Master Specification
Part TUN-ME-DC5

Supply of Tunnel Air Monitoring Instrumentation

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Contents

TUN-ME-DC5 Supply of Tunnel Air Monitoring Instrumentation

1 General

a) This Master Specification Part sets out the requirements for the supply of instruments for in-Tunnel air monitoring, including:

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

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

iii) the environmental requirements, as set out in section 4.

b) Within this Master Specification Part, in-Tunnel air monitoring applies to:

i) in-Tunnel air quality monitoring;

ii) in-Tunnel air velocity monitoring;

iii) in-Tunnel smoke detection;

iv) ventilation station outlet (VSO) air quality monitoring; and

v) VSO air velocity monitoring.

c) This Master Specification Part does not apply to Tunnel sump hydrocarbon monitoring.

d) The performance requirements for VSO air monitoring instruments defined in section 3.5 may be applied to surface located ambient air quality monitoring instruments where required by the Contract Documents.

e) The instruments for in-Tunnel air monitoring must comply with the Reference Documents, including:

i) AS/NZS 2312.2 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings, Part 2: Hot dip galvanising;

ii) AS/NZS 3000 Electrical Installations (known as the Australian/New Zealand Wiring Rules);

iii) AS/NZS 3013 Electrical Installations - classifications of the fire and mechanical performance of wiring system elements;

iv) AS 3580.5.1 Methods for sampling and analysis of ambient air, Method 5.1: Determination of oxides of nitrogen - Direct-reading instrumental method;

v) AS 3580.7.1 Methods for sampling and analysis of ambient air, Method 7.1: Determination of carbon monoxide - Direct-reading instrumental method;

vi) AS 3580.9.8 Methods for continuous determination of suspended particulate matter in ambient air, Determination of suspended particulate matter - PM10 continuous direct mass method using a tapered element oscillating microbalance analyser;

vii) AS/NZS 3580.9.13 Methods for sampling and analysis of ambient air, Method 9.13: Determination of suspended particulate matter - PM2.5 continuous direct mass method using a tapered element oscillating microbalance monitor;

viii) AS 3580.14 Methods for sampling and analysis of ambient air, Part 14: Meteorological monitoring for ambient air quality monitoring applications;

ix) AS/NZS 3580.18 Methods for sampling and analysis of ambient air, Method 18: Measurement of road tunnel air quality;

x) AS 4323.1 Stationary source emissions, Method 1: Selection of sampling positions and measurement of velocity in stacks;

xi) AS 4323.2 Stationary source emissions, Method 2: Determination of total particulate matter - Isokinetic manual sampling - Gravimetric method;

xii) AS 4312 Atmospheric corrosivity zones in Australia;

xiii) AS 4506 Metal finishing - Thermoset powder coatings;

xiv) AS/NZS 4680 Hot dip Galvanised (zinc) coatings on fabricated ferrous articles;

xv) AS/NZS ISO 9001 Quality management systems - Requirements;

xvi) AS 60529 Degrees of protection provided by enclosures (IP Code);

xvii) AS/NZS 61000 Electromagnetic compatibility (EMC); and

xviii) IEC 60751 Industrial platinum resistance thermometers and platinum temperature sensors.

f) 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) South Australia Environment Protection (Air Quality) Policy 2016 under section 28 of the *Environment Protection Act 1993* (SA);

ii) EPA, Ambient air quality assessment, August 2016; and

iii) EPA, Emission Testing Methodology for Air Pollution, Version 2, August 2012.

2 Documentation

2.1 Construction Documentation

In addition to the requirements of PC-CN3 "Construction Management", the Construction Documentation must include:

a) evidence that in-Tunnel air quality monitoring instruments have been successfully used for greater than 10 years in road Tunnels in Australia and globally;

b) evidence that in-Tunnel air velocity monitoring instruments have been successfully used for greater than 10 years in road Tunnels in Australia and globally;

c) evidence that in-Tunnel smoke detection instruments have been successfully used for greater than 5 years in road Tunnels globally;

d) evidence that VSO emissions monitoring instruments have been used successfully for greater than 10 years in road Tunnels in Australia and globally; and

e) technical data sheets for each type of sensor to be supplied.

2.2 Quality Management Records

In addition to the requirements of PC-QA1 "Quality Management Requirements" or PC-QA2 "Quality Management Requirements for Major Projects" (as applicable), the Quality Management Records must include testing and calibration certificates for each instrument supplied.

