ECFanGrid

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THE AIR MOVEMENT GROUP

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Whitepaper

Technical Information about Paralleling Fans

by

Version 2.0

Abstract

In recent months we have received many inquiries about how to construct units with using fans in parallel. These requests have led our organization to develop a concept for optimizing an energy efficient solution with a Rosenberg ECFanGrid.

Your Sincerely,

Christian Dorsch

Kuenzelsau, 06.03.2015
Eletrical Engineer

Special Thanks to Peter Sklar for his contributions to the document.

Contents

1 How-To – Select a Rosenberg ECFanGrid

When paralleling Fans, the Air Flow is multiplied by maintaining the same pressure, compare Equation 1 and 2. To get the Fan Curve of n Parallel Fans the Air Flow of the Single Fan is multiplied with n, while the Static Pressure remains constant. To simplify typical ECFanGrid construction Software Programs, like RoVent & RoVentMulti were developed, as illustrated in Fig. 1.

$$\dot{V} = n \times \dot{V}_{Single} \tag{1}$$

$$p = p_{Single} \tag{2}$$

$$\dot{V},\ Air\ Flow\ [m^3/h]$$

$$n,\ Number\ of\ Fans\ [1]$$

$$p,\ Pressure\ [Pa]$$

The Main Advantages of a Rosenberg ECFanGrid are:

Redundancy	**Compactness & Flexibility**	**Ease of Maintenance & Replacement**
Plug & PLay System	**Predestined for Retrofit Applications**	**Less Low Frequency Noises & Uniform Air Stream**

Note: A Presentation regarding Rosenberg ECFanGrids, which illustrates the benefits of applying this technology, is available for the asking.

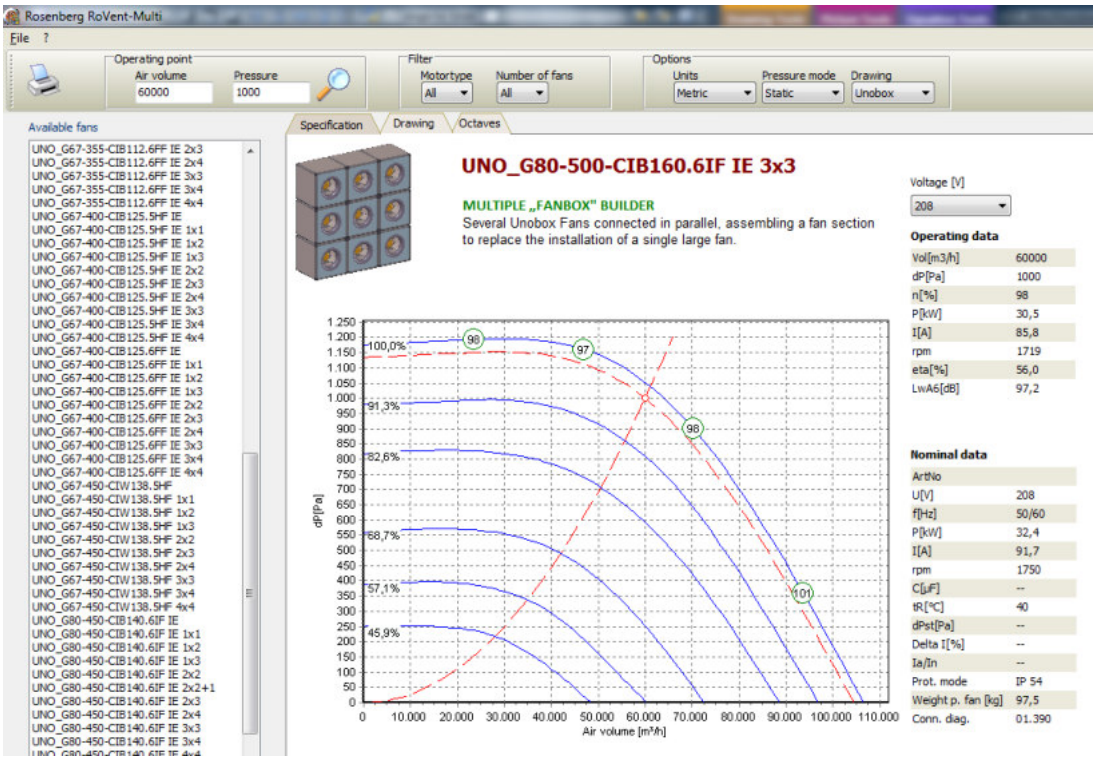


Figure 1: RoVentMulti Selection Software

2 How-To – Determine the Spacing between Fans

One of the more common questions regarding the design of a Rosenberg ECFanGrid is:

What is the recommended space between the fans to maintain optimum performance?

Measurements were carried out in our Certified Testing Labs, with respect to the impeller diameter and the duct dimensions as to how performance is affected by Fan spacing. As a result the following ratio was established:

$$\frac{A}{D} \geqslant 1,55 \tag{3}$$

In the ECFanGrid selection process, if this Ratio or a larger value is achieved, there will be no negative effect on performance. The calculation of the Ratio consists of two basic steps. First, to establish the A value, both the x and y dimensions of the duct are divided by the number of Fans in each direction. Second the result must be divided through the Impeller Diameter D of the fan, shown in Fig. 2 and in the calculation examples of Equation 4 and 5 on the next page. A good rule of thumb is:

Surround each fan with a fourth of it's impeller diameter

Then the ratio would be 1,5. The used Impeller Size is written in the Fan Type Code, e.g. GKHM **560**-CI**B**.160.6IF IE. 560 is the diameter of the blades in [mm] and B means B-Impeller. To get the needed Impeller Diameter refer to Fig. 3a on the facing page. In the Type-Code above the diameter D of the GKHM 560 is 635 mm (25 Inches). In practice there could be situations, in which the available space does not allow to maintain a Ratio of 1,55. If this is the case and Fans will be used with a ratio well below, the selection should be referred to Head Office for a recommendation.

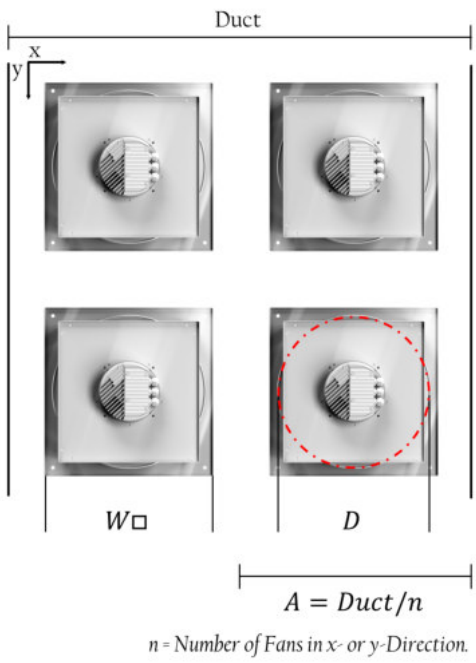


Figure 2: Calculation of the Spacing between Fans

Another spacing consideration should be the W or Inlet Cone Plate width, which is referred to in Fig. 2 on the preceding page and is part of the Table in Fig. 3b.

Outer Diameter *D for the B-Impeller*

	[mm]	[inch]
250	283	11.1
280	318	12.5
315	360	14.2
355	405	15.9
400	455	17.9
450	510	20.1
500	570	22.4
560	635	25.0
630	716	28.2
710	817	32.2

(a) B-Impeller

Standard Dimensions

Impeller	W [mm]	W [inch]
250, 280	430	16.9
315, 355, 400	500	19.7
400	550	21.7
450	630	24.8
500	700	27.6
560, 630	800	31.5

(b) Nozzle Wear Plate

Figure 3: Standard Dimensions of Mechanical Parts

EXAMPLE 1

Given an A value for a square duct, which has both x and y dimensions of 1,89 m (6.2 ft) with a ECFanGrid selection of 2x2 500 B-Impeller Fans, the ratio is:

$$\frac{A}{n \times D} = \frac{1890\ mm}{2\ Fans \times 570\ mm} \approx 1,65_{2x2\ 500} \tag{4}$$

EXAMPLE 2

Given an A value for a square duct, which has both x and y dimensions of 1,89 m (6.2 ft) with a ECFanGrid selection of 3x3 355 B-Impeller Fans, the Ration is:

$$\frac{A}{n \times D} = \frac{1890\ mm}{3\ Fans \times 405\ mm} \approx 1,55_{3x3\ 355} \tag{5}$$

A comparison of ECFanGrid performance in Example 1 and 2 is presented in Fig. 4 and 5 on the next page.
The Red Curve is the measured Curve of the ECFanGrid while the Blue Curve is a measured Curve of a single Fan of the same type, where the Air Flow is multiplied by 4 or 9 respectively. In both cases, the single Fan was measured with no duct, resulting in the A/D Ratio being ∞ (infinite).
It should be noted, that even though the difference between the two curves in Fig. 5 on the following page is increasing slightly towards the free blowing point – the area where one would normally run the ECFanGrid, remains almost identical.
In summary, if the A/D ratio is chosen right, there are no significant losses in performance when using Rosenberg EC Fans in parallel.

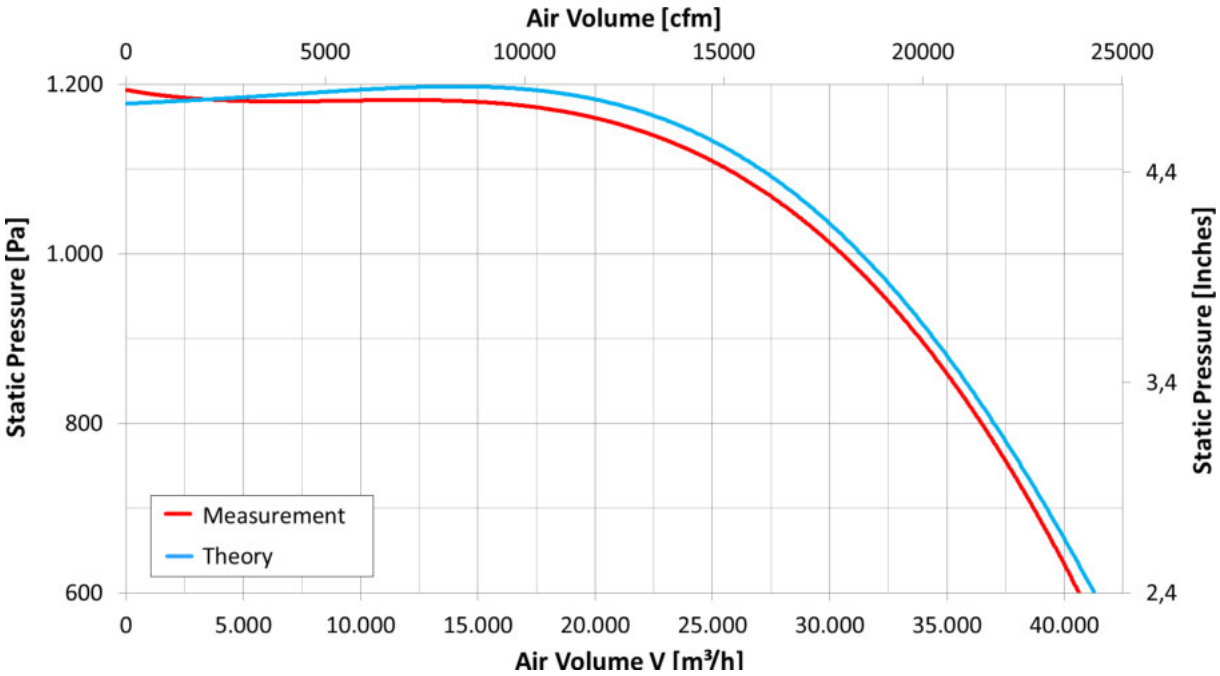


Figure 4: 2x2 GKHM 500.CIB.160.6IF IE with $^{A}/_{D}$=**1,65**

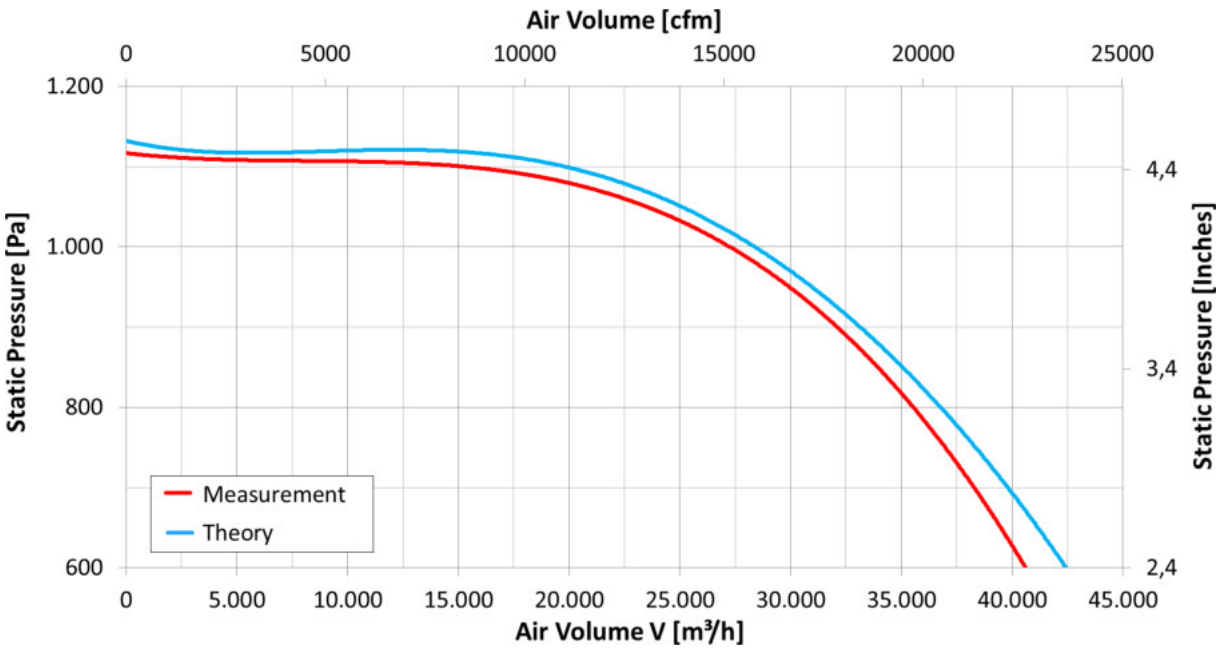


Figure 5: 3x3 GKHM 355.CIB.112.5HF IE with $^{A}/_{D}$=**1,55**

ECParam

Konfigurationssoftware
Configuration Software

Mit der kostenfreien Rosenberg-Software ECParam können über einen USB-zu-RS485 Wandler Einstellungen am EC-Ventilator vorgenommen und aktuelle Betriebszustände ausgelesen werden, wie zum Beispiel das Umstellen der Betriebsart, Vorgabe einer individuellen Minimal- oder Maximaldrehzahl und vieles mehr.

With the free Rosenberg software ECParam, changes to settings of the EC-fan can be made using a USB-to-RS485 adapter. Current operating conditions can also be read-out (changing the operating mode, setting a specific minimum or maximum speed, and much more).

Die Software ECParam ist auf Anfrage kostenfrei erhältlich. Systemvoraussetzung ist Windows XP oder Windows 7 (32/64 Bit). Eine Installation ist nicht notwendig! Informieren Sie sich vorab mit Hilfe der Betriebsanleitung über den Funktionsumfang von ECParam auf www.rosenberg-gmbh.com.

The software ECParam is available on request and free of charge. The system requirements are Windows XP or Windows 7 (32/64 Bit). No installation is necessary! Advance information about the features of ECParam can be found by downloading the instruction manual at www.rosenberg-gmbh.com.

3 How-To – Calculate & Attenuate Noise

The evaluation of a Rosenberg ECFanGrid versus a single, large radial Fan, is typical consideration. When operating points are compared, it is clear that a ECFanGrid will run at higher speed. And the greater the speed of an impeller the higher the level of noise. The large, single radial Fan, requires a much lower level of speed to achieve the same operating point. However the larger impeller creates greater noise than an individual smaller one. In the end, the Air Flow and the Pressure remains the same as well as the noise level.
For example, in Fig. 6 a DKNB (900 impeller) is compared with a 2x2 GKHM (500 impeller) and a 3x3 GKHM (355 impeller), based on an operating point at 30.000 $^{m^3}/_{\mathrm{h}}$ (17,650 cfm) & 1.000 Pa (4.00 Inches). The DKNB has a sound power value of L_{wA6} 97.7 dB_A whereas the 2x2 GKHM got L_{wA6} 95.7 dB_A and the 3x3 GKHM got L_{wA6} 95.5 dB_A. In conclusion, sound is not an issue when using ECFanGrids, on the contrary there will be more possibilities to significantly lower noise.

Further to calculate the Sound of a Rosenberg ECFanGrid is not difficult by comparing Equation 6 and Fig. 7. With every fan doubling, the noise is increased by 3 dB. The general equation used to calculate a rise in noise for multiple identical fans, is logarithmic.

