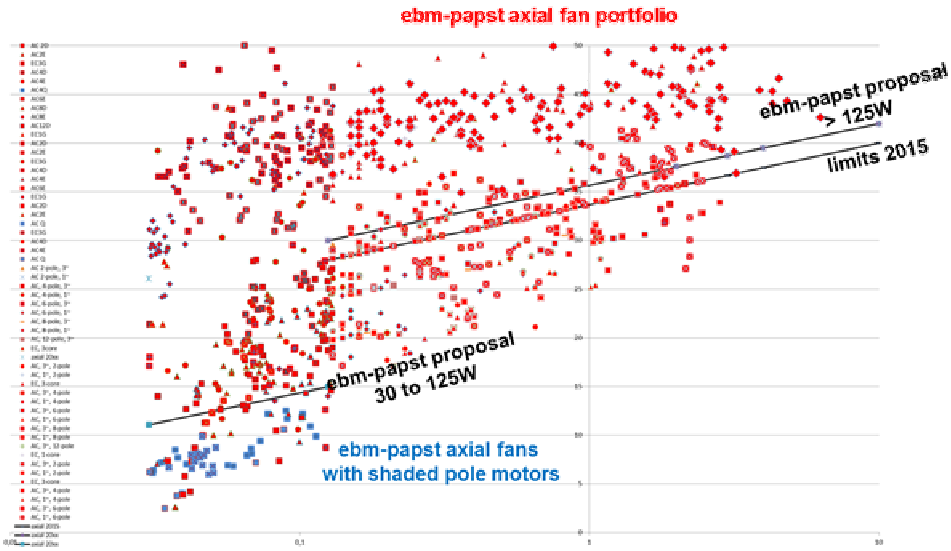
Rene Kemna

From: Sigloch, Uwe <Uwe.Sigloch@de.ebmpapst.com>
Sent: 27 October 2014 17:21
To: Roy van den Boorn
Cc: rené Kemna; Lockwood, Geoff
Subject: Data on efficiency VSD motors
Attachments: M3G084GF_K3G280AU11C9.pdf; M3G112EA_K3G310AX5290.pdf

Dear Mr. Van den Boorn,

yes, we mentioned that fan impeller efficiencies, motor efficiencies and drive efficiencies should not be seperated from each other. The better way is to use tested data for the complete impeller/motor/drive system. This is how the MEPS for the fan regulation have been derived some years ago (see „axial fan efficiency cloud“ below). Therefore it is not useful to re-calculate the limits by using motor default values that are, specially at the lower power end, not representative.



To support this please find attached sample test data for fan motors used in standard fan products from ebm-papst. Please note that such fans are not solely produced by ebm-papst. There are many manufacturers of such motors located all over the world…Ziehl-Abegg DE, Rosenberg DE, Rotomatika SLO, Regal Beloit US, FansTech CN, Panasonic JP, XiangMing CN, Sanwei CN, Dunli CN, and many others… . So such kind of motors are well established throughout the world. If you look at the limits oft he upcoming ventilation regulation (Lot6) you will see that the limits will only be achieved with fans operated with such kind of motors….So why talking about reducing the 2015MEPS in 2017 or 2018?

If you need further information, just let us know.

Mit freundlichen Grüßen / Best regards

i.V. Uwe Sigloch

Market Management
Vertrieb und Marketing

ebm-papst Mulfingen GmbH & Co. KG
Bachmühle 2
74673 Mulfingen

Phone: +49 (7938) 81 7021
Fax: +49 (7938) 81 97021

Uwe.Sigloch@de.ebmpapst.com
http://www.ebmpapst.com

Ein Zeichen, mit dem wir Zeichen setzen. A symbol that defines standards.

Von: Roy van den Boorn [mailto:r.van.den.boorn@vhk.nl]
Gesendet: Donnerstag, 9. Oktober 2014 15:08
An: Sigloch, Uwe
Cc: rené Kemna
Betreff: Data on efficiency VSD motors

Dear Mr. Sigloch

During the first stakeholder meeting for the fan review study, 1st of October, you mentioned that VSD motors are more efficient then mentioned in the motor regulation, which creates a wrong picture when calculating energy efficiency. Could you provide us with data so that we can analyse your statement not to link motor efficiencies with upcoming motor regulation efficiencies but look at real life efficiencies?

Kind regards,

For the VHK study team, Roy van den Boorn

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van Holsteijn en Kemna B.V.
Elektronicaweg 14
2628 XG Delft
Nederland
Mail: r.van.den.boorn@vhk.nl
Tel (NL): +31 (0) 15 2755 755
Tel (B) : +32 (0) 23 45 92 75

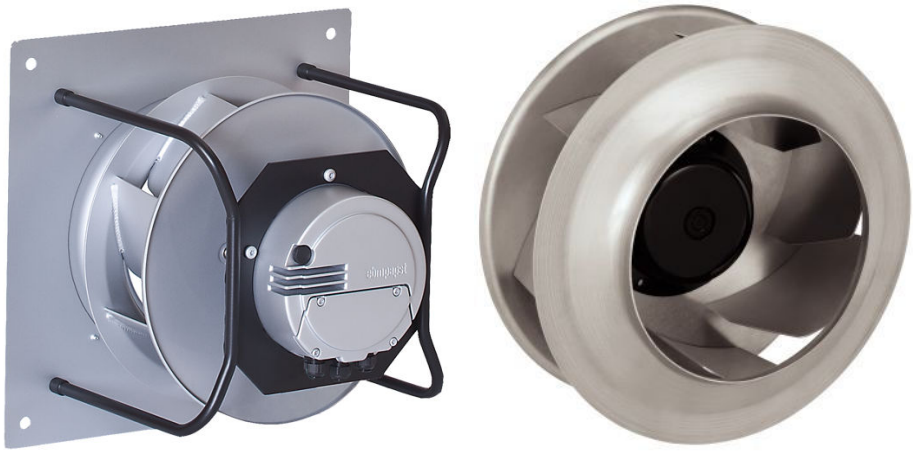
1. ECA Certification Summary Test Report 13

Motor: M3G084-GF – 2,67Nm-3116min-1

Winding reference: 57343-5-9910
Working Point: max. troque / speed
2,67Nm / 3116min-1
min^{-1}

picture 1. motor

Blower: K3G280-AU11-C9



picture 2. blower

Test sample:	Series production week 29/13	
Measurements according	60034-2-1:2007	Efficiency by Direct Testing Method(3.2.1)
Measurement: Reference No.	MNo.: 18846 MNo.: 12452	M-ID: 33025 M-ID: -
Measurements by: Approved by:	Wolfgang Eckl Oliver Bieber	
Quality Management System according	DIN EN ISO 9001:2008 List of epM Certificates see Detailed Test Report 1 –M3G150-NA-20Nm-1133	

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Table of contents

2. Introduction

2.1. Intension

This motor is tested to be qualified to the UK ECA Testing Programme and exceeds the following performance criteria form Table 1 of the

"ECA Energy Technology Criteria List 2010
– Motor & Drives –
– *"Permanent Magnet Synchronous Motors* – "

Output Power Rating:	1,59 kW	ECA
Max. continuous speed rating:	1501 rpm to 3000 rpm	Setpoint
Efficiency:	>= 85,9%	value

The motor is tested according the - IE standard product test –

2.2. Testing Laboratory: **ebm-papst Mulfingen - R&D Department -**
Bachmühle 2
Mulfingen

We confirm that the test facilities are permanently under control of the test laboratory
(It's a special lab only for R&D staff members).
The test facility is controlled by the ebm-papst quality department and the technicians of the test laboratory.

