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Measuring Institution accredited according to DIN EN ISO/IEC 17025
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Margam Green Energy Plant
Report: Combustion Conditions, Residence Time

DAkkS Deutsche Akkreditierungsstelle D-PL-14153-03-00

Operator	Margam Green Energy
Location	Port Talbot SA13 2NW United Kingdom
Customer	Babcock & Wilcox Vølund A/S
Type of measurement	Combustion Conditions
Purchase Order	4400051723
Date of Order	18th January 2019
Date of measurement:	28th February and 1st March 2019
Report contains	69 Pages

Subject	Performance Test, Residence Time

Projekt manager	Gaylord Höß
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Date: 2019-04-23

Our reference:
IS-US1-MUC/hg

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This document consists of
69 Pages.
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The test results refer exclusively to the units under test.

Certified System SWISSTS ISO 9001

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Compiled by: Gaylord Höß

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1 Conclusion

60 % MCR

Measuring no.:	date	time	lowest temperature in the grid	lowest oxygen content in the grid	mean value	less then ± 50 % of the average	residence time	time one hour measurement	temperature 95 % higher than 850 °C
1	28. Feb. 19	11:06 - 11:42	880 °C	2,4 Vol. %	3,3 Vol. %	yes	3,97 Sec.	11:45 - 12:45	100%
2	28. Feb. 19	13:29 - 14:05	877 °C	2,4 Vol.%	3,2 Vol. %	yes	4,06 Sec.	14:08 - 15:08	100%

100 % MCR

Measuring no.:	date	time	lowest temperature in the grid	lowest oxygen content in the grid	mean value	less then ± 50 % of the average	residence time	time one hour measurement	temperature 95 % higher than 850 °C
1	1. Mrz. 19	9:36 - 10:12	950 °C	2,6 Vol. %	3,2 Vol. %	yes	4,14 Sec.	10:15 - 11:15	100%
2	1. Mrz. 19	13:09 - 13:45	933 °C	2,3 Vol.%	3,2 Vol. %	yes	4,19 Sec.	13:48 - 14:48	100%

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2 Explanation of the scope of measurements

2.1 Operator

Margam Green Energy

2.2 Ordered by

Babcock & Wilcox Vølund A/S
Falkevej 2
6705 Esbjerg Ø
Denmark

2.3 Location

Port Talbot
SA13 2NW
United Kingdom

2.4 Plant

Margam Green Energy Plant

2.5 Date of the measurement

28th February and 1st March 2019

2.6 Reason of measurement

Report to the environment agency

2.7 Objectives

DIRECTIVE 2010/75/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 24 November 2010 on industrial emissions (integrated pollution prevention and control).

Sector Guidance Note IPPC S5.01: Guidance for the Incineration of Waste and Fuel Manufactured from or Including Waste.

German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety Research Report 360 16 004 UBA-FB 001090

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AEA technical report: Review of BAT for New Waste Incineration Issues – Part 2 Validation of Combustion Conditions.

BS EN ISO 16911-1:2013 Stationary source emissions. Manual and automatic determination of velocity and volume flow rate in ducts. Manual reference method.

2.8 Components to be measured

Temperature
Oxygen
Residence time

2.9 Local inspection before measurement

Last local inspection before measurement carried out on 25th February 2019.

2.10 Coordination of measuring plan

The measurements were coordinated by Thomas Norman (BWV), Daniel Pickett (BWV), Daniel Neubacher (TÜV SÜD) and Gaylord Höß (TÜV SÜD).

2.11 People involved in measurements

Gaylord Höß	Tel. +49 89 32950-526
Daniel Neubacher	Tel. +49 89 32950-514
Rene Walaczek	
Reinhard König	

2.12 Further laboratories involved

None

2.13 Responsible persons

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Gaylord Höß	Tel. +49 89 32950-526

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3 Description of the measuring points in the after burning chamber

3.1 Determination of measuring planes

For the measuring observation of the minimum temperature at least 2 measuring planes shall be assigned in the range of the after burning zone.

Measuring level 1

Measuring plane 1 shall be determined at the end of the after burning zone. The determination usually results on the basis of the manufacturer's theoretical considerations.

Level measuring area 1: 14,00 m

The temperatures at measuring plane 1 were measured by using suction pyrometer in a horizontal position. At the measuring level T_1 are 3 measuring axes available. There are 3 openings on both sides of the boiler.

Measuring level 2

The second measuring plane shall be installed at the defined beginning of the after burning zone. This measuring plane shall be determined after the last feeding with combustion air on the basis of the manufacturer's data.

Level measuring area 2: 7,90 m

The temperatures at measuring plane 2 were measured by using suction pyrometer in a horizontal position. At the measuring level T_2 are 3 measuring axes available. There are 3 openings on both sides of the boiler.

Beginning of the after burning zone

The plane, where, first of all, we may proceed from a uniform mixing of the incineration gases with incineration air is defined as the beginning of the afterburning zone.
Owing to the existing local conditions insignificant deviations of the position of the 2nd measuring plane from the actual beginning of the afterburning zone are possible. This will be compensated by respective conversions.

Last feeding of combustion air: 1,26 m

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3.2 Determination of the measuring points

The checking of the minimum temperature is taken by a grid measurement. The distribution of the measuring plane into the partial planes happens according to EN 13284-1. Especially because of the principle of relationship of the measuring expense (temporal, personal and technical expense) the number of measuring points is determined to be 1 in each 2 m^2. This value is valid as directional quantity and covers an area of 1 each 1,5 m^2 to 2,4 m^2.
This requirement takes into account of usually applied technology of the water-cooled walls. The 2 m² measuring area results in a minimum distance of the measured point to the boiler wall of 0,5 m.
In case of very large combustion chamber cross-sectional area 20 measuring points are regarded as sufficient on grounds of the principle of relationship.
If it is necessary to use shorter suction pyrometers, because of local conditions, which do not allow a measurement in the middle of the measuring cross section, the values at these measured points shall be interpolated from the measured values of the neighbouring measuring points.
But from that usually results a judgement of the incineration plant which is more unfavourable for the manufacturer.

The area in the measuring planes is 59,25 m²; this means following the rule above using a grid with 2 m² per measuring point we will find 30 measuring points.
By very big after burning chambers a grid with 20 measuring points is sufficient.

In the measuring planes, there are 3 openings on both sides of the boiler. The grid measurements were carried out by using these openings in the reachable deeps for the measuring points. Depend on the size of the furnace chamber a grid measurement can be realised with an exception. The three measuring points in the middle of the cross section are not reachable (see 3.3). These missing temperatures were interpolated from the measured values of the neighbouring measuring points.

6 grid measurements and 2 one-hour single point measurements on the point with the lowest temperature in the grid (measuring level 1) distributed were carried out for part (60% MCR) and nominal load (100% MCR) of the boiler.

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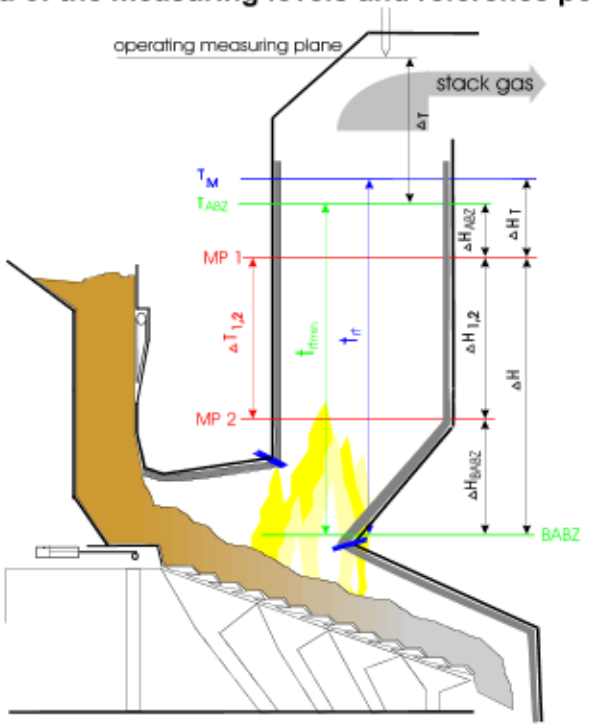
3.3 Measuring scheme

Schema of the measuring levels and reference points



beginning of after burning zone	BABZ	1,26 m
end of after burning zone	EABZ	18,13 m
measuring plane 2	MP2	7,90 m
measuring plane 1	MP1	14,00 m
operating measuring plane	OMP	18,13 m
(MP2 - BABZ)	ΔH_{BABZ}	6,64 m
(MP1 - MP2)	$\Delta H_{1,2}$	6,10 m
(MP1 - BABZ)	ΔH	12,74 m
BABZ-EABZ	H	16,87 m
Width		12,50 m
Depth		4,74 m
cross sectional area	A	59,25 m²

ΔH_{ABZ}	distance between the end of the afterburning zone plane and the 1st measuring plane
ΔH_T	distance between the plane in the incineration chamber where the flue gases just keep the minimum temperature on average and on the 1st measuring plane
T_M	minimum temperature of the flue gases
$\Delta T_{1,2}$	temperature difference between the 1st and the 2nd planes
T_{ABZ}	mean of the network temperature in the 1st measuring plane converted to the plane at the end of the afterburning zone (2 s residence time)
ΔT	mean temperature difference between the end of the afterburning zone and the measured operational values
t_{rt}	residence time of the flue gases above the minimum temperature

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Grid measuring points:

Measuring plane 1

	Axis 1	Axis 2	Axis 3	
	A 1	B 1	C 1	
	A 2	B 2	C 2	
	A 3	B 3	C 3	
feeding	interpolated	interpolated	interpolated	12,50 m
	D 3	E 3	F 3	
	D 2	E 2	F 2	
	D 1	E 1	F 1	
		4,74 m		

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Measuring plane 2

	Axis 1	Axis 2	Axis 3	
	G 1	H 1	J 1	
	G 2	H 2	J 2	
	G 3	H 3	J 3	
feeding	interpolated	interpolated	interpolated	12,50 m
	K 3	L 3	M 3	
	K 2	L 2	M 2	
	K 1	L 1	M 1	
		4,74 m		

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4 Method of measurement

4.1 Components to be measured

After burning zone:
- Temperature on two planes
- Oxygen content on two planes

Calculated values:
- Residence time of the flue gases in the after burning zone
- Volume flow of the flue gas in the after burning zone

4.2 Evaluation of the exhaust gas conditions

4.2.1 Temperature

Measuring method	thermoelectric
Guideline	VDI/VDE 3511 part 5
Probe	suction pyrometer with a triple ceramic shield, water-cooled
Suction	compressed air ejector
Speed of suction	ca. 80 m/s
Manufacturer	TÜV SÜD Industrie Service GmbH
Sensor	NiCr-Ni-Thermocouples
Type	K, class A (calibration by manufactory)
Manufacturer	Bauer GmbH

4.2.2 Oxygen content

Measuring method	electrochemical analysis of gas
Measuring instrument	O_2-measuring equipment type KE-25F-3
Manufacturer	TÜV SÜD Industrie Service GmbH / FIGARO

4.2.3 Registration of the measuring values for the minimum conditions

Measuring instrument	data acquisition and control system
Manufacturer	E. Kirsten
Type	Trendows XP

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4.3 Description of the comparative measuring procedure

Sampling system	
Probe	steel suction pyrometer
Filter	Quartz wool filter and scrubber (washing bottle)
Sampling line	
Before sampling preparation	length 5 - 24 m, material: PVC
After sampling preparation	length 1 m, material: PVC
Sampling preparation	
Cooler	Type CGEK 4
Manufacturer	Hartmann & Braun, Frankfurt
Temperature	4 °C
Instrument characteristic	
Zero gas	cleaned nitrogen
Test gas	ambient air
Response time	< 60 seconds
Registration of measured values	continuous with electronic data recorder saving of data acquisition and control system
Manufacturer	E. Kirsten
Type	Trendows XP
Calculation	program for calculation "Excel"

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5 Incinerator operation data during the measurement

The entire plant operation conditions are detected during measurements by reading the pointed results in the control room. The operator of the plant makes the data available.

5.1 Production facilities

The measurements were carried out in following state of operating:

- 60 % MCR condition
- 100 % MCR condition

5.2 Waste-gas purification facilities

The waste gas purification facilities haven't an influence of the measuring results in the after burning chamber.

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6 Summary of results and discussion

6.1 Evaluation of the operating conditions during the measurements

The comments on any deviation from the operations as well as any consequences are given with the results.

Introduction

This part describes the procedure for demonstrate that the combustion chamber minimum gas residence time (after the last injection of combustion air) and temperature in the combustion chamber are satisfied.

The residence time calculation protocol is based on the sector guidance note IPPC S5.01 combined with the requirements from the requirements stated in German Federal Ministry of the Environment, Nature Conservation and Nuclear Safety Research Report 360 16 004 UBA-FB 001090.

To demonstrate compliance, the temperature and oxygen concentration are measured at the bottom and the top of the first pass vertical radiant heating section. Simultaneously, flue gas flow, temperature and oxygen concentration measurements are carried out in the stack. The flow as measured in the stack is corrected to the temperature, oxygen concentration and density conditions pertaining to the first pass vertical radiant heating section and show the flow through the boiler for the residence time determination.

Test Protocol

The furnace temperature is measured at 2 cross section positions using suction pyrometers. The cross section is near as possible to the ABZ start and ABZ end.

The mean temperature is calculated from the temperature readings at the 2 cross-sectional areas. These are used to determine the temperature gradient.

The mean of the temperatures at the beginning of the after burning zone (T_{BABZ}) and the minimum temperature (850°C) is used as the boiler temperature (T_{ABZ}) to establish the boiler volume air flow.

