TRANSPORT FOR NSW (TfNSW)

QA SPECIFICATION R163

TUNNEL VENTILATION AXIAL FANS

REVISION REGISTER

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 0		First issue.	GM, CB	16.02.17
Ed 1/Rev 1	3.2 (l) 4.8.1 Annex M	Reference to "B241" replaced by "B201". Reference to "B201" inserted. Referenced documents updated.	DCS	27.10.17
Ed 1/Rev 2	Global	References to "Roads and Maritime Services" or "RMS" changed to "Transport for NSW" or "TfNSW" respectively.	DCS	22.06.20
Ed 1/Rev 3	1.3.1 2.4 (l) 3.1.1 (c) 3.1.2 3.1.5 3.1.8 3.2 4.1.3 (b)	Definition of "duty point" clarified. "Total pressure" added to definitions. "EN 12101-3" added as alternative to "ISO 21927-3". "water seepage" added as another source of water ingress. Design duty point of "static pressure" changed to "total pressure". Requirement to provide stall detection and warning system added. Option for contractor to propose alternative (lower) factors of safety for design loads, removed. Item (b) – "ANSI/AMCA 210" added as alternative to "ISO 5801". Item (k) – Corrosion protection treatment schemes to comply also with "ISO 14713" and "ISO 12944". "template" added as alternative to "index marks" for indicating design operating blade setting.	EDCS	18.11 20

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 3 (cont'd)	4.2.1	Item (e) – Minimum power factor clarified as that prior to installation of VSD.		
		Item (f) – enclosure IP rating clarified.		
	4.2.2	"IEC 60529" added as alternative to "AS 60529".		
		Motor control requirements clarified.		
	4.2.3	Previous clause titled "Removal of Motor" deleted and replaced by new clause titled "Motor Voltage Rating".		
	4.3.1	Basic rating life requirement updated.		
	4.3.3	Bearing design life to be independent of fan design life.		
	4.3.5	New clause on bearing insulation for fans operated by VSD.		
	4.4.1	Vibration monitoring requirements added.		
	4.4.3	"IEC 60529" added as alternative to "AS 60529".		
	4.5.5	"motor" added to "fan impeller" to be also accessible for inspection and maintenance in fully ducted fan.		
	5.2.2	Dynamic balancing requirements clarified.		
		"ISO 1940-1" changed to "ISO 21940-11" and "ANSI/AMCA 204" added as alternative to "ISO 21940-11".		
	5.3	NDE requirements updated.		
	5.4.1	"ASTM A123M" and "ISO 1461" added as alternatives to "AS/NZS 4680" for hot-dip galvanizing.		
	6.2.2	Item (a) – "ANSI/AMCA 210" added as alternative to "ISO 5801".		
		Item (b) – "ANSI/AMCA 301" added as alternative to "ISO 3744".		
		Item (f) – "EN 12101-3" added as alternative to "ISO 21927-3".		
	8.2	New clause titled "Fan Installation with VSDs". Subsequent clauses renumbered.		
	Annex A1	Table – default design life and warranty period specified.		
		Notes (3) & (4) added.		
	Annex A2	Table – Note (1) applicable to "Total pressure" instead of "Static pressure".		
		Note (1) – "static pressure" changed to "total pressure".		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 3 (cont'd)	Annex M	Referenced documents updated.		
Ed 1/Rev 4	1.2.3	References to "TfNSW Q" replaced by TS 01572.1 (TfNSW Q6).	DT-M&E	24.04.24
	2.4 (a) & (g)	Detailed drawings added to technical information		
	3.1.3	Time to change from full flow in one direction to full flow in the opposing direction updated.		
	3.1.5	Stall prevention requirements updated.		
	3.2 (k)	Documents on fan motors added.		
	3.2 (m)	Reference to "B201" replaced by "TS 01744.1"		
	3.2 (p)	Additional documents on welding added.		
	4.1.1	Consideration on design life added.		
	4.1.3 (c)	Provisions of blade stops removed.		
	4.1.5	Stresses at overspeed requirement clarified.		
	4.2.1 (a)	"AS 1359" replaced with "AS 60034".		
	4.2.1 (b)	Variable speed motors included		
	4.2.1 (c)	Soft starters included.		
	4.2.1 (g)	Anti-condensation heaters control requirement added.		
	4.2.1 (i)	Time to accelerate from standstill to full forward running speed updated.		
	4.2.1 (l)	Minimum motor efficiency in accordance with IEC 60034-30-1 Class IE3 or equivalent added.		
	4.2.1 (m)	Motors connected to variable speed drives to be in accordance with IEC TS 60034-25 added.		
	4.2.3	Motor voltage rating requirement updated.		
	4.3.1	"AS 2729" replaced with "ISO 281".		
	4.3.3	Lubricant availability requirement and ability for lubrication lines to be cleared included.		
	4.4.1	Vibration sensors requirement re-worded for clarity.		
	4.4.4	"Instrumentation and leads" replaced with "wiring and cabling".		
	4.5.2	Requirement for bushing in fan casing removed.		
	4.5.5	Access hatch requirement updated.		
	4.6.2	Flexible connection requirements updated.		