Date of product testing: Mai 2014

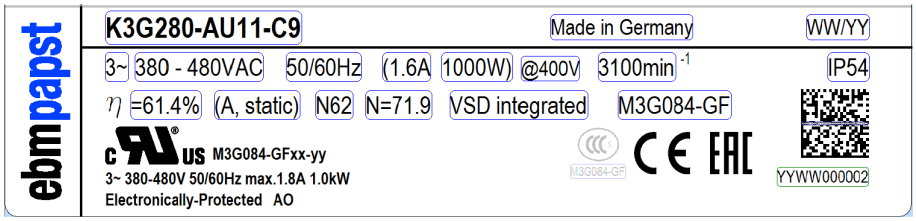
i.V. .....
R& D Manager

i.A. .....
Head of R&D EM-F

3. Product details

3.1. The motor M3G084-GF was taken from the production item fitted to Blower K3G280-AU11-C

3.2. see appendix a



3.3. Parts of the assembled motor

3.3.1. Stator:	40101-1-0248
3.3.2. Rotor:	20153-1-3428
3.3.3. Control unit:	10015-1-0173

3.4. control settings (testing configuration)

3.4.1. setup control unit:	no speed control (normally n_{max} = 3100 min^{-1})
3.4.2. software for motor control	ebm-papst motor control software: LISA
3.4.3. motor adjustment:	voltage control;
3.4.4. torque adjustment:	current control for the eddy current brakes

3.5. testing conditions

3.5.1. modifications of the motor from standard

- 3.5.1.1. rotor with a new shaft to connect it to the torque sensor.
- 3.5.1.2. control unit demounted to measure directly the electrical values of the motor
- 3.5.1.3. motor winding with implemented thermocouples to measure the winding temperature
- 3.5.1.4. additional connecting cable to link the motor to the control unit

3.5.2. start testing: motor stars at ambient temperature (20 to 30°C)

3.5.3. end testing: electrical and mechanical values were measured at steady state condition

4. Test procedure

4.1. Test procedure according to ebm-papst (epM) standard test: (EN 60034-2-1 direct measuring method)

4.1.1. validation of the torque sensor and torque evaluation device:

see Detailed Test Report 1 –M3G150-NA-20Nm-1133

4.1.2. motor installation

4.1.3. motor testing

4.1.4. connection of motor and torque sensor

4.1.5. start measuring

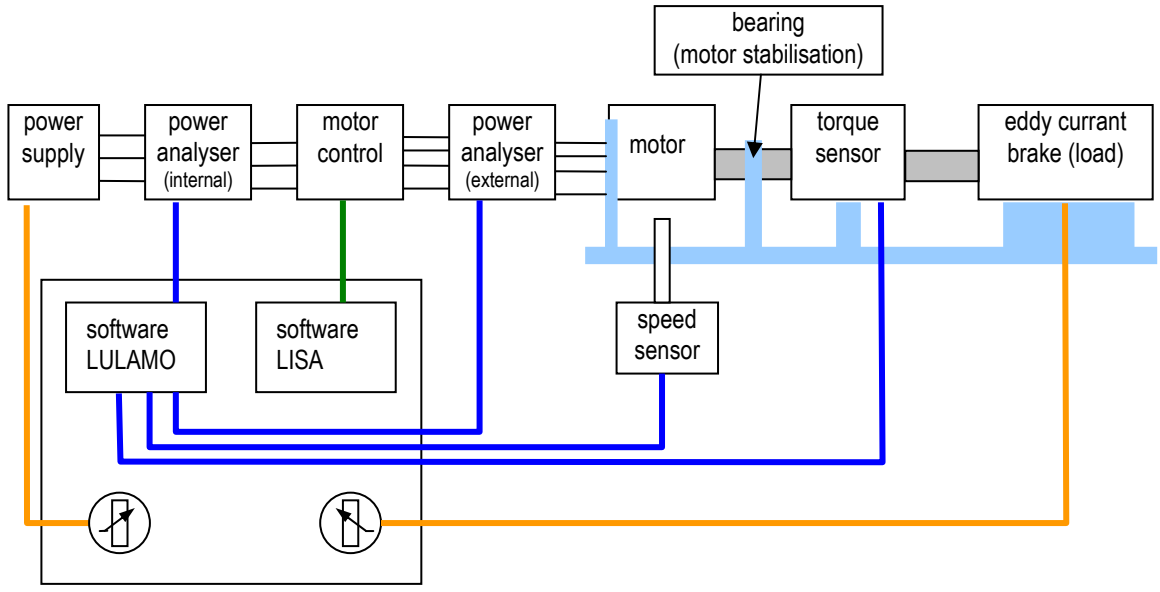
4.1.5.1. Md(n) measurement at ambient temperature

4.1.5.2. Temperature rise test at steady state condition

4.1.5.2.1. recording input power (P_1); output power (P_2= T x 2 π x n)

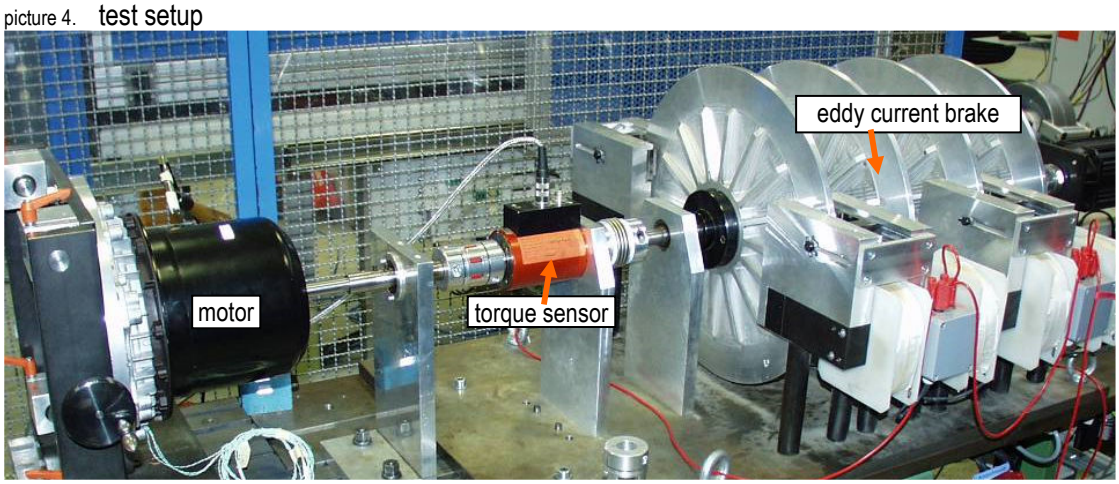
4.1.5.2.2. calculating and recording efficiency $\eta = O_{utput} / I_{nput} \times 100\%$

