NFPA 2112 and EN 11612

In general terms EN 11612 is equivalent to NFPA 2112.

Both address performance requirements for garments designed to protect against industrial flame and heat hazards.

However, it is not the case that EN 14116 is equivalent to NFPA 2113.

### Note the difference between "product" and "test" standards.

Product standards define performance requirements for items of PPE.

Test standards define test methods - how to conduct the tests required

In the USA product standards are generally issued by the National Fire Prevention Association (NFPA), whilst test standards are often issued by ASTM International - formerly the American Society for Testing & Materials (ASTM).

In Europe standards with the prefix "EN" (European Norm) may refer to both product standards and test methods.

Test methods may also be defined in ISO standards.

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## The Scope, Intention and Focus of the Standards

### The Difference between EN 14116 and NFPA 2113

#### NFPA 2113

A guidance document covering selection, maintenance, care and use of (NFPA 2112) FR workwear.

It contains no test requirements and only a single reference to Secondary FR Clothing, requiring that garments of flammable material should not be worn over NFPA 2112 certified FR workwear.

**Thus it specifies that standard disposable cannot be worn over FR workwear - FR rated disposables must be worn.**

#### EN 14116

**This EN standard assesses flammability of FR workwear fabric and components.**

It uses a single vertical flammability test (ISO 15025) with results classified as Index 1, 2 or 3 (3 being the highest), according to performance, as shown in the table below.

Garments to be worn OVER Primary FR workwear (i.e. Secondary FR Clothing) should at least meet the requirements of Index 1.

The same test is also used in EN 11612, with the minimum performance requirements being the same as Index 3 in EN 14116 (no burning to edge of fabric, no molten or flaming debris, afterflame & afterglow to be >2 seconds, and no hole formation greater than 5mm)

Note: The 2015 version of the EN 14116 standard requires fabric *and components* (zip, threads etc) to meet the flammability requirements. However, note that most low cost FR garments available often ONLY achieve this on the fabric - components have been excluded - so do not meet ALL the requirements. *Lakeland Pyrolon garments are fully certified to EN 14116 Index 1 and meet ALL the requirements.*

### ISO 15025: Vertical Flammability Test



A flame is applied to the centre of a fabric sample for 10 seconds. Fabrics are classified according to performance

Index 1	<ul style="list-style-type: none"> <li>No flame or melting to outer edges</li> <li>No Flaming or Molten debris</li> <li>Afterglow &lt;2 seconds</li> </ul>
Index 2	<ul style="list-style-type: none"> <li>As Index 1 plus</li> <li>No hole formation &gt;5mm</li> </ul>
Index 3	<ul style="list-style-type: none"> <li>As Index 2 plus</li> <li>Afterflame &lt;2 seconds</li> </ul>

- Certification to EN 14116 requires a minimum Index 1 performance.
- Certification to EN 11612 contains minimum performance requirements equivalent to Index 3 in the same test (see p. 4

### The Difference Focus of EN 11612 and NFPA 2112

The main standards for Primary FR Workwear are EN 11612 and NFPA 2112.

#### NFPA 2112

The standards states: "This standard shall provide minimum requirements for ... flame-resistant garments... for use by industrial personnel, with the intent of not contributing to the burn injury of the wearer, providing a degree of protection to the wearer, and reducing the severity of burn injuries during egress from or accidental exposure to short duration thermal exposure from fire".

Thus, the purpose of the standard is to:-

- Ensure garments do not contribute to injury
- Ensure garments provide a degree of protection
- Reduce severity of burn injuries during exposure to short duration flash-fire

It covers shrouds, hoods, balaclava's and gloves as well as coveralls

#### EN 11612

The standard states: "...to provide minimum performance requirements for clothing to protect against heat and flame, which could be worn for a wide range of end uses"

Thus purpose is to ensure garments meet a minimum level of protective performance against heat and flame.

EN 11612 covers only body protection, excluding protection of head, hands and feet

### Conclusions

Whereas the NFPA standard is focused on protection from exposure to short duration flash fire, the EN test has a wider objective of applying to a range of related applications



## Fabric and Garment Testing

Both EN 11612 and NFPA 2112 contain a range of testing of fabric and garments

In some cases the tests are similar with only minor differences in test conditions and requirements.

In other cases one or the other contains unique and useful tests

### Vertical Flammability / Flame Resistance Test

Vertical Flammability or Flame Resistance testing involves applying a small flame to a vertically suspended sample of fabric (See ISO 15025 - previous page).

The aim is to establish that the fabric does not ignite, continue to burn or to drip molten, burning debris.

This ensures that in the event of contact with a flame, such as a flash fire, the garment itself will not ignite and continue to burn, making burn injury worse.