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
	4.8.1	Reference to “B201” replaced by “TS 01744.1” and “B240” replaced by TS 00033.		
	5.2.2	Balancing requirement updated.		
	5.3	NDE requirements updated.		
	5.5.3 (f)	Asset identifier included.		
	6.2.2 (c)	Requirements on fan start stop and number of starts per hour included.		
	6.2.2 (e) & 6.3.2 (b)	Over speed test requirement clarified and moved to acceptance test instead of production test.		
	7.2.1	Transportation general requirements updated.		
	8.3.2 (e)	Factory acceptance test (FAT) test reports added.		
	9.5.2 (b), (d), (h) & (j)	Operation and maintenance manual content updated to include detailed drawings, refurbishment schedules, spare parts list, suppliers local contact details of maintenance partners.		
	Annexure A A2	Soft starters added.		
	Annexure C2	Reference to “TfNSW Q” replaced by TS 01572.1 (TfNSW Q6).		

GUIDE NOTES

(Not Part of Contract Document)

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 C12 "Request for Tenders" document.

Transport for NSW

QA SPECIFICATION R163

TUNNEL VENTILATION AXIAL FANS

TS 02174.1
IC-QA-R163

VERSION FOR:
DATE:

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CLAUSE PAGE

FOREWORD

TFNSW COPYRIGHT AND USE OF THIS DOCUMENT

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REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R163 Edition 1 Revision 3.

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~~.

TfNSW QA SPECIFICATION R163

TUNNEL VENTILATION AXIAL FANS

1 GENERAL

1.1 SCOPE

This Specification sets out the requirements for the supply of tunnel ventilation axial fans and related items such as casing, instrumentation, anti-vibration mounts and fan mounting frame, covering their design, manufacture, factory testing, documentation and delivery.

This Specification excludes requirements for installation of the axial fan equipment, supply and installation of anchor bolts, and the supply and installation of all cabling (power and communications) beyond the 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 R163/A.

The types of axial fans and the number of each type required under the Contract are stated in Annexure R163/A.

1.2.2 Measurement and Payment

The method of measurement and payment is detailed in Annexure R163/B.

1.2.3 Schedules of HOLD POINTS, WITNESS POINTS and Identified Records

The schedules in Annexure R163/C list the **HOLD POINTS** and **WITNESS POINTS** that must be observed. Refer to Specification TS 01572.1 (TfNSW Q6) for definitions of **HOLD POINTS** and **WITNESS POINTS**.

The records listed in Annexure R163/C are **Identified Records** for the purposes of TS 01572.1 (TfNSW Q6) Annexure Q/E.

1.2.4 Planning Documents

The PROJECT QUALITY PLAN must include each of the documents and requirements listed in Annexure R163/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 R163/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
Duty point	Operating point on the total pressure-flow performance curve for the fan
Flow reversal	Change in operating direction of fan flow, i.e. from flow in one direction to flow in the opposing direction
Total pressure	Static pressure plus dynamic pressure

1.3.2 Acronyms

DOL	Direct on line
ITP	Inspection and Test Plan
MTBF	Mean Time Between Failure
MTTR	Mean Time To Repair
NDE	Non-destructive examination
RTD	Resistance temperature detector
VSD	Variable speed drive

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 axial fan(s) proposed.

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

2.2 MANUFACTURER'S QUALIFICATIONS

Submit documentation demonstrating that:

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

(b) Comparable axial fan 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 axial 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 axial fan manufacturer:

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

(b) Typical Inspection and Test Plan (ITP) used for the manufacture and assembly of axial 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 fan system with this Specification, in the case where the 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, may require you to engage a third party certifier to undertake the audits and inspections, of the manufacturer's procedures and processes including testing during the course of the Contract.

2.4 TECHNICAL INFORMATION

Submit the following technical information:

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

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

(c) Performance curves in the forward flow direction, and reverse flow direction if specified, at all duty points.

(d) Aerodynamic efficiencies in the forward flow direction, and reverse flow direction if required, at all duty points.

(e) Anticipated sound power spectrum.

(f) Catalogue(s) of the proposed axial fans and their instrumentation sensors.

