# Master Specification
# Part TUN-FIRE-DC3

## Tunnel Fire Engineering

**September 2024**

Government of South Australia
Department for Infrastructure and Transport

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# Document Information

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# Document Management

# Contents

# TUN-FIRE-DC3 Tunnel Fire Engineering

## 1 General

a) This Master Specification Part sets out the requirements for Tunnel Fire Engineering including:

i) the documentation requirements, as set out in section 2;

ii) the technical requirements, as set out in section 3;

iii) the reliability, Design Life, and functional safety requirements, as set out in section 4;

iv) the Hold Point requirements, as set out in section 5; and

v) the verification requirements, as set out in section 6.

b) For the purposes of this Master Specification Part, Tunnel Fire Engineering applies to:

i) Tunnel infrastructure including the carriageway and associated plant rooms;

ii) surface infrastructure that supports the fire safety strategy of the Tunnel;

iii) egress and intervention infrastructure that supports the Tunnel; and

iv) systems that support the fire safety strategy for the Tunnel.

c) This Master Specification Part does not apply to:

i) surface roads that interface with the Tunnel; or

ii) Tunnels with bi-direction traffic.

d) The Fire Engineering design must comply with the Reference Documents, including:

i) AS/NZS 1170 Structural design actions;

ii) AS/NZS 1221 Fire hose reels;

iii) AS 1530.1 Methods for fire tests on building materials, components and structures, Part 1: Combustibility test for materials;

iv) AS 1530.2 Methods for fire tests on building materials, components and structures, Part 2: Test for flammability of materials;

v) AS 1530.3 Methods for fire tests on building materials, components and structures, Part 3: Simultaneous determination of ignitability, flame propagation, heat release and smoke release;

vi) AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction;

vii) AS 1668.1 The use of ventilation and air conditioning in buildings, Part 1: Fire and smoke control in buildings;

viii) AS 1670 Fire detection, warning, control and intercom systems - System design, installation and commissioning;

ix) AS 1682 Fire, smoke and air dampers;

x) AS 1851 Routine service of fire protection systems and equipment;

xi) AS 2118 Automatic fire sprinkler systems;

xii) AS 2304 Water storage tanks for fire protection systems;

xiii) AS/NZS 2327 Composite structures - Composite steel-concrete construction in buildings;

xiv) AS 2419 Fire hydrant installations;

xv) AS 2441 Installation of fire hose reels;

xvi) AS 2444 Portable fire extinguishers and fire blankets - Selection and location;

xvii) AS 2941 Fixed fire protection installations - Pumpset systems;

xviii) AS/NZS 3500 Plumbing and drainage;

xix) AS 3600 Concrete structures;

xx) AS 3700 Masonry Structures;

xxi) AS 3786 Smoke alarms using scattered light, transmitted light or ionization;

xxii) AS/NZS 4087 Metallic flanges for waterworks purposes;

xxiii) AS 4100 Steel structures;

xxiv) AS 4214 Gaseous fire-extinguishing systems;

xxv) AS 4312 Atmospheric corrosivity zones in Australia;

xxvi) AS 4428 Fire detection, warning, control and intercom systems - Control and indicating equipment;

xxvii) AS/NZS 4600 Cold-formed steel structures;

xxviii) AS 4825 Tunnel fire safety;

xxix) AS 5100 Bridge design;

xxx) AS 7240 Fire detection and alarm systems (set);

xxxi) AS 60849 Sound systems for emergency purposes;

xxxii) BS 476-20 Fire Tests on Building Materials and Structures - Part 20: Method for Determination of the Fire Resistance of Elements of Construction (General Principles);

xxxiii) National Construction Code (NCC); and

xxxiv) Australian Fire Engineering Guidelines (AFEG), ABCB.

e) Without limiting the obligation to comply with the document to the extent they form Reference Documents in other Master Specification Parts, the following guidance documents must be considered and applied to the extent required by law and to meet the Contractor's Best Industry Practice obligations:

i) ASTM C1116 Standard Specification for Fibre-Reinforced Concrete Fibre Type III;

ii) Austroads Guide to Road Tunnels (AGRT);

iii) Australasian Fire and Emergency Service Authorities Council, 2018, Fire Safety for Road Tunnels, (AFAC Publication No. 3003);

iv) AFAC Fire Brigade Intervention Model Manual;

v) AFAC Fire Brigade Intervention Model Dataset;

vi) ITA Guidelines for Structural Fire Resistance of Road Tunnels;

vii) ITA Structural Fire Protection for Road Tunnels;

viii) EFNARC Specification and Guidelines for Testing of Passive Fire Protection for Concrete Linings;

ix) Efectis R0695 Fire testing procedure for concrete tunnel linings and other tunnel components (2020 version);

x) EN 1992-1-1 Eurocode 2: Design of concrete structures - Part 1-1 General rules and rules for buildings;

xi) EN 1992-1-2 Eurocode 2: Design of concrete structures - Part 1-2 General rules - Structural fire design;

xii) EN 14889-2 Fibres For Concrete - Part 2: Polymer Fibres - Definitions, Specifications and Conformity;

xiii) PIARC 2016R03E Fixed fire fighting systems in road tunnels: Current practices and recommendations;

xiv) PIARC 2017R01EN Design fire characteristics for road tunnels;

xv) PIARC 2008R07EN Road tunnels: an assessment of fixed fire fighting systems;

xvi) PIARC 05.16.BEN Systems and equipment for fire and smoke control in road tunnels;

xvii) PIARC 05.05.BEN Fire and Smoke Control in Road Tunnels;

xviii) SAMFS Equipment Specification 001 Storz Couplings, Adaptors and Reducers;

xix) SAMFS Policy 006 Control and Indication for Diesel & Electric Fire Pumps;

xx) SAMFS Built Environs Section Policy No. 006 - Control & Indication for Diesel & Electric Fire Pumps;

xxi) SAMFS Policy 014 Above Ground Water Storage Tanks for Fire Fighting Purposes; and

xxii) SAMFS Policy 037 Fire Alarm Conditions of Connection.

f) For the purposes of this Master Specification Part the terms structural adequacy, integrity and insulation must have the same meaning as that defined in the NCC.

# 2 Documentation

## 2.1 Design Documentation

### 2.1.1 General

a) In addition to the requirements of PC-EDM1 “Design Management”, the Design Documentation must include:

i) a Performance Based Design Brief (PBDB), also referred to as a Fire Engineering Brief (FEB), which must include the items set out in section 2.1.2;

ii) a Tunnel Fire Engineering Report (Tunnel FER), which must include the items set out in section 2.1.3;

iii) a Surface Infrastructure Fire Engineering Report (Surface FER), which must include the items set out in section 2.1.4;

iv) a Tunnel Fire Resistance Report (Tunnel FRR), which must include the items set out in section 2.1.5; and

v) a Fire Engineering Design Requirements Report (FEDR), which must include the items set out in section 2.1.6.

b) The design review and acceptance process for the Design Documentation required by section 2.1.1a) must be defined by the Contractor and agreed with the Principal, which will constitute a **Hold Point**. Submission of Design Documentation relating to Tunnel fire engineering must not commence until the Hold Point has been released.

c) Table TUN-FIRE-DC3 2-1 provides guidance as to the design review and acceptance process for Tunnel fire engineering which may be adopted.

