Documentation
System Test Field

HELMKE

Contents

1. Performances and technical opportunities

The testing station established at HELMKE-France in 1999 allows detailed tests of drives resp. complete drive systems in DC or AC for industrial applications.

- Routine tests
- Type tests
- System checkouts
- Development tests
- Acceptance tests (marine acceptances, Ex acceptances)

During routine and type tests drive components as motors, transformers or frequency converters are tested according to the current standards.

In case of system checkouts not only single components are considered, but also their interactions. An existing torque measuring flange allows the determination of the shaft power.

A load machine slows down the drive system according to the specific load conditions and simulates in this way pumps, compressors or similar systems to be used in real operation later.

The load machine can also be used as driving machine and consequently facilitates the test of generator systems.

The attainable continuous limit rating at load tests is 1500 kW and 10 MW at no-load tests; the maximum speed is 4000 1/min; the voltage range is up to 14 kV at 50/60 Hz (due to the application of modern frequency converter systems smaller frequencies - as for example 16 2/3 Hz – are also possible).

A water re-cooling system – developed by the group's own engineering department - allows the performance of tests at water-cooled motors resp. drive systems.

In case of higher powers alternative techniques apply.

In case of special drives mechanical adjustments that might be necessary can be carried out by the workshop (e. g. assembly of external fans at machines cooled by tube systems).

The tests of vertical flange machines are also possible; an existing fixing angle allows the operation in horizontal position and therewith the coupling at the load machine.

Due to HELMKE's large stock of motors and transformers nearly every specific test can be performed.

2. References / Examples of Application

2.1. Checkout at a Medium Voltage Drive

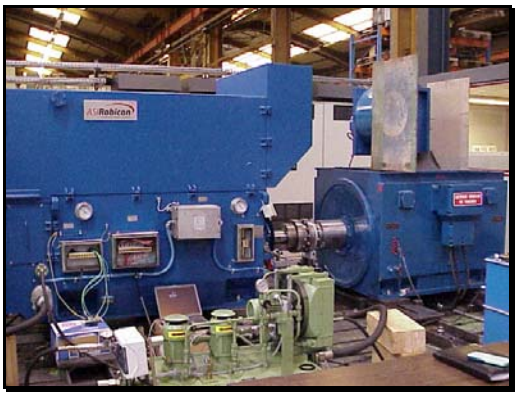
Scope of Order:

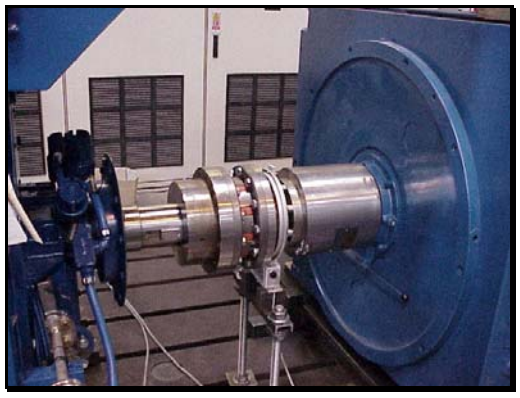
Acceptance test at a system consisting of:

Medium voltage frequency converter and asynchronous motor with no-load and load test as well as extensive function tests at the frequency converter

Frequency converter	*2500 kVA, 6000 V, 50 Hz*
Motor	*1560 kW, frame size 500, 4pole, 6000 V / 50 Hz* *Speed range 0 – 1500 1/min (M • n²),* *explosion protection EEx nA II T3*

- Performance of various function tests at the frequency converter (Failure of IGBT module, voltage drop in the power system, etc.)
- Load test with temperature rise test and determination of the efficiency of the single components as well as of the total system
- Analysis of the harmonic distortion
- Overspeed test
- Analysis of the vibration characteristics





2.2.Acceptance Test at an Oil-Cooled High Voltage Machine

Scope of Order:

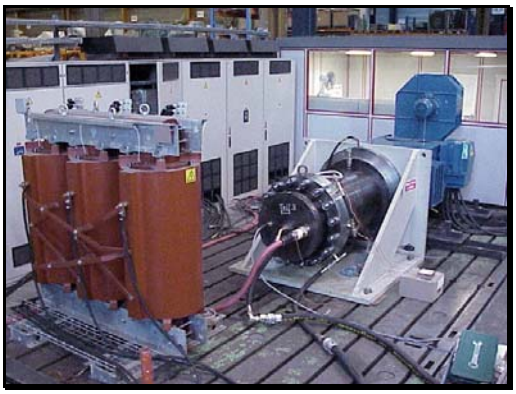
Acceptance test at a converter-fed high voltage machine with direct oil cooling.
Performance of an extensive no-load and load test at different speeds.

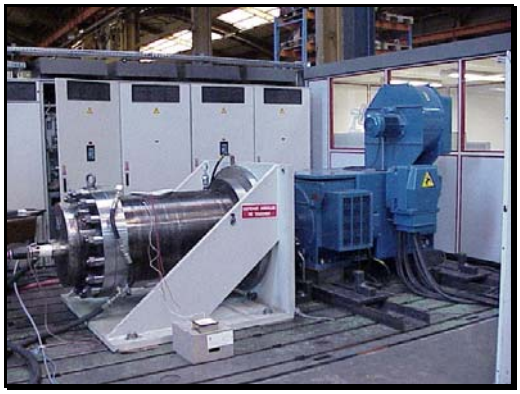
Particularities:

The directly oil-cooled machine requires the installation of an oil re-cooling system.

Motor	*800 kW, frame size 315, 4pole, 4000 V / 73 Hz,* *speed range 500 – 2160 1/min (M = constant)*

- Recording of no-load characteristic at various speeds (Supply frequencies 17, 33, 50, 60, 73 Hz)
- Load tests with temperature rise test and determination of the efficiency at various speeds (Supply frequencies 17, 33, 50, 60, 73 Hz)
- Overspeed test
- Analysis of the vibration characteristics





2.3.Type test at a flameproof high-voltage motor

Scope of order:

Acceptance test for the EExn certification of a high-voltage machine.

Particularities:

Ex certificate issued by HELMKE-own Ex expert.

