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Authorised: **Manager Built Environment Branch**

GL-15: FIRE SAFETY ENGINEERED PERFORMANCE SOLUTIONS

1. Purpose:

To provide guidance for fire engineers when consulting the Department of Fire and Emergency Services (DFES) in relation to Performance Solutions for building design; and for the preparation and formatting of a Fire Engineering Brief and Fire Engineering Report which is to be submitted to DFES for assessment.

2. DFES Role:

Under the Building Regulations 2012 (as amended), regulation 18B (1) a Building Surveyor signing a Certificate of Design Compliance (CDC) is required to provide a statement that plans and specifications in sufficient detail to allow assessment of compliance with DFES's operational requirements are to be provided to the Fire & Emergency Services (FES) Commissioner at least 15 business days before the CDC is signed. This enables DFES to provide advice in respect of the plans and specifications. Where appropriate, this documentation may include a Fire Engineering Brief (FEB) and a Fire Engineering Report (FER) where Performance Building Solutions are proposed.

This allows DFES to ensure that advice is provided to the Building Surveyor regarding the Performance Solution/s and with regard to the building design generally. However, in terms of DFES's involvement in the project, we are not designers and should not be regarded as part of a design team. As an advisory referral agency, we provide advice only at the concept, FEB, and FER stages. Under the current legislation we do not approve designs. Our advice and comments are also not a peer review. Ultimately, it is the Building Surveyor's and design team's responsibility to ensure that the Performance Requirements of the BCA are satisfied by the proposed building design.

3. Performance Solutions:

3.1 DFES endorses the Australian Building Codes Board's (ABCB) International Fire Engineering Guidelines (IFEG) current edition.

3.2 When submitting any preliminary fire engineering documentation (i.e. FEB or FER) prior to the CDC, then it is important to ensure that this is submitted to DFES using the on-line Electronic Lodgment Form:

https://beb.dfes.wa.gov.au/submissions.nsf/submission?openform

3.3 The Electronic Lodgement Form will enable fire engineers to submit FEBs or Building Surveyors to submit a FER and associated documents. Note that the form will not allow fire engineers to present a FER, as this should only be received as part of a complete submission in accordance with Building Regulation 18B(1) and DFES Guideline GL-07.

3.4 Apart from the buildings and facilities detailed in Clause 3.5, DFES endorses the use of Performance Solutions for building design that are supported by sound fire safety engineering principles, judgements, assumptions and analysis.

3.5 DFES strongly recommends that Performance Solutions should not be applied to fire safety aspects of facilities or buildings subject to the Dangerous Goods legislation e.g. buildings used for bulk storage or processing of flammable liquid, industrial chemicals or explosive materials.

Note: compliance with other regulatory requirements (outside of the BCA) may be required for special use buildings.

3.6 DFES strongly advocates the use of sprinklers in the occupancies listed in Table E1.5 of the BCA. Fire sprinkler systems provide a high degree of protection to life and property and greatly assist the fire suppression activities and safety of DFES firefighters.

3.7 A Performance Solution should account for and facilitate Fire Brigade intervention. In accounting for Fire Brigade intervention, firefighters should be given a reasonable time to rescue any remaining occupants, before conditions in the building or structure become untenable or unsafe for firefighters.

Note: the need to consider rescue activity should be determined in consultation with DFES, within the context of the building occupancy characteristics.

3.8 A Performance Solution should not use Fire Brigade intervention, in isolation, as a means or justification to reduce the BCA's requirements for fire resistance levels of a building's structural elements.

4. Performance Requirements Assessed by DFES:

DFES will generally provide advice on Performance Solutions involving the following Performance Requirements:

Performance Requirement	Relevance to DFES Operational Requirements
CP1	Performance Requirement directly references fire brigade intervention.
CP2	Performance Requirement directly references fire brigade intervention.
CP3	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
CP4	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
CP5	Outward collapse of external concrete walls poses a safety risk to fire fighters.

