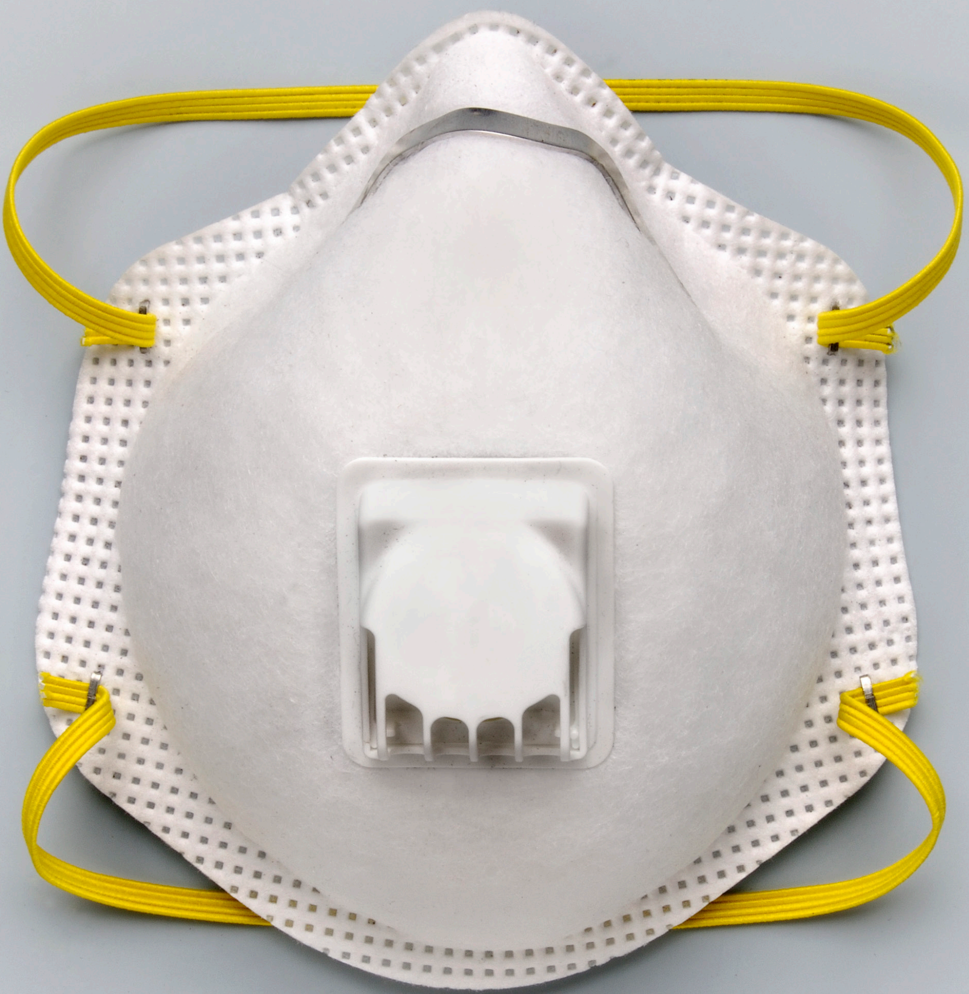

CONTROL OF INDOOR AIR POLLUTION

WHAT IS INDOOR AIR POLLUTION?

The term 'Indoor Air Pollution' describes the situation when gases or particulate pollutants build up in indoor atmospheres to the point where they affect human health or comfort. Whilst interior textiles are sometimes a source of gases associated with indoor air pollution, wool carpets are notably different in that they work to promote indoor air quality – actively removing several important indoor air pollutants.

Given humans spend the majority (~90%) of their lives indoors (CPSC, 2008), indoor air pollution is arguably of much greater importance to human health than outdoor air pollution. The effects of indoor air pollution on building occupants are varied, but can include irritation of the eyes, nose and throat, respiratory illness, headaches, dizziness and fatigue (EPA 2008).