Motor	*170 kW, frame size 315, 2pole, 3300 V / 50 Hz, EEx n AII T3*

- Recording of no-load characteristic
- Recording of short-circuit characteristic
- Load tests with temperature rise test and determination of the efficiency at 90%, 100% and 110% load
- Overspeed test
- Analysis of vibration characteristics
- Issue of Ex certificate by HELMKE-own Ex expert

2.4.Development test at hub wheel motor

Scope of order:

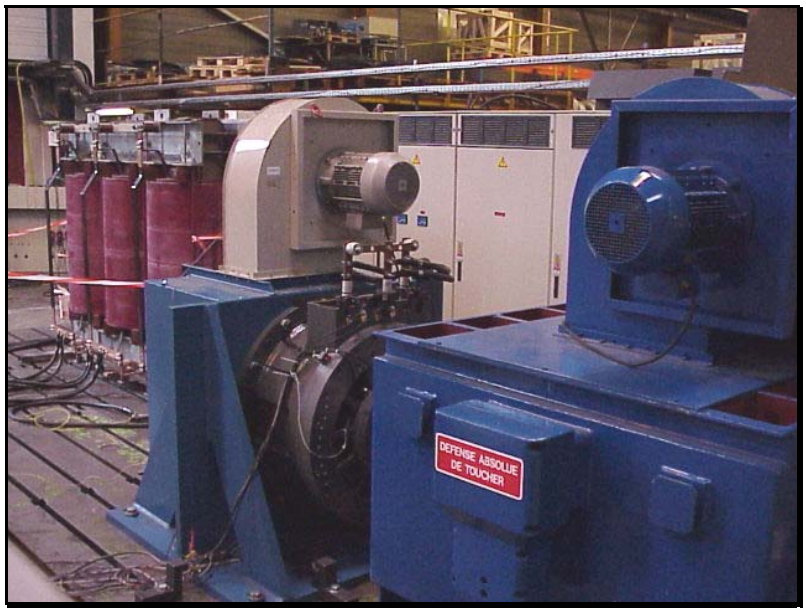
Development test at hub wheel motor of a mining truck. Determination of important parameters for the dimensioning and the future operation of the machine.

Particularities:

Making of a special rack for the mounting as well as for the ventilation of the machine.

Motor	*1500 kW, frame size 400, 4pole, 1310 V / 50 Hz,* *speed range 0 – 3000 1/min*

- Recording of no-load characteristics at various speeds (Supply frequencies 11, 33, 42, 50 Hz)
- Recording of short-circuit characteristics at various speeds (Supply frequencies 11, 33, 42, 50 Hz)
- Load test with temperature rise test and determination of the efficiency
- Overspeed test at 3400 1/min
- Analysis of vibration characteristics



3. Technical Specifications

Specification of routine tests on asynchronous machines with squirrel cage rotor

- Visual control
- Measurement of the insulation resistance of the stator winding and accessories
- Measurement of the DC-resistance of the stator winding at ambient temperature
- High-voltage test on stator winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the no-load current and no-load losses at rated voltage and rated frequency
- Measurement of the short-circuit losses at rated frequency and rated current
- Measurement of the vibration severity according to EN 60034 – 14
- Bearing temperature rise test at rated speed (only sleeve bearings with forced oil cooling or oil self-lubrication)
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Establishment of a test certificate

On request:

- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (P_{cc}, I_{cc}, $\cos\varphi_{cc}$)
- Measurement of the polarisation index of the stator winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on asynchronous machines with squirrel cage rotor (without heat run test)

- Visual control
- Measurement of the insulation resistance of the stator winding and accessories
- Measurement of the DC-resistance of the stator winding at ambient temperature
- High-voltage test on stator winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (P_{cc}, I_{cc}, $\cos\varphi_{cc}$)
- Measurement of the vibration severity according to EN 60034 – 14
- Bearing temperature rise test at rated speed (only sleeve bearings with forced oil cooling or oil self-lubrication)
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Measurement of the load-characteristic (25%, 50%, 75%, 100%, 125% load without heat run test)
- Establishment of a test certificate

On request:

- Measurement of the polarisation index of the stator winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on asynchronous machines with squirrel cage rotor (including heat run test)

- Visual control
- Measurement of the insulation resistance of the stator winding and accessories
- Measurement of the DC-resistance of the stator winding at ambient temperature
- High-voltage test on stator winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (Pcc, Icc, $\cos\varphi_{cc}$)
- Measurement of the vibration severity according to EN 60034 – 14
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Full-load heat run test according to EN 60034 – 1, – 2 with calculation of efficiency by summation of losses
- Measurement of the load-characteristic (25%, 50%, 75%, 100%, 125% load)
- Establishment of a test certificate

On request:

- Measurement of the polarisation index of the stator winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of routine tests on asynchronous machines with slipring rotor

- Visual control
- Measurement of the insulation resistance of the stator and rotor winding and accessories
- Measurement of the DC-resistance of the stator and rotor winding at ambient temperature
- High-voltage test on stator and rotor winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the voltage ratio between stator and rotor winding at rated voltage and rated frequency
- Measurement of the no-load current and no-load losses at rated voltage and rated fre-quency
- Measurement of the short-circuit losses at rated frequency and rated current
- Measurement of the vibration severity according to EN 60034 – 14
- Bearing temperature rise test at rated speed (only sleeve bearings with forced oil cool-ing or oil self-lubrication)
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Establishment of a test certificate

On request:

- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (P_{cc}, I_{cc}, $\cos\varphi_{cc}$)
- Measurement of the polarisation index of the stator and rotor winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on asynchronous machines with slipring rotor (without heat run test)

- Visual control
- Measurement of the insulation resistance of the stator and rotor winding and accessories
- Measurement of the DC-resistance of the stator and rotor winding at ambient temperature
- High-voltage test on stator and rotor winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the voltage ratio between stator and rotor winding at rated voltage and rated frequency
- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (P_{cc}, I_{cc}, $\cos\varphi_{cc}$)
- Measurement of the vibration severity according to EN 60034 – 14
- Bearing temperature rise test at rated speed (only sleeve bearings with forced oil cooling or oil self-lubrication)
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Measurement of the load-characteristic (25%, 50%, 75%, 100%, 125% load without heat run test)
- Establishment of a test certificate

On request:

- Measurement of the polarisation index of the stator and rotor winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on asynchronous machines with slipring rotor (including heat run test)

