THE OFFICIAL JOURNAL OF AIRAH

APRIL 2020 · VOLUME 19.3
RRP $14.95
PRINT POST APPROVAL
NUMBER PP352532/00001

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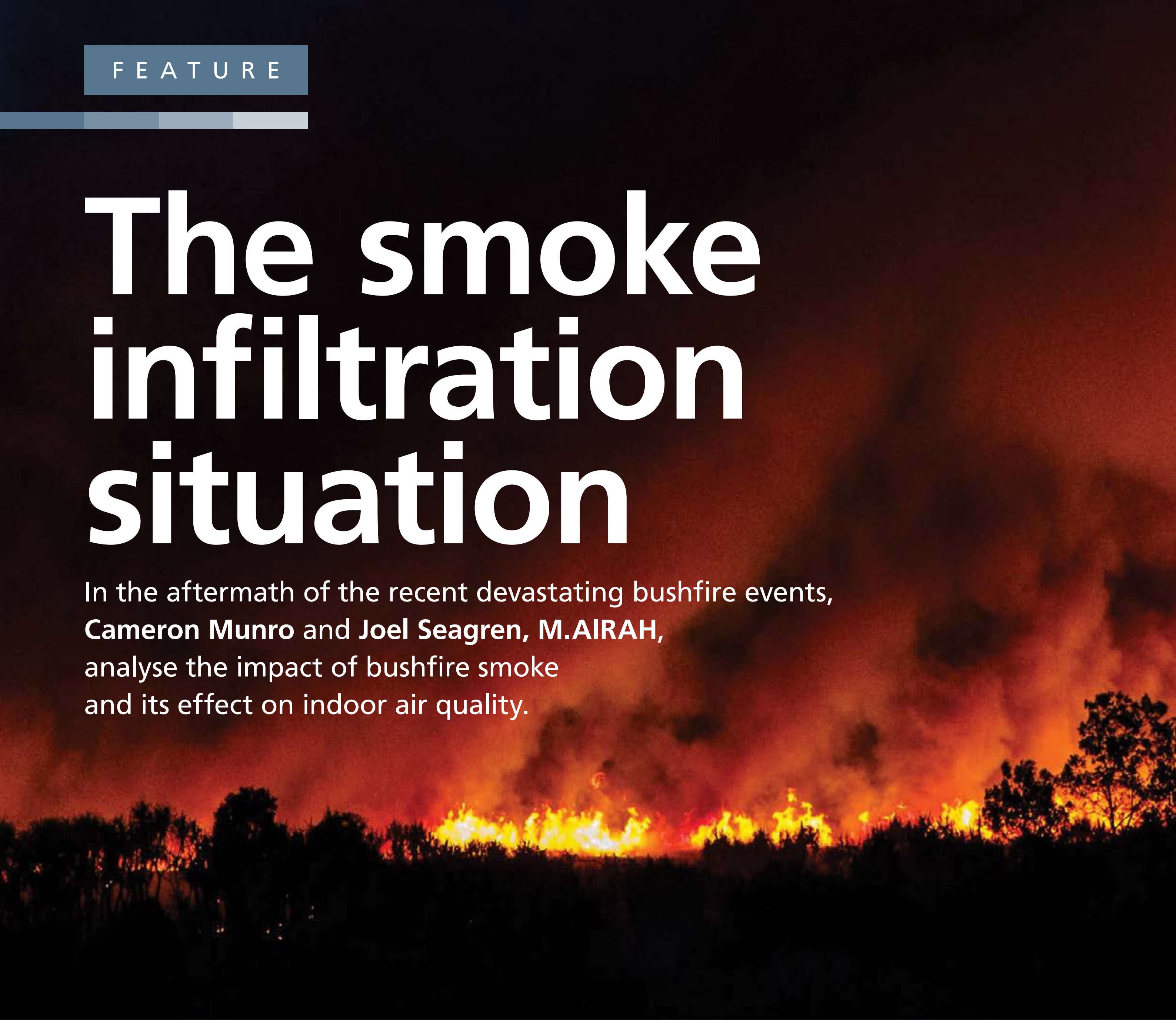
FEATURE



The smoke infiltration situation

In the aftermath of the recent devastating bushfire events, **Cameron Munro** and **Joel Seagren, M.AIRAH,** analyse the impact of bushfire smoke and its effect on indoor air quality.