WHAT CAUSES INDOOR AIR POLLUTION?

Indoor air pollution occurs when harmful gases and/or particles are present in the air of a house, apartment or any other building. When air exchange is inadequate, these contaminants can build up to potentially harmful levels. Sources of indoor air pollution can include (but are not limited to):

- Heating systems and other home appliances such as fireplaces, wood stoves, chimneys, water heaters, dryers and gas heaters. These may use gas, oil, kerosene, coal or wood and can (particularly if unflued) emit several gaseous indoor air pollutants such as carbon monoxide and nitrogen dioxide.
- Tobacco smoke: This contains about 4,000 chemicals, 43 carcinogens, formaldehyde and carbon monoxide.
- Building materials: Certain pressed wood products (eg. particleboard, hardwood plywood paneling, softwood plywood, oriented strand board and medium-density fibreboard) that contain formaldehyde-based resins can subsequently emit formaldehyde.
- Interior furnishings and household chemicals: products such as paint, lacquer, paint stripper, cleansers and disinfectants, pesticides, wood preservatives, aerosol spray, insect repellent, air freshener, stored fuel, automotive products and dry-cleaned clothing have been associated with release of Volatile Organic Compounds (VOC's).
- Office supplies and products: VOC's and ozone can be emitted from copy machines and printers, while correction fluid, carbonless copy paper, glue markers, etc are other sources of VOC's.
- Biological sources: Allergens from pets, house-dust mites, fungi, bacteria, pollens, etc.

WHAT ARE VOLATIVE ORGANIC COMPOUNDS (VOCs)?

Many new products have a characteristic odour – examples being the smell of a new car, fresh paint, new carpet, etc. This odour is due to the release of Volatile Organic Compounds (VOCs). VOCs are gases and vapours with boiling points from 50°-260°C, and typically dissipate within a short period (Figure 1). Any health effects due to exposure to VOCs are dependent on the specific composition of the VOCs present and the length of exposure.

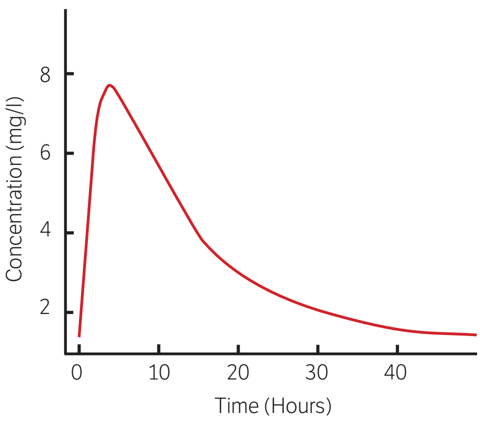

Figure 1. Decay curve for styrene, a typical VOC, emitted from a textile floorcovering (Hedge and Dietert 1995).

In comparison to most interior furnishings, carpets emit very low levels of Volatile Organic Compounds – with non-carpet components of carpet systems and other interior products typically emitting VOC levels orders of magnitude higher than those from carpets (Fig. 2) (Black et al 1991).

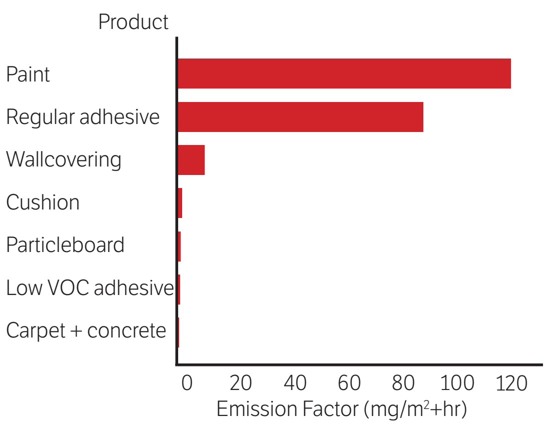

Figure 2. Typical VOC emission factors for a range of interior furnishings.

