Background briefings on emerging issues for
fire managers from AFAC and Bushfire CRC.

FIRE NOTE

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PASSENGER VEHICLE BURNOVER IN BUSHFIRES

SUMMARY

This research project investigated and clarified previous uncertainties relating to safety factors for passengers forced to take refuge inside a vehicle during a bushfire. Under investigation were key protective practices when faced with this situation, such as the use of air conditioning, the orientation of a car to the fire front, and seeking shelter under woollen blankets. The findings and lessons learned are helping authorities better understand measures relating to tenability and survivability in such situations, ultimately leading to better advice for people trapped in cars caught in a bushfire. The research demonstrates and reiterates warnings that sheltering inside a vehicle is a high risk strategy and that advice for doing so should be given with extreme caution.

ABOUT THIS PROJECT

Project D1 Building and Occupant Protection was part of Bushfire CRC Program D: Protection of People and Property.

Acknowledgments: The study was conducted in 2006 at the NSW Rural Fire Service Hot Fire Training Facility in Mogo, on the New South Wales south coast, using 2WD sedans ranging in size, age and make, which were donated by NRMA Insurance.

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BACKGROUND

The loss of life of civilians in vehicles during bushfires in Australia has been of concern for several decades. Preventable deaths related to vehicles used in untimely evacuation or travel have occurred with regular frequency. The 1965 fire in Longwood, Victoria, was the scene of a tragic mass fatality where a family of seven perished. In the Hobart bushfires of 1967, a total of 53 people perished (of which 26 people were in or near vehicles). Seventeen died in or near cars at Lara, Victoria, in 1969. On Ash Wednesday in 1983, in Victoria alone 16 civilian lives were lost in circumstances where a vehicle was involved. Between June 2000 and July 2005, at least four out of every 18 recorded bushfire fatalities were vehicle-related. In Victoria's Black Saturday bushfires of February 2009, 16 people died in or near cars.

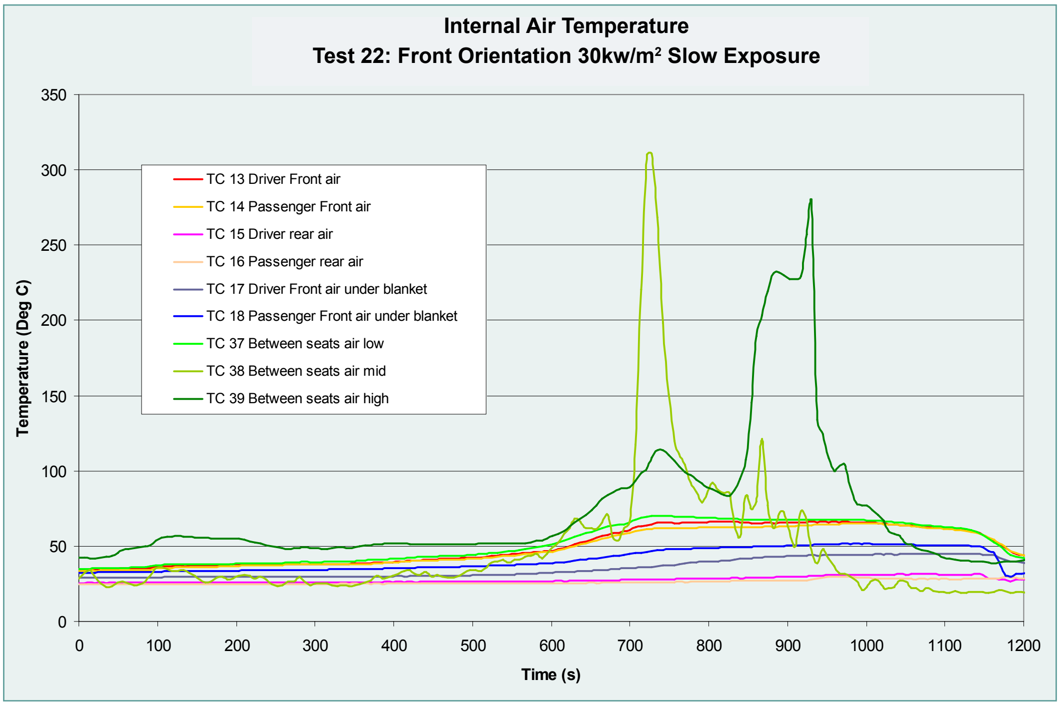
While it is understood that a range of factors can contribute to such fatalities, there is insufficient understanding of the subject and clear practices need to be recommended when faced with this situation.

