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D-PL-11120-02-00

Measurement report for the functional test / calibration on the measuring systems for T_{min} in the waste incineration plant of the company REC B.V. in Harlingen, Netherlands

TÜV Report No.: 936/21239402/A
Cologne, 21.08.2017

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DAkkS Deutsche Akkreditierungsstelle D-PL-11120-02-00

Measurement report for the functional test / calibration on the measuring systems for T_{min} in the waste incineration plant of the company REC B.V. in Harlingen, Netherlands

plant operator:	REC B.V.
Audited site:	Lange Lijnbaan 14 8861 NW Harlingen
Order number: **(of the customer)**	07862
Date of application:	02.03.2017
Customer ID:	3390254
Duration of the test:	21./22.06.2017
Scope of report:	32 pages in total Annex starts on page 28
Objectives:	Functional test of the measuring systems for T_{min}
Installation arrangement:	Activiteitenbesluit § 5.2

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1 Objectives

1.1	**Client:**	REC B.V.
1.2	**Plant operator:**	REC B.V.
	Contact person:	Mr. Seerp Bosch
	Telephone number:	0517-432396 or 06-20604459
	Work place number	0031-517-432396
1.3	**Location:**	Lange Lijnbaan 14 8861 NW Harlingen
1.4	**Plant:**	Waste incineration plant, plant according to article 10 of RL 2010/75/EU
	Plant number	1
1.5	**Date / Duration of the test:**	21./22.06.2017
	Functional test of the AMS:	21.06.2017
	Performance of parallel measurements:	Not applicable
	Functional test of the electronic data evaluation system:	Not applicable
	Previous functional test:	2016
	Next functional test:	2018
	Period of calibration:	21./22.06.2017
	Previous calibration:	05 / 2011
	Next calibration:	After an essential modification of the plant, the AMS, the operational mode or due to a special order
	Presence of certificate of proper installation:	No
1.6	**Reason:**	The reason for the repeated calibration is the modification of the first pass of the boiler. In 2015 the complete refractory in the first pass was changed.
	Approving authority:	Provincie Fryslan Gedeputeerde Staten
	Licence:	Az.: 00907403 dated on 05.10.2010
	Table 1.1 includes a listing of measured objects and emission limit value.	
1.6.1	**Deviation from EN 14181:**	none
1.7	**Measurement plan coordination:**	The measurement planning was consulted with the operator and the authority.
1.8	**Personnel involved in the test:**	Mr Dipl.-Ing. Ferdinand Lehmann (project manager), Mr. Ralf Ritter, Mr. Christain Winkler B.Eng.
1.9	**Participation of further institutes:**	No
1.10	**Technical supervisor:**	Dr. Peter Wilbring

Telephone number: 0221 806-2275

E-mail address: peter.wilbring@de.tuv.com

Table 1.1: Plant limit values and examined measured objects

Components	Unit	Limit values			Surveillance test	Calibration
		TMW	HMW	10-min-W		
T_{min}	°C			850	X	X

Key to table 1.1

T_{min}	Minimum temperature in the combustion chamber after the latest inflow of combustion air
TMW	Daily mean value
HMW	Half-hourly mean value
10-min-W	10-mean minute values

2 Description of the plants, the materials handled and basic measurement planning

2.1	**Type of plant:**	Waste incineration plant
2.2	**Description of the plant**	
	Brand:	AE&E Lentjes GmbH
	Type:	Moving grate, watercooled
	Year of manufacture:	2011
	Boiler No.:	1
	Steam output:	126 t/h ≙ 100 %
	Steam pressure:	85 bar
	Steam temperature:	465 °C
	Fuel:	Municipal and industrial waste
2.3	**Description of the emission sources**	
	Emission source:	Stack
	Height above ground:	44 m
	Cross-sectional area of outlet:	5 m²
	Easting/northing value	5,4291/53,19045
2.4	**Statement of raw materials possible according to the permit**	Municipal and industrial waste
2.5	**Operating times:**	Not applicable
2.6	**Device for collecting and reducing the emissions**	
2.6.1	**Device collecting the emissions**	
	Apparatus for emission collection:	Closed plant with directed emission source
	Collection element:	Suction draught ventilator
2.6.2	**Device reducing the emissions**	
	Electrostatic precipitator	
	Injection of sodiumbicarbonate and Active Coal (HOK)	
	Bag filter	
	SCR catalyst	

3 [Measured object] Description of the AMS and the electronic data evaluation system

3.1-3.3 Please refer to the respective component-specific sections

3.4 Electronic data evaluation system

Manufacturer:	DURAG
Type:	D-EMS 2000
Year of manufacture:	2010
Instrument no.:	33200 AAO 13761
Version number of the software used:	4.19
Declaration of suitability:	Yes
Suitability test report is available:	Yes
Test instituteDeclaration:	Suitability-tested emission measuring devices and electronic evaluation systems are announced in the Bundesanzeiger of Germany. The publication of the suitability notification of the electronic evaluation system can be found on the following website of the Umweltbundesamt: http://www.umweltbundesamt.de/themen/luft/messenbeobachtenueberwachen/anerkannte-messgeraete-messverfahren.
Installation location of the device:	MRA room
Type of data output:	Data file and printer (in network)
Installation location of the data output:	In control room
Ambient temperature (°C):	25
Protection against unauthorised parameter changes:	Yes, by means of a password
Date of last parameter change:	19.01.2016
Remote emission control:	No
Actual software version:	Like the software version of the emission calculator (Remote emission control (EFÜ) is a part of the emission calculator)
Redundant electronic recording system:	Second hard disk (external)
	Process control system

3 [T_{min}] Description of the AMS and the electronic data evaluation system

3.1	**Sampling location**	
3.1.1	**Location of measurement cross-section**	
	Sampling location takes place under the boiler roof of the 1st pass at 35,5 m.	
	Access is granted by	Elevator
	For measuring arrangement the following conditions are present:	
	- Installation certificate	
	- Successful calibration	
3.1.2	**Dimensions of the measurement cross-section:**	4,505 m x 11,305 m ≙ 50,93 m²
3.1.3	**Description of sampling**	
3.1.3.1	**Type of sampling:**	in situ
3.1.3.2	**Sampling method:**	Point measurement
3.2	**Sample gas conditioning:**	Not applicable
3.3	**Measuring system**	
3.3.1	**Measurement method:**	Electrical Temp.-measurement with thermocouple
3.3.2	**Analyser**	
	Manufacturer	Langkamp Technology
	Material / type:	NiCr-Ni / K
	Year of manufacture:	2017
	Instrument no:	-
	Lenght (installed) in m:	2 m (ca. 0,5 m)
	Software version:	Not applicable
	Installation location:	Construction and location of the temperature measuring device have not been changed since the latest calibration.
	Ambient temperature in °C:	30 - 50 °C
	Maintenance interval:	As required
	Type of span point check:	Not applicable
3.3.3	**Measuring ranges set:**	0 - 1200 °C ≙ 4 - 20 mA
3.3.4	**Declaration of suitability:**	Unnecessary
3.3.5	**Certificate on the correct installation:**	Unnecessary
3.3.6	**Recording system**	
	Measured object(s) monitored:	Comparable with 3.3.3 measuring ranges set
	Redundant electronic data evaluation system:	Please refer to section 3 [Measured object]
3.3.7	**Logbook (records) kept:**	Yes
3.4	**Electronic data evaluation system:**	Please refer to section 3 [Measured object]

4 [T_{min}] Sampling location for parallel measurements

4.1 Position of the measurement cross-section

Measurement plane 2

Position of the measurement takes place at the 18,0 m level of the first pass.

Access via:	elevator

Measurement plane 1

Position of the measurement takes place at the 24,0 m level of the first pass.

Access via:	elevator

Measurement plane of volume flow

Position of the measurement takes place at stack.