Both US and European standards contain a requirement for a flammability or flame resistance test

### ASTM 2112

#### NFPA 2112: Clause 7.1.2 : Flame Resistance Test

Fabric is tested for flame resistance according to ASTM D6413 (ref clause 8.3).

- The sample size is 76 x 305 mm (3" x 12")
- The sample is suspended vertically with the long edge to the side with flame applied to bottom edge, directly underneath, for 12 seconds (compared to 10 seconds on EN/ISO 15025 test)
- Assessment considers ignition, melting, dripping and records afterflame and char length

#### Performance requirements: -

- No melting or dripping
- Char length not more than 100mm
- Afterflame not more than 2 seconds



### EN 11612

#### ISO 15025 Vertical Flammability test.

The fabric is tested to the ISO 15025 Vertical Flammability Test

- The sample is 160mm x 200mm (so the ASTM sample is longer but narrower)
- Flame is applied to the fabric sample according to EITHER to the centre of the fabric (Procedure A) OR to the bottom edge (Procedure B)
- Whilst a choice for manufacturers (either or both can be done) most use the centre (Procedure A) option. This is less demanding because when the flame is applied to the bottom edge the fabric is less able to shrink away from the flame (heat rises). So procedure A can be said to be less demanding than the US flame resistance test.
- Flame is applied for 10 seconds (compared to 12 in the US test)
- Assessment considers ignition, melting, dripping, afterglow, afterflame and holing.
- In both procedures the performance requirements are the same:
  - No flaming or melting to outer edge
  - No flaming or molten debris
  - Any afterglow must be less than 2 seconds
  - No hole formation greater than 5mm
  - Any afterflame must be less than 2 seconds
- Results are indicated on the garment label by the codes
  - Procedure A (fabric centre) "A1"
  - Procedure B (Bottom edge) "A2"

### Conclusions

The EN vertical flammability test is very similar to the US flame resistance test: -

- The sample sizes are different
- The NFPA test applies flame to the bottom edge only. The EN test allows the flame to be applied to the centre or bottom edge. Most manufacturers use the centre option.
- The US test applies a 12 second flame, the EN test 10 second
- Minimum performance requirements are similar.

*In general terms the tests are similar but the US test is marginally more demanding*

## Heat Transfer Resistance Testing

These tests assess the effectiveness of garment fabric in resisting the transfer of heat energy through it. To the wearers' skin.

Burns are caused when the skin cells absorb too much heat energy too quickly.

Within limits, the cells can manage a considerable range of temperatures, provide the rate of change is slow enough to manage. It is when the level of heat energy in the cells changes rapidly that they are unable to cope, and break down and die.

So it is the RATE of energy transfer that is critical. Rapid changes in energy level can cause skin burns even at relatively low temperatures.

The purpose, therefor of thermal protective workwear is to prevent, delay and slow the transfer of heat energy from the source to the wearers skin,

These tests make an assessment of that ability.

## Both US and European standards contain tests to assess Heat Energy Transfer Resistance

### NFPA 2112 - Test ASTM F2700

#### NFPA 2112: Clause 7.1.1: Heat Transfer Performance

- Fabric samples are tested for Heat Transfer Performance according to test ASTM F2700 – (ref clause 8.2) to calculate the Heat Transfer Performance (HTP)
- The fabric sample is suspended horizontally with a small flame applied underneath (so the heat energy is both convective and radiant)
- There are spaced and contact settings (both are required) to simulate the fabric being in contact or not with the skin.
  - A flame energy level of 2 cal/second is used
  - A sensor measures the energy transferring through the fabric
  - Exposure is terminated once sufficient energy has passed through to result in a 2nd degree burn
  - Calculation of the Heat Transfer Performance (HTP) is:
    - o *Energy exposed to the fabric, LESS the energy that transfers through = fabric Heat Transfer Performance*

HTP is the difference between the exposed energy and the energy passing through the fabric at the point where a 2nd degree burn is likely – in other words the proportion of the energy transfer that is resisted by the fabric.

NFPA 2112 heat Transfer Performance Requirements	
Contact Or Spaced	Minimum HTP Required
For Spaced Setting	Not less than 6.0 cal/cm <sup>2</sup>
For Contact Setting	Not less than 3.0 cal/cm <sup>2</sup>

### Conclusions

The EN test can be said to be more useful for users because

- It provides for specific testing of different types of heat energy whereas the US test uses a single test with a mix of radiant and convective heat energy. The EN tests can therefor be used to ensure suitability for particular applications and to compare with other garments
- Whilst the US test establishes only a minimum performance requirement (pass or fail), the EN tests provides a minimum performance and classifications above that minimum so can be used to assess suitability for different levels of risk (Low, Medium, High, Very High) in general terms

### EN 11612 - Multiple Tests

The EN standard uses similar testing to the ASTM test. Heat energy at a specific calorific level is applied to one side of the fabric and a measurement of heat transfer through is recorded.

