

**REFERENCE
INFORMATION**

MOTOR INFORMATION

External Rotor Motors

Introduction

The external rotor motor offers many attractive features such as space saving, compact design, optimum cooling, full speed controllability and low starting currents.

Single and three-phase motors are produced to the highest International Quality Assurance Standards.

Sealed-for-life ball bearings are fitted throughout the range with an L_{10} life expectancy of approximately 40,000 hours depending upon conditions of operation.

Temperature Range

The motors are designed to operate in the ambient temperature range of -15°C to $+40^{\circ}\text{C}$, but external rotor motors are often capable of operating in higher ambient temperatures. Should you have such a need, refer your enquiry to one of our sales offices.

Enclosure Standard

The minimum is IP44 in accordance with DIN40050 and AS 60529: 2004.

Special Features

Speed Control

External rotor motors are inherently suited to speed control using either electronic or auto-transformer controllers.

Three phase external rotor motors can be speed controlled using Inverters with the following restrictions:

1. Inverter output frequency must not be set over 50Hz. External rotor motors are sized to suit the fan impeller at the maximum synchronous speed and do not have the reserve capacity to provide the extra power required for faster speeds.
2. All frequency Inverters must include “all pole effective sinusoidal filters”
3. DV/DT filters are not a suitable replacement for “all pole sinusoidal filters”

Note that warranty is void if an all pole sinusoidal filter is not used when speed controlling an external rotor with a frequency inverter.

Care must be taken when selecting speed controllers as the amperage drawn by some motors when being speed-controlled, can exceed the rated full load amps. This characteristic is more apparent at approximately 70% of full speed and must be considered when selecting the controller to ensure the controller rating is sufficient for all conditions.

Whilst the drawn amps may exceed the nominal nameplate amps, there is little likelihood of damage being done to the motor. The overload should be sized to accommodate the excess amperage.

A number of identical fans can be controlled from a single controller but the total amps of all the motors must not exceed 85% of the controller rating.

Star/Delta Motors

Most three-phase external rotor motors used with backward-curved centrifugal fans are fitted with 2-speed star/delta motors as standard.

These motors enable full speed to be obtained when connected in delta and a reduced speed when connected in star. The ratio of the speeds obtained is approximately 1.3:1 (reduced speed in slip) which approximates to a slightly higher speed than the next synchronous speed down.

These speeds can be obtained by connecting directly to either delta or star. Alternatively, by using a star/delta switch, either speed can be obtained at will.

Thermal Contacts

Thermal contacts are fitted as standard to all external rotor motors.

Embedded deep in the windings of the motors, the contacts are bi-metal cutout design which are temperature-dependent. Should the temperature of the motor rise to the limit, the bi-metal cutouts activate and cut off the power, thereby providing full protection to the motor.

Re-starting the motors is achieved by two methods:-

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- Auto-reset.
- Manual-reset.

The 'auto-reset' will permit the fan motor to automatically re-start when the windings cool down. It is recommended they be connected to a current control relay.

The 'manual-reset' type requires the thermal contacts to be wired to a remote trip contactor which has to be reset manually.

Supply Voltage

As the speed of external rotor motors can be controlled by varying the applied voltage, they can be used where the voltage varies from the standard of 240V/1ph/50Hz or 415V/3ph/50Hz without detrimental effect to the motor. Indeed, on voltages as low as 200 volt on single-phase, or 346 volt on three-phase supply, only a slight reduction of the motor speed would be detected.

Tropic-Proofing

Tropic-proofing consists of an anti-fungal treatment of the windings. Further modifications may be necessary for high humidity applications.

Warranty

Note that warranty is void if the thermal contacts are not used.

AS/NZS3000:2007 wiring rules state that motors required to run unattended shall be fitted with over-temperature devices such as thermal overload relays. If this is not complied with warranty will be void.

A licensed electrical contractor or engineer, experienced in motor protection, should be engaged to assess the motors and specific requirements of the installation.

Standard Motors

Introduction

Constructed to appropriate Australian, European and International Standards, standard motors are used to drive a range of fans extending from window and wall units to large industrial axial flow and centrifugal fans.