Figure 6: DKNB vs. 2x2 GKHM vs. 3x3 GKHM

$$s = 10 \times \log(n) + s_{Single} \tag{6}$$
$$s,\ Noise\ [dB]$$
$$n,\ Number\ of\ Fans\ [1]$$

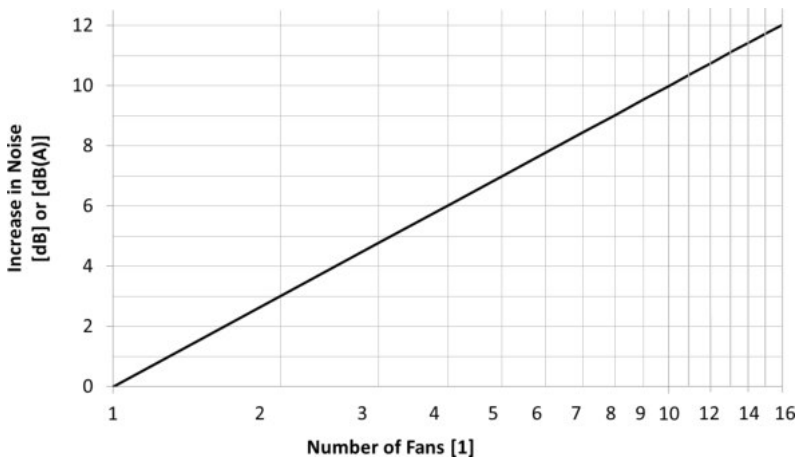


Figure 7: Sound Calculation Diagram

How to attenuate noise in an ECFanGrid?

With using a Rosenberg ECFanGrid there are two major advantages to attenuate noise. First, the Noise Spectrum of smaller impellers contains higher frequencies, thus the wave lengths are shorter, allowing for the use of shorter attenuators. Second, the required length of the Fan Section in a typical Air Handling Unit, using a single large radial fan can be reduced dramatically – in some cases up to 50 %. Thus, the availability of this free space installing a sound attenuator, is not complicated.
In Fig. 8 a measurement of the Air Velocity, 1,1 m (3.6 ft) behind the Fans of the 2x2 ECFanGrid, is shown. It is easy recognizable, that in this configuration the valleys are representing the places of the four Fans. A possible approach is to place attenuators into the "valleys" directly behind the fans. Because there are low air velocities and so the placement of attenuators will cause low losses in Air Performance, as illustrated in Fig. 9.

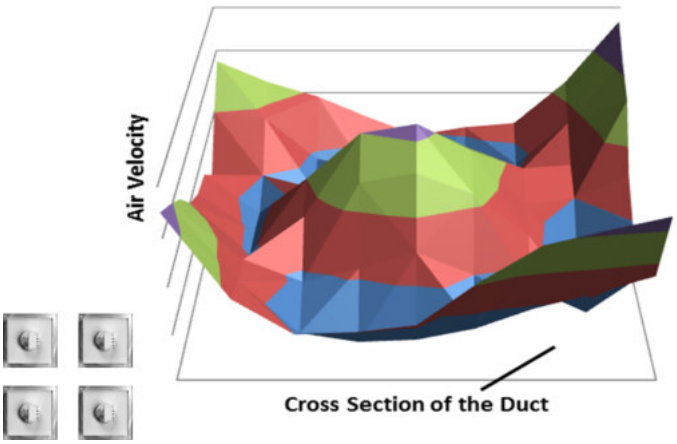


Figure 8: Air Velocity over the Cross Section

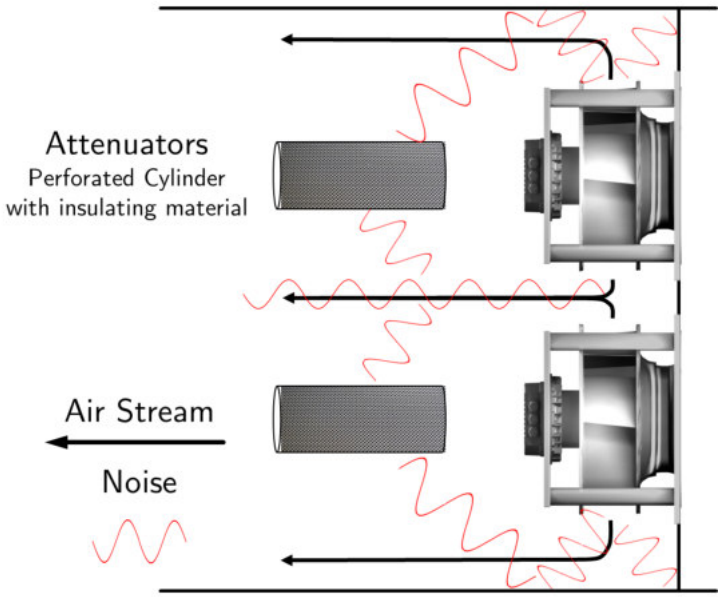


Figure 9: Possible Places for Attenuation

4 How-To – Determine the need of Separators between Fans

Separators as shown in Fig. 10, are not required. Without them there is no influencing between Fans and they do not have any positive effect on the Air Performance or Noise. The only requirement is to establish the correct A/D Ratio as shown in Section 2 on page 2. Fig. 11 illustrates three measurements, one without Separators and two with a variation in height – 300 mm (11.8 Inches) and 500 mm (19.7 Inches). In the area of the typical operating point there is a small gain in performance compared to the use of separators. To this point, there are higher friction losses when the air must go along the surface of the separators. The Blue Curve of Fig. 11 is directly under the Red Curve, therefore variation in separator height has no effect. In addition, Air Velocities without Separators are more stable. The Air Stream after 1,1 m (3.6 ft.) is more uneven with Separators, compare Fig. 12a and 12b on the next page.

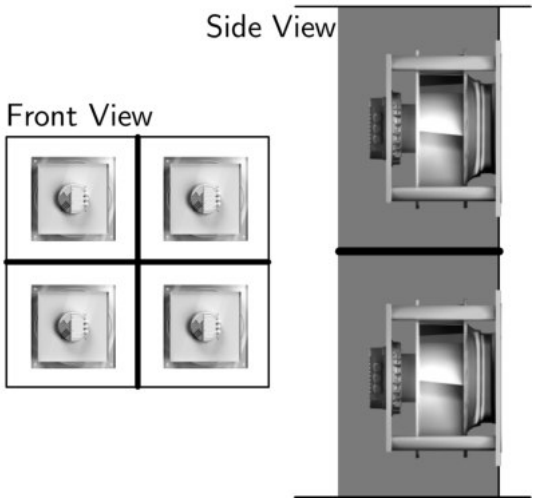


Figure 10: Placement of Separators

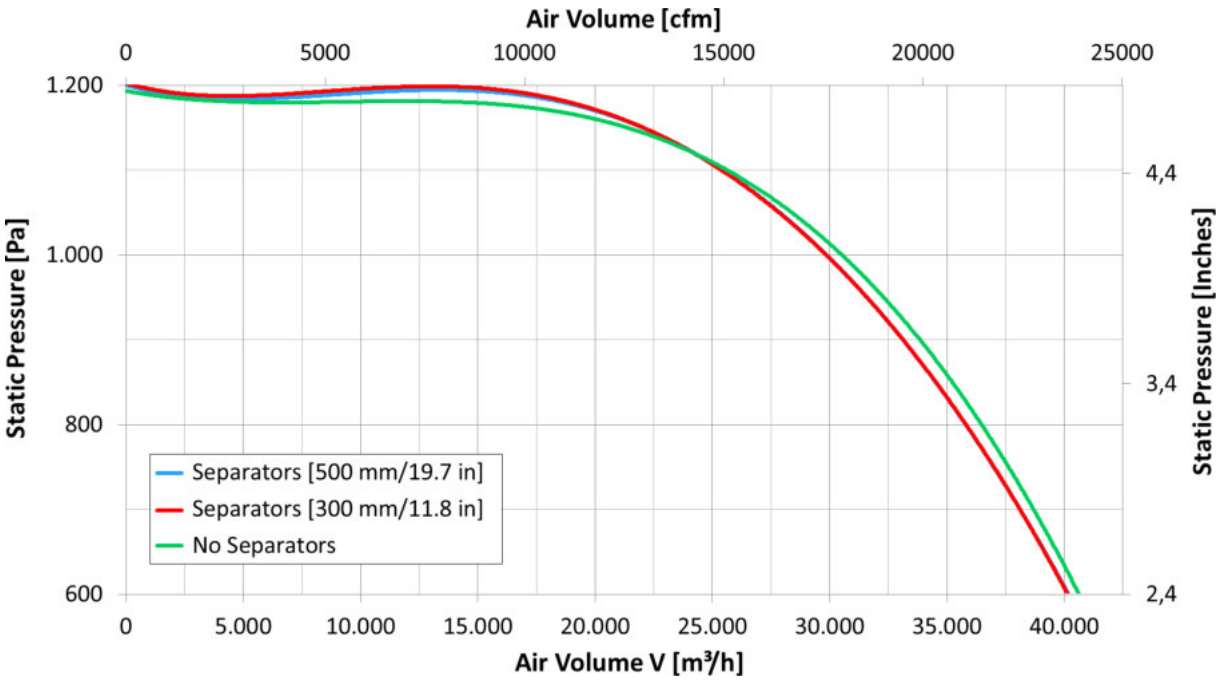
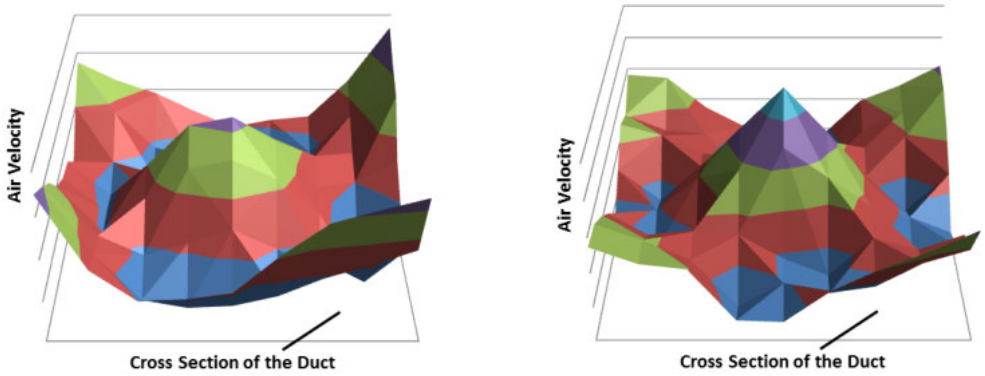


Figure 11: Comparison of the Benefits of Separators



(a) No Separators

(b) 500 mm (19.7 Inches) Separators

Figure 12: Air Velocity with and without Separators

5 How-To – Control a Rosenberg ECFanGrid

Operating an ECFanGrid at a fixed speed is inefficient and strictly not recommended. In general, to be efficient, a Closed Loop Control is preferred. The most common Control challenges that Air Movement Industry is faced with, are:

Air Flow **Pressure** **Temperature**

To this point, Rosenberg EC Fans have built-in ability to manage Air Flow and Pressure with the aid of a 'Static Pressure Transducer with Controller'. Under laboratory conditions, the performance of a Rosenberg ECFanGrid (3x3) was measured for the following:

- In Fig. 13, a Constant Air Flow Control of 22.500 $^{m^3}/_{\mathrm{h}}$ (13,243 cfm).
- In Fig. 14 on the next page, a Constant Pressure Control of 600 Pa (2.4 Inches).

In both cases, the measured points (diamonds and triangles) are equivalent to unique operating points of the system. The conclusion to be drawn from the two examples is, that a **System may change** as a result of Dampers opening, closing and or change in Pressure due to dirty Filters, but the **Fans always maintain the desired conditions**. The Red Curve in Fig. 13 and 14 on the facing page is representative of the Rosenberg ECFanGrid, operating at maximum speed.

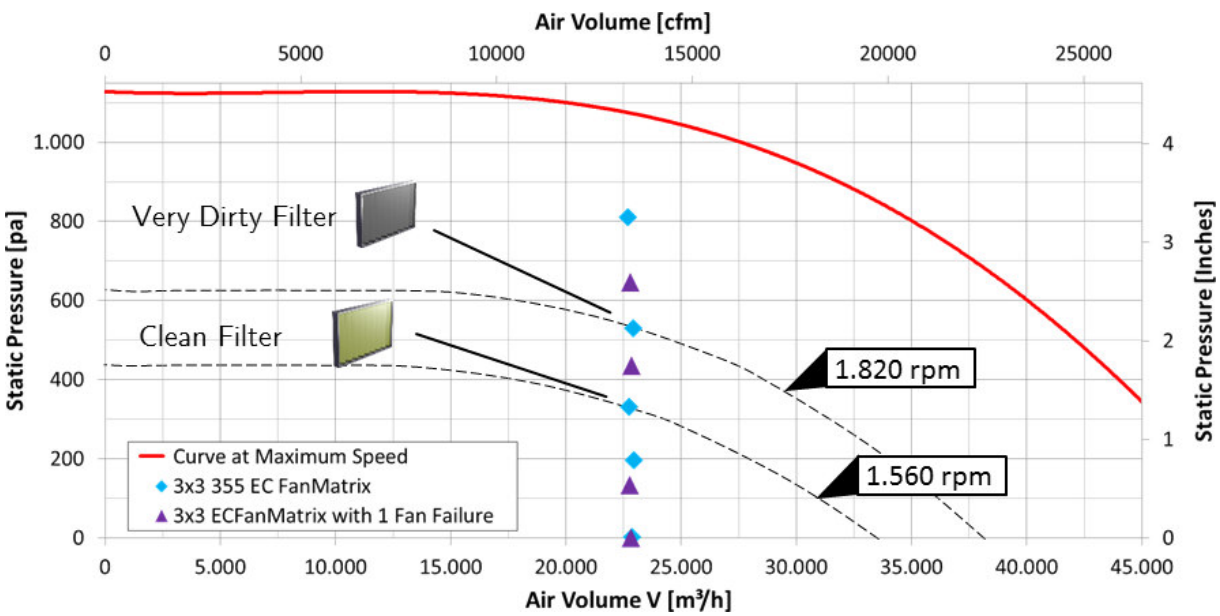


Figure 13: Constant Air Flow Control 22.500 $^{m^3}/_{\mathrm{h}}$ (13,243 cfm)

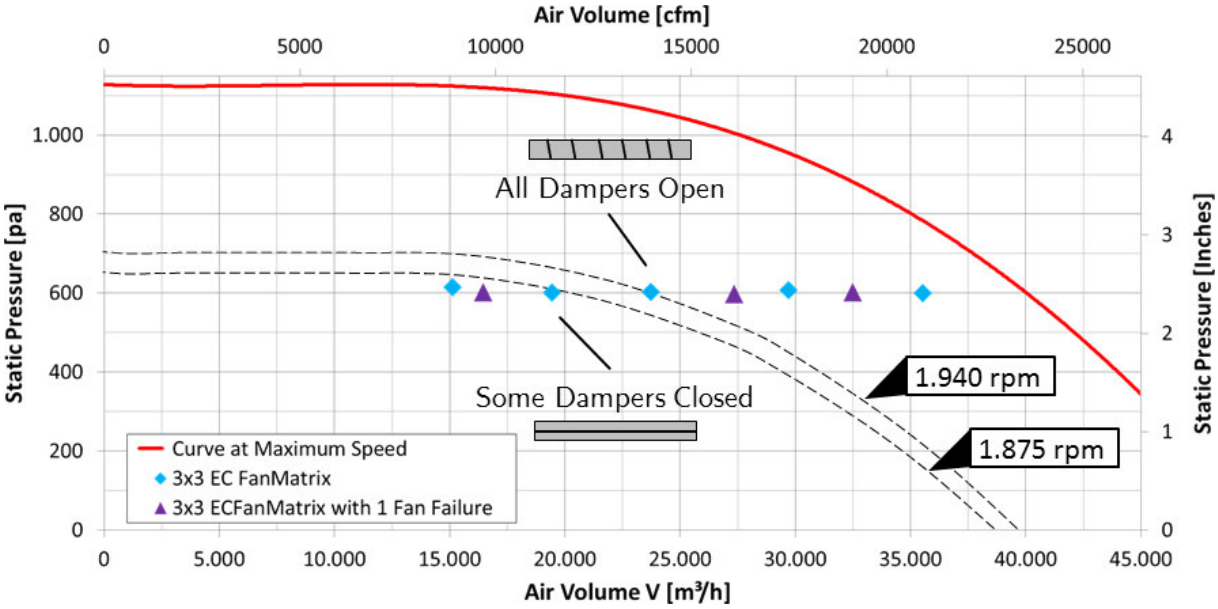


Figure 14: Constant Pressure Control 600 Pa (2.4 Inches)

6 How-To – Set up a Constant Pressure Control

Constant Pressure Control is applied in cases where a System must maintain a specific Static Pressure at various Operating Points. In Fig. 15 the components to set-up a Rosenberg EC-FanGrid have been indicated, which connect to a remote 'Static Pressure Transducer with Controller'.

For accurate Pressure Control – the set-up of Measurement Components is important

Fig. 15 shows a typical setup for an excess pressure control. The Duct has (4) measurement points, at the mid-point of each side. This protocol is supported through DIN EN ISO 5801:2008(D), page 34. In Addition this Standard recommends maintaining a minimum distance of C respectively $C/2$ between the measurement point and the outlet (Excess/Positive Pressure Control) or Inlet (Negative Pressure Control) of the Fan. C for the calculation refers to the Duct Diameter. The diameter of a rectangular or square duct is the square-root of the duct height and width. Precisely it is $C = \sqrt{a^2 + b^2}$. The configuration, which was tested in the laboratory got a square 1,89x1,89 m (6.2x6.2 ft.) duct. The equation leads in the example to $C = \sqrt{1,89\ m^2 + 1,89\ m^2} = 2,67\ m$ and $C/2 = 1,34\ m$. In practice, this is a good initial value. However in cases, where it is not possible to hold the recommended distance, this value must be reduced. Rosenberg is able to give individual recommendations for the asking. The reason for the distance is to try to avoid to measure at turbulent air flows, which are existent direct before and after the Fans.
Again regarding accuracy – the measurement tubes must be mounted perpendicular to the Air Stream as indicated in Fig. 15. If the tubes are not accurate perpendicular, the readings will provide shares of Dynamic instead of pure Static Pressure readings. This will result in wrong Operating Points.