3 Technical requirements

3.1 General

a) In-Tunnel instruments for air quality monitoring, air velocity monitoring and smoke detection must:

i) be designed for use in road Tunnels;

ii) operate without being adversely affected by electromagnetic interference from other Tunnel systems or from land mobile radio systems;

iii) have self-diagnostic capability to report maintenance alerts and system faults;

iv) report general faults, instrument failure, instrument contamination and out of range;

v) have self-calibration capability;

vi) not need manual recalibration post installation;

vii) be low maintenance, requiring only periodic cleaning and inspection;

viii) be designed to have a maintenance interval of greater than 12 months;

ix) be provided with enclosures that are vermin and insect proof;

x) have enclosures fabricated from powder coated 316 stainless steel or hard anodised die cast aluminium;

xi) have cable entry systems that ensure the retention of the enclosure IP rating whether occupied or empty; and

xii) incorporate gaskets or seals suitable for use in the road Tunnel environment.

b) In-Tunnel instrument analogue outputs must provide outputs accurately scaled for the resolution of each of range of measurement.

3.2 In-Tunnel air quality monitoring instruments

3.2.1 General

In-Tunnel air quality monitoring instruments must have a user configurable measurement time of 5 seconds or greater.

3.2.2 Tunnels shorter than 1 km in length

a) For Tunnels less than 1 km in length, in-Tunnel air quality instruments must be in accordance with this section 3.2.2.

b) In-Tunnel air quality monitoring instruments must be capable of accurately measuring NO_2, CO and visibility within the same integrated instrument.

c) In-Tunnel air quality instruments must:

i) measure NO_2 using differential optical absorption spectroscopy technology or electro chemical cell technology; and

ii) measure CO using electrochemical cell technology.

d) For NO_2 measurement, in-Tunnel air quality monitoring instruments must include:

i) a range of 0 ppm to 3 ppm; and

ii) a detection resolution of 0.05 ppm.

e) For CO measurement, in-Tunnel air quality monitoring instruments must include:

i) a range of 0 ppm to 300 ppm; and

ii) a detection resolution of 0.5 ppm.

f) For visibility measurement, in-Tunnel air quality monitoring instruments must include:

i) an extinction coefficient range of 0 to 15 /km; and

ii) an extinction coefficient detection limit of 0.001 /km.

g) In-Tunnel air quality monitoring instruments must provide:

i) individual analogue 4-20 mA output for measured values for:

A. CO;

B. NO_2; and

C. visibility;

ii) status information, including operation and fault status, using digital output or other communications interface; and

iii) local status and fault information display capability via an LCD display.

3.2.3 Tunnels 1 km or greater in length

a) For Tunnels 1 km or greater in length, in-Tunnel air quality instruments must be in accordance with this section 3.2.3.

b) In-Tunnel air quality monitoring instruments must be capable of accurately measuring NO, NO_2, CO and visibility within the same integrated instrument.

c) In-Tunnel air quality monitoring instruments must:

i) measure NO and NO_2 using differential optical absorption spectroscopy technology; and

ii) measure CO using electrochemical cell technology.

d) For NO measurement, in-Tunnel air quality monitoring instruments must include:

i) a range of 0 ppm to 30 ppm; and

ii) a detection resolution of 0.5 ppm.

e) For NO_2 measurement, in-Tunnel air quality monitoring instruments must include:

i) a range of 0 ppm to 3 ppm; and

ii) a detection resolution of 0.05 ppm.

f) In-Tunnel air quality monitoring instruments must derive NOx values from NO and NO_2 measurements.

g) For CO measurement, in-Tunnel air quality monitoring instruments must include:

i) a range of 0 ppm to 300 ppm; and

ii) a detection resolution of 0.5 ppm.

h) For visibility measurement, in-Tunnel air quality monitoring instruments must include:

i) an extinction coefficient range of 0 to 15 /km; and

ii) an extinction coefficient detection limit of 0.03 /km.

i) In-Tunnel air quality monitoring instruments must provide:

i) individual analogue 4-20 mA output for measured values for:

A. NO;

B. NO_2;

C. NOx;

D. CO; and

E. visibility;

ii) status information, including operation and fault status, using digital output or other communications interface;

iii) status and fault information display capability via an LCD display; and

iv) parameterisation facility capability via an LCD display.

