Guide to Selection of

Direct Driven, Frequency Controlled Fans

PFN 3 and PFN 5 units

Complementary documentation to the Ventil Selection Program

Version 1.0.0 and higher

1. Foreword

Starting with Version 1.0.0 onwards, Ventil includes an archive covering performance of the PFN1 fans, allowing calculation of air and sound performance in accordance with a required operating point.

The PFN fan is dealt with exactly as a belt driven fan, as it's actually a fan whose variable speed must be selected, within an allowable range, to achieve the required performance.

Version 1.0.0 of Ventil will provide the required speed and all the operating parameters at the design operating point, and also a motor selection for a belt driven application, with a PFN 1 wheel mounted on a belt driven shaft, appropriately supported on bearings. This type of unit can be supplied by Nicotra as PFN2, with a front panel supporting the inlet cone, a base frame, a bearing pedestal and, optionally, motor and belt drive.

2. Motor an drive selection for belt driven units

Motor selection is carried out with the usual procedure used for fans driven through V-belts and pulleys by a standard motor with 50 or 60 Hz line supply: the shaft power required by the fan is adjusted adding a safety margin (to cope with drive losses and operating point uncertainties) of 20% up to 10 kW shaft power, and of 15% at higher power levels. The smallest standard motor with a nominal shaft power higher than the adjusted value is than specified, and its power output is used as a starting point for drive calculation.

Drive design calculation can be carried out with the usual internal functions of the Ventil program. As the PFN2 range is still partially under development, a specific archive was not added to Ventil, and the bearing parameters included in the PFN1 archive are not representative of the real, standard PFN2 range.

As a consequence, fan bearing life figures, quoted in the belt drive selection windows and printouts, for PFN1 fans, are arbitrary and not representative of the actual PFN 2 bearings life. Real bearing life for belt driven units assembled by the customer must, of course, be calculated according to the type of arrangement and of bearings actually employed.

Please, if you need any information, ask our technical department for details.

3. Motor selection for direct driven fans with variable frequency supply

Most plug fans are used in a direct driven arrangement (similar to a standard ISO 13349 - Arrangement 4, but without a scroll) and the performance is adjusted using a static, variable frequency converter for motor supply.

The selection of a motor for direct drive, with variable speed and variable frequency operation, differs somewhat from a motor selection intended for belt driven, standard frequency operation.

For this type of unit the minimum motor power quoted by Ventil should be discarded, and the following procedure applied instead.

3.1. Standard procedure

The useful power output of a standard motor changes with the supply frequency. Downrating may be required to cope with the increased heating of the motor, when the not truly sinusoidal waveform generated by the static converter will apply high frequency harmonics to the motor windings. Any reduction in motor speed will also reduce the effectiveness of the mechanically driven auxiliary fan of the externally cooled motors.

The downrating factor for standard motors with external cooling varies somewhat between different motor manufacturers, but for prime level manufacturers the user can employ the following diagram, stating output power to nominal power ratio as a function of the ratio between applied frequency and nominal frequency.

This diagram was produced recalculating data commonly available from ABB.

If the user has any doubt that the motor actually used may be subject to more severe restrictions, it is recommended to use downrating factors supplied by the actual motor manufacturer.

The user should also remember that not all the manufacturers of standard motors will guarantee their products for use with PWM waveform supply from static converters.

Many manufacturers recommend also, in motors to be used at speeds higher than 3000 r.p.m., the use of special bearings or, at least, special grease. The user should check these details with the motor supplier.