As part of the manufacturing process, carpet is generally baked in a finishing oven at 150˚C to 170˚C. This process drives off chemicals, including solvents in adhesives and raw materials, leaving a product with a low remaining VOC content.

The VOC most commonly associated with new carpet is 4-phenylcyclohexene (4-PCH) – a by-product of the manufacture of synthetic latex. 4-PCH is notable mainly in that it has a low odour threshold (0.5 parts per billion) so its presence can be detected at extremely low concentrations when the carpet is first laid.

Approximately 90% of all VOC's discharged from carpet dissipate within 2 days of installation and, with good room ventilation, new carpet VOC emissions will drop below most indoor air quality criteria within a few days. Table 1 (Carpet Institute of Australia Ltd) contrasts the performance of carpet with that of other interior products, showing it to be a relatively low emitter of VOCs.

Table 1. VOC emissions of building products

Product	Initial emission rate of VOCs ($mg/m^2.h$)	Time for 90% loss of VOC's emissions	Total VOC emissions per square metre ($mg/m^2.h$)	VOC emissions after 96 hours ($mg/m^2.h$)
Carpet*	3.0	2 days	58	Less than 0.5
Particle board	1.2	1 week approx.	1000	
Medium density fibre board	0.4 (formaldehyde only)	5 months	650 (formaldehyde only)	
Enamel paint	7,600	6 hours	20,000	
Acrylic paint (water based)	151 average	1 day	1260 (average)	Approx. 40
Low odour acrylic paint	80	1 day	730	

*tested loose laid

HOW DOES WOOL CARPET ASSIST IN CONTROLLING INDOOR AIR POLLUTION?

Interior furnishings and textiles can act as 'sinks' to absorb certain particulate and gaseous atmospheric pollutants from the indoor environment. Because of their nature and materials used in their construction, carpets present a much larger area for gas absorption than other interior fixtures and furnishings. 1 m^2 painted wall represents little more than 1 m^2 of absorbing suface, whereas 1 m^2 of carpet containing 1000g of wool 35 μm in diameter in the surface pile presents a fibre surface of at least 100 m^2. Hence, carpets have the potential to make a greater contribution to the removal of indoor air pollutants than many other interior fixtures.

DOES WOOL CARPET REMOVE INDOOR AIR POLLUTANTS MORE EFFECTIVELY THAN SYNTHETIC CARPET?

Three common gaseous indoor air pollutants with known adverse health effects on humans are nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and formaldehyde (HCOH) – all of which are effectively removed by wool carpet.

Nitrogen Dioxide Absorption

Work completed to investigate the rates and mechanisms of NO_2 removal from indoor air with 35 types of building materials and furnishings (Spicer et al 1986, 1989) found that the highest removal rates were for wool carpet, wallboard, cement block, and brick. Acrylic, polyester and nylon carpets had NO_2 removal rates under one third those of 100% wool carpet, (Figure 4).

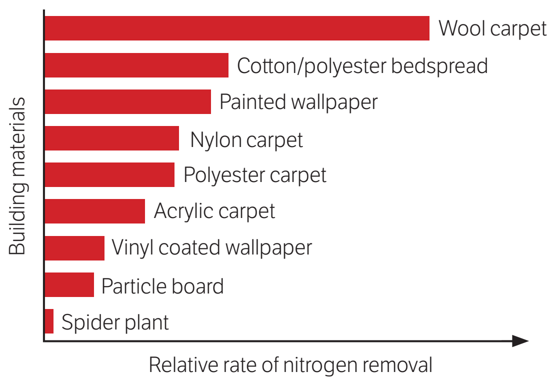

Figure 4. NO_2 removal rates for various residential materials (Spicer et al 1986).

