SATRA SPOTLIGHT

EN 407:2020 – protective gloves against thermal risks

Explaining the revised requirements of this updated PPE legislation.

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Many workers – such as those in manufacturing operations, foundries or catering kitchens – are exposed to thermal risks while undertaking their job. It may not be possible to simply remove these thermal hazards, and in such circumstances suitable personal protective equipment (PPE), which may include protective gloves (often made from leather), will need to be provided to the worker to protect him or her from injury.

A revision to the European standard EN 407 – 'Protective gloves against thermal risks (heat and/or fire)' has been published by the European Committee for Standardisation (CEN). This standard is used to assess the degree of protection offered by a glove against thermal risks. The revised edition supersedes the previous 2004 version, and contains a number of changes which will be explained in this article.

This document specifies the glove requirements in terms of performance, marking and user information. It also outlines the test methods and user information requirements for protective gloves and other hand protective equipment which are claimed to offer protection against thermal risks for professional, consumer and domestic use. This standard does not apply to gloves for firefighters or welders, as these occupations

have their own performance standards. It is used for all gloves and other protective equipment which protect the hands, part of the hand or arm against heat and/or fire in one or more of the following forms: flames, contact heat, convective heat, radiant heat, small splashes of molten metal or large quantities of molten metal.

European PPE Regulation

When the European PPE Regulation (EU) 2016/425 was first applied on 21st April 2018, it replaced the previous legislation (Directive 89/686/EEC). The directive excluded domestic oven gloves from its scope, so CE marking for these products was not possible. However, Regulation 2016/425 does include gloves 'explicitly described and marketed accordingly by their manufacturers for private use to protect against heat' within its scope. The regulation clearly defines the obligations and responsibilities of manufacturers, authorised representatives, importers and distributors of PPE. This newly-added group of products that must be CE marked when sold in Europe includes oven gloves, pan holders, gloves for use with barbecues and any other piece of hand protection intended to be used in a domestic setting.

Therefore, as part of its review of EN 407, the committee took the opportunity to further develop the standard to include testing methods, performance requirements and a new pictogram for hand protection for the domestic market.

Physical testing

The 2004 version of the standard contained two mechanical test requirements based on tests carried out under EN 388 'Protective gloves against mechanical risks', for abrasion and tear resistance. The revised 2020 version contains a single mechanical test requirement for tear resistance which is applicable to all types of gloves. The resistance to tear is defined as 'the force necessary to propagate a tear in a rectangular specimen slit half way along its length'. The test method is contained within EN 407:2020, although this procedure is equivalent to that contained within EN 388:2016+A1:2018. The standard states that glove material(s) must be tested and adhere to at least 10N, which is equivalent to the 'Level 1' requirement of EN 388.

In addition to this, the 2020 version of the standard contains sizing requirements for the minimum length of gloves that are claimed to protect against small and large splashes of molten metal.

During some tasks, gloves may become soiled and therefore require cleaning. If gloves are intended to be cleaned, the manufacturer will need to supply cleaning instructions to the wearer, while demonstrating that the cleaning has no significant detrimental effect on the glove's protective properties. All tests within this standard are performed on unused gloves or hand protective equipment. However, for products that are intended to be cleaned, tests must also be carried out on the products after the required cleaning cycles, following the procedures instructed by the manufacturer. For example, if the manufacturer intends the gloves to be laundered up to five times in a washing machine at 30°C and then line dried, they will need testing evidence to support this. Likewise, if they intend the gloves to be tumble dried, testing evidence will be required to support this claim.

Thermal performances

EN 407 specifies six thermal properties, each with four associated performance levels. These allow manufacturers to create a range of gloves offering differing properties for various requirements. The four performance levels range from 'Level 1', which is the lowest level of protection to 'Level 4' (the highest level).

To claim performance levels of 3 or 4 for any of the thermal properties, the limited flame spread test must

also be performed and must obtain a minimum rating of Level 3. If this requirement is not met, the maximum level that can be reported for any of the thermal properties will be Level 2.

Limited flame spread test

The limited flame spread test is used to assess the ability to protect the wearer's hand if it comes into close proximity with a naked flame. To give good results in this test, the gloves do not need to be non-flammable, but they must inhibit combustion and burn slowly enough for the wearer to recognise this and safely remove the gloves.

In the test, a whole glove sample is held vertically over a test burner with the flame in contact with the end of the middle finger of the glove or at the longest position for mitts (figure 1). The flame is brought into contact with the test sample for ten seconds, after which the flame is withdrawn and the degree of after-flame and after-glow of the sample is recorded. This test is different to that contained within the 2004 version of the standard, which allowed for two flame exposure times of 3 and 15 seconds. In this latest version of the test, a metal rod is inserted into the glove to prevent the material retracting from the flame.