Standards

The standard motors used are foot, flange or pad mounted, metric type and totally enclosed as produced by most of the world's major manufacturers. They will run continuously with the minimum of attention and have been selected for their universal interchangeability and availability in countries throughout the world. The motors comply with the appropriate British, Australian and International Standards as far as:-

- Output.
- Performance.
- Dimensions.
- Minimum energy performance standard (MEPS) to AS/NZS1359.5:2004 are concerned.

Temperature Range & Altitude

In general the motors can operate in ambients from -20°C to +40°C at altitudes up to 1000 metres above sea level. Motors to operate outside this range can be supplied if required.

Enclosure Standard

The minimum is IP54 in accordance with the appropriate standards. IP55 enclosure can be supplied for fully weatherproof applications.

Finish

Standard finish is enamel paint top coat on suitable primer to give good appearance and protection for general usage. Alternative finishes such as epoxy coating can also be provided.

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Standard Motors (Cont.)

Speed Control

Certain sizes of single and three-phase motors are suitable for variable speed control. If the fan is controlled by a variable speed drive, the installation must be compliant with CISPR14.1:2003 to satisfy EMC compliances.

Bearings

Unless otherwise nominated, all fans are fitted with ball or roller bearings. The bearing housing of motors up to frame size D132 as a minimum, are fully enclosed, sealed-for-life and therefore do not require maintenance.

Bearings are pre-packed with grease and, under normal circumstances, last for several years.

Larger frame sizes are fitted with lubrication nipples. When these motors are fitted to axial flow fans, lubricators, extended to the outside of the fan casing to facilitate lubrication, are fitted. Grease relief valves must be fitted when extended lubrications are fitted.

Electrical Supply

Motors are generally wound for 415V/3ph/50Hz or 220-240V/1ph/50Hz, however, we can provide motors wound for all voltage and frequency variations.

Insulation

Insulation to Class F with Class B temperature rise is used throughout, allowing for operation in ambients up to +40°C. Motors for higher temperatures can be provided upon request.

Tropic-Proofing

Tropic-proofing consists of an anti-fungal treatment of the windings. Further modifications may be necessary for high humidity applications.

Multi-Speed Motors

Many applications require the maximum design conditions for only relatively short time periods, resulting in a waste of energy and consequently, a high running cost. To overcome this, fans can be supplied with 2-speed motors.

Using this method, power savings can be substantial, as well as generating much lower noise levels.

Thermal Protection

Thermal protection in the form of thermistors can be incorporated in any of the squirrel cage induction motors on request.

Thermistor overloads must be used in conjunction with these motors.

High Temperature Applications

When continuous operation in higher ambients is essential, the motor can be wound with Class H insulation.

The maximum continuous ambient temperature for Class H insulation is:-

- Class H - 80°C.

The above figure is a guide only as the maximum ambient depends upon the load being applied to the motor and the temperature rise of the motor.

If in doubt, refer to our sales office.

Smoke-Spill Applications

Contact your local Elta office.

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Motors For Hazardous Areas

Types Of Motors

The following are the main groups of motors used in hazardous locations, but not all situations are covered. Should you have an application not covered by the following, please refer to one of our sales offices.

- Ex d Flameproof motors.
- Ex e Increased safety motors.
- Ex nA Non-sparking motors.
- Ex tD Dust ignition protection motors.

Compliance To Standards

All motors suitable for use in hazardous areas are manufactured/modified in strict accordance with the conditions required by the relevant standards and the issued Certificate of Compliance, and are fully tested prior to despatch by the manufacturer.

Selection Of Motors For Use In Hazardous Areas

There are a number of defined hazardous areas covering gases and dusts. It is therefore strongly recommended that the relevant Australian Standards and Statutory Authorities be consulted prior to final selection of the motor.

Hazardous Areas

Many gases, vapours and dusts or fibres which are generated, processed, handled and stored in industry are combustible. When ignited they may burn rapidly and with considerable explosive force if mixed with air in the appropriate proportions.

Areas where gases, vapours, dusts and fibres occur in dangerous quantities are classified as HAZARDOUS.

The relevant groupings are :-

- a) **Group I:** electrical equipment for mines susceptible to firedamp.
- b) **Group II:** electrical equipment for places with an explosive gas atmosphere, other than mines susceptible to firedamp.
- c) **Group III:** electrical equipment for places with an explosive dust atmosphere.

With Group II gases, they are further subdivided into sub-groups IIA, IIB, IIC, depending upon the ignition point of the gas.

