# NOTICE

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## REVISION REGISTER

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<th>Clause Number</th>
<th>Description of Revision</th>
<th>Authorised By</th>
<th>Date</th>
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<td>Ed 1/Rev 0</td>
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<td>GM, CB</td>
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<td>Ed 1/Rev 1</td>
<td>3.2 (k)</td>
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<td>Annex M</td>
<td>Referenced documents updated.</td>
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Submission at Tender Stage

Clause 2 of this Specification requires that details of the manufacturer’s qualifications, quality system, and some technical information be submitted at the time of tender.

To ensure that tenderers are aware of this requirement, the Tender Documenter should highlight these requirements in the C12 “Request for Tenders” document.
TUNNEL JET FANS
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FOREWORD

TFNSW COPYRIGHT AND USE OF THIS DOCUMENT

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When this document forms part of a contract

This document should be read with all the documents forming the Contract.

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R164 Edition 1 Revision 1.

All revisions to the previous version (other than minor editorial and project specific changes) are indicated by a vertical line in the margin as shown here, except when it is a new edition and the text has been extensively rewritten.

PROJECT SPECIFIC CHANGES

Any project specific changes are indicated in the following manner:

(a) Text which is additional to the base document and which is included in the Specification is shown in bold italics e.g. Additional Text.

(b) Text which has been deleted from the base document and which is not included in the Specification is shown struck out e.g. Deleted Text.
1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the supply of tunnel jet fans and related items such as casing, instrumentation, inlet and outlet silencers, anti-vibration mounts, fan mounting frame and installation cradle, including their design, manufacture, factory testing, documentation and delivery.

This Specification excludes requirements for installation of the jet fan equipment, supply and installation of anchor bolts, and supply and installation of all cabling (power and communications) beyond the jet fan terminal boxes.

1.2 STRUCTURE OF THE SPECIFICATION

This Specification includes a series of annexures that detail additional requirements.

1.2.1 Project Specific Requirements

Project specific details of work are shown in Annexure R164/A.

The types of jet fan and the number of each fan type required under the Contract are stated in Annexure R164/A. The number of maintenance cradles required under the Contract is also stated in Annexure R164/A.

1.2.2 Measurement and Payment

The method of measurement and payment is detailed in Annexure R164/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure R164/C list the HOLD POINTS and WITNESS POINTS that must be observed. Refer to Specification TfNSW Q for definitions of HOLD POINTS and WITNESS POINTS.

The records listed in Annexure R164/C are Identified Records for the purposes of TfNSW Q Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure R164/D and must be implemented.

1.2.5 Referenced Documents

Unless otherwise specified, the applicable issue of a referenced document, other than a TfNSW Specification, is the issue current at the date one week before the closing date for tenders, or where no issue is current at that date, the most recent issue.
Standards, specifications and test methods are referred to in abbreviated form (e.g. AS 1234). For convenience, the full titles are given in Annexure R164/M.

1.3 DEFINITIONS AND ACRONYMS

1.3.1 Definitions

The terms “you” and “your” mean “the Contractor” and “the Contractor’s” respectively.

The following definitions apply to this Specification:

**Critical speed**  
Speed at which the natural frequency is generated

**Flow reversal**  
Change in the operating direction of fan flow, i.e. from flow in one direction to flow in the opposing direction

1.3.2 Acronyms

<table>
<thead>
<tr>
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<td>DOL</td>
<td>Direct on line</td>
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<tr>
<td>ITP</td>
<td>Inspection and Test Plan</td>
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<tr>
<td>MTBF</td>
<td>Mean Time Between Failure</td>
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<td>MTTR</td>
<td>Mean Time To Repair</td>
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<tr>
<td>NDE</td>
<td>Non-destructive examination</td>
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<tr>
<td>RTD</td>
<td>Resistance temperature detector</td>
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<tr>
<td>VSD</td>
<td>Variable speed drive</td>
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2 TENDER SUBMISSION AND FAN SELECTION

2.1 GENERAL

Submit in your tender the following information under Clauses 2.2 to 2.4 for consideration by the Principal of the jet fan(s) proposed.

The Principal will select the make and model for each type of jet fan required under the Contract using the tender submissions received. When assessing the proposed jet fan submitted, the Principal will give preference to jet fans (including motors) that can be serviced locally.

2.2 MANUFACTURER’S QUALIFICATIONS

Submit documentation demonstrating that:

(a) the jet fan manufacturer has at least 10 years of recent experience in the manufacture of jet fans of the type, size and capacity described in this Specification;

(b) comparable jet fans and drive systems have been in satisfactory operation for a minimum of five years in at least three projects.
2.3 MANUFACTURER’S QUALITY SYSTEM

2.3.1 Quality System Certification

The jet fan manufacturer must have a quality management system independently certified as fully complying with AS/NZS ISO 9001, by an organisation accredited by JAS-ANZ or an affiliated international certification organisation. Submit current documentation as proof of this certification.

2.3.2 Documentation Submission

Submit also the following quality system documentation from the jet fan manufacturer:

(a) List of all technical procedures, work instructions and processes used for the manufacture and assembly of the jet fans.

(b) Typical Inspection and Test Plan (ITP) used for manufacture and assembly of jet fans, detailing inspection and testing methods and their applicable standards.

(c) Contact details of a third party certifier, whom the Principal may use to verify compliance of manufacturing and testing of the jet fans with this Specification, in the case where the jet fans are manufactured overseas.

2.3.3 Standards and Specifications

Where any of the standards or specifications used or proposed by the manufacturer for any material, manufacturing or testing method is different to what is specified in this Specification, submit details of such standard or specification with your tender, for assessment by the Principal.