The recent bushfires have exposed the population to levels of particulate matter (PM) far beyond what is typical for our Australian cities and regional areas, and well above recommended levels for healthy air quality (ABCB, 2018). Finer particulate matter (PM2.5, or particles of less than 2.5µm diameter) can make their way deep into the lungs and can be absorbed into the bloodstream leading to short- and long-term health consequences.

Bushfire smoke particles tend to be very fine, usually under 0.5µm (Figure 1). These very small particles tend to be able to penetrate standard-grade filters on HVAC systems. For example, a coarse G4 filter will only capture around 10 per cent of smoke particles, and a finer F6 filter may capture about half of these particles.

Buildings that are airtight will reduce the infiltration of smoke through the building envelope and so provide an opportunity to control particulate matter introduction via mechanical ventilation systems. For example, Figure 2 shows two homes

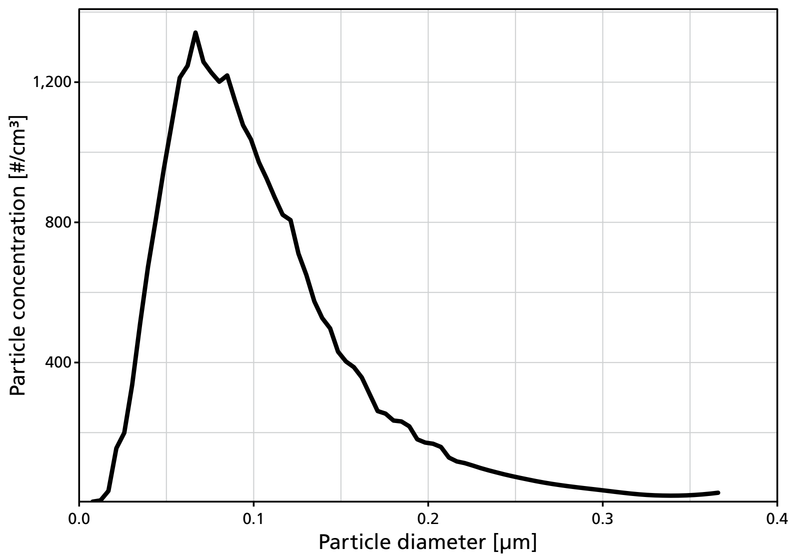


Figure 1: Typical particle composition in bushfire smoke (Morawska, Moore and Ristovski, 2004)

adjacent to one another during the recent smoke events. The conventional leaky building without mechanical ventilation reached PM2.5 concentrations of just under 500 µg/m³ when the outdoor levels were close to 600µg/m³. By comparison the airtight home reached peaks of 320 to 380µg/m³. In other words, the airtight home seemed to achieve smoke concentrations about 30 per cent lower than the leaky home. This is achieved by a building using a centralised mechanical ventilation with an F7-grade filter and an air permeability of 0.93m³/m²h at 50Pa, or about 15 times more airtight than standard new Australian homes.

Even extraordinarily airtight buildings will experience some smoke infiltration. Figure 3 shows several days of smoke events at a home with an air permeability of 0.08m³/m²h, or about 150 times tighter than standard new Australian homes. The indoor PM2.5 concentrations peak at around half of the outdoor levels. The majority of smoke infiltration in this case would be expected to come through the mechanical ventilation system.