**Table TUN-FIRE-DC3 2-1 Fire Engineering stakeholders and actions**

| Stakeholder | PBDB | Tunnel FER | Surface FER | Tunnel FRR | FEDR |
|---|---|---|---|---|---|
| Principal | R/N | R/N | R/N | R/N | R/N |
| Maintainer (Principal or identified relevant entity) | R/N | R/N | R/N | R/N | R/N |
| SAMFS | R/N | R/N | R/N | R/N | R/N |
| SAPOL | R | R | R | - | R |
| SAAS | R | R | R | - | R |
| DDA consultant | R/N | R/N | R/N | R/N | R/N |
| Independent Design Certifier | R/C | R/C | R/C | R/C | R/C |
| Fire Engineering Proof Engineer | R/C | R/C | R/C | R | R/C |
| Relevant Authorities | R/N | R/N | R/N | - | R/N |
| Neighbouring properties / developments | R | R | R | R | R |
| Design disciplines | R | R | R | R | R |
| Building Certifier | R*/C* | R*/C* | R*/C* | R* | R* |
| Network operator | R/N | R/N | R/N | R/N | R/N* |

**Table notes**:

| | |
|---|---|
| R | Review, meaning that the stakeholder reviews the document and provides comment. Comments must be addressed by the Contractor to the satisfaction of the Principal. |
| N | Notice of no objection, meaning that the stakeholder must provide confirmation that they have no objection to the design before the document is accepted by the Principal. |
| C | Issue a certificate in a format as defined in the Contract Documents or otherwise as agreed with the Principal. |
| - | Stakeholder involvement is not applicable. |
| * | Surface infrastructure/NCC aspects only. |

### 2.1.2 Performance Based Design Brief

a) The Contractor must prepare a PBDB that details Fire Engineering for the areas of the Project identified by section 1b).

b) The PBDB must be delivered for Preliminary Design review and include as a minimum:

i) details of the Lead Fire Engineer and Fire Engineering Proof Engineer;

ii) approaches to Fire Engineering for each relevant area of the Project;

iii) a detailed Fire Engineering Plan in accordance with section 3.3.1b);

iv) identification of stakeholders and their roles with guidance from Table TUN-FIRE-DC3 2-1;

v) compliance with AFEG guidance for content and structure;

vi) design inputs;

vii) trial concept design for assessment;

viii) proposed software to be used for modelling;

ix) evidence of validation and verification for the proposed software;

x) assessment methodologies finalised;

xi) acceptance criteria finalised;

xii) identification of Design Departures;

xiii) identification of risk assessments to be included in the Tunnel FER and Surface FER;

xiv) description of risk assessment process; and

xv) preliminary derived requirements.

c) The PBDB delivered for Preliminary Design review must have sufficient detail to:

i) inform the Tunnel space-proofing;

ii) enable stakeholder review of the trial concept design; and

iii) facilitate stakeholder engagement.

d) Key interfaces for the PBDB at Preliminary Design review must include:

i) fire resistance strategy for the Tunnel FRR;

ii) derived requirements as input into the FEDR; and

iii) SAMFS and other stakeholder consultation.

e) The PBDB delivered for Detailed Design review must include as a minimum:

i) revised trial concept design based on stakeholder feedback and design development;

ii) records of stakeholder consultation;

iii) split between Tunnels and non-Tunnel areas identified for the Tunnel FER and Surface FER respectively;

iv) Building Certifier identified non-compliances for non-Tunnel areas;

v) strategy for materials management to limit combustible materials;

vi) updated derived requirements;

vii) agreement on Design Departures to be assessed;

viii) evidence of engagement with a DDA consultant; and

ix) identification of SAMFS involvement for each fire system.

f) The PBDB at Detailed Design review must have sufficient detail to:

i) enable detailed design of fire safety systems to begin; and

ii) obtain notices of no objection from stakeholders.

g) Key interfaces for the PBDB delivered at Detailed Design review must include:

i) fire resistance strategy updated based on Preliminary Design Tunnel FRR;

ii) trial concept design updated based on Preliminary Design Tunnel FRR; and

iii) SAMFS consultation.

h) The PBDB delivered for Final Design review must include as a minimum:

i) final trial concept design for assessment in the Tunnel FER and Surface FER;

ii) records of stakeholder consultation;

iii) evidence that all stakeholder comments have been addressed;

iv) updated derived requirements; and

v) draft compartmentation drawings.

i) The PBDB delivered for Final Design review must have sufficient detail to:

i) resolve all stakeholder comments or obtain confirmation of no objections; and

ii) enable stakeholders to certify or provide notice of no objection (as applicable) to the PBDB.

j) Key interfaces for the PBDB delivered at Final Design review must enable commencement of Tunnel FER and Surface FER assessments.

k) The PBDB must be updated in accordance with PC-EDM1 “Design Management” for:

i) Issued for Acceptance; and

ii) Issued for Construction.

### 2.1.3 Tunnel Fire Engineering Report

a) The Contractor must prepare a Tunnel FER specific to the Tunnel and underground infrastructure that provides Fire Engineering performance solutions for these areas.

b) The Tunnel FER must be delivered for Preliminary Design review and include as a minimum:

i) preliminary tenability and egress performance assessments including smoke and egress modelling;

ii) preliminary performance assessments of other aspects including fire spread;

iii) preliminary assessments of Design Departures;

iv) quantification of methodologies for any risk assessments;

v) updated derived requirements; and

vi) compartmentation drawings.

c) The Tunnel FER delivered for Preliminary Design review must have sufficient detail to:

i) inform updated space-proofing requirements for other disciplines;

ii) enable stakeholder engagement to be undertaken; and

iii) allow for stakeholder comment on risk assessments.

d) Key interfaces for the Tunnel FER at Preliminary Design review must include Tunnel ventilation system design for smoke control.

e) The Tunnel FER delivered for Detailed Design review must include as a minimum:

i) detailed tenability and egress assessments;

ii) detailed performance assessments;

iii) smoke dispersion modelling;

iv) assessments of fire safety related Non-Conformances from the Master Specification;

v) linear heat detection assessment as required by section 3.8c);

vi) detailed risk assessment documentation;

vii) updated derived requirements including all functional and commissioning aspects;

viii) compartmentation drawings; and

ix) cause and effect matrix to describe the operation of systems in the event of fire.

f) The Tunnel FER delivered for Detailed Design review must have sufficient detail to:

i) enable detailed operational coordination;

ii) allow for final definition of the fire safety related systems; and

iii) enable stakeholders to certify or provide notice of no objection (as applicable) to risk assessment outcomes.

g) Key interfaces for the Tunnel FER delivered at Detailed Design review must include Tunnel ventilation system design for smoke control.

h) The Tunnel FER must be delivered for Final Design review and include as a minimum:

i) final performance design;

ii) final risk assessments;

iii) final operational requirements;

iv) final commissioning requirements;

v) records of stakeholder consultation;

vi) evidence that all stakeholder comments have been addressed;

vii) updated derived requirements;

viii) compartmentation drawings; and

ix) final cause and effect matrix.

i) The Tunnel FER delivered for Final Design review must have sufficient detail to:

i) ensure all stakeholder comments are resolved or no objections obtained; and

ii) enable stakeholders to certify or provide notice of no objection (as applicable) to the Tunnel FER.

j) Key interfaces for the Tunnel FER delivered at Final Design review must include input into incident management procedures.

k) The Tunnel FER must be updated in accordance with PC-EDM1 “Design Management” for:

i) Issued for Acceptance; and

ii) Issued for Construction.

### 2.1.4 Surface Infrastructure Fire Engineering Report

a) The Contractor must prepare a Surface FER specific to the surface infrastructure that documents “Deemed to Satisfy” provisions of the NCC where possible and Fire Engineering performance solutions for any non-conformances identified by the Building Certifier.

b) The Surface FER must be delivered for Preliminary Design review and include as a minimum:

i) preliminary assessments of NCC non-conformances; and

ii) updated derived requirements.

c) The Surface FER delivered for Preliminary Design review must have sufficient detail for:

i) Building Certifier agreement on approach to NCC non-conformances; and

ii) Fire Engineering Proof Engineer agreement on approach to NCC non-conformances.

d) Key interfaces for the Surface FER at Preliminary Design review must include:

i) Building Certifier compliance assessments; and

ii) architectural and building space-proofing coordination.

e) The Surface FER delivered for Detailed Design review must include as a minimum:

i) detailed performance assessments of NCC non-conformances; and

ii) updated derived requirements.

f) The Surface FER delivered for Detailed Design review must have sufficient detail for:

i) Building Certifier agreement on NCC non-conformance assessments; and

ii) Fire Engineering Proof Engineer agreement on NCC non-conformance assessments.

g) Key interfaces for the Surface FER delivered at Detailed Design review must include:

i) Building Certifier compliance assessments; and

ii) architectural and building layout coordination.

h) The Surface FER must be delivered for Final Design review and include as a minimum:

i) final performance design;

ii) final risk assessments;

iii) final operational requirements;

iv) final commissioning requirements;

v) records of stakeholder consultation;

vi) evidence that all stakeholder comments have been addressed;

vii) updated derived requirements; and

viii) compartmentation drawings.

i) The Surface FER delivered for Final Design review must have sufficient detail for:

i) all stakeholder comments resolved or no objections obtained from stakeholders; and

ii) enable stakeholders to certify or provide notice of no objection (as applicable) to the Surface FER.

j) Key interfaces for the Surface FER delivered at Final Design review must include Building Certifier certification in a format as defined in the Contract Documents or as otherwise agreed with the Principal.

k) The Surface FER must be updated in accordance with PC-EDM1 “Design Management” for:

i) Issued for Acceptance; and

ii) Issued for Construction.