2.3.4 Audits and Inspections

The Principal may conduct its own audits and inspections, or alternatively where the fans are to be manufactured overseas, have you engage a third party certifier to undertake the audits and inspections, of the manufacturer’s procedures and processes including during the course of the Contract.

2.4 TECHNICAL INFORMATION

Submit the following technical information:

(a) General arrangement drawings, showing all components of the proposed jet fan assembly. The drawings must show the overall dimensions of the fan assembly, the mounting frame and the mounting arrangement. The drawings must also show details of the installation cradle and proposed lifting methodology.

(b) General information about the proposed jet fan including type, size, thrust rating, performance, motor rating and operational parameters including estimated Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR).

(c) Data sheets showing jet fan performance in the forward flow direction, and reverse flow direction if specified.

(d) Anticipated sound power spectrum at the specified forward and reverse operating thrust.

(e) Catalogue(s) of the proposed jet fans and their instrumentation sensors.
(f) General assembly drawings for jet fans of the same or similar design as that proposed. The drawings must include a list of system components, stating for each component the name of supplier, the material used and applicable manufacturing standards and drawing reference.

(g) Details of standards for material, welding, manufacturing and testing for use in the design and manufacture of the fans and supports, where they are not referenced or are different from that which is specified in this Specification.

(h) Proposed corrosion protection treatment regimes.

(i) Sample copies of recent test reports showing compliance of various materials, components and manufacturing procedures with their respective standards and associated ITPs.

(j) Proposed non-destructive examination (NDE) methods for all fan blades, hubs and welded connections in the fans and mounting frames.

(k) Evidence that fans of the same or similar design as that proposed are capable of operating at the elevated temperature specified in Annexure R164/A and resisting thermal shock.

Such evidence may be in the form of copies of certificates of tests carried out in accordance with ISO 21927-3 on comparable fans of the same manufacture and using the same components, at a date no longer than two years prior.

(l) Contact details and experience of proposed maintenance service provider who must have at least five years recent experience in maintaining fans similar to those proposed.

3 DESIGN AND PERFORMANCE

3.1 PERFORMANCE REQUIREMENTS

3.1.1 Operating Conditions

The jet fans and fan mounting frame must be suitable for operation in a tunnel environment, taking into consideration the following conditions under which they will be operating:

(a) continuous operation in polluted air, including but not limited to high concentrations of carbon monoxide, oxides of nitrogen, volatile organic compounds and particulate matter;
(b) 24-hour operation;
(c) water ingress from high pressure washing;
(d) normal operating temperature ranging from 0 to 55°C;
(e) attack by vermin and insects;
(f) subjected to vandalism.

The jet fans must also be suitable for operation using the electrical power supply stated in Annexure R164/A.

3.1.2 Fan Performance

The jet fans must be capable of meeting the minimum thrust requirements stated in Annexure R164/A.

In the design of the jet fan, take into consideration vehicle induced pressure transients.
The nominal absorbed power of the axial fans is stated in Annexure R164/A.

3.1.3 Reversibility

Where so specified in Annexure R164/A, the jet fans must be capable of reversible flow operation.

Such fans must be capable of changing from full flow in one direction to full flow in the opposing direction, with a de-energised period in between, within 30 seconds. Three flow reversals must be possible during a 20 minute period. (Refer Clause 1.3.1 for definition of “flow reversal”.)

3.1.4 Aerodynamic Efficiency

Design the jet fan to operate at maximum aerodynamic efficiency for flow in the forward direction.

If reversible fans are required, the thrust generated in the reverse flow direction must not be less than 90% of that in the forward direction.

3.1.5 Stalling

Jet fans must be able to operate with the flow in the same or opposite direction to that of vehicle travel without stalling.

3.1.6 Elevated Temperature Operation

Design the jet fans and all components required for a fully functioning fan assembly, to continue to operate at the elevated temperature specified in Annexure R164/A.

3.1.7 Design Life

Design the jet fans and other components for the design life specified in Annexure R164/A.

3.1.8 Static and Dynamic Design Loads

Design all structural and mechanical parts of the jet fan assembly for strength, serviceability, fatigue and durability as required by the applicable design standard.

Apply a minimum factor of safety of 1.5 to all loads, or higher factors of safety where such higher factors of safety are specified by the design codes (e.g. AS 4100). You may also propose alternative factors of safety to the Principal for approval.

Loads must include, but are not limited to:

(a) gravity, including any lateral components;
(b) thrust and aerodynamic loads from fan operation;
(c) torque reaction loads, including fan start-up torque reaction loads;
(d) fan/motor imbalance loads;
(e) loads generated during any flow reversal operations;
(f) loads generated by air flows within the tunnel;
(g) loads generated by traffic flows within the tunnel.

3.1.9 Balancing

Design the jet fan so that they are balanced both statically and dynamically.
3.1.10 Accessibility for Maintenance

Design the jet fans to be accessible for maintenance in a safe manner.

Jet fans must be removable from the mounting frame.

3.1.11 Lifting Points

Provide lifting points to lift the complete jet fan assembly in accordance with the methodology shown in the general arrangement drawings stated in Clause 2.4.

3.1.12 Dimensions

The nominal diameter of the fan impeller is stated in Annexure R164/A.

The dimensions of the jet fans and their supports must be such that, when installed, they do not encroach into the clearance envelope of the tunnel shown in the Drawings.

3.2 DOCUMENTATION SUBMISSION

Prior to commencement of manufacture of the jet fans for the Contract, submit the following information:

(a) Completed equipment schedule for the jet fan system as set out in Annexure R164/E.

(b) Fan performance data sheet, based on an air density of 1.2 kg/m³.
   If reverse flow is required, provide data for both forward and reverse flow.