Access via:	stairs

4.2 Dimensions of the measurement cross-section

Measurement plane 2:	4,505 m x 11,305 m ≙ 50,93 m²
Measurement plane 1	4,505 m x 11,305 m ≙ 50,93 m²
Measurement plane of volume flow:	Ø 2,55 m ≙ 5 m²

4.3 Number of measurement axes and position of the measurement points in the measurement cross-section

Measurement plane 2

Axes:	3
Measurement points per axis:	6
Distance of measurement points from duct site:	94, 283, 471 cm from each side, on the central axis only 94 cm, because of the burners here are placed on both sides
Size of measurement ports:	3“
Location of measurement ports:	on the left und right side of the first pass

Measurement plane 1

Axes:	3
Measurement points per axis:	4
Distance of measurement points from duct site:	94, 283 cm from each side, because there is not more backlessness on this measurement plane
Size of measurement ports:	3“
Location of measurement ports:	on the left und right side of the first pass

Measurement plane of volume flow

Axes:	2
Measurement points per axis:	6
Distance of measurement points from duct site:	21, 64, 106, 149, 191, 234 cm
Size of measurement ports:	3“
Location of measurement ports:	offset by 90 ° on the circumference

Location and number of measurement points in both measurement planes meet the requirements according to E 4 of the Uniform Practice in Monitoring Emissions in the Federal Republic of Germany (RdSchr. d. BMU dated on 04 August 2010) with the exceptions mentioned above.

5 [T_{min}] Measurement methods for parallel measurements

5.1	**Determination of waste gas conditions**	
5.1.1	**Volumetric flow:**	Determination by calibrated measuring instrument
	Continuous determination and recording:	Readings of the electronic data evaluation system
5.1.2	**Static pressure in the waste gas duct:**	Manometer according to 5.1.1
5.1.3	**Air pressure at the height of the sampling location:**	Barometer
	Manufacturer / type / measuring range:	Lufft / Dosenb. / 913 - 1113 mbar
	Last check/ calibration:	Before measuring and 11 / 2016
5.1.4	**Waste gas temperature (volume flow):**	Ni-Cr-Ni-thermocouple
	Continuous determination and recording:	Readings of the electronic data evaluation system
5.1.4	**Waste gas temperature (afterburning zone):**	Water cooled suction pyrometer
	Manufacturer / type /measuring range / length:	Ritter / 0 - 1350 °C / 1,5 m - 5 m
	Temperature measuring device:	Measurement data acquisition according to 5.3.8
	Continuous determination and recording:	Parallel measurements of 14 points in measurement cross-section 2 (18 m) and 12 points in measurement cross-section 1 (24 m), recording by recording system/ measurement data acquisition according to 5.3.8.
	Sampling probe:	Unheated
	Particle filter:	without
	Material of gas-bearing parts:	Heat-resistant steel / ceramic
	Sample gas conditioning:	without
5.1.5	**Water vapour content in the waste gas (waste gas moisture):**	Determination by calibrated measuring instrument
	Continuous determination and recording:	Readings of the electronic data evaluation system
5.1.6	**Waste gas density:**	Calculated taking into account the waste gas content of oxygen (O_2), carbon dioxide (CO_2), atmospheric nitrogen (N_2 with 0,933 % Ar), carbon monoxide (CO), waste gas moisture (water vapour content in the waste gas) and other waste gas components as well as waste gas temperature and pressure conditions in the duct.
5.2	**Discontinuous measurement methods for gaseous measured objects:**	Not applicable

5.3	**Automated measurement methods for gaseous measured objects**		
5.3.1		O_2: paramagnetism / EN 14789	
5.3.2	Analyser:	O_2, afterburning zone	
	Manufacturer / type (O_2):	M und C / PMA 10 and	Servomex / OA 570 A
5.3.3	**Measuring range set (O_2):**	0 - 25 Vol.-%	
5.3.4	**Declaration of suitability:**	Yes	
5.3.5	**Sampling system**		
	Measuring method / VDI Guideline:	Unheated	
	Particle filter:	Without	
	Sample gas line before gas treatment:	Unheated	
	Sample gas line after gas treatment:	Unheated	
	Material of gas-bearing parts:	Heat-resistant steel / ceramics /PTFE	
	Sample gas conditioning:	Water separator, Silica gel, fine filter	
5.3.6	**Check of the instrument characteristic with the following test gases:**	O_2	
	Zero gas:	N_2	
	Test gas:	Dried outside air	20,95 Vol.-%
	Manufacturer / production date:	-	
	Guarantee of stability:	-	
	Certified:	-	
	Check of the certificate by / on:	-	
5.3.7	**Response time of the entire measuring system:**		
	Feeding of test gases via the probe:	< 120 s	
5.3.8	**Recording of measured values**		
	With a data logging system (calculator), manufacturer / type:	Hitec Zang / msr manager	
	Data collection programme (software):	Hitec Zang	

6 [T_{min}] Annual surveillance test of the AMS

6.1 Functional test for extractive sampling: Not applicable

6.2 Functional test of in situ measurements

6.2.1 Description of instrument status

Instrument status:	Instrument status is fine
Visual inspection:	No particularities are identifiable
Testing of location and construction:	Location and construction of AMS have not been changed since the latest calibration.

6.2.2 Check of the linearity of the temperature converter

The linearity was tested with the help of a precision voltage transducers (class 0.3) and a precision ammeter (class 0.3).

Deviation of the instrument characteristics shall not exceed ± 2 % referring to the measuring range (16 mA). Requirements to the linearity are met. Test data as well as the used test medium are in Annex 1 under the component T_{min}.

6.2.3 Check of the zero point and the span point

Carrying out the plausibility check is not possible (no parallel measurement openings, pulling the thermocouples is not possible due to destruction).

6.2.4 Determination of the response time (90% time): not applicable

6.2.5 Check of the cross-sensitivities: not applicable

6.2.6 Description of the test gas of the operator: not applicable

6.2.7 Check of the records and the logbook: not applicable

6.2.8 Check of the zero point and span point drift: not applicable

6.3 Check of the validity of the calibration function

Not applicable, because a calibration were carried out.

7 [T_{min}] Determination of the calibration function and validation of the AMS

Therefore, the mean temperature difference as well as its lower confidence limit between the operating temperature and the mean temperature, which is determined as part of the grid measurement, are calculated.

For each operating condition, namely full load and part load, 6 grid measurements for temperature and oxygen content are carried out in the measurement planes 1 and 2.

In cleaned gas not only the volume flow is regularly registrated, but also the oxygen content, the waste gas moisture, the waste gas temperature and the waste gas pressure.

At boiler outlet the oxygen content and the waste gas moisture are measured. Furthermore, the boiler roof temperatures and the steam performance are regularly recorded.

The measurement points in the 1st boiler pass and their determinations are presented in the Annex of the report. There are also the single values of the measurements.

In order to explain the nomenclature of the following calculation, figure 7.1 [T_{min}] presents the 1st pass of a waste incineration plant with the measurement planes. Please find the explanation of the used designations in the key.

In deviation to the guideline of Uniform Practice for Emission Monitoring (BMU Circular from August 4th, 2010) there is the need to make the restrictions mentioned in 4 [Tmin]. The named limitations can be accepted.

In the following, the mathematical procedure for determining the incineration conditions in accordance with the E 4 of the Uniform Federal Practice for Emission Monitoring (BMU Circular from August 4th, 2010) is presented in tabular form.

Table 7.1 [T_{min}]: Data of the location of the measuring point and dimension of the afterburning zone.