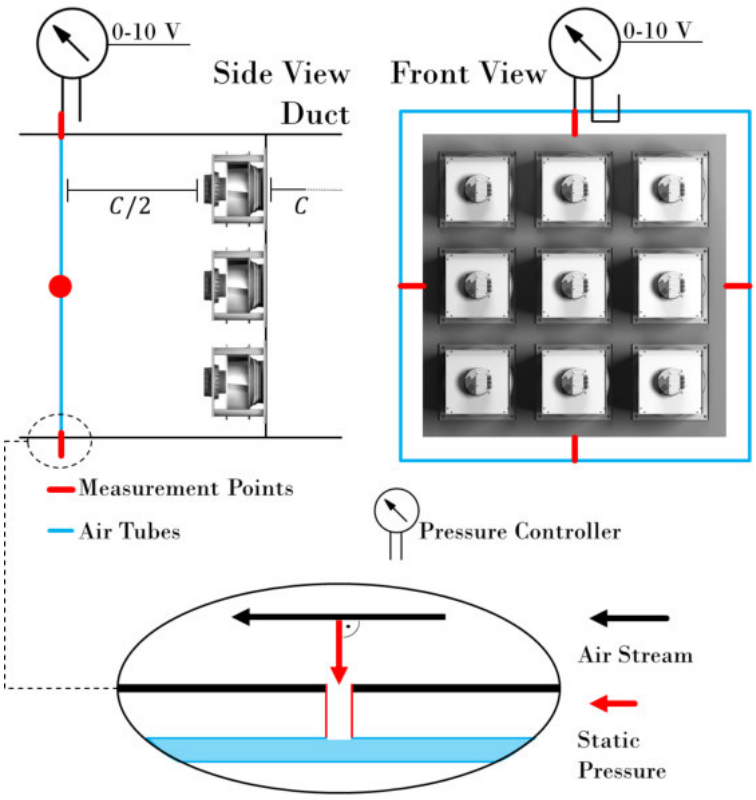


Figure 15: Measurement of the Static Pressure

In Fig. 16 an operating Constant Pressure Control with a 3x3 ECFanGrid is shown. As the curve indicates the speed is changing and therefore the desired pressure is always maintained – 600 Pa (2.4 Inches). At the time t_0 the damper was slightly closed and thus the static pressure in the system increased. Hence the ECFanGrid is decreasing the speed to reduce the pressure. When the pressure again reaches the desired 600 Pa (2.4 Inches) the speed remains.

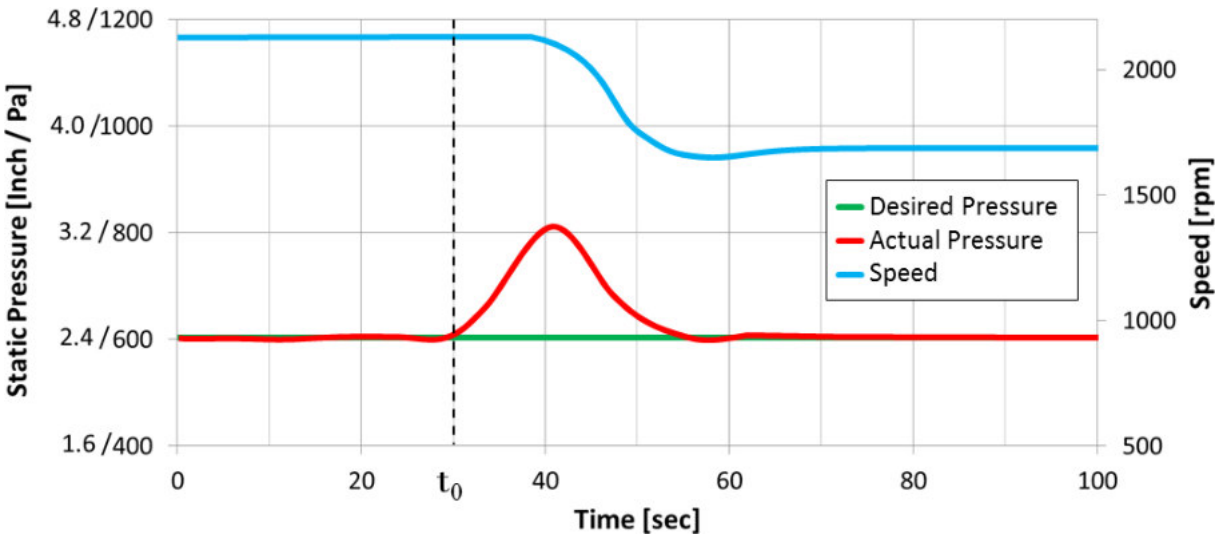


Figure 16: Real-Time Constant Pressure Control with an ECFanGrid

7 ECFanGrid Cookbook – Constant Pressure Control

A Rosenberg ECFanGrid can be setup for Constant Pressure Control with a Pressure Controller, some electrical materials and of course, the Rosenberg EC Fans. All Fans operate in 0-10 V open loop speed control, compare Fig. 18. The desired set point is adjustable in the Pressure Controllers display menu.

The setup of a Constant Pressure Control when paralleling fans is not a complex procedure!

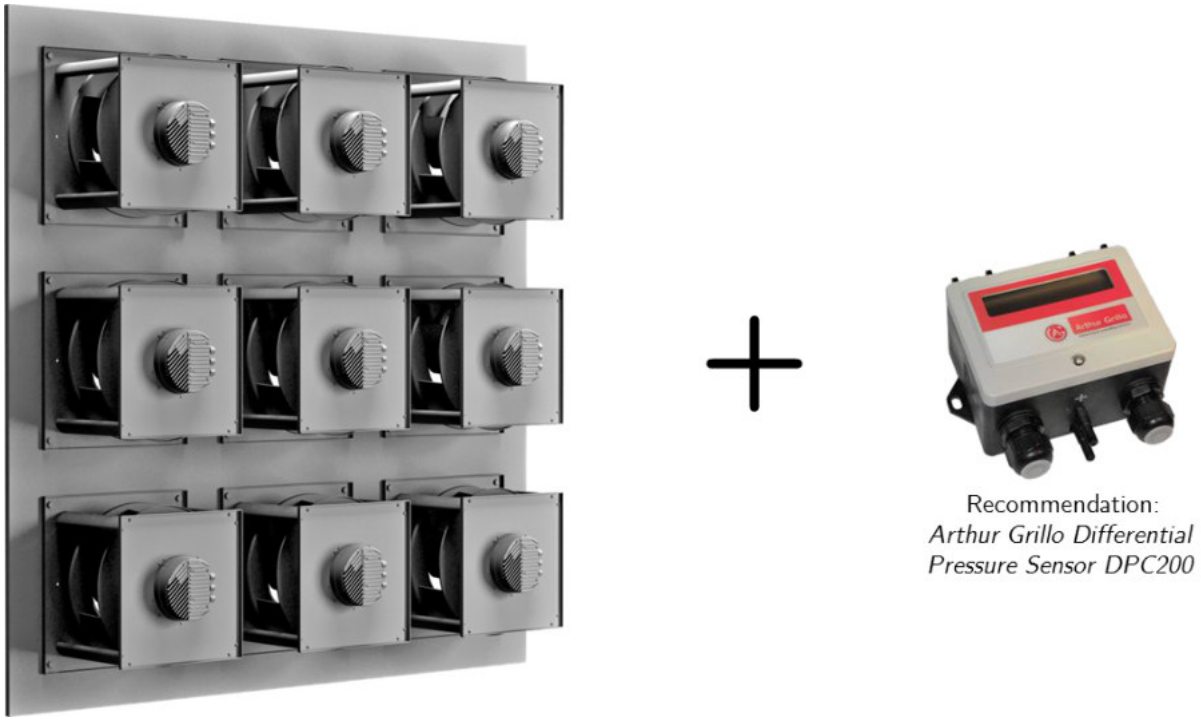


Figure 17: Rosenberg ECFanGrid with Pressure Controller

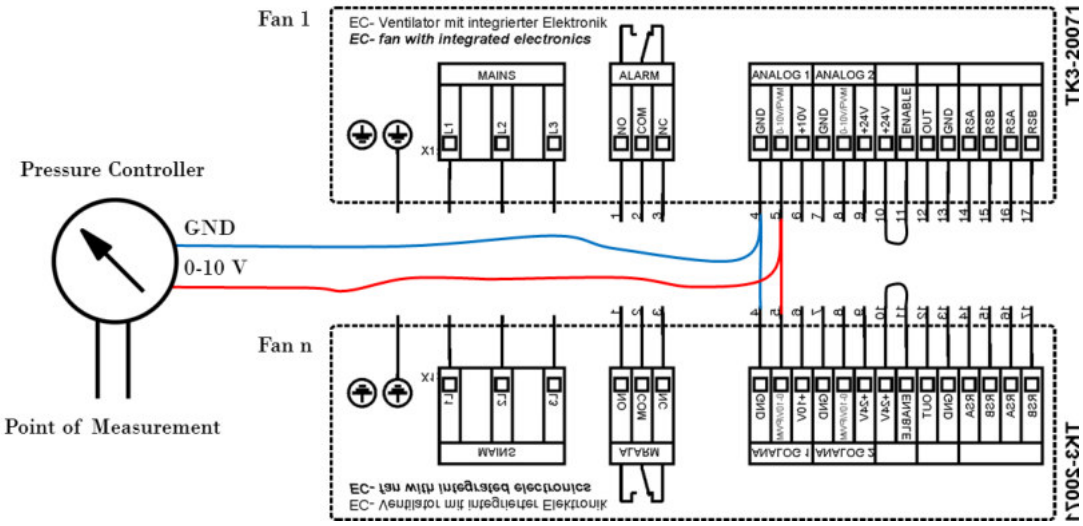


Figure 18: Electric Wiring Schematic – Pressure Control

RoVent®

Ventilatorenauswahlprogramm
Fan Selection Software

Mit unserem Auswahlprogramm RoVent ist eine betriebspunktgenaue Auswahl aus mehr aus 1.700 Ventilatorenmodellen schnell und einfach möglich. Weiterhin steht Ihnen eine umfangreiche Dokumentation des ausgewählten Ventilatortyps zur Verfügung. Durch regelmäßige Updates bleibt die Software ständig auf dem aktuellsten Stand.

With our fan selection software RoVent an operating point specific fan selection can be made quickly and easily from over 1.700 fan models. Furthermore, detailed documentation on the selected fan type is available. The software is kept up to date through regular automatic updates.

Die RoVent CD-ROM erhalten Sie jederzeit kostenfrei von einer unserer Niederlassungen.
Alternativ steht die Software auch auf www.rosenberg-gmbh.com zum Download bereit.

You can receive the RoVent CD-ROM anytime free of charge from one of our subsidiaries.
Alternatively, it can be downloaded anytime from our website www.rosenberg-gmbh.com.

8 How-To – Set up a Constant Air Flow Control

There are several methods to measure the air flow, like Calorimetric Flow Meters (Heated Wire), Pitot Tubes or Grids and Anemometers to name the most common. However all these methods are not very efficient when applied in a large duct. Calorimetric Flow Meters and Anemometers are very accurate, but in order to get a good average of the air velocity, multiple devices are required over the cross section, which result in massive cost. A Pitot Grid would be a accurate approach, but therefore air velocities must be higher than 3,0 m/s (9.8 ft/s). And based on the Guideline RLT-01 of the German AHU Manufacturer Association it is recommended to stay clearly below 3,0 m/s (9.8 ft/s) to ensure high system efficiencies.

Air Flow with a Rosenberg ECFanGrid is measured by Pressure Taps in the Inlet Cone

Every Rosenberg EC Fan or to be more precise every inlet cone used with an Rosenberg EC Fan has a Circular Measurement Tube with four measurement taps, as indicated in Fig. 19.
Four taps are used with arrangement in order to obtain a correct mean value. This feature is critical if the Air Flow at the inlet is not even, namely if the available space in front of the inlet is limited.

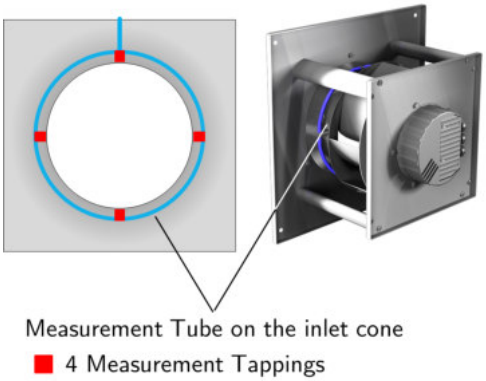


Figure 19: Circular Measurement Tube of Rosenberg EC Fans

Pressure measurement is converted to actual Air Flow through Inlet Cone

With the use of Bernoulli's Incompressible Flow Equation and the Law of Continuity the Air Flow is calculated by measuring differential pressure and applying a calibration factor. Of course air is compressible and can only be seen as incompressible until 3.000 Pa (12.0 Inches) – this falls into our range of Fan Applications. The actual measurement is the differential pressure between the Inlet Cone (Measurement Tube) and the Inlet Area of the Application, as shown in Fig. 20 on the next page. The arrangement to measure the pressure of the Inlet Cone is already defined by Rosenberg, whereas to define the arrangement to measure the Static Pressure of the Inlet Area, please refer back to Section 6 on page 12. In addition, Section 6, provides the equation to calculate the recommended distance C between the circular measurement and the Inlet Area of the fans. However in practice it is not always possible to maintain the recommended distance, if for some reasons the design requires a much shorter distance Rosenberg is able to give individual recommendations for the asking.

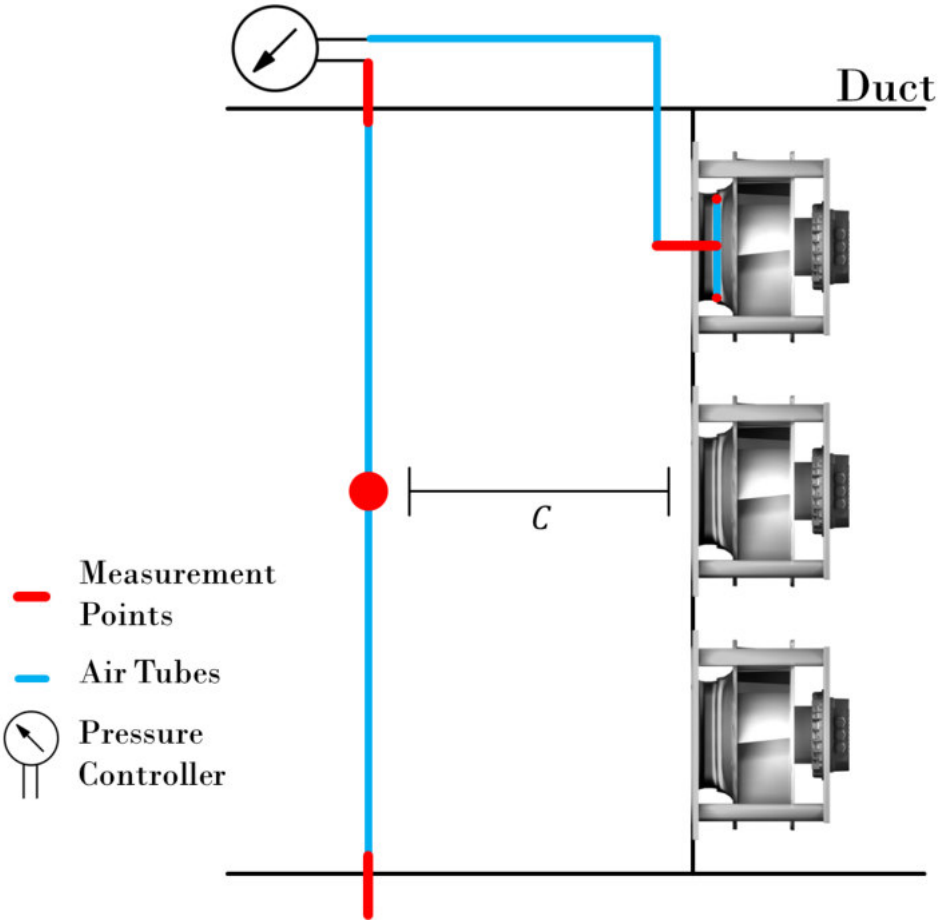


Figure 20: Measurement Arrangement for a Constant Air Flow Control

The calculation of desired Air Flow requires a conversion of the differential Pressure, with the calibration factor (k-factor). The factor corresponds to a specific Fan size and is marked on the name plate of the Fan as well as can be viewed in RoVent. The equation for calculation is:

$$\Delta p = \left(\frac{V}{k}\right)^2 \times \frac{\rho}{2} \tag{7}$$

$\Delta p,\ Differential\ Pressure\ [Pa]$

$V,\ Air\ Flow\ [{}^{m^3}/_{h}]$

$\rho,\ Air\ density\ [{}^{kg}/_{m^3}]$

$k,\ k-Factor\ [{}^{m^2 \times s}/_{h}]$

It should be noted that the units in Equation 7 are SI-Units and if Imperial System with Foot, Inches and Pounds is to be applied, there are two applicable approaches. First, calculate the equation in SI-Units and convert the results into Imperial or second, contact Rosenberg Sales for a modified equation.

