FLAMMABILITY

WHY IS FLAMMABILITY OF CARPETS IMPORTANT?

The flammability of carpets is an important determinant of the flammability of a whole building. Carpets have a large influence on aspects such as spread of flame, smoke generation, toxic gas evolution and burning. The less flammable interior textile, such as carpets, are, the safer it is for the entire building.

The fire safety of floor coverings does not rely solely on the ease with which a carpet ignites, but also on the rate of flame spread and smoke generation. In experiments conducted by the Wool Research Organisation of New Zealand (WRONZ), wool, nylon and polypropylene carpets were tested using the NBS Flooring Radiant Panel Test. The results showed that wool carpets:

- Had the lowest propensity for flame spread (as measured by the critical radiant flux CRF), and,
- Produced much lower levels of smoke (IWTO, 2010).

WHAT FACTORS INFLUENCE FLAMMABILITY?

Wool carpet is naturally flame resistant, and the performance of wool exceeds that of all other commonly encountered textile fibres. This flame retardancy arises from wool's unique chemical structure (for example, its high nitrogen (14%) and water content), which confers the following beneficial properties and behaviours.

- A very high ignition temperature (570-600˚C).
- A high Limiting Oxygen Index (20- 25%) – with the LOI being a measure of the minimum % of oxygen required to sustain combustion.
- A low heat of combustion.
- A low rate of heat release.
- Doesn't melt or stick upon burning.
- Self extinguishing.
- Formation of an insulating char when it burns.
- Evolution of less smoke and toxic gases than formed during combustion of most synthetic fibres.

Carpet is almost always the last interior furnishing to ignite in a house fire which is one reason, in conjunction with minimising the incidence of smoke inhalation, fire services advise dropping to the floor and crawling to escape a burning building.

HOW IS THE FLAMMABILITY OF CARPETS DETERMINED?

Carpet is rarely the ignition source for fires and virtually all performance standards currently specified require that the carpet self-extinguish. It has been demonstrated (King-mon Tu and Davis, 1976) that given a situation where a chair, or similar, becomes the first and only item to burn in a room, there is little reason to expect involvement of the carpet.

There are numerous standards for measuring the flammability of carpets, with the emphasis being on four key aspects of burning behaviour:

- Propensity for ignition and then burning.
- Smoke density.
- Toxicity of products evolved from burning.
- Speed of flame spread.

Several of these tests are listed below by way of example:

- ASTM E648 Radiant Panel Test - This fire testing standard provides a basis for estimating one aspect of the fire exposure behaviour of a floor covering system installed in a building corridor. It involves a horizontally mounted floor covering system exposed to radiant energy from a gas/air fuel radiant panel. The radiant panel generates a heat profile along the length of the sample. A gas-fired pilot burner is used to ignite the sample, and the distance the floor covering system burns to extinguishment is converted to watts per square centimetre (watts/cm^2).
- ASTM D2859 - 06 Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials or the Methenamine Pill. This test provides a procedure for identification of those finished textile floor covering materials that can be rated as flame-resistant under specific controlled laboratory conditions. The Methenamine Pill Test indicates how quickly a flooring material can be easily ignited by a small ignition source.
- ISO 5657:1997 – Reaction to Fire Tests - Ignitability of building products using a radiant heat source. This standard specifies a method for examining the ignition characteristics of the exposed surfaces of specimens of essentially flat materials, composites or assemblies not exceeding 70mm in thickness, when placed horizontally and subjected to specified levels of thermal irradiance.
- BS 4790 - Determination of flammability of all types of textile floor coverings. This standard uses a heated stainless steel nut placed on the material surface. The times of flaming and of afterglow and the greatest radius of the effects of ignition from the point of application of the nut, are measured.

There are a plethora of other textile fire testing standards. Most of these are product and application specific, such as those used for vertical drape applications, horizontal seating upholstery, mattresses, bedding products and other building elements such as wall boards and insulation material.

NB. ASTM = American Society for Testing of Materials, ISO = International Standards Organisation. BS = British Standard.

HOW DOES THE PERFORMANCE OF WOOL COMPARE TO THAT OF OTHER FIBRES?

Table 1 and Figure 1 afford a comparison of the flammability characteristics of wool with those of other important textile fibres, demonstrating superior performance across virtually all parameters measured.

Table 1. Key measures of flammability for common textile fibres.