Operating condition			Full load and part load
Begin of afterburning zone	ℓ_{BNBZ}	=	14,2 m
Measurement plane operating	ℓ_B	=	35,5 m
Measurement plane 1	ℓ_1	=	24,0 m
Measurement plane 2	ℓ_2	=	18,0 m
MB - ME 2		=	17,5 m
MB - ME 1		=	11,5 m
ME 2 - BNBZ	$\Delta\ell_{BNBZ}$	=	3,8 m
ME 1 - BNBZ	$\Delta\ell$	=	9,8 m
ME 1 - ME 2	$\Delta\ell_{1.2}$	=	6,0 m
Cross-sectional area	A	=	50,93 m²

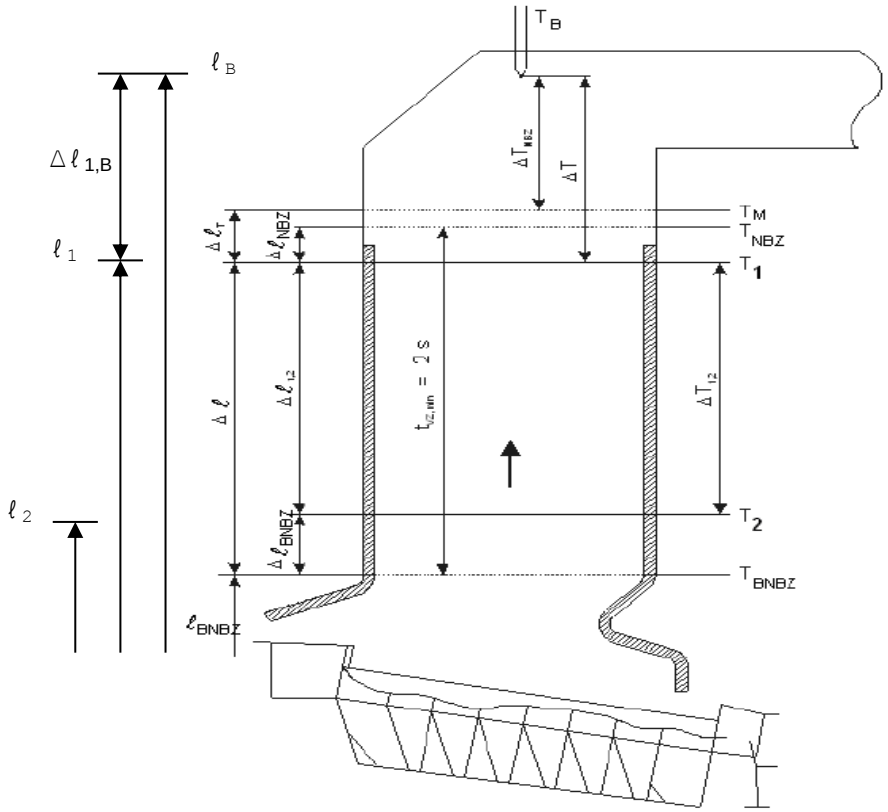

Figure 7.1 [T_{min}]: The 1st pass of a waste incineration plant

Key:

T_1	Mean value of termperature grid measurement, plane 1	$\Delta T_{1,2}$	Mean temperature difference between measuring plane 1 and 2
T_2	Mean value of termperature grid measurement, plane 2	ℓ_{BNBZ}	Hight to the beginning of afterburning zone
T_M	Minimum temperature of waste gas	$\Delta \ell_T$	Distance between plane of the minimum temperature and the measuring plane 1
T_B	Temperature operational measuring system	$\Delta \ell_{NBZ}$	Distance between plane of the end of the afterburning zone and measuring plane 1
T_{NBZ}	Temperature at the end of the after-burning zone	$\Delta \ell$	Distance between plane of the beginning of the afterburning zone and measuring plane 1
T_{BNBZ}	Temperature at the beginning of the afterburning zone	$\Delta \ell_{1,2}$	Distance between measuring plane 1 and 2
ΔT	Temperature difference between measuring plane 1 and operating measuring value	$\Delta \ell_{BNBZ}$	Distance between plane of the beginning of the afterburning zone and measuring plane 2
ΔT_{NBZ}	Temperature difference between the end of the afterburning zone and oper-ating measuring value	$t_{VZ,min}$	Minimum residence time, normally 2 s
ℓ_1	Hight to measuring plane 1	ℓ_2	Hight to measuring plane 2
ℓ_B	Hight to operational measuring plane	$\Delta \ell_{1,B}$	Distance between measuring plane 1 and operating measuring value

7.1 Measured results for the determination of the calibration function

Table 7.2 [T_{min}]: Results of temperature and oxygen content measurement at full-load

Grid measurement	No.	1	2	3	4	5	6	average
Date		21.06.17	21.06.17	21.06.17	21.06.17	21.06.17	21.06.17	
Time (start)	Uhr	14:50	15:20	15:50	16:20	16:50	17:20	
Time (end)	Uhr	15:20	15:50	16:20	16:50	17:20	17:50	
Steam output	t/h	127,6	124,4	123,4	124,5	126,4	126,1	125,4
Operating plane MB								
Height	m	35,50	35,50	35,50	35,50	35,50	35,50	35,50
Temperature	°C	894	885	884	894	892	889	890
Measuring plane 1 (ME 1)								
Height ℓ_1	m	24,00	24,00	24,00	24,00	24,00	24,00	24,00
Temperature	°C	1065	1051	1035	1036	1064	1067	1053
Oxygen content dry, std.	Vol.-%							
Measuring plane 2 (ME 2)								
Height ℓ_2	m	18,00	18,00	18,00	18,00	18,00	18,00	18,00
Temperature	°C	1195	1194	1172	1170	1207	1203	1190
Oxygen content dry, std.	Vol.-%	7,2	6,9	7,1	6,8	5,0	5,1	6,3
Temperature difference								
$T_1 - T_B$	K	171	166	151	141	173	178	163
$\Delta T / \Delta \ell_{1,B}$	K/m	14,9	14,4	13,1	12,3	15,0	15,5	14,2
$\Delta T_{1,2}$	K	130	143	137	134	142	136	137
$\Delta T_{1,2} / \Delta \ell_{1,2}$	K/m	21,7	23,8	22,8	22,4	23,7	22,7	22,9
$T_2 - T_B$	K	302	309	287	275	315	314	301
$\Delta T_{2,B} / \Delta \ell_{2,B}$	K/m	17,2	17,7	16,4	15,7	18,0	18,0	17,2
Oxygen content								
Boiler exit dry, std.	Vol.-%	8,9	9,0	9,0	8,7	8,4	8,3	8,7
chimney dry, std.	Vol.-%	9,0	9,1	9,0	8,8	8,5	8,5	8,8

Table 7.3 [T_{min}]: Results of temperature and oxygen content measurement at part load

Grid measurement	No.	1	2	3	4	5	6	average
Date		22.06.17	22.06.17	22.06.17	22.06.17	22.06.17	22.06.17	
Time (start)	Uhr	10:30	11:00	11:30	12:00	13:20	13:50	
Time (end)	Uhr	11:00	11:30	12:00	12:30	13:50	14:20	
Steam output	t/h	105,9	102,0	102,8	102,2	104,1	107,8	104,1
Operating plane MB								
Height	m	35,50	35,50	35,50	35,50	35,50	35,50	35,50
Temperature	°C	868	860	866	863	862	870	865
Measuring plane 1 (ME 1)								
Height ℓ_1	m	24,00	24,00	24,00	24,00	24,00	24,00	24,00
Temperature	°C	1019	1020	1027	1013	1002	1054	1022
Oxygen content dry, std.	Vol.-%							
Measuring plane 2 (ME 2)								
Height ℓ_2	m	18,00	18,00	18,00	18,00	18,00	18,00	18,00
Temperature	°C	1146	1145	1148	1142	1119	1166	1144
Oxygen content dry, std.	Vol.-%	7,3	7,1	7,4	7,5	7,7	6,3	7,2
Temperature difference								
$T_1 - T_B$	K	151	159	161	150	140	184	157
$\Delta T / \Delta \ell_{1,B}$	K/m	13,1	13,9	14,0	13,1	12,2	16,0	13,7
$\Delta T_{1,2}$	K	127	126	121	129	117	112	122
$\Delta T_{1,2} / \Delta \ell_{1,2}$	K/m	21,2	21,0	20,2	21,5	19,5	18,6	20,3
$T_2 - T_B$	K	278	285	282	279	257	296	279
$\Delta T_{2,B} / \Delta \ell_{2,B}$	K/m	15,9	16,3	16,1	15,9	14,7	16,9	16,0
Oxygen content								
Boiler exit dry, std.	Vol.-%	8,6	8,9	8,9	9,3	9,2	8,3	8,9
chimney dry, std.	Vol.-%	8,8	9,0	9,1	9,5	9,3	8,8	9,1