(g) General assembly and detailed drawings for axial fans of the same or similar design as that proposed including impeller and motor mount details. The drawings must include a list of fan components, stating for each component the name of supplier, the material used and applicable manufacturing standards and drawing reference.

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

(i) Proposed corrosion protection treatment regimes.

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

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

(l) Evidence that fans of the same or similar design as that proposed are capable of operating at the elevated temperature specified in Annexure R163/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 and/or EN 12101-3 on comparable fans of the same manufacture and using the same components, at a date no longer than two years prior.

(m) 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 axial fans and fan mounting frames 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 general washing and water seepage

(d) normal operating temperatures ranging from 0 to 55°C

(e) attack by vermin and insects.

The axial fans must also be suitable for operation using the electrical power supply stated in Annexure R163/A.

3.1.2 Fan Performance

The axial fans must be capable of continuous operation at the design duty points (flow rate and total pressure) stated in Annexure R163/A.

The nominal speed and nominal absorbed power of the axial fans are stated in Annexure R163/A.

3.1.3 Reversibility

Where so specified in Annexure R163/A, the axial fans must be capable of reversible flow operation.

Reversible fans must be capable of changing from full flow in one direction to full flow in the opposing direction, within 90 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 axial fan to operate at maximum aerodynamic efficiency at the design duty point flow rate (refer Clause 3.1.2) in the forward flow direction.

For single duty fans, efficiency in the forward flow direction must not be less than 70%. If reversible fans are required, the aerodynamic efficiency in the reverse flow direction must not be less than 90% of the forward flow direction.

3.1.5 Stalling

The fan pressure must be able to increase continuously without stalling from the full flow/zero pressure to the maximum design pressure required during operation. The transient back pressure must be taken into consideration in the design and selection of the fan to ensure that the fans will not stall.

Provide stall detection, and associated warning system capable of sending alarm notifications to the control system. Alternatively, fans must be fitted with anti-stall devices.

This is applicable to both directions for reversible fan.

3.1.6 Elevated Temperature Operation

Design the axial fans and all components required for a fully functioning fan assembly, to continue to operate at the elevated temperature performance where so specified in Annexure R163/A.

3.1.7 Design Life

Design the axial fans and other components for the design life specified in Annexure R163/A.

3.1.8 Static and Dynamic Design Loads

Design all structural and mechanical parts of the axial 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).

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.

3.1.9 Balancing

Design the axial fans so that they are balanced both statically and dynamically.

3.1.10 Accessibility for Maintenance

Design the axial fan to be accessible for maintenance in a safe manner.

Axial fans must be removable from the mounting frame and any connected ductwork.

3.1.11 Lifting Points

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

3.1.12 Dimensions and Mounting Orientation

The nominal diameter of the fan impeller, and the fan mounting orientation are stated in Annexure R163/A.

3.2 DOCUMENTATION SUBMISSION

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

(a) Completed equipment schedule for the axial fan system as set out in Annexure R163/E.

(b) Fan performance curves, tested in accordance with ISO 5801 and/or ANSI/AMCA 210, including contours of fan shaft power, based on an air density of 1.2 kg/m^3.

If reverse flow is required, provide data for both forward and reverse flow.

(c) Workshop drawings of the axial 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 axial fan assembly, details of their interface points with the plant room structure and details of their interface with any connected components.

(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) Details of the fan bearings if "sealed for life" type bearings are proposed.

(k) Details of the fan motor and its components including workshop drawings, motor winding and insulation details, manufacturer's operating and maintenance instructions and part lists.

(l) 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, ISO 14713 and ISO 12944. The nominated treatment must be based on the installation conditions and the corrosion rate classification specific to the equipment location.

(m) Nominated standards or procedures for the fabrication of all steel components, where these are not in accordance with Specification TS 01744.1 (TfNSW B201). In particular, provide details of the welding standards for fabrication of all steel components, including fan casings and support frames.

(n) Nominated standards or procedures for the fabrication of all non-steel components.

(o) ITP for manufacture of the fans detailing inspection and testing methods and their applicable standard, including NDE procedures.

(p) Welding and material procurement plan that includes proposed material standards, welding procedure specifications, procedure qualification records, welder qualification records, weld maps and fatigue life enhancement methods.

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

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

(s) Manufacturing and delivery programme.

(t) Installation and commissioning manual(s).

(u) Operations and maintenance manual(s).

For items (t) and (u) 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 8.3 and 9.5.

4 MATERIALS AND COMPONENTS

4.1 IMPELLER

4.1.1 Materials

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

4.1.2 Impeller Blade Section

For unidirectional axial 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 Adjustable Pitch Blades

Fit the fans with adjustable pitch blades that:

(a) are adjustable in their installed position when the fan is stationary, without removing the hub

(b) have index marks or a template indicating the design operating blade setting and a minimum of three increments of stagger angle above and below the operating point

(c) cannot be set at angles that will overload the motor

(d) will not seize over time.