ZONAL CLASSIFICATION is also required where explosive atmospheres are present and they indicate the probability of the presence of a flammable, combustible or explosive material, the extent, dimension and shape of the hazardous areas, together with the volume in which the hazardous material can be expected. There are three zones for each:-

Gases and Vapours

- ZONE 0 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is present continuously or for long periods or frequently.
- ZONE 1 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is likely to occur in normal operation occasionally.
- ZONE 2 - place in which an explosive atmosphere consisting of a mixture with air of flammable substances in the form of gas, vapour or mist is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Dusts

- ZONE 20 - area in which an explosive atmosphere in the form of a cloud of combustible dust in air is present continuously, or for long periods or frequently.
- ZONE 21 - area in which an explosive atmosphere in the form of a cloud of combustible dust in air is likely to occur, occasionally, in normal operation.

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- ZONE 22 - area in which an explosive atmosphere in the form of a cloud of combustible dust in air is not likely to occur in normal operation but, if it does occur, will persist for a short period only.

Motors For Hazardous Areas (Cont.)

Temperature Classification

Hot surfaces can cause auto ignition of gases, vapours and dust, therefore it is necessary to ensure that the maximum surface temperature of equipment introduced into a hazardous area does not exceed the auto ignition temperature for the gas, vapour or dust in the hazardous area.

Group I - Maximum Surface Temperature 150°C

Group II - are given a Temperature Class (T) based on the maximum surface temperature of the equipment.

Temperature Classes are:-

T1 - 450°C	T4 - 135°C
T2 - 300°C	T5 - 100°C
T3 - 200°C	T6 - 85°C

ExtD motors will have a maximum permissible surface temperature rating, but do not follow the above temperature classes.

Note: For Ex d flameproof apparatus the external surface is the measured surface. For other types of protection (e.g. Ex e) internal surfaces are of equal importance if the explosive atmosphere has access to them.

Flameproof Motors Ex d, For Industrial Use

Three-phase motors

These motors are certified to Ex d and can fit a wide range of products as shown throughout the catalogue. The certificate covers gas groups IIA and IIB, temperature classification T4 and enclosure protection IP66.

The Standards complied with are IEC 60079-0:2004 and IEC 60079-1: 2007-04.

Single-phase motors

The certificate covers gas groups IIA, IIB and IIC, temperature classification T6 and enclosure protection IP66.

The Standards complied with are IEC 60079-0:2004 and IEC 60079-1: 2007-04.

Explosion Proof Motors Ex e, Increased Safety

Standard three-phase motors

These motors are certified to Ex e and can fit a wide range of products as shown throughout the catalogue. The certificate covers gas groups IIA, IIB and IIC, temperature classification T3 and enclosure protection IP55.

The Standards complied with are IEC 60079-0:2004 and IEC 60079-7:2006-07.

This Standard means the motors are also suitable for Ex n applications.

Electrical & Mechanical Specification

Voltage:	Up to 500 Volts
Insulation:	Class 'F'
Enclosure:	Totally enclosed, fan-cooled
Degree of Protection:	Up to IP66
Frequency:	50 or 60 Hz

Limited Temperature

The temperature of an external or internal surface to which the surrounding atmosphere has access, shall not exceed the LIMITING TEMPERATURE specified.

Range

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It is possible variations will arise in the kW/frame size/rpm, from one manufacturer to another from that normally referred to in normal motor standards.

Fans For Ex d & Ex e Applications

Fans for Ex d and Ex e applications, or indeed any hazardous application, can be constructed of special materials and incorporate special features.

Anti-static impellers and earthing leads are just some of the features we can provide.

Electronically Commutated (EC) DC Motors

Introduction

The Electronically Commutated DC motors featured in this catalogue are external-rotor DC motors which are suitable for AC mains supply. These motors have no wear and tear elements such as collectors or carbon brushes which used to be an undesirable component of DC motors and would require regular maintenance. The EC units consist of a brushless DC external-rotor motor with an EC controller that commutates the current in the motor windings electronically. The EC controller monitors the motor and provides interfaces for easy control of the drive. EC motors provide a high level of motor efficiency and carry on-board features that offers almost limitless flexibility in terms of automatic and manual fan speed control.

Temperature Range

These motors are generally suitable for operating in ambients from -25°C to +60°C.

Enclosure Standard

The motor enclosure standard is IP54 in accordance with the appropriate Standards.