Table 7.4 [T_{min}]: Temperature and residence time in the afterburning zone at full load

Grid measurement	No.	1	2	3	4	5	6	average
Date		21.06.17	21.06.17	21.06.17	21.06.17	21.06.17	21.06.17	
Time (start)	Uhr	14:50	15:20	15:50	16:20	16:50	17:20	
Time (end)	Uhr	15:20	15:50	16:20	16:50	17:20	17:50	
Steam output	t/h	127,6	124,4	123,4	124,5	126,4	126,1	125,4
Volume flow dry, std. chimney	m³/h	254900	246400	246100	252000	259500	254100	252200
O2 - NBZ	Vol.-%	7,2	6,9	7,1	6,8	5,0	5,1	6,3
Volume flow wet, std. NBZ	m³/h	227000	213600	219000	223200	214300	210700	218000
Calculation of the average temperature NBZ								
T_B	°C	894	885	884	894	892	889	890
T_1	°C	1065	1051	1035	1036	1064	1067	1053
T_2	°C	1195	1194	1172	1170	1207	1203	1190
$\Delta T_{1,2}$	K	130	143	137	134	142	136	137
$\Delta T_{1,2} / \Delta \ell_{1,2}$	K/m	21,7	23,8	22,8	22,4	23,7	22,7	22,9
T_{BNBZ}	°C	1278	1285	1258	1255	1297	1289	1277
$T_{average}$	°C	1064	1067	1054	1052	1073	1070	1063
Calculation of the after-burning zone (NBZ) for 850 °C minimum temperature								
V t,wet (T average)	m³/h	1109400	1046500	1062500	1081400	1054800	1034100	1064800
V t,wet (T average)	m³/s	308,17	290,69	295,14	300,39	293,00	287,25	295,77
ℓ_{BNBZ}	m	14,20	14,20	14,20	14,20	14,20	14,20	14,20
ℓ_{NBZ}	m	12,58	11,89	12,07	12,27	11,98	11,76	12,09
ℓ_{ENBZ}	m	26,78	26,09	26,27	26,47	26,18	25,96	26,29
nominal temperature	°C	850	850	850	850	850	850	850
actual temperature	°C	1005	1001	983	980	1013	1022	1001
nominal residence time	s	2	2	2	2	2	2	2
actual residence time	s	3,2	3,1	3,0	3,0	3,2	3,3	3,1
After-burning zone, measured								
Exit NBZ at 850 °C	m	33,90	32,44	32,11	32,29	33,03	33,55	32,89
Nominal temperatures								
Nominal temperature MP 1	°C	910	900	902	905	902	894	902
Nominal temperature MP 2	°C	1041	1043	1038	1040	1044	1031	1039

Conversion of the measured volume flow in cleaned waste gas (chimney) with reference to the after-burning zone was based on the temperature, the oxygen content and the waste gas humidity.

Table 7.5 [T_{min}]: Temperature and residence time in the afterburning zone at part load

Grid measurement	No.	1	2	3	4	5	6	average
Date		22.06.17	22.06.17	22.06.17	22.06.17	22.06.17	22.06.17	
Time (start)	Uhr	10:30	11:00	11:30	12:00	13:20	13:50	
Time (end)	Uhr	11:00	11:30	12:00	12:30	13:50	14:20	
Steam output	t/h	105,9	102,0	102,8	102,2	104,1	107,8	104,1
Volume flow dry, std. chimney	m³/h	209700	207000	208000	200000	212700	228800	211000
O2 - NBZ	Vol.-%	7,3	7,1	7,4	7,5	7,7	6,3	7,2
Volume flow wet, std. NBZ	m³/h	191400	183600	186200	176000	191700	196600	187600
Calculation of the average temperature NBZ								
T_B	°C	868	860	866	863	862	870	865
T_1	°C	1019	1020	1027	1013	1002	1054	1022
T_2	°C	1146	1145	1148	1142	1119	1166	1144
$\Delta T_{1,2}$	K	127	126	121	129	117	112	122
$\Delta T_{1,2} / \Delta \ell_{1,2}$	K/m	21,2	21,0	20,2	21,5	19,5	18,6	20,3
T_{BNBZ}	°C	1226	1225	1224	1224	1193	1237	1222
$T_{average}$	°C	1038	1037	1037	1037	1022	1044	1036
Calculation of the after-burning zone (NBZ) for 850 °C minimum temperature								
V t,wet (T average)	m³/h	927500	889100	901400	851900	917100	956500	907300
V t,wet (T average)	m³/s	257,64	246,97	250,39	236,64	254,75	265,69	252,01
ℓ_{BNBZ}	m	14,20	14,20	14,20	14,20	14,20	14,20	14,20
ℓ_{NBZ}	m	10,59	10,18	10,31	9,77	10,48	10,91	10,37
ℓ_{ENBZ}	m	24,79	24,38	24,51	23,97	24,68	25,11	24,57
nominal temperature	°C	850	850	850	850	850	850	850
actual temperature	°C	1002	1012	1016	1014	989	1034	1011
nominal residence time	s	2	2	2	2	2	2	2
actual residence time	s	3,4	3,6	3,7	3,6	3,4	3,9	3,6
After-burning zone, measured								
Exit NBZ at 850 °C	m	31,94	32,09	32,77	31,59	31,81	34,97	32,53
Nominal temperatures								
Nominal temperature MP 1	°C	867	858	860	849	863	871	861
Nominal temperature MP 2	°C	994	984	981	978	980	982	983

Conversion of the measured volume flow in cleaned waste gas (chimney) with reference to the after-burning zone was based on the temperature, the oxygen content and the waste gas humidity.

7.2 Calculation of the temperature difference including the confidence level.

Table 7.6 [T_{min}]: Calibration of operating thermocouples for the full-load operation

Company:		REC B.V.
Plant:		waste incineration plant
Date:		21.06.2017
Operating condition:	-	full load
Steam output:	t/h	125,4
$\Delta\ell_{NBZ}$	m	2,29
$\Delta\ell_{BNBZ} + \Delta\ell_{1,2} + \Delta\ell_{NBZ}$	m	12,09
$\Delta T_{1,2}$	K	137
$\Delta T_{1,2} / \Delta\ell_{1,2}$	K/m	22,9
T_{NBZ1}	°C	1005
T_{NBZ2}	°C	1001
T_{NBZ3}	°C	983
T_{NBZ4}	°C	980
T_{NBZ5}	°C	1013
T_{NBZ6}	°C	1022
$T_{NBZ\ 1,6}$	°C	1001
T_{B1}	°C	894
T_{B2}	°C	885
T_{B3}	°C	884
T_{B4}	°C	894
T_{B5}	°C	892
T_{B6}	°C	889
$T_{B\ 1,6}$	°C	890
S_{TBTNBZ}	-	16
S_{TBTB}	-	95
$S_{TNBZ\ TNBZ}$	-	1353
S^2	-	338
S	K	18,4
t_{n-2}	-	2,776
V_B	K	20,8
ΔT_{NBZ}	K	111
ΔT_{NBZ}*	K	90
$T_{B\ min}$	°C	760