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6.2 Measuring Time

60 % MCR	***28th February 2019***	
Grid measurement 1	10:30 till 11:06	
Grid measurement 2	11:06 till 11:42	
One hour measurement	11:45 till 12:45	measuring point A1
Grid measurement 3	12:53 till 13:29	
Grid measurement 4	13:29 till 14:05	
One hour measurement	14:08 till 15:08	measuring point A1
Grid measurement 5	15:16 till 15:52	
Grid measurement 6	15:52 till 16:28	

100 % MCR	***1st March 2019***	
Grid measurement 1	9:00 till 9:36	
Grid measurement 2	9:36 till 10:12	
One hour measurement	10:15 till 11:15	measuring point C1
Grid measurement 3	11:21 till 11:57	
Grid measurement 4	11:57 till 12:33	
Grid measurement 5	12:33 till 13:09	
Grid measurement 6	13:09 till 13:45	
One hour measurement	13:48 till 14:48	measuring point C1

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7 Checking of the Burning Conditions

7.1 60 % MCR

Grid measurement	No.:	1	2	3	4	5	6	Average
Date of measurement		28.02.2019	28.02.2019	28.02.2019	28.02.2019	28.02.2019	28.02.2019	
Beginning of measurement		10:30	11:06	12:53	13:29	15:16	15:52	
End of measurement		11:06	11:42	13:29	14:05	15:52	16:28	
Measuring plane 2	°C	925	927	931	931	935	945	932
Measuring plane 1	°C	798	801	808	809	807	818	807
Temperature operating plane [average]	°C	715	712	717	717	715	727	717
Temperature operating plane [HBK11CT001XQ01]	°C	709	706	710	711	710	720	711
Temperature operating plane [HBK11CT002XQ01]	°C	718	716	721	721	719	731	721
Temperature operating plane [HBK11CT003XQ01]	°C	717	714	720	720	718	731	720
T ABZ (single measurement)	°C	955	957	960	958	965	973	961
delta T ABZ-T_{OP}	°C	240	245	243	241	250	246	244
delta T=T1-T_{OP}	°C	83	89	91	91	92	91	90
Oxygen content plane 2	Vol.%	3,3	3,3	3,1	3,3	3,1	2,8	3,1
Oxygen content plane 1	Vol.%	3,4	3,3	3,2	3,4	3,2	2,9	3,2
Oxygen content [HNA01CQ901XJ61]	Vol.% (wet)	5,0	5,0	4,9	5,0	4,9	4,6	4,9
Volume flow stack [HNA03CF001XJ62]	Nm^3/h (wet)	132163	132688	132555	132907	135730	134085	133355
Oxygen content stack [HNA03CQ040XQ01]	Vol.% (dry)	6,4	6,3	6,2	6,3	6,5	6,0	6,3
Temperature stack [HNA03CT001XQ01]	°C	109	109	109	109	109	109	109
Pressure stack [HNA03CP001XQ01]	hPa	1008	1008	1008	1009	1008	1009	1008
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,3	16,5	16,5	16,4	17,0	16,8	16,6
Volume flow stack [calculated]	Nm^3/h (dry, 0 Vol.% O2)	76925	77435	77839	77783	77961	79860	77967
Recirculation gas flow [HNF10CF001XJ61]	Nm^3/h (wet)	14999	14998	15006	14998	14982	15023	15001
Recirculation gas flow normalized	Nm^3/h (dry, 0 Vol.% O2)	8730	8753	8812	8778	8605	8948	8771
Volume flow in boiler	Nm^3/h (dry, 0 Vol.% O2)	85655	86187	86651	86581	86566	88808	86738
Volume flow in boiler	m^3/h (Operating state)	555717	557019	554697	561020	556399	563290	558023
Volume flow in boiler	m^3/s (Operating state)	154	155	154	156	155	156	155
Velocity in boiler	m/s (Operating state)	2,6	2,6	2,6	2,6	2,6	2,6	2,6
Oxygen content ABZ	Vol.% (dry)	3,4	3,3	3,1	3,4	3,1	2,8	3,2
Moisture ABZ [HNA01CQ007XQ02]	Vol.%	17,2	17,1	17,1	17,1	17,1	17,1	17,1
Air pressure	hPa	1013	1013	1013	1013	1013	1013	1013
Pressure in boiler [average HBK01CP001-4XQ01]	hPa	-2,0	-2,0	-2,0	-2,0	-2,0	-2,0	-2,0
Temperature BABZ	°C	1064	1065	1064	1064	1074	1082	1069
TABZ mean	°C	957	957	957	957	962	966	959
Steam flow [LBA10CF901XJ61]	t/h	92,4	93,1	93,7	92,7	92,8	96,5	93,5
Primary air flow [HLA10CF001XJ61]	Nm^3/h (wet)	38258	38656	37934	38126	39155	37581	38285
Primary air temperature [average HLA08-9CT001XQ01]	°C	172	172	171	172	172	171	172
Secondary air flow [HLA50CF001XJ61]	Nm^3/h (wet)	23604	23708	23736	23665	23737	24136	23764
Secondary air temperature [HLA62CT001XQ01]	°C	172,8	173	172	173	171	173	173
Recirculation air flow [HNF10CF001XJ61]	Nm^3/h (wet)	14999	14998	15006	14999	14998	15006	15001
Recirculation air temperature [HNF11CT001XQ01]	°C	129	129	128	129	128	128	129
Retention time total	**Sec**	**3,93**	**3,97**	**4,09**	**4,06**	**4,10**	**4,25**	**4,07**
T 1	°C	798	801	808	809	807	818	807
delta H T	m	-2,49	-2,36	-2,10	-2,07	-2,04	-1,52	-2,10
delta H ABZ	m	-7,53	-7,52	-7,54	-7,48	-7,52	-7,46	-7,51
delta T 1,2	°C	127	126	123	122	128	126	125
delta T 1,2 / delta H 1,2	°C/m	20,85	20,70	20,15	20,02	20,97	20,69	20,56

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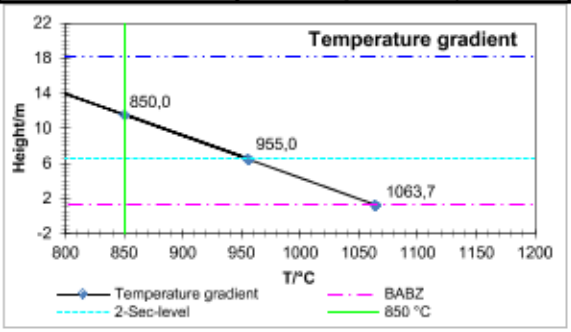
Series of measurements 1, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **10:30** **End** **11:06**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	706	751	732
	O2	Vol.%	3,7	3,4	3,9
2	Temp.	°C	767	785	757
	O2	Vol.%	3,5	3,3	3,6
3	Temp.	°C	785	794	755
	O2	Vol.%	4,1	3,4	4,0
4	Temp.	°C	816	840	808
	O2	Vol.%	3,8	3,1	3,4
5	Temp.	°C	848	887	861
	O2	Vol.%	3,5	2,7	2,7
6	Temp.	°C	832	857	831
	O2	Vol.%	3,1	3,1	3,0
7	Temp.	°C	755	792	799
	O2	Vol.%	3,4	3,5	3,4
Components			**mean**	**min**	**max**
Temperature			798	706	887
Oxygen Content			3,4	2,7	4,1

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	809	836	883
	O2	Vol.%	3,6	3,9	2,5
2	Temp.	°C	941	919	912
	O2	Vol.%	3,7	3,4	2,4
3	Temp.	°C	946	932	905
	O2	Vol.%	4,4	4,1	2,9
4	Temp.	°C	944	947	935
	O2	Vol.%	4,4	3,7	2,7
5	Temp.	°C	942	962	965
	O2	Vol.%	4,3	3,4	2,4
6	Temp.	°C	954	966	941
	O2	Vol.%	3,6	2,7	2,0
7	Temp.	°C	931	945	914
	O2	Vol.%	3,4	3,3	2,5
Components			**mean**	**min**	**max**
Temperature			925	809	966
Oxygen Content			3,3	2,0	4,4



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	92,4
Primary air flow [HLA10CF001XJ61]	m³/h	38258
Secondary air flow [HLA50CF001XJ61]	m³/h	23604

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	715
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,0

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	132163
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,4
Temperature stack [HNA03CT001XQ01]	°C	109,2
Pressure stack [HNA03CP001XQ01]	hPa	1008,0
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,3

Temperature gradient		
Mean value of temperature MP 1	°C	798
Mean value of temperature MP 2	°C	925
delta T1,2=T2-T1	°C	127
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	20,9

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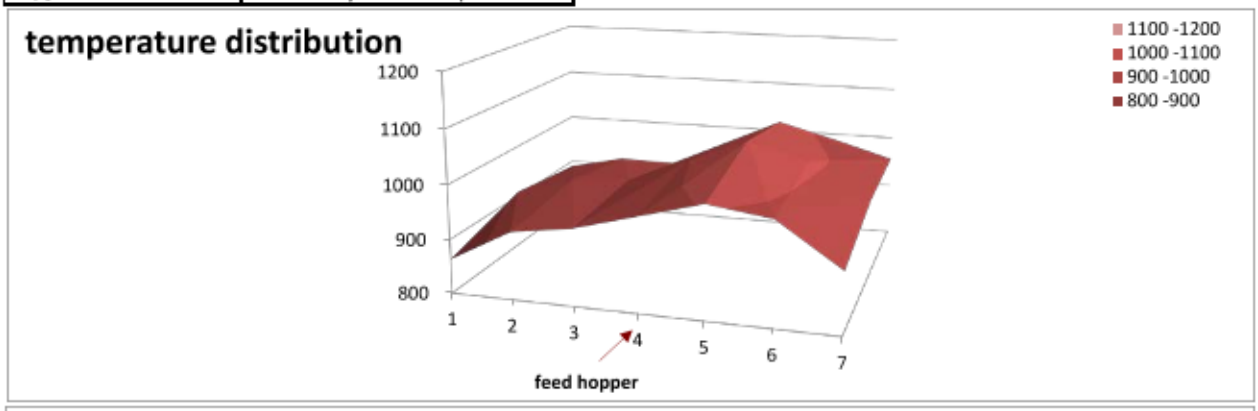
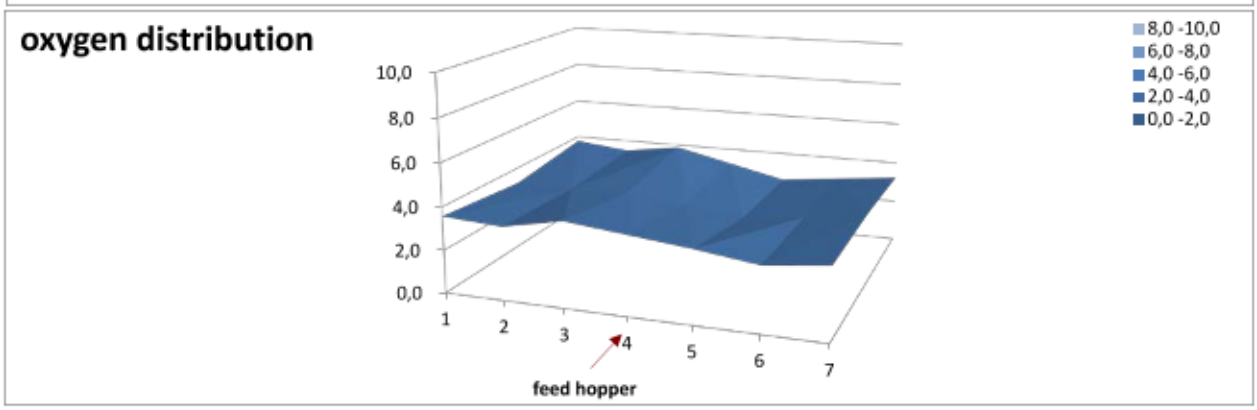
Series of measurements 1, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **10:30** **End** **11:06**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	863	908	889
	O2	Vol.%	3,6	3,2	3,8
2	Temp.	°C	924	942	914
	O2	Vol.%	3,4	3,2	3,5
3	Temp.	°C	942	951	912
	O2	Vol.%	3,9	3,3	3,9
4	Temp.	°C	973	997	965
	O2	Vol.%	3,7	3,0	3,2
5	Temp.	°C	1005	1044	1018
	O2	Vol.%	3,4	2,6	2,6
6	Temp.	°C	989	1014	988
	O2	Vol.%	3,0	2,9	2,9
7	Temp.	°C	912	949	956
	O2	Vol.%	3,3	3,4	3,2
Components			**mean**	**min**	**max**
Temperature			955	863	1044
Oxygen Content			3,3	2,6	3,9

Retention time		
Volume flow in boiler	m^3/h	85655
Oxygen content boiler	Vol.%	3,4
Moisture boiler	Vol.%	17,2
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	957
Volume flow boiler [operating state]	m^3/s	555717
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,53
Plane of retention time 2 sec	m	6,47
Retention time	**Sec**	**3,93**





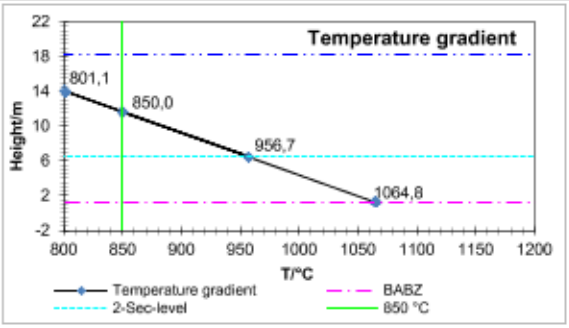
Industrie Service

Series of measurements 2, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **11:06** **End** **11:42**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	724	755	733
	O2	Vol.%	3,8	3,3	4,0
2	Temp.	°C	773	781	754
	O2	Vol.%	3,8	3,2	3,8
3	Temp.	°C	790	795	756
	O2	Vol.%	3,9	3,3	3,9
4	Temp.	°C	823	844	811
	O2	Vol.%	3,4	2,9	3,2
5	Temp.	°C	856	893	866
	O2	Vol.%	2,9	2,5	2,5
6	Temp.	°C	827	858	839
	O2	Vol.%	3,1	3,0	3,1
7	Temp.	°C	754	796	798
	O2	Vol.%	3,3	3,4	3,4
Components			**mean**	**min**	**max**
Temperature			801	724	893
Oxygen Content			3,3	2,5	4,0

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	831	845	887
	O2	Vol.%	3,6	3,9	2,3
2	Temp.	°C	938	923	905
	O2	Vol.%	3,8	3,8	2,5
3	Temp.	°C	951	934	906
	O2	Vol.%	4,3	4,0	2,9
4	Temp.	°C	950	951	937
	O2	Vol.%	4,2	3,7	2,5
5	Temp.	°C	948	969	968
	O2	Vol.%	4,1	3,3	2,1
6	Temp.	°C	955	960	943
	O2	Vol.%	3,4	2,7	2,2
7	Temp.	°C	931	929	915
	O2	Vol.%	3,5	3,5	2,7
Components			**mean**	**min**	**max**
Temperature			927	831	969
Oxygen Content			3,3	2,1	4,3



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	93,1
Primary air flow [HLA10CF001XJ61]	m³/h	38656
Secondary air flow [HLA50CF001XJ61]	m³/h	23708

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	712
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,0

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	132688
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,3
Temperature stack [HNA03CT001XQ01]	°C	109,3
Pressure stack [HNA03CP001XQ01]	hPa	1008,4
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,5

Temperature gradient		
Mean value of temperature MP 1	°C	801
Mean value of temperature MP 2	°C	927
delta T1,2=T2-T1	°C	126
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	20,7