(c) Workshop drawings of the jet fans and mounting frames. The drawings must include information about the material of each component and applicable standard, characteristics of finished surfaces and tolerances and their respective standards.

(d) General arrangement drawings showing the complete jet fan assembly, and details of their interface points with the tunnel structure.

(e) Fan mounting frame structural design calculations. Include any proposed modifications to the structural and mechanical design interface.

(f) Fan lifting methodology and lifting design calculations.

(g) Design load factors.

(h) Certification that the design complies with this Specification and the relevant standards.

(i) Details of the fan instrumentation sensors, including details on the output to the control system.

(j) Nominated corrosion rate classifications in accordance with AS 4312, and corresponding nominated corrosion protection treatment schemes for the various fan components in accordance with AS/NZS 2312. The nominated treatment must be based on the installation conditions and the corrosion rate classification specific to the equipment location.

(k) Nominated standards or procedures for the fabrication of all steel components, where these are not in accordance with Specification TfNSW B201. In particular, provide details of the welding standards for fabrication of all steel components, including fan casings and support frames.
(l) Nominated standards or procedures for the fabrication of all non-steel components.

(m) Inspection and Test Plan (ITP) for manufacture of the jet fans detailing inspection and testing methods and their applicable standard, including NDE procedures.

(n) Evidence that the materials selected and the assembled product will meet the required design life with a reasonable level of maintenance.

(o) Proposed product identification nameplates, which must be in accordance with Clause 5.5.3.

(p) Manufacturing and delivery programme.

(q) Installation and commissioning manual(s).

(r) Operations and maintenance manual(s).

For items (q) and (r) above, a preliminary version containing only outline content is acceptable at this stage of the submission. The final manuals submitted must include the details specified in Clauses 8.2 and 9.5 respectively.

4 MATERIALS AND COMPONENTS

4.1 IMPELLER

4.1.1 Materials

Select materials for the impeller that are suitable for the specified temperature, anticipated pollution conditions, speeds, dynamic loads and fatigue loads.

4.1.2 Impeller Blade Section

For unidirectional jet fans, provide blades that are of true aerofoil section. If reversible fans are required, provide blades that are of symmetrical section to maximise efficiency in both directions.

4.1.3 Critical Speed

Design the shaft impeller motor assembly such that the first critical speed is at least 50% higher than the design maximum operating speed.

4.1.4 Stresses at Over-speed

Design the impeller to withstand stresses generated by over-speed testing to 125% of the nominal operating speed.

4.2 MOTOR

4.2.1 Operating Characteristics

Jet fan motors must have the following characteristics:

(a) conformity with AS 1359;

(b) single speed;
(c) direct on line (DOL) starting or variable speed drive (VSD) control, if so specified in Annexure R164/A;
(d) operate at maximum motor efficiency under normal operating conditions;
(e) of a minimum power factor of 0.85;
(f) housed in a “totally enclosed, air over” enclosure of IP65 rating to AS 60529;
(g) fitted with anti-condensation heaters;
(h) capable of being run in an inclined position of up to 15 degrees from the horizontal;
(i) capable of operating at the elevated temperature where so specified in Annexure R164/A for the fan;
(j) able to accelerate from standstill to full forward running speed in not more than 10 seconds;
(k) for reversible fans, compliance with the flow reversal requirement specified in Clause 3.1.3;
(l) capable of six starts per hour, or for reversible fans, six starts per hour in either direction including at least three reversals within 20 minutes.

4.2.2 Motor Power Terminal Box

Fit a motor power terminal box, of IP65 rating to AS 60529, external to each fan casing, easily accessible from a platform below the fan.

4.3 Bearings

4.3.1 Basic Rating Life

Provide fan and motor bearings with a minimum basic rating life (L10) in accordance with AS/NZS 2729 of either 40,000 hours or 10 years, depending on which is reached first operationally.

4.3.2 Damage to Stationary Fans

Design the bearings to avoid permanent damage when the jet fans are not operating, over the design life of the jet fan.

4.3.3 Lubrication

Equip the fans with “sealed for life” bearings if the bearing design life is at least equal to that of the fan.

Otherwise, equip the fans with non-sealed lubricated bearings and include a lubrication system with lubrication points external to the fan casing at a location that is accessible from a platform below a suspended jet fan. Fix covers to lubrication points to prevent water and dust ingress.

4.3.4 Elevated Temperature Performance

Bearing lubricant must be capable of operating at the same elevated temperature as that for the fan where so specified in Annexure R164/A.
4.4 INSTRUMENTATION

4.4.1 Vibration Sensor

Equip each jet fan with permanent sensors to measure and report out of balance vibration from the impeller, motor and bearings. These sensors must monitor the jet fan continuously while it is running, and generate an alarm condition to the control system if the vibration exceeds a preset design limit.

Connect the sensors to the instrumentation terminal box.

4.4.2 Resistance Temperature Detector (RTD)

Equip each jet fan motor with motor bearing RTDs and motor winding RTDs connected to the instrumentation terminal box on the jet fan casing. These sensors must generate an alarm condition to the control system when bearing or winding over-temperature is detected.

4.4.3 Instrumentation Terminal Box

Provide an instrumentation terminal box, IP65 rating to AS 60529, external to the fan casing and separate from the motor terminal box, easily accessible from a platform below the fan.

4.4.4 Elevated Temperature Performance

All instrumentation and leads within the air stream must be capable of operating at the same elevated temperature conditions, in accordance with AS/NZS 3013, as that for the fan where so specified in Annexure R164/A.

4.5 FAN CASING

4.5.1 Material

Manufacture jet fan casings of welded mild steel with a minimum thickness of 6 mm and with continuously welded flanged ends for connection to silencers.