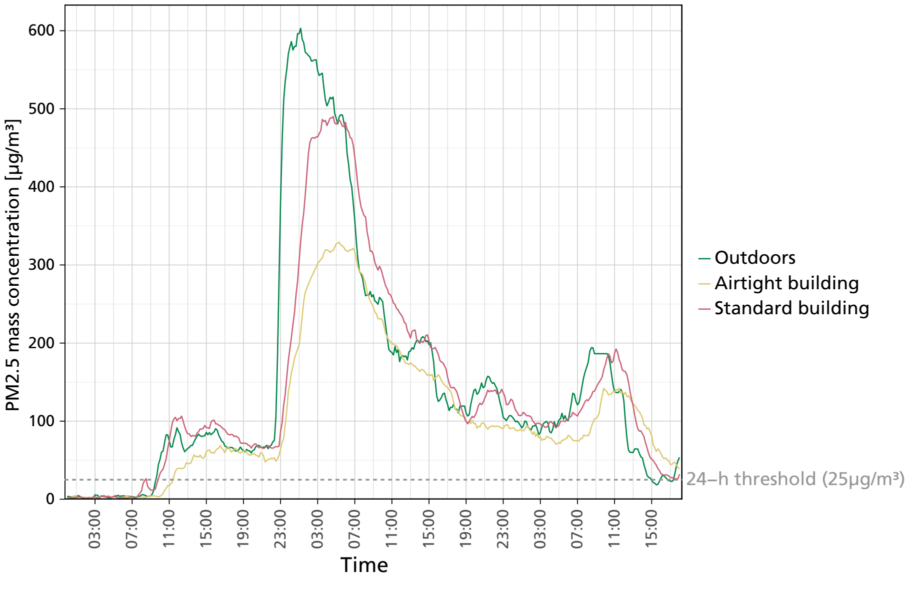


Figure 2: Performance of airtight and standard buildings during smoke event

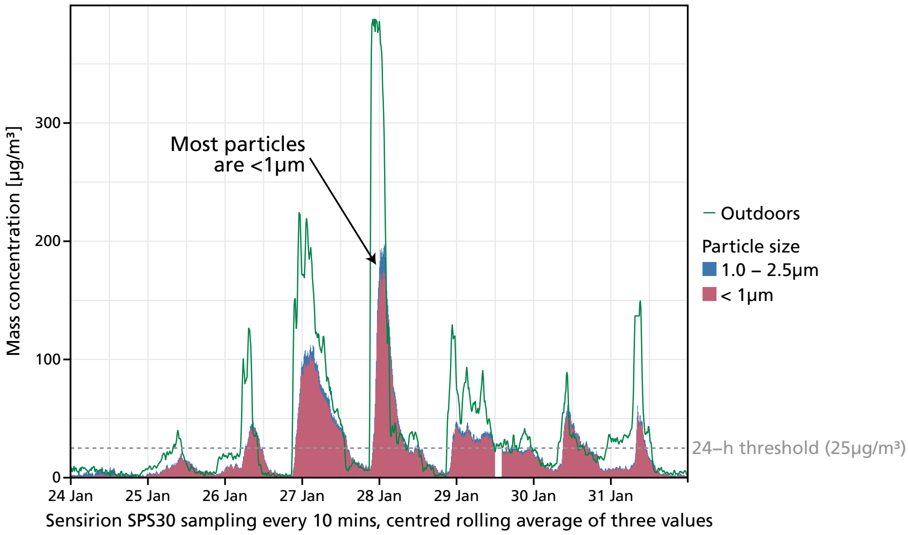


Figure 3: Smoke infiltration in an extremely airtight building

Although the reduction in smoke concentrations from the airtight home are encouraging, they are still well beyond the recommended threshold of 25µg/m³ averaged over 24 hours (ABCB, 2018). To achieve healthy indoor air quality in these extreme conditions will require more than an airtight building and standard filtration. To achieve a healthy indoor air quality in this condition will require either air purification independent of the mechanical ventilation system or some finer particle filtration in the mechanical ventilation system.

