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Natural
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WOOL for Interior Textiles

I.W.T.O.

Wool for interior textiles

Wool is a popular fibre for the various types of interior textiles, including carpets, rugs, upholstery and bedding, largely because of the numerous benefits which it confers to these products[1].

Carpets

Various scientific studies have highlighted significant benefits that wool carpets contribute to the indoor environment. These benefits include:

- Fire safety
- Removal of indoor air contaminants
- Humidity control
- Improvement of safety by slip prevention
- Promotion of the various components of comfort (ie, acoustic, thermal and walking comfort)

Fire safety

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)[2], 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.

For example, the CRF values measured for wool carpets were up to 50% higher than equivalent nylon carpets and up to 440% higher than equivalent polypropylene carpets. All of the wool styles tested met or exceeded the USA and German requirements for both residential and contract carpets.

The smoke levels detected were around 10 times higher for nylon carpets than wool, and around 80 times higher for polypropylene carpets. Furthermore, the use of waffle rubber underlay did not increase the smoke emission with a wool carpet, but with nylon and polypropylene carpets there were substantial increases (ie, their respective smoke indices were 50 and 100 times higher than wool).

Figure 1 shows the total smoke emission results (Smoke Index).

Wool's superiority in carpets stems largely from its inherently lower flammability and the fact that the surface pile forms a thick, foam-like, charred layer which effectively protects the lower pile, backing and underlay. In contrast, synthetic fibres melt, allowing the heat to decompose the backing and underlay so that large amounts of smoke are generated.

For installations such as high rise buildings, where resistance to fire is critical, the wool pile may be treated with Zirpro™ to meet the most stringent specifications.

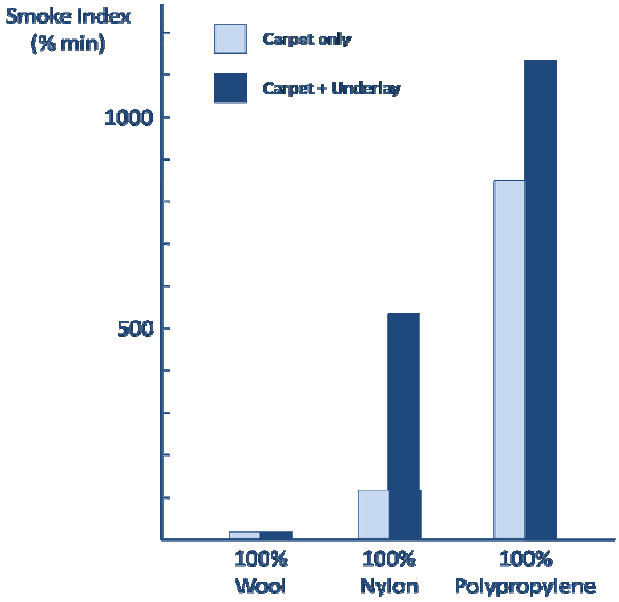
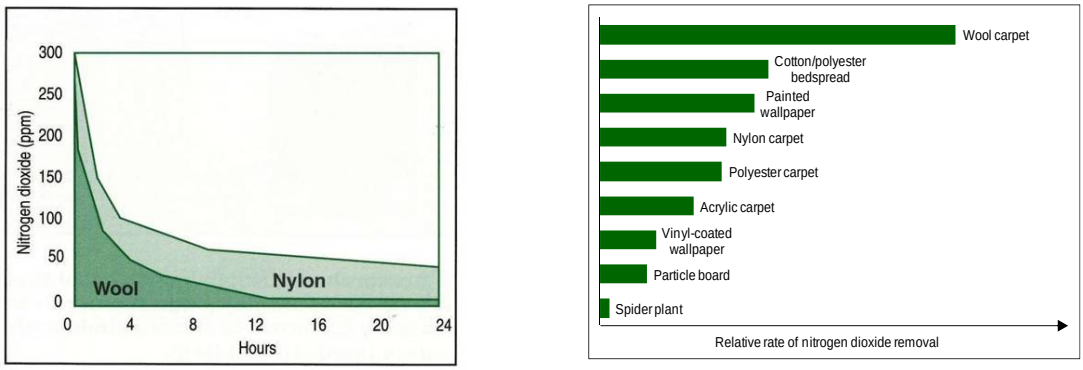


