The Adequacy of the Australian Standards AS3959-1999 Construction of Buildings in Bushfire-Prone Areas

Statement to

The Select Committee of the NSW Parliament, on Bushfires

Forestry and Forest Products

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SUMMARY

1. The risk of loss of property during bushfires depends not only on separation distances between houses and vegetation and construction standards but also on the standard of maintenance of house and garden, resident preparedness, access and resources including water. In bushfire-prone areas it is possible to minimise, but not eliminate, this risk.

2. Most houses are destroyed by ignition from embers which penetrate through gaps or through windows that are broken by radiant heat or by airborne debris. Other causes include the ignition of external timbers, combustion of adjacent sources of fuel and house-to-house spread.

3. A "sensible" separation distance between a house and "the bush" (viz un-managed vegetation) is required not only to ensure that the structure is not damaged or ignited by radiant heat, but also to reduce:
    - the numbers of embers landing on the structure,
    - the risk of damage to windows by air-borne debris,
    - the risk to residents so that they can extinguish external ignition points, and
    - the risk to fire-fighters attending the home.

4. The Planning for Bushfire Protection 2001 document prescribes minimum separation distances (Tables 4.1 and 4.2) between New developments and "bush", which are based on a model of radiant heat in front of a bushfire (Ellis 2000). The expected intensity of the bushfire is calculated for the given vegetation type carrying its theoretical equilibrium fuel load, and slope, and for a fire danger rating of "extreme". For Infill development this Planning document prescribes minimum separation distances which are dependent on category of bushfire attack, and hence vegetation type and slope (Table A3.3). The document recommends that Australian Standards AS3959-1999 be applied for all cases within areas defined as bushfire prone. The aim of the standard is to prescribe four levels of construction, which will correspond with four categories of bushfire attack. Where construction standards and separation distances cannot be met the Planning for Bushfire Protection 2001 document states that an applicant may achieve "a more appropriate performance standard" in consultation with Rural Fire Service officers.

5. The application of Planning for Bushfire Protection, in conjunction with the AS3959-1999 document, has the aim of matching the standard of construction with the category of potential bushfire attack. Thus the documents have the potential to reduce the risk of damage to or loss of structures and the loss of human life.

6. However, in some situations, the application of Australian Standard AS3959-1999 at the minimum separation distances recommended (Tables 4.1 and A3.3) in Planning for Bushfire Protection could result in a structure being sited such that the modelled radiant heat exceeds its design standards. In these cases the model shows that

standard windows, which are allowed in Construction Levels 1 and 2, will be inadequate.

7. Australian Standards AS3959-1999 is based on construction standards alone and does include consideration of the additional factors listed above (Point 3). This allows buildings which are built to higher standards to be sited at correspondingly closer distances to “bush”. Closer siting implies that residents who evacuate buildings in panic or under direction may be exposed to higher levels of radiation and heat than would otherwise be the case. Thus it is possible that if structures are sited at the minimum distances prescribed in Table A3.3 that structures, residents and fire-fighters will be exposed to additional risks which are not acknowledged in the standard.

8. The NSW Rural Fire Service recognise possible shortcomings in the application of AS3959-1999. They also recognise the need to address the issues of assessment of bushfire attack and the inadequacy of the available fire-retardant treatment for timber.

9. Standards Australia AS3959-1999 does not prescribe minimum separation distances between houses. This may be a weakness as house-to-house spread is a significant cause of property damage during bushfires.

BACKGROUND

1. Historically, the annual threat of bushfires in rural Australia led to practical "commonsense" precautions to protect dwellings. Paddocks close to homesteads were kept in check by close grazing, gardens were maintained with little or no flammable plants giving a distinctly "English" look about them, and dead flammable fuels in areas surrounding homesteads in the bush were burnt off prior to each summer. The capacity of fibrous barked eucalypts to produce prodigious numbers of firebrands and flying embers was quickly recognised as the principle ignition source of homes threatened by bushfires. The "commonsense" recommendations to homeowners included:

- Screening windows and vents with fly-wire to prevent the sparks entering the internal structure of the home,
- Closing in open eaves,
- Cleaning accumulated litter from roof guttering and filling them with water, and
- Having people at the home during a bushfire with the capacity extinguish ignition points from sparks and embers as they occurred.