Below is an example of the calculaion for a 3x3 ECFanGrid with an oparating Point of 30.000 ${}^{m^3}/_{\mathrm{h}}$ (17,650 cfm) & 1.000 Pa (4.00 Inches). For the purpose of the equation, the total Air Flow is divided by the number of fans n = 9. The standard Air Density at 20 °C (68 °F) and 101.325 kPa atmospheric pressure is about 1,2 ${}^{\mathrm{kg}}/_{m^3}$. The k-factor for these fans is 101 ${}^{m^2 \times s}/_{\mathrm{h}}$. After inserting the values into Equation 7 the result is:

$$\Delta p = \left(\frac{3.333\ {}^{m^3}/_{h}}{101\ {}^{m^2 \times s}/_{h}}\right)^2 \times \frac{1,2\ {}^{kg}/_{m^3}}{2} = 653\ Pa \tag{8}$$

In summary, if the pressure of 653 Pa (2.6 Inches) measured, between the Inlet cone of a single fan and the Inlet Area of the whole ECFanGrid, the fan is providing 3.333 m^3/h (1,962 cfm). At the point of setting up Constant Air Flow, the next step is to adjust the set-point of the pressure controller to 653 Pa (2.6 Inches). With the difference between the desired and the actual pressure, the controller is able to control the speed of the fans, e.g. through a 0-10 V Signal, and to hold the values at the same level.

Consideration of connecting the measurement tubes of the Fans in parallel

If a single pressure measurement device is used, it is recommended to connect only one Measurement Tube at the Inlet Cone. The reason being, if all Circular Measurement Tubes are connected in parallel the pressure measured will be the same as if only one Measurement Tube, was connected. This subject is based on the fact, that all Fans are running at same speed. The only benefit of connecting all in parallel is, that it provides a slightly better mean value, because small variations in speed cannot be avoided. This gain is only of interest when the Air Flow over the cross section is very uneven, e.g. because of very limited space. Next it follows, that there is a disadvantage of connecting all in parallel particularly if one fan fails, resulting in the defecting having an incorrect inlet cone value and providing the wrong measurement for the parallel group of Fans. In one Case – the Cone is Open, air is drifting backwards and the pressure will be negative at the defective fan, thereby influencing the result of the group, as shown in Fig. 21. In a second Case – the Cone is closed, no air is drifting back, however again the wrong value is being measured – in fact the total Pressure Increase of the Fan instead of the differential pressure between the Inlet Cone and the Inlet Area. In both Cases, the measurement will remain wrong and redundancy is lost unless the Measurement Tube of the defective Fan is disconnected from the parallel group. In contrast, when connecting only one Measurement Tube all that is required is to close the open cone and increase the set point to maintain proper operation. Of course there is a chance of $1/n$ the Master Fan will fail. In this case additionally the tube must be plugged into the Circular Tap of another Fan.

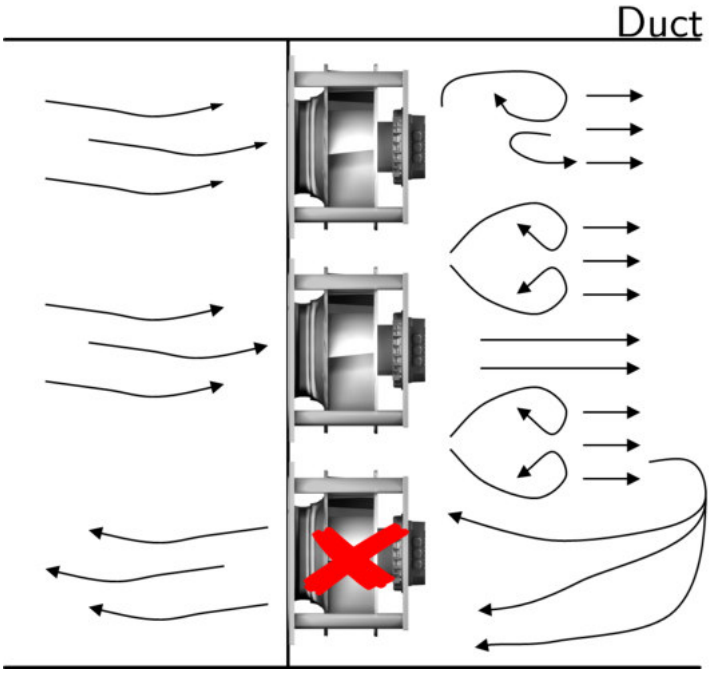


Figure 21: Air Flow in Case of a Failure

In Fig. 22 an operating Constant Air Flow Control with a 3x3 ECFanGrid is shown. As the curve indicates the speed is changing and therefore the desired air flow is always maintained – 22.500 m^3/h (13,243 cfm). At the time t_0 the damper was slightly closed and thus the air flow in the system decreased. Hence the ECFanGrid is increasing the speed to enlarge the air flow. Again air flow reaches the desired 22.500 m^3/h (13,243 cfm) and the speed remains.

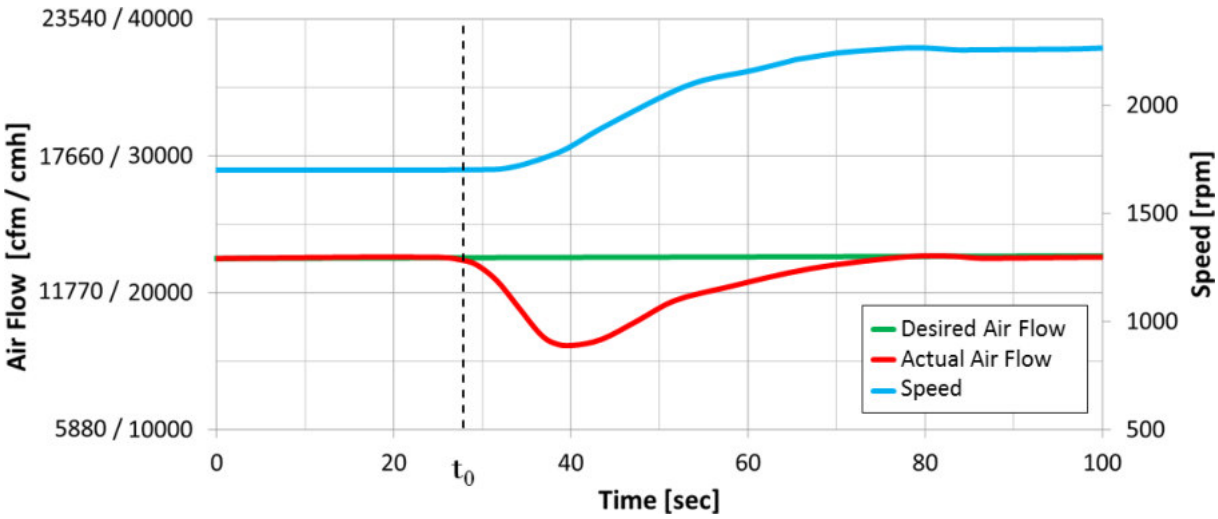


Figure 22: Real-Time Constant Air Flow Control with an ECFanGrid

9 ECFanGrid Cookbook – Constant Air Flow Control

A Rosenberg ECFanGrid can be setup as a Constant Air Flow System, basically with a Pressure Controller, some electric materials and of course, the Rosenberg EC Fans. All of them are used in 0-10 V open loop speed control as illustrated in Fig. 24. The desired set point is adjustable in the Pressure Controllers display menu.

The set-up of a Constant Air Flow Control when paralleling fans is not a complex procedure!

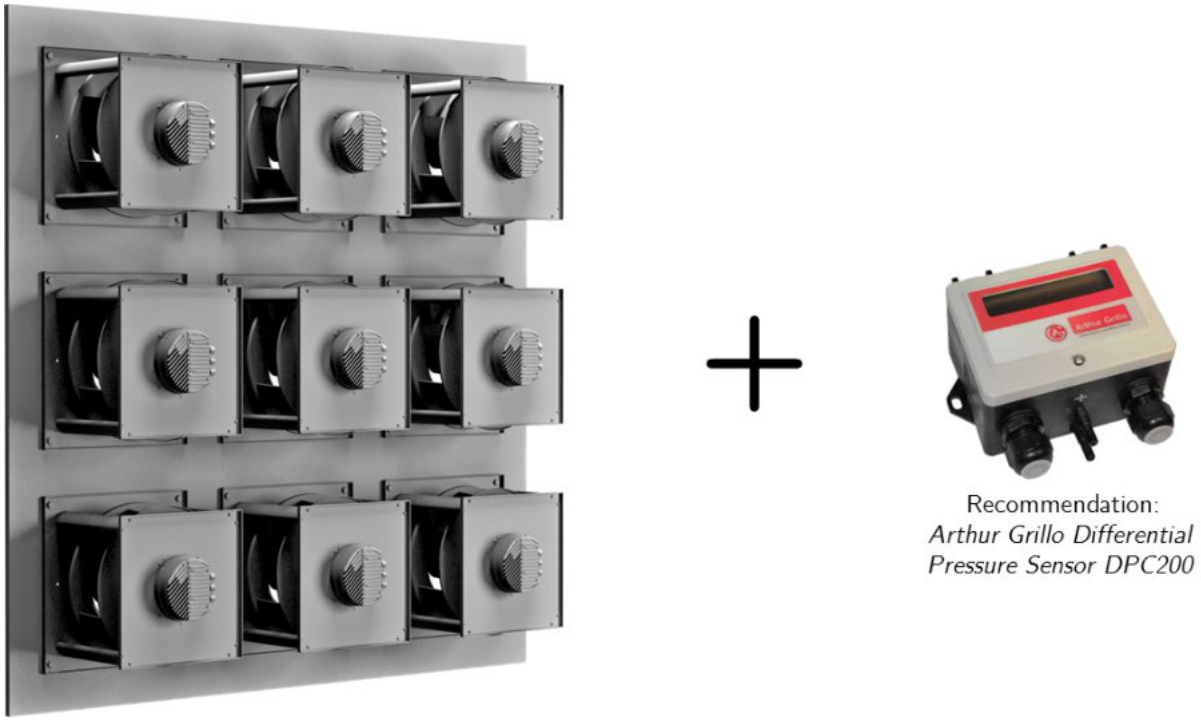


Figure 23: Rosenberg ECFanGrid with Pressure Controller

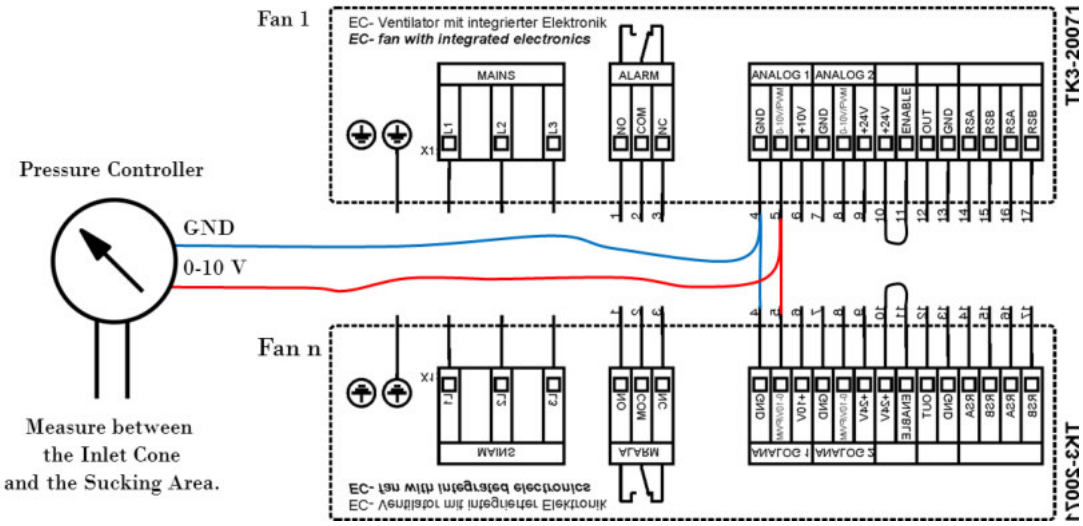


Figure 24: Electric Wiring Schematic – Air Flow Control

10 How-To – Use ModBus RTU

Rosenberg EC Fans can be integrated into a Building Management System with a ModBus RTU enabled Controller.

Rosenberg ECFanGrid with ModBus RTU Control

The main benefit is, that the wiring of the control cables like the 0-10 V, Enable or Alarm Relay signal is reduced to one single cable. So in the end, instead of connecting n control cables for n fans only one daisy chained Shielded Twisted-Pair cable, as shown in Fig. 25, is needed.
In addition to the valuable information, which can be read and written through ModBus, there are four main registers that require access:

1. Enable the Fan, Register 0029_{hex}
2. Write the Set Point, Register $002B_{hex}$
3. Read the Alarm Status, Register 0055_{hex}
4. Read the Actual Speed, Register 0052_{hex}

These four registers allow for the following tasks; Start/Stop the ECFanGrid, Change the Set Point; Detect and React on Alarms and monitor the actual Speed of the Fans. With ModBus RTU protocol it is absolutely mandatory, that every EC Fan receive it's own unique address. The address can be set by a third party or with the use of Rosenberg free available parametrization software – EC Param. The Rosenberg ModBus RTU implementation supports as a standard, the Baudrate 19.200 $^{\text{Bit}}/_{\text{sec}}$ and the Parity Even. The Function Codes for Writing and Reading a Single Register are 06_{hex} respectively 04_{hex}. At the Rosenberg Homepage a detailed ModBus RTU Manual for EC fans is available. The document includes all information required to hook up a ModBus RTU system when using Rosenberg EC Fans.
In a previous section, how to set up a Pressure or Air Flow Control was outlined. Instead of using a Pressure Controller, now a Pressure Sensor becomes the controlling element because the function is now managed by a PLC.

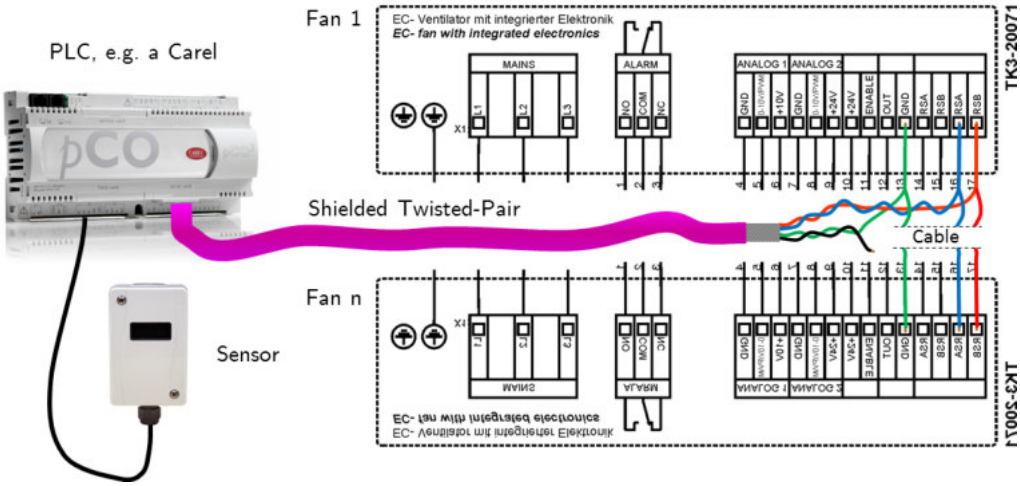


Figure 25: Connecting a Rosenberg ECFanGrid via ModBus RTU

11 How-To – Cover and Handle a Failure

The Redundancy is one major aspect as to why Fans are connected in parallel. This section is about how to detect, cover and handle a Failure. The first question is "How many fan failures should be covered?" therefore it should be known:

How to Select an ECFanGrid which can cover X amount of Failures

At this point reference should be made to Selection Software RoVent & RoVentMulti, which was introduced at the beginning. Applying a basic example, the operating point of the ECFanGrid should be 25.000 m^3/h (14,715 cfm) & 800 Pa (3.21 Inches) with a selection to cover a single fan failure. The point being, should one of Fans fail, the others could be able to maintain the operating point by increasing their speed. With the help of the selection Software it is seen that a 2x2 GKHM 500.CIB.160.6IF IE ECFanGrid is a fit for the requirement. The red curve in Fig. 26 represents the case when all four fans run at full speed (1750 rpm). The blue curve is showing three fans running at full speed (1750 rpm). The green line is the system curve and the black dot is the operating point of the Application. It is evident if all fans are running, each fan should run at 1.560 rpm. In contrast, if one fan fails the remaining three fans must increase their speed up to 1.720 rpm to maintain the operating point.
Additionally, to verify the concept of paralleling the blue and the red curve were taken in our testing laboratory and therefore confirmed by measurement. Further, observing the orange horizontal line in Fig. 26 it is evident that the factor between the red and the blue curve is four-thirds, see also Equation 1 and 2 on page 1.

$$\frac{4}{3} \times 22.500\ m^3/h\ (13,243\ cfm) = 30.000\ m^3/h\ (17,658\ cfm) \tag{9}$$