Electrical Details

Motors are suitable for 240V or 415V, 50 or 60Hz supply. These motors should not be speed controlled by VSD or VA controller.

Insulation; Motor insulation is Class F with a 60°C winding temperature rise.

Bearings

Motors are fitted with sealed for life maintenance free bearings.

Parameter Settings

Parameters of the EC fans are programmed in our factory for best possible operation to suit the specific application requirements. It is necessary for the mechanical designer or contractor to provide details as to the application and system control requirements at the time of order.

Protection

The EC motors feature their own integral current overload and over-temperature protection. No other electrical protection is required with these units.

MOTOR ELECTRICAL PROTECTION

Introduction

Electrical supply, while generally very reliable, is subject to influences that can result in inadequately protected motors being damaged.

As the heart of the motor is the windings, they need to be protected from failure.

During normal operation, thermal, mechanical and electrical stresses can be encountered by motors.

Possible Problems

Refer to “Fan Trouble Shooting”, for a list of possible problems and solutions.

Protection Devices

There are motor protective devices available which detect a range of abnormal conditions and automatically switch off the motor.

Different protective devices and the conditions they protect are:-

Fuses

- Short circuit between phases or earth.
- High current overload.

Thermal Overload Relays

- Current overload.
- Start-up problems.
- Stalling.
- Phase imbalance (three-phase motors).
- Over-temperature.
- Phase loss (single-phasing of three-phase motors)
- Under-voltage.
- Incorrect phase sequences (three-phase motors).

Thermistors and Thermal Contacts

- Over-temperature of the windings.

INGRESS PROTECTION (IP) RATING

There is a wide range of applications that require special treatment to the motor and the various degrees of protection that are available are detailed below:-

Designation	First Numeral Protection against contact and ingress of foreign bodies	Second Numeral Protection against water.
IP44	Protection against contact with live or moving parts inside the enclosure by tools, wires, or such objects of thickness greater than 1mm. Protection against ingress of small solid foreign bodies (diameter greater than 1mm) excluding the ventilation openings (intake and discharge of external fans) and the drain hole of enclosed machine, which may have degree 2 protection.	Water splashed against the enclosure from any direction shall have no harmful effect
IP54		Water splashed against the enclosure from any direction shall have no harmful effect.
IP55	Complete protection against contact with live or moving parts inside the enclosure. Protection against harmful deposits of dust. The ingress of dust is not totally prevented, but cannot enter in an amount sufficient to interfere with satisfactory operation of the machine.	Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.
IP56		Water from heavy seas or water projected from jets shall not enter the enclosure in any harmful quantity.
IP65		Water projected by a nozzle against the enclosure from any direction shall have no harmful effect.
IP66	Complete protection against contact with live or moving parts inside the enclosure and against the ingress of dust.	Water from heavy seas or water projected from jets shall not enter the enclosure in any harmful quantity.