The need to protect the home from radiant heat from a bushfire was not considered. If the heat and flames were so hot that you couldn't work outside with the normal firefighting clothing of the day (heavy long-sleeved shirts and long trousers) then you had no hope protecting the home. The relative isolation and the lack of formal firefighting services meant that house protection was entirely the homeowner’s responsibility.

Urban development, the increase in the rural and urban Fire Brigade services and the reduction of fire in the landscape as a commonplace event each summer, led to a decline in individual responsibility and to increasing reliance on fire brigades to provide home protection. When major bushfire events did threaten the urban environment the same

commonsense recommendations continued. The first investigation of home-loss by bushfire (P. Cheney *pers.comm.* 2002) found that external cladding of the building was irrelevant as to whether the home caught alight, reinforcing the adage that houses burn down from the inside caused by embers entering the interior structure. Separation of homes from tall forest or wood-land vegetation was still a minor issue: people intuitively knew that it was foolhardy to build homes too close to the bush and, by and large, gardens were composed of low-flammability exotic shrubs and trees, rather than native plants.

2. In the last two decades, the changes in the fire environment have arguably made homeowners more reliant on planners and bushfire brigades, and less self-reliant. At the bush-urban interface the pressure for land development has encouraged councils and developers to seek specifications for the minimum distance that houses can be built from natural flammable vegetation, usually national parks or other reserves. In addition, the trend of homeowners establishing native gardens and the desire to build homes close to or into native bushland has the led to the concept of building a more fire resistant home to minimise the amount of clearing required.

3. The Australasian Fire Authorities Council (AFAC) Position Paper (2000) identifies level of bushfire attack and provides physical measures in response to this attack to habitable buildings and the people who shelter within them. The Bushfire Safety Objectives for Habitable Buildings are to ensure that the buildings provide shelter long enough to protect occupants for 10 minutes while the fire-front passes and to improve the structural performance of habitable buildings in bushfires against a 1 in 50 year type bushfire. The former objective implies that during the passage of the fire front levels of radiant heat outside the house may exceed the critical value for a human. The Paper defines four categories of bushfire attack:

- **Low.** Minimal attack insufficient to warrant bushfire related planning and building. This is defined as greater than 100 m from standing vegetation. Note that house at distances of up to 200 metres or more from vegetation may still be ignited by embers (Ahern and Chladil 1998).
- **Medium**. Embers. Low level radiation which does not threaten windows. This implies that the radiant heat should be less than the threshold value for standard windows (McArthur *et al*. 2000 determined a value of about 14 kW m^{-2}).
- **High.** Embers and limited radiation that threatens windows but not other building elements such as walls, roofs and doors. McArthur *et al*. 2000 determined that a radiant heat flux of greater than about 29 kW m^{-2} will ignite timber.
- **Extreme**. Subject to direct flame and/or radiation levels greater than High.

The AFAC Position Paper recognized that the behaviour of individuals and communities is a major factor in safety within bushfire prone areas but did not further address this factor.

4. However, the way that houses are attacked by a bushfire remains the same. Embers that penetrate the internal structure of the building cause most losses, although masonry-clad buildings have been shown to have a lower relative risk of destruction than timber-clad ones

(Ramsay and McArthur 1995). Penetration may occur through gaps and apertures and through windows, which may be broken by radiant heat or airborne debris. External timbers may catch alight and burn but this does not necessarily threaten the house unless the fire penetrates the interior of the structure. External ignitions can be easily extinguished if the width cleared around the house, including the house gardens, is such that it is safe to work outside (with the normal protective clothing used by firefighters) as the fire passes. The last consideration implies that the radiant heat outside the house should be less than 7 kW m^{-2} (Butler and Cohen 1998), and that separation distances should be large. For example, the minimum separation distance from wet sclerophyll forest required such that the peak levels of radiant heat are less than 7 kW m^{-2} are greater than 80 metres for forest on level ground and greater than 100 metres for forest on sloping ground (Ellis 2000).
There is always some risk of houses being burnt down by bushfire. Minimising this risk requires that:

A. the house is sited at a commonsense" distance from flammable vegetation in order to:

- reduce the number of embers landing on the house,
- reduce the risk of damage to windows by wind-borne debris (e.g. branches)
- reduce the risk to residents so that they can quickly extinguish ignition points
- reduce the risk to firefighters attending the home.

B. the immediate surrounds, including garden beds, contain minimal flammable material

C. residents have adequate water supplies and basic knowledge and ability to minimise the risk to themselves, and the ability to suppress small ignitions as they occur.