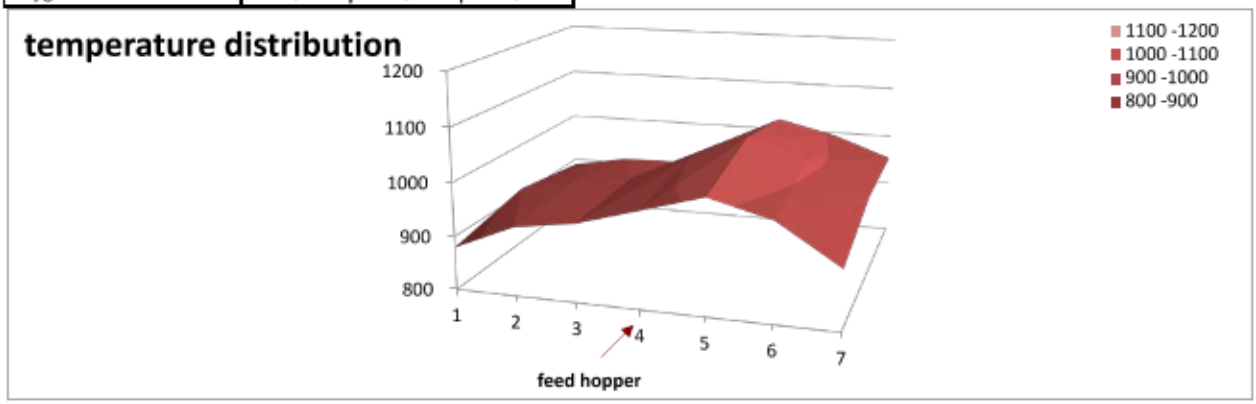
Industrie Service

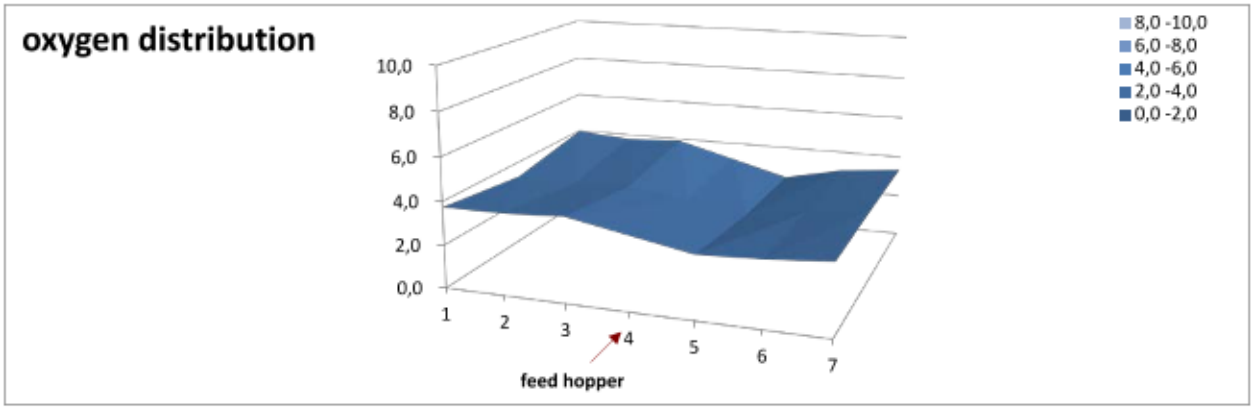
Series of measurements 2, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **11:06** **End** **11:42**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	880	910	888
	O2	Vol.%	3,7	3,3	4,0
2	Temp.	°C	928	937	909
	O2	Vol.%	3,8	3,2	3,8
3	Temp.	°C	945	950	912
	O2	Vol.%	3,9	3,3	3,9
4	Temp.	°C	979	999	967
	O2	Vol.%	3,4	2,9	3,2
5	Temp.	°C	1012	1048	1022
	O2	Vol.%	2,9	2,5	2,4
6	Temp.	°C	982	1013	995
	O2	Vol.%	3,0	2,9	3,0
7	Temp.	°C	910	951	954
	O2	Vol.%	3,3	3,3	3,3
Components			**mean**	**min**	**max**
Temperature			957	880	1048
Oxygen Content			3,3	2,4	4,0

Retention time		
Volume flow in boiler	m^3/h	86187
Oxygen content boiler	Vol.%	3,3
Moisture boiler	Vol.%	17,1
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	957
Volume flow boiler [operating state]	m^3/s	557019
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,52
Plane of retention time 2 sec	m	6,48
Retention time	**Sec**	**3,97**



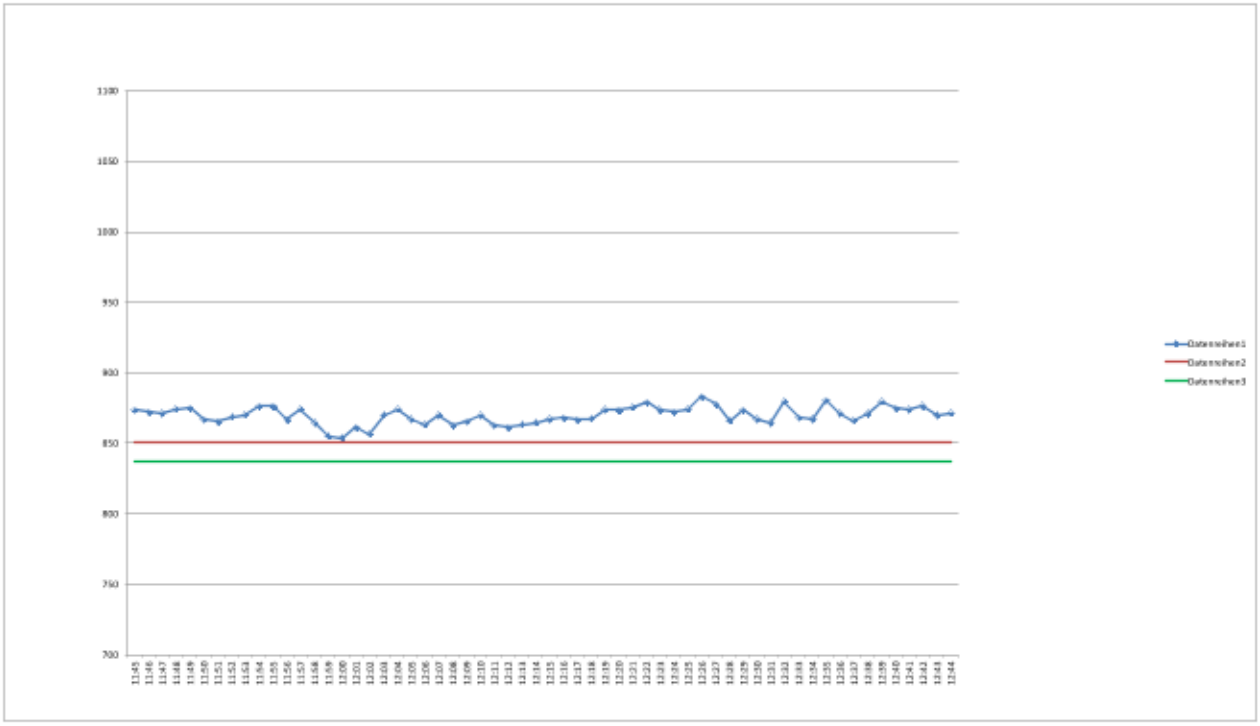


Industrie Service

60 % MCR, measurement 2, measuring point A1:
Confirmation that 95 % of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

date	time	temperature 2 Sec °C	temperature °C	volume flow Nm³/h (wet)	moisture ABZ Vol.%	oxygen containt Vol.% (dry)	recirculation flow Nm³/h (wet)	volume flow cor. Nm³/h (dry)	oxygen stack Vol.% (dry)	moisture stack Vol.%	volume flow cor. m³/s	delta H m	delta H max	temp gradient °C/m
28.02.2019	11:45	873	718	132219	17,1	3,4	15013	85925	6,3	16,6	155,0	-7,5	-7,5	20,7
	11:46	872	722	133841	17,1	3,8	15024	88090	6,1	16,9	162,2	-7,3	-7,3	20,7
	11:47	871	723	135694	17,1	3,8	15031	90079	5,8	17,2	166,1	-7,1	-7,1	20,7
	11:48	874	721	130933	17,1	3,5	15028	86543	6,0	17,1	157,5	-7,4	-7,4	20,7
	11:49	875	719	131137	17,1	3,3	15019	86698	6,1	16,9	154,8	-7,5	-7,5	20,7
	11:50	887	716	131262	17,1	4,0	15006	86268	6,1	16,8	161,1	-7,3	-7,3	20,7
	11:51	885	714	132133	17,1	3,8	15014	86791	6,2	16,5	160,2	-7,3	-7,3	20,7
	11:52	869	714	132246	17,1	3,2	14962	86841	6,2	16,5	155,1	-7,5	-7,5	20,7
	11:53	870	719	135887	17,1	3,4	14961	89240	6,1	16,7	160,6	-7,3	-7,3	20,7
	11:54	876	718	133192	17,1	2,8	15014	86917	6,2	16,7	151,5	-7,6	-7,6	20,7
	11:55	876	717	130699	17,1	3,0	14997	85356	6,3	16,7	150,4	-7,7	-7,7	20,7
	11:56	887	717	134337	17,1	3,8	14996	88306	6,0	16,9	162,8	-7,2	-7,2	20,7
	11:57	874	720	130495	17,1	3,5	15017	86297	6,0	16,9	156,3	-7,5	-7,5	20,7
	11:58	864	715	131906	17,1	4,0	15030	87809	5,9	17,0	163,6	-7,2	-7,2	20,7
	11:59	855	707	131532	17,1	4,2	15053	87736	5,9	17,0	165,4	-7,2	-7,2	20,7
	12:00	854	704	132826	17,1	3,9	15030	87694	6,2	16,6	162,1	-7,3	-7,3	20,7
	12:01	861	705	131354	17,1	3,3	14995	85704	6,3	16,3	154,2	-7,5	-7,5	20,7
	12:02	857	704	132883	17,1	3,7	14941	86177	6,4	16,2	158,1	-7,4	-7,4	20,7
	12:03	870	710	132779	17,1	2,8	14965	85010	6,6	16,1	148,2	-7,7	-7,7	20,7
	12:04	874	715	135362	17,1	2,5	14952	86947	6,5	16,3	149,5	-7,7	-7,7	20,7
	12:05	867	714	132041	17,1	3,7	14989	86348	6,2	16,6	158,1	-7,4	-7,4	20,7
	12:06	863	713	132847	17,1	4,0	15036	87419	6,1	16,8	163,1	-7,2	-7,2	20,7
	12:07	870	716	131364	17,1	3,3	15074	87432	5,9	17,0	157,0	-7,4	-7,4	20,7
	12:08	863	713	131024	17,1	3,8	15036	88317	5,7	17,2	162,7	-7,2	-7,2	20,7
	12:09	865	713	132449	17,1	3,4	14979	87965	5,9	17,1	159,0	-7,4	-7,4	20,7
	12:10	870	715	131316	17,1	3,4	14999	86277	6,1	16,7	156,1	-7,5	-7,5	20,7
	12:11	863	710	132976	17,1	3,5	15015	87642	6,1	16,6	159,2	-7,4	-7,4	20,7
	12:12	861	707	132489	17,1	3,3	14973	87404	6,1	16,6	156,8	-7,4	-7,4	20,7
	12:13	863	707	128657	17,1	3,4	14976	85496	6,0	16,7	154,7	-7,5	-7,5	20,7
	12:14	865	711	129637	17,1	3,5	14982	86570	5,9	16,8	156,8	-7,4	-7,4	20,7
	12:15	867	715	133041	17,1	3,4	15031	88350	5,9	16,8	159,3	-7,4	-7,4	20,7
	12:16	868	714	131440	17,1	3,3	15034	87260	6,0	16,6	156,2	-7,5	-7,5	20,7
	12:17	866	717	136661	17,1	3,2	14990	91762	5,7	16,9	163,4	-7,2	-7,2	20,7
	12:18	868	719	135820	17,1	3,2	14992	91068	5,5	17,1	164,3	-7,2	-7,2	20,7
	12:19	874	718	128411	17,1	3,3	15012	86388	5,8	16,9	156,1	-7,5	-7,5	20,7
	12:20	873	720	132072	17,1	3,2	14980	88259	5,8	16,8	157,5	-7,4	-7,4	20,7
	12:21	875	724	135207	17,1	3,2	14986	90165	5,9	16,7	160,5	-7,3	-7,3	20,7
	12:22	879	724	132024	17,1	3,2	14958	87504	6,0	16,5	156,3	-7,5	-7,5	20,7
	12:23	874	720	131272	17,1	3,4	14984	87067	6,0	16,6	156,9	-7,4	-7,4	20,7
	12:24	872	718	131229	17,1	3,5	15002	86900	6,0	16,7	157,5	-7,4	-7,4	20,7
	12:25	874	724	133320	17,1	3,8	15040	88165	6,0	16,8	162,7	-7,2	-7,2	20,7
	12:26	883	728	131452	17,1	3,2	15045	87499	6,0	16,5	156,0	-7,5	-7,5	20,7
	12:27	878	729	133431	17,1	4,0	14991	88294	6,1	16,3	165,0	-7,2	-7,2	20,7
	12:28	866	717	130883	17,1	4,3	14999	86279	6,2	16,2	164,5	-7,2	-7,2	20,7
	12:29	873	721	132955	17,1	3,6	15041	87486	6,2	16,2	159,3	-7,4	-7,4	20,7
	12:30	867	717	130856	17,1	4,0	15015	86566	6,1	16,3	162,2	-7,3	-7,3	20,7
	12:31	884	712	129878	17,1	3,9	15008	85418	6,2	16,2	158,8	-7,4	-7,4	20,7
	12:32	880	722	130530	17,1	3,4	14955	84424	6,5	15,9	152,4	-7,6	-7,6	20,7
	12:33	868	716	129918	17,1	4,3	14979	84333	6,4	16,0	160,0	-7,3	-7,3	20,7
	12:34	867	712	128713	17,1	3,8	14997	84072	6,4	16,1	155,5	-7,5	-7,5	20,7
	12:35	880	725	130400	17,1	3,6	14987	84970	6,4	16,1	155,1	-7,5	-7,5	20,7
	12:36	871	719	130685	17,1	4,0	14967	85545	6,3	16,2	160,3	-7,3	-7,3	20,7
	12:37	868	716	131285	17,1	4,3	15004	85471	6,4	16,2	162,4	-7,3	-7,3	20,7
	12:38	871	721	131433	17,1	4,3	14995	84972	6,5	15,9	162,1	-7,3	-7,3	20,7
	12:39	880	725	128970	17,1	3,9	14982	84513	6,3	16,0	156,7	-7,4	-7,4	20,7
	12:40	875	722	131475	17,1	3,8	14984	85822	6,4	15,9	158,9	-7,4	-7,4	20,7
	12:41	874	720	132299	17,1	3,8	14970	85225	6,6	15,7	157,2	-7,4	-7,4	20,7
	12:42	877	722	132011	17,1	3,7	15004	84873	6,6	15,8	156,8	-7,5	-7,5	20,7
	12:43	870	717	133578	17,1	3,8	15044	86343	6,5	15,9	159,4	-7,4	-7,4	20,7
	12:44	871	718	133289	17,1	3,8	14971	86526	6,3	16,1	158,3	-7,4	-7,4	20,7

Industrie Service



Evaluation according IPPC S5.01, measurement 1, 60 % MCR

- Measure worst case gas residence time using a time of flight method.
  (here used the plug flow method)

  residence time more than 2 seconds: yes

- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

  95% of the one-minute mean temperatures above 850 °C: yes

- above 850 °C for at least 2 seconds (IED Article 50(2)):

  above 850 °C for at least 2 seconds: yes

- IED does not specify oxygen concentrations for the combustion gases. It should however be noted that BAT requires sufficiently oxidising conditions at the final combustion stage to provide for good combustion, and the operator will be required to demonstrate this in his application. In many situations, the BAT oxygen concentration is likely to be about 6%.

  sufficiently oxidising conditions: yes

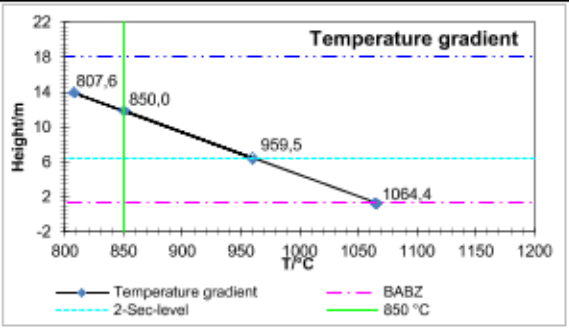
Industrie Service

Series of measurements 3, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **12:53** **End** **13:29**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	719	752	729
	O2	Vol.%	3,8	3,5	4,1
2	Temp.	°C	786	774	744
	O2	Vol.%	3,7	3,4	4,0
3	Temp.	°C	825	816	763
	O2	Vol.%	2,9	2,3	3,1
4	Temp.	°C	846	861	821
	O2	Vol.%	2,8	2,0	3,1
5	Temp.	°C	866	906	879
	O2	Vol.%	2,6	1,8	3,1
6	Temp.	°C	826	856	842
	O2	Vol.%	3,1	3,1	3,2
7	Temp.	°C	750	797	799
	O2	Vol.%	3,6	3,7	3,8
Components			**mean**	**min**	**max**
Temperature			808	719	906
Oxygen Content			3,2	1,8	4,1