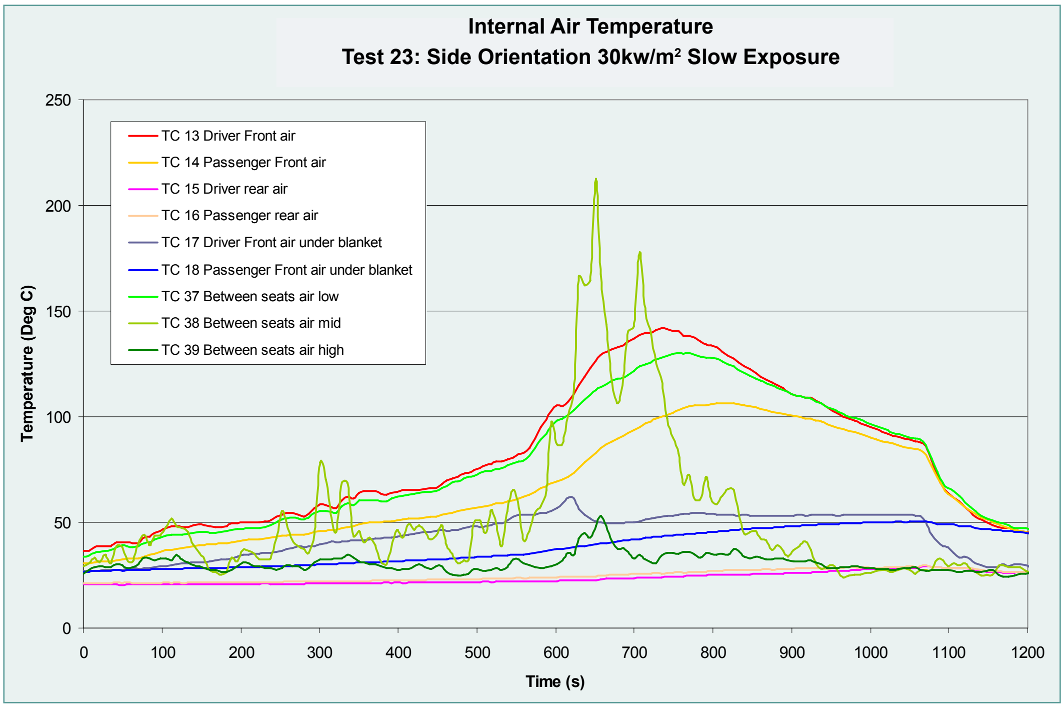
In 2006, the Australasian Fire and Emergency Service Authorities Council (AFAC) working together with CSIRO sanctioned the document *Guidance for people in cars during bushfires*, which provided clear advice on the most appropriate actions to take if caught in a vehicle during a passing fire front. However, the guide was largely based on a collation of advice and recommendations given by state fire authorities and recommendations in the limited literature available. A number of points of advice in the 2006 document were not backed by clear scientific observation and there were uncertainties on protective actions relating to the use of air conditioning, the value of woollen blankets, and the orientation of the car to the fire front.

DEFINITIONS

Air toxics and thermal exposure within the car cabin during experiments were based on criteria described previously by Knight et al. 2001:

- **Tenability:** the occupants will be able to occupy the cabin for the bushfire burnover period without experiencing intolerable irritation, significant loss of alertness, or irreversible health effects.
- **Survivability:** the occupants will be able to occupy the cabin for the bushfire burnover period without long term loss of function and consciousness or loss of life.