4.5.2 Lifting Points

Provide lifting points on the fan casing to allow the fan to be lifted in a stable manner whilst orientated in its final installed layout.

4.6 SILENCERS

4.6.1 General

Supply all jet fans complete with inlet and outlet silencers such that after the jet fans have been installed and with all jet fans operating at synchronous speed, the noise level does not exceed the requirement specified in Annexure R164/A.

4.6.2 Self-draining

Silencers must be self-draining cylindrical type silencers.
4.6.3 Elevated Temperature Performance

Silencers must be capable of operating at the same elevated temperature as that for the fan where so specified in Annexure R164/A.

4.6.4 Acoustic Lining Protection

Provide measures to protect the acoustic lining from deterioration over the life of the silencers.

4.7 ANTI-VIBRATION MOUNTS

4.7.1 General

Mount each jet fan on anti-vibration spring mounts designed to isolate the fan vibration from the supporting structure under the dynamic design load expected during operation and outlined in Clause 3.1.8.

4.7.2 Failure of Anti-vibration Mounts

Design the mounts such that a complete failure of the anti-vibration elements would not allow the jet fan to fall.

4.7.3 Elevated Temperature Performance

Anti-vibration mounts must be capable of withstanding the same high temperature as that for the fan where so specified in Annexure R164/A.

4.8 FAN MOUNTING FRAME

4.8.1 General

Provide each jet fan with a mounting frame to independently support or suspend the fan assembly (comprising the fan, silencers, connectors, etc) from the tunnel structure.

4.8.2 Interface with Tunnel Structure

The interface between the fan mounting frame and the tunnel structure must fully comply with the drawings submitted under Clause 3.2. Where you propose modifications to the interface, submit details of any such modifications to the Principal for approval.

4.8.3 Supports

Provide all jet fans with safety chains or cables fixed to the support frame, capable of supporting the jet fan in the event of failure of the fan supports and withstanding the dynamic shock loads that may occur during that failure.

Under normal operating conditions (i.e. non-failure), the safety chains or cables must not carry any equipment loads or abrasively contact any part of the fan or silencer casings.

Provide adequate bracing to the mounting frame so that it remains stable during start up, operation, testing and shut down.

Provide additional supports for silencers if such supports are required.
4.8.4  **Elevated Temperature Performance**

Design the mounting frame to be capable of withstanding the same elevated temperature as that specified for the fan in Annexure R164/A.

4.9  **FASTENERS**

4.9.1  **General**

Supply all fasteners (e.g. nuts, bolts, spacers, washers, seals, packers, etc) necessary for the complete assembly and mounting of the fans and other components which are supplied together with the fans, such as silencers.

All bolts, nuts, screw and washers provided must be in accordance with the Drawings and Specifications TfNSW B201 and TfNSW B240.

4.9.2  **Corrosion Protection**

Unless otherwise specified, all fasteners must be hot-dip galvanized.

Care must be taken to avoid galvanic and other corrosion of fasteners.

4.10  **CRADLES**

4.10.1  **Installation Cradles**

Unless otherwise approved, supply the number of installation cradles required for the fan installation in accordance with your installation methodology submitted in Clause 3.2.

You may propose changes to the installation arrangements, including changes to the number of cradles, from those submitted in Clause 3.2.

4.10.2  **Maintenance Cradles**

To facilitate maintenance and servicing of the jet fans, supply the minimum number of maintenance cradles specified in Annexure R164/A.
5 MANUFACTURE

5.1 GENERAL

5.1.1 Hold Point

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<td>Release of Hold Point</td>
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5.1.2 Third Party Certifier

Where jet fans are to be manufactured overseas, the Principal may order that you engage a third party certifier approved by the Principal to verify compliance of the manufacture of the fans with this Specification.

Payment for the services of the third party certifier, if ordered, will be made under Pay Item R164P4.

5.2 FANS

5.2.1 General

Carry out the fabrication of fan assembly, including its individual components and associated items such as the mounting frame, in accordance with the approved standards and/or procedures submitted under Clause 3.2.

5.2.2 Dynamic Balance

Balance each axial fan dynamically in accordance with ISO 1940-1. Once balanced, the maximum vibration measured of the fan must not exceed 5 mm/s.

5.3 NON-DESTRUCTIVE EXAMINATION

Carry out non-destructive examination (NDE) of the fan blades, hub and all welds in accordance with AS/NZS 1554.1, except that ultrasonic examination must be in accordance with AS 2207.

Submit the test results as evidence of conformity in accordance with Clause 7.1.1.

5.4 SURFACE CORROSION PROTECTION AND FINISH

5.4.1 General

Apply corrosion protection treatment to all fan assembly components, including the mounting frames, in accordance with your nominated treatment schemes submitted under Clause 3.2. Unless otherwise
approved, the fan casing including all flanges must be hot-dip galvanized in accordance with AS/NZS 4680.

5.4.2 Seal All Crevices

Weld fully or otherwise seal all crevices in the fan casing or at the connection to flanges, to protect against crevice corrosion.

5.4.3 Prevent Galvanic Corrosion

Provide measures to prevent galvanic corrosion of fan components and supports due to contact between dissimilar metals.

5.4.4 Painting

Paint all jet fan and silencer casings matt black to match or blend in with the tunnel soffit. Unless otherwise agreed, painting schemes must be in accordance with AS/NZS 2312. Use paint that is suitable for the tunnel environment including the elevated temperature requirements specified in Clause 3.1.6.

5.5 PRODUCT IDENTIFICATION

5.5.1 General

Identification plates must be fabricated from stainless steel and permanently attached to the motor housing or fan outer casing, as appropriate.