4.2. test rig 3

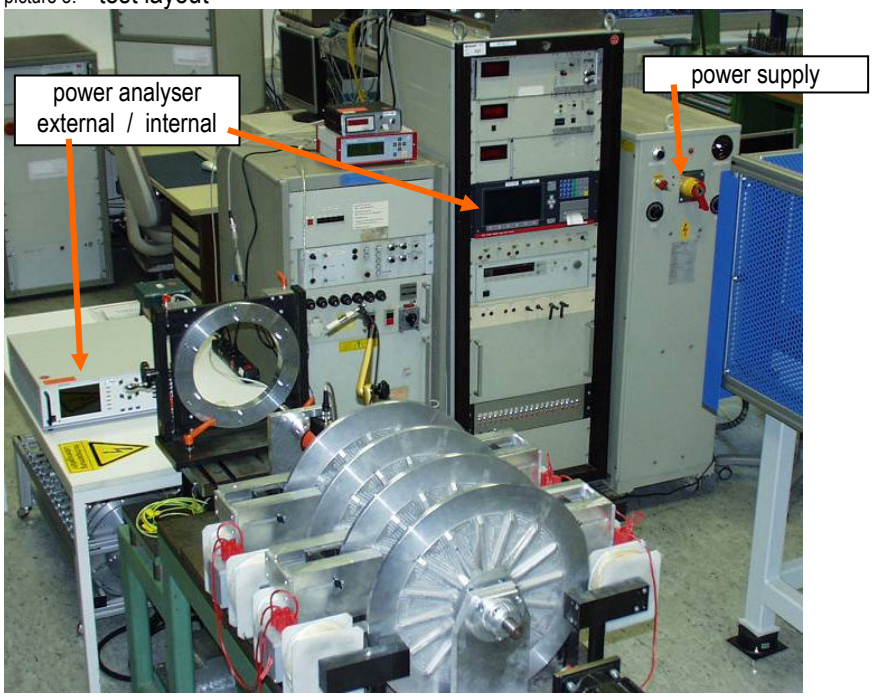


picture 3.

picture 4. test setup



picture 5. test layout



4.3. Details of the measurement equipment: see Detailed Test Report 1 –M3G150-NA-20Nm-1133

all instruments are controlled by the ebm-papst quality department and documented in a database

4.3.1. List of measurement equipment

Test bench: Rack 3	cerificates see: Detailed Test Report 1 –M3G150-NA-20Nm-1133
Torque sensor:	K1Z0.
mass 1&2	K5K0.0023 & K5K0.17
Torsion arm:	L9K9.007
Torque evaluation device:	K1D0.0018
Speed measurement:	D2D0.0072
External Power Analyser:	E6D0.0049
Internal Power Analyser:	E6D0.0025

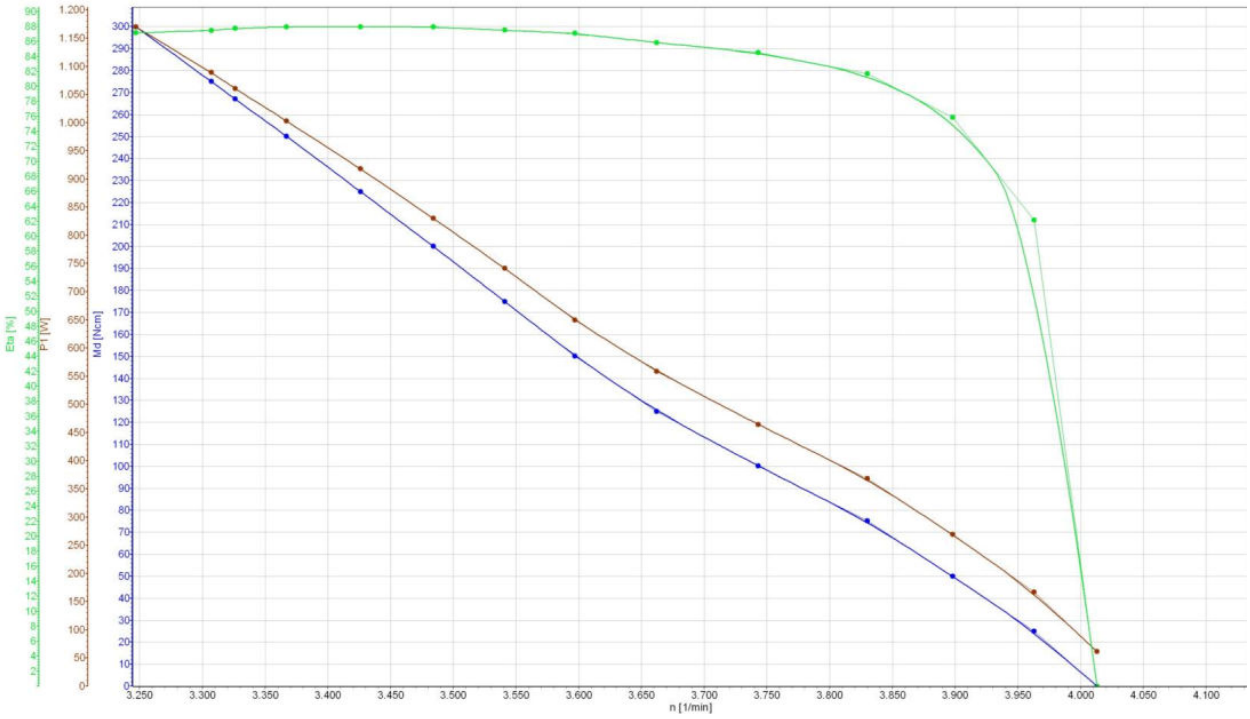
5. Test results of M3G084-GF

5.1. Torque / speed curve

**Diagramm für Messprotokoll,
nach DIN EN 60034-2**

ebmpapst

IdNo	Motortyp	Index	Messnr.	U[V]	F[Hz]	C[yF]	Muster	Stufe
53481	M3G084GF	02A	18846	400	50	0	ECA	0



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**Motor test record for EC motor (AC supply),
according to DIN EN 60034-2**

ebmpapst

Date:	28.04.2014	Editor:	Eckl
Customer:	ebm-papst Mulfingen GmbH & Co.KG		
Motor type:	M3G084GF		
Voltage:	400 V	Frequency:	50Hz
Meas. Station:	Rack 3	Sensor range:	50Nm

Proj. no.:	49842
Measurement:	18846
Sample:	ECA
Protection class:	IP54
Meas. range:	10Nm

Nr.	U~ [V]	I1~ [A]	I2~ [A]	I3~ [A]	P1 [W]	λ	n [1/min]	Md [Ncm]	P2 [W]	η [%]
0	400,8	0,19	0,19	0,19	61,34	0,466	4013	0	0	0
1	400,8	0,372	0,372	0,373	167	0,647	3963	25	103,8	62,16
2	400,7	0,552	0,554	0,555	269,1	0,7	3898	50	204,1	75,85
3	400,6	0,727	0,729	0,73	368,6	0,729	3830	75,1	301,2	81,71
4	400,6	0,892	0,895	0,897	464,3	0,748	3743	100,1	392,4	84,51
5	400,5	1,052	1,053	1,057	558,4	0,764	3662	125	479,4	85,85
6	400,5	1,199	1,2	1,204	649,3	0,779	3597	150,1	565,4	87,08
7	400,4	1,32	1,328	1,335	741,7	0,806	3541	175	648,9	87,49
8	400,4	1,44	1,442	1,452	830,3	0,829	3484	200,1	730,1	87,93
9	400,3	1,558	1,563	1,572	918,2	0,847	3426	225	807,2	87,91
10	400,3	1,674	1,679	1,691	1003,2	0,86	3367	250,2	882,2	87,94
11	400,3	1,756	1,759	1,769	1060,4	0,868	3326	267,1	930,3	87,73
12	400,3	1,796	1,799	1,811	1089,4	0,872	3307	275,1	952,7	87,45
13	400,2	1,911	1,913	1,926	1170	0,88	3247	299,9	1019,7	87,15