### 2.1.5 Tunnel Fire Resistance Report

a) The Contractor must prepare a Tunnel FRR that is specific to the fire resistance of the Tunnel and underground areas, including the interfaces with any surface structures.

b) The Tunnel FRR must be delivered for Preliminary Design review and include as a minimum:

i) an assessment of the applicable fire curve to be applied to each structural element;

ii) draft Fire Resistance Testing Specification (as an appendix), in accordance with section 3.6.16e);

iii) documentation of the fire resistance requirements, including:

A. compartmentation drawings; and

B. detailed fire resistance level (FRL) provisions;

iv) analysis methodology for the application of finite element analysis and EN 1992-1-1 Eurocode 2: Design of concrete structures to be used to assess the concrete performance when exposed to fire;

v) proposed fire testing requirements including:

A. test panel manufacturing details;

B. list of concrete mixes that require testing;

C. full specification of the concrete mixes to be tested;

D. proposed polypropylene dosage and evidence of efficacy;

E. evidence that the proposed test samples cover all relevant concrete mix types;

F. thermocouple details;

G. handling and storage procedures; and

H. proposed test facility and equipment to be used; and

vi) any proposed use of passive fire protection in accordance with section 3.6.15b).

c) The Tunnel FRR delivered for Preliminary Design review must have sufficient detail to:

i) enable space-proofing allowing for fire resistance and separation provisions; and

ii) derived requirements for FRLs and fire separation.

d) Key interfaces for the Tunnel FRR at Preliminary Design review must include Tunnel structural design coordination.

e) The Tunnel FRR delivered for Detailed Design review must include as a minimum:

i) analysis for the performance of structures to the defined fire curves using finite element analysis and EN 1992-1-1 Eurocode 2: Design of concrete structures methodologies;

ii) Fire Resistance Testing Specification and ITP; and

iii) updated FRLs including updated compartmentation drawings.

f) Where passive fire protection is provided, the Tunnel FRR for Detailed Design review must include evidence that the passive fire protection will:

i) achieve the high temperature performance as required by section 3.6.15c); and

ii) be implemented to achieve the requirements of section 3.6.15f).

g) The Tunnel FRR delivered for Detailed Design review must have sufficient detail to:

i) document the completed numerical analysis; and

ii) enable fire testing to commence.

h) Key interfaces for the Tunnel FRR delivered at Detailed Design review must include Tunnel structural design.

i) The Tunnel FRR must be delivered for Final Design review and include as a minimum:

i) complete analysis and fire testing report;

ii) final analysis and fire testing results and validation of modelling; and

iii) mapping showing all relevant concrete mixes, identification of relevant tests and results.

j) The Tunnel FRR delivered for Final Design review must have sufficient detail to:

i) document for each concrete mix:

A. the locations where the concrete mix will be used;

B. the types of structures applied to;

C. a reference to the test report that demonstrates compliance; and

D. a summary of the testing outcomes;

ii) demonstrate that the numerical analysis has been validated by fire testing;

iii) demonstrate that the Tunnel design will achieve the required FRLs as required by section 3.6.16b);

iv) demonstrate that the Tunnel design will achieve the required spalling performance as required by section 3.6.16c);

v) confirm the concrete design for fire resistance;

vi) evidence that all stakeholder comments have been resolved or no objections obtained; and

vii) enable stakeholders to certify or provide notice of no objection (as applicable) to the Tunnel FRR.

k) Key interfaces for the Tunnel FRR delivered at Final Design review must include Tunnel structural design.

l) The Tunnel FRR must be updated in accordance with PC-EDM1 “Design Management” for:

i) Issued for Acceptance; and

ii) Issued for Construction.

m) Dependent on the agreed review and acceptance process pursuant to section 2.1.1b), the Fire Resistance Testing Specification and test reporting may be issued in advance of the Tunnel FRR review stages.

### 2.1.6 Fire Engineering Design Requirements Report

a) The Contractor must prepare a FEDR that is a standalone document which compiles all Fire Engineering design requirements from the Master Specification and all derived requirements from the Fire Engineering reports required by this Master Specification Part.

b) The FEDR must be delivered for Preliminary Design review and include as a minimum:

i) process for managing Fire Engineering requirements;

ii) systems engineering interfaces defined;

iii) derived requirements from each Fire Engineering report required by section 2.1.1a);

iv) traceability for each Fire Engineering requirement; and

v) Fire Engineering derived requirements assigned to relevant disciplines or stakeholders.

c) The FEDR delivered for Preliminary Design review must have sufficient detail to:

i) enable design development by other disciplines; and

ii) be provided to stakeholders for review and comment.

d) Key interfaces for the FEDR at Preliminary Design review must include:

i) review and comment by other design disciplines;

ii) stakeholder reviews; and

iii) systems engineering requirements database integration.

e) The FEDR delivered for Detailed Design review must include as a minimum:

i) updated Fire Engineering requirements;

ii) updated traceability for each Fire Engineering requirement;

iii) testing and commissioning Fire Engineering requirements; and

iv) Fire Engineering requirements assigned to relevant disciplines or stakeholders.

f) The FEDR delivered for Detailed Design review must have sufficient detail to:

i) enable design development by other disciplines;

ii) enable testing and commissioning scheduling; and

iii) enable stakeholder review and comment.

g) Key interfaces for the FEDR delivered at Detailed Design review must include:

i) review and comment by other design disciplines;

ii) stakeholder reviews; and

iii) systems engineering requirements database.

h) The FEDR must be delivered for Final Design review and include as a minimum:

i) final compilation of all Fire Engineering derived requirements;

ii) evidence of acceptance by each design discipline or stakeholders; and

iii) evidence of stakeholder review and comment resolution.

i) The FEDR delivered for Final Design review must have sufficient detail to:

i) finalise and agree all Fire Engineering derived requirements; and

ii) ensure all stakeholder comments are addressed.

j) Key interfaces for the FEDR delivered at Final Design review must include:

i) review and comment by other design disciplines; and

ii) systems engineering requirements database integration.

k) The FEDR must be updated in accordance with PC-EDM1 “Design Management” for:

i) Issued for Acceptance; and

ii) Issued for Construction.

## 2.2 Construction Documentation

In addition to the requirements of PC-CN3 “Construction Management”, the Construction Documentation must include Fire Engineering Construction Process Plan as required by section 3.3.2c).

# 3 Technical requirements

## 3.1 Fire Engineering scope

### 3.1.1 General requirements

a) The Contractor must provide a Fire Engineering design that provides for the timely evacuation of occupants and staff to a nominated point of safety in the event of a fire.

b) The Contractor must provide a Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel that provides for the response of Emergency Services in the event of a fire.

c) The Contractor’s Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel must include strategies and systems that:

i) minimise fire ignition sources;

ii) minimise fire loads within the Tunnel and infrastructure associated with the Tunnel;

iii) prevent the spread of fire;

iv) allow for the rapid detection of fires;

v) control fire growth; and

vi) enable fire suppression.

d) The Contractor must facilitate and manage a Project wide process including all coordination and stakeholder consultation needed to implement the Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel.

e) The Contractor's Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel must be developed in alignment with and integrated into any Project wide safety strategy.

f) The Contractor's Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel must be developed in alignment with and integrated into Tunnel and road network operational plans including consideration of the following after detection of fire:

   i) means of stopping traffic entering the Tunnel; and

   ii) means of clearing traffic downstream of the fire site.

g) The Contractor's Fire Engineering design for the Tunnel and infrastructure associated with the Tunnel must provide derived requirements from each Fire Engineering document required by section 2.1.1a) that are in a format and style that can be directly integrated with the Project's system engineering process that is developed in accordance with PC-EDM6 "Systems Engineering Management".