3.3 In-Tunnel air velocity monitoring instruments

a) In-Tunnel air velocity monitoring instruments must be capable of reporting velocities with directionality relative to vehicle travel.

b) In-Tunnel air velocity monitoring instruments must provide accurate readings during fire incidents accounting for the presence of smoke, temperature changes and air density changes within the thermal operating range of the instrument.

c) In-Tunnel air velocity monitoring instruments must use ultrasonic transit time technology.

d) In-Tunnel air velocity monitoring instruments must have:

i) a measurement velocity range of ±20 m/s;

ii) a measurement velocity accuracy of ±0.1 m/s; and

iii) a measurement velocity sample width range reflective of the cross section of the Tunnel within which the instrument will be installed.

e) In-Tunnel air velocity monitoring instruments must:

i) provide air velocity measurement values via an analogue 4-20 mA output;

ii) provide status information, including operation / fault status, using digital output or other communications interface; and

iii) have status and fault information capability via an LCD display.

3.4 In-Tunnel smoke detection instruments

a) In-Tunnel smoke detection instruments must:

i) use scattered light measurement technology (forward scattering) that minimises false alarms from vehicle exhaust and fog conditions; and

ii) be wholly independent of the Tunnel air quality monitoring systems.

b) Building type point smoke detectors must not be used within the Tunnel carriageways.

c) In-Tunnel smoke detection instrument air inlets and outlets must be vermin and insect proof.

d) In-Tunnel smoke detection instrumentation must have:

i) an extinction coefficient measurement range of 0 to 150 /km;

ii) an extinction coefficient resolution of 1 /km;

iii) a measurement repeatability of ±2% of rating; and

iv) a response time of less than 5 seconds.

e) In-Tunnel smoke detection instruments must provide:

i) analogue 4-20 mA output for smoke detection;

ii) analogue 4-20 mA output for measured temperature values;

iii) status information, including operation and fault status, using digital output or other communications interface;

iv) local status and fault information display capability via an LCD display; and

v) parameterisation facility capability via an LCD display.

3.5 VSO air monitoring instruments

a) VSO air monitoring instruments must:

i) comply with EPA requirements;

ii) be designed for use in Tunnels or industrial flue monitoring applications;

iii) operate continuously in vitiated air at levels defined by the ventilation system design;

iv) be protected from corrosion suitable for the installed conditions;

v) operate reliably accounting for electromagnetic interference from other Tunnel systems;

vi) feature dedicated on-board data capture and logging facilities; and

vii) be protected from vermin and insects.

b) VSO air quality monitoring instruments for NO and NO_2 must include:

i) measurement technology based on chemiluminescence;

ii) a range of at least 0 ppm to 30 ppm for NO;

iii) a range of at least 0 ppm to 3 ppm for NO_2;

iv) a noise of less than 0.2 ppb;

v) a lower detectable limit of less than 0.4 ppb;

vi) a linearity of less than 1% of full scale;

vii) a precision of 0.4 ppb or better;

viii) a zero drift of less than 0.5 ppb in 24 hours;

ix) a zero drift of less than 0.5 ppb in 7 days;

x) a span drift of less 1% of reading in 7 days; and

xi) a response time of at least 15 seconds.

c) VSO air quality monitoring instruments for CO must include:

i) measurement technology based on non-dispersive infrared gas filter correlation;

ii) a range of at least 0 ppm to 200 ppm;

iii) a noise of less than 0.02 ppm;

iv) a lower detectable limit of less than 0.04 ppm;

v) a linearity of less than 1% of full scale;

vi) a precision of 0.1 ppm or better;

vii) a zero drift of less than 0.1 ppm in 24 hours;

viii) a zero drift of less than 0.1 ppm in 7 days;

ix) a span drift of less 0.5% of reading in 7 days; and

x) a response time of 60 seconds or less.

d) VSO air quality monitoring instruments for particulate matter must include:

i) measurement technology based on Tapered Element Oscillating Microbalance;

ii) capability to measure both PM2.5 and PM10 or total suspended particulates;

iii) a measurement range of between at least 0 µg/m³ to 1,000,000 µg/m³;

iv) a measurement resolution of at least 0.1 µg/m³;

v) an accuracy of at least ±1%;

vi) a 1 hour precision of ±1.5 µg/m³;

vii) a 24 hour precision of ±0.5 µg/m³; and

viii) a response time of less than 2 seconds.