CP6	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
CP7	Fire fighters operations will be adversely impacted if emergency equipment does not continue to operate during a fire.
CP8	Fire fighters operations will be adversely affected by additional demands to prevent fire spread.
CP9	Performance Requirement directly references fire brigade intervention.
DP2	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
DP4	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
DP5	Performance Requirement directly references fire brigade intervention.
DP6	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
DP7	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
DP9	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
EP1.1	If a fire cannot be successfully extinguished by first-aid firefighting then this will place additional demands on fire fighter resources.
EP1.2	If a fire cannot be successfully extinguished by first-aid firefighting then this will place additional demands on fire fighter resources.
EP1.3	Performance Requirement directly references fire brigade intervention.
EP1.4	An automatic suppression system is considered an integral part of the response to a fire by fire fighters and occupants.
EP1.5	Performance Requirement directly references fire brigade intervention.
EP1.6	Performance Requirement directly references fire brigade intervention.
EP2.1	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
EP2.2	Performance Requirement directly references fire brigade intervention.
EP3.1	Stretcher facilities are required by firefighters/other emergency services.
EP3.2	Performance Requirement directly references fire brigade intervention.
EP3.3	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
EP3.4	Fire fighters will have to conduct search and rescue activities if occupants are unable to evacuate or their evacuation is hindered by the proposed design.
GP5.1	Not currently assessed by DFES BEB.

It should be noted that the above is a guide only. DFES will only provide advice on the Performance Requirements directly referencing fire brigade intervention unless DFES BEB decides otherwise that it would be necessary or advantageous to provide additional comment.

5. Fire Engineering Brief (FEB):

5.1 It is recommended that in order to minimise or avoid delays in gaining DFES's advice for the Performance Solution/s, initial consultation in accordance with this guideline should be followed. Initial consultation with DFES regarding the use of a Performance Solution for building works that deviate from the Deemed-to-Satisfy (DtS) provisions of the BCA should occur by way of: written correspondence, minuted meetings or specific FEB deliberation meetings. It should be noted that the advice DFES provides at this meeting is preliminary only. Further advice will be provided at the FEB and FER stages.

5.2 In the interests of an efficient building design approval process, an FEB meeting should be attended by the relevant stakeholders in the building project. Such stakeholders may include all or some of the following as applicable:

- DFES personnel
- Building Surveyor, Permit Authority or other approving authority.
- Fire engineer(s)
- Fire services consultants
- Architect or designer
- Building regulations consultant
- Building owner(s)/management
- Occupant/client representative
- Hydraulic / Structural / Electrical / Mechanical engineer(s)
- Project management representative

6. Fire Engineering Report (FER):

6.1 The final document containing the fire safety engineering analysis and methodology to demonstrate that the Performance Solution/s has addressed the relevant BCA Performance Requirements, should be entitled 'Fire Engineering Report'.

Note: DFES requires the FER documentation to be submitted in hard copy (paper) and electronic format e.g. pdf.

Where the FER relies on colour diagrams to illustrate the assessments and hence to demonstrate compliance with the Performance Requirements of the Building Code of Australia; it is considered that the FER should be submitted to DFES in colour.

6.2 The FER should be consistent with the methodologies detailed in the IFEG.

6.3 If the FER addresses a building already subject to a number of existing Performance Solutions; it should be demonstrated the building has been considered holistically and that the new Performance Solutions will not have an adverse impact on the existing Performance Solutions and vice versa. Consequently, it is considered that the relevant FERs should be appropriately merged into one document.

6.4 If the FER is a reissue of a previous FER, then to allow DFES to provide advice on the changed sections only; the changed text sections should be coloured in a different colour to the main body of text e.g. blue text instead of black text, and changes should be referred to in the revision history table at the front of the report.

6.5 The FER should be written clearly and concisely and in a manner that persons external to the fire engineering profession are able to understand and follow. Fire engineering terminology should be explained, and acronyms should be written out in full when they first appear in the report.

6.6 Any data, findings, research, certificates, statistics or evidence of suitability detailed in the FER should be clearly referenced in order to demonstrate their authenticity (where applicable, a copy of data or references used in support of a proposal should be included as addenda to the report).

6.7 The FER should detail all of the related essential fire safety measures in the building project and include recommendations for an essential services maintenance regime to be followed by the building owner/s after the building construction and commissioning phase.

6.8 The Building Surveyor's fire engineer must make available to all the stakeholders as well as those responsible for installing, commissioning and maintaining the building's passive and active fire safety features, systems and essential services, all of DFES's advice.

6.9 When using expert judgment, the relevant accreditation details, qualifications and industry related experience of the party providing the expert judgement, should be detailed in the FER.

7. Basic Fire Engineering Criteria:

In the absence of other suitably referenced and justified inputs, the following standard values or input criteria should be used in calculations and modelling for the fire engineering analysis.