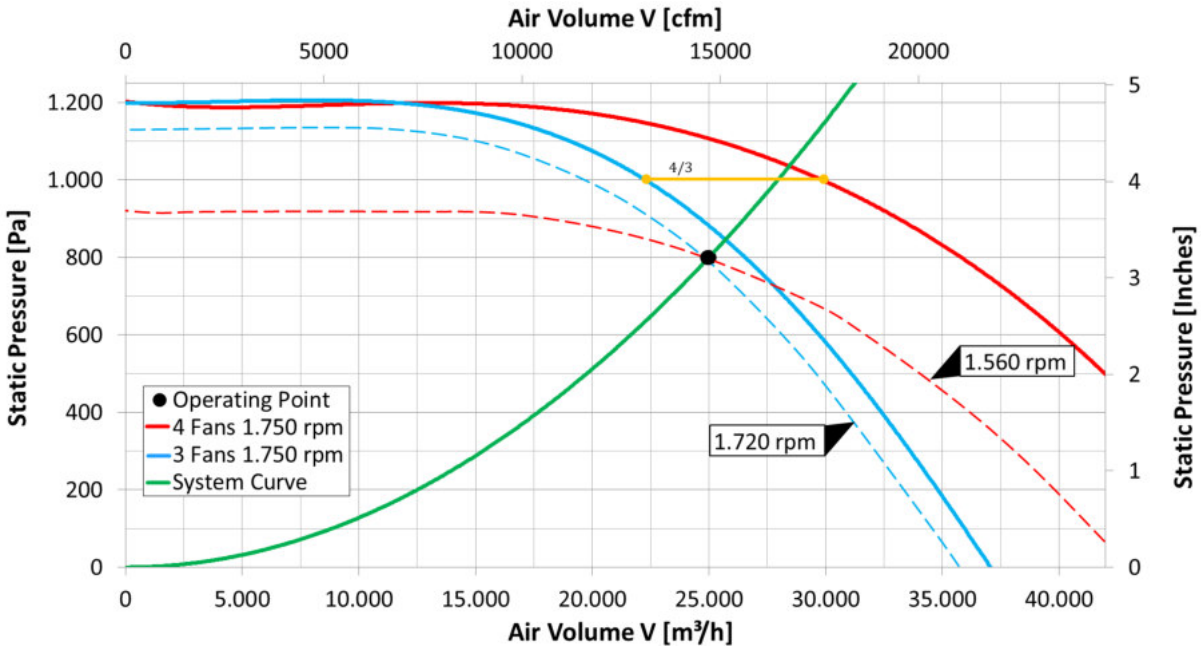


Figure 26: Selecting a Redundant ECFanGrid

Based on knowing how to select a redundant Rosenberg ECFanGrid, the next step is:

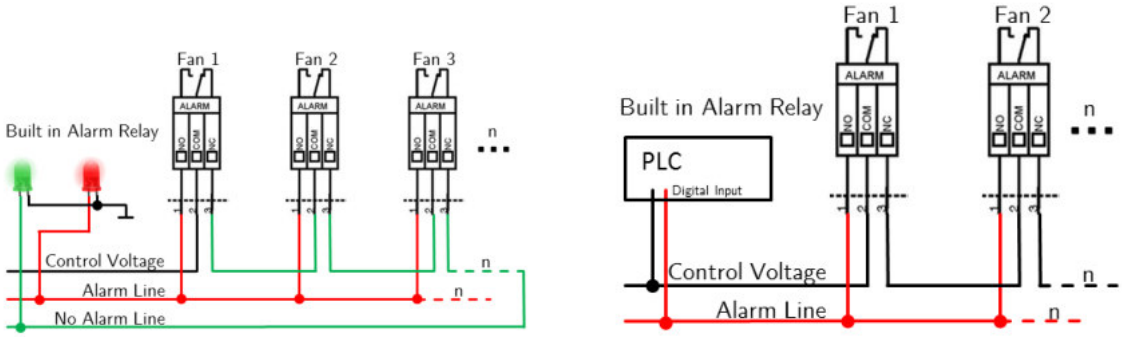
Detecting a Failure

Every Rosenberg EC Fan used in a ECFanGrid has a potential free alarm contact. The contacts are COM, NO (normally open) and NC (normally closed), compare Fig. 27a and 27b. It should be noted, that when using Rosenberg EC Fans "normally" means the fan is Powered AND No Alarms occurred. Then NC is closed and the NO is open.

One approach is to connect and evaluate the alarm relay, as shown in Fig. 28a. It is possible to get one terminal for No Failure and another terminal for Failure. If two LEDs are connected to the respective terminals, the green one will light when all fans are fine and the red one will light if one fan got a failure. If a PLC is used to control the Rosenberg ECFanGrid the fans can be connected according to Fig. 28b. Again if one fan has a failure the Digital 1, will appear at the input of the PLC.
In most of the cases, it is enough to know that there is a Failure, on the site. However, if it is of interest, from a remote location, to know specifically which Fan has failed on site – using ModBus RTU to evaluate the alarms, would be the most reliable.

(a) Powered AND No Alarm ***(b)*** Not Powered OR Alarm

Figure 27: Behavior of the Alarm Relay



(a) Detecting a Failure and Proper Operation ***(b)*** Detecting an Alarm when using a PLC

Figure 28: Possible Wirings for Alarm Detection

Now, with the knowledge as to how to select a redundant Rosenberg ECFanGrid and detecting a Fan failure, a logical next step would be, as to how to cover the defective Fan.

Closing Off the Open Cone of the defective Fan

There are three possible solutions. The first is to leave the cone open until the Fan can be repaired. In this option, there are large losses and the probability, that the remaining Fans will not succeed due to their performance limitations is very high. If, despite of the losses, it is decided to leave the cone open, it may an option to set the remaining fans to maximum speed to maintain an emergency mode.

However, if it is deciced to close the open cone, of the defective fan, as recommended by Engineering, there are two options as shown in Fig. 29.

- Option One: Close off the open cone with a Metal Sheet.
- Option Two: Provide Auto-Backdraft Dampers for all Fans respectively Cones.

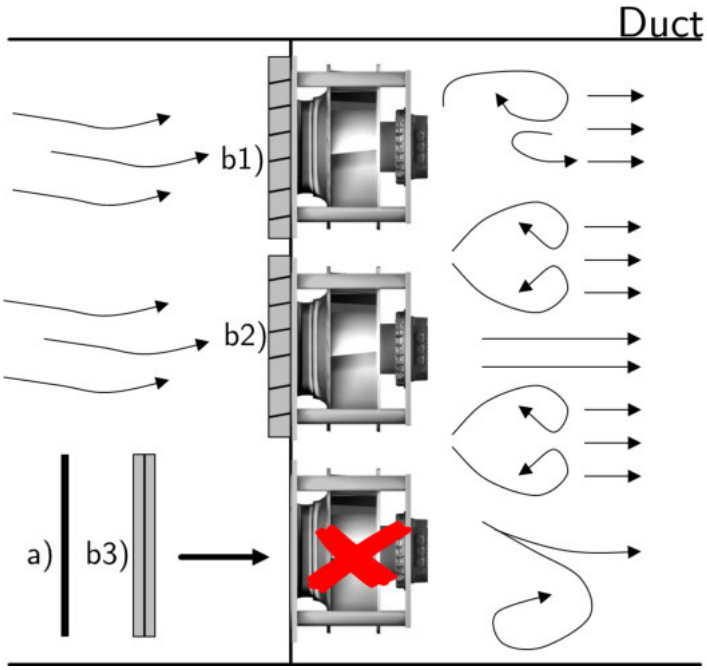


Figure 29: Possible Solutions to Close an Open Cone.
a) Manual with a simple Metal Sheet.
b) 1-3 Automatic with Backdraft Dampers at every Fan.

It is interesting to note, that Backdraft Dampers would be of value only in the rare cases of a fan failure. The benefit of using Backdraft Dampers is, that the cone is closed automatically, however they will cause some losses.
In units under lab test, a simple, sealed metal sheet was used to close open cones, as shown in Fig. 30. It is recommended to provide Rivnut fasteners into the support frame of each EC Fan, allowing easy mounting of the sheets, in the event of an Error. In addition, the metal sheet should be reinforced due to possible static pressures of 1.000 Pa (4.00 Inches) or higher while an average sized Metal Sheet of 0,25 m^2 (2.69 ft^2) – the actual force acting on the sheet is 250 Newton or about 25 kg (55 lb).

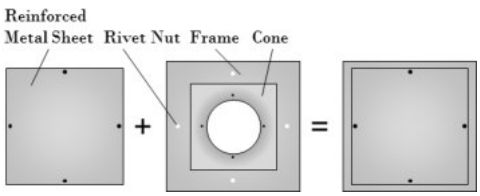


Figure 30: Closing the Cone with a Metal Sheet

With Pressure or Speed Control, closing the Inlet Cone is all that is required

With the use of Speed Control the superordinate system must increase the speed. Whereas in case of a Pressure Control the failure will be recovered automatically, within the fan's performance limitations.

Constant Air Flow Control Operation

When setting up Constant Air Flow Control as recommended in Section 8 on page 16 there would be one Master Fan. It is clear, that with the total number of fans, the probability of a failure of Master Device decreases. The Master Device is the Fan, where the Measurement Tube of the inlet cone, is connected. The curves in Fig. 31 indicate the probability of failure for this Master Fan. Using our stereotype 3x3 ECFanGrid, as an example – the probability of failure is equal for all fans, the chance that the Master Fan fails is $^1/_n$, where n is the number of fans. In this case $^1/_9$=11,1 %, refer to red curve in Fig. 31.
This logic leads us to an important aspect, the probability of a failure with nine or even more fans is justifiable. While with four or less fans, the probability increases significantly. To be precise, with four fans the probability is 25 % and with two fans 50 % – compare red curve in Fig. 31. On the bottom page it is shown, that even this scenario is not critical, but easy to manage. Some applications may require to cover more than one fan failure. The green curve in Fig. 31 indicates the probability that the Master Fan fails in case of two random fan defects. The calculation is based on the hyper-geometric distribution and in our case it is simplified to:

$$\frac{N}{n} \tag{10}$$

N, $Number\ of\ Fan\ Failures$ [1]

n, $Total\ Number\ of\ Fans$ [1]

Another example with a 3x3 ECFanGrid is, that the chances that the Master Fan would fail for two random failures is 22 %.

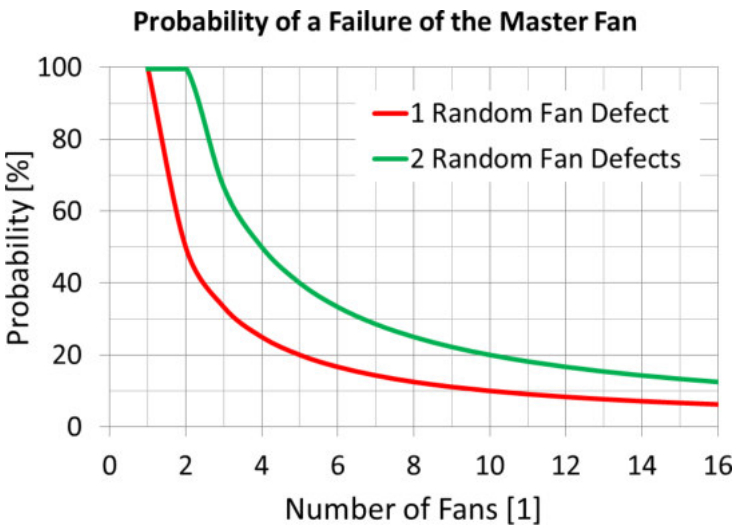


Figure 31: Probability of a Failure of the Master Fan in dependence of the Total Fan Number

Action to be taken if the Master Device fails against all Probabilities

Then only solution is to change the Master Device by using the Measurement Tubes from a different fan – so change the wiring of the Measurement Tube. Therefore it is recommended to make all Circular Measurement Tubes from all Fans accessible from the outside. In case of a

Master Fan failure, the air tube must be plugged from the Master Fan's Measurement Tube to another Fan's tube. This will take only seconds.
In summarizing, the entire Section with one possible situation of handling a failure. An example would be a 2x2 ECFanGrid with Constant Air Flow Control 25.000 m^3/h (14,715 cfm) with a selection of covering one Fan Failure. The key for the selection is to check if three fans are also able to maintain the operating point. When a failure occurs it is detected by evaluating the Alarm Relay of the EC Fans as discussed previously. At this Point, the Building Management System is displaying an Alarm and the duty officer goes on site to check which of the four fans has a malfunction. He proceeds to close the cone by screwing the reinforced, sealed Metal Sheet into the prepared rivnuts. If it is the Master Fan he would additionally change the Measurement Tubes. This should not take him more than ten minutes. The duty officer must also increase the Set Point to maintain the designed Operating Point. The question is by how much and the answer is that Rosenberg Sales Engineering can provide individual **ECFanGrid Diagrams** which can indicate the required increase of the Set Point, as shown in Fig. 32. The black vertical line in the Diagram is the required Air Flow per Fan. The demanded total operating point is 25.000 m^3/h (14,715 cfm), which in turn is 6.250 m^3/h (3,679 cfm) per fan. The intersection between this line and the blue curve is the regular Set Point, which should be adjusted in case of no failure. In the current situation, one fan has a failure so that the total number of fans is reduced to three. Now, the Set Point of the intersection between the black vertical line and the red curve should be set. The red curve is representative for three fans, like the blue curve is for four fans. In the end, the duty officer changes the set point from 600 Pa (2.4 Inches) to 1.050 Pa (4.2 Inches) within maximum five minutes. The green and the yellow curve have no intersections with the black vertical line, because only one fan failure has been considered. Rosenberg has also designed systems, where the Set Point is increased automatically without any additional manual adjustment. Information is available for the asking.

Following a Failure the ECFanGrid can be back in Proper Operation within approximately 15 Minutes

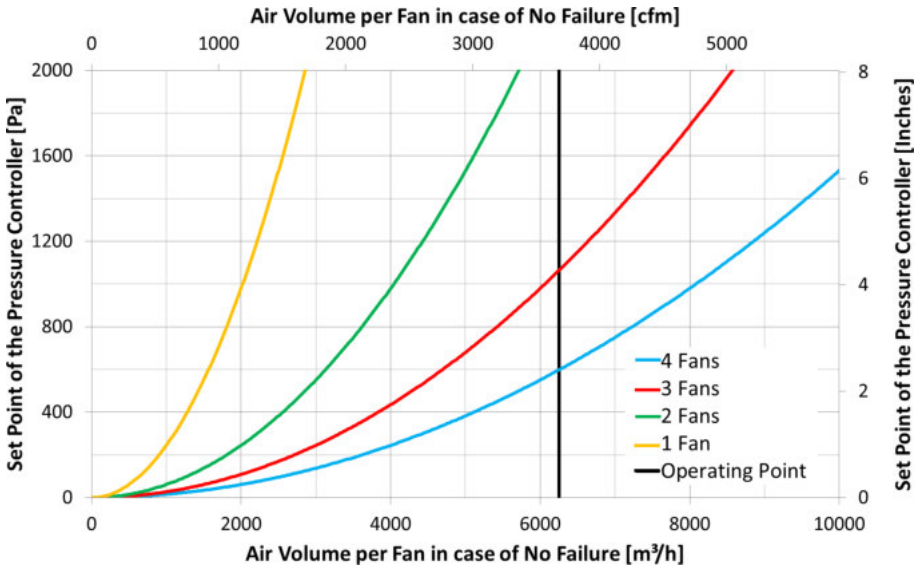


Figure 32: Using Rosenberg ECFanGrid Diagrams for covering Fan Failures

12 How-To – Electric Wiring Example 2x2 ECFanGrid

A Wiring Schematic Example is shown in Appendix C on page 37. The following text is referring to it. Every bold written name is a component, which can be found by name in the schematic. The following is required to connect the 2x2 ECFanGrid:

4x GKHM 500 Fans	**1x Pressure Controller**	**4x Fuses**
1x Main Power Switch	**1x Enable Switch**	**2x LEDs**

In addition, a cabin, terminals and wiring material, would also be required. The Schematic could be used for setting up both a Constant Pressure Control or a Constant Air Flow Control. It depends on, what the connected air tubes of the pressure controller are measuring. For an Air Flow Control they measure the differential pressure between Inlet Cone and Inlet Area and for a Pressure Control they measure for example the Outlet Area against Atmosphere.
The whole ECFanGrid can be disconnected from the Mains through one main Switch – **HS1**. Prior to connecting the fans to the power supply, the wiring diameter is reduced from 4 mm^2 (AWG 11) to 1,5 mm^2 (AWG 15). To protect the new diameter properly four 10 A fuses, one for each fan, are used – **F1 to F4**. A Rosenberg EC Fan does not require separate motor protection. A nice side effect is, in the unlikely case of a short circuit only the affected fuse is reacting and the remaining fans are able to continue their operation.
The Pressure Controller is supplied with 24 VDC and GND by Fan 1 – **P1** respectively **M1**. All fans are in open loop speed control and all are connected to the 0-10 V signal of the Pressure Controller. To guarantee a common potential all GNDs of all fans must be connected together. In case of an Air Flow Control the Measurement Tubes from Fan 1 are used, because this fan is anyway the Master Fan of the application – he is supplying the Pressure Controller. Like discussed in the previous sections the chance that this fan fails is 25 % with four fans. There are two tasks left, the evaluation of the alarm relay and the enable signal of the fans. For enabling all fans the 24 V of Fan 1 are connected through the switch – **S1** – to the Enable terminals of all fans. Once the switch is closed all fans are enabled. Last but not least, the Alarm Relays of all fans are connected as discussed in a previous section to a light indicator – **H1** – to visualize the status of the ECFanGrid. If everything is Ok a green light will show up and if one fan has a failure the red light is showing up.
With this wiring schematic the ModBus RTU terminals are also wired into the cabin. For the wiring an extra Twisted-Pair Shielded cable is used. If ModBus RTU is used only for diagnosing purposes with ECParam plus short derivation lengths (<20 m/<65 ft), it could be an option to include it into the control cable. When ModBus RTU is used for managing the whole ECFanGrid, skip the control cables – **W3, W7, W10 and W13**, but a Twisted-Pair Shielded cable is mandatory. This single cable only, is daisy chained through all fans, according to Fig. 33.