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	818	838	878
	O2	Vol.%	3,9	4,1	2,8
2	Temp.	°C	924	906	885
	O2	Vol.%	4,1	3,5	3,0
3	Temp.	°C	966	938	902
	O2	Vol.%	3,3	3,0	2,0
4	Temp.	°C	973	963	943
	O2	Vol.%	3,3	3,3	1,5
5	Temp.	°C	980	989	985
	O2	Vol.%	3,4	3,6	1,1
6	Temp.	°C	961	958	947
	O2	Vol.%	3,4	3,7	1,8
7	Temp.	°C	934	931	922
	O2	Vol.%	3,7	4,3	2,1
Components			**mean**	**min**	**max**
Temperature			931	818	989
Oxygen Content			3,1	1,1	4,3



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	93,7
Primary air flow [HLA10CF001XJ61]	m³/h	37934,3
Secondary air flow [HLA50CF001XJ61]	m³/h	23736,1

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	717
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,9

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	132555
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,2
Temperature stack [HNA03CT001XQ01]	°C	109,1
Pressure stack [HNA03CP001XQ01]	hPa	1008
Volume flow stack [calculated]	Vol.%	16,5

Temperature gradient		
Mean value of temperature MP 1	°C	808
Mean value of temperature MP 2	°C	931
delta T1,2=T2-T1	°C	123
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	20,2

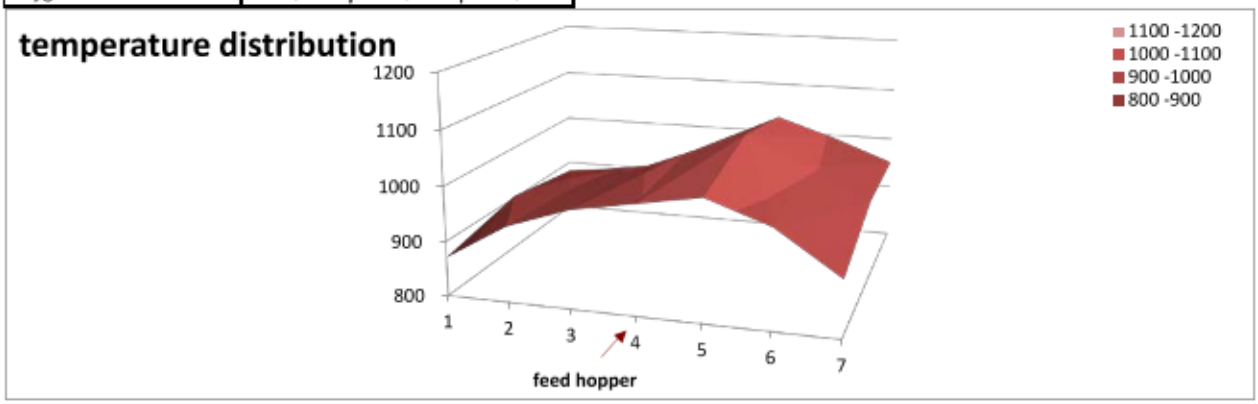
Industrie Service

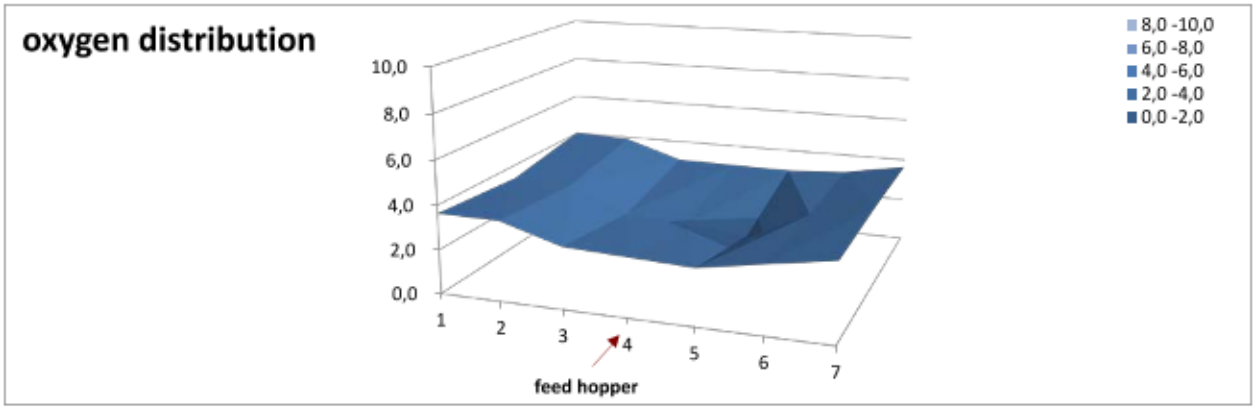
Series of measurements 3, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **12:53** **End** **13:29**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	871	904	881
	O2	Vol.%	3,6	3,4	4,0
2	Temp.	°C	938	926	896
	O2	Vol.%	3,6	3,3	3,9
3	Temp.	°C	977	968	915
	O2	Vol.%	2,8	2,2	3,0
4	Temp.	°C	998	1013	973
	O2	Vol.%	2,7	1,9	3,0
5	Temp.	°C	1018	1058	1031
	O2	Vol.%	2,5	1,7	3,0
6	Temp.	°C	978	1008	994
	O2	Vol.%	3,0	3,0	3,1
7	Temp.	°C	902	949	951
	O2	Vol.%	3,5	3,6	3,6
Components			**mean**	**min**	**max**
Temperature			960	871	1058
Oxygen Content			3,1	1,7	4,0

Retention time		
Volume flow in boiler	m^3/h	86651
Oxygen content boiler	Vol.%	3,1
Moisture boiler	Vol.%	17,1
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	957
Volume flow boiler [operating state]	m^3/s	554697
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,54
Plane of retention time 2 sec	m	6,46
Retention time	**Sec**	**4,09**





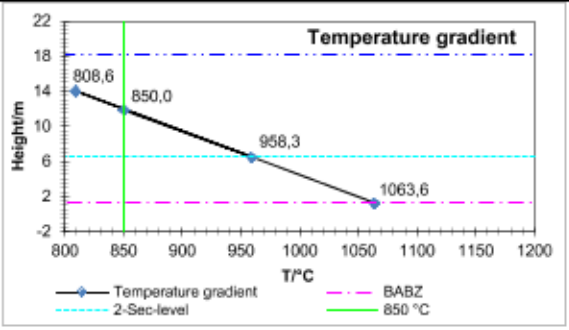
Industrie Service

Series of measurements 4, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **13:29** **End** **14:05**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	727	757	734
	O2	Vol.%	3,6	3,3	4,0
2	Temp.	°C	792	783	754
	O2	Vol.%	3,9	3,5	4,1
3	Temp.	°C	824	816	770
	O2	Vol.%	3,6	3,1	3,8
4	Temp.	°C	851	857	820
	O2	Vol.%	3,5	2,8	3,3
5	Temp.	°C	878	898	871
	O2	Vol.%	3,4	2,6	2,8
6	Temp.	°C	821	850	833
	O2	Vol.%	4,0	3,4	3,2
7	Temp.	°C	751	793	801
	O2	Vol.%	3,8	3,4	3,2
Components			**mean**	**min**	**max**
Temperature			809	727	898
Oxygen Content			3,4	2,6	4,1

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	839	851	879
	O2	Vol.%	3,6	4,1	2,5
2	Temp.	°C	939	925	897
	O2	Vol.%	3,8	3,7	2,7
3	Temp.	°C	957	935	902
	O2	Vol.%	4,1	3,9	2,9
4	Temp.	°C	959	956	941
	O2	Vol.%	4,2	3,9	2,2
5	Temp.	°C	962	977	980
	O2	Vol.%	4,2	4,0	1,6
6	Temp.	°C	958	956	941
	O2	Vol.%	3,5	3,5	2,0
7	Temp.	°C	930	938	923
	O2	Vol.%	3,2	3,6	1,9
Components			**mean**	**min**	**max**
Temperature			931	839	980
Oxygen Content			3,3	1,6	4,2



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	92,7
Primary air flow [HLA10CF001XJ61]	m³/h	38126
Secondary air flow [HLA50CF001XJ61]	m³/h	23665

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	717
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,0

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	132907
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,3
Temperature stack [HNA03CT001XQ01]	°C	109,2
Pressure stack [HNA03CP001XQ01]	hPa	1008,8
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,4

Temperature gradient		
Mean value of temperature MP 1	°C	809
Mean value of temperature MP 2	°C	931
delta T1,2=T2-T1	°C	122
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	20,0

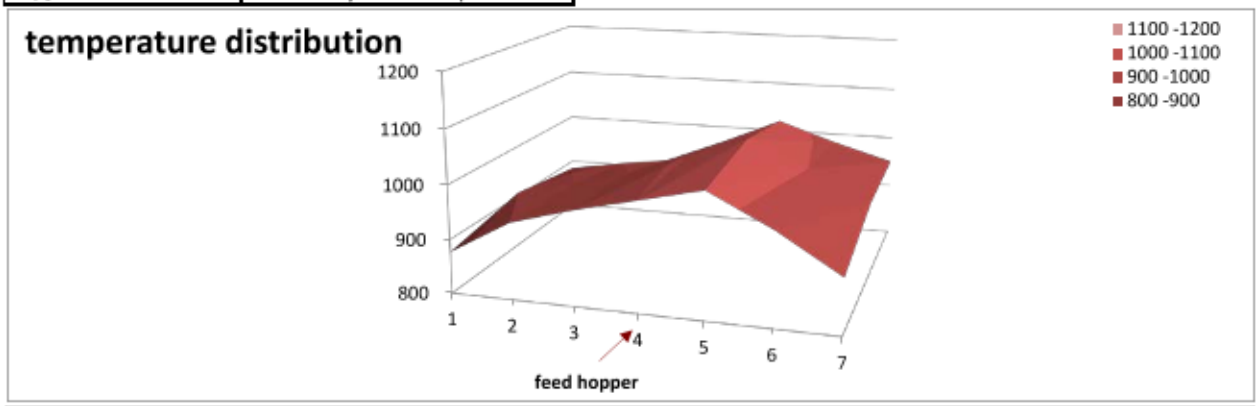
Industrie Service

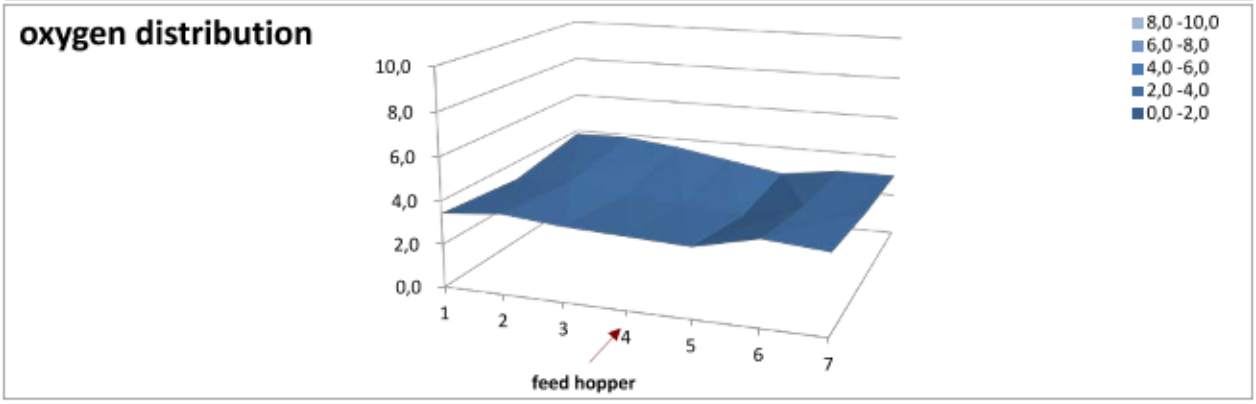
Series of measurements 4, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **13:29** **End** **14:05**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	877	907	884
	O2	Vol.%	3,4	3,1	3,8
2	Temp.	°C	941	932	903
	O2	Vol.%	3,7	3,3	3,9
3	Temp.	°C	974	965	920
	O2	Vol.%	3,4	2,9	3,6
4	Temp.	°C	1001	1006	970
	O2	Vol.%	3,3	2,6	3,1
5	Temp.	°C	1028	1047	1020
	O2	Vol.%	3,2	2,4	2,6
6	Temp.	°C	971	1000	983
	O2	Vol.%	3,8	3,2	3,0
7	Temp.	°C	901	943	950
	O2	Vol.%	3,6	3,2	3,0
Components			**mean**	**min**	**max**
Temperature			958	877	1047
Oxygen Content			3,2	2,4	3,9

Retention time		
Volume flow in boiler	m^3/h	86561
Oxygen content boiler	Vol.%	3,4
Moisture boiler	Vol.%	17,1
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	957
Volume flow boiler [operating state]	m^3/s	561020
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,48
Plane of retention time 2 sec	m	6,52
Retention time	**Sec**	**4,06**



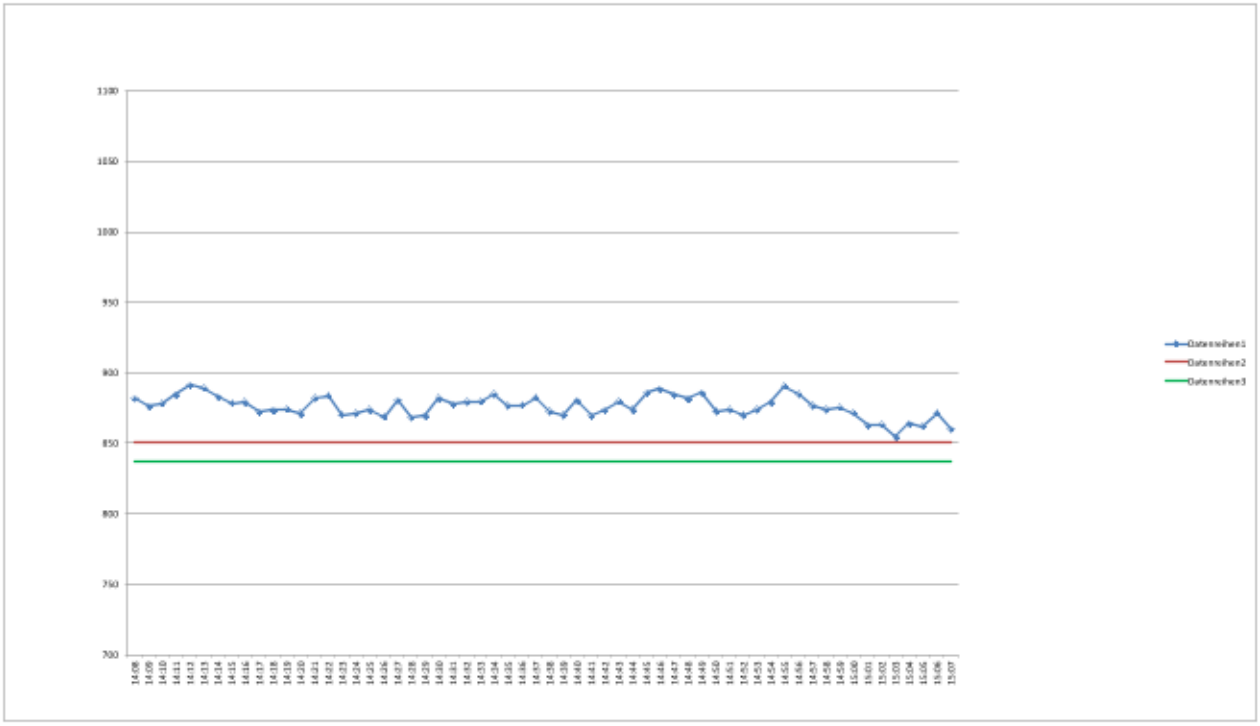


Industrie Service

60 % MCR, measurement 4, measuring point A1:
Confirmation that 95 % of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