D. the construction of the house is sufficient to withstand the wind, embers, and radiant heat generated by a high intensity bushfire in the adjacent vegetation.

E. the houses are sited at such distances from each other that will minimise the risk of house-to-house spread.

F. the houses and gardens are properly maintained.

PRESCRIPTIONS

The Planning for Bushfire Protection 2001 (PFBP2001) document prescribes minimum separation distances between structures and vegetation and recommends that construction standards follow the Australian Standard AS3959-1999.

For New developments minimum separation distances between structures and vegetation for Residential and for Special Protection Developments are prescribed by PFBP2001 in Tables 4.1 and 4.2 respectively. These separation distances were determined by comparing the critical values for radiant heat flux of timber and windows (McArthur *et al*. 2000) to the modelled levels of radiant heat in front of bushfires in different vegetation and for different slopes (Ellis 2000).

For Infill development PFBP2001 also recommends the use of Tables 4.1 and 4.2 and that construction standards are appropriate to Table A3.3. Table A3.3 classifies different levels of bushfire attack for different combinations of separation distance, vegetation type and slope. The five classes of bushfire attack are Low, Medium, High, Extreme and Flame Zone. The levels of construction required under AS3959-1999 for the first four categories are N/A, Level 1, Level 2 and Level 3 respectively. The Flame Zone class of bushfire attack is outside the scope of AS3959-1999. Table A3.3 supersedes AS3959-1999 Table 2.1 which also relates construction level to bushfire attack (*pers. comm*. Grahame Douglas[1]). Where construction standards and/or separation distances cannot be met PFBP2001 recommends consultation with the Rural Fire Service.

AS3959-1999 Construction Levels 1, 2 and 3 prescribe meshing on opening windows only. Levels 2 and 3 require that external timber is fire-retardant treated. Level 3 requires toughened (viz heat resistant glass). Houses which meet these standards construction, and which are well maintained, and which have well maintained gardens, will have a lower risk of bushfire damage (than would houses not thus constructed/maintained).

Combining prescriptions for minimum separation distances (PFBP2001) with appropriate levels of construction (AS3959-1999) is sound in principle and has the potential to reduce the risk of damage/loss by bushfires.

THE ADEQUACY OF AS3959-1999

The adequacy of AS3959 is appraised by comparing the construction Levels to their corresponding category of bushfire attack, and by comparing the recommended construction Levels, for different forests, slopes and separation distances, to the radiant heat flux modelled for these different situations. The minimum separation distances given in Table A3.3 (PFBP2001) refer to Inner Protection Areas only.

An additional 10 metres of Outer Protection Area, where the understorey is managed, is required (Grahame Douglas *pers. comm*. 2002). This means that the total separation distance required between the structure and un-managed forest is obtained by adding 10 metres to the given minimum separation distances (Table A3.3). However it is not known how effective a 10 metre wide strip of managed vegetation would be in reducing fire intensity. For vegetation like heath there is little opportunity for vegetation management by thinning the under-storey.

1. Comparing Construction Level with defined Bushfire Attack

- A Medium category of bushfire attack is defined as significant ember attack and radiant heat greater than 14.5 and not greater than 16 kW m^{-2}, and requires Level 1 construction (PFBP2001, Appendix 3). However the critical radiant heat flux for standard windows is about 14 kW m^{-2} (McArthur *et al*. 2000). Hence at these levels of radiant heat there is a risk of breakage of standard non-meshed windows, which are

[1] Grahame Douglas is Manager Planning Services and Operational Support, of the NSW Rural Fire Service.

allowed in construction Level 1. This construction level requires that only opening windows require meshing.

- A High category of bushfire attack is defined as significant ember attack and radiant heat greater than 16 and not greater than 21 kW m^{-2} and requires Level 2 construction (PFBP2001, Appendix 3). However at these levels of radiant heat there is significant risk of breakage of standard windows (see above).

2. Comparing Construction Level with modelled Bushfire Attack at minimum separation distances prescribed in Table 4.1 (PBP).

- For Forest on Slope 0 – 5 degrees the minimum separation distance is 40 m (PFBP, Table 4.1). The modelled values for radiant heat (Ellis 2000) 40 m from wet and dry sclerophyll forest on a % degree slope are greater than 21 kW m^{-2} and about 14 kW m^{-2} respectively. For this Vegetation/Slope category Table A3.3 describes a High bushfire attack, and prescribes Level 2 construction. It is likely that standard windows, and possibly meshed windows, will be inadequate 40 m from wet sclerophyll forest.