The standard contains four levels of protection, based on the duration of time for the after-flame and after-glow (see table 1). The standard does not permit the innermost surface of the test sample to show any signs of melting, complete holing of the sample or for it to come apart at the seams. These requirements differ slightly to those contained within the 2004 version, with the lowest level of protection being slightly less demanding in the 2020 version.

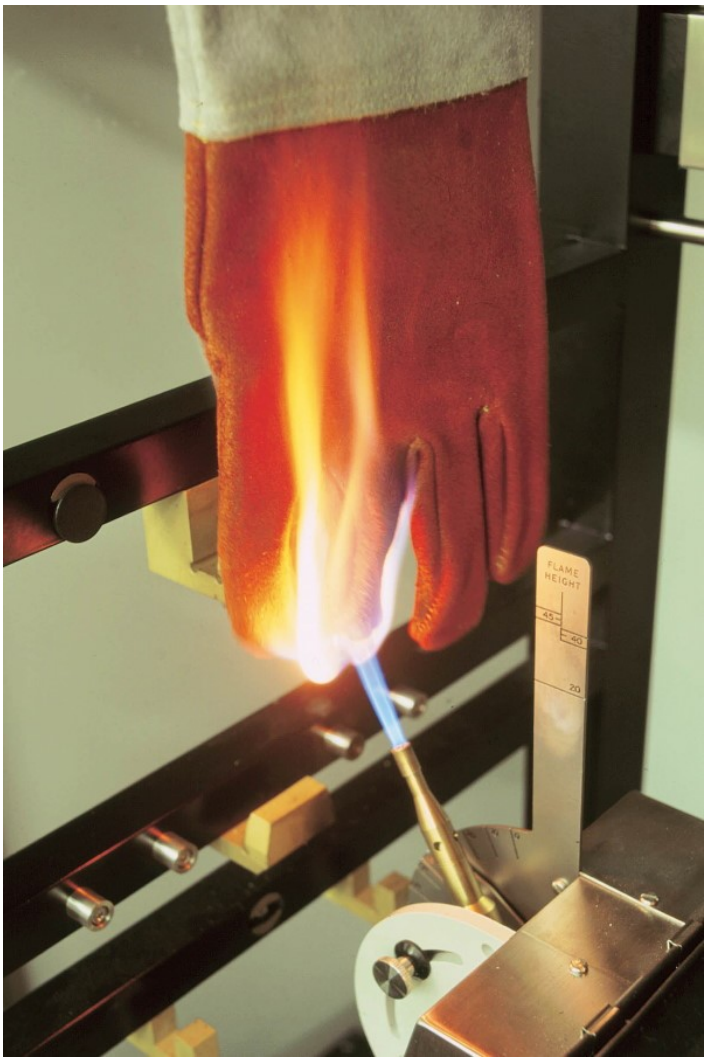

Figure 1: The limited flame spread test

Table 1: Performance levels for limited flame spread

Performance level	After-flame time (s)	After-glow time (s)
1	≤ 15	no requirement
2	≤ 10	≤ 120
3	≤ 3	≤ 25
4	≤ 2	≤ 5

For high thermal resistant gloves (Levels 3 or 4), all outer materials different to the finger area must be tested according to EN ISO 15025:2016 method A, and comply at least with Level 3. Seams and outer accessories with a surface area greater than 10 cm^2 are also to be tested and must meet these requirements.

Contact heat

Through conduction, heat is transferred within and through physical bodies. During use, the wearer of the gloves will intend to hold a hot item and the heat may transfer through the gloves and into the wearer's hand. Gloves with this type of contact heat protection would also be able to protect from any accidental contact, such as the back of the hand touching the internal sides of an oven.

The amount of heat transferred during conduction depends on many factors – surface area, actual temperature of the hot object, the conductivity and heat capacity of the glove and object, and the pressure of the contact. For instance, a hot cup of coffee at 70 to 80°C can easily raise a blister, because the contact pressure is high to hold it. In contrast, a spark from a grinder, despite being 1,000°C-plus, is barely noticeable, because the contact pressure is light and the object is very small with a very low heat capacity.

The test method used to evaluate protection against contact heat is EN ISO 12127-1:2015 – 'Clothing for protection against heat and flame – Determination of contact heat transmission through protective clothing or constituent materials – Part 1: Contact heat produced by heating cylinder'. Within this test, the palm region of all gloves is tested, along with any other areas that either differ in materials and construction from the palm region or are intended to be exposed to contact heat and provide protection to the wearer.