ELECTRICAL DATA & WEIGHTS

Standard Three Phase Motors

Motor Frame	Motor Shaft Dia.	App. wt. kg**	2 Pole* 48 rev/sec				4 Pole* 24 rev/sec				6 Pole* 16 rev/sec				8 Pole* 12 rev/sec			
			kW#	FLA	LRC	Eff%†	kW#	FLA	LRC	Eff%†	kW#	FLA	LRC	Eff%†	kW#	FLA	LRC	Eff%†
D71 _B	14	11	0.37	0.9	6.1	67.7	0.37	1.0	4.1	69.3	-	-	-	-	-	-	-	-
D71	14	16	0.55	1.3	6.1	76.0	-	-	-	-	-	-	-	-	-	-	-	-
D80 _A	19	18	0.75	1.5	7.0	83.4	0.55	1.4	4.8	72.8	0.37	1.1	2.8	66.5	-	-	-	-
D80 _B	19	22	1.1	2.2	7.3	84.4	0.75	1.9	7.5	82.2	0.55	1.7	3.1	68.2	-	-	-	-
D90S	24	25	1.5	2.9	8.4	86.4	1.1	2.6	6.2	84.0	0.75	2.0	5.5	77.7	-	-	-	-
D90L	24	30	2.2	4.3	8.7	86.5	1.5	3.4	7.0	86.2	1.1	2.8	6.2	79.9	0.55	2.0	3.26	65.5
D100L	28	38	3.0	5.7	9.0	86.7	2.2	4.7	8.3	86.5	1.5	3.6	6.0	81.9	0.75	2.1	5.7	77.2
D100L	28	44	-	-	-	-	3.0	6.2	8.0	87.4	-	-	-	-	1.1	2.9	5.6	78.6
D112M	28	52	4.0	7.1	9.2	89.6	4.0	8.2	7.3	88.9	2.2	5.2	5.7	84.9	1.5	4.2	4.7	80.8
D132S	38	70	5.5	9.9	8.0	90.2	5.5	10.6	7.1	90.2	3.0	6.6	5.9	86.3	2.2	5.1	5.6	84.9
D132S	38	73	7.5	13.3	7.9	90.6	-	-	-	-	-	-	-	-	-	-	-	-
D132M	38	85	-	-	-	-	7.5	14.3	7.4	90.5	4.0	8.8	6.4	87.2	3.0	7.0	5.8	85.6
D132M	38	87	-	-	-	-	-	-	-	-	5.5	11.8	6.6	87.9	-	-	-	-
D160M	42	130	11.0	19.5	8.0	92.0	11	20.7	7.4	91.0	7.5	15.4	6.4	89.2	4.0	9.4	5.7	86.0
D160M	42	130	15.0	26.4	7.8	92.4	-	-	-	-	-	-	-	-	5.5	12.8	6.0	86.6
D160L	42	150	18.5	32.5	7.6	92.2	15	27.6	7.5	91.8	11	22.7	6.9	89.9	7.5	16.4	6.3	87.6
D180M	48	185	22	38.6	7.9	93.0	18.5	32.8	7.9	92.3	-	-	-	-	-	-	-	-
D180L	48	200	-	-	-	-	22	38	7.9	92.8	15	29.8	6.5	90.8	11	24.5	5.8	88.7
D200L	55	260	30	53	9.0	94.1	30	53	8.8	93.6	18.5	35	8.4	92.3	15	32.8	6.6	90.8
D200L	55	265	37	65	6.5	93.3	-	-	-	-	22	42.5	8.8	92.5	-	-	-	-
D225S	55/60	310	-	-	-	-	37	64	7.6	94.1	-	-	-	-	18.5	38.5	5.6	91.4
D225M	55/60	330	45	79	9.0	93.7	45	79	9.0	94.3	30	54	7.4	92.6	22	44	5.2	92.0
D250M	60/65	430	55	93	8.9	94.6	55	95	9.1	94.4	37	65	8.0	93.2	30	59	6.0	92.4
D280S	65/70	660	75	126	9.2	94.9	75	126	7.4	95.2	45	78	7.8	93.5	37	73	6.8	93.0
D280M	65/80	700	90	147	7.1	95.4	90	151	6.6	95.9	55	96	9.0	94.2	45	86	6.7	93.4
D315S	80	1000	110	181	6.2	95.5	110	185	7.2	95.8	75	131	7.0	94.4	55	101	7.1	93.7
D315M	80/85	1100	132	222	6.0	95.5	132	221	7.0	95.5	90	155	7.1	95.0	75	139	7.3	94.5
D315L	80/85	1180	160	263	5.4	95.5	160	261	7.2	95.7	110	189	7.0	95.4	90	168	6.5	94.8
D315L	80/85	1320	-	-	-	-	-	-	-	-	132	229	7.8	95.6	110	205	6.5	95.3

* The figures in this table are to be used as a guide only.

For direct drive axial flow fan applications in normal ambient temperatures, airstream cooling enables the power available from the motors to be increased without detriment to the motor. Elta will utilise this facility whenever possible.

** Motor weight will vary depending on the manufacturer. Our data is based upon a commonly used brand of motor.

† Efficiency is at 100% of full load and will vary depending on the manufacturer. Our data is based upon a commonly used brand of motor.

Starting Amps:

Direct-on-line (D.O.L.).

= Full Load Amps x Locked Rotor Current Multiplier

= FLA x LRC

Star/delta starting

= $\frac{\text{FLA} \times \text{LRC}}{3}$

Where:

DOL = Direct-on-line

FLA = Full Load Amps

LRC = Locked Rotor Current Multiplier

The data on this page does not apply to external rotor motors.