5.2. Temperature rise test at steady state condition

		P_1 [W]	P_2 [W]	Σ Losses [W]	$\overline{T}_{Winding}$ [K]	eff. η	A_{mbient} [°C]
Nominal torque according test chart for ventilator K3G280-AU11-C(see appendix b page 1)	2,67Nm / **3116min-1**	**1019,7**	**872,1**	**147,6**	**85,4**	**85,53**	**26,0**

Table 5.1

5.3. boundary conditions for temperature rise test

- Temperature rise test at steady state condition (see appendix b page 2)
- The set up torque is manually controlled
- Time period for achieving the steady state condition app. 3h

5.4. efficiency calculations for winding temperature 115°C (according to EN 60034-2-1)

Winding temperature at nominal torque measurement:

$T_{winding}$ = 85,5K+ 26°C = 111,5 °C
Copper losses ($P_{V\,Cu}$) at 111,5°C = 58,47 W (see appendix b page 2)
Copper losses ($P_{V\,Cu}$) at 115°C = 59,24 W
Difference of copper losses $\Delta P_{V\,Cu}$ = 0,77 W

Total losses ($P_{V\,tot}$) at 115°C = 147,6W +0,77 W = 148,37W

Efficiency at 115°C Winding temperature:
$\eta_{115°C}$ = 85,5%

5.5. Discussion of the test results: see Detailed Test Report 1 –M3G150-NA-20Nm-1133

6. Appendix

6.1. appendix a List of parts

a complete list of parts is available in our SAP software “ZPPCS11”

6.2. appendix b

Test chart K3G280AU11C9
page 1: Air performance
page 2: values of temperature rise test of the motor

Test chart for ventilator
R3G280-AU11-C1

Performance testing of fans

ebmpapst

Header data

Type:	R3G280AU11C1-01A	Const. type:	Centrifugal bwc without housing	Idno:	130335
Customer:	ebm-papst Mulfingen GmbH & Co.KG	Motor layout:		Subsidary:	Mulfingen
Application:		Flow direction:		Project No.:	45219
Date:	14.12.2010	Voltage:	400 V	Test No.:	12452
Motor:	M3G084GF	Frequency:	50 Hz	Prototyp No.:	
Responsible:	Paul Hammer	Capacitor:		Modul No.:	61015/1
Stage:		Cont. volt./PWM:	11 V	Safety class:	

Conditions of measurement

Inlet:	28070-2-4013	Wall ring:		Protective grid:	
Housing:		Outlet:	0,09018 m²	Dim. c:	196 mm
Air density:	1,166 kg/m³	Air pressure:	992,5 hPa	Air humidity:	30,02 %
Air temperature:	20,22 °C	Install. situation:	W		
Surface LwAIn:	27 m² (B=3 H=3 T=2)	Surface LwAOut:	36 m² (B=3 H=3 T=3)	Lp dist. (In/Out):	1 / 2 m
Test b. air:	Kombikanal	Test b. sound:	Kombikanal		

Reference impedances acc. DIN EN 61000-3-3:

Measured Data

No.	DB	U [V]	I_1 [A]	I_2 [A]	I_3 [A]	P_e [W]	λ	n [1/min]	p_{sf} [Pa]	p_{sf12} [Pa]	p_f [Pa]	q_v [m³/h]	η_e [%]	M [Ncm]	η_m [%]	η_r [%]	LpA_{In} [dBA]	LpA_{Out} [dBA]	LwA_{In} [dBA]	LwA_{Out} [dBA]	LwA [dBA]
1	4	400,13	1,04	1,08	1,11	644,5	0,86	3132	0,0	0,0	86,1	3936,0	14,6	172,3	87,7	16,7	78,1	77,0	85,8	92,7	93,5
2	4	401,63	1,23	1,22	1,31	767,2	0,88	3134	183,5	187,4	258,9	3678,5	34,5	204,8	87,6	39,4	76,8	76,0	84,6	91,6	92,4
3	4	401,50	1,34	1,34	1,43	849,2	0,89	3112	362,4	370,2	427,1	3410,2	47,7	227,8	87,4	54,6	75,1	74,5	83,1	89,9	90,7
4	4	401,26	1,41	1,39	1,45	881,6	0,90	3128	566,5	578,7	617,7	3033,2	59,2	236,1	87,7	67,5	72,5	72,1	80,3	87,0	87,8
5	4	401,06	1,58	1,56	1,61	997,1	0,91	3116	757,5	773,8	797,3	2674,5	59,6	266,8	87,3	68,3	71,7	70,9	79,9	86,1	87,0
6	4	401,23	1,56	1,57	1,60	992,2	0,91	3121	929,1	949,2	954,5	2134,5	57,3	265,1	87,3	65,6	71,7	71,8	79,5	87,0	87,7
7	4	401,20	1,45	1,43	1,51	913,2	0,90	3129	1016,5	1038,0	1031,8	1659,6	52,4	244,1	87,6	59,8	76,0	72,5	83,7	88,8	90,0
8	4	401,16	1,32	1,29	1,37	822,4	0,89	3131	1035,8	1058,0	1044,2	1234,8	43,8	220,1	87,8	49,9	76,6	75,1	84,6	90,7	91,6
9	4	401,46	1,06	1,02	1,13	638,5	0,86	3132	1057,0	1079,0	1059,0	610,9	28,3	169,8	87,2	32,4	77,4	75,8	85,4	90,8	91,9
10	1	401,20	0,76	0,72	0,77	408,4	0,79	3129	1090,9	1114,0	1090,9	0,0	0,0	106,8	85,7	0,0	76,2	75,9	84,1	90,5	91,4

No. 5: Nominal torque: T_N = 2,67 Nm
Nominal speed: n = 3116 rpm

U	= supply voltage (effective voltage)	λ	= Power factor (λ=Pe/(U·I))
I_1	= current draw (phase U1, effective current)	I_2	= current draw (phase V1, effective current)
P_e	= input power (active power)	I_3	= current draw (phase W1, effective current)
P_u	= output power of fan	η_e	= overall efficiency of fan (ηe=Pu/Pe)
Rho	= density of flow medium	v_m	= medium exhaust speed (vm=qv/discharge area)
p_f	= total pressure increase (pf=psf+pd)	p_d	= dynamic pressure (pd=Rho·vm²/2)
p_{sf}	= static pressure increase	p_{sf12}	= static pressure increase converted into standard density (Rho=1.2kg/m³)
n	= speed	q_v	= flow rate
LpA_{In}	= sound pressure level suction side	LwA_{In}	= sound power level suction side
LpA_{Out}	= sound pressure level pressure side	LwA_{Out}	= sound power level pressure side
η_r	= fan impeller efficiency (ηr=(Pu/Po))	P_o	= output power at motor shaft (Po=M·2·pi·n)
M	= torque at motor shaft	η_m	= fan motor shaft efficiency (ηm=(M·2·pi·n)/Pe))

active power: $P = \frac{1}{T} \bullet \int_0^T u(t) \bullet i(t) dt$

effective current: $I_{RMS} = \sqrt{\frac{1}{T} \bullet \int_0^T i^2(t) dt}$

effective voltage: $U_{RMS} = \sqrt{\frac{1}{T} \bullet \int_0^T u^2(t) dt}$

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Motor test record for EC motor (AC supply), according to DIN EN 60034-2

ebmpapst

Date: 08.05.2014 Editor: Eckl Project no.: 49842
Customer: ebm-papst Mulfingen GmbH &CO.KG Measurement: 17089
Motor type: M3G084GF-01A Sample: D (ECA)

