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Your last resort options

Chair: Malcolm Hackett OAM

Presenter: Dr Justin Leonard

Chair

Now I'd like to welcome Justin who's supported us in these webinars on many occasions, we'll hear your presentation, thank you Justin.

Justin Leonard

I'm going to focus on private bushfire shelters in the context of using them in a sheltering process. This particular image of a private bushfire shelter was actually drawn up by one of my daughters as an example of what they would ideally have in their shelter to make it nice and comfortable during the fire event and it certainly raises some interesting perspectives and questions about what a bunker should or shouldn't have and what degree of comfort it should offer. Things like two exits and plenty of backup processes and everything to make it comfortable.

Just to put a little bit of context into what event we're looking at here. It's the more extreme events up around the catastrophic and this category around severe and extreme is really the type of circumstance we're looking to be relevant for and to prepare for in terms of our shelter options. These are very very extreme weather events that offer a lot of thermal stress and heat exhaustion in themselves. So, we're actually seeking refuge away from those severe weather conditions as well as obviously trying to protect ourselves from the effects of fire which Jim highlighted quite articulately.

It's not surprising that in the catastrophic category people are actually drawn to and seek shelter within their houses. Those houses are places that are readily losing tenability and burning down and obviously contributing to the fatalities. You can see the relative categories of where fatalities have occurred and they escalate quite quickly into catastrophic around that structural adequacy. The propensity for our shelters to offer protection changes through these contexts. It's important to have multiple options if we're actually trying to choose to be in place at the time which isn't recommended, it's much better to be away from these locations outside of bushfire prone areas when the weather can potentially reach into catastrophic conditions.

In terms of the fatalities over recently studied bushfires, so going back through the last few decades, it's important to note that this iconic line here around an FFDI of 100 which is actually the divide between catastrophic and the rest in this area here. Over 60% of all our house loss and fatalities actually occur above that. The context of being ready for conditions that far exceed this FFDI of 100 is quite important. So that's damaging winds, temperatures up and well above 35 well into the 40s, extremely low humidity - really challenging conditions in themselves.

It's also important to focus on this concept, that of the fatalities that have occurred outside the home it's really interesting to note that around 60% of those fatalities outside the home actually occur in less than 100m from the person’s actual home. Not any home, the home that belongs to the fatality. So, the loss context immediately around these structures is key. And it's key to understand the sheltering options and the various backup processes like a shelter, a bunker, a dam, an open area where your vehicles are all within the context of your own property and neighbouring properties.

Let’s delve into what drove a lot of the recent design and consideration around personal bushfire shelters. it was actually fatalities around the 2009 Black Saturday fires where people were losing their lives in makeshift bunkers and shelters. They might be a mix of things like cellars or workshops that were close to or associated with the house itself, so it was actually threatened directly by the house burning down as well as the bushfire, so it had two types of fires to put up

with. And other ones which were detached makeshift shelters that weren't adequately sealed or protected from the effects of fire.

That led to a lot of delving into how you would go about actually defining what a personal bushfire shelter would be designed around. What its performance would need to be and how you could write design codes and accreditation processes so that those types of shelters could perform adequately. And they've come up with some various specifications which I'll give you a distilled version of. They are required to be placed at least 6m from any significant fuels including structured fuels. That might be retaining walls or adjacent sheds or any significant fuel sources. But they also should be no greater than 20m from the house. So that manages the travel time and the complexity of moving between the house and one of these bushfire shelters.

In terms of tenability, they also need to be able to be sealed up to a completely airtight state so that when you're in them and can close them, you'll lock a confined volume of air that you then breathe and sustains you for the duration where it's untenable outside. That's particularly important. It has provision for air ventilation, if you get in it early while the air is still tenable outside you can continue to ventilate this shelter until the point where the air starts to lose its quality and that's when you lock it up. So that maximizes the time that you can have from that time that you lock up the shelter to an airtight state, gives you the time that you can exist with that good air inside the shelter.

It should have sufficient air volume for the occupants inside it to last at least one hour and that's why various shelters have a rating for how many people it can house for that one-hour period. If you're lucky enough to be in one with less than the maximum occupant rating well then you've got more air in there to sustain you for longer. The regulations specify that the temperature should be below 45 degrees with an average temperature duration below 39. And I'll put a question mark beside that because existing in a closed box that's sealed up tight at those temperatures is not going to be comfortable and particularly sustainable for very long. And think about this one-hour period. And I'll come back to those thermal conditions a bit later.