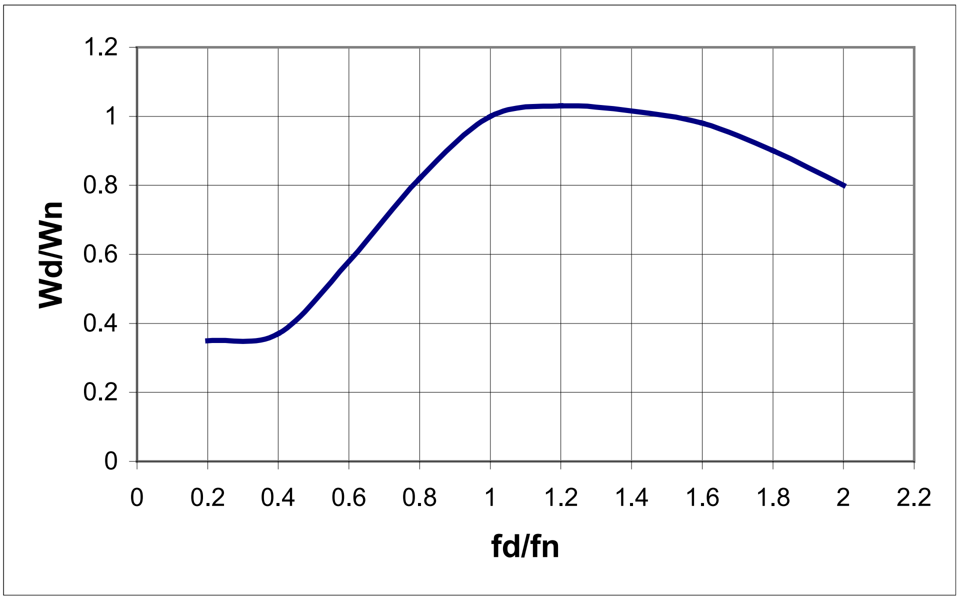

Fig. 1: Downrating factor diagram for externally cooled standard motors.

Where:

fd	*is drive frequency*
fn	*is nominal frequency of the motor*
Wd	*is motor maximum power output at drive frequency*
Wn	*is motor nominal power output*

The calculation process is relatively straightforward: first of all, from the required fan speed, estimate the driving frequency for a motor with the expected pole number:

$$f_d = (n_d + S) \cdot \frac{p}{120}$$

Where

f_d	is the estimated drive frequency in Hz
n_d	is the required speed in r.p.m.
S	is the slip speed, which, whenever cannot be better estimated, can be supposed to be equal to 50 r.p.m.
p	is the number of motor poles, e.g. 2 or 4 or 6….

Note: the diagram at the preceding page shows clearly how the pole number should be selected to avoid, whenever possible, the use of a motor with a driving frequency lower than some 35 Hz (with 50 Hz rated motors), to avoid an excessive downrating and consequently a costly oversizing of the motor.

Calculating the ratio between the required operating frequency and the nominal frequency of the motor (50 or 60 Hz), the downrating factor can be read on the diagram shown above.

The minimum required nominal power of the motor is given by the shaft power of the PFN wheel <u>divided</u> by the downrating factor read on the diagram. A further reasonable safety factor should then be added: a 5% margin is the absolute minimum recommended.

The smallest standard motor size, with a nominal power higher than the calculated minimum power, can consequently be safely selected.

The motor appropriately selected for a maximum speed power requirement can then be safely slowed down to smaller frequencies, as the shaft power requirement of the fan wheel, against a constant resistance air system, will drop more steeply then the maximum available power output of the motor. Motor manufacturers usually recommend an absolute minimum safe driving frequency of 5 Hz.

The user should also note that motors with an independently driven cooling fan or motors with an integrated frequency converter may have a significantly different, and often better, downrating curve than that shown in the diagram.

Important note:

This calculation procedure can also be applied to the selection of frequency controlled motors to be connected, through a coupling, to other types of fans, like the ADN/RDN double inlet, double width fans.

3.2. Simplified method for motor selection with direct driven PFN fans

A simplified procedure can be used to select motors for variable frequency drive in connection with PFN wheels, for PFN 3, PFN 5 or customer assembled units.

These tables cannot be used to calculate minimum motor requirements for types of fans different from the PFN range.

The following tables show, for each PFN wheel size, the maximum speed which can be achieved with each size of standard motors designed for 50 Hz operation. This speed is the maximum speed which guarantees at least a 5% power margin, in the highest load operating point along the constant speed curve, keeping into consideration the downrating factor at the necessary driving frequency.

Besides the maximum safe speed for each motor nominal power, an indication is given of the recommended pole number, the corresponding standard frame size and the driving frequency necessary to achieve the maximum allowable speed for that motor size. The different motor options are then classified in columns according to the motor shaft diameter, which *<u>must always be specified explicitly, when ordering the wheels as PFN 1</u>*.

Knowing the wheel required size and speed, from the output of the Ventil selection program, the following tables should be entered through the line referring to the selected size, looking for the smallest motor power which allows to drive the wheel at a speed equal to or higher than the required speed.

The selection achieved with this simplified method may frequently be more on the safe side than that calculated from the power consumption at the actual operating point, as the power requirement at best efficiency will be some 15% lower than the maximum power requirement at the same speed, which can be achieved at roughly 60% of the best efficiency pressure and with higher volume flow.