Table 7.7 [T_{min}]: Calibration of operating thermocouples for the part-load operation

Company :		REC B.V.
Plant :		waste incineration plant
Date :		22.06.2017
Operating condition :	-	part load
Steam output:	t/h	104,1
$\Delta \ell_{NBZ}$	m	0,57
$\Delta \ell_{BNBZ} + \Delta \ell_{1,2} + \Delta \ell_{NBZ}$	m	10,37
$\Delta T_{1,2}$	K	122
$\Delta T_{1,2} / \Delta \ell_{1,2}$	K/m	20,3
T_{NBZ1}	°C	1002
T_{NBZ2}	°C	1012
T_{NBZ3}	°C	1016
T_{NBZ4}	°C	1014
T_{NBZ5}	°C	989
T_{NBZ6}	°C	1034
$T_{NBZ\ 1,6}$	°C	1011
T_{B1}	°C	868
T_{B2}	°C	860
T_{B3}	°C	866
T_{B4}	°C	863
T_{B5}	°C	862
T_{B6}	°C	870
$T_{B\ 1,6}$	°C	865
S_{TBTNBZ}	-	143
S_{TBTB}	-	72
$S_{TNBZ\ TNBZ}$	-	1129
S^2	-	211
S	K	14,5
t_{n-2}	-	2,776
V_B	K	16,5
ΔT_{NBZ}	K	146
ΔT_{NBZ}*	K	130
$T_{B\ min}$	°C	720

As part of the static evaluation, the connection between the temperature in the minimum level of residence time and the temperature at the boiler top provided by operating side are determined in consideration of the respective set operational condition (steam performance). Determination is carried out according to the Uniform practice in monitoring emissions in theFederal Republic of Germany, Annex E4 testing of combustion conditions (BMU newsletter dated 4th August 2010).

The parameterising of the electronic data evaluation system is carried out in compliance to the following connections:

$$T_{KalB} = T_{B10} + \Delta T_{NBZ}^{*}$$

$$T_{B10} = a + b \cdot x$$

Whereby:

$$\Delta \overline{T}_{NBZ}^{*} = f(steamoutput, \dot{m}_D)$$

$$\Delta \overline{T}_{NBZ}^{*} = a + b \cdot \dot{m}_D$$

For the start-up procedure applies:

$$\Delta \overline{T}_{NBZ}^{*} = \text{Constant}$$

T_{KalB} = Calibrated 10-minute averages

T_{B10} = 10-minute averages of the operational temperature measuring system

$\Delta \overline{T}_{NBZ}^{*}$ = Mean temperature difference between the end of afterburning zone (minimum residence time) and operational measuring value minus confidence level

x = mA signal of the operational temperature measuring system

a, b = Coefficients of calibration curve

The characteristics for parameterising the minimum temperature are summerized hereinafter:

Operational temperature T_{B10}			
Measuring range of the temperature measuring system		0 - 1200 °C	4 - 20 mA
Slope	b	75	K/mA
Distance of ordinates	a	- 300	°C
Load dependent temperature difference $\Delta \overline{T}_{NBZ}$*			
Measuring range of steam mass flow – measuring system		0 - 160 t/h	4 - 20 mA
Slope	b	-1,85	$\frac{K}{t/h}$
Distance of ordinates	a	322	K
Limit value		850	°C

In figure **7.2 [T_{min}]** the connections between ΔT_{NBZ}* and operational conditions are graphically presented.

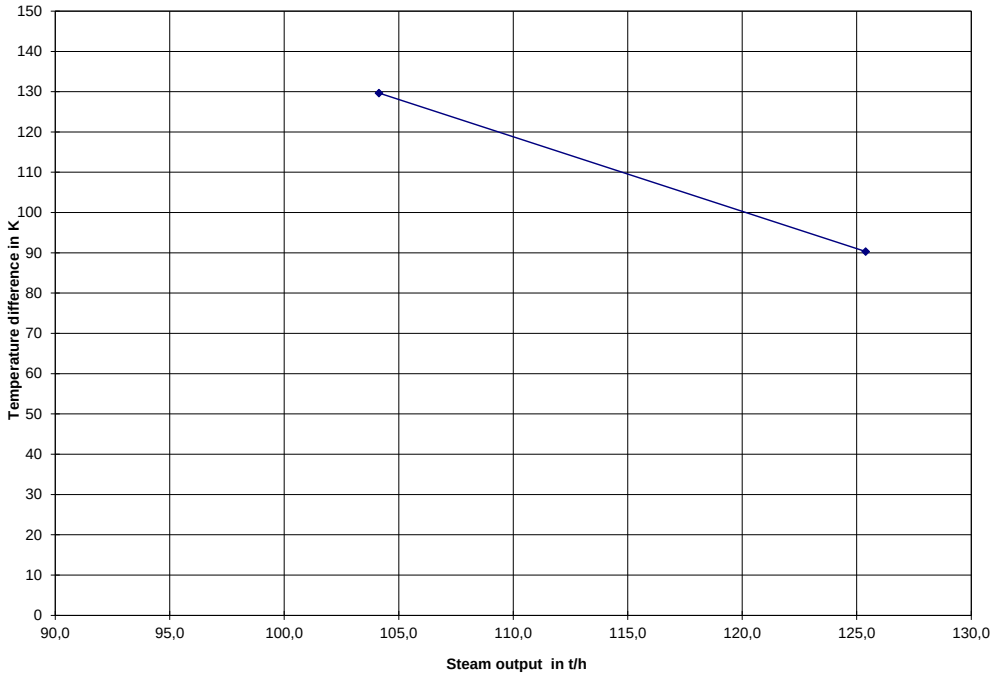

Figure 7.2 [T_{min}]: Mean temperature difference incl. confidence level between the end of afterburning zone (minimum level of residence time) and the operational measuring value

Table 7.8 [T_{min}]: Summery of measuring results

Operation condition		**full load**	**part load**
Steam output	t/h	125,4	104,1
Waste throughput	t/h	35,7	30,3
Caloric value of the waste	MJ/kg	10,3	10,1
Temperatures			
Operation			
Measuring plane 35,5 m	°C	890	865
Measuring grid			
Measuring plane 1	°C	1053	1022
Measuring plane 2	°C	1190	1144
Gradient	K/m	22,9	20,3
Oxygen content			
Measuring plane 2 dry, std.	Vol.-%	6,3	7,2
Boiler outlet dry, std.	Vol.-%	8,7	8,9
Cleaned gas dry, std.	Vol.-%	8,8	9,1
After-burning zone			
Temperature			
Limit value	°C	850	850
Actual	°C	1001	1011
Residence time			
Limit value	s	2	2
Actual	s	3,1	3,6
Calibration			
ΔT_{NBZ}*	K	90	130
$T_{B\,min}$	°C	760	720

8 Operating state of the plant during the parallel measurements

The operating data of the production plant can be obtained by the recording of measuring values of the operating measuring system in control station.

8.1 Production plant

The operating data of the plant during the measurement are indicated below. Further indications can be find in the Annex.

Raw materials/fuels: Municipal and industrial waste

Operating state: Full load and part load

Throughput/output: See table 7.8

8.2 Waste gas cleaning units

The operating data of the waste gas cleaning units are not relevant for after-burning zone measurements.

9 Annual surveillance test of the electronic data evaluation system

Not applicable

10 Summary of the results

10.1 Annual surveillance test of the AMS

The tested emission measuring systems are functional and met the requirements according to EN 14181.