5.5.2 Motor Identification Plate

Fix to each motor an identification plate showing the following:

(i) name and address of the motor manufacturer;
(ii) serial number of the motor;
(iii) model number;
(iv) motor speed in revolutions per minute;
(v) nominal power rating;
(vi) electrical characteristics of the motor.

5.5.3 Fan Identification Plate

Fix to each jet fan an identification plate showing the following:

(a) name and address of the fan manufacturer;
(b) serial number of the fan;
(c) model number;
(d) maximum safe rotational speed of the fan in revolutions per minute;
(e) design operating thrust of the fan.

5.6 MATERIAL AND COMPONENT CERTIFICATION

Submit the following documentation prior to delivery of the fans in accordance with Clause 7.1:
(a) certified inspection and test reports for fan materials verifying compliance in accordance with the ITP submitted by the fan manufacturer;

(b) certified welding inspection test results and non-destructive examination results verifying compliance for fan components and frames in accordance with the ITP submitted by the fan manufacturer.

6 FACTORY TESTING

6.1 GENERAL

Factory testing under this Specification comprises acceptance testing and production testing.

6.1.1 Hold Point

<table>
<thead>
<tr>
<th>HOLD POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Held</td>
</tr>
<tr>
<td>Submission Details</td>
</tr>
<tr>
<td>Release of Hold Point</td>
</tr>
</tbody>
</table>

The above Hold Point applies wherever different testing setups, testing procedures or acceptance criteria are proposed, and the required details have not been previously submitted.

6.1.2 Witness Point

<table>
<thead>
<tr>
<th>WITNESS POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process to be Witnessed:</td>
</tr>
<tr>
<td>Submission Details:</td>
</tr>
</tbody>
</table>

6.1.3 Third Party Certifier

Where factory testing is to be carried out overseas, the Principal may order that you engage a third party certifier approved by the Principal to verify compliance of the fan testing with this Specification. Factory testing not witnessed by the approved certifier or another party delegated by the Principal for this purpose will not be accepted for compliance verification purposes.

Payment for the services of the third party certifier, if ordered, will be made under Pay Item R164P4.
6.2 ACCEPTANCE TESTING – JET FANS

6.2.1 Number of Tests

Carry out acceptance testing on 10% of the jet fans of each type. Where the 10% value is a fraction, round it up to the next higher integer.

6.2.2 Details of Tests

Carry out the following tests as part of acceptance testing:

(a) **Thrust performance** to ISO 13350 giving measurements of developed thrust, in both forward and reverse directions (where applicable). Test the fan assembly complete with silencers for thrust performance.

Take measurements of the thrust, speed of rotation, and electrical power input at the duty point for the proposed system.

Record the motor performance characteristics including voltage, current, input power and power factor.

(b) **Noise tests** to ISO 3744 as part of item (a) under this Clause. These must be free field tests.

Record sound power levels both upstream and downstream of the fan. Measure inlet and outlet sound power levels and in the case of reversible fans, in both airflow directions.

Record sound pressure levels at 1 m and 10 m at angles of 0 and 45 degrees to the axis of the fan, both upstream and downstream of the fan. Measure inlet and outlet sound pressure levels and in the case of reversible fans, in both airflow directions.

(c) Prove the reversing cycle (if required).

(d) Prove the instrumentation operation including the output from the vibration sensors and the RTDs when the fan is operating at the design duty point.

(e) Validate the structural design with strain gauge measurements, including but not limited to the motor mounting frame.

(f) If the fan is required to operate at the elevated temperature as specified in Annexure R164/A, and acceptance testing at the elevated temperature has been ordered by the Principal, prove the fan at this elevated temperature and verify its resistance to thermal shock in accordance with ISO 21927-3.

Payment for this work will be made under Pay Item R164P5.

In lieu of carrying out acceptance testing at the elevated temperature, the Principal may accept certificates of such tests carried out on comparable fans of the same manufacture and using the same components, submitted under Clause 2.4.

6.3 ACCEPTANCE TESTING – CRADLE

6.3.1 Number of Tests

Carry out acceptance testing on at least one installation cradle and one maintenance cradle.

6.3.2 Details of Tests

Carry out the following tests as part of acceptance testing:
(a) **Functionality:**
Demonstrate the capabilities of the cradle to perform all functions of the cradle using a production jet fan complete with silencers and mounting brackets.

(b) **Lifting capacity:**
Test the cradle for lifting capacity using a test load of at least twice the intended working load.

### 6.4 PRODUCTION TESTING

#### 6.4.1 Number of Tests

Carry out production testing on all fans to be delivered.

#### 6.4.2 Details of Tests

Carry out the following tests as part of production testing:

(a) **Maximum speed test**, at 100% of maximum rated speed for 3 minutes.
Examine for loose components, damage, excessive vibration or adverse behaviour.

(b) **Over-speed test**, at 125% of maximum rated speed for 3 minutes.
Examine for loose components, damage, excessive vibration or adverse behaviour.

### 6.5 FAN CERTIFICATION

Prior to delivery of the jet fans and cradles, submit certificates of compliance for the following:

(a) acceptance testing for jet fans;

(b) production testing for jet fans;

(c) acceptance testing for installation/maintenance cradles.
7 TRANSPORT AND DELIVERY

7.1 GENERAL

7.1.1 Hold Point

**HOLD POINT**

<table>
<thead>
<tr>
<th>Process Held</th>
<th>Dispatch of jet fans, supporting frames, cradles and other ancillary items.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submission Details</td>
<td>At least 10 working days prior to dispatch, submit to the Principal: NDE test results (refer Clause 5.3), certification documents (refer Clauses 5.6 and 6.5), installation and commissioning manual(s) (refer Clause 8.2), warranty (refer Clause 9.1), and operations and maintenance manual(s) (refer Clause 9.5).</td>
</tr>
<tr>
<td>Release of Hold Point</td>
<td>The Principal will examine the submitted items prior to authorising the release of the Hold Point.</td>
</tr>
</tbody>
</table>

7.1.2 Delivery Location

Deliver the jet fans, supporting frames, cradles and other ancillary items to the location(s) stated in Annexure R164/A.