Figure 1. Results of the NBS Flooring Radiant Panel Test for total smoke emission (Smoke Index) for Saxony style carpets[2]

Indoor air quality

Polluted indoor air can lead to discomfort, reduced efficiency and even ill health amongst occupants of both commercial and residential buildings. The problem is exacerbated by the use of air conditioning systems which effectively trap the pollutants inside. Common air pollutants associated with health hazards include formaldehyde, nitrogen dioxide and sulphur dioxide. Formaldehyde can be introduced by emissions from certain building materials and furniture while nitrogen and sulphur dioxides are by-products of combustion processes (eg, gas stoves and heaters).

WRONZ studies[3] have shown that wool carpet can remove formaldehyde, nitrogen dioxide and sulphur dioxide from the air more rapidly and effectively than synthetic carpet fibres. Furthermore, wool does not release these gases, even when heated, and may continue to purify indoor air for up to 30 years. This long-term benefit is due to the acid-combining potential of wool. Figure 2 shows absorption of nitrogen dioxide by wool, nylon and other materials. Tests conducted in a chamber showed that wool carpet can remove 99% of sulphur dioxide gas from the air in 4 hours whereas nylon carpet removes 82%.



(a) (b)

Figure 2 (a) Nitrogen dioxide remaining in the air after 24 hours exposure of carpet yarns; (b) comparative rate of nitrogen dioxide removed by selected interior furnishings.

Wool does not promote the growth of bacteria or dust mites, nor does it give off harmful gases. In addition, the fibres are too long and too coarse to be inhaled, so wool will not irritate the respiratory system or trigger an allergic reaction.

Humidity control

In unventilated buildings, moisture from human breath and perspiration, plants, cooking and washing can accumulate to give condensation problems such as growth of moulds and mildew, and deterioration of decorations. High indoor humidity levels promote dust mites and may affect human health. Research has shown that wool carpets, furnishings and curtains exert a significant buffering effect on changes in the humidity of indoor air[4]. Condensation on cold surfaces is inhibited and dehumidifiers may be rendered unnecessary.

Figure 3 shows the effect of wool carpet on reducing the relative humidity in an environmental chamber.

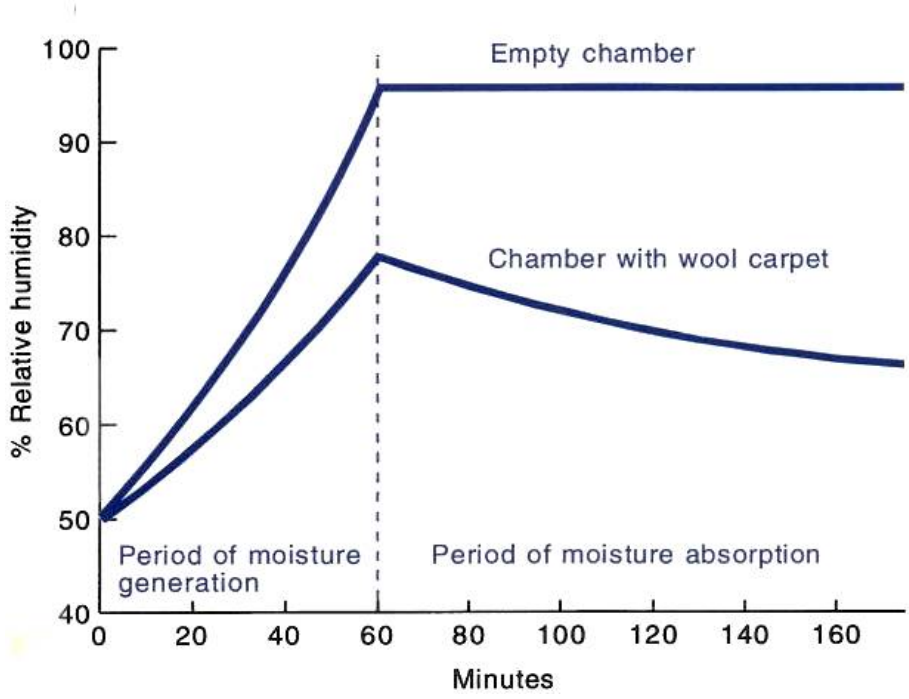


Figure 3. Effect of wool carpet on ambient relative humidity.