- Visual control
- Measurement of the insulation resistance of the stator and rotor winding and accessories
- Measurement of the DC-resistance of the stator and rotor winding at ambient temperature
- High-voltage test on stator and rotor winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the voltage ratio between stator and rotor winding at rated voltage and rated frequency
- Measurement of the no-load characteristic (P_0, I_0, $\cos\varphi_0$)
- Measurement of the short-circuit characteristic at partial voltage (P_{cc}, I_{cc}, $\cos\varphi_{cc}$)
- Measurement of the vibration severity according to EN 60034 – 14
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed
- Full-load heat run test according to EN 60034 – 1, – 2 with calculation of efficiency by summation of losses
- Measurement of the load-characteristic (25%, 50%, 75%, 100%, 125% load)
- Establishment of a test certificate

On request:

- Measurement of the polarisation index of the stator and rotor winding
- Frequency analysis of the vibration measurement (FFT)
- Measurement of the starting torque at locked rotor and reduced voltage
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of routine tests on DC-machines

- Visual control
- Measurement of the insulation resistance of the windings and accessories
- Measurement of the DC-resistance of the windings at ambient temperature
- High-voltage test on the windings according to EN 60034 – 1 (on agreement in case of repair or revision)
- Function test of accessories and sensors
- Verification of the neutral zone
- Control of the commutation
- No-load test
- Measurement of the vibration severity according to EN 60034 – 14
- Establishment of a test certificate

On request:

- Frequency analysis of the vibration measurement (FFT)
- Overspeed test
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on DC-machines (without heat run test)

- Visual control
- Measurement of the insulation resistance of the windings and accessories
- Measurement of the DC-resistance of the windings at ambient temperature
- High-voltage test on the windings according to EN 60034 – 1 (on agreement in case of repair or revision)
- Function test of accessories and sensors
- Verification of the neutral zone
- Control of the commutation
- No-load test
- Measurement of the load-characteristic (without heat run test) with recording of the variation of rotating speed
- Measurement of the vibration severity according to EN 60034 – 14
- Establishment of a test certificate

On request:

- Frequency analysis of the vibration measurement (FFT)
- Overspeed test
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on DC-machines (including heat run test)

- Visual control
- Measurement of the insulation resistance of the windings and accessories
- Measurement of the DC-resistance of the windings at ambient temperature
- High-voltage test on the windings according to EN 60034 – 1 (on agreement in case of repair or revision)
- Function test of accessories and sensors
- Verification of the neutral zone
- Control of the commutation
- No-load test
- Full load heat run test
- Measurement of the load-characteristic with recording of the variation of rotating speed
- Measurement of the vibration severity according to EN 60034 – 14
- Establishment of a test certificate

On request:

- Frequency analysis of the vibration measurement (FFT)
- Overspeed test
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on drives composed of frequency converter and asynchronous machine (without heat run test)

Motor:

- Visual control
- Measurement of the insulation resistance of the stator winding and accessories
- Measurement of the DC-resistance of the stator winding at ambient temperature
- High-voltage test on stator winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed

Converter:

- Visual control
- Programming of motor parameters

Converter + motor:

- Measurement of the vibration severity according to EN 60034 – 14
- Measurement of the load-characteristic according to the drive characteristic
- Establishment of a test certificate

On request:

- Frequency analysis of the vibration measurement (FFT)
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

Specification of type tests on drives composed of frequency converter and asynchronous machine (including heat run test)

Motor:

- Visual control
- Measurement of the insulation resistance of the stator winding and accessories
- Measurement of the DC-resistance of the stator winding at ambient temperature
- High-voltage test on stator winding according to EN 60034 – 1 (on agreement in case of repair or revision)
- Control of sense of rotation
- Function test of accessories and sensors
- Measurement of the shaft voltage at rated voltage, rated frequency and no-load speed

Converter:

- Visual control
- Programming of motor parameters

Converter + motor:

- Measurement of the vibration severity according to EN 60034 – 14
- Full-load heat run test with determination of efficiency of the motor by direct measuring method using a torque meter
- Measurement of the load-characteristic according to the drive characteristic
- Establishment of a test certificate

On request:

- Frequency analysis of the vibration measurement (FFT)
- Determination of efficiency of converter and motor
- Measurement of the noise level according to EN 60034 – 9 (only at no-load)

4. Criteria for the practicability of load tests

Power limit at load tests

In the testing station of HELMKE France the power capability at load tests is 1500 kW. Which power is possible in the individual case depends on the voltage, power, current and speed of the machine to be tested.

On the one hand enough current has to be provided at the given voltage for a test, on the other hand the load machine has to be able to slow down the required shaft output at the given speed.

Following limit values can be applied for the standard configuration of the testing station:

a) Maximum currents depending on the voltage of the machine to be tested

AC machines

- Voltage range up to *1000 V (max. 60 Hz*): max. current: *1155 A*
- Voltage range *1000 V to 3500 V (max. 60 Hz):* max. current: *330 A*
- Voltage range *3500 V to 7000 V (max. 60 Hz):* max. current: *165 A*
- Voltage range *7000 V to 14000 V (max. 60 Hz):* max. current: *82.5 A*

DC machines

- Voltage range up to *1000 V:* max. current: *1200 A*

Should the current requirement of a machine to be tested be higher than the values mentioned here-above, a consultation will be necessary.

a) Maximum attainable shaft outputs by using the load machines available as standard