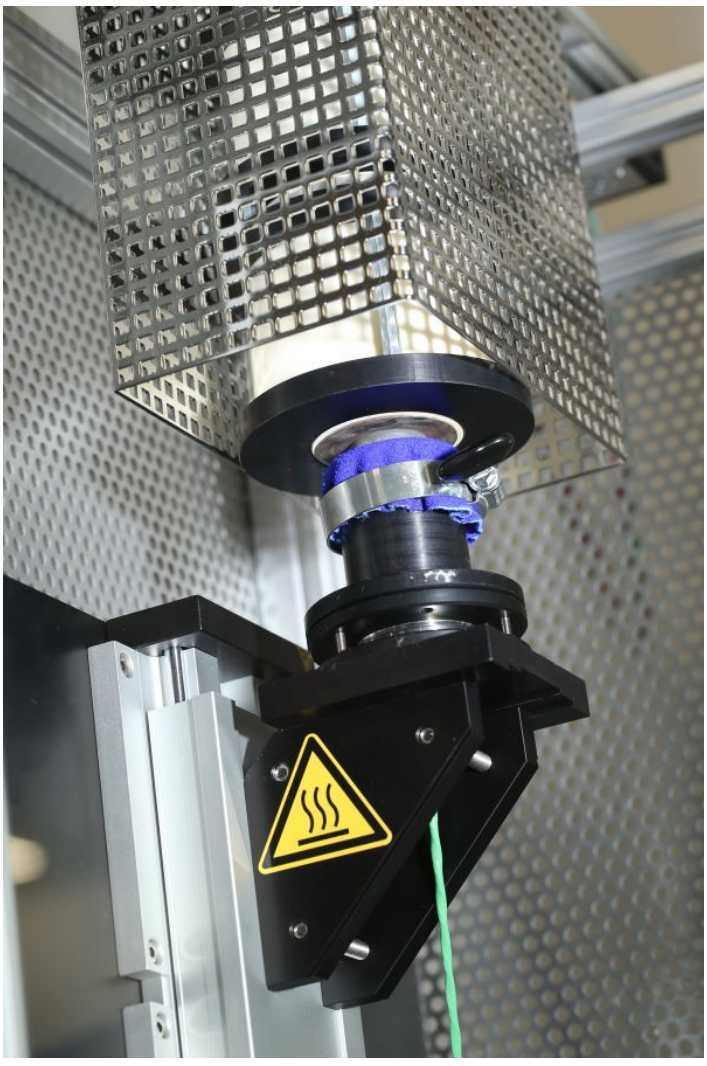

Figure 2: The contact heat test

The test specimen should include all layers of materials – such as outer, lining and mid-layer – but exclude any localised reinforcement. In this test, a metal cylinder is heated to the required temperature (100°C, 250°C, 350°C or 500°C) and brought into contact with the outer surface of the specimen, as shown in figure 2. A calorimeter (temperature-measuring device) is placed on the underside of the test sample to replicate where the wearer's hand would make contact, and the 'threshold time' – the time taken for the temperature to rise to 10°C above the starting temperature – is measured. The levels relate to the temperatures at which the materials are being tested. Performance Level 1 is the lowest at 100°C and performance Level 4 is the highest at 500°C (see table 2).

Table 2: Performance levels for contact heat		
Performance level	Contact temperature Tc (°C)	Threshold time tt (s)
1	100	≥ 15
2	250	≥ 15
3	350	≥ 15
4	500	≥ 15

Convective heat

'Convection' is the mechanism of transfer of heat from the source to another place by the movement of fluids such as water or air. Heat transmission through gloves is largely determined by its thickness, including any air gaps trapped between the adjacent layers.

In this test, the glove's palm region is to be assessed, along with any other areas that differ in materials and construction from the palm region, and which are intended to be exposed to contact heat and provide protection to the wearer. The samples are exposed to a heat source – a flame composed of turbulent combustion gases.

The EN ISO 9151:2016 test method is used, and the thermal insulation of the glove is measured by the rate of temperature rise of a calorimeter on the inside of the glove while the glove outer is placed in contact with a controlled gas flame. The four levels within this test are based on the 'heat transfer index' (see table 3). This is the rate at which the temperature can rise by a specified amount in a specified amount of time.

Table 3: Performance levels for convective heat	
Performance level	Heat transfer index HTI (s)
1	≥ 4
2	≥ 7
3	≥ 10
4	≥ 18

Radiant heat

Heat will transfer between physical bodies which may be separated spatially through thermal radiation in the form of electromagnetic waves in the infrared spectrum in all directions from the hot body. The intensity of the radiation (characterised by the 'heat flux density' – the flow of energy per unit area per unit of time, expressed in the SI system as W/m²) will influence the degree of transfer that occurs. It also depends on the distance from the object according to an inverse square law. Radiant heat from hot bodies can be very intense and is invisible. It can result in injury or even spontaneous ignition long before any conductive contact is made with the source. A dramatic example is how the Sun's rays can be concentrated through a magnifying glass to ignite paper.