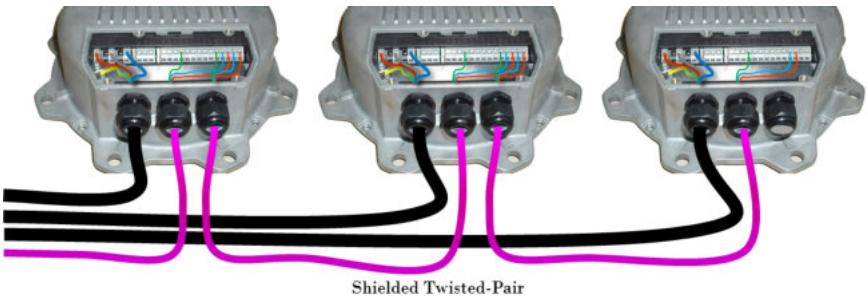


Figure 33: Wiring in case of using ModBus RTU

13 How-To – Retro-Fit with an ECFanGrid UnoBox

In the past Sections the Design of a ECFanGrid based on a pre-defined Frame Size has been presented. However, in the case of a Retro-Fit of an existing System, which has limited time frame to replace a Fan Section – Rosenberg offers an ECFanGrid UnoBox construction solution. The concept consists of a series of UnoBox cubes, which can be stacked in any configuration, to provide the required Operating Point, as shown in Fig. 34.

Figure 34: ECFanGrid UnoBox

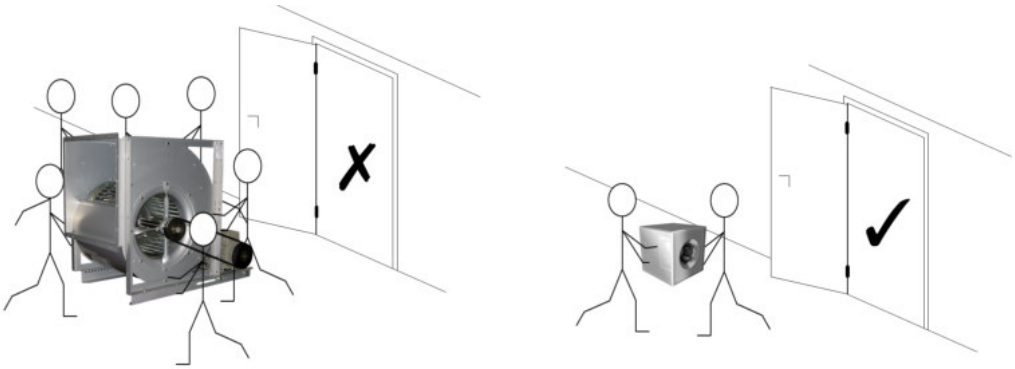
When up-grade or retro-fit of the Fan Section in an AHU requires replacement and/or removal of a large Radial Fan – this typically is a costly project, due to the construction of the building and Air Handling Unit. Often the building is grown around the Fan Unit within the years of operation.

There are two options to remove and install a new Fan System

One option would be to modify the building to allow the removal and installation of the new Fan, which could prove to be costly. The other approach would be to dismantle the old Fan into a physical size, which could be removed via doorways, as illustrated in Fig. 35 on the facing page, and install an ECFanGrid UnoBox System. As the UnoBox System is easily transportable through doorways and can be assembled on site – it is the Cost Effective Retro-Fit Solution. To get an idea about the available UnoBox range the standard dimensions are shown in Fig. 36.

A replacement can offer extensive Opportunities to increase Efficiency

The topic will be closed with a Retrofit example, which is already implemented. The operation point of the unit shown in Fig. 37 on the next page was 30.600 m^3/h (18,000 cfm) & 500 Pa (2.7 Inches). It was replaced by a 2x3 ECFanGrid UnoBox, which not only supplies the same operation point, but having a redundancy factor included. Through increasing the speed it can maintain the operation point in case of an one fan failure. Moreover a power reduction of 40 % was achieved in this configuration. Instead of 22,37 kW the 2x3 ECFanGrid consumes only 13,34 kW.



(a) The single Radial Fan won't fit through.

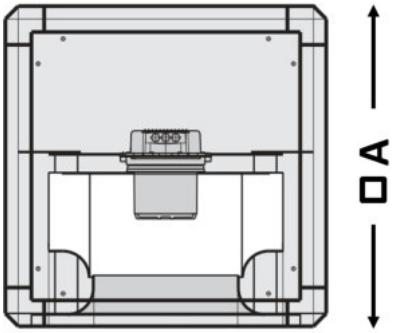
(b) The GKHM Modules or UnoBoxes fit through easily.

Figure 35: Retrofit single, large Radial Fans

Type	[mm]	[inch]
UNO 50	500	19.7
UNO 67	670	26.4
UNO 80	800	31.5
UNO 102	1.020	40.2

Note: Of course you can reduce the double dividing walls between two units.

(a) Standard Dimensions



(b) Technical Drawing

Figure 36: Mechanical Configuration of UnoBoxes

(a) Situation before. For disassembling the unit was cut into pieces.

(b) Situation After. The new ECFan-Grid was built directly on site.

Figure 37: Before & After. Retrofitting a single, large Radial Fan.

List of Figures

Appendix

A Our Test Configurations: 2x2 and 3x3 ECFanGrid

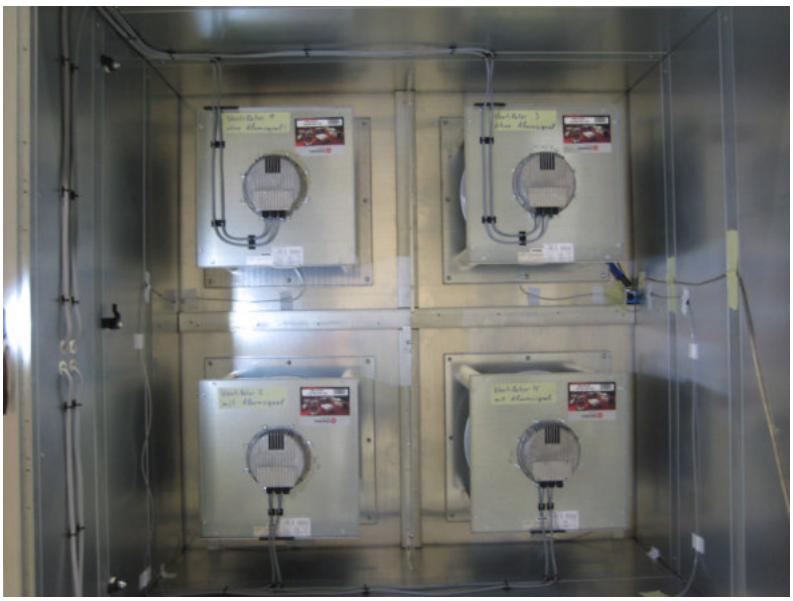


Figure 38: 2x2 GKHM 500.CIB.160.6IF IE.

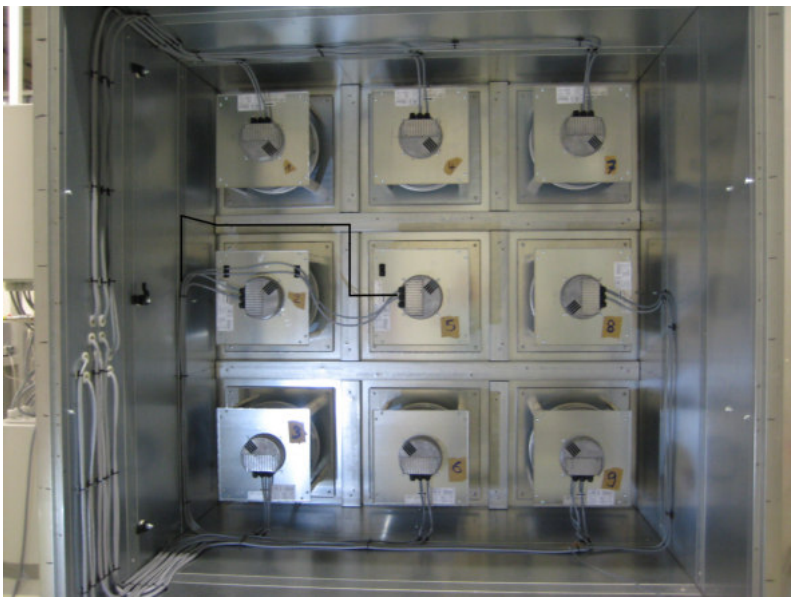


Figure 39: 3x3 GKHM 355.CIB.112.5HF IE. The Fan in the middle should be wired like indicated black. In humid environments all cable glands should point downwards.

B Some Random Impressions of the Testing Configurations

Figure 40: The Inlet Area of the 3x3 ECFanGrid

Figure 41: The Damper used for changing the System Curve, that is for simulating filter, heat exchangers, etc.

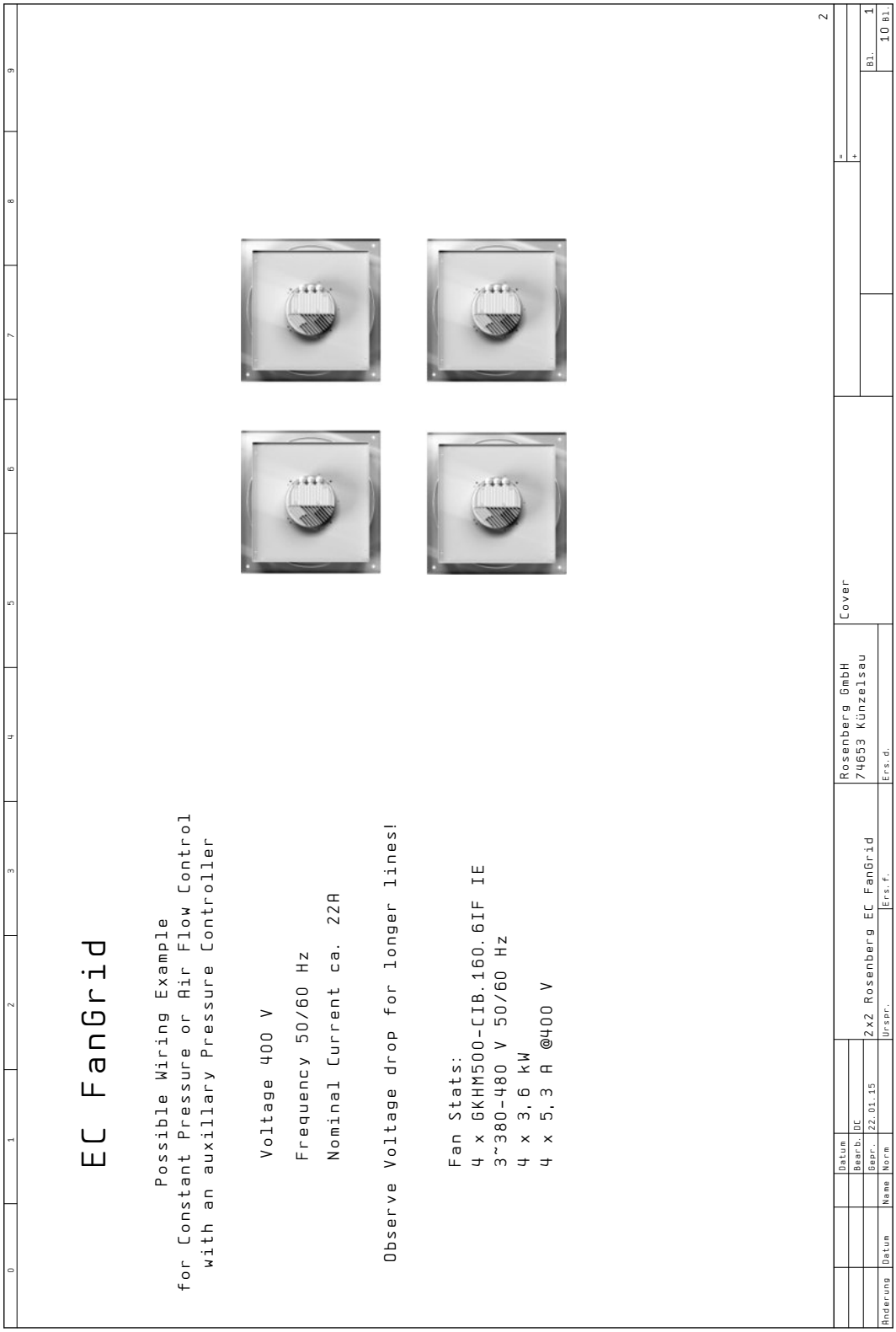
Figure 42: Side View with different sensors needed for the various measurements and two cabins one for the 2x2 and one for the 3x3 ECFanGrid.

Figure 43: A closed Cone in case of a Fan Failure.

Figure 44: Normal Air Flow direction for a Radial Fan. The fan above this one is shown in the next picture.

Figure 45: Fan Failure, Cone not Closed. The air is pushed back through the cone. Some amount of air is going in a circle.

C Wring Schematic of a 2x2 ECFanGrid



C Wring Schematic of a 2x2 ECFanGrid

0 1 2 3 4 5 6 7 8 9

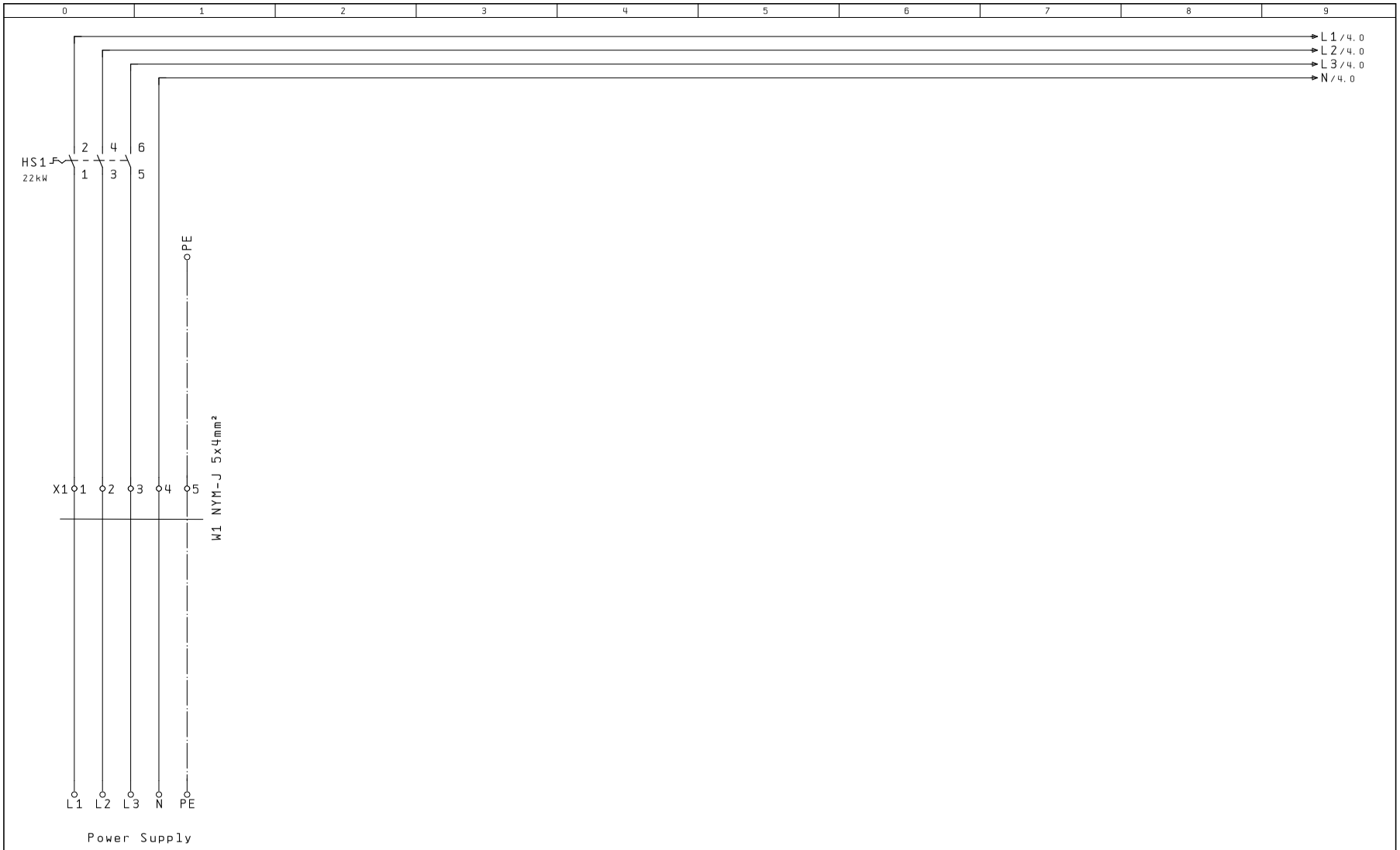
Inhaltsverzeichnis

Spalte X: eine automatisch erzeugte Seite wurde manuell nachbearbeitet

WUPJ002D 24.02.1994

1 3

			Datum		2x2 Rosenberg EC FanGrid		Rosenberg GmbH 74653 Künzelsau	Content	=	
			Bearb.	DC					+	
			Gepr.	22.01.15						Bl. 2
Änderung	Datum	Name	Norm		Urspr.	Ers. f.	Ers. d.			10 Bl.