date	time	temperature 2 Sec °C	temperature °C	volume flow Nm³/h (wet)	moisture ABZ Vol.%	oxygen containt Vol.% (dry)	recirculation flow Nm³/h (wet)	volume flow cor. Nm³/h (dry)	oxygen stack Vol.% (dry)	moisture stack Vol.%	volume flow cor. m³/s	delta H m	delta H max	temp gradient °C/m
28.02.2019	14:08	881	729	131492	17,0	3,4	14982	84487	6,5	16,4	152,2	-7,6	-7,6	20,0
	14:09	876	727	134137	17,0	3,6	14974	85484	6,6	16,2	156,3	-7,5	-7,5	20,0
	14:10	878	727	135666	17,0	3,2	14977	86440	6,6	16,3	154,4	-7,5	-7,5	20,0
	14:11	884	732	133633	17,0	3,2	15012	85681	6,5	16,4	152,5	-7,6	-7,6	20,0
	14:12	891	738	131408	17,0	3,0	15020	85611	6,3	16,6	150,7	-7,7	-7,7	20,0
	14:13	889	739	136849	17,0	2,8	15011	89004	6,2	16,8	155,5	-7,5	-7,5	20,0
	14:14	883	738	133692	17,0	3,8	14983	87585	6,1	16,7	152,1	-7,3	-7,3	20,0
	14:15	878	731	131697	17,1	3,6	15011	87174	6,0	16,9	150,1	-7,4	-7,4	20,0
	14:16	879	732	132893	17,1	3,4	15049	88253	5,9	17,0	150,7	-7,4	-7,4	20,0
	14:17	872	727	134823	17,0	3,6	15018	89646	5,9	17,1	153,1	-7,2	-7,2	20,0
	14:18	873	727	134741	17,0	3,6	14954	88417	6,1	16,8	151,1	-7,3	-7,3	20,0
	14:19	875	728	133372	17,0	3,8	14987	87138	6,2	16,7	150,4	-7,3	-7,3	20,0
	14:20	871	724	135416	17,0	3,4	14995	88594	6,1	16,8	150,9	-7,3	-7,3	20,0
	14:21	882	733	134699	17,0	3,3	14996	87843	6,2	16,8	157,2	-7,4	-7,4	20,0
	14:22	883	731	132003	17,0	3,1	14967	85706	6,3	16,7	152,1	-7,6	-7,6	20,0
	14:23	870	723	134676	17,0	3,7	14964	88938	6,4	16,6	159,2	-7,4	-7,4	20,0
	14:24	871	725	133385	17,0	4,0	15008	88468	6,3	16,6	161,4	-7,3	-7,3	20,0
	14:25	874	726	134425	17,0	3,4	14998	87783	6,2	16,8	158,5	-7,4	-7,4	20,0
	14:26	869	725	133171	17,0	3,9	15012	88065	6,0	17,1	163,5	-7,2	-7,2	20,0
	14:27	880	730	135168	17,0	2,9	15033	88216	6,2	16,9	154,8	-7,5	-7,5	20,0
	14:28	868	724	141800	17,1	3,4	15002	91196	6,3	16,7	164,7	-7,2	-7,2	20,0
	14:29	869	721	134196	17,0	3,7	14967	86176	6,5	16,5	157,8	-7,4	-7,4	20,0
	14:30	882	730	132011	17,0	3,3	14994	84843	6,5	16,6	152,0	-7,6	-7,6	20,0
	14:31	878	727	133576	17,0	3,1	14992	86930	6,2	16,9	153,8	-7,5	-7,5	20,0
	14:32	879	728	132441	17,0	3,1	15000	86856	6,1	17,1	153,3	-7,6	-7,6	20,0
	14:33	880	729	133860	17,0	3,3	15028	86301	6,4	16,8	154,9	-7,5	-7,5	20,0
	14:34	885	734	133603	17,0	3,1	15066	87050	6,2	16,8	154,4	-7,5	-7,5	20,0
	14:35	876	730	134782	17,0	3,6	15008	88427	6,1	17,1	161,5	-7,3	-7,3	20,0
	14:36	877	729	135048	17,1	3,4	15011	87091	6,1	17,2	157,4	-7,4	-7,4	20,0
	14:37	883	730	132749	17,1	2,9	15025	86420	6,2	17,0	151,1	-7,6	-7,6	20,0
	14:38	873	727	135546	17,1	3,7	15006	88144	6,2	16,8	161,7	-7,3	-7,3	20,0
	14:39	870	724	135358	17,1	3,8	14975	87878	6,2	16,8	162,5	-7,3	-7,3	20,0
	14:40	880	731	132379	17,1	3,5	14981	86064	6,3	16,8	156,1	-7,5	-7,5	20,0
	14:41	889	722	132980	17,1	3,8	14995	86872	6,2	17,0	160,0	-7,3	-7,3	20,0
	14:42	873	723	133608	17,1	3,3	14991	86766	6,3	16,8	155,3	-7,5	-7,5	20,0
	14:43	880	731	135754	17,1	3,4	14989	86894	6,5	16,5	156,3	-7,5	-7,5	20,0
	14:44	874	727	133621	17,1	4,0	14940	85824	6,5	16,4	160,1	-7,3	-7,3	20,0
	14:45	886	735	134365	17,1	3,1	14981	86732	6,4	16,5	154,0	-7,5	-7,5	20,0
	14:46	889	740	136589	17,1	3,2	14998	88373	6,3	16,7	157,7	-7,4	-7,4	20,0
	14:47	884	736	134249	17,1	3,4	14997	86916	6,3	16,8	156,3	-7,5	-7,5	20,0
	14:48	882	730	133718	17,1	3,1	14986	86261	6,4	16,7	153,3	-7,6	-7,6	20,0
	14:49	886	733	133545	17,1	2,8	14994	86956	6,2	16,8	151,4	-7,6	-7,6	20,0
	14:50	873	727	134893	17,1	3,6	15017	88775	6,0	17,1	162,3	-7,3	-7,3	20,0
	14:51	874	728	133618	17,1	3,7	15028	88040	6,0	17,0	161,3	-7,3	-7,3	20,0
	14:52	870	722	132661	17,1	3,7	15006	86998	6,1	16,8	159,2	-7,4	-7,4	20,0
	14:53	874	732	134725	17,1	4,2	14972	88660	6,0	16,9	167,2	-7,1	-7,1	20,0
	14:54	878	733	131391	17,1	4,1	14988	86171	6,1	16,8	162,2	-7,3	-7,3	20,0
	14:55	891	740	131282	17,1	3,3	14989	85614	6,3	16,5	153,4	-7,6	-7,6	20,0
	14:56	885	735	132087	17,1	3,6	14986	85790	6,3	16,5	156,3	-7,5	-7,5	20,0
	14:57	876	726	132131	17,1	3,8	14982	84472	6,6	16,3	155,6	-7,5	-7,5	20,0
	14:58	874	725	135349	17,1	3,5	14977	86215	6,6	16,2	156,5	-7,5	-7,5	20,0
	14:59	875	727	135008	17,1	3,4	14987	87218	6,4	16,5	157,8	-7,4	-7,4	20,0
	15:00	871	727	134014	17,1	4,1	15010	87280	6,2	16,8	163,8	-7,2	-7,2	20,0
	15:01	863	721	138280	17,1	4,1	15078	89297	6,3	16,7	168,1	-7,1	-7,1	20,0
	15:02	863	719	131697	17,1	4,5	14995	85211	6,4	16,6	164,1	-7,2	-7,2	20,0
	15:03	855	713	130410	17,1	5,1	14997	84453	6,4	16,6	168,3	-7,1	-7,1	20,0
	15:04	864	718	132430	17,1	4,3	15014	84797	6,6	16,3	161,7	-7,3	-7,3	20,0
	15:05	862	717	132267	17,1	4,7	15036	83864	6,8	16,1	163,0	-7,2	-7,2	20,0
	15:06	871	721	132078	17,1	4,0	14978	83119	6,9	15,8	156,2	-7,5	-7,5	20,0
	15:07	880	714	132459	17,1	4,7	14967	82444	7,1	15,6	160,7	-7,3	-7,3	20,0

Industrie Service



Evaluation according IPPC S5.01, measurement 6, 60 % MCR

- Measure worst case gas residence time using a time of flight method.
  (here used the plug flow method)

  residence time more than 2 seconds: yes

- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

  95% of the one-minute mean temperatures above 850 °C: yes

- above 850 °C for at least 2 seconds (IED Article 50(2)):

  above 850 °C for at least 2 seconds: yes

- IED does not specify oxygen concentrations for the combustion gases. It should however be noted that BAT requires sufficiently oxidising conditions at the final combustion stage to provide for good combustion, and the operator will be required to demonstrate this in his application. In many situations, the BAT oxygen concentration is likely to be about 6%.

  sufficiently oxidising conditions: yes

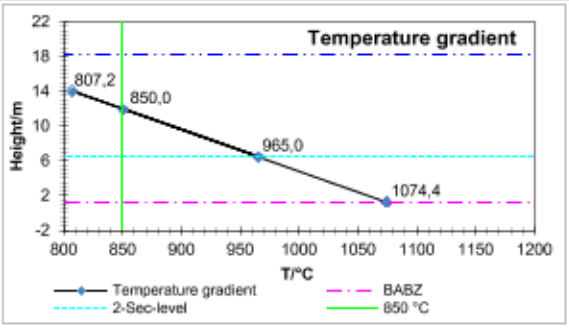
Industrie Service

Series of measurements 5, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **15:16** **End** **15:52**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	714	746	721
	O2	Vol.%	4,5	4,2	4,7
2	Temp.	°C	767	764	740
	O2	Vol.%	3,5	3,3	3,8
3	Temp.	°C	837	812	771
	O2	Vol.%	2,7	2,4	3,0
4	Temp.	°C	856	863	829
	O2	Vol.%	2,7	2,1	2,3
5	Temp.	°C	875	914	887
	O2	Vol.%	2,8	1,7	1,6
6	Temp.	°C	832	877	860
	O2	Vol.%	3,2	2,5	2,4
7	Temp.	°C	729	775	786
	O2	Vol.%	4,9	4,4	4,1
Components			**mean**	**min**	**max**
Temperature			807	714	914
Oxygen Content			3,2	1,6	4,9

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	820	838	857
	O2	Vol.%	4,7	4,8	3,4
2	Temp.	°C	915	884	863
	O2	Vol.%	4,3	4,4	3,1
3	Temp.	°C	973	953	910
	O2	Vol.%	3,2	3,7	2,2
4	Temp.	°C	990	974	948
	O2	Vol.%	3,1	3,1	1,5
5	Temp.	°C	1007	995	986
	O2	Vol.%	3,0	2,5	0,8
6	Temp.	°C	991	991	949
	O2	Vol.%	2,9	2,3	1,3
7	Temp.	°C	947	937	909
	O2	Vol.%	4,2	3,5	2,7
Components			**mean**	**min**	**max**
Temperature			935	820	1007
Oxygen Content			3,1	0,8	4,8



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	92,8
Primary air flow [HLA10CF001XJ61]	m³/h	39155
Secondary air flow [HLA50CF001XJ61]	m³/h	23737

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	715
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,9

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	135730
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,5
Temperature stack [HNA03CT001XQ01]	°C	109,3
Pressure stack [HNA03CP001XQ01]	hPa	1008,1
Moisture stack [HNA03CQ001XQ01]	Vol.%	17,0

Temperature gradient		
Mean value of temperature MP 1	°C	807
Mean value of temperature MP 2	°C	935
delta T1,2=T2-T1	°C	128
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	21,0

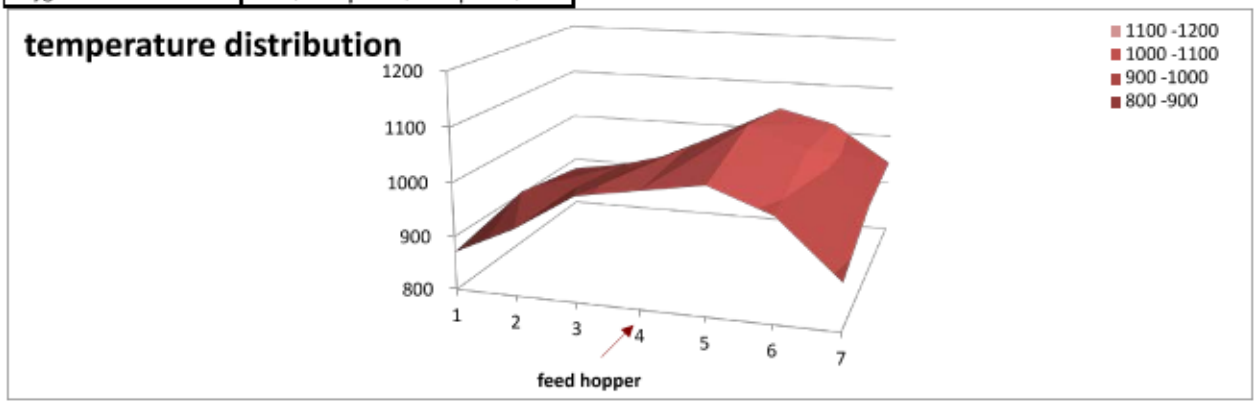
Industrie Service

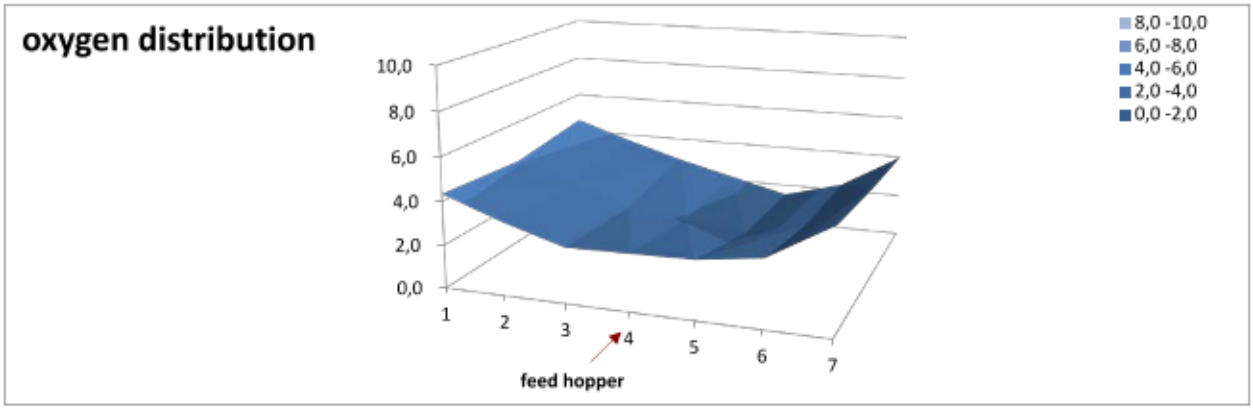
Series of measurements 5, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **15:16** **End** **15:52**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	871	904	879
	O2	Vol.%	4,3	4,1	4,6
2	Temp.	°C	925	922	898
	O2	Vol.%	3,4	3,2	3,7
3	Temp.	°C	995	970	929
	O2	Vol.%	2,5	2,3	2,9
4	Temp.	°C	1014	1021	987
	O2	Vol.%	2,6	1,9	2,2
5	Temp.	°C	1032	1071	1045
	O2	Vol.%	2,7	1,6	1,5
6	Temp.	°C	990	1035	1018
	O2	Vol.%	3,1	2,3	2,3
7	Temp.	°C	887	933	943
	O2	Vol.%	4,7	4,3	4,0
Components			**mean**	**min**	**max**
Temperature			965	871	1071
Oxygen Content			3,1	1,5	4,7