ENERGY SUSTAINABLE DESIGN

Greenhouse Gas & Buildings

To sustain a comfortable environment within buildings we have to use energy in order to provide heating, cooling and ventilation. Reducing a building's energy usage will ultimately reduce greenhouse gas and carbon emissions, as well as save cost for the building occupant.

Electricity as generated in NSW, Australia, produces approximately 0.99kg of greenhouse gas (CO₂) for every kWh (1.3kg in Victoria); each kg contains approximately 272 grams of carbon. If we assume a fan runs for 10 hours/day, 200 days per year, then the table shown below can be used to calculate the greenhouse gas and carbon output attributable to any installation.

kW	kWh/pa	Greenhouse gas, tonnes	Carbon, tonnes
1.0	2000	1.98	0.54
2.0	4000	3.96	1.18
3.0	6000	5.94	1.62
4.0	9000	7.92	2.15

Minimising The Energy Used By Fans

Fans are a significant energy consumer but the energy that goes into running them can be minimised with careful and appropriate fan selection, ducting design and installation.

To achieve the best power saving solution:

- Select the most suitable fan for the specified duty. But remember, this may not always be the lowest cost fan. Refer to "Fan Selection - First Cost versus Life Cycle Cost" on this page.
- Ensure the fan is given a chance to operate to its fullest potential. Space restraints can result in negative system effects.
- Even without space restrictions, a lack of attention to detail can result in negative effects. For example, a slack or misaligned flexible connection on the fan inlet can cause serious loss of capacity and efficiency.
- Systems should be designed to minimise the pressure drop by paying particular attention to bad practices such as:
 - Slack or excessive length of flexible ducting.
 - Locating high pressure drop fittings close to bends or other disturbances in airflow.

An energy efficient fan and system combination is not necessarily expensive. Indeed, when running costs are considered, which they should, it generally works out to be more economical after a short running time.

Fan Selection - First Costs Versus Life Cycle Cost

A cheap fan often means that while you think you have a bargain, it may end up costing you more in the long run.

For example, we have chosen a duty of 12,000L/s @ 300Pa. Using the Intelligent Ventilation Product Selection Program, the lowest cost in-line duct mounted fan selection is a model AP1004GP6/29: a 1000 diameter fan absorbing 9.91kW with an 11kW motor running at 24r/s.

An alternative selection is a model AP1254GP6/16: a 1250 diameter fan, absorbing 7.54kW with a 7.5kW motor (in air-stream rating) at 24r/s. This difference in list price between the two fans is approximately \$400, with the second one being the more expensive and 250mm larger in diameter.

If the fan is to run for 10 hours a day, 200 days/year, then the running power used for the first selection is 22mWh and 16.7mWh for the second (using fan absorbed power (AkW) and motor efficiency @ 90%). At approximate Sydney, Australia electricity prices, this equates to an annual running cost of \$3380 and \$2500 respectively, with greenhouse gas being 21.8 tonnes and 16.6 tonnes and carbon usage being 5.9 tonnes and 4.5 tonnes.

In the period of one year, the second fan, while more expensive on first cost, will have already saved the difference in running cost against the cheaper fan. Fans have a normal life of 10-20 years, which means that the more expensive fan will save the building occupant a considerable amount over its working life. In addition, the saving in greenhouse gas and carbon will be substantial. With responsible selection of fans, energy use can be optimised.

Fan Efficiency Versus Fan Power

Fan efficiency is the energy needed to drive a fan as a comparison of the energy imparted to the air. It is usually expressed as a percentage and is traditionally based on the motor output energy. Fan efficiency is important but only has meaning when comparing fans of the same size. Here the fans showing higher efficiency levels consume less energy.

When comparing fans of different sizes, selecting on the basis of the efficiency percentage is unlikely to give the most energy efficient fan. The figure to focus on when fans of different sizes are involved is the AkW (Fan absorbed power).

Given a duty of 40,000 L/s @ 500Pa, and using the Intelligent Ventilation Product Selection Program, the selection AP1404CA9/30, a 1400 diameter in-line fan with a total efficiency of 82% appears to be the most efficient selection, consuming 46.3kW. However, the AP1806DA9/21, and 1800 diameter fan with a lower total efficiency of 77% consumes only 35.2kW – almost 25% less!

The difference comes about because of the impact the velocity pressure has on the total pressure: with the same airflow passing through each fan the velocity pressure through the 1400 dia unit will be much greater than that through the 1800 dia fan.