Motortemperature rise test at different working points - steady state condition-

Drehmoment [Ncm]		**300,1**	**267**	**249,9**			Input power [W]
Spannung [V]		400,2	400,3	400,3		**Elektronik Eingangseite**	
Strom [A]		1,894	1,704	1,608			
Pzu [W]		1153,6	1019,7	950,4			
U1Str [V]		201,1	196,7	194,5		**Elektronik Ausgangsseite**	
U2Str [V]		201,1	196,7	194,4			
U3Str [V]		201	196,6	194,4			
I1Str [A]		2,145	1,886	1,755			
I2Str [A]		2,114	1,858	1,729			
I3Str [A]		2,142	1,885	1,756			
P1Str [W]		369,8	326,7	304,3			
P2Str [W]		366,1	323,3	301,1			
P3Str [W]		372,6	329,3	306,9			
Pgesamt (Elektronik) [W]		1108,5	979,3	912,3			
Lambda1Str		0,858	0,881	0,891			
Lambda2Str		0,861	0,885	0,896			
Lambda3Str		0,866	0,889	0,899			
S1Str [mm^2]		7,586	6,67	6,207			
S2Str [mm^2]		7,477	6,571	6,115			
S3Str [mm^2]		7,576	6,667	6,211			
Eta Elektronik [%]		96,09	96,04	95,99			
Nennmoment [Nm]		3,001	2,67	2,499		**Motor**	torque [Nm]
Drehzahl [1/min]		3114	3119	3117			speed [rpm]
Pab [W]		978,6	872,1	815,7			output power [W]
Eta Motor [%]		88,28	89,05	89,41			efficiency motor [%]
Verluste Elektronik [W]		45,1	40,4	38,1		**Verluste gemessen bei Raumtemp.**	
Ständerkupferverluste [W]		79,95	58,47	49,42			
Verluste (Fe + Reib.) [W]		49,95	48,73	47,18			
Verluste Gesamt [W]		175	147,6	134,7			total losses [W]
Eta Gesamt [%]		84,83	85,53	85,83			total effiency [%]
W1 [K]	**nm**	109,4	87,4	78,3		**Erwärmung**	
W2 [K]	**nm**	101,1	81,3	73,2			temperature rise
W3 [K]	**nm**	109,7	87,7	78,1			
T ambient	**[°C]**	24,4	26	26,4			

Data projekted on the basis of 115°C winding temperatur

ETA Mot.	88,98
Pv Elek. [W]	40,4
Pv Cu [W]	59,24
Pv (Fe + Reib.) [W]	48,73
Pv gesamt [W]	148,37
Eta ges [%]	85,46
Umgebung	29,53
W1 [°C]	116,9
W2 [°C]	110,8
W3 [°C]	117,2

ebmpapst

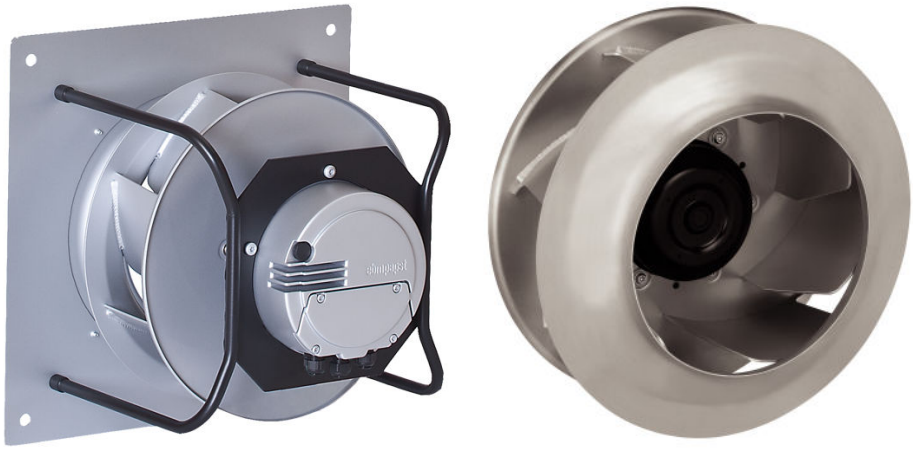
1. ECA Certification Summary Test Report 15

Motor: M3G112-EA – 3Nm-2600min-1

Winding reference: 56955-5-9910
Working Point: max. troque / speed
3Nm / 2600min-1
min-1

picture 1. motor

Blower: K3G310-AX52-90



picture 2. blower

Test sample:	Series production week 29/13	
Measurements according	60034-2-1:2007	Efficiency by Direct Testing Method(3.2.1)
Measurement: Reference No.	MNo.: 18850 MNo.: 18597	M-ID: 53583; 53584; 53585; 53586 M-ID: 163292
Measurements by: Approved by:	Wolfgang Eckl Oliver Bieber	
Quality Management System according	DIN EN ISO 9001:2008 List of epM Certificates see Detailed Test Report 1 –M3G150-NA-20Nm-1133	

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Table of contents

2. Introduction

2.1. Intension

This motor is tested to be qualified to the UK ECA Testing Programme and exceeds the following performance criteria form Table 1 of the

"ECA Energy Technology Criteria List 2010
– Motor & Drives –
– *"Permanent Magnet Synchronous Motors* – "

Output Power Rating: Max. continuous speed rating: Efficiency:	<1,1 kW 1500 to 3000 rpm >= 82,7%	ECA Setpoint value

The motor is tested according the - IE standard product test –

2.2. Testing Laboratory:

ebm-papst Mulfingen - R&D Department -
Bachmühle 2
Mulfingen

We confirm that the test facilities are permanently under control of the test laboratory
(It's a special lab only for R&D staff members).
The test facility is controlled by the ebm-papst quality department and the technicians of the test laboratory.

Date of product testing: Mai 2014

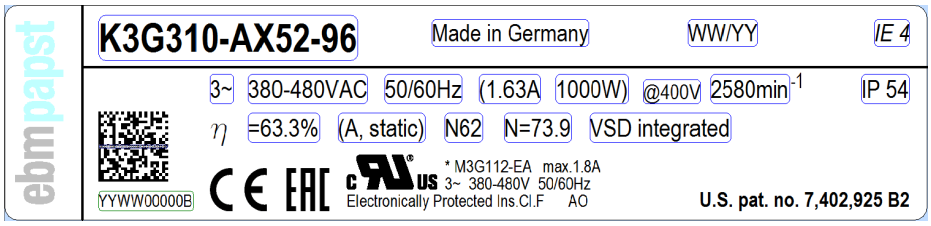
i.V. S C
.....
R& D Manager

i.A. Lo
.....
Head of R&D EM-F

3. Product details

3.1. The motor M3G112-EA was taken from the production item fitted to Blower K3G310-AX52-90

3.2. see appendix a



3.3. Parts of the assembled motor

3.3.1. Stator:	61063-1-0249
3.3.2. Rotor:	40024-1-3429
3.3.3. Control unit:	10068-1-0173

3.4. control settings (testing configuration)

3.4.1. setup control unit:	no speed control (normally n_{max} = 2580 min^{-1})
3.4.2. software for motor control	ebm-papst motor control software: LISA
3.4.3. motor adjustment:	voltage control;
3.4.4. torque adjustment:	current control for the eddy current brakes