Acoustical advantages

Carpets have long been used in passenger aircraft, cinemas, offices etc, because of their acoustical properties, in particular their ability to reduce airborne sound, control surface noise and isolate impact sounds. The porosity of carpets enables sound waves to penetrate into the pile and become dissipated. Acoustic ceiling panels absorb sound but cannot reduce surface noise or isolate impact sounds.

Wool carpets have particularly good acoustic properties because of their generally higher weight and pile density than carpets made from synthetic fibres. Various studies[5] have confirmed these observations. It has been demonstrated that as the pile density and height of a carpet is increased the Noise Reduction Coefficient (NRC) and Impact insulation also increase, as shown in Figure 4.

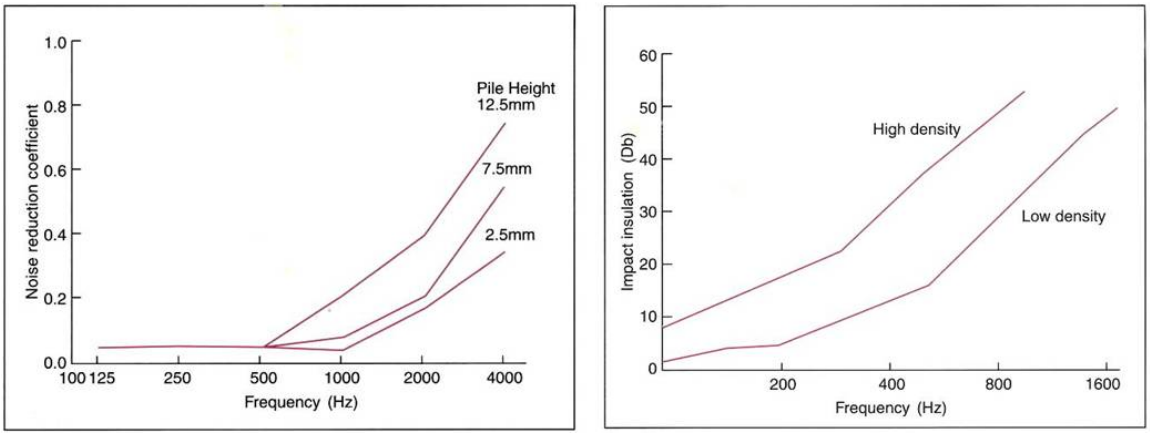


Figure 4. Effect of carpet pile height on noise reduction coefficient (left); effect of pile density on impact insulation (right).

The NRC values of heavy duty wool carpets are in the range 0.5 – 0.7, which match the best acoustical ceiling materials. The following observations are also relevant:

1. Because of their more open surface, cut pile carpets are generally better sound absorbers than loop pile carpets;
2. Sound absorption is reduced if the carpet backing is too impermeable (wool carpets mostly have permeable backings which assist sound absorption);
3. An underlay can contribute to the absorption of sound, as long as the carpet backing is permeable;
4. Carpets and rugs on walls have the same sound absorbing effect as carpet on the floor;
5. Bare tile floors produce 7-12 times more surface noise than carpets with or without underlay;
6. Because of their high resilience, wool carpets show only small decreases (around 16%) in their sound absorbing efficiency after sustained foot traffic, and the decrease improves to just 10% after shampooing.

Thermal comfort

The thermal insulation properties of wool carpets are beneficial in two respects: (1) energy saving and (2) comfort to the occupants of the building. Building design has a strong influence on the costs of heating and air conditioning. Single story buildings having ventilated floors clearly benefit the most from the insulating properties of carpets. Energy savings of 5-13% have been recorded in practical situations.

Wool carpets increase the perception of comfort because they reduce heat loss from the body to the floor by radiation, and by contact with the feet. Because of the superior insulation properties of air compared with wool and other carpet fibres, it is advantageous for some air to be trapped in the pile. Therefore, wool carpets of intermediate pile density (rather than the densest piles) tend to have the highest thermal resistance. The low thermal conductivity of wool and its natural crimp (which restricts convection) contribute to the thermal resistance of wool carpets[3].