Formaldehyde Absorption

Carpet has also been shown to be effective at absorbing formaldehyde. Wool and nylon carpets begin to absorb formaldehyde as soon as it is introduced to their surroundings. This is true even in the case of very high atmospheric concentrations, much higher than is ever likely to occur in indoor environments. For example, wool carpets have been shown to reduce levels of formaldehyde from 420 ppm to 0.5 ppm in four hours (Causer et al 1995). In the same study, nylon carpets exhibited a slower rate of absorption, reducing 420 ppm to 80 ppm in four hours.

Sulphur Dioxide Absorption

When wool, nylon, cotton and viscose rayon fibres are exposed to sulphur dioxide it was shown nylon became saturated quite quickly, rayon became saturated within an hour, but wool and cotton continued to absorb sulphur dioxide after 1 hour (Crawshaw 1978) (Figure 5).

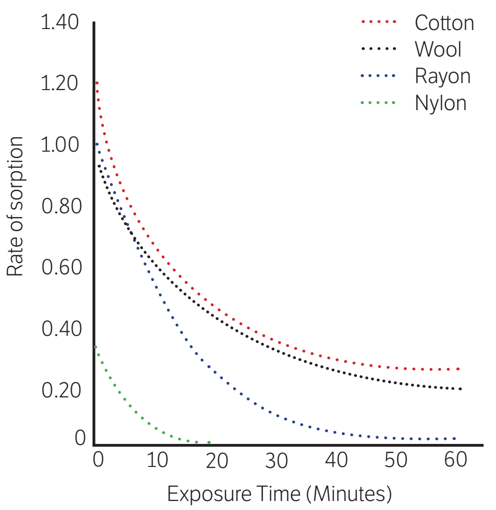

Figure 5. Comparison of SO_2 absorption rates for wool, cotton, nylon and rayon equilibrated at 84% RH and exposed to 2.92 µg/l SO_2 at an airflow of 1 l/min (Walsh et al 1977).

Pollutant Re-emission

It has been shown (Spicer et al 1986, 1989) that re-emission of NO_2 from wool carpet and cement block is negligible, even with moderate increases in temperature or relative humidity. Previous work has shown that SO_2 and formaldehyde are also not readily re-emitted by wool carpet (Crawshaw 1978, Walsh et al 1977).

The complex chemistry of the wool fibre enables it to bind pollutant gases chemically in its structure and it has been estimated that wool carpets can continue purifying indoor air for up to 30 years.

Particulate Air Pollutants

Particulate pollutants are also a source of indoor air quality issues. Such pollutants can include allergens (dust mite, cat, cockroach, etc), pollens, moulds, etc and can contribute to respiratory problems and other allergic reactions. Whilst carpeting (both wool and synthetic) undoubtedly acts as a sink for particulate pollutants, it has been shown that these particulates are no more likely to build up in wool products than those made from other fibres (Klingenburger and Elixmann 1990) and can easily be removed by vacuuming.

Carpeting also has a much reduced propensity for particulate disturbance than hard flooring. This is a key point, as particulate pollutants only become of clinical importance if aerosolised by a disturbance and subsequently breathed in. Thus, carpeting provides a means of actively removing such pollutants from the air, trapping them within its structure until they can be removed by vacuuming. Such cleaning processes have been shown to be very effective at reducing levels of allergens from cats, dust mites, etc (Lewis et al 1998, Causer et al 2004 a,b, Lewis and Breyse 2000).

KEY POINTS:

- Wool carpet is an efficient absorber of potentially harmful indoor air pollutants such as formaldehyde, nitrogen dioxide and sulphur dioxide, effectively removing them from the environment.
- Wool carpets out perform nylon carpets in terms of their capacity to purify the indoor air.
- Under normal circumstances, no risk is posed to human health by emissions from carpets, and selection of wool carpeting may even permit optimisation of the process for indoor air quality improvement.
- Interior textiles such as carpeting can act as filters for particulate pollutants and subsequent cleaning provides an easy means of managing human exposure to such hazards.
- Particulate pollutants such as mite allergens are no more likely to build up in wool carpet than synthetic carpet and are readily removed by vacuuming.
- Carpet has a much reduced propensity for disturbance of particulate pollutants (allergens, etc) than hard flooring.
- Wool's ability to effectively buffer heat and moisture, in combination with its propensity to control indoor air pollutants, make it ideal for creating safe and healthy interior environments.