Retention time		
Volume flow in boiler	m^3/h	86566
Oxygen content boiler	Vol.%	3,1
Moisture boiler	Vol.%	17,1
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	962
Volume flow boiler [operating state]	m^3/s	556399
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,52
Plane of retention time 2 sec	m	6,48
Retention time	**Sec**	**4,10**





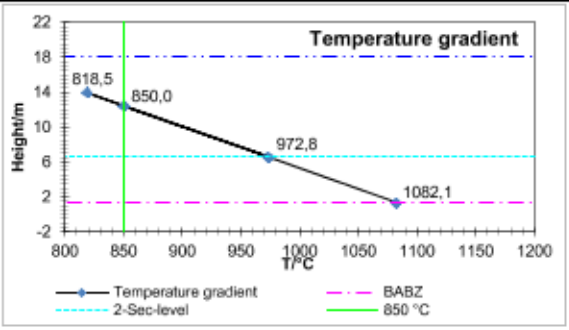
Industrie Service

Series of measurements 6, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **15:52** **End** **16:28**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	732	758	733
	O2	Vol.%	3,8	3,5	4,1
2	Temp.	°C	813	798	764
	O2	Vol.%	3,2	2,8	3,3
3	Temp.	°C	846	821	778
	O2	Vol.%	2,8	2,4	3,0
4	Temp.	°C	859	866	830
	O2	Vol.%	2,8	2,0	2,3
5	Temp.	°C	872	911	881
	O2	Vol.%	2,8	1,5	1,5
6	Temp.	°C	846	866	854
	O2	Vol.%	3,2	2,1	1,8
7	Temp.	°C	768	791	804
	O2	Vol.%	3,8	3,6	3,4
Components			**mean**	**min**	**max**
Temperature			818	732	911
Oxygen Content			2,9	1,5	4,1

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	847	840	877
	O2	Vol.%	3,7	4,5	3,1
2	Temp.	°C	941	914	893
	O2	Vol.%	4,5	4,6	3,7
3	Temp.	°C	978	967	918
	O2	Vol.%	3,4	3,8	2,1
4	Temp.	°C	991	978	947
	O2	Vol.%	3,1	2,9	1,5
5	Temp.	°C	1004	990	976
	O2	Vol.%	2,9	2,0	0,8
6	Temp.	°C	1002	993	965
	O2	Vol.%	2,4	1,5	0,9
7	Temp.	°C	951	943	921
	O2	Vol.%	3,6	2,9	1,7
Components			**mean**	**min**	**max**
Temperature			945	840	1004
Oxygen Content			2,8	0,8	4,6



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	96,5
Primary air flow [HLA10CF001XJ61]	m³/h	37581,3
Secondary air flow [HLA50CF001XJ61]	m³/h	24136,0

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	727
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,6

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	134085
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,0
Temperature stack [HNA03CT001XQ01]	°C	109,4
Pressure stack [HNA03CP001XQ01]	hPa	1009
Volume flow stack [calculated]	Vol.%	16,8

Temperature gradient		
Mean value of temperature MP 1	°C	818
Mean value of temperature MP 2	°C	945
delta T1,2=T2-T1	°C	126
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	20,7

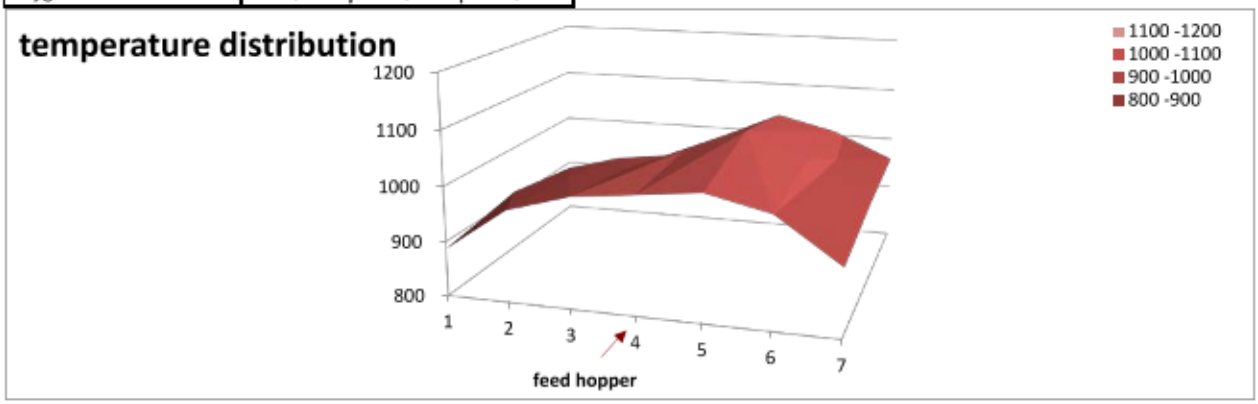
Industrie Service

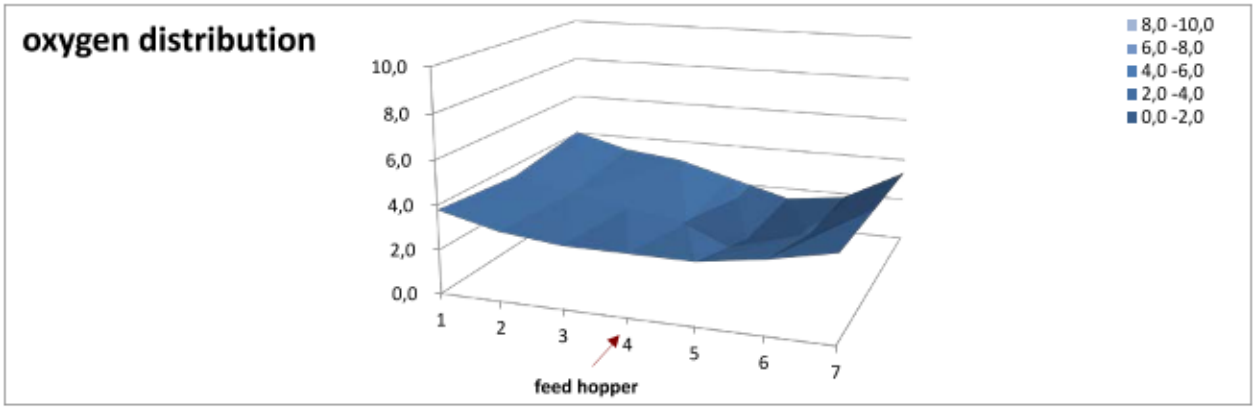
Series of measurements 6, minimum thermal load 60 % MCR
Normal operation without Interference
measured value

Date of Measuring **28.02.2019** **Beginning** **15:52** **End** **16:28**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	887	912	888
	O2	Vol.%	3,8	3,5	4,1
2	Temp.	°C	967	952	919
	O2	Vol.%	3,1	2,8	3,3
3	Temp.	°C	1000	976	933
	O2	Vol.%	2,8	2,4	3,0
4	Temp.	°C	1013	1020	984
	O2	Vol.%	2,8	2,0	2,2
5	Temp.	°C	1026	1065	1035
	O2	Vol.%	2,8	1,5	1,5
6	Temp.	°C	1000	1020	1008
	O2	Vol.%	3,2	2,1	1,8
7	Temp.	°C	922	945	958
	O2	Vol.%	3,8	3,6	3,3
Components			**mean**	**min**	**max**
Temperature			973	887	1065
Oxygen Content			2,8	1,5	4,1

Retention time		
Volume flow in boiler	m^3/h	88808
Oxygen content boiler	Vol.%	2,8
Moisture boiler	Vol.%	17,1
Pressure comb. boiler and air	hPa	1011
T ABZ Mean	°C	966
Volume flow boiler [operating state]	m^3/s	563290
Area of boiler	m^2	59,25
Velocity of flow	m/s	2,6
delta H ABZ	m	-7,46
Plane of retention time 2 sec	m	6,54
Retention time	**Sec**	**4,25**





Industrie Service

7.2 100 % MCR

Grid measurement	No.:	1	2	3	4	5	6	Average
Date of measurement		01.03.2019	01.03.2019	01.03.2019	01.03.2019	01.03.2019	01.03.2019	
Beginning of measurement		09:00	09:36	11:21	11:57	12:33	13:09	
End of measurement		09:36	10:12	11:57	12:33	13:09	13:45	
Measuring plane 2	°C	1024	1030	1024	1036	1031	1029	1029
Measuring plane 1	°C	926	930	921	930	923	924	926
Temperature operating plane [average]	°C	828	829	825	828	829	825	827
Temperature operating plane [HBK11CT001XQ01]	°C	817	817	815	817	819	815	817
Temperature operating plane [HBK11CT002XQ01]	°C	835	835	832	835	836	832	834
Temperature operating plane [HBK11CT003XQ01]	°C	832	834	827	832	832	828	831
T ABZ (single measurement)	°C	1000	1005	998	1012	1006	1005	1004
delta T ABZ-T_{OP}	°C	172	176	173	184	177	180	177
delta T=T1-T_{OP}	°C	98	101	97	102	94	99	98
Oxygen content plane 2	Vol.%	3,4	3,2	3,6	3,0	3,0	3,1	3,2
Oxygen content plane 1	Vol.%	3,4	3,2	3,6	3,2	3,2	3,3	3,3
Oxygen content [HNA01CQ901XJ61]	Vol.% (wet)	5,0	4,9	5,2	4,9	4,9	5,1	5,0
Volume flow stack [HNA03CF001XJ62]	Nm^3/h (wet)	207548	210965	206638	206607	206825	206977	207593
Oxygen content stack [HNA03CQ040XQ01]	Vol.% (dry)	6,6	6,5	6,7	6,5	6,5	6,6	6,6
Temperature stack [HNA03CT001XQ01]	°C	117	117	117	117	117	117	117
Pressure stack [HNA03CP001XQ01]	hPa	1020	1019	1019	1012	1011	1013	1016
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,4	17,1	16,1	16,4	16,8	16,5	16,5
Volume flow stack [calculated]	Nm^3/h (dry, 0 Vol.% O2)	119261	120849	118073	119224	119124	118582	119185
Recirculation gas flow [HNF10CF001XJ61]	Nm^3/h (wet)	20495	20509	20499	20511	20491	20512	20503
Recirculation gas flow normalized	Nm^3/h (dry, 0 Vol.% O2)	11777	11748	11713	11836	11802	11752	11771
Volume flow in boiler	Nm^3/h (dry, 0 Vol.% O2)	131038	132597	129786	131060	130926	130334	130957
Volume flow in boiler	m^3/h (Operating state)	868471	869180	872298	861007	858290	858941	864696
Volume flow in boiler	m^3/s (Operating state)	241	241	242	239	238	239	240
Velocity in boiler	m/s (Operating state)	4,1	4,1	4,1	4,0	4,0	4,0	4,1
Oxygen content ABZ	Vol.% (dry)	3,4	3,2	3,6	3,1	3,1	3,2	3,3
Moisture ABZ [HNA01CQ007XQ02]	Vol.%	16,9	16,8	16,8	16,7	16,8	16,8	16,8
Air pressure	hPa	1018	1018	1017	1017	1017	1017	1017
Pressure in boiler [average HBK01CP001-4XQ01]	hPa	-2,0	-2,0	-2,0	-2,0	-2,0	-2,0	-2,0
Temperature BABZ	°C	1131	1138	1136	1155	1148	1144	1142
TABZ mean	°C	990	994	993	1003	999	997	996
Steam flow [LBA10CF901XJ61]	t/h	160,5	160,1	156,6	160,6	159,7	158,2	159,3
Primary air flow [HLA10CF001XJ61]	Nm^3/h (wet)	67715	68316	67063	67080	66857	67395	67371
Primary air temperature [average HLA08-9CT001XQ01]	°C	169	168	168	169	168	168	168
Secondary air flow [HLA50CF001XJ61]	Nm^3/h (wet)	56483	56644	56285	56592	56688	56409	56517
Secondary air temperature [HLA62CT001XQ01]	°C	177	176	176	176	176	175	176
Recirculation air flow [HNF10CF001XJ61]	Nm^3/h (wet)	20495	20509	20499	20511	20491	20512	20503
Recirculation air temperature [HNF11CT001XQ01]	°C	131	131	130	130	130	130	130
Retention time total	**Sec**	**4,14**	**4,14**	**4,13**	**4,18**	**4,19**	**4,19**	**4,16**
T 1	°C	926	930	921	930	923	924	926
delta H T	m	4,13	4,13	4,13	4,13	4,13	4,13	4,13
delta H ABZ	m	-4,60	-4,59	-4,56	-4,67	-4,69	-4,69	-4,63
delta T 1,2	°C	98	100	103	108	108	105	104
delta T 1,2 / delta H 1,2	°C/m	16,09	16,32	16,87	17,69	17,68	17,29	16,99

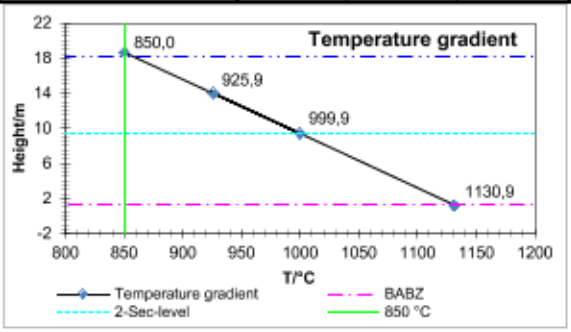
Industrie Service

Series of measurements 1, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **09:00** **End** **09:36**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	871	890	871
	O2	Vol.%	3,7	3,3	4,0
2	Temp.	°C	951	956	901
	O2	Vol.%	4,0	3,4	4,1
3	Temp.	°C	976	960	919
	O2	Vol.%	3,4	3,2	4,1
4	Temp.	°C	971	959	923
	O2	Vol.%	3,1	3,1	3,6
5	Temp.	°C	966	957	927
	O2	Vol.%	2,8	3,0	3,2
6	Temp.	°C	945	938	909
	O2	Vol.%	3,0	3,2	3,3
7	Temp.	°C	888	883	884
	O2	Vol.%	3,0	3,2	3,1
Components			**mean**	**min**	**max**
Temperature			926	871	976
Oxygen Content			3,4	2,8	4,1

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	1023	992	983
	O2	Vol.%	3,6	3,7	3,8
2	Temp.	°C	1050	1018	994
	O2	Vol.%	3,7	3,6	3,5
3	Temp.	°C	1070	1041	1009
	O2	Vol.%	3,4	3,3	3,4
4	Temp.	°C	1080	1036	1020
	O2	Vol.%	3,2	3,5	2,9
5	Temp.	°C	1091	1031	1031
	O2	Vol.%	2,9	3,6	2,5
6	Temp.	°C	1062	984	979
	O2	Vol.%	3,2	4,6	3,2
7	Temp.	°C	1047	982	981
	O2	Vol.%	3,4	4,1	3,2
Components			**mean**	**min**	**max**
Temperature			1024	979	1091
Oxygen Content			3,4	2,5	4,6