Walking comfort

The differences in comfort perceived when a person walks on a carpet is largely due to the cushioning effect of the pile in reducing the sudden shock to the body as the foot strikes the floor[4]. A firm carpet that resists compression should be used to prevent muscle fatigue in areas where people are required to walk or stand for long periods. On the other hand, a soft, more easily compressed carpet should be used where a luxurious ambience is required. Wool carpets can be manufactured to meet either of these requirements.

Slip resistance and safety

Slip and fall injuries are a significant health and safety issue in many countries. As part of their obligation to make property safe for people to use, building owners need to ensure that the risks of slips and falls are minimised.

Frictional contact between two surfaces enables slippage between them to be resisted. Two types of friction are involved in walking: static friction (when the foot rests on the floor) and dynamic friction (when the foot slides on the floor). Because most slips occur when a person is moving, dynamic friction is more appropriate when considering the risk of slipping between two surfaces (ie, the shoe sole and floor).

Measurements of the Coefficients of Friction between pairs of surfaces have been conducted and the results are shown in Figure 5[6]. The graph shows that, when dry, the wool carpet had better slip resistance than varnished wood surfaces and slightly lower slip resistance than vinyl flooring surfaces. However, the slight advantage that vinyl has over carpets in slip resistance is negated when the effects of falls are taken into account. Falls on carpet lead to softer impacts than falls on harder surfaces such as vinyl.

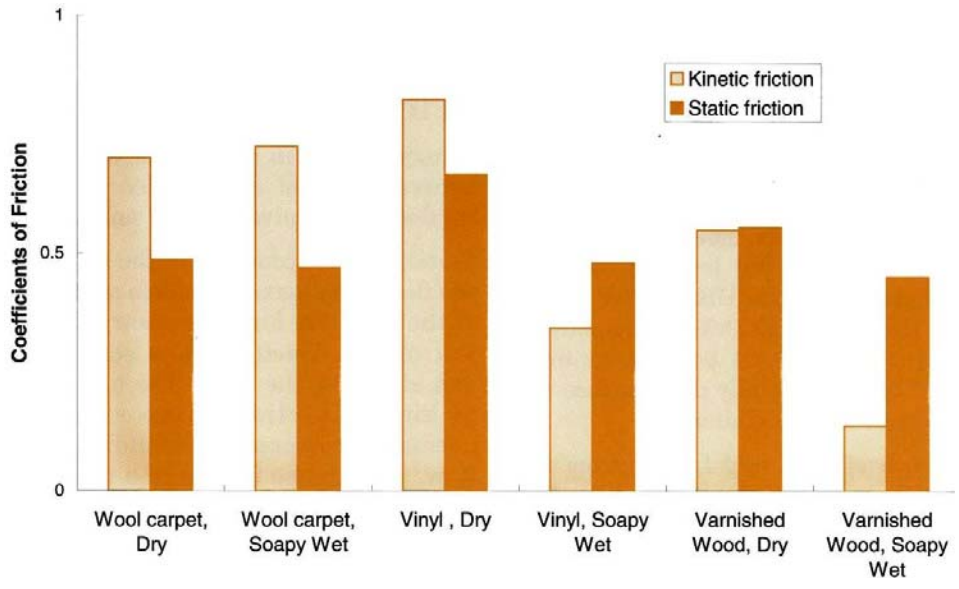


Figure 5 Comparison of the coefficients of static and dynamic friction using a men's shoe for various flooring surfaces when wet and dry.

The chief cause of falls is wet floors. Figure 5 shows that the kinetic friction (which is the more frequent determinant of falls) decreased dramatically for vinyl and varnished wood when they become wet, while there was little change in wool carpet friction.

Because friction is a surface property, the construction and installation of a carpet can significantly affect its frictional properties. It has been found that:

- Loop pile carpets tend to have lower coefficients of friction (both static and dynamic) than cut pile carpets. For this reason cut pile carpets are favoured in locations where higher traction is required, eg, stairs;
- Laying carpet against the direction of pile lay increases its coefficient of friction and hence its slip resistance. This effect is more evident in cut pile carpets.

Static electricity

Safety from electrostatic shock needs to be considered when carpet is being installed in commercial and public buildings. Wool carpets may release their moisture and thus become less conductive in buildings with air conditioning systems without rehumidification facilities. However, to eliminate static electricity under low humidity conditions, wool carpet pile can be treated with Disperstat™ or have a small amount of conductive fibre blended with the wool in yarn manufacture.