	Hub bore in mm:			
PFN	**11**	**14**	**19**	**24**
250	0.18 kW 63 (2p) - 2200 rpm (40 Hz) 0.25 kW 63 (2p) - 2400 rpm (44 Hz)	0.37 kW 71 (2p) 2800 rpm (50 Hz) 0.55 kW 71 (2p) 3100 rpm (75 Hz)	0.75 kW 80 (2p) 3500 rpm (61 Hz) 1.1 kW 80 (2p) 4000 rpm (70 Hz)	1.5 kW 90S (2p) 4500 rpm (78 Hz) 2.2 kW 90L (2p) 5000 rpm (86 Hz)
280		0.25 kW 71 (4p) 1950 rpm (70Hz) 0.37 kW 71 (4p) 2200 rpm (80 Hz) 0.55 kW 71 (2p) 2600 rpm (47 Hz)	0.75 kW 80 (2p) 2900 rpm (51 Hz) 1.1 kW 80 (2p) 3300 rpm (58 Hz)	1.5 kW 90S (2p) 3700 rpm (65 Hz) 2.2 kW 90L (2p) 4200 rpm (72 Hz)
315		0.25 kW 71 (4p) 1550 rpm (57Hz) 0.37 kW 71 (4p) 1800 rpm (65 Hz) 0.55 kW 71 (4p) 1950 rpm (74 Hz)	0.75 kW 80 (4p) 2200 rpm (81 Hz) 1.1 kW 80 (2p) 2500 rpm (47 Hz)	1.5 kW 90S (2p) 2800 rpm (51 Hz) 2.2 kW 90L (2p) 3100 rpm (58 Hz)
355		0.37 kW 71 (4p) 1500 rpm (55 Hz) 0.55 kW 71 (4p) 1700 rpm (61 Hz)	0.75 kW 80 (4p) 1900 rpm (66 Hz)	1.1 kW 90S (4p) 2200 rpm (67 Hz) 1.5 kW 90L (4p) 2450 rpm (85 Hz) 2.2 kW 90L (2p) 2800 rpm (49 Hz)
400			0.37 kW 80 (6p) 1200 rpm (65 Hz) 0.55 kW 80 (4p) 1400 rpm (51 Hz) 0.75 kW 80 (4p) 1550 rpm (57 Hz)	1.1 kW 90S (4p) 1750 rpm (62 Hz) 1.5 kW 90L (4p) 1950 rpm (68 Hz)
450			0.55 kW 80 (6p) 1100 rpm (60 Hz) 0.75 kW 80 (4p) 1250 rpm (46 Hz)	1.1 kW 90S (4p) 1400 rpm (50 Hz) 1.5 kW 90L (4p) 1600 rpm (57 Hz)
500			0.55 kW 80 (6p) 1000 rpm (55 Hz)	0.75 kW 90S (6p) 1050 rpm (57 Hz) 1.1 kW 90L (6p) 1200 rpm (62 Hz) 1.5 kW 90L (4p) 1300 rpm (47 Hz)
560				0.75 kW 90S (6p) 900 rpm (49 Hz) 1.1 kW 90L (6p) 1000 rpm (54 Hz)
630				
710				
800				
900				
1000				

Table 1: PFN wheels - installed power and maximum speed combinations.