10.2 Results of the calibration and validation and of the plausibility checks

The comparison of the parameters shows that the new calibration for the individual load states results in smaller ΔT_{NBZ}* compared to previous parameters in the electronic data evaluation system. The main reason why they are different is that the refractory in the first pass of the boiler was changed.

With the new parameters for ΔT_{NBZ}* the temperatures at the end of the afterburning zone are still far above the limit value. The limit value is given in Table 1.1.

Measureme object	Parameter	till now	Measuring range till now	Parameter	new	Measuring range new	Unit
ΔT_{NBZ}*	**b**	-1,06		**b**	-1,85		K / mA
	a	282	172 - 160	**a**	322	130 - 90	K
			104,1 - 125,4			104,1 - 125,4	t/h

10.3 Results of the check of the electronic data evaluation system

Not applicable

Environmental protection / Air pollution control Dept. (936)

Editor

F. Lehmann

Dipl.-Ing. Ferdinand Lehmann

Representative of the person responsible

T. Noll

Dipl.-Ing.(FH) Thorsten Noll

Cologne, 21.08.2017
936/21239402/A

11 Appendices

A1: Measured values and calculated values

A2: Operating data

A3: Boiler drawing

Annex A1: Measured values and calculated values

Component T_{min}

Functional test temperature [Tmin]

Thermocouple: NiCrNi

To 6.2.2 Checking the device characteristic with test standards

Operating element:		**CT001**	**Measuring range:**		**0 - 1200 °C**
Voltage Typ K mV	Temperature setpoint at 0°C °C	Temperature setpoint at *) °C	Amperage setpoint mA	Temperature actual value °C	Deviation %
0	0	33	4,44	39	0,5
10	246	279	7,72	284	0,4
20	485	518	10,91	521	0,3
30	721	754	14,05	758	0,3
40	967	1000	17,33	1007	0,6

*) Clamping temperature in °C	33

The deviations refer to the measuring range (16 mA)

Operating element:		**CT002**	**Measuring range:**		**0 - 1200 °C**
Voltage Typ K mV	Temperature setpoint at 0°C °C	Temperature setpoint at *) °C	Amperage setpoint mA	Temperature actual value °C	Deviation %
0	0	33	4,44	40	0,6
10	246	279	7,72	286	0,6
20	485	518	10,91	523	0,4
30	721	754	14,05	759	0,4
40	967	1000	17,33	1008	0,7

*) Clamping temperature in °C	33

The deviations refer to the measuring range (16 mA)

Operating element:		**CT003**	**Measuring range:**		**0 - 1200 °C**
Voltage Typ K mV	Temperature setpoint at 0°C °C	Temperature setpoint at *) °C	Amperage setpoint mA	Temperature actual value °C	Deviation %
0	0	34	4,45	41	0,6
10	246	280	7,73	286	0,5
20	485	519	10,92	523	0,3
30	721	755	14,07	760	0,4
40	967	1001	17,35	1009	0,7

*) Clamping temperature in °C	34

The deviations refer to the measuring range (16 mA)

Adjusting aids

Ammeter

Manufacturer / Type:	Fluke / 85		
Grade:	0,3		
Last check/calibration	July	//	2016

Current source / voltage source

Manufacturer / Type:	Burster / Digistant 4422		
Grade:	0,1		
Last check/calibration	February	//	2017

Component T_{min}, Parallel measurements

Temperatures in the after-burning zone and of the operation thermocouples

Date/ Operating condition	Time from -	to	Smp. point	Individual values T_{ME2_1l}	T_{ME2_2l}	T_{ME2_3l}	T_{ME2_1r}	T_{ME2_2r}	T_{ME2_3r}	T_{ME1_1l}	T_{ME1_2l}	T_{ME1_3l}	T_{ME1_1r}	T_{ME1_2r}	T_{ME1_3r}	$O_{2,ME1\_1l}$	$O_{2,ME1\_2l}$	$O_{2,ME1\_3l}$	$O_{2,ME1\_1r}$	$O_{2,ME1\_2r}$	$O_{2,ME1\_3r}$	R1HBK10CT001	R1HBK10CT002	R1HBK10CT003	Grid averages T_{ME2}	T_{ME1}	T_B
				°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	Vol.-%	Vol.-%	Vol.-%	Vol.-%	Vol.-%	Vol.-%	°C	°C	°C	°C	°C	°C
21.06.2017	14:50	15:00	1	1279	1174	1261	1136	1068	1053	1152	1105	1069	1041	986	932	5,8	9,1	3,3	8,3	14,0	12,7	910	878	884			
Full load	15:00	15:10	2	1259	1250	1240	1202	1160	1119	1127	1095	1062	1111	1046	961	6,4	5,2	3,9	5,6	8,1	10,6	902	874	905			
	15:10	15:20	3	1201	1199	1197	1281	1240	1199	1101	1075	1025	1164	1108	1012	7,3	6,8	6,3	3,1	5,3	7,5	889	877	923	1195	1065	894
	15:20	15:30	3	1219	1230	1241	1195	1157	1119	1118	1100	1048	1068	997	956	6,4	5,8	5,2	6,0	8,2	10,3	893	877	904			
	15:30	15:40	2	1255	1264	1274	1160	1123	1087	1116	1095	1059	1052	990	929	6,6	4,7	2,7	6,8	8,9	11,0	893	876	880			
	15:40	15:50	1	1250	1130	1245	1225	1153	1165	1117	1089	1048	1114	1061	965	3,8	11,4	3,6	5,1	8,9	8,5	883	867	893	1194	1051	885
	15:50	16:00	1	1199	1085	1204	1233	1157	1207	1087	1058	1013	1125	1085	991	6,1	11,9	4,9	5,1	8,6	6,4	878	867	909			
	16:00	16:10	2	1171	1177	1182	1180	1153	1126	1055	1038	1001	1071	1013	956	7,2	6,6	6,0	6,6	8,1	9,6	880	870	900			
	16:10	16:20	3	1198	1216	1234	1138	1123	1108	1084	1072	1030	1033	981	936	5,8	5,0	4,2	7,8	8,7	9,6	887	874	893	1172	1035	884
	16:20	16:30	3	1189	1218	1247	1120	1109	1097	1082	1075	1043	1023	976	919	6,0	4,9	3,9	8,4	9,1	9,9	905	880	890			
	16:30	16:40	2	1165	1199	1233	1190	1174	1157	1059	1047	1026	1089	1044	963	5,7	4,8	3,9	5,8	7,0	8,1	899	883	898			
	16:40	16:50	1	1132	1048	1198	1231	1154	1199	1043	1025	990	1131	1101	1005	5,9	12,9	4,7	4,7	9,7	6,6	891	883	921	1170	1036	894
	16:50	17:00	1	1159	1071	1212	1182	1111	1161	1066	1047	1013	1087	1048	967	4,5	11,9	4,2	6,2	10,6	7,8	888	878	897			
	17:00	17:10	2	1187	1213	1240	1206	1216	1226	1082	1059	1025	1112	1090	999	3,8	3,4	2,9	5,8	5,5	5,2	887	875	912			
	17:10	17:20	3	1250	1261	1272	1241	1252	1263	1124	1093	1064	1139	1116	1030	2,5	2,3	2,2	4,5	3,8	3,1	897	874	918	1207	1064	892
	17:20	17:30	3	1268	1274	1280	1214	1196	1179	1132	1097	1072	1116	1083	1000	2,1	2,1	2,1	4,8	5,6	6,3	904	873	899			
	17:30	17:40	2	1227	1242	1258	1205	1180	1154	1112	1077	1059	1104	1061	973	2,5	2,2	2,0	5,4	6,9	8,4	896	868	900			
	17:40	17:50	1	1198	1105	1243	1196	1100	1136	1094	1065	1048	1094	1052	966	3,7	10,8	2,5	5,1	10,9	8,9	898	864	895	1203	1067	889
22.06.2017	10:30	10:40	1	1202	1054	1201	1199	1053	1134	1075	1054	1013	1113	1049	957	4,6	13,7	4,1	4,8	13,4	8,7	867	858	875			
part load	10:40	10:50	2	1177	1151	1124	1185	1159	1133	1050	1013	963	1074	1011	950	4,1	6,2	8,3	5,7	7,3	8,9	868	854	886			
	10:50	11:00	3	1197	1163	1130	1154	1122	1089	1060	1029	990	1036	976	923	3,3	5,4	7,5	6,5	8,6	10,8	869	855	879	1146	1019	868
	11:00	11:10	3	1237	1201	1165	1114	1077	1041	1079	1050	1025	998	955	909	2,4	4,6	6,8	7,5	9,8	12,2	871	856	873			
	11:10	11:20	2	1228	1214	1200	1124	1088	1052	1060	1042	1031	1023	970	908	1,9	3,2	4,6	6,8	9,3	11,9	845	854	867			
	11:20	11:30	1	1254	1071	1215	1199	1027	1109	1103	1074	1059	1094	1036	935	1,1	13,8	3,7	4,2	13,9	9,8	855	849	871	1145	1020	860
	11:30	11:40	1	1266	1077	1232	1117	979	1049	1120	1078	1062	1026	980	918	0,9	14,3	3,7	7,8	14,2	11,7	886	842	857			
	11:40	11:50	2	1277	1244	1211	1086	1053	1019	1116	1073	1058	994	955	902	1,3	3,4	5,6	8,7	10,9	13,1	889	843	864			
	11:50	12:00	3	1289	1266	1243	1114	1083	1051	1125	1086	1071	1028	980	908	1,4	2,8	4,2	7,5	9,8	12,0	894	850	869	1148	1027	866
	12:00	12:10	3	1289	1275	1261	1128	1090	1052	1120	1085	1077	1041	989	919	1,5	2,2	2,9	7,3	9,6	12,0	880	855	869			
	12:10	12:20	2	1287	1259	1232	1120	1078	1036	1100	1067	1061	1023	976	916	1,5	2,7	3,8	7,6	10,0	12,5	865	856	867			
	12:20	12:30	1	1193	982	1073	1141	1008	1050	1025	996	962	1008	956	914	3,0	15,4	10,3	6,4	13,8	12,9	848	855	869	1142	1013	863
	13:20	13:30	1	1123	942	1019	1132	959	1042	996	967	942	1013	963	903	5,9	16,1	11,0	5,9	15,7	13,0	862	846	866			
	13:30	13:40	2	1201	1155	1109	1170	1130	1090	1040	1019	1008	1050	998	922	3,3	5,6	8,0	4,8	7,8	10,7	863	849	874			
	13:40	13:50	3	1265	1219	1173	1188	1138	1088	1095	1058	1063	1063	1010	930	1,2	2,9	4,6	4,6	7,5	10,3	883	852	866	1119	1002	862
	13:50	14:00	3	1287	1265	1243	1149	1127	1105	1123	1088	1098	1047	1028	950	0,7	0,8	0,9	6,3	7,5	8,6	897	853	845			
	14:00	14:10	2	1303	1274	1246	1123	1095	1067	1132	1092	1100	1042	1014	944	1,4	1,5	1,7	7,6	9,2	10,7	910	851	856			
	14:10	14:20	1	1293	1033	1225	1140	949	1068	1127	1084	1094	1061	1021	936	1,9	17,0	3,0	6,6	15,5	12,3	911	852	857	1166	1054	870