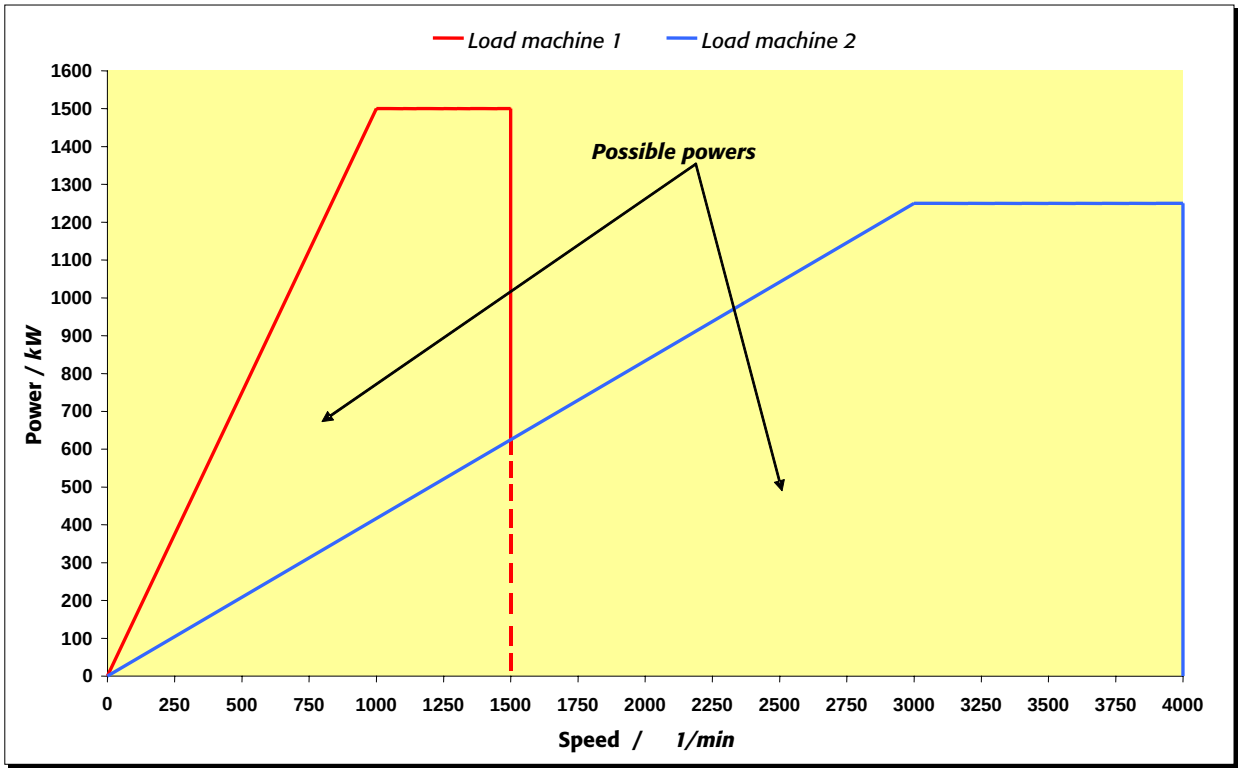
The below-mentioned presentation shows the possible shaft outputs of the two "standard" load machines against the speed of the motor to be tested.

Examples for load tests of AC machines:

- 2pole machines *50/60 Hz (3000/3600 1/min)* can be loaded up to *1250 kW* (load machine 2)
- 4pole machines *50 Hz (1500 1/min)* can be loaded up to *1500 kW* (load machine 1). However, 4pole machines *60 Hz (1800 1/min)* can only be loaded up to *750 kW* (load machine 2)
- 6pole machines *50/60 Hz (1000/1200 1/min)* can be loaded up to *1500 kW* (load machine 1)
- 8pole machines *50 Hz (750 1/min)* can be loaded up to *1125 kW*, 8pole machines *60 Hz (900 1/min)* can be loaded up to *1350 kW* (load machine 1)

Should the power requirement of a machine to be tested be higher than the values mentioned here-above, a consultation will be necessary.

The decisive factor for the practicability of a test is the **simultaneous fulfilment** of the conditions mentioned under point a) and b).



Shaft output of the load machine

If further powers are required, the partial load technique according to IEC can be applied up to certain limits. This allows to determine the temperature rise to be expected at rated power by extrapolation (further information after consultation).

Power limit of torque measuring system

In case of system checkouts (frequency converter + motor) the torque and the speed have to be measured in order to determine the shaft output of the machine to be tested. This is done by means of the available torque measuring system (Hottinger T10FS), whereas the torque is limited to *10000 Nm* at a speed of up to *4000 1/min*.

Power limit of the water re-cooling system

The total re-cooling power already considers future power extensions of the testing station, which means that water-cooled drives resp. drive systems can be tested without limit.

5. Test certificates

All values recorded during a test are summed up in a detailed test certificate. The data gained in the course of a load test are analysed according to the procedure described in the standards.

A test certificate as well as the appropriate recording of a load test at an asynchronous motor with squirrel-cage is exemplified here-after.

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MOTEURS ET MACHINES ELECTRIQUES
MOYENNE ET GRANDE PUISSANCE

Prüfungsnachweis Lastprüfung / Test certificate load test

Herst. / Man. **HELMKE**		
Type **DOR 400 - 02 - 050**		
Nr / No		
Y 5500 V		**74,9** A
630 kW	IC **411**	cos φ **0,91**
2978 min^{-1} / rpm		**50** Hz
Drehrichtung / Sens of rot. <==		
U_2 - V	I_2	- A
WKL / Th.Cl. **F**	IP **55**	**4200** kg

Kunde / Customer	
Auftrag-Nr. / Order-no	AR
	OF
Maschinenart / Kind	**3ph squirrel cage motor**
Lager AS / Bearing DE	**Gleitlager / Sleeve bearing**
Schmierfrist / Relubrication	**ISO VG 32 2,9 l**
Lager BS / Bearing NDE	**Gleitlager / Sleeve bearing**
Schmierfrist / Relubrication	**ISO VG 32 2,9 l**
Kühlart / Cooling	**IC411**
Betriebsart / Duty type **S1**	Bauf. / Frame type IM **B3**

Prüfungen / Tests (Standards: EN 60034-1, EN 60034-14)

Wicklungswiderstände / Winding resistance	Stator	U1-V1	**0,5540** Ω	V1-W1	**0,5540** Ω	W1-U1	**0,5540** Ω
	Rotor	K-L	- Ω	L-M	- Ω	M-K	- Ω
Raumtemp. / Amb. temp.	**23,2** °C						
Isolationswiderstand	Stator	**20000** MΩ		**5,0** kV		Polarisationsindex	**8,0**
Insulation resistance	Rotor	- MΩ		- kV		Index of polarisation	-
Hochspannungsprüfung	Stator	**9,6** kV		**60** sec			
High-voltage test	Rotor	- kV		- sec			