Costs of maintenance

Table 1 compares the costs of maintaining various types of floor coverings[1]. When all contributing costs are taken into account, carpet is by far the cheapest to maintain.

Table 1

COMPARATIVE MAINTENANCE COSTS FOR CARPET AND HARD FLOORINGS, TAKING THE TOTAL ANNUAL USE-COST FOR CARPET AS 100.

	CARPET	SHEET VINYL	REINFORCED VINYL TILE	TERRAZZO
Material Installed	30	26	13	38
Cleaning Labour	58	91	91	91
Capital Equipment	6	91	91	91
Expendable Supplies	5	36	36	36
Maintenance of Equipment Allowance	1	3	3	3
Annual use-Cost	100	166	153	178

Appearance Retention

The superior resilience of the wool fibre and pile structures show excellent resistance to pile crushing (loss of thickness and/or matting) under the pressures of walking people and wheeled traffic (trolleys, suitcases, castor chairs and wheelchairs). The high natural resilience of the wool fibre in well designed and well set yarns will also ensure that the definition of the pile tufts is maintained when subjected to the stresses and strains of everyday usage, and the carpet retains its initial appearance for a long and useful service life.

It is this property of wool that is largely responsible for the fact well-known to carpet users for many years, and recently verified by scientific studies, that wool carpets "age gracefully" by comparison to synthetic carpets. Figure 6 shows the appearance change with wear in controlled floor trials. The wool carpet changes slightly ("beds down") before settling on a slow decline, whereas the nylon and polyester carpets exhibit rapid short term change and continue to change at a higher rate with time.

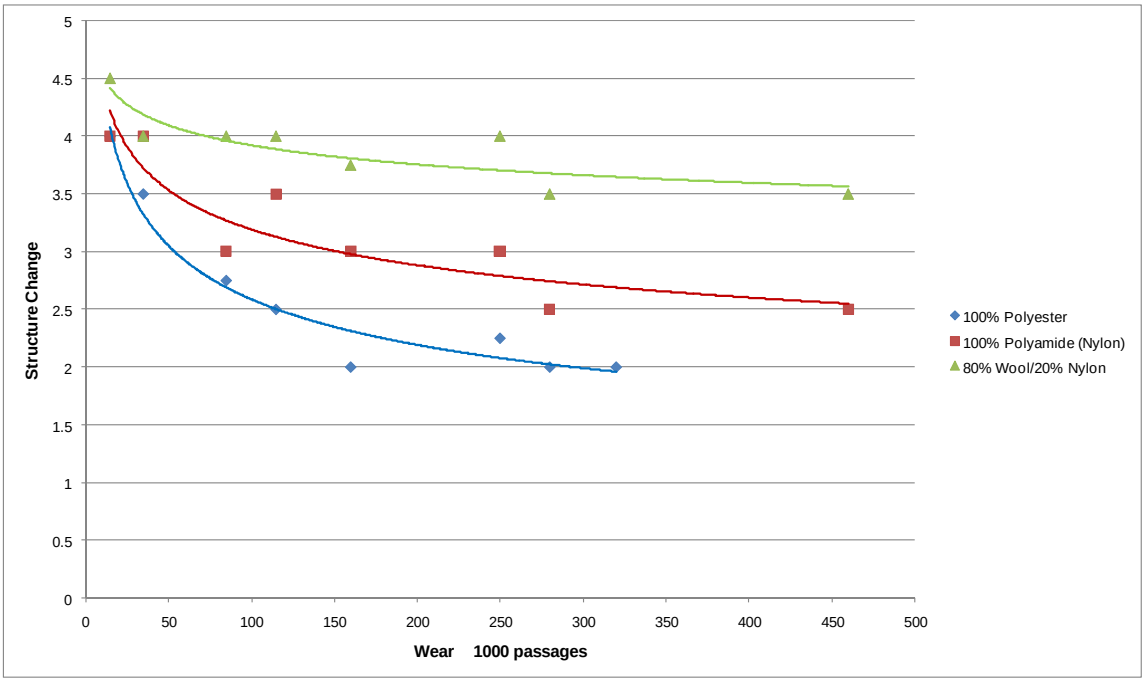


Figure 6. Carpet structure change versus tread count in a controlled floor trial.