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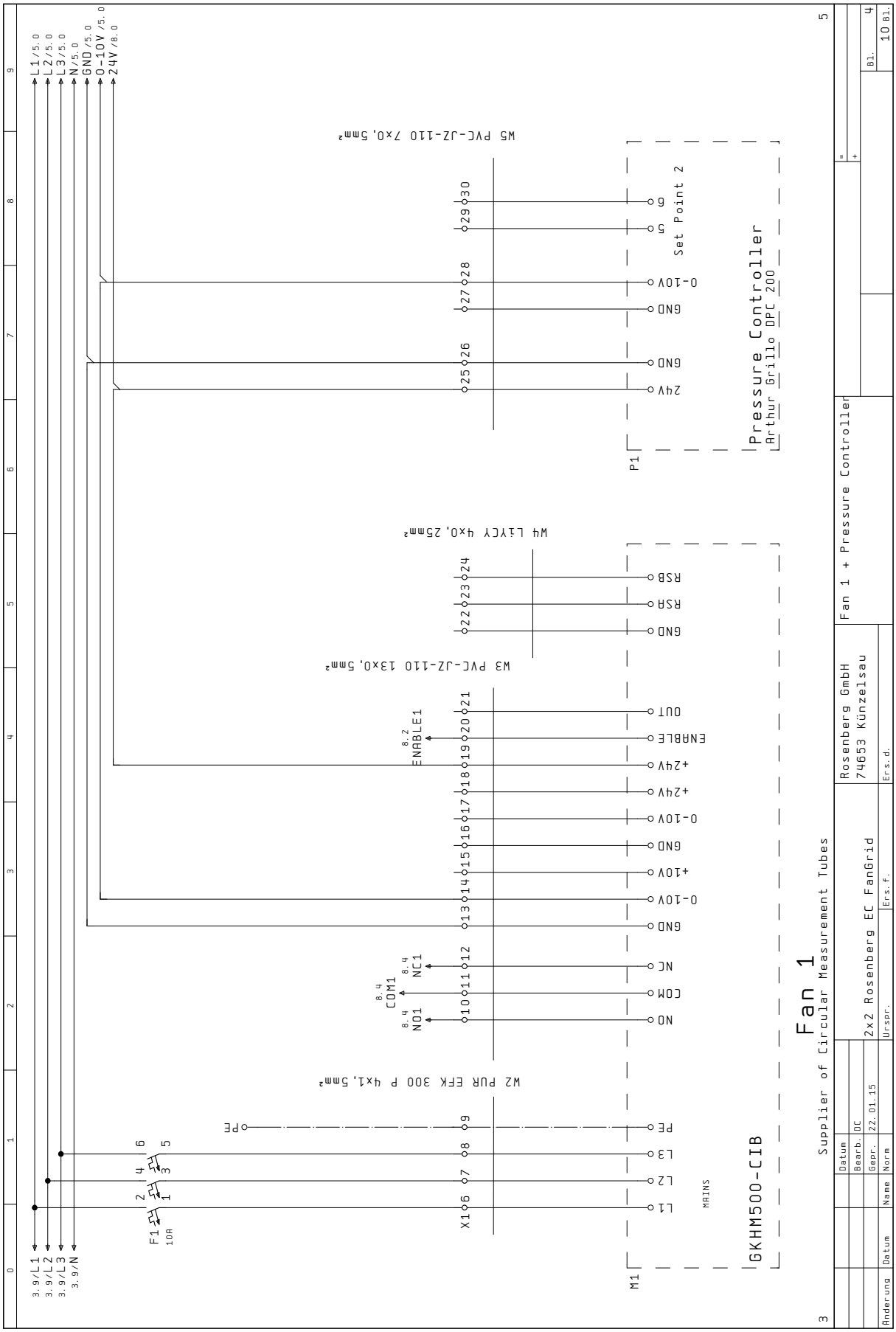
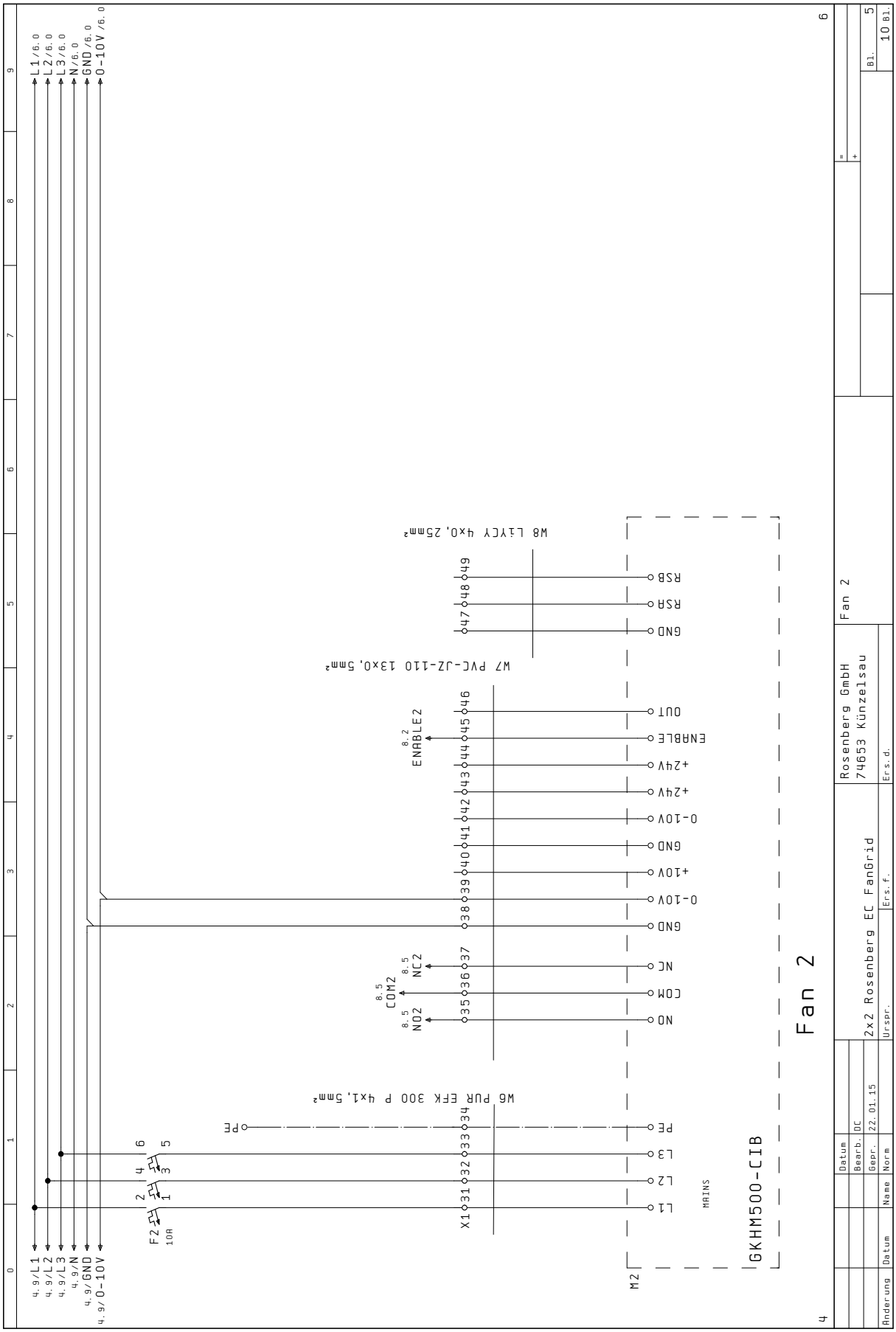
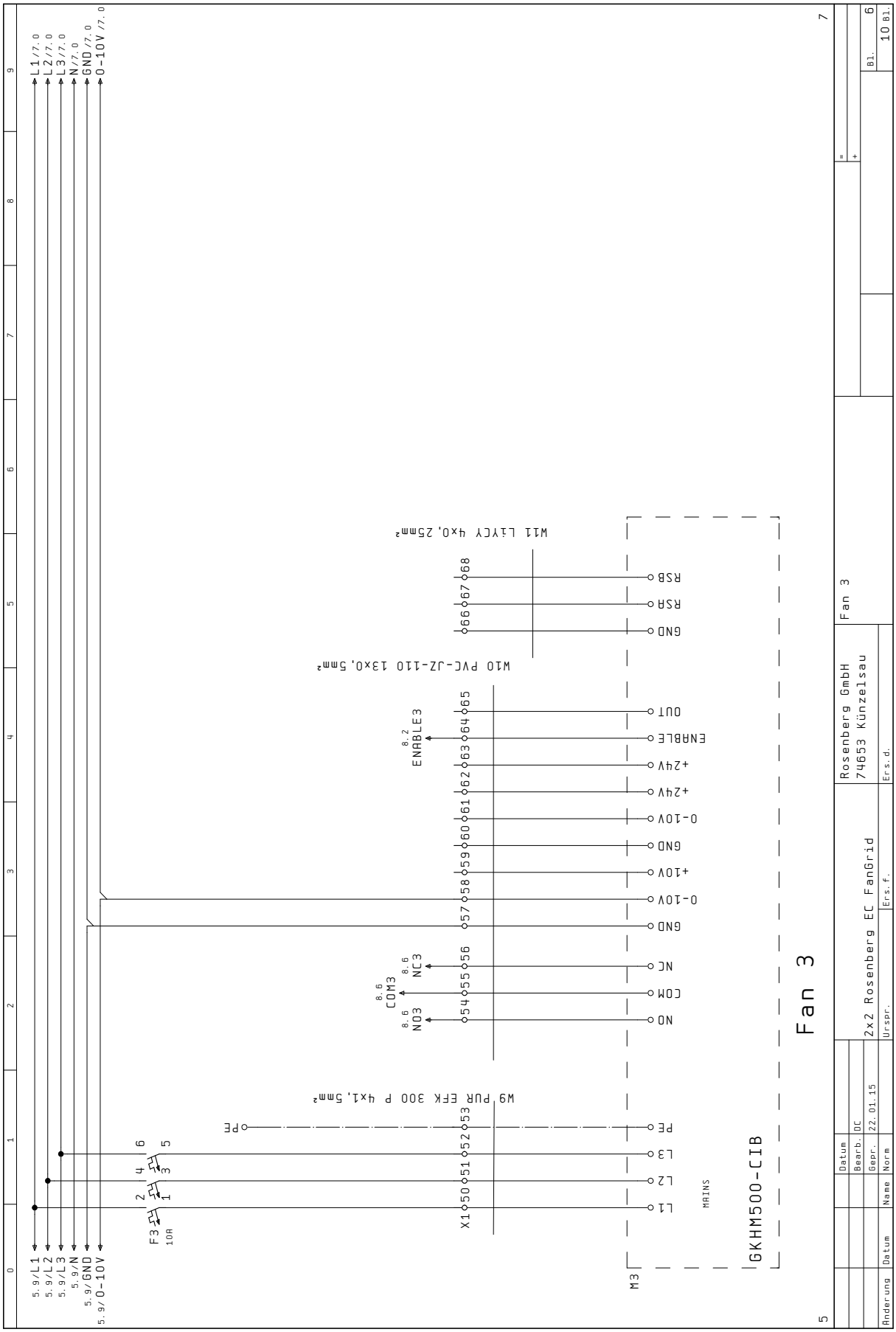
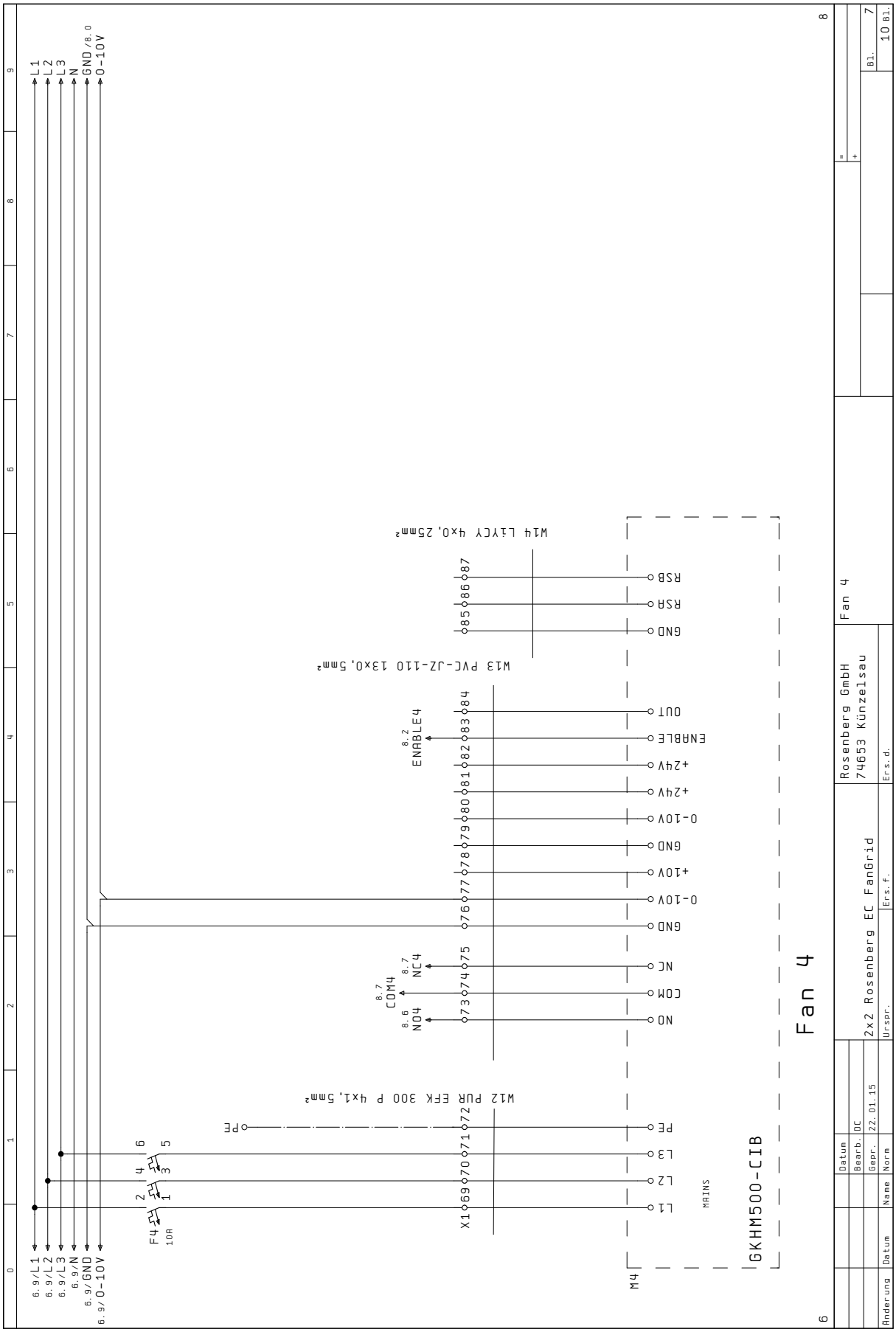
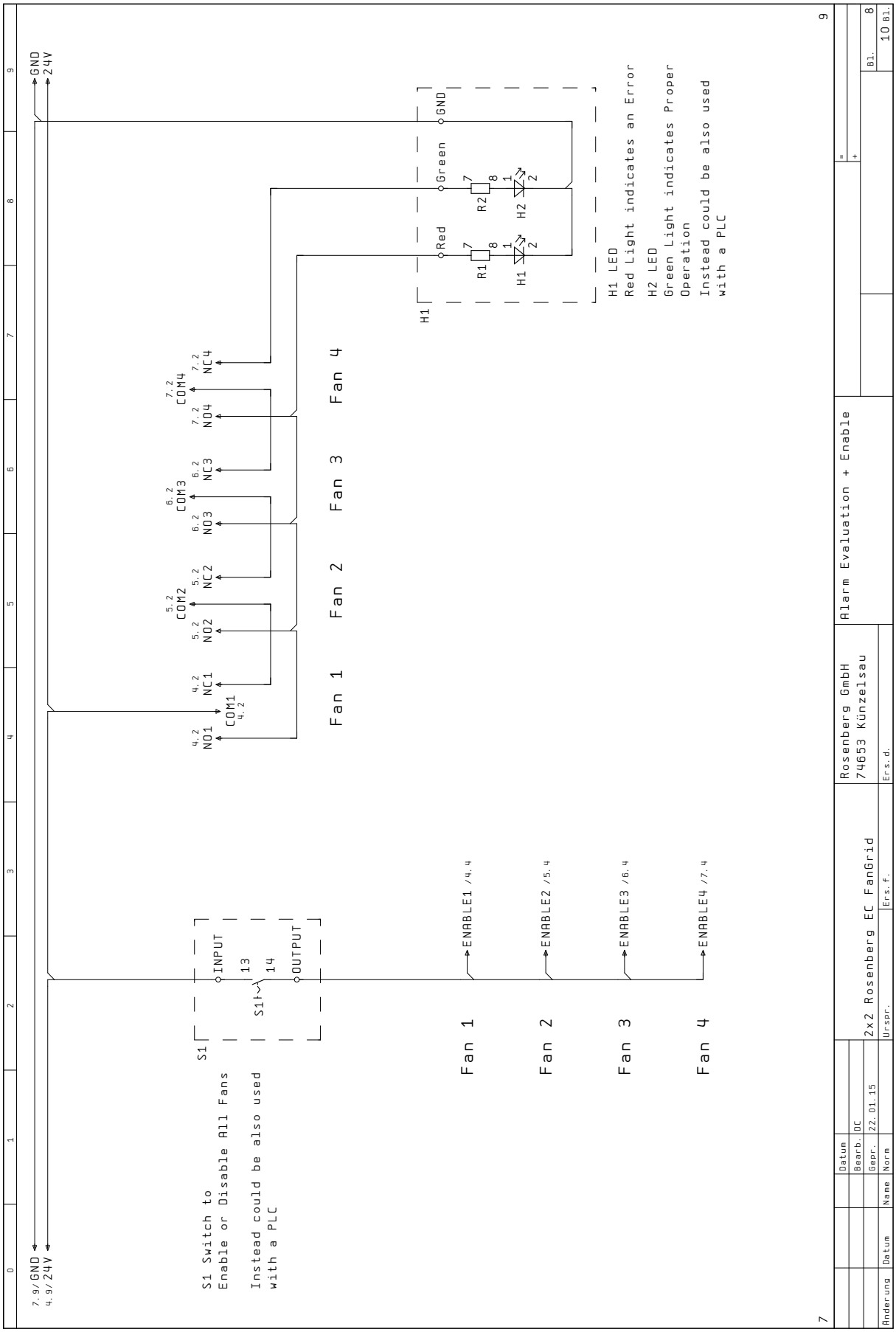
			Bearb.	DC						+	
			Gepr.	22.01.15							Bl. 3
Änderung	Datum	Name	Norm		Urspr.	Ers. f.	Ers. d.				10 Bl.