Leerlaufprüfung	Spg. / Voltage	Strom / Current	$P_{aufgen.}$ / $P_{absorbed}$	cosφ	Freq. / Freq.
No-load test	**6050,0** V	**13,92** A	**9,3** kW	**0,0635**	**50,0** Hz
	5500,0 V	**12,56** A	**8,9** kW	**0,0741**	**50,0** Hz
	4950,0 V	**11,09** A	**8,0** kW	**0,0841**	**50,0** Hz
	4125,0 V	**9,34** A	**7,2** kW	**0,1072**	**50,0** Hz
	3300,0 V	**7,50** A	**6,5** kW	**0,1523**	**50,0** Hz
	2200,0 V	**5,26** A	**5,7** kW	**0,2894**	**50,0** Hz

Übersetzung / Ratio	U_{stator} - V	U_{rotor} - V		
Windungsschlussprüfung mit offenem Rotor	- V	- Hz	- min	
Interturn test with open rotor				

Kurzschlussprüfung	Spg. / Voltage	Strom / Current	$P_{aufgen.}$ / $P_{absorbed}$	cosφ	Freq. / Freq.
Short-circuit test	**1474,5** V	**93,60** A	**29,6** kW	**0,1237**	**50,0** Hz
	1220,8 V	**74,94** A	**18,9** kW	**0,1191**	**50,0** Hz
	952,8 V	**56,65** A	**10,8** kW	**0,1156**	**50,0** Hz
	647,3 V	**37,61** A	**4,8** kW	**0,1138**	**50,0** Hz
	326,3 V	**18,72** A	**1,2** kW	**0,1144**	**50,0** Hz

Bemerkungen / Notes

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MOTEURS ET MACHINES ELECTRIQUES
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Prüfungen / Tests (Standards: EN 60034-1, EN 60034-14)

AR /OF

Wellenspannung / Shaft voltage - mV bei / at - V

Wicklungsfühler / Wind. Sensors				Lagertherm. / Bearing sensors		Stillstandsheizung / Space heater			
Type:	PT100			Type:	PT100	U:	220,0 V	f:	50 Hz
1R	109,8 Ω	4R	109,8 Ω	AS / DE	109,2 Ω	P:	250,0 W	R:	192,1 Ω
2R	110,0 Ω	5R	109,3 Ω	BS / NDE	109,1 Ω	Isolationswiderst. / Insulation resistance:			
3R	109,6 Ω	6R	109,8 Ω			1000 MΩ		500 V	

Wuchtung / Balancing H [X] F [ ] Schwingstärkestufe / Level of vibration: N

Machinenaufstellung / Mounting of machine	freie Aufhängung / free suspension		starre Aufst. / rigid mounting		Kupplung / Coupling	mit / with		ohne / without	
		[ ]		[X]			[X]		[ ]

Schwingungsprüfung / Vibration measurement

	Horizontal		Vertical		Axial	
AS / DE	0,80	mm/s	1,10	mm/s	1,00	mm/s
BS / NDE	1,20	mm/s	1,10	mm/s	-	mm/s

Erwärm. bei / Temp. rise at P/P_N 1,00 U_1 5500,0 V f_1 50,0 Hz Dauer / Length 5 h 15 min

Temperaturen / Temperatures	Kühlmittel / Cooling fluid	Stator / Stator	Rotor / Rotor	Gehäuse 1 / Hous. 1
	ϑ 25,6 °C	Δϑ 77,8 K	Δϑ - K	ϑ - °C
	Gehäuse 2 / Hous. 2	Lager AS / Bearing DE	Lager BS / Bearing NDE	
	ϑ - °C	ϑ 66,0 °C	ϑ 69,0 °C	

	P/P_N	U_1 [V]	f_1 [Hz]	I_1 [A]	P_{abs} [kW]	P_{mec} [kW]	η [%]	cos φ	n [min^{-1}]
Lastpunkte	1,25	5515,0	50,0	94,1	818,7	788,6	96,32	0,911	2970,6
	1,00	5504,0	50,0	74,9	655,7	632,8	96,51	0,918	2977,2
	0,75	5500,0	50,0	56,1	490,3	473,2	96,50	0,918	2983,9
Load points	0,50	5500,0	50,0	38,2	327,0	314,0	96,02	0,899	2990,1
	0,24	5500,0	50,0	21,9	163,9	153,6	93,70	0,785	2995,7

Bemerkungen / Notes

Pulversheim le : ***25.08.2004***

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Aufzeichnung Lastprüfung / load test record

Herst. / Man.	HELMKE			
Type	DOR 400 - 02 - 050			
Nr/ No				
Y 5500 V		74,9 A		
630 kW	IC 411	cos φ 0,91		
2978 min^{-1} / rpm		50 Hz		
Drehricht. / Sens of rot.	<==			
U_2 - V		I_2 - A		
WKL / Th.Cl. F	IP 55	4200 kg		

Kunde / Customer	
Auftrag Nr. / Order-no	AR
	OF
Masch.art / Kind	**3ph squirrel cage motor**
Lager AS / Bearing DE	**Gleitlager / Sleeve bearing**
Schmierfrist / Relubrification	**ISO VG 32 2,9 l**
Lager BS / Bearing NDE	**Gleitlager / Sleeve bearing**
Schmierfrist / Relubrification	**ISO VG 32 2,9 l**
Kühlart / Cooling	**IC411**
Betrieb / Duty type **S1**	Bauform / Frame type IM **B3**

Prüfungen / Tests (Standard: EN 60034-1)

Betriebspunkt / Duty point:

Voltage / Spannung:	U_1: **5500,0**	V
Frequenz / Frequency:	f_1: **50,0**	Hz
Leistung / Power:	P_N: **630,0**	kW
Polzahl / Number of poles:	2p: **2**	
Strom / Current:	I_1: **74,9**	A

Bemerkungen / Notes:

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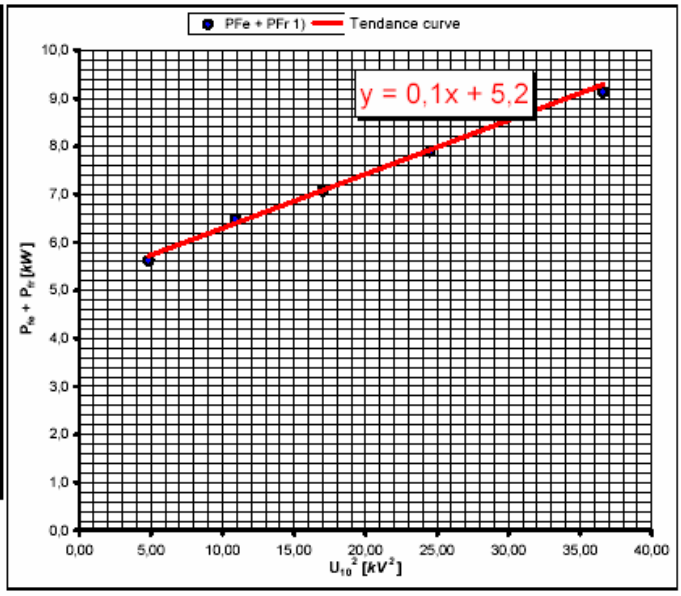
Trennung der Leerlaufverluste / Separation of the no-load losses