Sampling point 1 located at 94 cm distance from the border of the 1st flue
Sampling point 2 loacted at 283 cm distance from the border of the 1st flue
Sampling point 3 located at 471 cm distance from the border of the 1st flue
T_{ME2_1l} waste gas temperature on measuring axis 1 at the left side of the boiler, plane 2 (18,0 m)
T_{ME2_1r} waste gas temperature on measuring axis 1 at the right side of the boiler, plane 2 (18,0 m)
T_{ME1_1l} waste gas temperature on measuring axis 1 at the left side of the boiler, plane 1 (24,0 m)
T_{ME1_1r} waste gas temperature on measuring axis 1 at the right side of the boiler, plane 1 (24,0 m)
T_B average temperature of the operation thermocouples of the 1st flue (35,5 m)
further nomenclature analogous to the above given information
all data presented in the direction of waste flow

Oxygen content in the after-burning zone, at boiler exit and in cleaned waste gas (chimney)

				Individual values								Grid averages		
Date/ Operating condition	Time from -	to	Smp. point	$O_{2,ME1\_1l}$ dry,std. Vol.-%	$O_{2,ME1\_2l}$ dry,std. Vol.-%	$O_{2,ME1\_3l}$ dry,std. Vol.-%	$O_{2,ME1\_1r}$ dry,std. Vol.-%	$O_{2,ME1\_2r}$ dry,std. Vol.-%	$O_{2,ME1\_3r}$ dry,std. Vol.-%	$O_{2,BE}$ dry,std. Vol-%	$O_{2,cleaned\ gas}$ dry,std. Vol-%	$O_{2,ME2}$ dry,std. Vol.-%	$O_{2,BE}$ dry,std. Vol.-%	$O_{2,cleaned\ gas}$ dry,std. Vol-%
21.06.2017	14:50	15:00	1	5,8	9,1	3,3	8,3	14,0	12,7	8,9	9,3			
Full load	15:00	15:10	2	6,4	5,2	3,9	5,6	8,1	10,6	8,8	9,0			
	15:10	15:20	3	7,3	6,8	6,3	3,1	5,3	7,5	8,8	8,8	7,2	8,9	9,0
	15:20	15:30	3	6,4	5,8	5,2	6,0	8,2	10,3	8,9	8,9			
	15:30	15:40	2	6,6	4,7	2,7	6,8	8,9	11,0	9,2	9,4			
	15:40	15:50	1	3,8	11,4	3,6	5,1	8,9	8,5	8,9	9,1	6,9	9,0	9,1
	15:50	16:00	1	6,1	11,9	4,9	5,1	8,6	6,4	8,9	8,8			
	16:00	16:10	2	7,2	6,6	6,0	6,6	8,1	9,6	9,1	9,1			
	16:10	16:20	3	5,8	5,0	4,2	7,8	8,7	9,6	8,9	8,9	7,1	9,0	9,0
	16:20	16:30	3	6,0	4,9	3,9	8,4	9,1	9,9	8,9	8,9			
	16:30	16:40	2	5,7	4,8	3,9	5,8	7,0	8,1	8,7	8,7			
	16:40	16:50	1	5,9	12,9	4,7	4,7	9,7	6,6	8,6	8,6	6,8	8,7	8,8
	16:50	17:00	1	4,5	11,9	4,2	6,2	10,6	7,8	8,7	8,9			
	17:00	17:10	2	3,8	3,4	2,9	5,8	5,5	5,2	8,5	8,5			
	17:10	17:20	3	2,5	2,3	2,2	4,5	3,8	3,1	8,1	8,0	5,0	8,4	8,5
	17:20	17:30	3	2,1	2,1	2,1	4,8	5,6	6,3	8,1	8,3			
	17:30	17:40	2	2,5	2,2	2,0	5,4	6,9	8,4	8,3	8,5			
	17:40	17:50	1	3,7	10,8	2,5	5,1	10,9	8,9	8,5	8,7	5,1	8,3	8,5
22.06.2017	10:30	10:40	1	4,6	13,7	4,1	4,8	13,4	8,7	8,8	8,9			
part load	10:40	10:50	2	4,1	6,2	8,3	5,7	7,3	8,9	8,4	8,7			
	10:50	11:00	3	3,3	5,4	7,5	6,5	8,6	10,8	8,7	8,8	7,3	8,6	8,8
	11:00	11:10	3	2,4	4,6	6,8	7,5	9,8	12,2	8,9	8,9			
	11:10	11:20	2	1,9	3,2	4,6	6,8	9,3	11,9	9,1	9,2			
	11:20	11:30	1	1,1	13,8	3,7	4,2	13,9	9,8	8,7	9,0	7,1	8,9	9,0
	11:30	11:40	1	0,9	14,3	3,7	7,8	14,2	11,7	8,9	9,2			
	11:40	11:50	2	1,3	3,4	5,6	8,7	10,9	13,1	9,1	9,2			
	11:50	12:00	3	1,4	2,8	4,2	7,5	9,8	12,0	8,7	9,0	7,4	8,9	9,1
	12:00	12:10	3	1,5	2,2	2,9	7,3	9,6	12,0	8,9	9,1			
	12:10	12:20	2	1,5	2,7	3,8	7,6	10,0	12,5	9,2	9,4			
	12:20	12:30	1	3,0	15,4	10,3	6,4	13,8	12,9	9,8	9,8	7,5	9,3	9,5
	13:20	13:30	1	5,9	16,1	11,0	5,9	15,7	13,0	9,6	9,7			
	13:30	13:40	2	3,3	5,6	8,0	4,8	7,8	10,7	9,3	9,3			
	13:40	13:50	3	1,2	2,9	4,6	4,6	7,5	10,3	8,6	8,9	7,7	9,2	9,3
	13:50	14:00	3	0,7	0,8	0,9	6,3	7,5	8,6	8,3	8,9			
	14:00	14:10	2	1,4	1,5	1,7	7,6	9,2	10,7	8,4	8,9			
	14:10	14:20	1	1,9	17,0	3,0	6,6	15,5	12,3	8,2	8,7	6,3	8,3	8,8