Source : "Characterisation of the Properties of Specific Textile Floorcoverings with Regard to their Performance in Use", DTFI Report No. 1984/22, Lüning, R., Funk, G., Steiner, E., Lehnen, A.

Observations have also shown that normal wet cleaning processes have a greater restorative effect on wool pile carpets than synthetic pile carpets. This is because vapour water absorbed by the wool fibres in the cleaning process relaxes the fibres so that they return to the configuration in which they were set during manufacture. This occurs because of the hygroscopic nature of the wool fibre which can absorb up to 30 % of its weight of moisture without feeling wet. Typical figures for the moisture content of synthetic fibres are in the region of 2-5%.

Bedding

Wool may be used in several types of bedding products, including duvets, pillows and underlays. When used in bedding, wool creates a microclimate which assists in regulating the temperature and humidity of the air around the body, thus providing a restful night's sleep.

Thermal comfort

Wool provides a high level of thermal comfort because it is an effective insulator. Air provides over six times the insulation of any textile fibre. The natural crimp of the fibres causes air to be trapped between the fibres, enabling wool to provide warmth in cool conditions. This insulating property of wool ensures that temperature changes in bedding are much smaller and slower than any changes in the ambient temperature.

Moisture management

If the humidity of the surrounding air rises wool fibres absorb and store the moisture, thus maintaining low humidity at the skin surface. The absorbed moisture in the fibres can also be diffused into the atmosphere. As a consequence, wool bedding never feels damp or clammy.

Dustmites thrive in hot, humid environments. By reducing the temperature and humidity more effectively within bedding than synthetics, wool bedcovers can influence the prevalence of respiratory allergies in children.

Thermo-physiological tests show that wool is beneficial for sufferers of arthritis, rheumatism and other muscular problems[1]. Fleecy underlays assist in the prevention of ulcerative pressure sores (or "bed sores") in hospitals. This is understood to arise from a more even distribution of a patient's weight, thus lowering pressure on sensitive areas such as shoulders, hips and ankles.

The science of better sleep

Recent research[7] conducted by The Woolmark Company and the University of Sydney has conclusively shown that wool bedding products:

- Breathe more naturally than synthetic products, so that dampness does not build up in bedding. Figure 7 compares the ability of wool-filled and polyester-filled quilts to control the humidity within the bed. It shows that the relative humidity is significantly lower under the wool quilt for over 70% of the time.
- Increase the duration of the most beneficial phase of sleep. This is the REM (or Rapid Eye Movement) phase, when the sleeper is fully relaxed and most dreaming occurs.
- Facilitate a comfortable body temperature, ie, the body reaches a comfortable sleeping temperature more quickly and maintains this temperature for longer. A skin temperature between 34^{o}C and 35^{o}C was assessed as being the most comfortable.

Superior temperature and humidity control of the microclimate around the body has been shown to produce a lower heart rate, a more rested condition, and ultimately a better night's sleep.

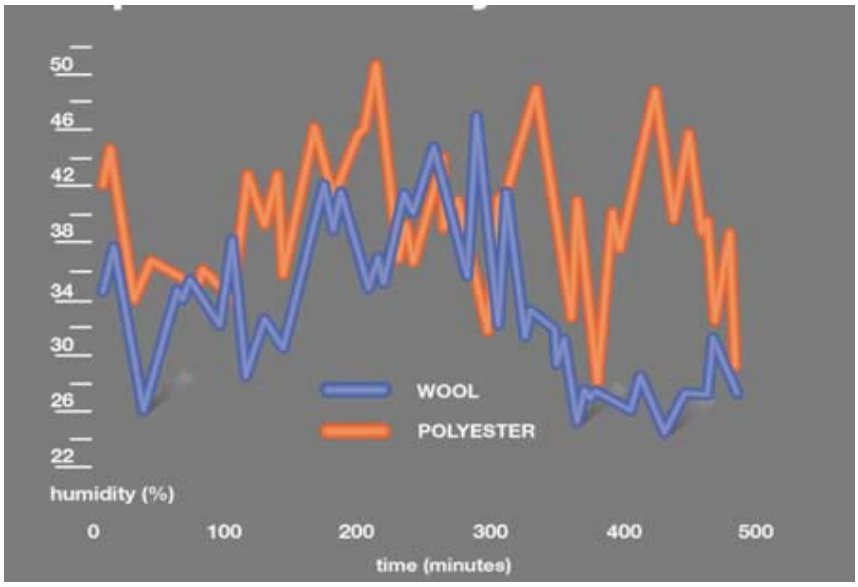


Figure 7. Control of humidity in bedding by a wool –filled and polyester filled quilt..