7.2 TRANSPORT

7.2.1 General

Load and transport the fans and associated ancillary items in a manner that avoids any distortion or damage to the fans, components and their protective coatings.

7.2.2 Labelling

Clearly label each packed item with the Contract number, description and quantity of the contents. Include details of the handling requirements.

7.2.3 Packing Protection

Protect the jet fans from heavy vibration during transport.

In the packing of the fans and ancillary items, use padding materials appropriate for the mode of transport to prevent damage to the fans or to their protective coatings during handling, storage and transport.

7.2.4 Corrosion Inhibitor

Protect any machined and unpainted surfaces with a temporary corrosion inhibitor compound prior to dispatch.
8 INSTALLATION SUPERVISION AND SITE ACCEPTANCE TESTING

Installation and commissioning of the jet fans is not within the scope of this Specification.

8.1 ATTENDANCE AT SITE DURING INSTALLATION AND COMMISSIONING

Provide a representative of the jet fan manufacturer who will be in attendance at the Site to supervise the installation, site acceptance testing and commissioning of the jet fans.

Payment for this attendance will be made under Pay Item R164P6.

8.2 INSTALLATION AND COMMISSIONING MANUAL(S)

8.2.1 Number of Copies

Provide three paper copies and an electronic copy of the final installation and commissioning manual(s), written in the English language, for the fans.

8.2.2 Contents

The manual(s) must include as a minimum the following:

(a) installation methodology;
(b) site acceptance testing (SAT) procedures;
(c) procedures for field testing of fans using their instrumentation sensors, in accordance with ISO 5802;
(d) commissioning procedures.

9 POST-COMMISSIONING AND MAINTENANCE

9.1 WARRANTY

Provide a written performance warranty from the manufacturer of the jet fans, for the warranty period stated in Annexure R164/A from the date of commissioning completion of the fans.

The warranty must be in the name of the Principal and must cover the repair or replacement of parts to the same standard as that required under this Specification.

9.2 DEFECTS RECTIFICATION

Rectify any defects, including replacing as necessary any defective parts, during the warranty period at no cost to the Principal.

Attend to any notification of defect within 24 hours, and complete the required rectification work within the minimum time period agreed with the Principal.
9.3 ROUTINE MAINTENANCE

The maintenance service provider must carry out routine maintenance of the fans in accordance with the submitted schedule in Clause 9.5, for the period stated in Annexure R164/A from the date of commissioning completion of the fans.

Payment for the routine maintenance including supply of spare parts and consumables will be made under Pay Item R164P3.

9.4 SPARE PARTS AND CONSUMABLES

Supply all parts and consumables required for defect rectification and routine maintenance over the warranty and routine maintenance period.

All replacement parts used must be new and of the same make and model as the original.

9.5 OPERATION AND MAINTENANCE MANUAL(S)

9.5.1 Number of Copies

Provide three paper copies and an electronic copy of the operation and maintenance manual(s), written in the English language, for the fans.

9.5.2 Contents

The manual(s) must include, but are not limited to, the following:

(a) operation procedures, including measures to maximise bearing life;
(b) routine maintenance/servicing procedures;
(c) routine maintenance schedules;
(d) all design parameters;
(e) schedule of fan and components models, serial numbers and suppliers;
(f) designation, part numbers and commercial sources of spare parts;
(g) storage and maintenance requirements for the fans and ancillary items.

9.6 TOOLS AND ACCESSORIES

Provide two sets of all special tools and accessories required for operation and maintenance of equipment provided.
ANNEXURE R164/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.2.1.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R164/A)

Complete the tables below by deleting whichever option is not applicable and filling in the required details. For advice on how to complete the tables, contact the Tunnel Technology Unit in Motorway Management.

A1  GENERAL REQUIREMENTS

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R164/A)

In the table below, the warranty period should normally be the same as the routine maintenance period.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.1</td>
<td>Electrical power supply (ph/V/Hz)</td>
<td>….. / ….. / …..</td>
</tr>
<tr>
<td>3.1.7</td>
<td>Design life</td>
<td>….. years</td>
</tr>
<tr>
<td>4.6.1</td>
<td>In-tunnel noise level</td>
<td>….. dBA or NR …..</td>
</tr>
<tr>
<td>7.1.2</td>
<td>Delivery location (1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jet fans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance cradles</td>
<td></td>
</tr>
<tr>
<td>9.1</td>
<td>Warranty period</td>
<td>….. years (2)</td>
</tr>
<tr>
<td>9.3</td>
<td>Routine maintenance period</td>
<td>….. years (2)</td>
</tr>
</tbody>
</table>

Notes:
(1) Delivery location is the Site unless stated otherwise above.
(2) Starting from the date of commissioning completion.

A2  FAN TYPE AND QUANTITY

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R164/A)

In the table below, “Fan designation” refers to an identifying code number for the particular fan type (e.g. JFN-01) shown on the Drawings.

Additional specific details may also be nominated within section A2 if required. This may include motor size, fan efficiency if there are known and project specific limitations with respect to power availability.