Bezugstemperatur / Reference Temperature: **23,2** °C

Frequenz f_1 [Hz] / Frequency f_1 [Hz]	Spannung U10 (V) / Voltage U_{10} [V]	Strom I_{10} [A] / Current I_{10} [A]	cos φ_0	Aufgenommene Leistung $P_{auf.0}$ [kW] / Absorbed power P_{abs0} [kW]	P_{au10} [kW] 1)	U_{10}^2 [kV^2] 1)	P_{Fe} + P_{Fr} 1)	P_{Fe} 1)
50,0	6050,0	13,92	0,0635	9,3	0,16	36,603	9,1	3,9
50,0	5500,0	12,56	0,0741	8,9	0,13	30,250	8,8	3,6
50,0	4950,0	11,09	0,0841	8,0	0,10	24,503	7,9	2,7
50,0	4125,0	9,34	0,1072	7,2	0,07	17,016	7,1	1,9
50,0	3300,0	7,50	0,1523	6,5	0,05	10,890	6,5	1,3
50,0	2200,0	5,26	0,2894	5,7	0,02	4,840	5,6	0,4

Reibungsverluste / Friction losses: P_{Fr} **5,2** kW

1) Berechnete Werte / Calculated values



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Last / Load — Températuren / Temperatures

Zeit / Time	Frequenz f_1 [Hz] / Frequency f_1 [Hz]	Spannung U_1 [V] / Voltage U_1 [V]	Strom I_1 [A] / Current I_1 [A]	cos φ	Aufgenommene Leistung P_{abs} [kW] / Absorbed power P_{abs} [kW]	Messung Schlupf / Slip measurement: Ausschläge / Pulsations	Zeit [sek] / Time [sec]	Schlupf s [%] 1) / Slip [%]	Drehzahl n [min^{-1}] 1) / Speed n [rpm]	Wicklung 1 [°C] / Winding 1 [°C]	Wicklung 2 [°C] / Winding 2 [°C]	Wicklung 3 [°C] / Winding 3 [°C]	Lager AS [°C] / Bearing DE [°C]	Lager BS [°C] / Bearing NDE [°C]	Gehäuse 1 [°C] / Frame 1 [°C]	Gehäuse 2 [°C] / Frame 2 [°C]	Kühlmittel [°C] / Cooling fluid [°C]	Luftaustritt [°C] / Air outlet [°C]	Verlauf Erw. Wickl. / Kühlm. [K] 1) / Evolution winding heating [K]	Verlauf Erw. Gehäuse 1 / Kühlm. [K] 1) / Evolution frame heating 1 [K]	Verlauf Erw. Gehäuse 2 / Kühlm. [K] 1) / Evolution frame heating 2 [K]
8:15	0,0	0,0	0,0							25,4	27,4	26,5	25,4	25,2			21,8				
8:30	50,0	5500,0	74,95	0,918	655,3	10	33,08	0,605	2981,9	39,9	40,2	38,8	40,0	44,7			21,8		13,2	0,0	0,0
8:45	50,0	5500,0	74,88	0,917	655,2	10	31,73	0,630	2981,1	53,6	56,1	53,3	45,9	50,2			22,3		14,2	-0,5	-0,5
9:00	50,0	5500,0	74,95	0,918	654,9	10	30,10	0,664	2980,1	64,7	67,2	63,8	49,3	54,0			22,3		10,9	0,0	0,0
9:15	50,0	5500,0	74,96	0,917	656,1	10	29,45	0,679	2979,6	73,7	76,0	72,2	52,0	56,7			22,1		8,9	0,2	0,2
9:30	50,0	5500,0	74,96	0,918	656,1	10	29,05	0,688	2979,3	80,8	82,8	79,0	54,3	58,8			22,1		6,9	0,0	0,0
9:45	50,0	5500,0	74,91	0,918	655,8	10	28,29	0,707	2978,8	83,3	85,1	80,8	54,9	59,5			22,1		2,2	0,0	0,0
10:00	50,0	5500,0	74,89	0,918	655,8	10	27,78	0,720	2978,4	89,2	90,7	86,2	57,0	61,1			23,0		4,7	-0,9	-0,9
10:15	50,0	5500,0	74,98	0,918	655,7	10	27,39	0,730	2978,1	92,6	93,9	89,4	58,1	62,0			23,0		3,3	0,0	0,0
10:30	50,0	5500,0	74,89	0,918	655,6	10	27,27	0,733	2978,0	96,6	97,5	93,0	59,7	63,1			23,8		2,9	-0,8	-0,8
10:45	50,0	5500,0	74,95	0,918	654,8	10	27,20	0,735	2977,9	98,5	99,4	94,6	60,4	63,8			23,8		1,8	0,0	0,0
11:00	50,0	5500,0	74,89	0,918	655,6	10	27,18	0,736	2977,9	100,9	101,6	96,9	61,3	64,5			23,8		2,3	0,0	0,0
11:15	50,0	5500,0	74,89	0,918	655,1	10	27,17	0,736	2977,9	102,8	103,4	98,5	62,0	65,1			23,8		1,8	0,0	0,0
11:30	50,0	5500,0	74,90	0,918	655,0	10	27,12	0,737	2977,9	104,2	104,6	99,8	62,4	65,6			23,8		1,3	0,0	0,0
11:45	50,0	5500,0	74,91	0,918	655,0	10	27,11	0,738	2977,9	105,3	105,9	101,0	63,1	66,0			23,8		1,2	0,0	0,0
12:00	50,0	5500,0	74,90	0,918	655,0	10	27,12	0,737	2977,9	106,5	106,9	101,6	63,3	66,5			23,8		0,9	0,0	0,0
12:15	50,0	5500,0	74,90	0,918	655,1	10	27,10	0,738	2977,9	107,6	107,9	102,5	63,8	66,9			24,3		0,5	-0,5	-0,5
12:30	50,0	5500,0	74,95	0,918	655,0	10	27,11	0,738	2977,9	108,3	108,6	103,2	64,2	67,4			24,5		0,5	-0,2	-0,2
12:45	50,0	5500,0	74,84	0,918	654,9	10	27,09	0,738	2977,9	109,0	109,3	103,9	64,7	67,6			24,8		0,4	-0,3	-0,3
13:00	50,0	5500,0	74,95	0,918	655,0	10	27,08	0,739	2977,8	109,7	110,0	104,6	65,1	68,1			25,0		0,5	-0,2	-0,2
13:15	50,0	5500,0	74,96	0,918	655,6	10	27,06	0,739	2977,8	110,5	110,7	105,4	65,4	68,3			25,4		0,4	-0,4	-0,4
13:30	50,0	5500,0	74,96	0,918	655,0	10	27,05	0,739	2977,8	111,0	111,2	106,0	65,8	68,8			25,4		0,5	0,0	0,0
13:45	50,0	5500,0	74,95	0,918	655,1	10	26,99	0,741	2977,8	111,6	111,8	106,5	66,0	69,0			25,6		0,4	-0,2	-0,2