However, 5 different tests are used to assess resistance to different types of heat energy transfer, each identified by a code letter on the label: -

EN 11612 Heat Energy Transfer Tests		
Test	Heat Energy Type	Code Letter used on Label
ISO 9151	Convective Heat	B
ISO 6942	Radiant Heat	C
ISO 12127	Contact Heat	F
ISO 9185	Molten Iron Splash*	D
ISO 9185	Molten Aluminium Splash*	E

A key difference from the US test is that the convective, radiant and contact tests measure the RHTi - the "Heat Transfer Factor". This is *the time until a specific rise in temperature is recorded by the sensor*. The longer the time taken, the more effective is the heat transfer resistance.

Results are classified as Class 1 to 3 (or 4 in the case of radiant heat) according to the table below with a minimum performance requirement of Class 1.

Certification requires a Class 1 in *at least one* of the five tests (manufacturers can choose to do one, a selection, or all five, according to intended application). Classes can be applied to general risk levels Low, Medium and High

(Note: The iron and aluminium splash tests are used only for garments intended for specific applications such as welding . These use a different measure and assessment

EN 11612 Heat Energy Transfer Test Classifications				
Test	RHTi Temp. Rise	Class	RHTi - Time to Temp. Rise in Seconds	General Risk level Applicable
ISO 9151 Convective Heat	10° C	Class B1 Class B2 Class B3	4s to 10s 10s to 20s >20s	Low Medium High
ISO 6942 Radiant Heat	10° C	Class C1 Class C2 Class C3 Class C4*	7s to 20s 20s to 50s 50s to 95s >95s	Low Medium High Very High
ISO 12127 Contact Heat	24° C	Class F1 Class F2 Class F3	5s to 10s 10s to 15s >15s	Low Medium High

\*Class 4 in the radiant heat test is specifically for aluminised garments that must cope with very high levels of heat energy

## Thermal Shrinkage Tests and Other Requirements

A critical factor in protection provided by primary FR clothing is the space between fabric and skin. It provides important additional insulation from the penetrating heat energy.

For this reason FR clothing should never be tight fitting. Tight clothing may be more stylish, but it is less likely to provide effective protection.

Thermal shrinkage of fabrics used in garments - that is, the tendency to shrink when subjected to high temperature - is vital. If fabric shrinks too much, in the event of a flash fire the garment will shrink on to the skin and increase body burn.

The thermal shrinkage tests set minimum performance for the percentage of shrinkage allowable

## Both US and European standards contain tests to Measure Thermal Shrinkage

### NFPA 2112 - Test ASTM F2894

#### NFPA 2112: Clause 7.1.3: Thermal Shrinkage Test

- Fabric samples are tested for Thermal Shrinkage at high temperature according to test ASTM F2894 (ref clause 8.2)
- A Fabric sample (size 15cm x 15cm) is placed in an oven at a temperature of 260°C for 5 minutes
- **Requirements**
  - The sample must not ignite or shrink by more than 10%

### Conclusions

The two tests are very similar, as indicated in the summary table below:

Thermal Shrinkage Tests			
Test	Oven temperature	Exposure Duration	Maximum Shrinkage allowed
US Test ASTM F2894	260°C	5 Minutes	10%
European test EN 17493	180°C	5 Minutes	5%
Optional EN Test	260°C	5 Minutes	10%

The EN Test uses at a lower temperature (but with a lower shrinkage requirement), but with an option that matches the US test

### Other General Requirements

Both US and EN standards also feature a similar range of more general design and performance requirements: -

- Both standards require that components such as threads, hardware (zips/fasteners etc) should be FR rated or should pass flammability testing
- Both tests include some design requirements such as that any pockets must have a covering flap and that in the case of a two piece jacket and pants configuration, the overlap should allow for bending without exposure of the skin
- Both tests require that garments/fabrics are conditioned by washing according to manufacturers instructions before performance testing, and should not shrink with washing

### EN 11612 - Test ISO 17493

#### Test ISO 17493

- Fabric samples are tested for Thermal Shrinkage at high temperature according to test ISO 17493. This is very similar to the US test but with slight differences
- The sample is placed in an oven at a temperature of 180°C for 5 minutes
- An additional option of 260°C for 5 minutes is provided
- **Requirements**
  - Required at 180°C : The sample must not ignite or shrink by more than 5%
  - Option at 260°C : The sample must not ignite or shrink by more than 10%

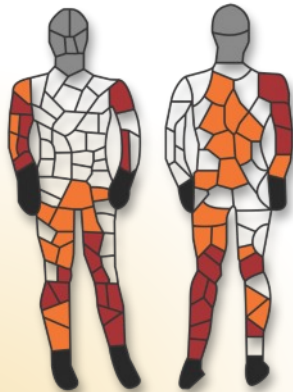


The Thermal Mannequin Test is the only test used that assess the whole garment and not just fabric