### 3.1.2 Tunnels and underground infrastructure

a) The Fire Engineering design for Tunnels and underground infrastructure must be:

   i) performance assessed in accordance with this Master Specification Part; and

   ii) demonstrated to be acceptable in consultation with stakeholders.

b) The Contractor must assess if Tunnel infrastructure such as underground plant rooms, underground ductwork and underground service routes are to be classified and assessed in accordance with the NCC.

c) The Contractor must determine the Tunnel smoke management strategy required to support the Fire Engineering design that is coordinated with the requirements of TUN-ME-DC7 "Ventilation Design".

d) The Contractor must determine the Tunnel egress systems required to support the Fire Engineering design accounting for the requirements of TUN-FIRE-DC2 "Tunnel Evacuation Systems".

### 3.1.3 Associated surface infrastructure

Any non-roadway infrastructure associated with the Tunnel not located underground, such as surface plant rooms, must meet the fire safety requirements of the NCC.

## 3.2 Requirements of the Lead Fire Engineer

### 3.2.1 Scope

a) The Contractor must appoint a Lead Fire Engineer who is responsible for the Fire Engineering design as required by this Master Specification Part.

b) The Lead Fire Engineer is responsible for the production and quality assurance of all Fire Engineering documentation required by this Master Specification Part.

c) The Lead Fire Engineer must review and certify design packages from other disciplines to confirm that the Fire Engineering design has been correctly incorporated.

d) The Lead Fire Engineer must develop the methodology for all structures that require fire resistance testing as required by this Master Specification Part.

e) The Lead Fire Engineer must review and confirm the fire resistance ITPs for each element being tested.

f) The Lead Fire Engineer must undertake site inspections during construction to confirm that the Fire Engineering design has been correctly incorporated.

g) The Lead Fire Engineer must undertake site inspections during testing and commissioning to confirm that the systems required by the Fire Engineering design operate as required.

h) The Lead Fire Engineer must document all outcomes and non-compliances associated with site inspections covering all stages of construction and testing and commissioning.

i) The Lead Fire Engineer must certify that the design and the final constructed infrastructure meets the requirements of the Fire Engineering design.

### 3.2.2 Experience

a) The Lead Fire Engineer must have demonstratable experience of leading the Fire Engineering design and stakeholder management of road Tunnels and associated infrastructure.

b) The Lead Fire Engineer must have a minimum of 10 years design experience directly related to Fire Engineering for road Tunnel and underground transport infrastructure projects.

c) The Lead Fire Engineer must be on the National Engineering Register, registered in the Fire Safety Engineering area of practice.

### 3.2.3 Approval

The approval for the Lead Fire Engineer must be in accordance with PC-PM3 “Contractor's Personnel and Training”.

## 3.3 Fire Engineering process

### 3.3.1 Design

a) The Fire Engineering design process is provided graphically for guidance and information in Appendix 1: Design Process Map (information only).

b) As part of the Preliminary Design PBDB, the Contractor must develop a detailed Fire Engineering Plan to identify:

i) the staging of the Fire Engineering to ensure coordination with the design and construction program;

ii) the documentation to be produced at each design stage;

iii) the interfaces between documents;

iv) the stakeholders and their roles and responsibilities;

v) the Fire Engineering design team and their roles and responsibilities;

vi) the overall Fire Engineering methodology for all Project stages; and

vii) the design review and acceptance requirements.

c) The Fire Engineering Plan must be submitted as part of the Preliminary Design Documentation and approved by the Principal prior to any other reports required by this Master Specification Part being submitted for review.

d) The documentation described in section 2 must be used to guide the Fire Engineering process undertaken in each design stage.

e) Stakeholder roles and responsibilities during design must be agreed with stakeholders early in the design.

### 3.3.2 Construction

a) The Fire Engineering construction process is provided graphically for guidance and information in Appendix 2: Construction Process Map (information only).

b) The Contractor must develop a detailed Fire Engineering Construction Process Plan prior to the commencement of any on-site activities related to the Fire Engineering design to identify:

i) stakeholder roles and responsibilities during all procurement and construction stages;

ii) witnessing and inspection requirements during procurement of materials and equipment for Fire Engineering related systems;

iii) witnessing and inspection requirements during all stages of construction;

iv) witnessing and inspection requirements during testing and commissioning; and

v) final acceptance requirements from stakeholder required by this Master Specification Part.

c) The Fire Engineering Construction Process Plan must be submitted as part of the Construction Documentation and approved by the Principal prior to the commencement of any on-site activities related to the Fire Engineering design.

## 3.4 Building Certifier

The Contractor must appoint a Building Certifier for the assessment and certification of elements of the infrastructure deemed to be assessable under the NCC.

## 3.5 Fire Engineering Proof Engineer

### 3.5.1 Scope

a) The Contractor must:

i) appoint a Fire Engineering Proof Engineer for the Fire Engineering design; and

ii) provide the Fire Engineering Proof Engineer with access to the Project document management system to enable access to documents without the need to make formal requests.

b) The Fire Engineering Proof Engineer must:

i) act independently to the Contractor and the Contractor's designers;

ii) engage directly with the Principal and stakeholders;

iii) undertake a detailed review of all Fire Engineering documentation to check the appropriateness of assumptions, inputs, analysis methodology, results interpretation and conclusions;

iv) undertake a detailed review of the Tunnel ventilation system design documentation to check the appropriateness of assumptions, inputs, analysis methodology, results interpretation and conclusions;

v) undertake a detailed review of all fire resistance design documentation including any relevant civil and structural engineering documents to check that fire resistance requirements have been correctly applied in the design;

vi) undertake a detailed review of all fire resistance testing procedures and fire resistance testing reports to check that requirements have been correctly applied and that the interpretation of the testing outcomes is correct;

vii) undertake a detailed review of any risk assessments that relate to fire safety risk to check the appropriateness of assumptions, inputs, analysis methodology, results interpretation and conclusions;

viii) undertake sufficient site inspections to ensure that the constructed infrastructure and installed systems meet the requirements of the Fire Engineering design; and

ix) undertake sufficient site inspections during testing and commissioning to check that the relevant operating systems meet the requirements of the Fire Engineering design.

c) Any errors or discrepancies identified by the Fire Engineering Proof Engineer must be addressed by the Contractor.

d) The Fire Engineering Proof Engineer must provide a written report detailing the design documentation reviewed and the results and outcomes of the review and inspection process.

e) The Fire Engineering Proof Engineer's report must be issued in 2 stages:

   i) stage 1 at the completion of the design reviews; and

   ii) stage 2 at the completion of the testing and commissioning inspections.

f) The Fire Engineering Proof Engineer must issue a certificate at each of the stages required by section 3.5.1e).

g) The Contractor must advise the Fire Engineering Proof Engineer of any amendments to the design or construction made post certification.

h) The Fire Engineering Proof Engineer must advise the Contractor if the amendments require recertification.

i) For recertification, the Contractor must provide the Fire Engineering Proof Engineer with required documentation to allow certification to be remade.

### 3.5.2 Experience

a) The Fire Engineering Proof Engineer must have demonstratable experience for the Fire Engineering design of road Tunnels and associated infrastructure.

b) The Fire Engineering Proof Engineer must have a minimum of 10 years design experience directly related Fire Engineering for road Tunnel and underground transport infrastructure projects.

c) The Fire Engineering Proof Engineer must be on the National Engineering Register, registered in the Fire Safety Engineering area of practice.