The testing is conducted in accordance with method B of EN ISO 6942:2002, on a specimen supported in a free-standing frame and exposed to a specific level of radiant heat (figure 3). The times for temperature rises of 12°C and 24°C measured by a calorimeter are recorded and are expressed as radiant heat transfer indexes. The percentage heat transmission factor is calculated from the temperature rise data. See table 4 for the radiant heat performance levels.

Figure 3: The radiant heat test

Table 4: Performance levels for radiant heat

Performance level	Heat transfer t24 (s)
1	≥ 7
2	≥ 20
3	≥ 50
4	≥ 95

Small splashes of molten metal

This test is used to assess the degree of protection offered to the wearer's hand from being struck by drops of molten metal, such as during metal grinding. In most circumstances where gloves give good results, the droplets of molten metal do not stick on the surface of the test sample but tend to run off. This significantly reduces the time in which they are in contact and does not raise the temperature of the test sample.

The testing is carried out in accordance with EN 348:1992 – 'Protective clothing – Determination of behaviour of materials on impact of small splashes of molten metal'. The thermal insulation of the glove is

measured by the rate of a temperature rise of a calorimeter placed on the underside of the test sample. Drops of molten metal of a specified size (0.5 g) impact the glove outer at a defined rate. The number of droplets which produce a temperature rise of 40°C is measured. The four levels of protection from small splashes of molten metal are based on the number of droplets of molten metal applied (outlined in table 5). Following testing, the outermost and innermost layers of the glove are inspected, and these should show no sign of melting with no hole appearing in the innermost layer.

Table 5: Performance levels for small splashes of molten metal

Performance level	Number of 0.5 g droplets
1	≥ 10
2	≥ 15
3	≥ 25
4	≥ 35

Large quantities of molten metal

If testing to this clause, the use of molten iron is mandatory. However, other optional molten materials (such as aluminium or molten glass) may be tested as required and the corresponding test results must be given on the information supplied by the manufacturer.

The test method is conducted according to EN ISO 9185:2007 – 'Protective clothing – Assessment of resistance of materials to molten metal splash', taking into account conditions given within EN 407. Materials are tested by pouring defined quantities of molten metal onto the test specimen which is supported at an angle to the horizontal.

Following pouring, damage is assessed by visual examination of an embossed thermoplastic polyvinyl chloride (PVC) sensor film placed directly behind and in contact with the test specimen during the test. Any adherence of the test metal to the surface of the glove is also recorded, and material assemblies which ignite during the test do not meet the requirement of this standard. Folds in the material or seams on the outside of the glove can act as trapping points for the molten metal, so the gloves must be designed to prevent the metal being retained. Material assemblies which ignite during the test do not meet the requirement of this standard. Innermost layers of the glove are to be inspected, and must show no sign of melting and holing. See table 6 for the performance levels.

Table 6: Performance levels for large quantities of molten metal	
Performance level	Molten iron (g)
1	30
2	60
3	120
4	200

Pictograms

EN 407, like other PPE glove standards, requires the glove to be marked with a symbol (pictogram) showing the performance levels of the standard that have been met. The 2020 version of the standard introduced a second pictogram to replace the pictogram used within the previous version of the standard under certain conditions.

The previously-used pictogram (figure 4 left) which incorporates a 'flame' icon is now used to label a product that is claimed to limited flame spread level to at least a Level 1 performance. The manufacturer may also claim other properties at the achieved levels. The new pictogram (figure 4 right) is now used to label a product that is not claimed to limit flame spread. The manufacturer must claim at least one other property up to Level 2, and the marking of a product with both pictograms is forbidden.

Figure 4: The 'flame' pictogram (left) and the 'hot contact' pictogram (right)

The level of performance for each property assessed is to be reported under the relevant pictogram as shown in figure 5. If the property is not claimed, this will be reported with the inclusion of an 'X' in the place

of the level numeral.

Figure 5: An example of product marking

An essential activity

Manufacturers who supply gloves which offer any degree of protection against thermal risks will undoubtedly be eager to undertake the necessary testing, in order to mark their products in compliance with the 2020 version of the standard.

How can we help?

15 PER CENT DISCOUNT ON FIRST SATRA TEST — please click here.

Please contact SATRA's PPE team (ppe@satra.com) for assistance with the testing of gloves designed to offer protection against thermal risks in accordance with EN 407:2020.