- For Forest on Slope 5 - 10 degrees the minimum separation distance is 50 m (PFBP2001, Table 4.1). At 51 metres and for a slope of 10 degrees the modelled values for radiant heat for wet and dry sclerophyll forest respectively are greater than 21 kW m^{-2} and about 14 kW m^{-2} respectively (Ellis 2000). For this Vegetation/Slope category Table A3.3 describes an Extreme bushfire attack, and prescribes Level 3 construction. Construction Level 3 prescribes toughened glass and fire-retardant treated external timber, which will probably be adequate.

3. Comparing Construction Level with modelled Bushfire Attack at minimum separation distances prescribed in Table A3.3 (PBP).

- Table A3.3 (PBP) describes a High category of Bushfire Attack for "Forest, 30 m separation, Slope 0 – 5 degrees". *If a 10 metre wide Outer Protection Area is also prescribed the total separation distance from un-managed vegetation will be 40 metres. If not the modelled values for radiant heat will be greater than given below.* The modelled values for radiant heat 40 metres from wet and dry sclerophyll are between 21 and 30 kW m^{-2} and between 14 and 21 kW m^{-2} respectively (Ellis 2000). Standard windows, which are permitted in Construction Level 2, and possibly meshed windows, will be inadequate in this situation.

- Table A3.3 (PBP) describes an Extreme category of Bushfire Attack for "Forest, 20 m separation, Slope 0 – 5 degrees". The modelled values for radiant heat *30 metres* from wet and dry sclerophyll are greater than 30 kW m^{-2} and between 21 and 30 kW m^{-2} respectively. Construction Level 3 prescribes toughened glass and fire-retardant treated external timber, which will probably be adequate. However AS3959-1999 does not address the issue of the possibility of burns to residents who are near the windows, or the ignition of materials inside the room.

- Table A3.3 (PBP) describes a Medium category of Bushfire Attack for "Forest, 51 m separation, Slope 0 – 5 degrees". The modelled values for radiant heat *60 metres* from wet and dry sclerophyll respectively are greater than 14 kW m^{-2} and less than 12 kW m^{-2} respectively. Construction Level 1 allows standard windows, which may be inadequate at this distance from wet sclerophyll forest.

OTHER CONSIDERATIONS

1. There are no **verified** models for radiant heat in front of bushfire flames (Ellis 2000) and the issue of assessment of bushfire attack is noted in AS3959-1999 Amendment 2. In addition it is difficult to determine the probability that damage to a given building component will occur by comparing peak radiant heat modelled for a bushfire, which may occur for periods of less than 1 minute, with the critical threshold of radiant heat for the component.

2. The NSW Rural Fire Service recognises inconsistencies in Planning for Bushfire Protection 2001 and intends to address them. The problem of inadequacy of windows, within the present construction levels, may be solved by prescribing meshing and/or toughened glass for all windows.

3. There is also the problem of the standard of fire-retardant treated timber. The present treatment is water-soluble and thus becomes ineffective with time. The industry apparently rejects the idea of using other treatments (McArthur *pers. comm.* 2001[2]). This problem is also recognised in AS3959-1999 Amendment 2.

4. Smaller separation distances from vegetation can be achieved by building houses to a higher construction level viz Level 3. However this may result in an increased risk both of burns to residents inside the house, and of ignition of flammable material adjacent to windows. In addition smaller separation distances will increase the risks referred to in the background discussion, section 4A.

About the author

Dr Peter Ellis developed a model for the radiant heat flux in front of bushfire flames for the NSW Rural Fire Service and which is incorporated in the joint *NSW RFS* and *planningNSW* 2001 document "Planning for Bushfire Protection". He has also prepared reports, for the Sutherland Shire Council and a private developer, on the implications for construction standards, of planned separation distances between structures and vegetation.

[2] Neville McArthur is a scientist with the CSIRO Division of Building Construction and Engineering at Clayton, Victoria.

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History of Statement

I was requested to supply a Statement for the Select Committee on Bushfires at short notice, with a deadline of 18/06/02.

Phil Cheney, Jim Gould and Dr Phil Polglase saw the Statement before despatch. Phil Polglase suggested I submit the Statement through the Editorial system.

Peter Ellis 19/06/02