### 3.5.3 Approval

The approval for the Fire Engineering Proof Engineer must be in accordance with PC-PM3 "Contractor's Personnel and Training".

## 3.6 Fire resistance of Tunnel infrastructure

### 3.6.1 Fire resistance general requirements

a) All Tunnel structures must be designed and constructed to ensure that in the event of a fire:

   i) Tunnel stability is achieved at any location in the Tunnel; and

   ii) there is no failure of the permanent Tunnel structure.

b) The Contractor's Fire Engineering design must assess the Tunnel infrastructure and allocate FRLs to all structural and separating elements.

c) Tunnel elements that are deemed to be accessible under the requirements of the NCC must:

   i) achieve the fire resistance requirements of the NCC as a minimum;

   ii) be assessed for fire resistance performance by the Contractor's Fire Engineering design specific to their location and function; and

   iii) achieve any additional fire resistance requirements defined by the Contractor's Fire Engineering design.

d) For fire resistance requirements not covered by Australian standards, the design of the Tunnel and portal carriageway load bearing structures fire resistance must be assessed using relevant parts of EN 1992-1-2 Eurocode 2 - Design of concrete structures - Part 1-2: General rules - Structural fire design.

e) The Contractor's Fire Engineering design must demonstrate that material controls have been included to limit the size and spread of a fire to within the originating fire compartment.

f) The allocation of fire resistance requirements must account for:

i) ground condition stability;

ii) load bearing criticality;

iii) risk of progressive collapse;

iv) cost and convenience of repair;

v) business continuity;

vi) road network criticality; and

vii) emergency response and operations.

g) The Contractor's Fire Engineering design must demonstrate through analysis that joints of nonconventional and nonrigid connections between structural elements do not compromise the fire resistance of the structural elements.

h) The fire resistance assessment process and outcomes must be documented in the Tunnel FRR.

i) The fire resistance requirements must be documented on fire compartmentation drawings.

### 3.6.2 Fire resistance of load bearing Tunnel structures

a) All Tunnel and Tunnel portal load bearing structure and structural linings that can be exposed to the direct effects of a Tunnel carriageway fire must as a minimum maintain structural adequacy for a time period of no less than 240 minutes (240/-/-) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

b) All Tunnel and Tunnel portal load bearing structures and structural linings that can be exposed to the direct effects of a Tunnel carriageway fire must as a minimum maintain structural adequacy for a time period of no less than 120 minutes when tested against the hydrocarbon modified fire time versus temperature curve defined in AS 4825 Tunnel Fire Safety.

c) The hydrocarbon modified fire curve is provided graphically for information in Appendix 3: Hydrocarbon Modified Fire Curve with Efectis (2020) decay curve (information only) based on:

i) AS 4825 Tunnel fire safety for the initial 120 minute duration; and

ii) Efectis R0695 Fire testing procedure for concrete tunnel linings and other tunnel components (2020 version) as guidance for the post-cooling phase.

### 3.6.3 Fire resistance of Tunnel separating structures

a) For the purposes of this section 3.6.3, Tunnel separating structures include structural elements that are required to achieve integrity and insulation fire separation from other areas.

b) All Tunnel and Tunnel portal load bearing separating structures must maintain as a minimum a structural adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

c) All Tunnel and Tunnel portal separating structures including doors must maintain as a minimum a separating integrity and insulation rating for a time period of no less than 120 minutes (-/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

### 3.6.4 Lowered motorway structures

a) For roadway alignments where the entry into the Tunnel portal structure is below grade, the Contractor's Fire Engineering design must establish the fire resistance requirements for the below grade lowered motorway structures.

b) Fire resistance requirements must be assessed accounting for:

   i) the geometry of the lowered motorway structure;

   ii) the proximity of the fire relative to the structure;

   iii) the characteristics of the fire behaviour including radiation and flame dynamics; and

   iv) fire scenarios considered in the assessment of the Tunnel.

c) The fire resistance requirements for propping elements within lowered motorway structures must consider the level of redundancy of the propping elements.

d) Analysis and modelling undertaken as part of the fire resistance assessment must be documented in the Tunnel FRR.

### 3.6.5 Fire resistance of egress structures

a) For the purposes of this section 3.6.5, egress structures include cross passages, long egress passages and egress shafts to surface that separate occupant egress spaces from the Tunnel carriageway.

b) All load bearing egress structures must maintain as a minimum a structural adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

c) All egress structures including doors must maintain as a minimum a separating integrity and insulation rating for a time period of no less than 120 minutes (-/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

### 3.6.6 Fire separation between parallel Tunnel carriageways

a) Fire separation between parallel Tunnel carriages must prevent fire spread between Tunnel carriages.

b) The fire resistance of load bearing structural elements that separate parallel Tunnel carriageways must as a minimum result in a structural adequacy, separating integrity and insulation rating for a time period of no less than 240 minutes (240/240/240) between the parallel carriageways when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4 Fire-resistance tests for elements of construction.

c) The fire resistance of structural elements that separate parallel Tunnel carriageways must as a minimum result in a separating integrity and insulation rating for a time period of no less than 240 minutes (-/240/240) between the parallel carriageways when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4 Fire-resistance tests for elements of construction.

d) Tunnel ventilation system dampers required to achieve fire separation between parallel Tunnel carriageways must:

   i) have a separating integrity level not less than 240 minutes (-/240/-) when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction; and

ii) be assessed to demonstrate that heat transfer effects will not result in the spread of fire between parallel Tunnel carriageways.

e) A single door including joints openings and sealants that allows a connection between parallel Tunnel carriageways, must have a separating integrity and insulation rating for a time period of no less than 240 minutes (-/240/240) when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

f) Where two consecutive doors including joints, openings and sealants allows a connection between parallel Tunnel carriageways, each door must each have a separating integrity and insulation rating for a time period of no less than 120 minutes (-/120/120) when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

g) Cross connections of services between parallel Tunnel carriageways, including drainage and cable penetrations, must be fire sealed with a separating integrity and insulation rating for a time period of no less than 240 minutes (-/240/240) when assessed against the standard fire curve in accordance with AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

h) The performance of the fire separation between parallel Tunnel carriages must be assessed against the hydrocarbon modified curve for a minimum of 2 hours.

### 3.6.7 Underground equipment rooms

a) Underground equipment room load bearing separating structures must maintain as a minimum a structural adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

b) Underground equipment room separating structures including doors must maintain as a minimum a separating integrity and insulation rating for a time period of no less than 120 minutes (-/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

c) Underground equipment room fire resistance requirements must be assessed by the Contractor's Fire Engineering design based on the contents and use of the rooms.

d) Fire resistance requirements applied to underground equipment rooms, if different to requirements in this Master Specification Part, must only act to improve fire resistance over the requirements of this Master Specification Part.

### 3.6.8 Vent tunnels and shafts

The fire resistance of any ventilation pathways must maintain the operational performance of the Tunnel ventilation system as required by TUN-ME-DC7 "Ventilation Design".

### 3.6.9 Tunnel equipment mounting structure

a) Tunnel equipment mounting structures in the Tunnel not otherwise addressed by Australian standards must maintain structural adequacy when exposed to airflow temperatures of 450°C for a minimum of 2 hours.

b) Mounting of Tunnel ventilation equipment must meet the fire resistance requirements of TUN-ME-DC6 "Tunnel Ventilation Equipment".

### 3.6.10 Tunnel equipment mounting fixings

a) Electrical cable containment systems (including anchors embedded in the Tunnel structure) must meet the requirements of TUN-ME-DC2 "Tunnel Power Systems".

b) Equipment mounting, other than electrical cable containment systems addressed in section 3.6.10a), that are installed in any Tunnel lining or Tunnel structure must maintain structural adequacy:

i) when exposed to airflow temperatures of 450°C for a minimum of 2 hours;

ii) in accordance with applicable Australian standards; and

iii) to satisfy any additional high temperature requirements of the Fire Engineering design.