7.1 Tenability Criteria for Building Occupants

A clear air layer height of at least 2.1m (i.e. above head height). However, if occupants are expected to be subjected to a lower smoke layer then the visibility through, and toxicity of, the smoke shall be analysed. In these circumstances it would be expected that the inputs to the fire modelling for the design fire chosen will produce smoke characteristics that closely replicate the likely combustion products of the building contents.

A maximum hot layer temperature of 200^oC to ensure that radiant heat to the occupants below is less than $2.5kW/m^2$.

Where the building occupants are subjected to convected heat it would be considered appropriate for the maximum temperature to be not in excess of 600^{o}C where the water vapour content of the air is likely to be high (i.e. as in most fire scenarios).

7.2 Tenability Criteria for Firefighters

Generally, the tenability criteria used for firefighters should only be based on the 'Routine Conditions' values. When a Performance Solution proposes a non-compliant booster location, then the assessment should consider an Acceptance Criterion of 2.5kW/m^2.

Routine Conditions
Elevated temperatures, but not direct thermal radiation
Maximum Time: 25 minutes
Maximum Air Temperature: 100^{o}C (at 1.5m)
Maximum Radiation: 1kW/m^2

Hazardous Conditions
Where firefighters would be expected to operate for a short period of time in high temperatures in combination with direct thermal radiation.
Maximum Time: 10 minutes
Maximum Air Temperature: 120^{o}C (at 1.5m)
Maximum Radiation: 3kW/m^2

Extreme Conditions
These conditions would be encountered in a snatch rescue situation or a retreat from a flashover.
Maximum Time: 1 minute
Maximum Air Temperature: 160^{o}C (at 1.5m)
Maximum Air Temperature: 280^{o}C (in upper layer)
Maximum Radiation: 4 - 4.5kW/m^2

7.3 Future Building Use

For some Performance Solutions to be valid into the future of the building, there is a reliance on a specific usage of a particular building classification e.g. a low fire loading associated with Class 8 stone masonry or similar. Where a change of these circumstances would negate the applicability of the Performance Solution without requiring further referral to the Permit Authority, (i.e. if there is no change of use) then an appropriate, enforceable legally binding mechanism for addressing the necessary variation to the fire safety system requirements in the case of a change of conditions should be agreed and included in the FER.

7.4 RTI

For calculation of sprinkler or other alarm activation times the following RTIs should be used with the associated activation temperatures. However, it should be noted that these numbers are provided for guidance only, and the Building Surveyor's fire engineer should select an appropriate value.

Detector Type	Value
Standard response sprinkler heads	RTI = 150
Fast response sprinkler heads	RTI = 50
Thermal detectors	RTI = 10
Smoke detectors	RTI = 1 (using a temperature rise of 5^{o}C in accordance with Bukowski & Averill, 1998)

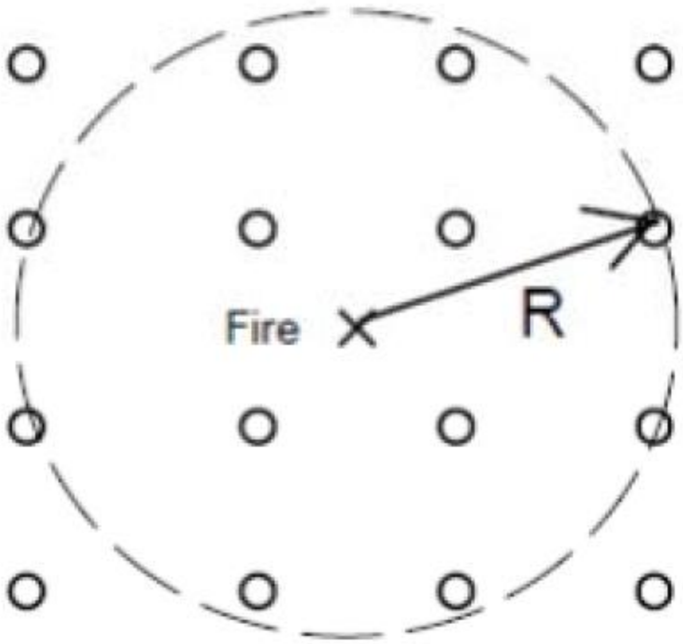
7.5 **Sprinkler Activation**

Where the heat release rate (HRR) of a fire is to be calculated in order to provide a peak fire size and the fire location is sprinkler protected, then the activation time based on the location of the second row of sprinkler heads (as per the International Fire Engineering Guidelines (IFEG)(ABCB, 2005) diagram below) should be used to add suitable robustness to the analysis.