e) VSO air velocity monitoring instruments for outlet air velocity must include:

i) ultrasonic transit time technology;

ii) velocities measured with directionality relative to the VSO's primary airflow direction;

iii) a measurement velocity range of at least ±30 m/s;

iv) a measurement velocity accuracy of at least ±0.1 m/s;

v) a maximum drift of ±1% over the full measurement range; and

vi) an adjustable response time of at least 5 seconds.

f) VSO air monitoring instruments for temperature must include:

i) a PT100 resistance temperature detector Class F0.1 in accordance with IEC 60751 Industrial platinum resistance thermometers and platinum temperature sensors;

ii) a temperature measurement accuracy of ±0.2°C; and

iii) a response time of less than 60 seconds.

g) VSO air monitoring instruments must provide individual analogue 4-20 mA output for measured values for each measured value.

h) The VSO air monitoring must include a weather station.

i) The VSO weather station required by section 3.5h) must:

i) sample meteorological conditions in accordance with Table TUN-ME-DC5 3-1;

ii) have continuous sampling frequency;

iii) undertake sampling in accordance with AS/NZS 3580.14 Methods for sampling and analysis of ambient air, Part 14: Meteorological monitoring for ambient air quality monitoring applications; and

iv) have instrument performance in accordance with Table TUN-ME-DC5 3-2.

Table TUN-ME-DC5 3-1 Meteorological monitoring and data gathering requirements

Parameter	Normal	Averaging period
Wind velocity	m / sec	1 hour
Wind direction	degrees	1 hour
Sigma Theta	degrees	1 hour
Temperature	degrees Celsius	1 hour
Humidity		1 hour
Precipitation	mm / hr	1 hour
Visibility (fog)		10 min

Table TUN-ME-DC5 3-2 VSO weather station performance requirements

Equipment	Measurement parameter	Parameter	Requirement
Anemometer or transducer	Wind speed at 10 m	Operating range	Threshold to 30 m/s or above
		Threshold	<0.5 m/s
		Distance constant	<2 m
		Linearity	±0.2 m/ s
		Accuracy	Below 10 m/s: ±0.2 to 0.5 m/s Above 10 m/s: ±0.5 to 1.0 m/s
Wind vane or transducer	Wind direction at 10 m	Operating range	Threshold to 30 m/s or above
		Threshold	<0.3 m/s
		Distance constant	<3 m
		Linearity	±2º
		Accuracy	±3º
	Sigma Theta(1) at 10 m	See wind speed and wind direction parameter requirements	-
Temperature sensor with radiation shield	Temperature at 2 m	Range	-40ºC to +60ºC
		Accuracy (error)	≤0.5ºC
		Radiation range (for radiation shield)	-100 to 1300 W/m^2
		Flow rate (for radiation shield)	3 m/s or greater
		Radiation error (for radiation shield)	<0.2ºC
	Temperature at 10 m	Range	-40º C to +60ºC
		Accuracy (error)	≤0.5ºC
		Radiation range (for radiation shield)	-100 to 1300 W/m^2
		Flow rate (for radiation shield)	3 m/s or greater
		Radiation error (for radiation shield)	<0.2ºC

Table notes:
(1) Sigma Theta is a measure of horizontal wind direction fluctuations derived from calculations using wind direction data.

4 Environmental requirements

a) In-Tunnel and VSO instruments for air quality monitoring, air velocity monitoring and smoke detection must maintain operational functionality:

i) in temperatures between -10°C and +55°C;

ii) in relative humidity between 10% and 95%;

iii) in cold smoke for a fire remote from the instrument;

iv) in average bulk air velocities of up to 11 m/s; and

v) in polluted air as defined by the Tunnel ventilation system design undertaken in accordance with TUN-ME-DC7 “Ventilation Design”.

b) In-Tunnel and VSO instruments for air quality monitoring, air velocity monitoring and smoke detection must maintain operational functionality in Tunnel conditions defined by the Tunnel ventilation system design pursuant to section 4a)v) that exceed the requirements of this section 4.

c) In-Tunnel and VSO instruments for air quality monitoring, air velocity monitoring and smoke detection must have an IP rating in accordance with AS 60529 Degrees of protection provided by enclosures (IP Code) of:

   i) IP66 for instruments installed in areas that could be exposed to deluge, high-pressure water washing or external weather conditions; and

   ii) IP65 for instruments installed elsewhere.