

# TRANSPORT FOR NSW (TFNSW)

## QA SPECIFICATION R164

### TUNNEL JET FANS

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#### 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 (k) 4.9.1 6.2.2 (a) Annex M	Reference to “B241” replaced by “B201”. Reference to “B201” inserted. “flow rate, pressure head” replaced by “thrust”. 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	3.1.1 (c) 3.1.2 3.1.8 3.1.8 (b) 4.2.1 (f) 4.2.3 4.3.3 4.4.1 4.4.2 4.5.1	“water seepage” added as another source of water ingress. “axial fans” changed to “jet fans”. Option for contractor to propose alternative (lower) factors of safety for design loads, removed. “vibration” added. “IEC 60529” added as alternative to “AS 60529”. New clause titled “Motor Voltage Rating”. Bearing design life to be independent of fan design life. Bearings to be provided with vibration sensors elaborated. “motor winding IMPR” added as alternative to “motor winding RTD”. “spun flanges” added as alternative to “continuously welded flanges” for connection to silencers.	EDCS	18.11.20

Ed/Rev Number	Clause Number	Description of Revision	Authorised By	Date
Ed 1/Rev 3 (cont'd)	4.6.2	Requirement to provide drain points at ends of silencers added.		
	4.7.1	Mounts for mounting jet fans no longer restricted to spring mounts.		
	5.2.2	Dynamic balancing requirements clarified.		
	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 (b) - noise tests requirements revised. Item (d) – “IMPR” added as alternative to “RTD”. Item (f) - “EN 12101-3” added as alternative to “ISO 21927-3”.		
	6.5	Requirement for fan to be certified to “EN 12101-3” and “ISO 21927-3” added.		
	8.2	New clause on “Fan Installation with VSDs”. Subsequent clauses renumbered.		
	Annex A1	Table - design life and warranty period specified. Notes <sup>(3)</sup> & <sup>(4)</sup> added.		
	Annex E	“Unweighted” added before “sound power spectrum”.		
Annex M	Referenced documents updated.			

## **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 the C12 "Request for Tenders" document.





# TUNNEL JET FANS

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VERSION FOR: DATE:
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## FOREWORD

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### REVISIONS TO PREVIOUS VERSION

This document has been revised from Specification TfNSW R164 Edition 1 Revision 2.

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 R164

## TUNNEL JET FANS

### 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:

<b>Critical speed</b>	Speed at which the natural frequency is generated
<b>Flow reversal</b>	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**

<b>DOL</b>	Direct on line
<b>ITP</b>	Inspection and Test Plan
<b>MTBF</b>	Mean Time Between Failure
<b>MTTR</b>	Mean Time To Repair
<b>NDE</b>	Non-destructive examination
<b>RTD</b>	Resistance temperature detector
<b>VSD</b>	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 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, may require you to 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 and water seepage;
- (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 jet 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).

Loads must include, but are not limited to:

- (a) gravity, including any lateral components;
- (b) thrust, vibration 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  $1.2 \text{ kg/m}^3$ .  
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) 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 8.3 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 or IEC 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.

#### **4.2.3 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 the 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 AS 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.

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 every bearing (including the bearings at both drive end and non-drive end), the impeller, and the motor. 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 or motor winding intelligent motor protection relays (IMPRs), 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 spun or 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 with drain points at each end of each silencer compartment such that water is not able to form a pool inside each compartment.

#### **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 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

#### **HOLD POINT**

Process Held	Manufacture of each type of jet 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 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 21940-11 to fan application category BV-4 in ISO 14694. Once balanced, the maximum vibration measured of the fan must not exceed 5 mm/s.

### 5.3 NON-DESTRUCTIVE EXAMINATION

In addition to the visual inspection in accordance with AS/NZS 5131, carry out ultrasonic and/or radiographic (x-ray) non-destructive examination (NDE) of the fan blades, hub and welds in accordance with AS/NZS 1554.1, AS/NZS 1554.4, AS/NZS 1554.5, AS 2207, ASTM E-164, EN 12681, AWS D1.1 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 that for Category SP and/or Category FP in the above standards, whichever is the most stringent.

Submit NDE regimes, including the method and extent for each part, 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 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, 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.

### **5.4.4 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:

- (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 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 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 jet fans.
Submission Details	At least 10 working days prior to commencement of acceptance and/or 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 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 13350 Section 8 “Determination of sound level”.
- (c) Prove the **reversing cycle** (if required).
- (d) Prove the **instrumentation operation** including the output from the vibration sensors and the RTDs or IMPRs 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 and/or EN 12101-3.