The minimum distance values based on standard spacing should be calculated as per the table below:

Sprinkler System Type	Area of Sprinkler Coverage	First Row Distance	Second Row Distance (R)
Light Hazard	21m^2	3.24m	7.25m
Ordinary Hazard	12m^2	2.45m	5.48m
High Hazard	9m^2	2.12m	4.74m

Note: This assumes a square array pattern layout. Rectangular or staggered spacing layouts will require appropriate calculation.



Note: Where no sprinkler protection is provided in a building, then fire growth should be considered to continue unabated to involve the entire fire compartment, unless otherwise justified.

7.6 **Radiant Heat Flux Calculations**

For calculation of radiant heat flux levels, a general emissivity value of 1 should be used with the following temperatures.

For fires clearly open to the external atmosphere (i.e. the roof of the building is considered to have collapsed and there is no radiative heat feedback involved) a flame temperature of 680°C.
For fires in residential, office or assembly type buildings (Classes 2, 3, 5 or 9) a flame temperature of 830°C (relating to a heat flux of 84kW/m^2).

For fires in shops, storage or factory use buildings (Classes 6, 7 or 8) a flame temperature of 1038°C (relating to a heat flux of 168kW/m^2).

For the prevention of ignition, maximum heat flux values of less than 12.6kW/m^2 should be achieved for both piloted and non-piloted ignition. This value is based on a value of 20kW/m^2, but includes a safety factor, as per the guidance provided by BS7974-3.

Unless a system is put in place to restrict flames emerging from the openings, e.g. flame inhibiting screen mesh fixed over the entire opening, then some appropriate means should be used to assess external flame extension.

In order to substantiate the different dimensions and distances, it may be necessary to consult the R Codes as well as Volumes 1 and 2 of the BCA.

Any assumptions made in the fire engineering assessment should become conditions in an appropriate legally binding arrangement so that should a neighbouring building be of different type and/or with larger/closer openings the subject building should be re-assessed to ensure that spread of fire is prevented.

7.7 **Occupant Characteristics**

The following should be viewed as a guide only. In some cases a lower movement speed may be required.

	Occupant Characteristic	Maximum Movement Speed
Level travel	Fully mobile	0.93 m/s (or less)
	Mobility difficulty	0.80 m/s (or less)
Stair movement upwards	Fully mobile	0.50 m/s (or less)
	Mobility difficulty	0.24 m/s (or less)

Element	Boundary Layer Width (each side)
Stairway	150 mm
Handrails	90 mm
Corridor, Ramp walls	200 mm
Obstacles	100 mm
Door	150 mm

Flow rate = 1.0 person/s/m of effective width for an average occupant density. For high density occupant loading refer to the SFPE Handbook or other appropriate reference document.

7.8 Fire Modelling

Where the modelled design fire is based on a sprinkler controlled scenario it is considered that zone models (such as BRANZFIRE and CFAST) are not sufficiently technically robust to assess the likely effects of sprinkler activation and cooling where a zone model will only consider a homogeneous hot layer above a cooler lower layer. The use of a computational fluid dynamics modelling package, such as Fire Dynamics Simulator (FDS), to assess conditions for occupants would be considered necessary.

7.9 Soot Yield

When an input for soot yields for fire modelling is required it is considered that a minimum value of 0.1g/g should be utilised. However, a higher value may be more appropriate and this should be investigated by the Building Surveyor's fire engineer.

7.10 Heat of Combustion

When using fire modelling software that includes an input value for the heat of combustion then this should be no more than 20MJ/kg unless otherwise justified. It is noted that where unrealistic higher values are used this can affect the level of visibility achieved through smoke and provide artificially extended tenability times.

7.11 Loss of Tenability

The output of FDS fire modelling requires careful consideration to quantify when visibility (and as appropriate, toxicity) for occupant tenability is lost. This is a very subjective decision. Where the assessment involves only a scenario with a single fire location modelled, then to extrapolate this to provide a generic assessment where the fire could, in reality, be located anywhere within the space is very challenging.