Upholstery

Wool has a number of performance attributes that enhance its attractiveness as an upholstery fabric. Paramount amongst these attributes are its fire safety qualities, but its ability to provide seating comfort and to make positive contribution to the indoor environment is also important.

Fire safety qualities of wool

Polyurethane foam is widely used as a cushioning component in furnishings, but this material is very flammable and produces large volumes of smoke and toxic gases when ignited. While the polyurethane cushion is almost always covered with a textile fabric, the protective abilities of commonly used upholstery fabrics against ignition vary widely.

Ignition tests have been carried out on a range of upholstery fabrics stretched over polyurethane foam cushions[1]. The fibres in the fabrics included wool, polypropylene, acrylic, nylon, cotton and linen (all 100%) and blends (acrylic/cotton/rayon and cotton/rayon). The results confirmed that that fabrics composed of cellulosic fibres are prone to smouldering ignition (eg, from cigarettes) while those composed of synthetic fibres are easily ignited by flaming sources such as matches. Only wool fabrics gave protection against the three ignition sources, a smouldering cigarette, a flaming match and a flaming newspaper.

Wool's excellent fire safe qualities which are important for upholstery and other interior furnishings include:

- Inherent flame retardancy;
- Difficult to ignite due to a high ignition temperature;
- Low flame spread;
- Low heat release and low heat of combustion;
- Does not melt or drip if used vertically;
- Forms an insulating charred layer (which protects the cushion from burning) and self-extinguishes;
- Produces less to smoke and toxic gas than synthetic fibres.

Seating comfort

Research by the Swedish Textile Research Institute (TEFO) showed that the moisture transport properties of the seat cover in a car govern the perceived comfort of the seat[8]. A range of commercially available seat covers were evaluated, including three wool-rich fabrics. Under simulated real-life conditions of a car journey, subjects were required to rate the fabrics according to their "feel" (moisture accumulation and temperature). The wool-rich fabrics were consistently rated as the most comfortable, by substantial margins, over the other fabrics. These results were consistent with the fact that wool is highly effective in transporting water vapour away so that the area of the body and the clothing in contact with the seat remain relatively dry. While this study was carried out on car upholstery fabrics, the findings are clearly relevant to commercial and domestic upholstery too.

Soiling and staining

Controlled soiling trials were conducted by WRONZ on 16 upholstery fabrics of different constructions and fibre compositions. These included wool-rich/nylon blends, polyester, acrylic, cotton and nylon[8]. Regardless of the shade of the cloth, all the wool-rich samples performed well while the other fabrics varied widely in their performance depending on the original shade.

In an IWS trial six loop-pile upholstery fabrics (made of wool, nylon, cotton, acrylic, polyester and polypropylene) were subjected to dry and greasy soiling and assessed before and after cleaning[8]. For the dry soiling, cotton performed the best, with wool similar to the other fibres. For the greasy soiling, the cotton fabric was the worst, and wool was slightly better than the others. It is concluded from this study that wool fabrics can resist soiling, hide soil and release it as well as any synthetic rival, and in many cases better.

The appearance retention of fabrics is also affected by staining, and the ability to remove the stain by cleaning. The fabrics used in the WRONZ soiling trial above were also subjected to a range of water-based and oil-based stains. The findings were that all fabrics showed good stain removal, even after prolonged exposure. Wool's overall stain resistance was significantly better than cotton, acylic and polyester fabrics.

Upholstery and the indoor environment

Many of the wool properties which apply to carpets are also relevant to upholstery fabrics. The important issue of fire safety has already been discussed, but other significant benefits are:

- Wool's buffering action with respect to moisture absorption assists in maintaining consistent humidity levels indoors. The environment remains comfortable and condensation and mould growth is reduced.
- Wool fabrics purify the indoor air by absorbing noxious gases.