Sampling point 1 located at 94 cm distance from the border of the 1st flue
Sampling point 2 loacted at 283 cm distance from the border of the 1st flue
Sampling point 3 located at 471 cm distance from the border of the 1st flue
$O_{2,ME2\_1l}$ Oxygen content on measuring axis 1 at the left side of the boiler; plane 2; (18,0 m) condition dry, standard
$O_{2,ME2\_1r}$ Oxygen content on measuring axis 1 at the right side of the boiler; plane 2 (18,0 m) condition dry, standard
$O_{2,BE}$ Oxygen content of the waste gas behind boiler; condition: dry, standard (measuring system of the operator)
$O_{2,cleaned\ gas}$ Oxygen content in the cleaned gas (chimney); condition: dry, standard (measuring system of the operator)
further nomenclature analogous to the above given information
all data presented in the direction of waste flow

Annex A2: Operating data

			Individual values								Grid averages					
Date/ Operating condition	Time from -	to	R1HBK10CT001 °C	R1HBK10CT002 °C	R1HBK10CT003 °C	$O_{2,BE}$ dry,std. Vol-%	$O_{2,cleaned\ gas}$ dry,std. Vol-%	$H_2O_{cleaned\ gas}$ Vol.-%	$V_{cleaned\ gas}$ dry,std. m³/h	m_D t/h	T_B °C	$O_{2,BE}$ dry,std. Vol.-%	$O_{2,cleaned\ gas}$ dry,std. Vol-%	$H_2O_{cleaned\ gas}$ Vol.-%	$V_{cleaned\ gas}$ dry,std. m³/h	m_D t/h
21.06.2017	14:50	15:00	910	878	884	8,9	9,3	14,5	217703	127,2						
Full load	15:00	15:10	902	874	905	8,8	9,0	14,4	219374	128,0						
	15:10	15:20	889	877	923	8,8	8,8	14,4	217261	127,5	894	8,9	9,0	14,4	218113	127,6
	15:20	15:30	893	877	904	8,9	8,9	14,3	212516	126,0						
	15:30	15:40	893	876	880	9,2	9,4	14,1	207946	123,0						
	15:40	15:50	883	867	893	8,9	9,1	14,1	214281	124,0	885	9,0	9,1	14,1	211581	124,4
	15:50	16:00	878	867	909	8,9	8,8	14,3	212131	124,7						
	16:00	16:10	880	870	900	9,1	9,1	14,4	207733	122,8						
	16:10	16:20	887	874	893	8,9	8,9	14,7	211695	122,7	884	9,0	9,0	14,5	210520	123,4
	16:20	16:30	905	880	890	8,9	8,9	14,8	211871	123,6						
	16:30	16:40	899	883	898	8,7	8,7	14,9	215640	124,5						
	16:40	16:50	891	883	921	8,6	8,6	14,7	216576	125,5	894	8,7	8,8	14,8	214696	124,5
	16:50	17:00	888	878	897	8,7	8,9	14,6	214815	123,8						
	17:00	17:10	887	875	912	8,5	8,5	15,6	221676	126,7						
	17:10	17:20	897	874	918	8,1	8,0	15,7	222942	128,7	892	8,4	8,5	15,3	219811	126,4
	17:20	17:30	904	873	899	8,1	8,3	15,1	215884	127,4						
	17:30	17:40	896	868	900	8,3	8,5	15,2	214546	125,6						
	17:40	17:50	898	864	895	8,5	8,7	15,8	214752	125,4	889	8,3	8,5	15,4	215061	126,1
22.06.2017	10:30	10:40	867	858	875	8,8	8,9	15,6	176804	108,2						
Part load	10:40	10:50	868	854	886	8,4	8,7	16,3	177450	104,6						
	10:50	11:00	869	855	879	8,7	8,8	16,4	173552	104,8	868	8,6	8,8	16,1	175935	105,9
	11:00	11:10	871	856	873	8,9	8,9	16,0	170599	104,2						
	11:10	11:20	845	854	867	9,1	9,2	15,6	172152	100,9						
	11:20	11:30	855	849	871	8,7	9,0	16,0	179696	100,9	860	8,9	9,0	15,9	174149	102,0
	11:30	11:40	886	842	857	8,9	9,2	15,3	174758	102,0						
	11:40	11:50	889	843	864	9,1	9,2	14,9	175599	102,9						
	11:50	12:00	894	850	869	8,7	9,0	15,2	179055	103,5	866	8,9	9,1	15,1	176471	102,8
	12:00	12:10	880	855	869	8,9	9,1	14,7	176610	103,3						
	12:10	12:20	865	856	867	9,2	9,4	13,9	170974	102,4						
	12:20	12:30	848	855	869	9,8	9,8	13,5	168471	101,0	863	9,3	9,5	14,0	172018	102,2
	13:20	13:30	862	846	866	9,6	9,7	13,9	179904	102,7						
	13:30	13:40	863	849	874	9,3	9,3	14,5	178959	104,3						
	13:40	13:50	883	852	866	8,6	8,9	15,6	185501	105,4	862	9,2	9,3	14,7	181454	104,1
	13:50	14:00	897	853	845	8,3	8,9	15,3	189327	104,8						
	14:00	14:10	910	851	856	8,4	8,9	15,0	192997	110,0						
	14:10	14:20	911	852	857	8,2	8,7	15,3	199564	108,7	870	8,3	8,8	15,2	193962	107,8

T_B average temperature of the operation thermocouples of the 1st flue (35,5 m)
$O_{2,BE}$ Oxygen content of the waste gas behind boiler; condition: dry, standard (measuring system of the operator)
$O_{2,cleaned\ gas}$ Oxygen content in the cleaned gas; condition: dry, standard (measuring system of the operator)
$H_2O_{cleaned\ gas}$ waste gas humidity in the cleaned gas (measuring system of the operator)
$V_{cleaned\ gas}$ waste gas volume flow in the cleaned gas; condition: dry, standard
m_D Steam output
further nomenclature analogous to the above given information

Annex A3: Boiler drawing