The solution for this is to either use a specific objective basis for the assessment of tenability loss, or to model all possible fire locations within the space. The latter option is obviously impractical. Consequently in order to provide more general consistency with this issue, DFES recommends that tenability be considered to be lost when there is an area of approximately 100m^2 at the appropriate height where the visibility is less than the Acceptance Criteria. This would tend to indicate that this is not a transient condition but rather an indicator of the onset of untenable conditions.

7.12 **Toxicity**

When the fire modelling is to include specific analysis considering the toxicity conditions that will be encountered by occupants then reference to the proposed CO yield to be used in the fire modelling should be provided. From International Fire Engineering Guidelines (IFEG)(ABCB, 2005) Section 3.3.1, page 3.3-5:

'…Most of the data concerning the product yields from burning materials has been obtained under well-ventilated burning conditions. These conditions may not apply to many building fires. Data on product yields for well-ventilated burning may be obtained from such sources as Tewarson (2002) and BSI (2001).

Poorly ventilated fires may produce species yields many times greater than well-ventilated fires. The production of carbon monoxide is especially dependent on the ventilation conditions. In post-flashover fires, studies (Babrauskas 1995) have shown that the yield of CO can generally be approximated as being 0.2 g CO produced/g fuel lost, irrespective of the test results for the material under well-ventilated conditions.'

The value of the CO production rate to be used in the fire modelling should be identified and agreed at the FEB stage of the process. This should be based on the likely proposed building contents, or the use of a suitable correlation with the visibility criteria should be confirmed.

7.13 **Other Criteria**

If this list of criteria does not include sufficient suitable information to resolve any query relating to appropriate values/scenarios/acceptance criteria for the purposes of an FEB or FER, additional information may be obtained by contacting fireengineers@dfes.wa.gov.au.

8. Hydrant Testing:

Some Performance Solutions rely on the results of street main hydrant testing in support of the viability of the Performance Solution. For consideration of the viability of proposed Performance Solutions it is advised that the hydrant testing results provided should be recent, (within 6 months of the date of submission).

The results provided should be supported by appropriate certification to indicate that at the time of test the testing equipment used was certified as calibrated in accordance with the requirements of a NATA accredited laboratory.

However, it is noted that these values should only be considered to provide guidance on the likely flow and pressure on completion of construction. The Building Surveyor should perform a test at practical completion of the building.

9. Specific Hazards:

There are some types of buildings and structures that, when they are involved in fire, pose specific hazards to firefighters. To facilitate DFES operational requirements, it is considered that suitable additional provision must be made because of the special problems of fighting fire that could arise. These additional hazards can arise with such structures as multi-tiered vehicle stacking devices (car stackers) (see also DFES Guideline No. 14) and multi-level self-storage facilities where the provision of a sprinkler system to moderate the hazard is considered essential.

10. Post Construction and Commissioning of the Building:

It is recommended that prior to DFES carrying out any post-construction testing or inspection, that the Building Surveyor's fire engineer should be involved during the commissioning phase for the fire safety system installations. This should ensure that the building design, as constructed, is consistent with the design assumptions made in the FER and the input data used in the analysis.

This will also assist in ensuring that the fire safety systems have been installed as specified in the trial concept design of the FER. The Building Surveyor's fire engineer should ensure that the fire safety systems operate and interface with each other, as required, in a timely and reliable manner to the requirements of the BCA, and relevant Australian Standards, and in accordance with the requirements of the FER.

11. References:

National Construction Code Series (current edition) Volume One Building Code of Australia 'Class 2 to 9 Buildings'. ABCB.

National Construction Code Series (current edition) Building Code of Australia 'Guide'. ABCB.

International Fire Engineering Guidelines (IFEG) 2005 Edition, ABCB.

Published Document PD7974 Application of fire safety engineering principles to the design of buildings. Part 3, Structural response and fire spread beyond the enclosure of origin. British Standards Institution 2003.

SFPE Handbook of Fire Protection Engineering 3rd & 4th Editions, National Fire Protection Association. 2002 & 2008.

12. Legislation:

Building Act 2011

Building Regulations 2012 (as amended)

***Please note**: This is a controlled document. DFES guidelines are available on the DFES Website: www.dfes.wa.gov.au under Regulation and Compliance, Building Plan Assessment then click on Publications/Guidelines.*

Should the information provided in this guideline require further clarification, please contact fireengineers@dfes.wa.gov.au.

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