### 3.6.11 Tunnel smoke management equipment

Tunnel ventilation equipment used for smoke management must meet the operational fire resistance requirements of TUN-ME-DC6 “Tunnel Ventilation Equipment”.

### 3.6.12 Electrical systems

a) Fire separation and fire resistance of electrical systems must meet the requirements of TUN-ME-DC2 “Tunnel Power Systems”.

b) HV cables must be contained to provide an adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) between the cables and the Tunnel carriageway when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

c) Where redundant A and B HV circuits are used, the A and B circuits must be arranged and contained:

i) to provide an adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) between the circuits when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction; and

ii) to provide an adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) between each circuit and the Tunnel carriageway when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

d) Electrical equipment within egress passageways must be contained in rooms that are fire separated from the path of egress with a minimum FRL of 120/120/120 when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

e) Main switchboards, motor control centre switchboards, lighting boards and general power distribution boards installed within electrical equipment rooms, substations or switchrooms that serve different Tunnel bores must be fire separated from each other to provide an adequacy, separating integrity and insulation rating for a time period of no less than 120 minutes (120/120/120) when tested against the standard time versus temperature curve defined in AS 1530.4 Methods for fire tests on building materials, components and structures, Part 4: Fire-resistance tests for elements of construction.

### 3.6.13 Penetrations

a) All penetrations through any structure that has a specified fire resistance must have fire stopping installed to achieve the required fire resistance.

b) Any fire stopping of penetrations required by section 3.6.13a) must:

i) be undertaken by competent and licenced personnel specialising in fire-rated penetrations;

ii) ensure that the fire rating of the structure is retained after service installation, with the use of a certified fire-stopping method; and

iii) be certified after the installation is complete.

### 3.6.14 Spalling provisions

a) The Tunnel structures must be designed to control and limit concrete spalling to maintain required structural adequacy and fire resistance.

b) All concrete Tunnel structures that can be exposed to the direct effects of a Tunnel carriageway fire must contain polypropylene fibres with a dosage demonstrated to achieve the spalling requirements required by section 3.6.14c).

c) All concrete Tunnel structures must be designed and constructed to limit spalling to a depth no greater than 25 mm (measured at any one point) when exposed to the design fire curves.

d) The design provisions for spalling must be documented in the Tunnel FRR.

e) Micro-synthetic fibres used in Tunnel structural linings must comply with either EN 14889-2 Fibres for Concrete - Part 2: Polymer Fibres - Definitions, Specifications and Conformity Fibre Class 1a or ASTM C1116 Standard Specification for Fibre-Reinforced Concrete Fibre Type III.

### 3.6.15 Passive fire protection

a) Passive fire protection such as fire boards and spray on materials may be used to achieve fire resistance requirements.

b) The proposed use of passive fire protection to achieve the fire resistance requirements must be submitted with the Design Documentation.

c) Passive fire protection must achieve a maximum temperature at the interface with the element being protected against the design fire curve that is the lower of:

i) 450°C; and

ii) the maximum temperature that allows the element to maintain structural adequacy.

d) Passive fire protection must remain in place for the full duration of the design time versus temperature curve as required by 3.6.15c).

e) The Design Documentation must include evidence from testing conducted by a NATA accredited (or equivalent) testing authority to demonstrate that the passive fire protection will achieve the requirements of section 3.6.15c).

f) The Design Documentation must demonstrate that the passive fire protection implementation:

i) allows for the movement of joints;

ii) allows for inspection and maintenance of covered elements;

iii) allows for operational air pressure variations;

iv) is able to withstand cleaning by the use of a high-pressure water spray; and

v) will satisfy the durability requirements of the Contract Documents.

### 3.6.16 Fire resistance testing requirements

a) Fire resistance testing must comply with the requirements of:

i) PC-CN1 “Testing and Commissioning”; and

ii) PC-CN3 “Construction Management”.

b) The Contractor must submit, prior to construction and installation, design and test evidence that demonstrates the Tunnel design will achieve the required FRLs as part of the Design Documentation.

c) The Contractor must submit, prior to construction and installation, design and test evidence that demonstrates the Tunnel design will achieve the required spalling performance as part of the Design Documentation.

d) The Contractor must submit as an appendix to the Tunnel FRR, a Fire Resistance Testing Specification.

e) The Fire Resistance Testing Specification required by section 3.6.16d) must document:

i) the proposed fire resistance testing procedure;

ii) the specific concrete mixes and materials to be tested;

iii) details of the samples of each type of material;

iv) details of the preparation of samples;

v) the instrumentation of samples; and

vi) details of the testing facility.

f) The fire resistance testing procedure must be based on:

i) Efectis R0695 Fire testing procedure for concrete tunnel linings and other tunnel components (2020 version); and

ii) EFNARC Specification and Guidelines for Testing of Passive Fire Protection for Concrete Linings.

g) The fire resistance testing procedure required by section 3.6.16f) must include adaptations made in order to comply with Australian standards as required.

h) The fire resistance testing procedure for load tested samples must be in accordance with 3.6.16f)i).

i) Fire resistance testing must be undertaken on all types of concrete mixes to be used on all Tunnel structures.

j) Fire resistance test samples must include any embedded items including fixtures for mounted equipment that would be present in the final constructed form.

k) Fire resistance testing must demonstrate that the FRLs and spalling requirements can be achieved with embedded items included as required by section 3.6.16j).

l) Fire resistance testing under load simulating constructed conditions must be undertaken to demonstrate fire resistance requirements have been achieved.

m) The Contractor must show that the number of samples to be tested and the types of tests undertaken demonstrate that fire resistance requirements have been achieved.

n) A minimum of 2 cores must be taken from each test sample post testing for petrographic analysis of the damaged concrete.

o) The petrographic testing required by section 3.6.16n) must determine the strength profile of the tested concrete.

p) The strength profile of the tested concrete determined in accordance with the petrographic testing must be used in the assessment of the concrete fire resistance performance.

q) Fire resistance testing must be undertaken by a NATA accredited organisation to undertake these types of tests.

r) Fire resistance test evidence must include Project specific reports authored by a NATA accredited organisation to undertake this type of reporting.

s) Each fire resistance test report produced by the NATA accredited testing organisation must be submitted to the Principal for approval and will constitute a **Hold Point**. Site construction and installation of structural elements that are the subject of fire testing must not occur until this Hold Point is released.

t) Fire testing must also demonstrate that the Tunnel and Tunnel portal load bearing structures can maintain structural adequacy in the cooling down period post testing.

u) Structural elements that cannot be exposed to the direct effects of a Tunnel carriageway fire and require compliance with the fire resistance requirements of the NCC do not need to be subjected to fire resistance testing required by this section 3.6.16 if they are otherwise designed to relevant Australian standards.

v) The Contractor must document all test evidence in the Tunnel FRR demonstrating that the Tunnel design will achieve the required FRLs.

## 3.7 Fire suppression

a) Tunnel fire suppression systems must comply with the requirements of TUN-FIRE-DC1 “Tunnel Fire Detection and Suppression Systems”.

b) Tunnel fixed fire suppression systems must use the dual solenoid control defined by TUN-FIRE-DC1 “Tunnel Fire Detection and Suppression Systems”.

c) The Contractor may consider the provision of a misting Tunnel fixed fire suppression system to fulfill the performance requirements of a deluge system.

d) Misting fixed fire suppression systems used instead of deluge fixed fire suppression systems in the Tunnel must:

   i) satisfy the requirements of the Contractor’s Fire Engineering design;

   ii) be demonstrated to achieve performance equivalence to the deluge system defined by TUN-FIRE DC1 “Tunnel Fire Detection and Suppression Systems”;

   iii) be approved by the Principal; and

   iv) be approved by SAMFS.

e) The zoning and coverage of the Tunnel fixed fire suppression system must:

   i) determine any fire resistance benefits of extending zone coverage limits in excess of minimum requirements;

   ii) determine any potential reduction in Tunnel reopening times afforded by extending zone coverage limits in excess of minimum requirements;

   iii) be approved by the Principal; and

   iv) be approved by the SAMFS.