BUSHFIRE CRC RESEARCH

Research by CSIRO scientists in conjunction with the Bushfire CRC investigated the above uncertainties in full-scale experiments where used cars (generally 10 to 20 years old) were exposed to simulated burn-over conditions using a Liquid Propane Flame Front Simulator at the NSW Rural Fire Service's Hot Fire Training Facility in Mogo, New South Wales, in early 2006. The aims were:

- To determine the maximum heat load at which a vehicle typical of a bushfire burnover event in Australia (i.e. late model passenger car) would still retain its integrity and provide a safe haven for its occupants.
- To assess the pros and cons of leaving an engine operating during a burnover, with respect to in-cabin tenability and survivability (see definitions box), post-burnover vehicle function, and flammability with respect to the fuel system (fuel lines, tank, fuel pump).
- To assess if car orientation with respect to the fire front provides specific protection to occupants.
- To assess whether the cabin air recirculation system or air conditioning system should be left operating.
- To gain insight into the duration a vehicle occupant is required to withstand burnover conditions, and to observe which signs are reliable for an occupant to determine the most appropriate condition at which to egress the vehicle.
- To assess the advantage of crouching under a woollen blanket in a specific location within the vehicle interior and/or other common self-protection measures in a burnover situation.

Each vehicle, after being fully instrumented to measure in-cabin temperature, radiation and air quality, was exposed to the test facility's "flame immersion" phase, where heat transfer and ignition may occur by direct flame contact both on the windward and leeward sides and beneath the vehicle. Test duration

was fast (less than 4 minutes) to simulate a grass fire under high wind conditions, or slow (12 to 15 minutes) to simulate the longest practical high fuel load forest fire. Tests were conducted at different peak radiant intensities (in the range of 10-40 kW/m2), simulating different separation distances from the main fine fuel load. And some tests used additional under body burners for short periods (less than 1 minute) during burnover, to simulate the parking of a vehicle over short dry grass.

TESTING METHODS

Car interiors were monitored for air toxics at seated head height, between the front seats, and below a wool blanket (less than 30cm above floor) in the front seat well. Air from the cabin was drawn to a remote tank from which the following air toxics were sampled:

- Respirable particles (RP, mg/m^3) were measured as particle mass in air using a 90° lightscattering laser diode, calibrated to the respirable fraction of a standard ISO 12103–1 A1 test dust.
- Carbon monoxide (CO) was monitored using a Q-Trak™ Model 8550/8551 IAQ Monitor (TSI Inc., USA) or a Drager PacIII (Drager), both calibrated with 100ppm CO prior to each day of test.
- Hydrogen chloride (HCl) and Hydrogen cyanide (HCN) were measured by sampling cabin air directly via openable holes through the cabin body at the front seat height of an occupant. These were collected immediately after flame-out at the end of each test.

END USER STATEMENT

"Sheltering in cars from the onset of bush fire has long been held by fire services to be the 'second best option' in providing a buffer between people and radiant heat. Much of the assumed wisdom was based on 'suck it and see' experiments on vehicles constructed in the 1950s and 60s when vehicle manufacture and accessories were vastly different to modern vehicles. 'Would chemicals in modern upholstery make a significant difference?' was but one question requiring testing. This research greatly adds to the understanding of how vehicle tenability and survivability is compromised with the passage of various fire types and differing intensities. It demonstrates quite clearly that sheltering in vehicles is a highly risky business and advice needs to be given with extreme caution. As a result of this research fire agencies will modify their advice to the public. Sheltering in a vehicle is now regarded as being well below the 'second best option' to one of extreme risk and to be avoided wherever and whenever possible."

– Russell Taylor, AFSM, Group Manager Executive Support, NSW Rural Fire Service

Temperatures were measured using 1.5 mm Type 'K' MIMS thermocouples. Thermocouple wires were held in position with self-tapping screws and bent to create a positive pressure between the first 10mm of the thermocouple wire and the surface to be measured.