Where there is more than one fan type, insert additional columns in the table.
<table>
<thead>
<tr>
<th>Clause</th>
<th>Parameter</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2.1</td>
<td>Fan designation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Installation location</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Type</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quantity required:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Jet fans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maintenance cradles</td>
<td></td>
</tr>
<tr>
<td>3.1.2</td>
<td>Forward thrust, nominal (N)</td>
<td></td>
</tr>
<tr>
<td>3.1.3</td>
<td>Flow direction</td>
<td>Unidirectional / Reversible</td>
</tr>
<tr>
<td>3.1.6</td>
<td>Elevated temperature operation</td>
<td>.....°C for ..... hours</td>
</tr>
<tr>
<td>3.1.12</td>
<td>Impeller diameter, nominal (mm)</td>
<td></td>
</tr>
<tr>
<td>4.2.1</td>
<td>Variable speed drive operation</td>
<td>Yes / No</td>
</tr>
</tbody>
</table>
ANNEXURE R164/B – MEASUREMENT AND PAYMENT

B1 MEASUREMENT AND PAYMENT

Refer to Clause 1.2.2.

Payment will be made for all costs associated with completing the work detailed in this Specification in accordance with the following Pay Items.

Where no specific pay items are provided for a particular item of work, the costs associated with that item of work are deemed to be included in the rates and prices generally for the Work Under the Contract.

Pay Item R164P1 - Supply of Tunnel Jet Fans

The unit of measurement is “each” tunnel jet fan supplied.

The rate covers the cost of all work and materials associated with the supply of the jet fans and associated ancillary items such as mounting frames, including their design, manufacture, factory testing and certification, and provision of manuals and any tools and accessories required for operation and maintenance.

The rate excludes acceptance testing at elevated temperature, which is paid under Pay Item R164P5 below.

Unless stated otherwise, the rate includes delivery to the Site or to a location stated in Annexure R164/A.

Where more than one jet fan type is required under this Specification, provide separate rates for each fan type.

Where complete jet fans are proposed by the Contractor and ordered by the Principal as spares, they will be paid under this Pay Item.

Pay Item R164P2 - Supply of Cradles

The unit of measurement is “each” cradle supplied.

The rate covers the cost of all work and materials associated with the supply of the cradles, including design, fabrication and corrosion protection treatment of the cradles, and material and component certification.

Unless stated otherwise, the rate includes delivery to the Site or to a location stated in Annexure R164/A.

   Pay Item R164P2.1 - Installation Cradles
   Pay Item R164P2.2 - Maintenance Cradles

Pay Item R164P3 - Routine Maintenance Including Supply of Spare Parts

This is a Lump Sum item.
The Lump Sum covers the cost of all work and materials associated with routine maintenance of the jet fans for the period specified in Annexure R164/A3, including supply of all spare parts and consumables.

**Pay Item R164P4 - Third Party Certifier (Provisional Sum)**

This Pay Item is a Provisional Sum.

Payment will be the amount paid to the third party certifier, engaged by you, for verification of the jet fan manufacture and testing, plus the provisional sum margin added in accordance with Clause 55.4 of the GC21 “General Conditions of Contract”.

**Pay Item R164P5 - Acceptance Testing at Elevated Temperature (Provisional Quantity)**

The unit of measurement is “each” acceptance testing carried out at elevated temperatures. The quantity is a Provisional quantity.

The rate covers the cost of all work and materials associated with carrying out the acceptance testing at the specified elevated temperature, including the costs of any additional fans required to be manufactured for the test.

Where acceptance testing at elevated temperature for more than one jet fan type is required under this Specification, provide separate rates for each type.

**Pay Item R164P6 - Attendance by Fan Manufacturer’s Representative at the Site (Provisional Quantity)**

The unit of measurement is the “man-day”. This quantity is a Provisional quantity, and is measured as the number of days spent by the fan manufacturer’s representative in attendance during installation, acceptance testing and commissioning of the jet fans. It includes any time required for travelling from the location where the representative is normally based to the Site.
ANNEXURE R164/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

<table>
<thead>
<tr>
<th>Clause</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.1</td>
<td>Hold</td>
<td>Manufacture of each type of jet fan</td>
</tr>
<tr>
<td>6.1.1</td>
<td>Hold</td>
<td>Acceptance and production testing of each type of jet fan</td>
</tr>
<tr>
<td>6.1.2</td>
<td>Witness</td>
<td>Each acceptance and production testing of jet fans</td>
</tr>
<tr>
<td>7.1.1</td>
<td>Hold</td>
<td>Dispatch of jet fans and ancillary items.</td>
</tr>
</tbody>
</table>

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TfNSW Q Annexure Q/E.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description of Identified Record</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>Details of proposed fan system maintenance service provider</td>
</tr>
<tr>
<td>3.2</td>
<td>Drawings and other technical information of fans</td>
</tr>
<tr>
<td>5.3</td>
<td>NDE test reports</td>
</tr>
<tr>
<td>5.6</td>
<td>Material and component certification</td>
</tr>
<tr>
<td>6.4</td>
<td>Fan acceptance and production testing certification</td>
</tr>
<tr>
<td>8.2</td>
<td>Installation and commissioning manual(s)</td>
</tr>
<tr>
<td>9.1</td>
<td>Warranty</td>
</tr>
<tr>
<td>9.5</td>
<td>Operation and maintenance manual(s)</td>
</tr>
</tbody>
</table>
ANNEXURE R164/D – PLANNING DOCUMENTS

Refer to Clause 1.2.4.

The following documents are a summary of documents that must be included in the PROJECT QUALITY PLAN. The requirements of this Specification and others included in the Contract must be reviewed to determine additional documentation requirements.