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	160,5
Primary air flow [HLA10CF001XJ61]	m³/h	67715
Secondary air flow [HLA50CF001XJ61]	m³/h	56483

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	828
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,0

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	207548
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,6
Temperature stack [HNA03CT001XQ01]	°C	117,5
Pressure stack [HNA03CP001XQ01]	hPa	1020,5
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,4

Temperature gradient		
Mean value of temperature MP 1	°C	926
Mean value of temperature MP 2	°C	1024
delta T1,2=T2-T1	°C	98
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	16,1

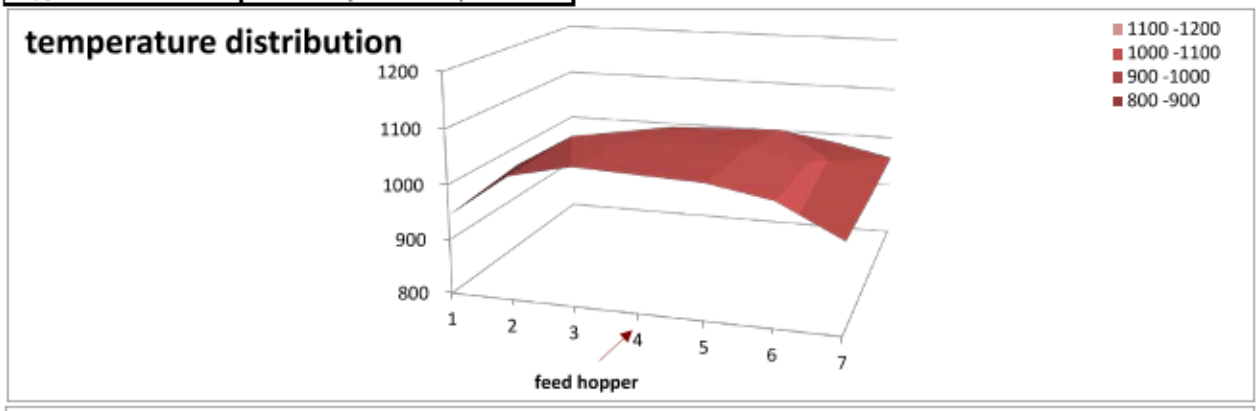
Industrie Service

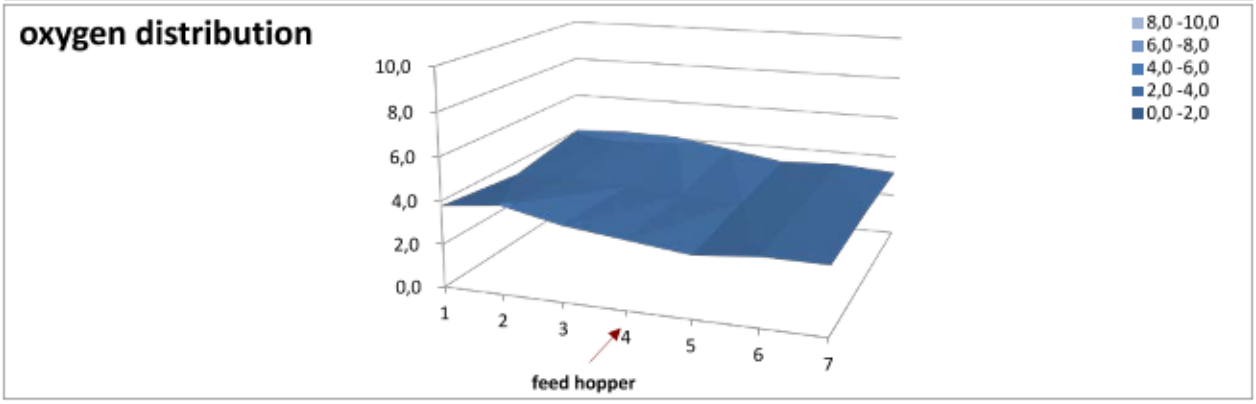
Series of measurements 1, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **09:00** **End** **09:36**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	945	964	945
	O2	Vol.%	3,8	3,4	4,0
2	Temp.	°C	1025	1030	975
	O2	Vol.%	4,1	3,4	4,2
3	Temp.	°C	1050	1034	993
	O2	Vol.%	3,5	3,3	4,1
4	Temp.	°C	1045	1033	997
	O2	Vol.%	3,1	3,2	3,7
5	Temp.	°C	1040	1031	1001
	O2	Vol.%	2,8	3,1	3,2
6	Temp.	°C	1019	1012	983
	O2	Vol.%	3,1	3,3	3,4
7	Temp.	°C	962	957	958
	O2	Vol.%	3,1	3,2	3,2
Components			**mean**	**min**	**max**
Temperature			1000	945	1050
Oxygen Content			3,4	2,8	4,2

Retention time		
Volume flow in boiler	m^3/h	131038
Oxygen content boiler	Vol.%	3,4
Moisture boiler	Vol.%	16,9
Pressure comb. boiler and air	hPa	1016
T ABZ Mean	°C	990
Volume flow boiler [operating state]	m^3/s	868471
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,1
delta H ABZ	m	-4,60
Plane of retention time 2 sec	m	9,40
Retention time	**Sec**	**4,14**





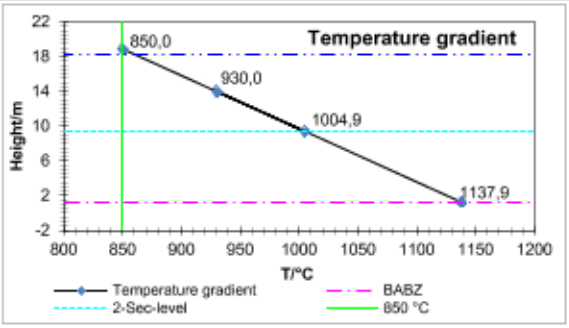
Industrie Service

Series of measurements 2, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **09:36** **End** **10:12**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	892	907	875
	O2	Vol.%	3,4	3,1	3,8
2	Temp.	°C	969	961	910
	O2	Vol.%	3,4	3,2	4,0
3	Temp.	°C	977	963	924
	O2	Vol.%	3,3	3,1	3,9
4	Temp.	°C	971	960	925
	O2	Vol.%	2,9	3,0	3,5
5	Temp.	°C	964	956	926
	O2	Vol.%	2,6	2,9	3,0
6	Temp.	°C	944	943	907
	O2	Vol.%	2,8	2,9	3,0
7	Temp.	°C	880	895	882
	O2	Vol.%	2,8	2,9	2,9
Components			**mean**	**min**	**max**
Temperature			930	875	977
Oxygen Content			3,2	2,6	4,0

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	1046	1005	997
	O2	Vol.%	3,4	3,4	3,3
2	Temp.	°C	1074	1019	987
	O2	Vol.%	3,4	3,6	3,5
3	Temp.	°C	1081	1043	1008
	O2	Vol.%	3,3	3,2	3,3
4	Temp.	°C	1085	1036	1017
	O2	Vol.%	3,0	3,3	2,8
5	Temp.	°C	1088	1029	1026
	O2	Vol.%	2,7	3,4	2,4
6	Temp.	°C	1071	1005	995
	O2	Vol.%	2,9	3,6	2,8
7	Temp.	°C	1043	984	982
	O2	Vol.%	3,0	3,7	2,9
Components			**mean**	**min**	**max**
Temperature			1030	982	1088
Oxygen Content			3,2	2,4	3,7



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	160,1
Primary air flow [HLA10CF001XJ61]	m³/h	68316
Secondary air flow [HLA50CF001XJ61]	m³/h	56644

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	829
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,9

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	210965
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,5
Temperature stack [HNA03CT001XQ01]	°C	117,4
Pressure stack [HNA03CP001XQ01]	hPa	1018,9
Moisture stack [HNA03CQ001XQ01]	Vol.%	17,1

Temperature gradient		
Mean value of temperature MP 1	°C	930
Mean value of temperature MP 2	°C	1030
delta T1,2=T2-T1	°C	100
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	16,3

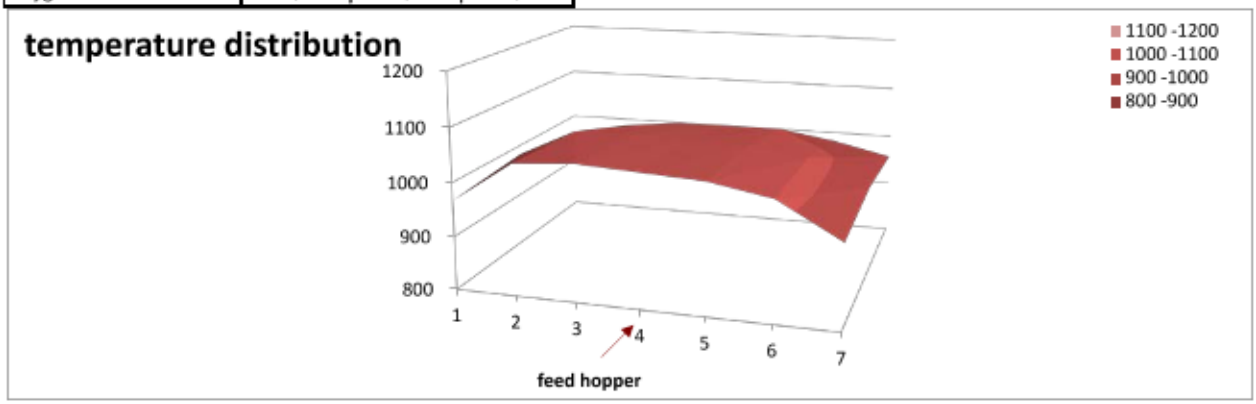
Industrie Service

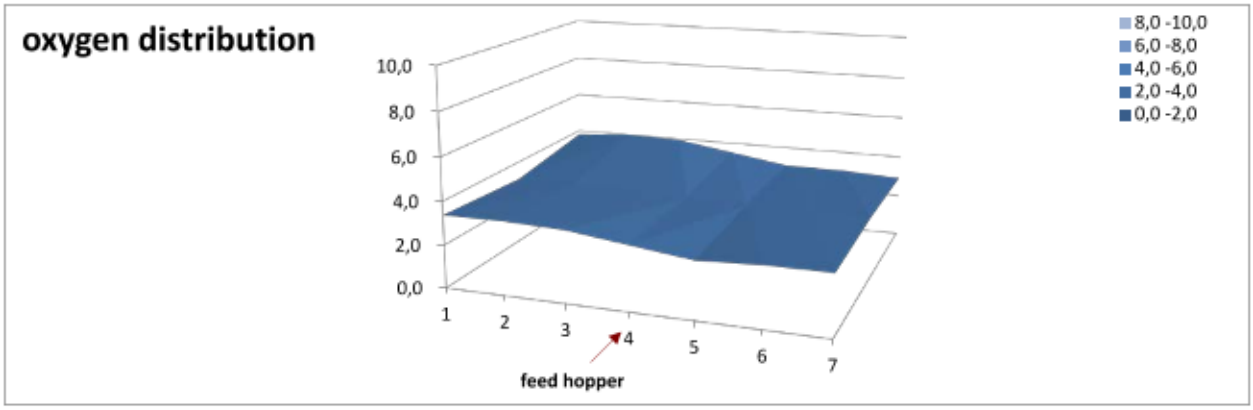
Series of measurements 2, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **09:36** **End** **10:12**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	967	982	950
	O2	Vol.%	3,4	3,1	3,8
2	Temp.	°C	1043	1036	985
	O2	Vol.%	3,4	3,2	4,0
3	Temp.	°C	1052	1038	999
	O2	Vol.%	3,3	3,2	3,9
4	Temp.	°C	1046	1034	1000
	O2	Vol.%	3,0	3,0	3,5
5	Temp.	°C	1039	1031	1000
	O2	Vol.%	2,6	2,9	3,1
6	Temp.	°C	1019	1017	982
	O2	Vol.%	2,8	3,0	3,0
7	Temp.	°C	955	970	957
	O2	Vol.%	2,8	3,0	2,9
Components			**mean**	**min**	**max**
Temperature			1005	950	1052
Oxygen Content			3,2	2,6	4,0

Retention time		
Volume flow in boiler	m^3/h	132597
Oxygen content boiler	Vol.%	3,2
Moisture boiler	Vol.%	16,8
Pressure comb. boiler and air	hPa	1016
T ABZ Mean	°C	994
Volume flow boiler [operating state]	m^3/s	869180
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,1
delta H ABZ	m	-4,59
Plane of retention time 2 sec	m	9,41
Retention time	**Sec**	**4,14**



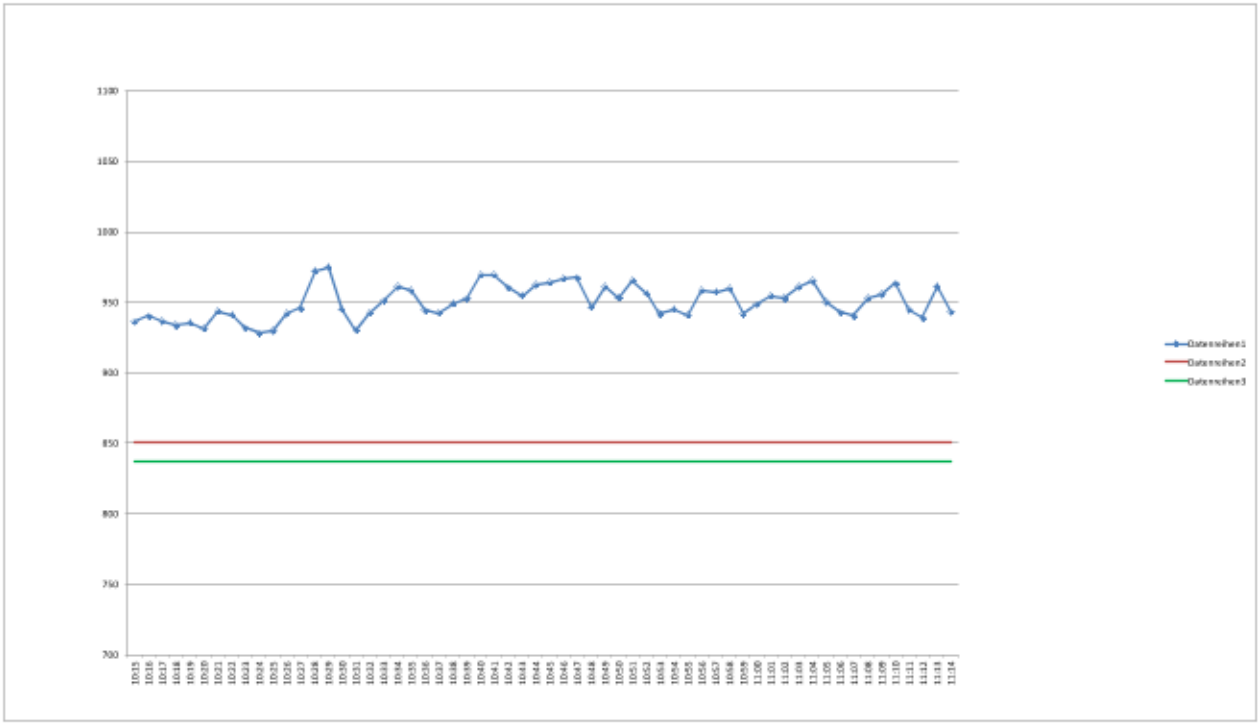


Industrie Service

100 % MCR, measurement 2, measuring point C1:
Confirmation that 95 % of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