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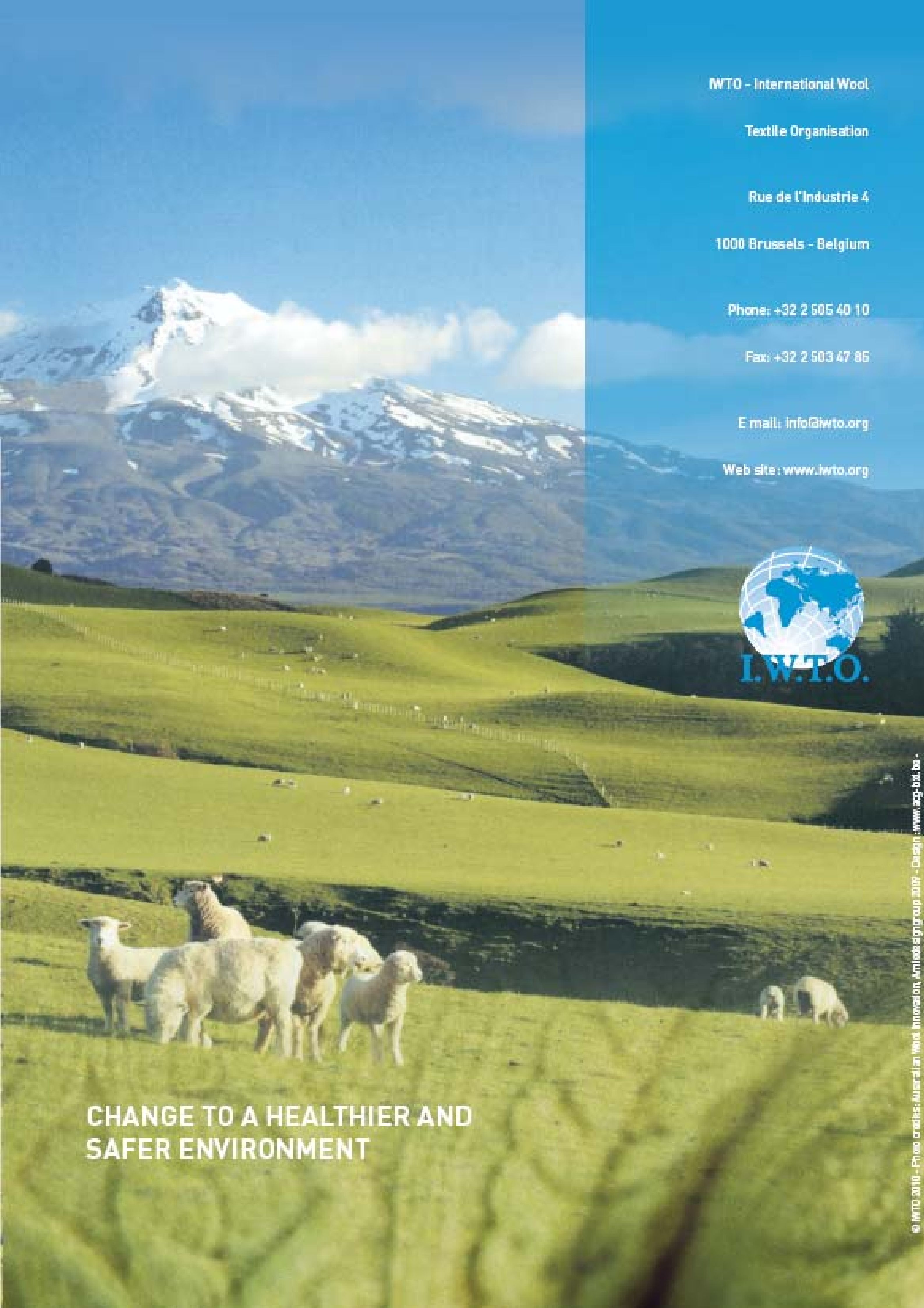

IWTO - International Wool

Textile Organisation

Rue de l'Industrie 4

1000 Brussels - Belgium

Phone: +32 2 505 40 10

Fax: +32 2 503 47 85

E mail: info@iwto.org

Web site : www.iwto.org

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