Make allowance when sizing the motor during fan selection for pitch adjustment to give higher or lower flow rates.

4.1.4 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.

4.1.5 Stresses at Over-speed

Design the impeller to withstand stresses generated from 125% of the maximum rated speed.

4.2 MOTOR

4.2.1 Operating Characteristics

Axial fan motors must have the following characteristics:

(a) conformity with AS 60034

(b) single speed or variable speed as per duty specified in Annexure R163/A

(c) direct on line (DOL), using soft starter or variable speed drive (VSD) control, as specified in Annexure R163/A

(d) operate at the maximum motor efficiency under normal operating conditions

(e) minimum power factor of 0.85 prior to installation of VSD

(f) housed in a “totally enclosed, air over” enclosure of IP65 rating to AS 60529 and/or IEC 60529, or a “totally enclosed, fan cooled” enclosure of IP65 rating to AS 60529 and/or IEC 60529

(g) fitted with anti-condensation heaters. Heaters to be turned on automatically when motors are not operating

(h) capable of operating at the elevated temperature where so specified in Annexure R163/A for the fan

(i) able to accelerate from standstill to full forward running speed in not more than 30 seconds for DOL or soft starters and 60 seconds for VSD operated

(j) for reversible fans, compliance with the flow reversal requirement specified in Clause 3.1.3

(k) 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

(l) minimum motor efficiency in accordance with IEC 60034-30-1 Class IE3 or equivalent

(m) motors connected to VSD in accordance with IEC TS 60034-25.

4.2.2 Motor Power Terminal Box

Fit a motor power terminal box, of IP65 rating to AS 60529 and/or IEC 60529, external to each fan casing with easy access for maintenance.

Provide motor control via local isolation switches at the VSDs and the switch room, and local emergency STOP button in the terminal box.

4.2.3 Motor Voltage Rating

Where the fans are installed with VSDs, voltage impulses generated by the VSDs must not exceed the fan motor insulation voltage rating. Ensure that the motor voltage rating is suitable for the installation with respect to the locations of the VSDs, the length and types of cables between the VSDs and the fans, and overvoltage limiting devices such as dV/dt filters.

Submit an engineering analysis report to the Principal demonstrating that suitable motor impulse voltage insulation class (IVIC) is selected and VSDs comply with the motor insulation capability. The report must include calculations and measurement methodologies, testing procedures, testing outcomes, and measurements of switching amplitudes, peak voltage, voltage rise and dV/dt at motor terminals.

4.3 BEARINGS

4.3.1 Basic Rating Life

Provide fan and motor bearings with a minimum basic rating life (L_{10}) in accordance with ISO 281 of either 100,000 hours or 10 years, whichever is more stringent.

4.3.2 Damage to Stationary Fans

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

4.3.3 Lubrication

Use non-sealed lubricated bearings with a lubrication system that includes lubrication points external to the fan casing at a location that is easily accessible. Fix covers to lubrication points to prevent water and dust ingress.

Lubrication lines must be able to be cleared to eliminate blockages during lubrication.

Lubricants must be available locally within Australia throughout the design life of the fan.

You may submit for approval use of “sealed for life” bearings.

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 R163/A.

4.3.5 Bearing Insulation

Where the fans are operated by VSD, all bearings must be insulated in accordance with IEC TS 60034-25 and must be suitable for use with a VSD without an output filter.

4.4 INSTRUMENTATION

4.4.1 Vibration Sensor

Equip each axial fan with permanent sensors to measure and report out of balance vibration from the impeller, motor and bearings.

Vibration monitoring must include:

(a) Fan motor drive and non-drive end bearing accelerometers, connected to the instrumentation terminal box. These sensors must monitor the axial fan continuously while it is running and generate an alarm condition to the control system if the vibration exceeds a pre-set design limit.

(b) Fan motor drive and non-drive end bearing shock pulse monitoring sensors, terminated outside the fan room, to provide for local connection to portable vibration analysis equipment.

(c) Data acquisition by Plant Management and Control System (PMCS), which can be downloaded for the purpose of detecting trends.

4.4.2 Resistance Temperature Detector (RTD)

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

4.4.3 Instrumentation Terminal Box

Provide an instrumentation terminal box, of IP65 rating to AS 60529 and/or IEC 60529, external to the fan casing and separate from the motor terminal box, with easy access for maintenance.