REFERENCES

Black, M. S., W. J. Pearson and L. M. Work, 1991. A methodology for determining VOC emissions from new SBR latex-backed carpet. adhesives, cushions and installed systems and predicting their impact on indoor air quality, IAQ'9I: Healthy Buildings, ASHRAE, Washington, 1991,267-72.

Carpet Institute of Australia Ltd, Consumer Health Information, Indoor Air Quality, Fact sheet

Causer, S. M., Shorter, C. L., and Lewis, R. D., 2004a, Factors determining efficiency of Der f I and Fel d I removal from carpet. Proceeding of the 33rd meeting of the Christchurch Medical Research Society, Apr 28, Christchurch, NZ, (Abstract in New Zealand Medical Journal, 117: 1195, 2004, 1 p)

Causer, S.M., Lewis, R. D., Batek, J. M., and Ong, K-H., 2004b. Influence of wear, pile height and cleaning method on removal of mite allergen from carpet. Journal of Occupational and Environmental Hygiene. 1:4, 237-42.

Causer S.M., McMillan, R.C., and Bryson, W.G., 1995. The role of wool carpets and furnishings in reducing indoor air pollution. Proc. 9th Int. Wool Text. Res. Conf., Biella, Vol I, 155-161. .

CPSC, The Inside Story- A Guide to Indoor Air Quality, CPSC Document # 454, US Consumer Product Safety Commission Accessed 25/6/08.

Crawshaw, G. H., 1978. The role of wool carpets in controlling indoor air pollution. Textile Institute and Industry, 1978, 12, 12-15

EPA 402/F-08/008, September 2008, Care For Your Air, A Guide to Indoor Air Quality

Hedge, A. and R. R. Dietert, 1995. Effects of carpet emissions on indoor air quality and human health, Report for the Carpet and Rug Institute, April 1995.

Klingenberger, J., and Elixmann J.H., 1990. Distribution of dust mites in home textiles in German households. Proceedings of the 8th International Wool Textile Research Conference, Volume IV, 1990 Feb 7-14, Christchurch, New Zealand, Wool Research Organisation of New Zealand, Christchurch, New Zealand, p 635 - 42.

Lewis, R. D., and Breysse, P.N., 2000. Carpet properties that affect the retention of cat allergens. Annals of Allergy, Asthma and Immunology, 84: 1, 31-6.

Lewis, R. D., Breysse, P.N., P. S. J., Dienar-West, M., Hamilton, R. G., and Egglestion, P., 1998. Factors affecting the retention of dust mite allergen on carpet. American Industrial Hygene Association Journal, 59: 9, 606-13.

Spicer, C. W., R. W. Coutant, G. F. Ward, D. W. Joseph, A. J. Gaynor and I. H. Billick, 1989. Rates and mechanisms of NO_2 removal from indoor air by residential materials. Environment International, 1989, 15,643-654.

Spicer, C. W., R. W. Coutant. G. F. Ward, D. W. Joseph, A. J. Gaynor and I. H. Billick, 1986. Removal of nitrogen dioxide from indoor air by residential materials. Proceedings of IAQ '86, American Society of Heating, Refrigerating and Air Conditioning Engineers Inc., Atlanta, 1986, pp 584¬590.

U.S. EPA/Office of Air and Radiation, Office of Radiation and Indoor Air (6609J)Cosponsored with the Consumer Product Safety Commission, The Inside Story: A Guide to Indoor Air Quality

Walsh, M. , A Black, A Morgan, and G.H. Crawshaw, 1977. Sorption of SO_2 by typical indoor surfaces including wool carpets, wallpaper and paint. Atmospheric Environment, 11, 1107-1111.

This report was prepared by the New Zealand Merino Company Limited, funded by WR Inc.