1) Berechnete Werte / Calculated values

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Daten am Ende des Erwärmungslaufes / Values at the end of heat run test

	Dauer Erwärmungslauf / Time of load test:	5 h		15 min
Last / Load	Fréquenz / Frequency:	f_1	50,0	Hz
	Spannung / Voltage:	U_1	5500,0	V
	Strom / Current:	I_1	74,9	A
	cos φ:	cos φ	0,918	
	Aufgenommene Leistung / Absorbed power:	P_{abs}	655,00	kW
	Schlupf / Slip:	g	0,741	%
	Drehzahl / Rotation speed:	n	2977,8	min^{-1}
Temperaturen / Temperatures	Wicklung 1 / Winding 1:	111,6	°C	
	Wicklung 2 / Winding 2:	111,8	°C	
	Wicklung 3 / Winding 3:	106,5	°C	
	Lager AS / Bearing DE:	66,0	°C	
	Lager BS / Bearing NDE:	69,0	°C	
	Gehäuse 1 / Frame 1:	-	°C	
	Gehäuse 2 / Frame 2:	-	°C	
	Luftaustritt / Air outlet :	-	°C	

Bestimmung der Erwärmung / Evaluation of the load test

Kühlmitteltemperatur kalt / Temperature of the cooling fluid (cold): **23,2** °C

Wicklungswiderstände kalt / Winding resistance cold:

Stator	U_1-V_1	0,5540	Ω
Rotor	K-L	-	Ω

Kühlmitteltemperatur nach E-Lauf / Temperature of the cooling fluid after heat run test: **25,6** °C

Wicklungswiderstände nach E-Lauf / Winding resistances after heat run test:

Stator	U_1-V_1	0,7260	Ω
Rotor	K-L	-	Ω

Mittl. Wicklungserwärm. nach E-Lauf / Winding temperature rise after test :

Stator	Δϑ	77,8	K
Rotor	Δϑ	-	K

$$\Delta\vartheta = \vartheta_2 - \vartheta_{F.R.} = \frac{R_{closed} - R_{frold}}{R_{frold}} \cdot (k + \vartheta_1) + \vartheta_1 - \vartheta_{F.R.}$$

ϑ_1 : Winding temperature during measurement in cold condition
ϑ_2 : Winding temperature during measurement in warm condition
$\vartheta_{F.R.}$: Cooling medium temperature in warm condition
k : Coefficient of copper : 235

$$\Delta\vartheta = \vartheta_2 - \vartheta_{KM} = \frac{R_{warm} - R_{kalt}}{R_{kalt}} \cdot (k + \vartheta_1) + \vartheta_1 - \vartheta_{KM}$$

ϑ_1 : Wicklungstemperatur während der Messung im kalten Zustand
ϑ_2 : Wicklungstemperatur während der Messung im warmen Zustand
ϑ_{KM} : Kühlmitteltemperatur im warmen Zustand
k : Koeffizient für Kupfer : 235

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Bestimmung der Verluste und des Wirkungsgrades / Evaluation of the losses and the efficiency

Lastunabhängige Verluste / Losses not depending of the load :		
Eisenverluste / Iron losses :	P_{Fe}	**3,6** kW
Reibungsverluste / Friction losses :	P_{Fr}	**5,2** kW
Lastabhängige Verluste / Losses depending of the load :		
Zusatzverluste / Additionnal losses :	P_{sup}	**3,3** kW
Ständerkupferverluste / Stator copper losses:	P_{cu1}	**6,1** kW
Läuferkupferverluste / Rotor copper losses :	P_{cu2}	**4,8** kW
Mech.Leistung nach Erwärmung/Mech. power at the end of test :	P_{mec}	**632,1** kW
Verhältnis von mech. Leistung E-Lauf zu Bemessungsleist / Ratio between mec.test power and nominal mec. power.	P / P_N	**1,00**
Wirkungsgrad / Efficiency :	η	**96,50** %

$$P_{mec.} = P_{absorb.} - P_{fer} - P_{Cu1} - P_{sup.} - P_{Cu2} - P_{Frottem.} = P_{\delta} - P_{Cu2} - P_{Frottem.} \; ; \qquad \eta = \frac{P_{mec}}{P_{absorb.}} \cdot 100\%$$

P_{fer} : Coreloss (obtained by separation of the no-load losses)
P_{Cu1} : Stator copper losses
$P_{sup.}$: Additionnal losses
P_{Cu2} : Rotor copper losses
$P_{Frottem.}$: Friction losses

$$P_{mec.} = P_{auf.} - P_{fe} - P_{Cu1} - P_{Zus.} - P_{Cu2} - P_{Reib.} = P_{\delta} - P_{Cu2} - P_{Reib.} \; ; \qquad \eta = \frac{P_{mec}}{P_{auf.}} \cdot 100\%$$