4.4.4 Elevated Temperature Performance

All wiring and cabling within the air stream must be capable of operating at the same elevated temperature, in accordance with AS/NZS 3013, as that for the fan where so specified in Annexure R163/A.

4.5 FAN CASING

4.5.1 Material

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

4.5.2 Not Used

4.5.3 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, i.e. horizontally or vertically, depending on installation arrangement.

4.5.4 Location of Connections

If fan casings comprise multiple sections connected with fasteners, they must be at easily accessible locations to facilitate inspections and maintenance.

4.5.5 Access Hatch

Where the fan is fully ducted, provide an inspection panel in the fan casing and an access hatch in the transition duct to facilitate access to the fan impeller and motor for inspections and maintenance.

4.6 ANTI-VIBRATION MOUNTS AND FLEXIBLE CONNECTIONS

4.6.1 Anti-vibration Mounts

Mount each axial 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.

4.6.2 Flexible Connections

Provide flexible connections between the flanges of each fan casing and its diffusers, so that no axial or transverse forces are transmitted between the two. Flexible connections must be of the minimum length required to accommodate any vibration movement and thermal expansion and designed to ensure cross-sectional area of the air path is not less than the fan internal cross-sectional area.

4.6.3 Elevated Temperature Performance

Anti-vibration spring mounts and flexible connections must be capable of withstanding the same high temperature as that for the fans where so specified in Annexure R163/A.

4.7 FAN MOUNTING FRAME

4.7.1 General

Provide the axial fans with mounting frames to support the design loads identified in Clause 3.1.8.

4.7.2 Interface with Plant Room Structure

The interface between the fan mounting frame and the plant room structure must comply fully 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.

4.7.3 Elevated Temperature Performance

Design the mounting frame to be capable of withstanding the same elevated temperature as that specified for the fan in Annexure R163/A.

4.8 FASTENERS

4.8.1 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.

All bolts, nuts, screw and washers provided must be in accordance with the drawings and Specifications TS 01744.1 (TfNSW B201) and TS 00033.

4.8.2 Corrosion Protection

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

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

5 MANUFACTURE

5.1 GENERAL

5.1.1 Hold Point

HOLD POINT	
Process Held	Manufacture of each type of axial fans and their supports.
Submission Details	At least 20 working days prior to commencement of fabrication, submit to the Principal the documentation detailed in Clause 3.2.
Release of Hold Point	The Principal will examine the submitted items prior to authorising the release of the Hold Point.

5.1.2 Third Party Certifier

Where 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 R163P3.

5.2 FANS ASSEMBLY

5.2.1 General

Carry out the fabrication of the fan assembly, including all its individual components and related 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 to balance quality grade G 2.5 in accordance with ISO 21940-11 and/or ANSI/AMCA 204, and the appropriate fan application category in ISO 14694 and/or ISO 10816-3. Once balanced, the maximum vibration measured of the fan must not exceed the following vibration limits.

Motor rating (kW)	**Vibration limit – r.m.s (mm/s)**
≤ 300	4.5
> 300	3.5

5.3 NON-DESTRUCTIVE EXAMINATION

In addition to visual inspection in accordance with AS/NZS 5131, carry out ultrasonic and/or radiographic (x-ray), magnetic particle and/or penetrant non-destructive examination (NDE) of all components and welds in accordance with AS/NZS 5131, AS/NZS 1554.1, AS/NZS 1554.4, AS/NZS 1554.5, AWS D1.1, ASTM E164 and ISO 15614.

Welds must be able to withstand dynamic loading and high-level fatigue condition. The type and minimum extent of NDE for welds subject to fatigue must conform to the acceptance criteria specified in above standards.

Carry out radiographic (x-ray) NDE of all fan blades and hubs in accordance with EN 12681 and/or ASTM E155 for detection of discontinuities including cracks, porosity, inclusions, and cavities.

Submit NDE regimes, including the method, extent for each part and acceptance criteria, for approval by the Principal prior to manufacturing.

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

5.4 SURFACE CORROSION PROTECTION

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, ASTM A123M and/or ISO 1461.

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.

5.5 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:

(a) name and address of the motor manufacturer

(b) serial number of the motor

(c) model number

(d) motor speed in revolutions per minute

(e) nominal power rating

(f) electrical characteristics of the motor.

5.5.3 Fan Identification Plate

Fix to each axial 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 performance of the fan

(f) asset identifier.

5.6 MATERIAL AND COMPONENT CERTIFICATION

Submit the following documentation before delivery of the fans:

(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 NDE 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

HOLD POINT	
Process Held	Acceptance and production testing of each type of axial fans.
Submission Details	At least 10 working days prior to commencement of acceptance and production testing, submit to the Principal details of the testing setups, testing procedures and acceptance criteria.
Release of Hold Point	The Principal will examine the submitted items prior to authorising the release of the Hold Point.