L1/5.0
L2/5.0
L3/5.0
N/5.0
GND/5.0
0-10V/5.0
24V/8.0
W5 PVC-JZ-110 7x0,5mm²
Set Point 2
Pressure Controller
Arthur Grillo DPC 200
P1
W4 LiYCY 4x0,25mm²
W3 PVC-JZ-110 13x0,5mm²
ENABLE1
W2 PUR EFK 300 P 4x1,5mm²
NO1
COM1
NC1
F1
10A
3.9/L1
3.9/L2
3.9/L3
3.9/N
GKHM500-CIB
MAINS
M1
Fan 1
Supplier of Circular Measurement Tubes
Rosenberg GmbH
74653 Künzelsau
2x2 Rosenberg EC FanGrid
Fan 1 + Pressure Controller


4.9/L1
4.9/L2
4.9/L3
4.9/N
4.9/GND
4.9/0-10V
L1/6.0
L2/6.0
L3/6.0
N/6.0
GND/6.0
0-10V/6.0
F2
10A
X1
W6 PUR EFK 300 P 4x1,5mm²
PE
NO2
COM2
NC2
GND
0-10V
+10V
GND
0-10V
+24V
+24V
ENABLE2
ENABLE
OUT
W7 PVC-JZ-110 13x0,5mm²
GND
RSA
RSB
W8 LiYCY 4x0,25mm²
L1
L2
L3
MAINS
M2
GKHM500-CIB
Fan 2
Rosenberg GmbH
74653 Künzelsau
2x2 Rosenberg EC FanGrid
Datum
Bearb. DC
Gepr. 22.01.15
Änderung
Name
Norm
Urspr.
Ersf.
Ersd.
B1. 5
10 B1.


L1/7.0
L2/7.0
L3/7.0
N/7.0
GND/7.0
0-10V/7.0
5.9/L1
5.9/L2
5.9/L3
5.9/N
5.9/GND
5.9/0-10V
F3
10A
X1
W9 PUR EFK 300 P 4x1,5mm²
PE
L1
L2
L3
MAINS
M3
GKHM500-CIB
NO
COM
NC
8.6 NO3
8.6 COM3
8.6 NC3
GND
0-10V
+10V
GND
0-10V
+24V
+24V
ENABLE
OUT
8.2 ENABLE3
W10 PVC-JZ-110 13x0,5mm²
GND
RSA
RSB
W11 LiYCY 4x0,25mm²
Fan 3
Rosenberg GmbH
74653 Künzelsau
2x2 Rosenberg EC FanGrid
Datum
Bearb. DC
Gepr. 22.01.15
Änderung
Datum
Name
Norm
Urspr.
Ers. f.
Ers. d.
B1. 6
10 B1.


6.9/L1
6.9/L2
6.9/L3
6.9/N
6.9/GND
6.9/0-10V
L1
L2
L3
N
GND/8.0
0-10V
F4
10A
X1
W12 PUR EFK 300 P 4x1,5mm²
PE
L1
L2
L3
PE
MAINS
M4
GKHM500-CIB
NO
COM
NC
GND
0-10V
+10V
GND
0-10V
+24V
+24V
ENABLE
OUT
8.6 NO4
8.7 COM4
8.7 NC4
8.2 ENABLE4
W13 PVC-JZ-110 13x0,5mm²
GND
RSA
RSB
W14 LiYCY 4x0,25mm²
Fan 4
Rosenberg GmbH
74653 Künzelsau
2x2 Rosenberg EC FanGrid
Datum
Bearb. DC
Gepr. 22.01.15
Änderung
Datum
Name
Norm
Urspr.
Ers. f.
Ers. d.
Bl. 7
10 Bl.


GND
24V
7.9/GND
4.9/24V
S1 Switch to
Enable or Disable All Fans
Instead could be also used
with a PLC
S1
INPUT
13
S1
14
OUTPUT
ENABLE1 /4.4
ENABLE2 /5.4
ENABLE3 /6.4
ENABLE4 /7.4
Fan 1
Fan 2
Fan 3
Fan 4
4.2 NO1
4.2 NC1
COM1 4.2
5.2 NO2
5.2 NC2
5.2 COM2
6.2 NO3
6.2 NC3
6.2 COM3
7.2 NO4
7.2 NC4
7.2 COM4
H1
Red
Green
GND
R1
R2
H1
H2
H1 LED
Red Light indicates an Error
H2 LED
Green Light indicates Proper
Operation
Instead could be also used
with a PLC
Rosenberg GmbH
74653 Künzelsau
Alarm Evaluation + Enable
2x2 Rosenberg EC FanGrid
Datum
Bearb. DC
Gepr. 22.01.15
Norm
Name
Änderung
Datum
Urspr.
Ers.f.
Ers.d.
B1. 8
10 B1.

Klemmenplan

WUPK006D 24.02.1994

Leistenbezeichnung

X1

W13 PVC-JZ-110 13x0.5mm²	W12 PUR EFK 300 P 4x1.5mm²	W11 LiYCY 4x0.25mm²	W10 PVC-JZ-110 13x0.5mm²	W9 PUR EFK 300 P 4x1.5mm²	W8 LiYCY 4x0.25mm²	W7 PVC-JZ-110 13x0.5mm²	W6 PUR EFK 300 P 4x1.5mm²	W5 PVC-JZ-110 7x0.5mm²	W4 LiYCY 4x0.25mm²	W3 PVC-JZ-110 13x0.5mm²	W2 PUR EFK 300 P 4x1.5mm²	W1 NYM-J 5x4mm²	Kabeltyp	Ziel-bezeichnung	Anschluß	Klemmen-nummer	Brücken	Geräte-Anschluß	Ziel-bezeichnung	Anschluß	Kabeltyp	1.5mm² sw	Seite/Pfad
												1		L1		1			HS1	1		X	3.0
												2		L2		2			HS1	3		X	3.0
												3		L3		3			HS1	5		X	3.0
												4		N		4			N			X	3.1
												PE		PE		5		PE					3.1
											1			M1	L1	6			F1	1		X	4.0
											2			M1	L2	7			F1	3		X	4.1
											3			M1	L3	8			F1	5		X	4.1
											PE			M1	PE	9		PE					4.1
										1				M1	NO	10			X1	35		X	4.2
										2				M1	COM	11			S1	INPUT		X	4.2
										3				M1	NC	12			X1	36		X	4.2
										4				M1	GND	13			X1	26		X	4.3
										5				M1	0-10V	14			X1	28		X	4.3
										6				M1	+10V	15							4.3
										7				M1	GND	16							4.3
										8				M1	0-10V	17							4.3
										9				M1	+24V	18							4.4
										10				M1	+24V	19			X1	25		X	4.4
										11				M1	ENABLE	20			X1	83		X	4.4
										12				M1	OUT	21							4.4
									1					M1	GND	22							4.5
									2					M1	RSA	23							4.5
									3					M1	RSB	24							4.5
								1						P1	24V	25			X1	19		X	4.7
								2						P1	GND	26			X1	13		X	4.7
								3						P1	GND	27							4.7
								4						P1	0-10V	28			X1	14		X	4.7
								5						P1	5	29							4.8
								6						P1	6	30							4.8
							1							M2	L1	31			F2	1		X	5.0
							2							M2	L2	32			F2	3		X	5.1
							3							M2	L3	33			F2	5		X	5.1
							PE							M2	PE	34		PE					5.1
						1								M2	NO	35			X1	10		X	5.2
						2								M2	COM	36			X1	12		X	5.2
						3								M2	NC	37			X1	55		X	5.2
						4								M2	GND	38			X1	26		X	5.3
						5								M2	0-10V	39			X1	28		X	5.3
						6								M2	+10V	40							5.3
						7								M2	GND	41							5.3
						8								M2	0-10V	42							5.3
						9								M2	+24V	43							5.4
						10								M2	+24V	44							5.4
						11								M2	ENABLE	45			X1	83		X	5.4
						12								M2	OUT	46							5.4
					1									M2	GND	47							5.5
					2									M2	RSA	48							5.5
					3									M2	RSB	49							5.5
				1										M3	L1	50			F3	1		X	6.0
				2										M3	L2	51			F3	3		X	6.1
				3										M3	L3	52			F3	5		X	6.1
				PE										M3	PE	53		PE					6.1
			1											M3	NO	54			X1	35		X	6.2
			2											M3	COM	55			X1	37		X	6.2
			3											M3	NC	56			X1	74		X	6.2
			4											M3	GND	57			X1	38		X	6.3
			5											M3	0-10V	58			X1	39		X	6.3
			6											M3	+10V	59							6.3
			7											M3	GND	60							6.3
			8											M3	0-10V	61							6.3
			9											M3	+24V	62							6.4
			10											M3	+24V	63							6.4
			11											M3	ENABLE	64			X1	83		X	6.4
			12											M3	OUT	65							6.4
		1												M3	GND	66							6.5
		2												M3	RSA	67							6.5
		3												M3	RSB	68							6.5
	1													M4	L1	69			F4	1		X	7.0
	2													M4	L2	70			F4	3		X	7.1
	3													M4	L3	71			F4	5		X	7.1
	PE													M4	PE	72		PE					7.1
1														M4	NO	73			X1	54		X	7.2
2														M4	COM	74			X1	56		X	7.2
3														M4	NC	75			H1	Green		X	7.2
4														M4	GND	76			X1	57		X	7.3
5														M4	0-10V	77			X1	58		X	7.3
6														M4	+10V	78							7.3

8

10

0 1 2 3 4 5 6 7 8 9

		Datum	22.01.15
		Bearb.	IM1
		Gepr.	22.01.15
Änderung	Datum	Name	Norm

2x2 Rosenberg EC FanGrid

Urspr.

Ers.f.

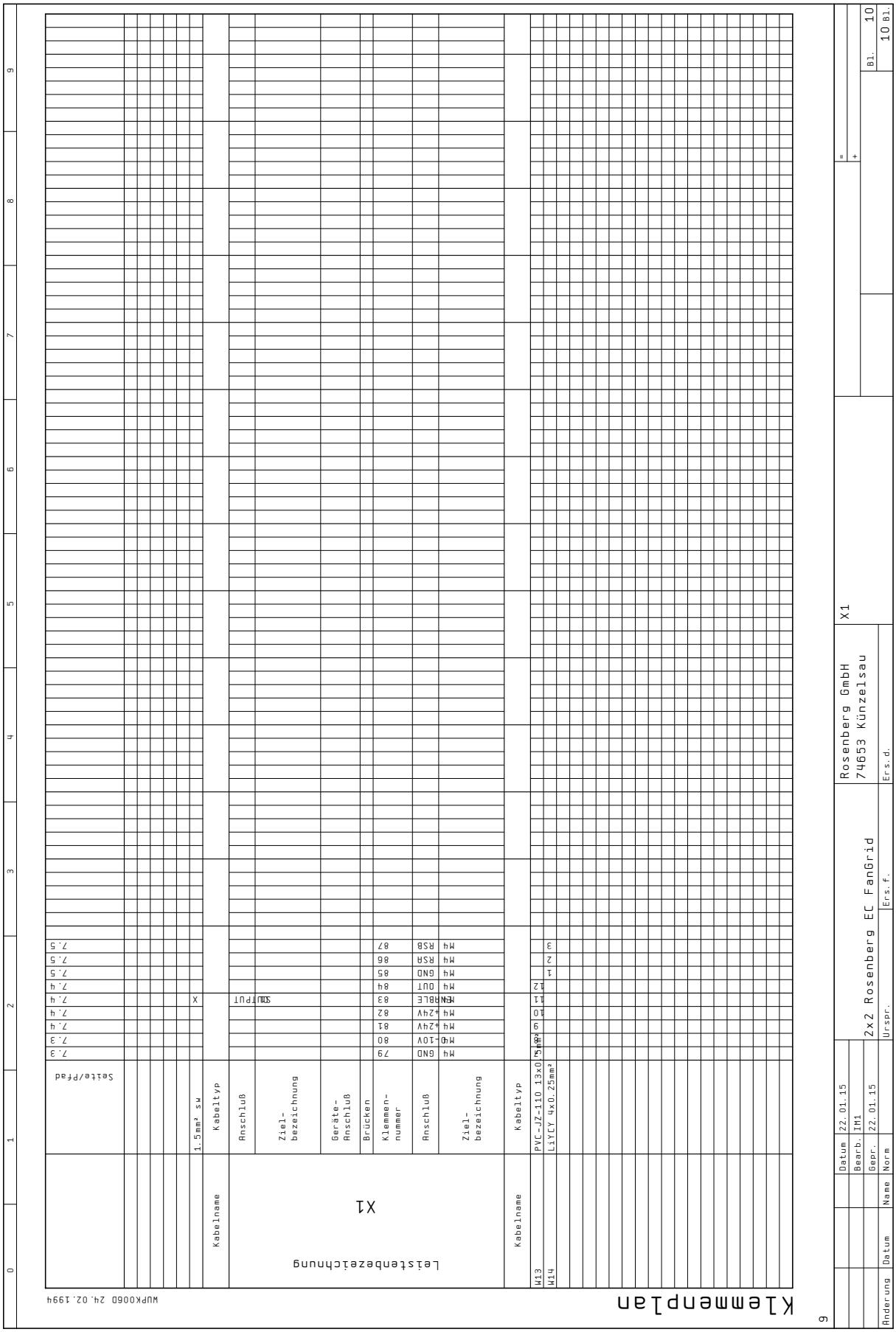
Rosenberg GmbH
74653 Künzelsau

Ers.d.

X1

=
+

Bl. 9
10 Bl.


Klemmenplan
WUPK0060 24.02.1994
Leistenbezeichnung
X1
Kabelname
Kabeltyp
Anschluß
Ziel-
bezeichnung
Geräte-
Anschluß
Brücken
Klemmen-
nummer
Anschluß
Ziel-
bezeichnung
Kabeltyp
Kabelname
Seite/Pfad
1.5mm² sw
W13
W14
PVC-JZ-110 13x0.75mm²
LiYCY 4x0.25mm²
M4 GND 79 7.3
M4 +10V 80 7.3
M4 +24V 81 7.4
M4 +24V 82 7.4
M4 ENABLE 83 7.4
M4 OUT 84 7.4
M4 GND 85 7.5
M4 RSA 86 7.5
M4 RSB 87 7.5
X
SUMPUT
1 2 3 10 11 12
Rosenberg GmbH
74653 Künzelsau
X1
2x2 Rosenberg EC FanGrid
Datum 22.01.15
Bearb. IM1
Gepr. 22.01.15
Änderung Datum Name Norm
Urspr.
Ers. f.
Ers. d.
B1. 10
10 B1.

Rosenberg

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Subsidiaries and Partners

Als global agierendes Unternehmen sind wir überall dort vertreten, wo unsere Kunden uns brauchen. Mit Produktionsstandorten, Vertriebsniederlassungen und Partnern in über 45 Ländern sind wir weltweit präsent - ein starker und zuverlässiger Partner immer in Reichweite unserer Kunden.

As a globally operating company, we are represented wherever customers need us. We have a worldwide presence with production sites, sales offices and partners in over 45 countries - a powerful and reliable partner always close to our customers.

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