	Hub bore in mm:			
PFN	**28**	**38**	**42**	**48**
250	3 kW 100L (2p) 5600 rpm (96 Hz)			
280	3 kW 100L (2p) 4700 rpm (81 Hz) 4 kW 112M (2p) 5000 rpm (86Hz)			
315	3 kW 100L (2p) 3750 rpm (65 Hz) 4 kW 112M (2p) 4000 rpm (69 Hz)	5.5 kW 132S (2p) 4500 rpm (76 Hz)		
355	3 kW 100L (2p) 3150 rpm (55 Hz) 4 kW 112M (2p) 3450 rpm (60 Hz)	5.5 kW 132S (2p) 3850 rpm (65 Hz) 7.5 kW 132S (2p) 4000 rpm (68 Hz)		
400	2.2 kW 100L (4p) 2250 rpm (78 Hz) 3 kW 100L (4p) 2500 rpm (86 Hz) 4 kW 112M (2p) 2750 rpm (48 Hz)	5.5 kW 132S (2p) 3100 rpm (53 Hz) 7.5 kW 132S (2p) 3500 rpm (60 Hz)		
450	2.2 kW 100L (4p) 1800 rpm (63 Hz) 3 kW 100L (4p) 2000 rpm (70 Hz) 4 kW 112M (4p) 2200 rpm (75 Hz)	5.5 kW 132S (4p) 2450 rpm (84 Hz) 7.5 kW 132S (2p) 2750 rpm (47 Hz)	11 kW 160M (2p) 3100 rpm (53 Hz)	
500	2.2 kW 100L (4p) 1500 rpm (53 Hz) 3 kW 100L (4p) 1700 rpm (60 Hz) 4 kW 112M (4p) 1850 rpm (64 Hz)	5.5 kW 132S (4p) 2100 rpm (72 Hz) 7.5 kW 132M (4p) 2300 rpm (79 Hz)	11 kW 160M (2p) 2700 rpm (46 Hz)	
560	1.5 kW 100L (6p) 1150 rpm (61 Hz) 2.2 kW 100L (4p) 1300 rpm (46 Hz) 3 kW 100L (4p) 1450 rpm (51 Hz) 4 kW 112M (4p) 1600 rpm (56Hz)	5.5 kW 132S (4p) 1800 rpm (62 Hz) 7.5 kW 132M (4p) 2000 rpm (69 Hz)	11 kW 160M (4p) 2250 rpm (76 Hz) 15 kW 160M (2p) 2500 rpm (43 Hz)	
630	1.5 kW 100L (6p) 930 rpm (50 Hz) 2.2 kW 112M (6p) 1050 rpm (55 Hz) 4 kW 112M (4p) 1300 rpm (46 Hz)	3 kW 132S (6p) 1170 rpm (61 Hz) 5.5 kW 132S (4p) 1400 rpm (49 Hz) 7.5 kW 132M (4p) 1600 rpm (56 Hz)	11 kW 160M (4p) 1800 rpm (61 Hz) 15 kW 160L (4p) 2000 rpm (68 Hz)	18.5 kW 180M (4p) 2150 rpm (73 Hz) 22 kW 180L (4p) 2250 rpm (76 Hz)
710	2.2 kW 112M (6p) 880 rpm (47 Hz)	3 kW 132S (6p) 970 rpm (51 Hz) 4 kW 132M (6p) 1070 rpm (56 Hz) 5.5 kW 132M (6p) 1200 rpm (62 Hz) 7.5 kW 132S (4p) 1330 rpm (47 Hz)	11 kW 160M (4p) 1520 rpm (52 Hz) 15 kW 160L (4p) 1700 rpm (58 Hz)	18.5 kW 180M (4p) 1830 rpm (62 Hz) 22 kW 180M (4p) 1940 rpm (65 Hz)
800		3 kW 132M (8p) 750 rpm (52 Hz) 4 kW 132M (6p) 830 rpm (44 Hz) 5.5 kW 132M (6p) 930 rpm (49 Hz)	5.5 kW 160M (8p) 930 rpm (64 Hz) 7.5 kW 160M (6p) 1040 rpm (54 Hz) 11 kW 160L (6p) 1180 rpm (61 Hz) 11 kW 160M (4p) 1180 rpm (40 Hz) 15 kW 160L (4p) 1320 rpm (45 Hz)	18.5 kW 180M (4p) 1420 rpm (48 Hz) 22 kW 180M (4p) 1500 rpm (51 Hz)
900			4 kW 160M (8p) 690 rpm (49 Hz) 5.5 kW 160M (8p) 770 rpm (54 Hz) 7.5 kW 160M (6p) 850 rpm (44 Hz) 11 kW 160L (6p) 960 rpm (50 Hz)	11 kW 180L (8p) 960 rpm (65 Hz) 15 kW 180L (6p) 1070 rpm (55 Hz) 22 kW 180M (4p) 1230 rpm (42 Hz)
1000			5.5 kW 160M (8p) 640 rpm (45 Hz) 7.5 kW 160M (8p) 710 rpm (49 Hz)	11 kW 180L (8p) 810 rpm (55 Hz) 15 kW 180L (6p) 900 rpm (46 Hz)

Table 2: PFN wheels - installed power and maximum speed combinations.

	Hub bore in mm:		
PFN	**55**	**60**	**65**
250			
280			
315			
355			
400			
450			
500			
560			
630			
710	30 kW 200L (4p) 2000 rpm (67 Hz)		
800	30 kW 200L (4p) 1700 rpm (57 Hz)		
900	18.5 kW 200L (6p) 1170 rpm (60 Hz) 22 kW 200L (6p) 1230 rpm (63 Hz) 30 kW 200L (4p) 1370 rpm (46 Hz)	37 kW 225S (4p) 1470 rpm (49 Hz) 45 kW 225M (4p) 1500 rpm (51 Hz)	
1000	15 kW 200L (8p) 900 rpm (61 Hz) 18.5 kW 200L (6p) 960 rpm (49 Hz) 22 kW 200L (6p) 1020 rpm (52 Hz)	30 kW 225M (6p) 1140 rpm (58 Hz) 37 kW 225S (4p) 1220 rpm (41 Hz) 45 kW 225M (4p) 1300 rpm (44 Hz)	37 kW 250M (6p) 1220 rpm (62 Hz) 55 kW 250M (4p) 1350 rpm (45 Hz)

Table 3: PFN wheels - installed power and maximum speed combinations.