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

WITNESS POINT	
Process to be Witnessed:	Each acceptance and production testing of fans.
Submission Details:	Notification in writing of testing, at least 10 working days prior to the date of testing. Allow for this lead time in your delivery programme.

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 R163P3.

6.2 ACCEPTANCE TESTING

6.2.1 Number of Tests

Carry out acceptance testing of at least one axial fan for each fan type.

6.2.2 Details of Tests

Carry out the following tests as part of acceptance testing:

(a) **Performance testing** to ISO 5801 and/or ANSI/AMCA 210 giving fan static pressure as a function of air flow rate with efficiency contours. Carry out the testing for a range of blade pitch angles to cover the required range of operation. Prepare similar plots giving the fan total pressure as a function of air flow rate.

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

(b) **Noise tests** as part of item (a) under this Clause.

Record sound power levels upstream and downstream of the fan. Take noise measurements at the nominal operating duty point and at the highest pressure which is required at the maximum flow rate. Carry out the tests for ducted fans to ISO 5136 or open-ended fans to ISO 3744 and/or ANSI/AMCA 301.

(c) Validate the **time taken for the fan to reach full forward running speed** from standstill and the **capability of six starts per hour**. For reversible fans, prove the **reversing cycle** including six starts per hour in either direction with at least three reversals within 20 minutes.

(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) **Over-speed test** on the fan impeller, at 125% of nominal operating speed for three minutes. Examine for loose components, damage, excessive vibration, or adverse behaviour and carry out radiographic (x-ray) or dye penetrant inspection of all fan blades for detection of defects or cracks.

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

(g) If the fan is required to operate at the elevated temperature as specified in Annexure R163/A, and the Principal has ordered acceptance testing, prove the fan at this **elevated temperature** and verify its resistance to thermal shock in accordance with ISO 21927-3 and/or EN 12101-3.

Payment for this work will be made under Pay Item R163P4.

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 PRODUCTION TESTING

6.3.1 Number of Tests

Carry out production testing on all fans to be delivered.

6.3.2 Details of Tests

Carry out the following test as part of production testing:

Maximum speed test, at 100% of maximum rated speed for three minutes. Examine for loose components, damage, excessive vibration or other adverse behaviour.

6.4 FAN CERTIFICATION

Prior to delivery of the axial fans, submit certificates of compliance for the following:

(a) acceptance testing for axial fans

(b) production testing for axial fans.

7 TRANSPORT AND DELIVERY

7.1 GENERAL

7.1.1 Hold Point

HOLD POINT	
Process Held	Dispatch of axial fans, supporting frames and other ancillary items.
Submission Details	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 6.4), installation and commissioning manual(s) (refer Clause 8.3), warranty (refer Clause 9.1), and operations and maintenance manual(s) (refer Clause 9.5).
Release of Hold Point	The Principal will examine the submitted items prior to authorising the release of the Hold Point.

7.1.2 Delivery Location

Deliver the axial fans, supporting frames and other ancillary items to the Site unless stated otherwise in Annexure R163/A.

7.2 TRANSPORT

7.2.1 General

Load and transport the axial fans and related items and provide protection during sea and road transportation and long-term storage requirements where applicable 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 axial 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 AND COMMISSIONING

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

8.1 ATTENDANCE AT SITE DURING INSTALLATION AND COMMISSIONING

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

Payment for this attendance will be made under Pay Item R163P5.

8.2 FAN INSTALLATION WITH VSDS

Where the fans are installed with VSDs, the VSDs must be located at close proximity to the fans wherever possible. If dV/dt filters are required to limit the voltage impulses generated by VSDs, the filters must also be located as close as possible to the fan motor terminals.

Prior to running the fans, the representative of the fan manufacturer in attendance at the Site must inspect the electrical installation and verify that the motor and VSD manufacturers' recommendations have been followed with respect to the locations of the VSDs, the length and types of cables between

the VSDs and the fans, and the types and locations of overvoltage limiting devices, such as dV/dt filters.

8.3 INSTALLATION AND COMMISSIONING MANUAL(S)

8.3.1 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.

8.3.2 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

(e) factory acceptance test (FAT) reports.

9 POST-COMMISSIONING AND MAINTENANCE

9.1 WARRANTY

Provide a written performance warranty from the manufacturer of the axial fans, for the warranty period stated in Annexure R163/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 R163/A from the date of commissioning completion of the fans.

Payment for the routine maintenance will be made under Pay Item R163P2.