## 3.8 Fire detection

a) Tunnel fire detection systems must comply with the requirements of TUN-FIRE-DC1 “Tunnel Fire Detection and Suppression Systems”.

b) The Contractor must assess the benefit of linear heat detection for the Tunnel considering:

   i) the requirements of the Contractor’s Fire Engineering design;

   ii) efficacy, speed and reliability of detection when compared to other included systems;

   iii) value of any risk reduction by its inclusion; and

   iv) requirements of network operators.

c) The Contractor must include the assessment of linear heat detection required by section 3.8b) as part of the Design Documentation.

## 3.9 Emergency egress

a) Tunnel egress systems must comply with the requirements of TUN-FIRE-DC2 “Tunnel Evacuation Systems”.

b) Points of egress in the Tunnel must:

   i) be regularly spaced through the Tunnel;

   ii) be consistently configured with consideration to similar facilities found in other modern South Australian road tunnels;

   iii) provide a route from the incident Tunnel to a point of relative safety (e.g. non-incident Tunnel carriageway or uncovered roadway); and

   iv) have a maximum spacing of 120 m.

c) Tunnels located in parallel must have egress formed by cross passageways.

d) Long term refuge of occupants underground must not form part of the egress strategy.

e) Longitudinal egress passages must:

   i) account for the length and grade of the occupant travel route; and

   ii) consider the inclusion of rest and passing regions.

f) The egress strategy must include provisions for occupants to self-evacuate to a place of safety.

g) The egress spacing and strategy adopted must be demonstrated to provide the required performance requirements.

## 3.10 Scenario assessment

a) The Contractor's Fire Engineering design must identify incident scenarios for assessment based on the Tunnel use, operations, systems included and geometry.

b) Single location incident scenarios must be assessed as design cases.

c) Multiple location incident scenarios caused by an initial incident must be assessed:

   i) to determine the impact on the performance of the fire safety related systems; and

   ii) to demonstrate the level of risk associated is acceptable.

d) The Contractor's Fire Engineering design must determine the fire size for each incident scenario identified.

e) For Tunnels where dangerous goods vehicles are not permitted to operate, single incident scenarios assessed must include a fire size of 50 MW.

f) For fires assessed pursuant to section 3.10e), a range of t-squared fire growth rates must be considered including ultra-fast growth rate.

g) For Tunnels where dangerous goods vehicles are permitted to operate, dangerous goods vehicle fires must be assessed and allowed for in the Fire Engineering design.

h) For Tunnels where dangerous goods vehicles are not permitted to operate:

   i) the risks associated with the passage in the Tunnel of an errant dangerous goods vehicle must be included in the Fire Engineering design; and

   ii) it must be demonstrated that the risk associated with the passage in the Tunnel of an errant dangerous goods vehicle is acceptable.

i) Alternative fuel vehicles must be defined as vehicles that do not use petrol, diesel or compressed natural gas fuelled internal combustion engines as the primary source of propulsion power.

j) Fires from alternative fuel vehicles must be assessed and allowed for in the Fire Engineering design.

## 3.11 Smoke management

a) The smoke management system must provide a tenable environment for occupants that are located in the Tunnel upstream of the fire incident from a traffic flow sense.

b) The acceptability criteria for a tenable environment required by section 3.11a) must be agreed with stakeholders as part of the PBDB.

c) The smoke management system must provide an environment downstream of the fire incident from a traffic flow sense, that is acceptable to stakeholders given the Tunnel use and operations.

d) The smoke management system combined with other systems must provide an access route to approach the fire location that is acceptable to the SAMFS.

e) The smoke management system must provide cross passage pressurisation that:

   i) protects the non-incident Tunnel from the transfer of smoke through cross passages when cross passage doors are opened; and

   ii) is designed for a number and location of cross passage doors open that is coordinated with the design egress scenarios assessed.

f) Operation of the smoke management system must not result in exit door opening forces that exceed the requirements of TUN-FIRE-DC2 “Tunnel Evacuation Systems”.

g) The smoke management system must provide protection against the recirculation of smoke into the non-incident Tunnel.

h) The smoke management system must be high temperature rated in accordance with the requirements of TUN-ME-DC6 “Tunnel Ventilation Equipment”.

i) The high temperature requirements of section 3.11h) must be verified by the Contractor as part of the modelling assessments required by section 3.12 and if this shows higher temperatures, then the temperatures from the modelling assessments must be used for the equipment specification in TUN-ME-DC6 “Tunnel Ventilation Equipment”.

## 3.12 Assessment modelling requirements

a) Computational modelling undertaken that forms part of any Fire Engineering design must use software that has been verified and validated for the specific purpose of the modelling being undertaken.

b) Modelling software used for in-Tunnel smoke movement must be based on 3-dimensional computational fluid dynamics and not zone based or spreadsheet based model.

c) Modelling software used to assess near-field (local to the Tunnel) ambient smoke dispersion must be based on 3-dimensional computational fluid dynamics.

d) Modelling software used to assess far-field (remote from the Tunnel) ambient smoke dispersion from the Tunnel must be based on:

   i) 3-dimensional computational fluid dynamics; or

   ii) established pollutant dispersion modelling software.

e) In-Tunnel smoke modelling must be undertaken to demonstrate Tunnel conditions in the event of a fire.

f) Ambient (near-field) smoke modelling must be undertaken to demonstrate that the discharge of smoke from either a ventilation station, duct outlet or Tunnel portal will not adversely impact any Tunnel evacuation or emergency response.

g) Evacuation modelling must use established pedestrian modelling software that enables coupling of smoke modelling output with evacuation movement.

h) Fire brigade intervention modelling must be undertaken using software, methodology and inputs approved by the SAMFS.

i) Finite element software used to undertake thermal modelling to demonstrate fire resistance performance must be software specific to the modelling of structures subject to fire.

j) Verification and validation documentation must be documented in the PBDB for each software package proposed.

k) Proposed software and modelling methodologies must be documented in the PBDB.

l) All modelling scenarios and sensitivities must be documented in a model register that is available to the Principal on request.

m) Model input and output files must be made available to the Principal on request.

## 3.13 Risk assessments

a) The Contractor's Fire Engineering design must:

   i) identify and document all credible fire safety hazards and risks; and

   ii) document hazards and risks in a format that enables input into the safety assessment report in accordance with PC-EDM6 "Systems Engineering Management".

b) The Lead Fire Engineer must:

   i) participate in any hazard and risk assessments workshops; and

   ii) ensure the fire safety hazards and risks are coordinated with the safety assessment report undertaken in accordance with PC-EDM6 "Systems Engineering Management".

c) For each credible fire safety hazard and risk it must be demonstrated and documented that:

   i) all possible controls applicable to road Tunnel infrastructure have been assessed;

   ii) the safety benefit derived from the considered controls have been assessed;

   iii) the adoption or rejection of each considered control have been justified; and

   iv) the residual risks have been reduced SFAIRP.

d) The proposed Fire Engineering risk assessment process must be:

   i) based on the Principal's risk management framework; and

   ii) documented in the PBDB.

e) Fire engineering risk assessments must be:

   i) documented in the relevant Fire Engineering Report; and

   ii) confirmed to be valid in the event of any changes to design inputs or assumptions.

# 4 Reliability, Design Life, and functional safety requirements

The Fire Engineering design and any associated derived requirements must comply with the systems engineering requirements and the analysis for RAMS in accordance with PC-EDM6 "Systems Engineering Management".

# 5 Hold Points

Table TUN-FIRE-DC3 5-1 details the review period or notification period, and type (documentation or construction quality) for each Hold Point referred to in this Master Specification Part.