Heat flux was measured using water-cooled Schmidt Boelter total heat flux meters, with a sensing range of 0 to 100 kW/m^2. The total heat flux measured consisted of both radiative and convective heat.

KEY RESEARCH OUTCOMES

- Using a woollen blanket to shelter under in the front or rear foot-well of a vehicle reduces exposure to toxic gases (2 to 3 fold reduction observed in tests), while staying below the height of the windows is effective in protection against radiation. For air temperature exposure, staying below the blanket or as low as possible is the most effective strategy.
- An operating air conditioning system in recirculation mode does reduce the temperatures in the early stages of exposure. However, it does not have a significant effect on the tenability of the vehicle during the peak of the exposure.
- The orientation of the car to the fire front significantly influenced internal cabin conditions and ultimate survivability during a burnover event. Facing the front of the car towards the approaching fire was better than side or rear orientation.
- The vehicle should not be parked over dry, fine fuels, as the low level flame from these fuels can quickly cause

REFERENCES /FURTHER READING

Loane L.T. & Gould J.S. (1986) Aerial Suppression of Bushfires – cost benefit study for Victoria, CSIRO.

Krusel N. & Petris S. (1999) A study of civilian deaths in the 1983 Ash Wednesday Bushfires Victoria, Australia. CFA Community Safety Directorate, Country Fire Authority.

Morton S. (2005). NCIS Database Search, Bushfire and Wildfire Fatalities. Vic Institute of Forensic Medicine.

Knight I. Sullivan A. & Leonard J. (2001). Definition of Burn-over Conditions for the testing of Firefighter Tankers. Client Report No. 977 CSIRO Forestry and Forest Products, CSIRO Manufacturing and Infrastructure Technology -c-2003-059.

Guidance for people in cars during bushfires, January 2008 update, the Australasian Fire and Emergency Service Authorities Council (AFAC).

Haines K.A. et al (2009), 100 years of Australian bushfire fatalities – exploring the trends in relation to the 'stay or go' policy. Bushfire CRC report for the 2009 Victorian Bushfires Royal Commission.

Handmer J. O'Neil S. & Killalea D. (2010) Review of fatalities in the February 7 2009 bushfires. RMIT University and Bushfire CRC report for the 2009 Victorian Bushfires Royal Commission.

untenable conditions. (Test 28, where an underburn only treatment was applied, the vehicle became untenable within 1.5 minutes, compared to the average time to toxic air untenability, which was 10.2 minutes).

▲ Testing at the NSW Rural Fire Service Hot Fire Training Facility in Mogo.

- Thermoplastic body parts and the structural design features of a vehicle contribute to the loss of physical integrity of the vehicle envelope, with the more recent model vehicles performing worst.
- Engine operation during the event did not result in a significant change in cabin tenability during the test program, but may improve the chances of vehicle operation after the burnover.
- Direct flame contact from either the passing fire front of burning fuel located in the immediate area surrounding a vehicle will result in a near immediate exceedance of tenability.

FUTURE DIRECTIONS

Respirable particles were the main reason for tenability exceedance, and were lower below the blanket, indicating that strategies that reduce respirable particle intake could be considered for future research. Further assessment is also needed to test research findings against current model vehicles and utility-type vehicles, which would be found in many rural and peri-urban settings and have featured in a number of recorded fatalities.

As a result of this research, AFAC updated its document *Guidance for people in cars during bushfires* in January 2008.

Fire Note is published jointly by the Bushfire Cooperative Research Centre (Bushfire CRC) and the Australasian Fire and Emergency Service Authorities Council (AFAC). This Fire Note is prepared from available research at the time of publication to encourage discussion and debate. The contents of the Fire Note do not necessarily represent the views, policies, practices or positions of any of the individual agencies or organisations who are stakeholders of the Bushfire CRC.

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AFAC is the peak representative body for fire, emergency services and land management agencies in the Australasia region. It was established in 1993 and has 26 full and 10 affiliate members.