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description of Document</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2</td>
<td>Inspection and Test Plan (ITP) for manufacture of fans</td>
</tr>
<tr>
<td>5.3</td>
<td>NDE procedures</td>
</tr>
<tr>
<td>6.2</td>
<td>Acceptance testing procedures</td>
</tr>
<tr>
<td>6.4</td>
<td>Production testing procedures</td>
</tr>
</tbody>
</table>
## ANNEXURE R164/E – EQUIPMENT SCHEDULE

Complete the schedule shown below with details of the jet fan proposed for the Contract and submit it in accordance with Clause 3.2 prior to commencement of manufacture of the fans.

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designation</td>
<td></td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Make</td>
<td></td>
</tr>
<tr>
<td>Model</td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td></td>
</tr>
<tr>
<td>Rated thrust, minimum (N)</td>
<td></td>
</tr>
<tr>
<td>Forward</td>
<td></td>
</tr>
<tr>
<td>Reverse</td>
<td></td>
</tr>
<tr>
<td>Exit velocity (m/s)</td>
<td></td>
</tr>
<tr>
<td>Speed (rpm)</td>
<td></td>
</tr>
<tr>
<td>Absorbed power (kW)</td>
<td></td>
</tr>
<tr>
<td>Efficiency ($N_{thrust}/kW_{power}$)</td>
<td></td>
</tr>
<tr>
<td>Impeller diameter (mm)</td>
<td></td>
</tr>
<tr>
<td>Pitch angle (degrees)</td>
<td></td>
</tr>
<tr>
<td>Motor type</td>
<td></td>
</tr>
<tr>
<td>Motor frame size, L x W x D (m)</td>
<td></td>
</tr>
<tr>
<td>Motor power input (kW)</td>
<td></td>
</tr>
<tr>
<td>Electrical power supply (ph/V/Hz)</td>
<td></td>
</tr>
<tr>
<td>Power factor</td>
<td></td>
</tr>
<tr>
<td>Start up amperage (A)</td>
<td></td>
</tr>
<tr>
<td>Resistance temperature detector (Yes/No)</td>
<td></td>
</tr>
<tr>
<td>Elevated temperature operation ($\cdots{}^\circ{}C$ for $\cdots{}$ hours)</td>
<td></td>
</tr>
<tr>
<td>Variable speed drive capable (Yes/No)</td>
<td></td>
</tr>
<tr>
<td>Direct on line capable (Yes/No)</td>
<td></td>
</tr>
<tr>
<td>Corrosion protection type</td>
<td></td>
</tr>
<tr>
<td>Bearing type</td>
<td></td>
</tr>
<tr>
<td>Bearing life (hours)</td>
<td></td>
</tr>
<tr>
<td>Jet fan fall protection (Yes/No)</td>
<td></td>
</tr>
<tr>
<td>Anti-vibration mounting type</td>
<td></td>
</tr>
<tr>
<td>Bearing over temperature ($^\circ{}C$)</td>
<td></td>
</tr>
<tr>
<td>Motor rating</td>
<td></td>
</tr>
<tr>
<td>Description</td>
<td>Details</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Silencer length (m)</td>
<td></td>
</tr>
<tr>
<td>Total weight including silencers (tonne)</td>
<td></td>
</tr>
<tr>
<td>Sound power spectrum (dBW)</td>
<td></td>
</tr>
<tr>
<td>63 Hz</td>
<td></td>
</tr>
<tr>
<td>125 Hz</td>
<td></td>
</tr>
<tr>
<td>250 Hz</td>
<td></td>
</tr>
<tr>
<td>500 Hz</td>
<td></td>
</tr>
<tr>
<td>1000 Hz</td>
<td></td>
</tr>
<tr>
<td>2000 Hz</td>
<td></td>
</tr>
<tr>
<td>4000 Hz</td>
<td></td>
</tr>
<tr>
<td>8000 Hz</td>
<td></td>
</tr>
<tr>
<td>Sound pressure @ 3m dBA</td>
<td></td>
</tr>
<tr>
<td>MTBF (hours)</td>
<td></td>
</tr>
<tr>
<td>MTTR (hours)</td>
<td></td>
</tr>
</tbody>
</table>

ANNEXURES R164/F TO R164/L – (NOT USED)
ANNEXURE R164/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.5.

TfNSW Specifications

TfNSW B201    Steelwork for Bridges
TfNSW B240    Supply of bolts, nuts, screws and washers
TfNSW Q       Quality Management System

Other TfNSW Documents

GC21          General Conditions of Contract

Australian Standards

AS 1359       Rotating electrical machines (all parts)
AS/NZS 1554.1 Structural steel welding - Welding of steel structures
AS 2207       Non-destructive testing - Ultrasonic testing of fusion welded joints in carbon and low alloy steel
AS/NZS 2312   Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings - Parts 1 & 2
AS/NZS 2729   Rolling bearings - Dynamic load ratings and rating life
AS/NZS 3013   Electrical installations - Classifications of the fire and mechanical performance of wiring system elements
AS 4100       Steel structures
AS 4312       Atmospheric corrosivity zones in Australia
AS/NZS 4680   Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
AS 60529      Degrees of protection provided by enclosures (IP Code)

International Standards

ISO 1940-1    Mechanical vibration - Balance quality requirements for rotors in a constant (rigid) state - Part 1: Specification and verification of balance tolerances
ISO 3744      Acoustics - Determination of sound power levels and sound energy levels of noise sources using sound pressure - Engineering methods for an essentially free field over a reflecting plane
ISO 5802      Industrial fans - Performance testing in situ
ISO 9001      Quality management system - Requirements
ISO 13350     Fans - Performance testing of jet fans
ISO 21927-3   Smoke and heat control systems - Part 3: Specification for powered smoke and heat exhaust ventilators