9.4 SPARE PARTS AND CONSUMABLES

Supply all parts and consumables required for defect rectification and routine maintenance over the warranty period 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) operational procedures, including measures to maximise bearing life

(b) detailed drawings showing the complete fan assembly, details of interface points with the plant room structure and any connected components

(c) routine maintenance/servicing procedures

(d) routine maintenance schedules and recommended refurbishment schedules

(e) fan performance parameters

(f) schedule of fan and components models, serial numbers and suppliers

(g) designation, part numbers and commercial sources of spare parts

(h) recommended list of spare parts to be carried

(i) storage and maintenance requirements for the fans and ancillary items

(j) suppliers local contact details and maintenance partners.

9.6 TOOLS AND ACCESSORIES

Provide two sets of all special tools and accessories required for operation and maintenance of equipment provided.

ANNEXURE R163/A – PROJECT SPECIFIC REQUIREMENTS

Refer to Clause 1.2.1.

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R163/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.

A1 GENERAL REQUIREMENTS

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R163/A)

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

Clause	Description	Requirements
3.1.1	Electrical power supply (ph/V/Hz)	….. / ….. / …..
3.1.7	Design life	25 years ([3])
7.1.2	Delivery location ([1])	…….
9.1	Warranty period	five years ([2,4])
9.3	Routine maintenance period	….. years ([2])

Notes:

(1) Delivery location is the Site, unless stated otherwise above.

(2) Starting from the date of commissioning completion.

(3) Default design life is 25 years.

(4) Default warranty period is 5 years.

A2 FAN TYPE AND QUANTITY

NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R163/A)

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

Insert additional items in the table as required, for parameters such as:
- maximum motor size;
- minimum fan efficiency if known;
- project specific limitations with respect to power availability.

Where there is more than one fan type, insert additional columns in the table.

Clause	Parameter	Requirements
1.2.1	Fan designation	
	Installation location	
	Type	
	Quantity required	
3.1.2	Flow rate, nominal (m3/s) ([1])	
3.1.2	Pressure, nominal (Pa)	
	Total pressure ([1])	
	Static pressure	
3.1.2	Speed, nominal (rpm)	
3.1.2	Absorbed power, nominal (kW)	
3.1.3	Reversible flow operation	Yes/No
3.1.6	Elevated temperature operation	…..°C for ….. hrs
3.1.12	Impeller diameter, nominal (mm)	
3.1.12	Mounting orientation	Vertical/Horizontal
4.2	VSD operation	Yes/No ([2])

Notes:

(1) Design duty point (flow rate and total pressure).

(2) If requirement is “No”, then motor starter must be DOL or soft starter.

ANNEXURE R163/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 for the Work Under the Contract.

Pay Item R163P1 – Supply of Axial Fans

The unit of measurement is "each" tunnel ventilation axial fan supplied.

The rate covers the cost of all work and materials associated with the supply of axial 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 R163P4 below.

Unless stated otherwise, the rate includes delivery to the Site or to a location stated in Annexure R163/A.

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

Pay Item R163P2 – 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 axial fans for the period specified in Annexure R163/A, including supply of all spare parts and consumables.

Pay Item R163P3 – 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 R163P4 – Acceptance Testing at Elevated Temperature (Provisional Quantity)

The unit of measurements 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 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 R163P5 – Attendance by Fan Manufacturer's Representative at the Site (Provisional Quantity)

The unit of measurement is the "man-day". The 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 axial fans. It includes any time required for travelling from the location where the representative is normally based to the Site.

ANNEXURE R163/C – SCHEDULES OF HOLD POINTS, WITNESS POINTS AND IDENTIFIED RECORDS

Refer to Clause 1.2.3.

C1 SCHEDULE OF HOLD POINTS AND WITNESS POINTS

Clause	Type	Description
5.1.1	Hold	Manufacture of each type of axial fan
6.1.1	Hold	Acceptance and production testing of each type of axial fan
6.1.2	Witness	Each acceptance and production testing of axial fans
7.1.1	Hold	Dispatch of axial fans and ancillary items

C2 SCHEDULE OF IDENTIFIED RECORDS

The records listed below are Identified Records for the purposes of TS 01572.1 (TfNSW Q6) Annexure Q/E.

Clause	Description of Identified Record
2.4	Details of proposed fan system maintenance service provider
3.2	Drawings and other technical information of fans
5.3	NDE test reports
5.6	Material and component certification
6.4	Fan acceptance and production testing certification
8.3	Installation and commissioning manual(s)
9.1	Warranty
9.5	Operation and maintenance manual(s)

ANNEXURE R163/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.