And of course, no interior surface should get to 70 degrees or above that. That's the way you manage burn risk. So, if you touch the back of a door or a handle or you're leaning up against the wall if it was 70 degrees or above it would start to be a burn risk. And it should be constructed with non-combustible materials. If they've started to be heated for example up to 70 degrees or above they won't emit toxic gases into the bunker. You don't need to create much of a fume or emission from a material inside a confined space for that quickly to become untenable or extremely unpleasant.

How do we use one of these personal bushfire shelters? Well basically when we're thinking about getting into them we should be already wearing the appropriate PPE that you would expect to have if you were trying to survive, or do your best to survive outside. You need to bring that into the bunker and have it on you. That's particularly important when you get to the point of leaving the bunker of course. It should be adequately stocked. So, things like fresh water and other supplies. It should be in an area that's clear of all combustible elements. There's lots of things that are fixed but there's also mobile things like garden furniture and vehicles they have to be already away from the personal bushfire shelter. Remember that 6m rule.

You really need to make sure the bunker's in a good condition. So it's clean, dry, cool enough, been well ventilated, not locked up and stuffy. You don't want to open the door and realize that it's stuffy and putrid inside for example. You need to confirm and be clear about those access routes and criteria. And particularly also confirming when you've left it too late to get to the personal bushfire shelter. This is particularly important because you don't want to be arriving at and trying to get into one of these things when it's already smoky and risky outside. Jim mentioned the risk of trying to get from A to B while the fire's happening. You have to consider that you don't want to get into one of these things with smoke that pretty much defeats the purpose of getting into a sealed box.

I've already emphasized that already, entering it well ahead of time. Initially leave the door open and the vents open. Monitor conditions looking for that first sign of smoke arrival. Closing the doors in advance as soon as you start to smell smoke. If there is a little trace of smoke in there then face masks with the ability to filter out some nuisance volatile organic compounds and help with comfort. And certainly, take note of the time when you close it up because you need to monitor the

time. The process and the tenability of that bunker in terms of the stuffiness. And also begin to monitor the conditions outside. These private bushfire shelters should have a means or a sight glass that you can keep an eye out for outside activity.

So that leaves you with quite a lot of open questions - what if people or pets arrive once you're in it and you've closed up the bunker and there's smoke outside? How do you deal with that complexity of letting new people in but try not to compromise the air quality within the bunker? And I'll leave these as open questions.

What if smoke appears to have cleared but there's really no sign that the fire's passed yet or the passage of the fire's occurred? It can be quite ambiguous to know when it's been and gone.

And what if one or more occupants actually become stressed within the shelter due to confinement? They have issues with stuffy air or confined spaces.

In terms of an exit strategy well you're sure that PPE is on, that personal protective gear that you got into the shelter with. You're looking for those cues where the intensity of the fire has come and gone. You need clear line of sight, you should be able to see at least 20m away, and that air's consistently clear and looks tenable outside. And when it is consistently clear you can start to open the ports. Open the ports rather than the door. Open the ventilation ports and monitor that air quality to see whether it is genuinely good enough to breathe and exist outside.

And also look for a very large degree of absence of fire. You might see a lot of heavy elements still burning around. You really want to see well less than 10% of those still burning in a residual way, otherwise that radiant heat could still be quite strong. And you get a sense of that glow from those heat sources too. Be cautious in opening the door. Open it a small amount and then test that process. Exit towards a known area which is clear of heavy fuel - you want to be exiting into and heading towards a relatively the open and bare space.

And I guess what are you really leaving into? These regulations mean that you should already be 6m away from fuel sources but you need to be very careful of what's around you and what you're going to do next.

And I think that raises a fundamental question of why you were in the shelter in the first place and what are your next steps when you're coming out into a potentially well burnt-out scene.

Now these private bushfire shelters or bunkers whatever you may want to call them there's quite a lot of variation in their design and their design intent. And I guess you can split those into two categories, they are ones inherently above ground and the ones that are dug in or below ground. They're going to behave quite differently in a fire. Not so much in terms of their response to the fire impacting them but more so that their conditions that they're in when you get into them will be very different.

A concrete box above ground on one of these days is going to be close to the ambient temperature of the day. So, it could be 30 or even 40 degrees at the time you enter. Whereas an underground one is going to be more like the subsoil temperature, so it's going to be down around the 20 degrees or so temperature when you enter. And that could be a profound difference for the inconvenience of climbing down into a bunker. That thermal conflict could be quite significant and I'll delve into that a little more now.