Fibre:	Limiting Oxygen Index (%)	Heat of Combustion (Kcal/g)	Ignition temp (°C)	Melting temp (°C)
Wool	25.2	4.9	570-600	Does not melt
Cotton	18.4	3.9	255	Does not melt
Nylon	20.1	7.9	485-575	160-260
Polyester	20.6	5.7	485-560	252-292
Rayon	19.7	3.9	420	Does not melt

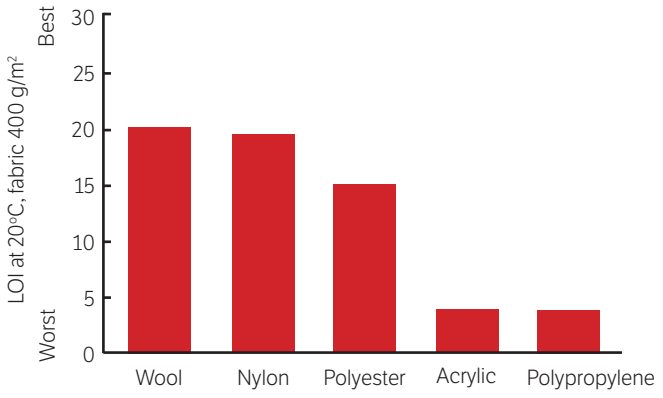

Figure 1. Limiting Oxygen Index (LOI) of common textile fibres (Source: Collie and Johnson, 1998)

Figure 2, Figure 3 and Table 2 compare the performance of wool and synthetic carpets, with and without underlay, in the most common flammability standard applied in the public transportation sector: the NBS Flooring Radiant Panel Test. Indices for smoke and flame spread as well as heat evolved when carpets of differing pile fibre were burned, are also listed.

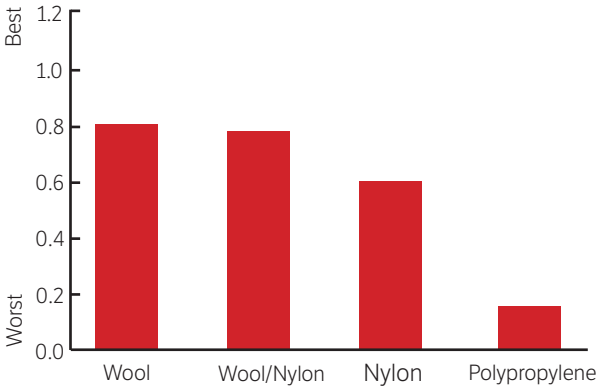

Figure 2. Energy (Radiant Panel Test) required to ignite carpets (Source: Wools of New Zealand)

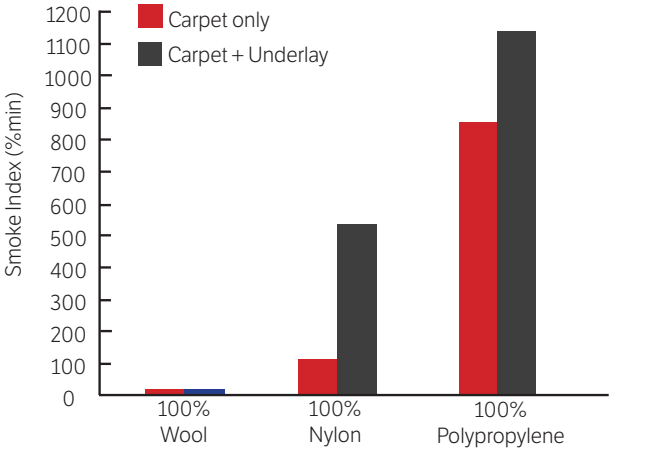

Figure 3. NBS Flooring Radiant Panel Test results for total smoke emission from Saxony carpets (Ingham 1999)

Table 2. Flamability Index of carpet (Leeder 1984)

Fibre:	Ignition Index (0-40)	Flame spread index (0-20)	Heat evolved index (0-20)	Smoke evolved index (0-20)	Overall flamability index (0-100)
Wool	26	0	0	10	36
Polypropylene	28	12	14	14	68
Nylon	30	14	16	16	76
Acrylic	28	16	20	14	78

The performance of wool can be improved even further by the addition of a flame retardant treatment such as Zirpro, which has been shown to raise the LOI to between 27 and 33%. This sort of treatment is most commonly applied to carpet wools for end-uses where exceptionally high performance levels are required (eg. aircraft carpet).

KEY POINTS

- Wool carpets have exceptionally low levels of flammability and represent the logical choice for creating safe, healthy indoor environments.
- Wool is naturally flame resistant, and its performance exceeds that of all other commonly encountered textile fibres.
- Wool has a low heat of combustion and a low rate of heat release.
- If wool comes into direct contact with another burning surface, it won't melt or stick, and is self extinguishing once the initial ignition source is removed.
- Wool forms an insulating char when it burns and evolves less smoke and toxic gases than formed during combustion of most synthetic fibres.

REFERENCES

Collie, S. R. and N. A. G. Johnson, 1998. The benefits of wearing wool rather than man-made fibre garments. WRONZ, Lincoln, Christchurch, New Zealand.

Ingham, P. E., 1999. Fire safety of wool carpets for public buildings, WRONZ Technical Bulletin.

King-mon Tu and Sanford Davis, 1976. Flame spread of carpet systems involved in room fires, National Bureau of Standards, US Department of Commerce, 37p

WTO, 2010.

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