3.5. testing conditions

3.5.1. modifications of the motor from standard

- 3.5.1.1. rotor with a new shaft to connect it to the torque sensor.
- 3.5.1.2. control unit demounted to measure directly the electrical values of the motor
- 3.5.1.3. motor winding with implemented thermocouples to measure the winding temperature
- 3.5.1.4. additional connecting cable to link the motor to the control unit

3.5.2. start testing: motor stars at ambient temperature (20 to 30°C)

3.5.3. end testing: electrical and mechanical values were measured at steady state condition

4. Test procedure

4.1. Test procedure according to ebm-papst (epM) standard test: (EN 60034-2-1 direct measuring method)

4.1.1. validation of the torque sensor and torque evaluation device:

see Detailed Test Report 1 –M3G150-NA-20Nm-1133

4.1.2. motor installation

4.1.3. motor testing

4.1.4. connection of motor and torque sensor

4.1.5. start measuring

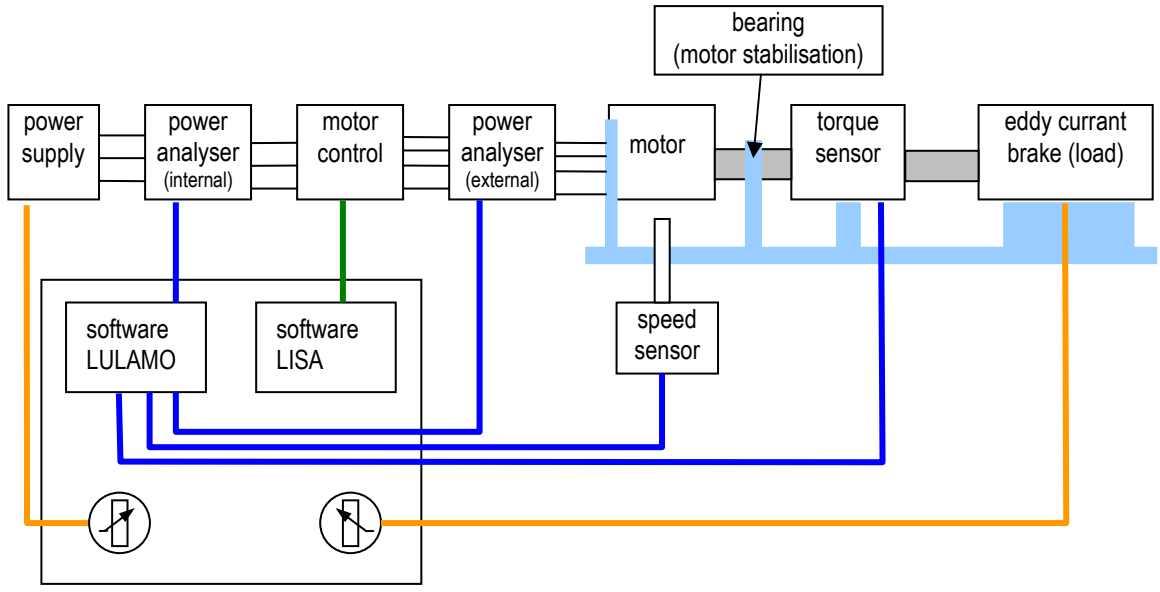
4.1.5.1. Md(n) measurement at ambient temperature

4.1.5.2. Temperature rise test at steady state condition

4.1.5.2.1. recording input power (P_1); output power (P_2= T x 2 π x n)

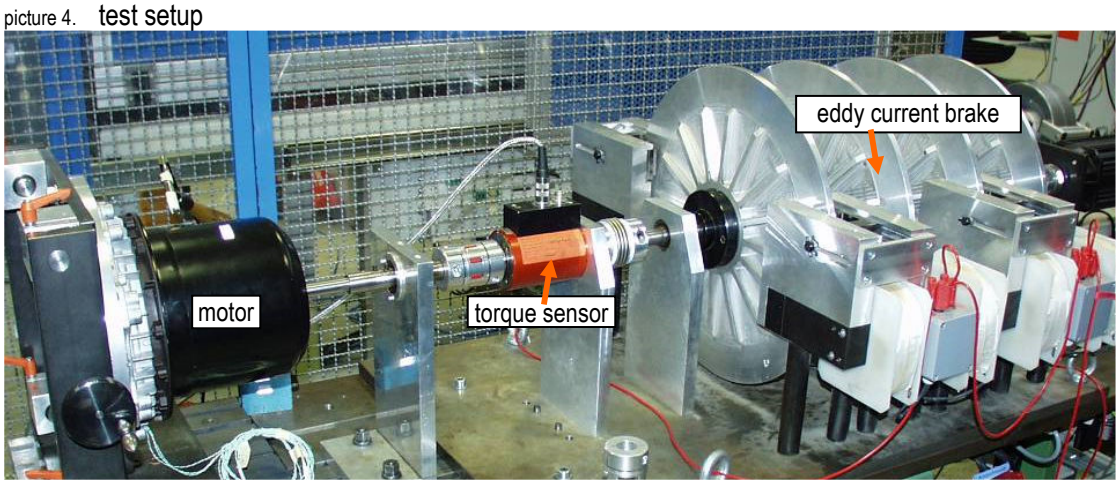
4.1.5.2.2. calculating and recording efficiency η = O_{utput} / I_{nput} x 100%

4.2. test rig 3

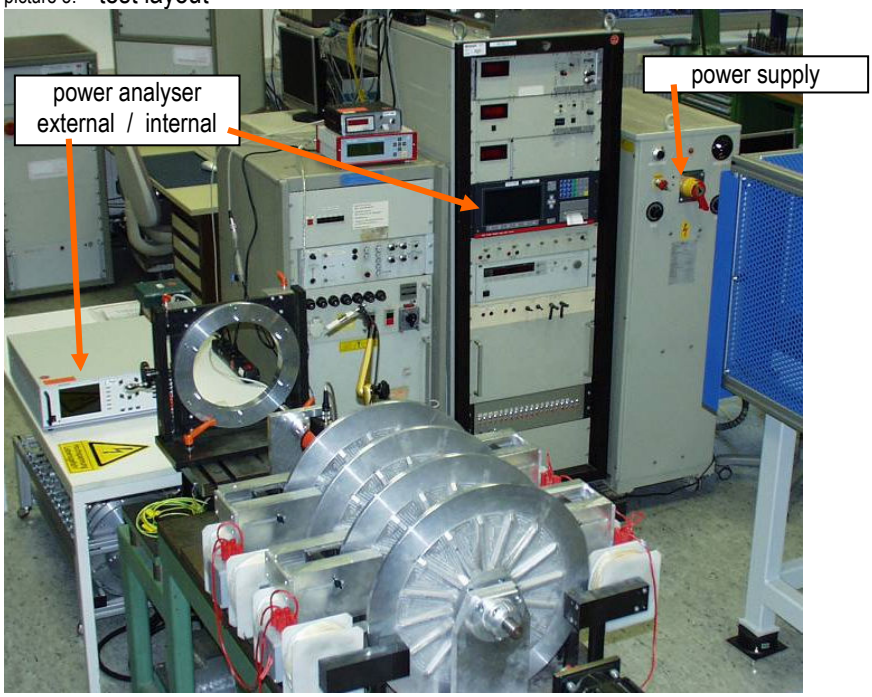


picture 3.

picture 4. test setup



picture 5. test layout



4.3. Details of the measurement equipment: see Detailed Test Report 1 –M3G150-NA-20Nm-1133

all instruments are controlled by the ebm-papst quality department and documented in a database