If you get into one of these bunkers there'll be different thermal comfort levels as I've mentioned. The hotter the conditions in that bunker, the more physically stressed the occupant group would be. The more stressed the occupant, then the higher the occupant's heart rate and breathing rate. The more dehydrated the occupants are, the more physically stressed they are also and the higher heart rate, the quicker they will consume the oxygen in that confined space. And the quicker the carbon dioxide levels will build up. So the air will get stuffier quicker.

And I guess if you've had any pre-exposure to smoke you've also got a reduced tolerance to that reducing oxygen level and increasing CO2. There's been some interesting university studies that have delved into what it's like to go through this. The combination of high thermal stress and at the same time be in an enclosed environment where the conditions get stuffier and stuffier. And they're quite revealing particularly around this thermal comfort issue. They made up a box which was basically the amount of air volume that each occupant utilizes during this bunker. If you imagine a

six-person bunker would be simply six times the volume. So, they've scaled it down and made it like a one-person bunker with the appropriate amount of air to last one hour. You can get a rough size of that. Made sure it was sealed but also made sure that they could control the temperature.

They put a healthy willing student in that bunker in that enclosure and noted that their oxygen consumption rate over the hour started up around the high 20s. So, 20 just above 20 which is ambient oxygen. And declined down to about 17 or so. Now the oxygen limit to where we'll get really drowsy is something like 13, so, over an hour's time oxygen really isn't a problem, there's plenty of oxygen around. The carbon dioxide levels start from very low insignificant level and by the end of the hour it reached something like 4%. Now the limit of CO2 exposure that we can tolerate is somewhere around the 4-7% CO2 level and that's age specific. So, a younger person can tolerate more like 7% and an older person can tolerate more like 4%.

It's actually the carbon dioxide build up in this bunker that is actually the limiting factor to surviving much more, or being able to handle, not much more than an hour. And it's interesting to work out why that's the case. And that's actually what gives you that respiratory distress or need to find cleaner air and move away from a stuffy place, it's the carbon dioxide build up that we can sense. The air temperature in that shelter, they actually preconditioned it up around about 43.5 degrees. And putting a student into that box with the body temperature is something like 39 degrees they actually managed to cool the box down because you're putting a cooler body inside one of these. And the temperature declined in the shelter from 43 down to about 40. So that's the conditions, very hot conditions in there. And they actually prestressed the person so they were getting in as if they were already stressed from say fighting a fire or dealing with the conditions on the day to be realistic.

Now the really interesting part which is the relative humidity in this sealed box that had the walls, and the air temperature were up in the 40s very quickly rose from something like 40% humidity up through 70 to 90. So, this is becoming very hot and sweaty in there and the issue with the very rapid rise of humidity is that the core body temperature of the occupant, basically after about 10 minutes, as it gets so humid in this hot bunker that the core body temperature of the person starts to increase in an uncontrolled way steadily towards a critical core body temperature for which the occupant can't tolerate. So, they can't cool down by sweating because the humidity is too high.

So, you're actually heading towards a worse and worse state of core body temperature the longer you stay in a hot bunker. And then you're actually faced at the end of the hour getting out into very hot conditions back into the environment outside.

The difference if you actually have a bunker that has very cool conditions inside it was something like 20 degrees. Then what ends up happening is the humidity will rise to about 50% and then it'll flatline because all the humidity will actually wet out onto the walls of the bunker and that caps the humidity and therefore the occupants would be far more comfortable and wouldn't have this uncontrolled rise in core body temperature.

What also happens with a core body temperature rise is that drives everyone's heart rate up. So the hotter you get internally the more your heart rate really starts running and the student in this experiment actually got up to a heart rate around 140. This is a fit healthy student, 140 isn't a problem for that individual. But we're all not created equal in terms of our fitness or our age and what our maximum tolerable heart rate is. Anyone with a heart condition or is starting to get elderly, then their maximum tolerable heart rates start to be threatened by simply existing in one of these bunkers if it's a hot bunker.

So, there's something to have a think about in terms of the type of bunker and the types of conditions it might be going through during the fire event.

Summing up these useful principles. You really want one of these to be a comfortable starting temperature and that will definitely provide much more tenable and comfortable conditions for a broader range of people in the community. And that means dug in or semi submerged or fully submerged bunkers.

And you really need to have a starting temperature ideally around 28 degrees or below to give you a reasonable chance of not being in a high degree of heat stress at that time when you exit. And you need to focus on staying hydrated throughout that event so you're in good condition to leave,

so having water in there with you. But splashing water around inside one of these personal bushfire shelters is an absolute no no because you'll quickly increase the humidity and that doesn't help anyone in particular. So, drink water, don’t splash it around. And I'll leave it there for the next session