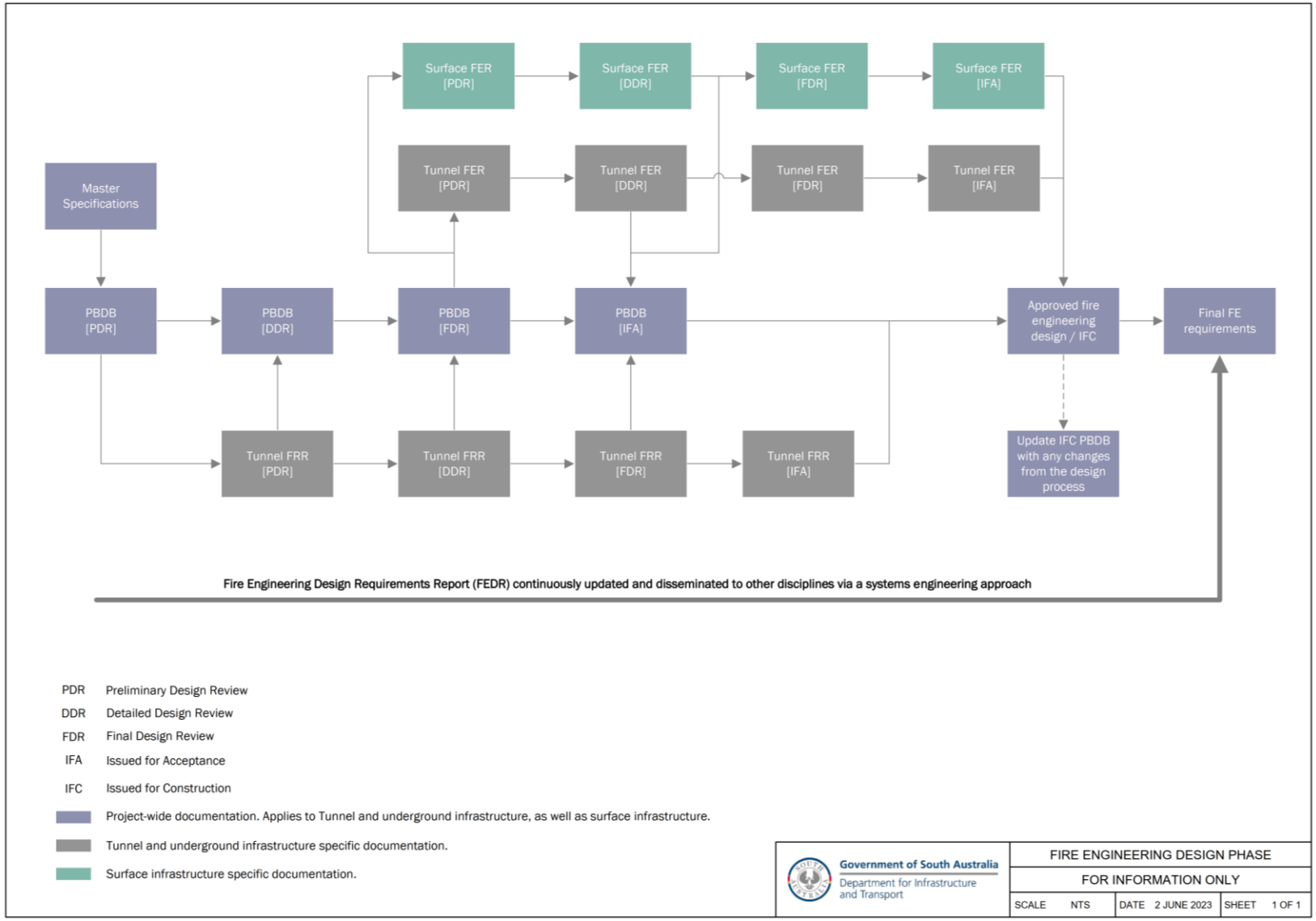
**Table TUN-FIRE-DC3 5-1 Hold Points**

| Section reference | Hold Point | Documentation or construction quality | Review period or notification period |
|---|---|---|---|
| 2.1.1b) | Definition of Tunnel fire engineering design review process | Documentation | 10 Business Days review |
| 3.6.16s) | Fire resistance test reports | Documentation | 10 Business Days review |

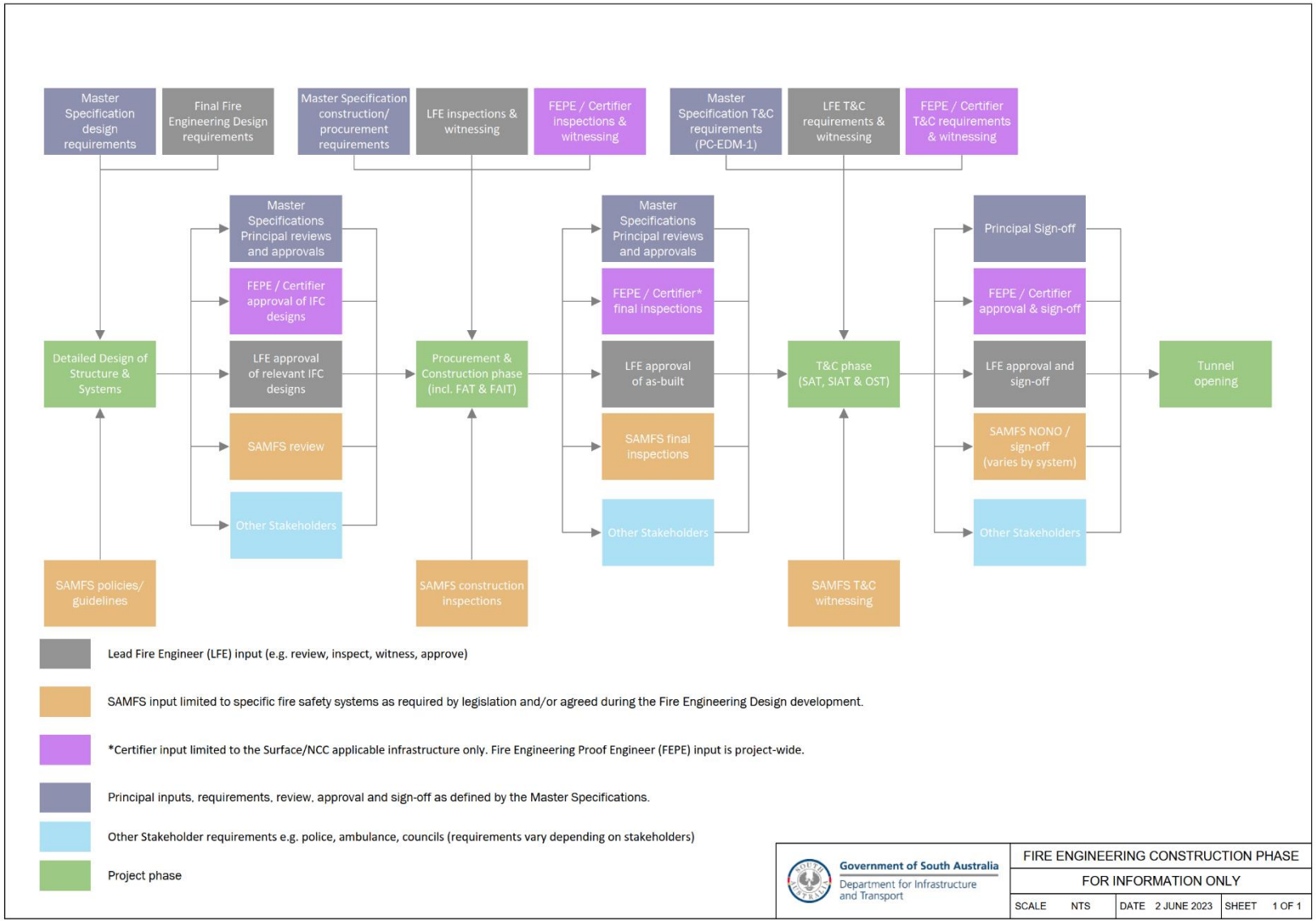
# 6 Verification requirements and records

Testing and commissioning procedures and documentation of the fire life safety related systems and all of the associated control and communications interfaces must be in accordance with PC-CN1 “Testing and Commissioning”.

# 7 Appendix 1: Design Process Map (information only)



# 8 Appendix 2: Construction Process Map (information only)



# 9 Appendix 3: Hydrocarbon Modified Fire Curve with Efectis (2020) decay curve (information only)