Formulae 1 to 4 can be applied to any fan provided the diameter does not change. If the diameter does not change the fans must be geometrically similar. The units of density, fan rotational speed and diameter are not important as long as both are the same.

In formulae 5 to 8 the units shown in the nomenclature must be used to satisfy the formulae.

$$1. \text{ Volume flow:- } q_{v2} = q_{v1} \times \left(\frac{n_2}{n_1}\right)^1 \times \left(\frac{d_2}{d_1}\right)^3$$

$$2. \text{ Pressure:- } p_2 = p_1 \times \left(\frac{n_2}{n_1}\right)^2 \times \left(\frac{d_2}{d_1}\right)^2 \times \left(\frac{\rho_2}{\rho_1}\right)^1$$

$$3. \text{ Absorbed power:- } P_{R2} = P_{R1} \times \left(\frac{n_2}{n_1}\right)^3 \times \left(\frac{d_2}{d_1}\right)^5 \times \left(\frac{\rho_2}{\rho_1}\right)^1$$

$$4. \text{ Sound Power Level:- } PWL_2 = PWL_1 + 70 \log_{10}\left(\frac{d_2}{d_1}\right) + 55 \log_{10}\left(\frac{n_2}{n_1}\right) + 20 \log_{10}\left(\frac{C_2}{C_1}\right)$$

$$5. \text{ Density:- } \rho_2 = \rho_1 \times \left(\frac{B_2}{B_1}\right) \times \left(\frac{T_1}{T_2}\right)$$

$$6. \text{ Fan Total Efficiency \%:- } \frac{q_v \times \rho_t F}{10 P_R}$$

$$7. \text{ Fan Total pressure:- } p_t F = p_s F + p_d F$$

$$\text{or Fan Static pressure:- } p_s F = p_t F - p_d F$$

$$8. \text{ Velocity pressure:- } p_d = 0.5 \rho V^2$$

$$p_d = 0.6 V^2 \text{ (Standard air, where } \rho = 1.2 \text{ kg/m}^3 \text{)}$$

Nomenclature for symbols used in this page:-

q_v	=	volume flow of air, m ³ /sec
n	=	rotational speed of fan
d	=	diameter of fan
p	=	pressure developed by the fan
ρ	=	density of air, kg/m ³
P_R	=	power absorbed by the fan, kW
B	=	barometric pressure (millibars)
T	=	absolute temperature, K (K = °C + 273)
$p_t F$	=	fan total pressure, Pa
$p_s F$	=	fan static pressure, Pa
$p_d F$	=	fan dynamic/velocity pressure, Pa
p_d	=	system dynamic/velocity pressure, Pa
V	=	velocity of air, m/sec
PWL	=	sound power level

NOMENCLATURE

	Symbol	Definition
Area	m ²	square metre
Density	r	density of air kg/m ²
Dimensions	mm	millimetre
	cm	centimetre
	m	metre
	o	square
	Ø	diameter
Electricity	Amps	amperes
	Extd	dust and ignition proof motor
	Ex d	flame-proof motor
	Ex e	explosion-proof motor
	Ex n	non-sparking motor
	kW	kilowatt
	ph	phase
	Ø	phase
Power	P _R	impeller absorbed power, kW
Pressure	kg/m ²	kilogram per square metre
	Pa	pascal
	kPa	kilopascals
	ρ _d ^F	fan dynamic/velocity pressure
	ρ _s ^F	fan static pressure
	ρ _t ^F	fan total pressure
Sound	dB	decibel
	dB(A)	decibel, A weighted
	dBW	sound power level, L _w
	Hz	frequency, Hertz
	L _p	sound pressure level, dB
	L _w	sound power level, dB
	NC	noise criteria
	NR	noise rating
	PNC	Preferred Noise Criterion
	pW	picowatt
	mpa	micropascal
Speed of rotation	r/s	revolutions per second
	rev/sec	revolutions per second
Temperature	°C	degrees celcius
	K	Kelvin, absolute temp.
Time	sec or s	seconds
Velocity	m/s	metres per second
Volumetric flow	L/s	litres per second
	m ³ /s	cubic metres per second
	q _v	volume flow
Volume	m ³	cubic metres
Weights	wt	weight
	kg	kilogram

NOMOGRAMS & CONVERSION FACTORS