4.3.1. List of measurement equipment

Test bench: Rack 3	cerificates see: Detailed Test Report 1 –M3G150-NA-20Nm-1133
Torque sensor:	K1Z0.
mass 1&2	K5K0.0023 & K5K0.17
Torsion arm:	L9K9.007
Torque evaluation device:	K1D0.0018
Speed measurement:	D2D0.0072
External Power Analyser:	E6D0.0049
Internal Power Analyser:	E6D0.0025

5. Test results of M3G112-

5.1. Torque / speed curve

Diagram for motor test record, according to DIN EN 60034-2

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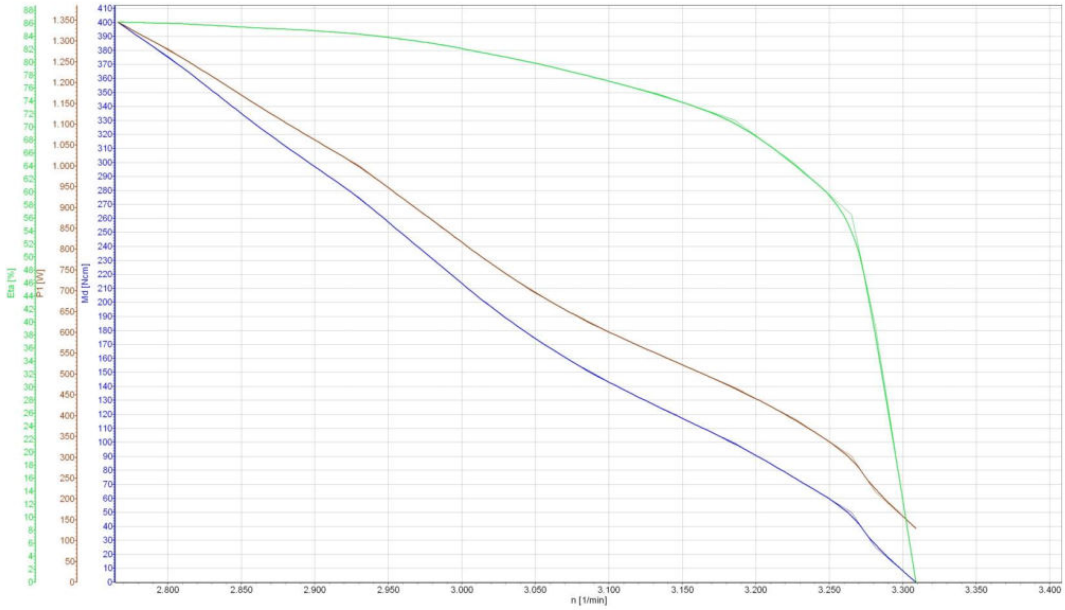
IdNo	Type	Index	No.	U[V]	F[Hz]	C[yF]	Sample	Stage
53584	M3G112EA	01B	18850	400	50	0	ECA	0



Motor test record for EC motor (AC supply), according to DIN EN 60034-2

ebmpapst

Date:	13.05.2014	Editor:	Eckl	Project no.:	49842
Customer:	ebm-papst Mulfingen GmbH & Co.KG			Measurement:	18850
Motor type:	M3G112EA-01B	Sample:	ECA	MeasID:	53584
Voltage:	3x400 V	Frequency:	50 Hz		
Lamination no.:	6955				
Rotor no.:	40024-1-3429				
Module no.:	61068				

No.	V~ [V]	I1~ [A]	I2~ [A]	I3~ [A]	P1 [W]	λ	n [rpm]	T [Ncm]	P2 [W]	η [%]
1	400,7	0,305	0,307	0,307	129,9	0,61	3309	0	0	0
2	400,7	0,461	0,463	0,463	218,2	0,68	3281	25,1	86,24	39,52
3	400,6	0,611	0,613	0,614	303	0,713	3265	50,1	171,3	56,53
4	400,6	0,767	0,771	0,772	393,2	0,736	3226	75	253,4	64,45
5	400,5	0,897	0,9	0,902	468,5	0,751	3185	99,9	333,2	71,12
6	400,5	1,029	1,032	1,035	546,5	0,764	3134	125	410,2	75,06
7	400,5	1,151	1,154	1,158	622	0,777	3087	149,8	484,3	77,86
8	400,4	1,257	1,265	1,271	698,6	0,797	3048	175,1	558,9	80
9	400,4	1,359	1,366	1,377	776,6	0,819	3015	200,3	632,4	81,43
10	400,3	1,46	1,466	1,477	851,5	0,837	2987	225,1	704,1	82,69
11	400,3	1,562	1,567	1,582	926,8	0,851	2958	250,2	775	83,62
12	400,3	1,664	1,672	1,684	1000,7	0,863	2930	275,1	844,1	84,35
13	400,2	1,764	1,769	1,783	1070,9	0,872	2896	299,9	909,5	84,93
14	400,2	1,868	1,872	1,883	1142,8	0,88	2862	325	974,1	85,24
15	400,2	1,966	1,968	1,981	1211,4	0,886	2832	349,9	1037,7	85,66
16	400,1	2,064	2,067	2,08	1279,2	0,891	2801	375	1100	85,99
17	400,1	2,161	2,163	2,177	1345,4	0,896	2766	400,2	1159,2	86,16

5.2. Temperature rise test at steady state condition

		P_1 [W]	P_2 [W]	Σ Losses [W]	$\overline{T}_{Winding}$ [K]	eff. η	A_{mbient} [°C]
Nominal torque according test chart for ventilator **Fehler! Verweisquelle konnte nicht gefunden werden.**(see appendix b page 1)	3Nm / 2600min-1	**962,9**	**817,1**	**147,6**	**44,6**	**84,86**	**27,2**

Table 5.1

5.3. boundary conditions for temperature rise test

- Temperature rise test at steady state condition (see appendix b page 2)
- The set up torque is manually controlled
- Time period for achieving the steady state condition app. 3h

5.4. efficiency calculations for winding temperature 115°C (according to EN 60034-2-1)

Winding temperature at nominal torque measurement:

$T_{winding}$ = 44,6K+ 70,4°C = 111,5 °C
Copper losses ($P_{V\,Cu}$) at 71,8°C = 23,68 W (see appendix b page 2)
Copper losses ($P_{V\,Cu}$) at 115°C = 27,35 W
Difference of copper losses $\Delta P_{V\,Cu}$ = 3,67 W

Total losses ($P_{V\,tot}$) at 115°C = 147,6W +3,67 W = 151,27W

Efficiency at 115°C Winding temperature:
$\eta_{115°C}$ = 84,38%

5.5. Discussion of the test results: see Detailed Test Report 1 –M3G150-NA-20Nm-1133

6. Appendix

6.1. appendix a List of parts

a complete list of parts is available in our SAP software “ZPPCS11”

6.2. appendix b

Test chart R3G310-AX52-90
page 1: Air performance
page 2: values of temperature rise test of the motor

Test chart for Ventilator
R3G310AX5290-01A

Performance testing of fans

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Header data

Type:	R3G310AX5290-01A	Const. type:	Centrifugal bwc without housing	Idno:	163292
Customer:	ebm-papst Mulfingen GmbH & Co.KG	Motor layout:		Subsidary:	Mulfingen
Application:		Flow direction:		Project No.:	304092
Date:	25.04.2014	Voltage:	400 V	Test No.:	18597
Motor:	M3G112EA	Frequency:	50 Hz	Prototyp No.:	
Responsible:	Thorsten Pissarczyk	Capacitor:		Modul No.:	61068/03
Stage:		Cont. volt./PWM:	10 V	Safety class:	