Clause	Description of Document
3.2	ITP for manufacture of fans
5.3	NDE procedures
6.2	Acceptance testing procedures
6.3	Production testing procedures

ANNEXURE R163/E – EQUIPMENT SCHEDULE

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

Description	Details
Designation	
Location	
Fan make	
Fan model	
Quantity supplied	
Flow rate (m3/s)	
Pressure (Pa) Total pressure Static pressure	
Speed (rpm)	
Electrical power supply (ph/V/Hz)	
Power factor	
Absorbed power (kW)	
Impeller diameter (mm)	
Pitch angle (degrees)	
Motor make	
Variable speed drive capable (Yes/No)	
Direct on line capable (Yes/No)	
Motor size	
Motor rated power (kW)	
Start-up amperage (A)	
Full load amperage (A)	
Bearing type (e.g. “sealed for life”)	
Bearing life (hours)	
Resistance temperature detector (Yes/No)	
Elevated temperature operation	…..°C for ….. hours
Anti-vibration mounting type	
Bearing over temperature (°C)	
Total weight (tonne)	
Mounting arrangement (vertical or horizontal)	

Description	Details
Sound power spectrum (dBW)	
63 Hz	
125 Hz	
250 Hz	
500 Hz	
1000 Hz	
2000 Hz	
4000 Hz	
8000 Hz	
Sound pressure @ 3 m (dBA)	
MTBF (hours)	
MTTR (hours)	

ANNEXURES R163/F TO R163/L – (NOT USED)

ANNEXURE R163/M – REFERENCED DOCUMENTS

Refer to Clause 1.2.5.

TfNSW Specifications

TS 01744.1 (TfNSW B201)	Steelwork for Bridges
TS 00033	Supply of Bolts, Nuts and Washers, ATS 5420-20, Ed 1.0 MOD
TS 01572.1 (TfNSW Q6)	Quality Management (Major Works)

Other TfNSW Documents

GC21	General Conditions of Contract

Australian Standards

AS/NZS 1554	Structural steel welding
AS/NZS 1554.1	Welding of steel structures
AS/NZS 1554.4	Welding of high strength quenched and tempered steels
AS/NZS 1554.5	Welding of steel structures subject to high levels of fatigue loading
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 and 2
AS/NZS 3013	Electrical installations – Classification 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/NZS 5131	Structural steelwork – Fabrication and erection
AS/NZS ISO 9001	Quality management system – Requirements
AS 60034	Rotating electrical machines (series)
AS 60529	Degrees of protection provided by enclosures (IP Code)

Overseas and International Standards

ANSI/AMCA 204	Balance Quality and Vibration Levels for Fans
ANSI/AMCA 210	Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating
ANSI/AMCA 301	Methods for Calculating Fan Sound Ratings from Laboratory Test Data
ASTM A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM E 155	Standard Reference Radiographs for Inspection of Aluminum and Magnesium Castings

ASTM E 164	Standard Practice for Contact Ultrasonic Testing of Weldments
AWS D1.1	Structural Welding Code – Steel
EN 1993	Design of Steel Structures
EN 1993.1	Eurocode 3: Design of steel structures
EN 12101-3	Smoke and Heat Control Systems – Part 3: Specifications for Powered Smoke and Heat Control Ventilators (fans)
EN 12681	Founding – Radiographic examination
EN 12681-1	Founding – Radiographic Testing – Part 1: Film Techniques
IEC 60034	Rotating Electrical Machines (series)
IEC TS 60034-25	Rotating electrical machines – Part 25: AC electrical machines used in power drive systems – Application guide
IEC 60034-30-1	Rotating electrical machines – Part 30-1: Efficiency classes of line operated AC motors
IEC 60529	Degrees of protection provided by enclosures (IP Code)
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles – Specifications and test methods
ISO 281	Rolling bearings – Dynamic load ratings and rating life
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 5136	Acoustics – Determination of sound power radiated into a duct by fans and other air-moving devices – In-duct method
ISO 5801	Industrial fans – Performance testing using standardised airways
ISO 5802	Industrial fans – Performance testing in situ
ISO 10816-3	Mechanical vibration – Evaluation of machine vibration by measurements on non-rotating parts – Part 3: Industrial machines with nominal power above 15 kW and nominal speeds between 120 r/min and 15 000 r/min when measured in situ
ISO 12944	Paints and varnishes – Corrosion protection of steel structures by protective paint systems
ISO 14694	Industrial fans – Specifications for balance quality and vibration levels
ISO 14713	Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures
ISO 15614	Specification and qualification of welding procedures for metallic materials – Welding procedure test
ISO 21927-3	Smoke and heat control systems – Part 3: Specification for powered smoke and heat exhaust ventilators
ISO 21940-11	Mechanical vibration – Rotor balancing – Part 11: Procedures and tolerances for rotors with rigid behaviour