P_{fe} : Eisenverluste (aus Trennung der Leerlaufverluste)
P_{Cu1} : Statorkupferverluste $(1{,}5 \cdot R_{warm} \cdot I_1^2)$
$P_{Zus.}$: Zusatzverluste $(0{,}5\% \cdot P_{auf.})$
P_{Cu2} : Rotorkupferverluste $(s \cdot P_{\delta})$
$P_{Reib.}$: Reibungsverluste (aus Trennung der Leerlaufverluste)

Lastpunkte / Load points

Wärmeklasse / Th. class: F — Erwärmung / Temp. rise: B — Referenztemperatur / Reference temperature : 95 °C

Messung Schlupf / Slip measurement

Frequenz f_1 [Hz] / Frequency f_1 [Hz]	Spannung U_1 [V] / Voltage U_1 [V]	Strom I_1 [A] / Current I_1 [A]	cos φ	Aufgenommene Leistung P_{auf} [kW] / Absorbed power P_{abs} [kW]	Ausschläge / Pulsations	Zeit [sek] / Time [sec]	Schlupf s [%] / Slip s [%]	Drehzahl n [min^{-1}] 1) / Speed n [rpm]	P_{Zus} [kW] / P_{add} [kW]	P_{cu1} [kW] 1)	P_{cu2} [kW] 1)	P_{mec} [kW] 1)	η [%] 1)	P_{mec} / P_N 1)
50,0	5515,0	94,1	0,911	818,7	10	20,41	0,980	2970,6	4,09	9,40	7,86	788,58	96,32	1,25
50,0	5504,0	74,9	0,918	655,7	10	26,31	0,760	2977,2	3,28	5,96	4,89	632,81	96,51	1,00
50,0	5500,0	56,1	0,918	490,3	10	37,30	0,536	2983,9	2,45	3,34	2,58	473,16	96,50	0,75
50,0	5500,0	38,2	0,899	327,0	10	60,78	0,329	2990,1	1,64	1,55	1,05	313,99	96,02	0,50
50,0	5500,0	21,9	0,785	163,9	10	141,00	0,142	2995,7	0,82	0,51	0,23	153,58	93,70	0,24

1) Berechnete Werte / Calculated values

Pulversheim le : ***25.08.2004***

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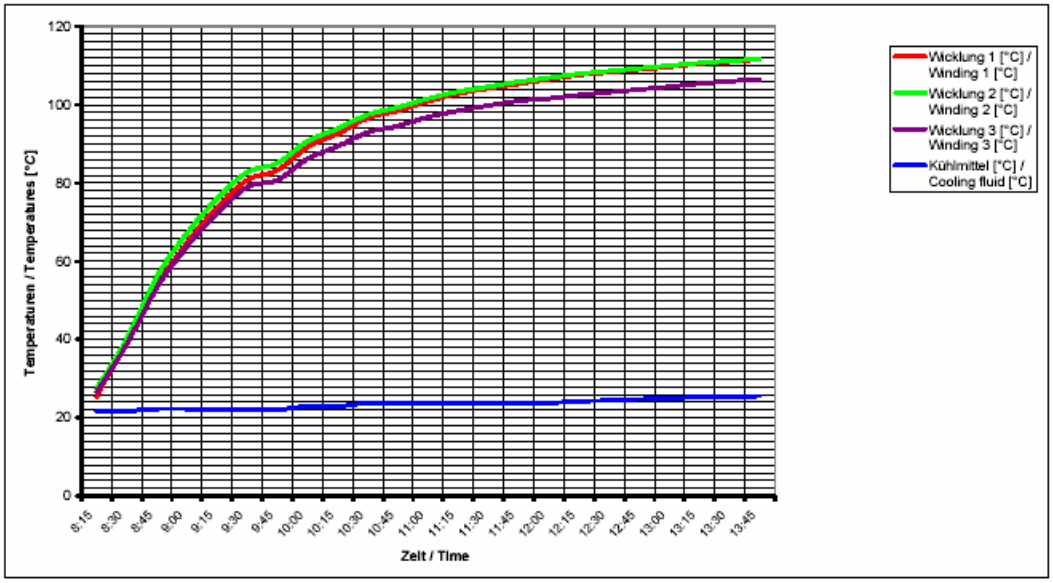

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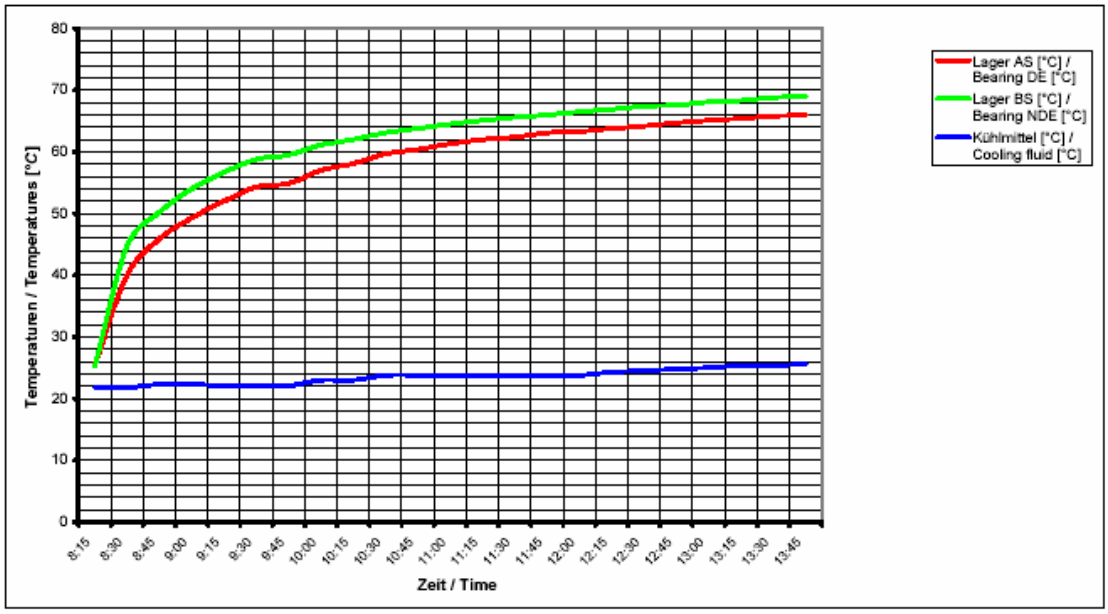

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