Conditions of measurement

Inlet:	31570-2-4013	Wall ring:		Protective grid:	
Housing:		Outlet:	0,10169356 m²	Dim. c:	
Air density:	1,141 kg/m³	Air pressure:	980,4 hPa	Air humidity:	34,65 %
Air temperature:	23,07 °C	Install. situation:			
Surface LwAIn:		Surface LwAOut:		Lp dist. (In/Out):	
Test b. air:	Kombikanal	Test b. sound:			

Reference impedances acc. DIN EN 61000-3-3:

Measured Data

No.	DB	U [V]	I_1 [A]	I_2 [A]	I_3 [A]	P_e [W]	λ	n [1/min]	p_{sf} [Pa]	p_{sf12} [Pa]	p_f [Pa]	q_v [m³/h]	η_e [%]	M [Ncm]	η_m [%]	η_r [%]
1	4	399,38	1,28	1,27	1,29	696,7	0,79	2611	0,8	0,8	96,1	4716,5	18,1	214,5	84,2	21,5
2	4	399,21	1,45	1,42	1,42	808,2	0,82	2597	181,2	189,4	263,3	4376,6	39,7	251,8	84,7	46,8
3	4	399,22	1,47	1,47	1,45	834,3	0,82	2610	348,4	364,2	416,8	3994,1	55,5	259,0	84,9	65,5
4	4	399,26	1,54	1,51	1,47	861,7	0,83	2607	462,0	483,0	516,6	3570,4	59,6	269,0	85,2	70,0
5	4	399,20	1,59	1,58	1,55	911,8	0,84	2598	609,3	636,9	650,3	3094,6	61,5	287,3	85,7	71,8
6	**4**	**399,17**	**1,64**	**1,63**	**1,60**	**951,4**	**0,85**	**2597**	**763,5**	**798,2**	**791,3**	**2545,7**	**59,1**	**301,0**	**86,0**	**68,6**
7	4	399,23	1,60	1,60	1,57	927,6	0,84	2606	860,8	899,9	877,6	1982,0	52,3	292,5	86,1	60,8
8	4	399,36	1,47	1,49	1,48	842,3	0,82	2606	902,4	943,4	911,0	1419,3	42,9	263,0	85,2	50,3
9	3	399,63	1,25	1,23	1,24	671,4	0,78	2612	924,0	966,0	926,2	714,7	27,5	205,3	83,6	32,9
10	1	399,98	0,89	0,85	0,87	449,7	0,75	2611	945,6	988,6	945,6	0,0	0,0	129,5	78,7	0,0

Air performance acc. ISO 5801, sound acc. ISO 3744 and ISO 3745

No. 6: Nominal torque: T_N = 3,01Nm
Nominal speed: n = 2597rpm

U	= supply voltage (effective voltage)	λ	= Power factor (λ=Pe/(U·I))
I_1	= current draw (phase U1, effective current)	I_2	= current draw (phase V1, effective current)
P_e	= input power (active power)	I_3	= current draw (phase W1, effective current)
P_u	= output power of fan	η_e	= overall efficiency of fan (ηe=Pu/Pe)
Rho	= density of flow medium	v_m	= medium exhaust speed (vm=qv/discharge area)
p_f	= total pressure increase (pf=psf+pd)	p_d	= dynamic pressure (pd=Rho·vm²/2)
p_{sf}	= static pressure increase	p_{sf12}	= static pressure increase converted into standard density (Rho=1.2kg/m³)
n	= speed	q_v	= flow rate
η_r	= fan impeller efficiency (ηr=(Pu/Po))	P_o	= output power at motor shaft (Po=M·2·pi·n)
M	= torque at motor shaft	η_m	= fan motor shaft efficiency (ηm=(M·2·pi·n)/Pe))

active power: $P = \frac{1}{T} \bullet \int_0^T u(t) \bullet i(t) dt$

effective current: $I_{RMS} = \sqrt{\frac{1}{T} \bullet \int_0^T i^2(t) dt}$

effective voltage: $U_{RMS} = \sqrt{\frac{1}{T} \bullet \int_0^T u^2(t) dt}$

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Motor test record for EC motor (AC supply), according to DIN EN 60034-2

ebmpapst

Date: 15.05.2014 Editor: Eckl Project no.: 49842
Customer: ebm-papst Mulfingen GmbH &CO.KG Measurement: 18850
Motor type: M3G112EA-01A Sample: D (ECA)

Motortemperature rise test at different working points - steady state condition-

Drehmoment [Ncm]		400	350	299,9	300		Input power [W]
Spannung [V]		400,1	400,1	400,2	399,3	Elektronik	
Strom [A]		2,196	1,996	1,791	1,623	Eingangseite	
Pzu [W]		1365,3	1228,1	1084,5	962,9		
U1Str [V]		211,4	211,7	212	188,4	Elektronik	
U2Str [V]		211,4	211,7	211,9	188,4	Ausgangsseite	
U3Str [V]		211,5	211,9	212,1	188,6		
I1Str [A]		2,356	2,067	1,784	1,765		
I2Str [A]		2,363	2,074	1,789	1,771		
I3Str [A]		2,352	2,063	1,779	1,76		
P1Str [W]		439,3	395,3	349,1	307,6		
P2Str [W]		439,7	395,8	349,4	308		
P3Str [W]		437,8	393,8	347,7	306,3		
Pgesamt (Elektronik) [W]		1316,8	1184,9	1046,2	921,9		
Lambda1Str		0,882	0,904	0,923	0,925		
Lambda2Str		0,88	0,901	0,921	0,923		
Lambda3Str		0,88	0,901	0,921	0,923		
S1Str [mm^2]		5,333	4,679	4,038	3,995		
S2Str [mm^2]		5,349	4,695	4,049	4,009		
S3Str [mm^2]		5,324	4,67	4,027	3,984		
Eta Elektronik [%]		96,45	96,48	96,47	95,75		
Nennmoment [Nm]		4	3,5	2,999	3	Motor	torque [Nm]
Drehzahl [1/min]		2798	2868	2936	2601		speed [rpm]
Pab [W]		1172	1051,2	922,1	817,1		output power [W]
Eta Motor [%]		89,00	88,72	88,14	88,62		efficiency motor [%]
Verluste Elektronik [W]		48,5	43,2	38,3	40,9	Verluste	
Ständerkupferverluste [W]		44,12	33,29	24,39	23,68	gemessen bei	
Verluste (Fe + Reib.) [W]		100,68	100,41	99,71	83,02	Raumtemp.	
Verluste Gesamt [W]		193,3	176,9	162,4	147,6		total losses [W]
Eta Gesamt [%]		85,84	85,60	85,03	84,86		total effiency [%]
W1 [K]	nm	60,8	54	48,5	45,40	Erwärmung	
W2 [K]	nm	56,3	50,3	45,5	42,90		
W3 [K]	nm	60,8	53,9	48,4	45,60		temperature rise
Lager	rs	52,2	48	44,6	40,9		
T ambient	[°C]	26,3	26,6	26,9	27,2		

Data projekted on the basis of 115°C winding temperatur

ETA Mot.	88,10
Pv Elek. [W]	40,9
Pv Cu [W]	27,34
Pv (Fe + Reib.) [W]	83,02
Pv gesamt [W]	151,26
Eta ges [%]	84,38
Umgebung	70,37
W1 [°C]	115,8
W2 [°C]	113,3
W3 [°C]	116,0