The effect of incorporating a HEPA filter (MERV 17 rating) downstream of an F7 filter is shown in Figure 4. In this example the homes are identical aside from the presence of the HEPA filter and cooking events. No occupants were present in the home with the F7 dwelling during this period. Again, the home with the F7 filter reaches peak PM2.5 concentrations around half of the outdoor levels but are still of a hazardous level. By contrast the home with the HEPA filter achieves markedly lower PM2.5 concentrations, which are almost always within healthy levels.

HEPA filters can capture over 90 per cent of smoke-sized particles and the resulting particulate levels shown here are consistent with this level of filtration. However, this performance comes at a cost. Increased pressure drop across the filters will increase fan power consumption, and care needs to be taken to ensure the resulting increase in fan noise level isn't going to be a nuisance. Additional filter replacement costs are also the other obvious change, with finer grade filters typically being more expensive, and possibly requiring more frequent replacement. Moreover, while finer filtration can reduce particle infiltration, additional carbon filtration may be required if odours (present in gaseous form) are to be fully eliminated.

Given these factors some judgement is needed. How often are these smoke events likely to occur? Are building occupants highly sensitive to increased particulate levels (and might this have a greater health impact)? Should extra filtration be applied just in response to smoke events, and can this be easily retrofitted? These are just some of questions that facility managers and building occupants need to work through.

What is clear is that higher airtightness construction provides the opportunity to take greater control over indoor air quality. When combined with the improved thermal performance and building fabric durability resulting from a carefully executed air-tightness strategy, it's little surprise we are seeing more projects with documented airtightness targets.

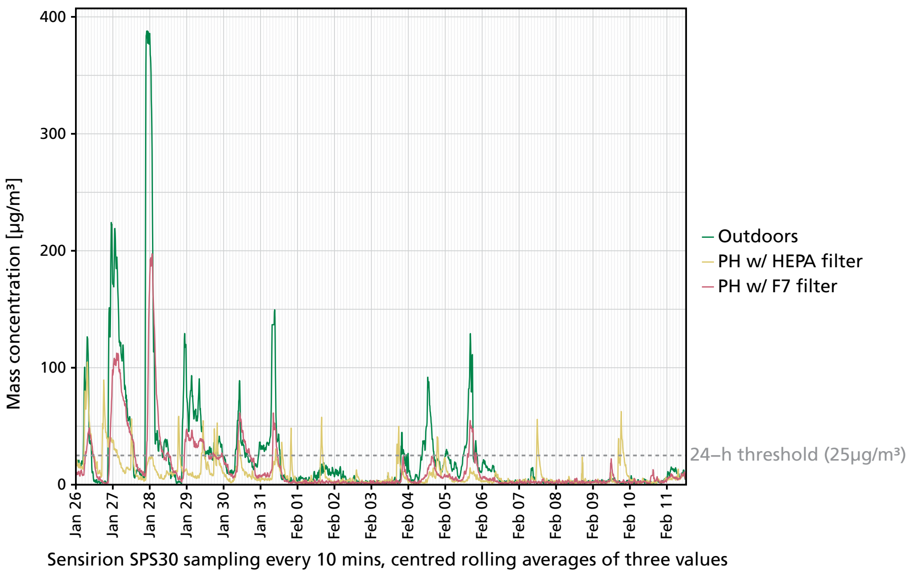


Figure 4: Two identical airtight homes with mechanical ventilation, one with a standard F7 filter and the other with a HEPA filter

References:

ABCB (2018) *Indoor Air Quality Handbook*, Australian Building Codes Board, Canberra.

Morawska, Moore and Ristovski (2004) *Health Impacts of Ultrafine Particles: Desktop Literature Review and Analysis*, Australian Department of the Environment and Heritage, Canberra.

About the authors

Cameron Munro is an engineer with expertise in environmental monitoring and an advocate for the Passive House standard.

Joel Seagren, M.AIRAH, is board member of the Australian Passive House Association, and supports the HVAC industry in the design of ventilation systems.

Would you like to know more?

For more info about IAQ, smoke and the impact on HVAC from bushfires, check out April HVAC&R Nation at www.airah.org.au/nation