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;
- (d) certification to EN 12101-3 and ISO 21927-3.

## **7 TRANSPORT AND DELIVERY**

### **7.1 GENERAL**

#### **7.1.1 Hold Point**

#### **HOLD POINT**

Process Held	Dispatch of jet fans, supporting frames, cradles 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 6.5), 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 jet fans, supporting frames, cradles and other ancillary items to the Site unless stated otherwise 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 FAN INSTALLATION WITH VSDS**

Where 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, 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.

## **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.*

### A1 GENERAL REQUIREMENTS

*NOTES TO TENDER DOCUMENTER: (Delete this boxed text after customising Annexure R164/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 <sup>(3)</sup>
4.6.1	In-tunnel noise level	..... dBA or NR .....
7.1.2	Delivery location <sup>(1)</sup>	
	Jet fans	.....
	Maintenance cradles	.....
9.1	Warranty period	5 years <sup>(2, 4)</sup>
9.3	Routine maintenance period	..... years <sup>(2)</sup>

#### Notes:

<sup>(1)</sup> Delivery location is the Site unless stated otherwise above.

<sup>(2)</sup> Starting from the date of commissioning completion.

<sup>(3)</sup> Default design life is 25 years.

<sup>(4)</sup> Default warranty period is 5 years.

### 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.*

<b>Clause</b>	<b>Parameter</b>	<b>Details</b>
1.2.1	Fan designation	.....
	Installation location	.....
	Type	.....
	Quantity required:	
	Jet fans	.....
	Maintenance cradles	.....
3.1.2	Forward thrust, nominal (N)	.....
3.1.3	Flow direction	Unidirectional / Reversible
3.1.6	Elevated temperature operation	.....°C for ..... hours
3.1.12	Impeller diameter, nominal (mm)	.....
4.2.1	VSD operation	Yes / No

## **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/A, 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**

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

### **C2 SCHEDULE OF IDENTIFIED RECORDS**

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

<b>Clause</b>	<b>Description of Identified Record</b>
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)

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## **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.

<b>Clause</b>	<b>Description of Document</b>
3.2	ITP for manufacture of fans
5.3	NDE procedures
6.2	Acceptance testing procedures
6.4	Production testing procedures

**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.

<b>Description</b>	<b>Details</b>
Designation	
Location	
Make	
Model	
Quantity	
Rated thrust, minimum (N)	
Forward	
Reverse	
Exit velocity (m/s)	
Speed (rpm)	
Absorbed power (kW)	
Efficiency ( $N_{\text{thrust}}/kW_{\text{power}}$ )	
Impeller diameter (mm)	
Pitch angle (degrees)	
Motor type	
Motor frame size, L x W x D (m)	
Motor power input (kW)	
Electrical power supply (ph/V/Hz)	
Power factor	
Start up amperage (A)	
Resistance temperature detector (Yes/No)	
Elevated temperature operation	.....°C for ..... hours
Variable speed drive capable (Yes/No)	
Direct on line capable (Yes/No)	
Corrosion protection type	
Bearing type	
Bearing life (hours)	
Jet fan fall protection (Yes/No)	
Anti-vibration mounting type	
Bearing over temperature (°C)	
Motor rating	

<b>Description</b>	<b>Details</b>
Silencer length (m)	
Total weight including silencers (tonne)	
Unweighted sound power spectrum (dBW)	
63 Hz	
125 Hz	
250 Hz	
500 Hz	
1000 Hz	
2000 Hz	
4000 Hz	
8000 Hz	
Sound pressure @ 3m dBA	
MTBF (hours)	
MTTR (hours)	

**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	Steel Fasteners
TfNSW Q	Quality Management System

**Other TfNSW Documents**

GC21	General Conditions of Contract
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**Australian Standards**

AS 1359	Rotating electrical machines
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 & 2
AS 2729-1994	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/NZS 5131	Structural steelwork – Fabrication and erection
AS/NZS ISO 9001	Quality management system – Requirements
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
ASTM A123M	Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
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
IEC TS 60034-25	Rotating electrical machines - Part 25: AC electrical machines used in power drive systems - Application guide
IEC 60529	Degrees of protection provided by enclosures (IP Code)
ISO 281	Rolling bearings - Dynamic load ratings and rating life
ISO 1461	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
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 12944	Paints and varnishes - Corrosion protection of steel structures by protective paint systems
ISO 12944-2	Classification of Environments
ISO 12944-5	Protective Paint Systems
ISO 13350	Fans - Performance testing of jet fans
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
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