Use the QR Code to watch the video showing how the Thermal Mannequin Test works

The body maps below show a predicted body burn of 53%, with both 2nd (orange) and 3rd (red) Degree burns



This resulted from a test using a Primary FR garment with a non-FR rated disposable coverall over it

## NFPA 2112 - Test ASTM F1930 - MANDATORY

### Test ASTM F1930

- This test assesses performance of the finished garment by subjecting it to a simulated flash fire whilst worn on a thermal mannequin. Multiple heat sensors on the mannequin simulate the wearers' skin, and record the heat energy penetrating through to the garment. The test can produce a map of the body, indicating where, pain and 1st, 2nd and 3rd degree burns are predicted. Normally focus is in 2nd and 3rd degree burns
- [You can watch a short explanatory video of this test here](#)
- Defined Test parameters are a 3 second burn at a calorific heat flux energy value of 84Kw/M<sup>2</sup>
- **Requirements:-**
  - Total Predicted Body Burn (2nd and 3rd degree) must be less than 50%

## EN 11612 - Test ISO 13506 - OPTIONAL

### Test ISO 13506

- This is essentially the same test as used in the US standard. However:-
  - The test is optional, so many garments on the market have not been subjected to it at all
  - It defines no minimum performance requirement for the test so has no pass or fail, and can be used only for comparison
  - No specific test parameters are defined, though the standard does suggest at least 4s at 84 kW/M<sup>2</sup>. For this reason, even when garments have been tested, the test parameters are often not quoted, making it impossible to compare. (If comparing performance in this test it is vital to ensure the burn duration, heat energy value and time for recording data is the same)

## Conclusions

The Thermal Mannequin Test is the only test subjecting whole garments to a simulated, real-world flash-fire situation, and the only test used that provides an indication of how well a garment will protect in terms of likely predicted body burn.

Being mandatory and defining test parameters and minimum performance, the US standard is much stronger in this respect than its EN equivalent.

A good policy for safety manager primarily using the EN standard should therefore consider only using garments tested to the ISO 13506 option, and applying a minimum performance requirement

## Thermal Mannequin Testing

All other tests described are on the fabric only (or on components). They do not test the whole garment, nor do they provide an indication to users of how well garments will protect in the real world.

The Thermal Mannequin Test, however, assess the whole garment performance in a simulated flash fire, providing Predicted Body Burn (both percentage and depth) for the wearer.

Both standards provide an option for this test.

However, importantly, the US test is mandatory and includes a minimum performance requirement, whilst the EN test is optional and defines no minimum performance.

Because it is expensive to do, many EN certified garments have not undergone this test.

# Conclusions:

Overall Comparison of standards  
NFPA 2112 and EN 11612 for Primary FR Clothing

## Flame Resistance (see page 4)

Both contain a vertical flammability test with minor differences but similar requirements. The NFPA version can be said to be marginally more demanding

## Heat Transfer Resistance (see page 5)

Both contain tests assessing heat energy transfer resistance. However,

- The US standard contains only 1 test with a minimum performance requirement
- The EN standard contains 5 optional tests against different types of heat energy transfer. As well as minimum performance for each it classifies results according to low, medium and high risk applications.

Although this reflects the slightly different objectives of the standards (see page 3), it does mean the EN test provides more useful information for users because garments can be selected according to class achieved and risk level

## Thermal Shrinkage (see page 6)

Both contain tests assessing shrinkage when subjected to high temperature.

The tests are very similar but with different details. The EN standard includes an option that matches the NFPA test.

## Predicted Body Burn (see page 7)

Both include a thermal mannequin test producing a predicted body burn. However:-

- The US test is mandatory and includes minimum performance requirements
- The EN test is optional and contains no minimum performance requirements

Thus, the US test is more useful in ensuring garments meet minimum protective performance in a simulated fire

Overall it can be concluded that:-

1. The US standard generally defines marginally higher performance levels and requirements than the European standard, especially given its mandatory thermal mannequin test, which is only optional in the EN standard.

*Users and Safety managers applying the EN test might consider only using garments that have been subjected to the thermal mannequin test and have met a minimum performance level*

2. The European standard contains more useful testing data in its range of heat transfer resistance tests which provide both minimum performance and classification according to risk levels

*Users and safety managers normally applying the US standard could gain useful information for specific applications by requiring testing to one or more of these heat transfer resistance EN tests*

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Information in this document was correct at the time of publishing and according to the latest versions of the standards.

Changes in standards might mean some information is obsolete.

For the latest information on standards contact  
sales@lakeland.com

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