date	time	temperature 2 Sec °C	temperature °C	volume flow Nm³/h (wet)	moisture ABZ Vol.%	oxygen containt Vol.% (dry)	recirculation flow Nm³/h (wet)	volume flow cor. Nm³/h (dry)	oxygen stack Vol.% (dry)	moisture stack Vol.%	volume flow cor. m³/s	delta H m	delta H max	temp gradient °C/m
01.03.2019	10:15	936	866	209389	16,8	3,9	20652	132102	6,6	16,5	250,5	-4,3	-4,3	16,3
	10:16	940	872	213659	16,8	3,8	20920	134138	6,6	16,4	253,1	-4,2	-4,2	16,3
	10:17	936	867	209671	16,8	4,1	20511	131118	6,7	16,4	252,4	-4,2	-4,2	16,3
	10:18	934	867	210868	16,8	4,2	20550	132722	6,6	16,6	256,2	-4,1	-4,1	16,3
	10:19	935	868	210673	16,8	4,0	20538	133547	6,4	16,8	254,7	-4,1	-4,1	16,3
	10:20	932	864	203998	16,8	4,7	20486	128058	6,6	16,7	255,0	-4,1	-4,1	16,3
	10:21	944	872	213225	16,8	3,7	20482	132334	6,8	16,5	248,1	-4,4	-4,4	16,3
	10:22	941	869	211624	16,8	3,7	20496	131970	6,7	16,4	246,8	-4,4	-4,4	16,3
	10:23	932	865	213124	16,8	4,3	20499	131957	6,8	16,3	256,2	-4,1	-4,1	16,3
	10:24	928	863	211570	16,8	4,5	20535	131868	6,7	16,4	259,1	-4,0	-4,0	16,3
	10:25	930	863	212017	16,8	4,1	20472	133972	6,5	16,6	257,2	-4,1	-4,1	16,3
	10:26	942	869	206765	16,8	3,8	20504	129939	6,6	16,6	245,0	-4,5	-4,5	16,3
	10:27	946	872	208030	16,8	4,0	20493	127891	6,8	16,4	244,1	-4,5	-4,5	16,3
	10:28	972	889	206422	16,8	2,8	20490	127174	7,0	16,1	227,2	-5,1	-5,1	16,3
	10:29	975	896	206447	16,8	3,1	20459	129158	6,7	16,3	234,3	-4,8	-4,8	16,3
	10:30	945	880	210452	16,8	4,3	20527	132871	6,5	16,6	257,7	-4,0	-4,0	16,3
	10:31	931	866	208830	16,8	4,7	20541	131413	6,4	16,8	260,9	-3,9	-3,9	16,3
	10:32	942	870	205074	16,8	3,8	20511	132205	6,2	16,9	248,3	-4,4	-4,4	16,3
	10:33	952	877	206921	16,8	3,3	20502	132222	6,4	16,8	242,6	-4,6	-4,6	16,3
	10:34	961	885	211714	16,8	3,1	20402	131621	6,8	16,1	239,1	-4,7	-4,7	16,3
	10:35	959	885	208645	16,8	3,8	20564	129478	6,9	16,0	243,9	-4,5	-4,5	16,3
	10:36	944	876	208622	16,8	4,1	20495	131837	6,4	16,5	253,9	-4,2	-4,2	16,3
	10:37	942	876	208609	16,8	3,9	20530	135698	6,1	16,9	257,2	-4,1	-4,1	16,3
	10:38	949	879	208007	16,9	3,9	20467	131835	6,3	16,8	250,2	-4,3	-4,3	16,3
	10:39	953	878	207835	16,9	3,6	20506	130329	6,7	16,1	242,8	-4,5	-4,5	16,3
	10:40	969	893	213157	16,9	2,8	20528	133729	6,7	16,0	238,2	-4,7	-4,7	16,3
	10:41	970	895	211699	16,9	3,1	20449	133729	6,6	16,1	242,6	-4,6	-4,6	16,3
	10:42	961	887	209993	16,8	3,6	20477	131456	6,5	16,2	244,7	-4,5	-4,5	16,3
	10:43	955	884	204470	16,8	3,8	20509	132379	6,2	16,5	249,8	-4,3	-4,3	16,3
	10:44	962	889	207126	16,8	3,0	20519	135417	6,0	16,8	244,3	-4,5	-4,5	16,3
	10:45	964	890	209673	16,8	3,0	20445	135237	6,2	16,5	244,0	-4,5	-4,5	16,3
	10:46	966	892	207844	16,8	3,2	20518	132910	6,4	16,3	242,8	-4,5	-4,5	16,3
	10:47	967	891	206308	16,8	2,9	20507	133424	6,2	16,6	256,5	-4,7	-4,7	16,3
	10:48	946	878	205547	16,8	3,8	20524	134642	6,0	16,7	254,1	-4,2	-4,2	16,3
	10:49	961	889	208429	16,8	2,9	20445	137252	5,9	16,8	248,2	-4,4	-4,4	16,3
	10:50	953	888	218517	16,8	3,1	20494	142565	5,9	17,0	258,6	-4,0	-4,0	16,3
	10:51	966	890	204821	16,8	3,2	20494	132316	6,2	16,4	240,6	-4,6	-4,6	16,3
	10:52	956	886	206693	16,8	3,6	20513	133961	6,2	16,5	250,2	-4,3	-4,3	16,3
	10:53	942	877	207667	16,8	4,0	20492	135832	6,0	16,6	259,4	-4,0	-4,0	16,3
	10:54	945	876	207728	16,8	3,6	20556	135457	6,1	16,6	252,6	-4,2	-4,2	16,3
	10:55	941	873	203770	16,8	4,1	20513	132303	6,2	16,4	253,8	-4,2	-4,2	16,3
	10:56	958	881	208343	16,8	3,0	20503	131457	6,5	16,1	238,6	-4,8	-4,8	16,3
	10:57	958	884	209027	16,8	3,3	20443	132480	6,6	15,9	243,4	-4,5	-4,5	16,3
	10:58	960	885	204542	16,8	3,5	20478	130459	6,5	16,1	241,5	-4,6	-4,6	16,3
	10:59	941	875	205476	16,8	4,3	20559	132814	6,2	16,4	257,7	-4,0	-4,0	16,3
	11:00	949	877	201584	16,8	3,8	20467	131070	6,2	16,5	246,9	-4,4	-4,4	16,3
	11:01	955	879	204049	16,8	3,1	20541	131933	6,3	16,3	239,3	-4,7	-4,7	16,3
	11:02	953	879	205362	16,8	3,6	20424	130700	6,5	16,0	243,2	-4,5	-4,5	16,3
	11:03	961	885	210044	16,8	3,2	20509	131306	6,8	15,7	239,5	-4,7	-4,7	16,3
	11:04	965	889	207403	16,8	2,9	20559	132876	6,4	16,1	238,8	-4,7	-4,7	16,3
	11:05	950	881	206069	16,8	3,9	20530	133386	6,2	16,3	253,0	-4,2	-4,2	16,3
	11:06	943	876	204024	16,8	4,2	20488	132099	6,2	16,5	255,9	-4,1	-4,1	16,3
	11:07	941	872	203275	16,8	4,0	20492	132526	6,1	16,5	252,3	-4,2	-4,2	16,3
	11:08	953	882	211256	16,8	3,3	20358	139040	6,3	16,1	249,3	-4,3	-4,3	16,3
	11:09	956	881	203792	16,8	3,7	20335	128268	6,6	15,7	241,9	-4,6	-4,6	16,3
	11:10	963	885	204266	16,8	3,2	20451	128731	6,8	15,6	234,8	-4,8	-4,8	16,3
	11:11	945	876	206073	16,8	3,9	20440	133162	6,4	15,9	252,7	-4,2	-4,2	16,3
	11:12	939	871	202072	16,8	4,3	20505	130901	6,3	16,1	254,7	-4,1	-4,1	16,3
	11:13	961	882	203229	16,8	2,8	20453	131422	6,3	16,1	233,8	-4,8	-4,8	16,3
	11:14	943	873	205506	16,8	3,9	20439	131171	6,5	15,9	249,5	-4,3	-4,3	16,3

Industrie Service



Evaluation according IPPC S5.01, measurement 1, 100 % MCR

- Measure worst case gas residence time using a time of flight method.
  (here used the plug flow method)

  residence time more than 2 seconds: yes

- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

  95% of the one-minute mean temperatures above 850 °C: yes

- above 850 °C for at least 2 seconds (IED Article 50(2)):

  above 850 °C for at least 2 seconds: yes

- IED does not specify oxygen concentrations for the combustion gases. It should however be noted that BAT requires sufficiently oxidising conditions at the final combustion stage to provide for good combustion, and the operator will be required to demonstrate this in his application. In many situations, the BAT oxygen concentration is likely to be about 6%.

  sufficiently oxidising conditions: yes

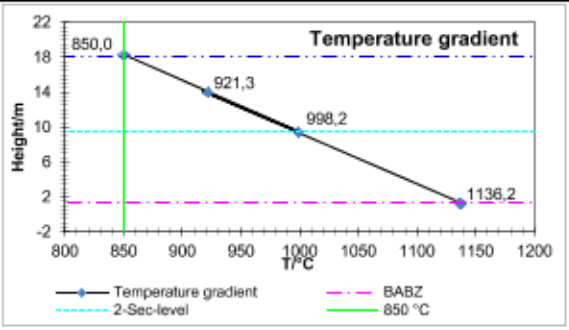
Industrie Service

Series of measurements 3, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **11:21** **End** **11:57**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	888	908	871
	O2	Vol.%	3,6	3,4	4,0
2	Temp.	°C	963	953	899
	O2	Vol.%	3,5	3,3	4,0
3	Temp.	°C	964	952	900
	O2	Vol.%	4,3	3,7	4,5
4	Temp.	°C	961	954	910
	O2	Vol.%	3,8	3,6	4,0
5	Temp.	°C	957	957	920
	O2	Vol.%	3,3	3,4	3,6
6	Temp.	°C	939	932	893
	O2	Vol.%	3,3	3,4	3,4
7	Temp.	°C	877	878	870
	O2	Vol.%	3,4	3,4	3,4
Components			**mean**	**min**	**max**
Temperature			921	870	964
Oxygen Content			3,6	3,3	4,5

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	1036	1004	995
	O2	Vol.%	3,7	3,8	3,6
2	Temp.	°C	1067	1020	992
	O2	Vol.%	3,4	3,5	3,3
3	Temp.	°C	1079	1038	1007
	O2	Vol.%	3,9	3,8	3,7
4	Temp.	°C	1077	1036	1022
	O2	Vol.%	3,6	3,7	3,3
5	Temp.	°C	1076	1035	1036
	O2	Vol.%	3,4	3,7	2,9
6	Temp.	°C	1046	992	976
	O2	Vol.%	3,5	4,1	3,4
7	Temp.	°C	1025	975	972
	O2	Vol.%	4,2	4,4	3,5
Components			**mean**	**min**	**max**
Temperature			1024	972	1079
Oxygen Content			3,6	2,9	4,4



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	156,6
Primary air flow [HLA10CF001XJ61]	m³/h	67062,6
Secondary air flow [HLA50CF001XJ61]	m³/h	56284,6

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	825
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,2

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	206638
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,7
Temperature stack [HNA03CT001XQ01]	°C	116,7
Pressure stack [HNA03CP001XQ01]	hPa	1019
Volume flow stack [calculated]	Vol.%	16,1

Temperature gradient		
Mean value of temperature MP 1	°C	921
Mean value of temperature MP 2	°C	1024
delta T1,2=T2-T1	°C	103
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	16,9

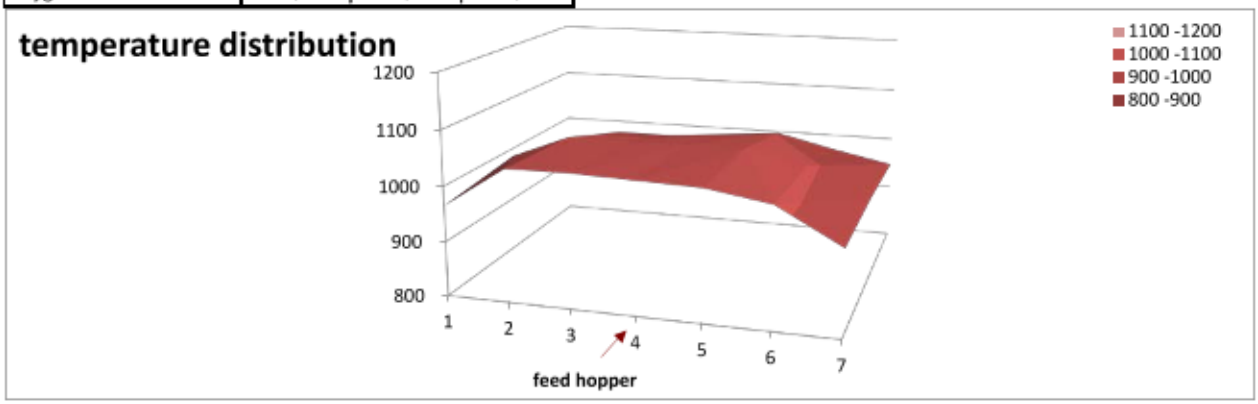
Industrie Service

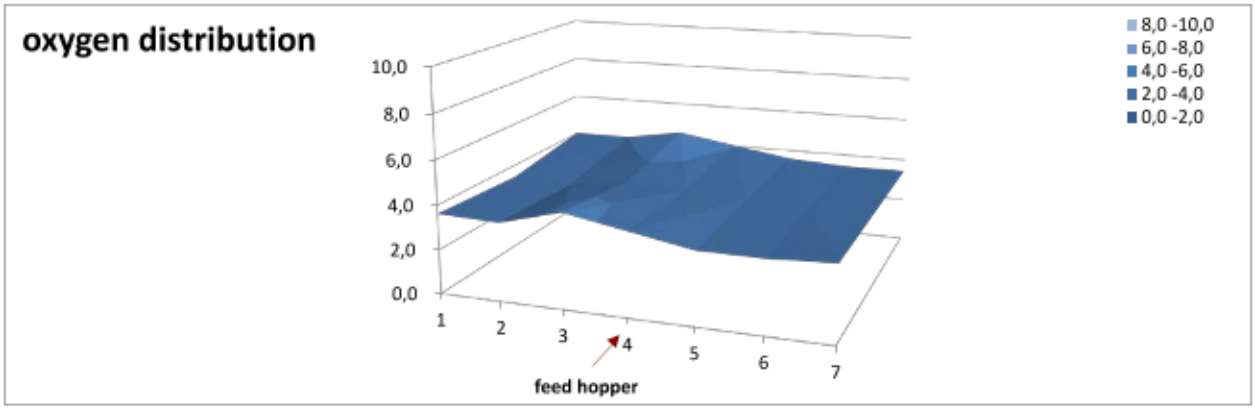
Series of measurements 3, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **11:21** **End** **11:57**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	965	985	947
	O2	Vol.%	3,6	3,4	4,0
2	Temp.	°C	1040	1030	976
	O2	Vol.%	3,5	3,3	4,0
3	Temp.	°C	1041	1029	977
	O2	Vol.%	4,3	3,7	4,5
4	Temp.	°C	1038	1031	987
	O2	Vol.%	3,8	3,6	4,0
5	Temp.	°C	1034	1034	997
	O2	Vol.%	3,3	3,4	3,6
6	Temp.	°C	1016	1009	970
	O2	Vol.%	3,3	3,4	3,4
7	Temp.	°C	954	955	947
	O2	Vol.%	3,4	3,4	3,4
Components			**mean**	**min**	**max**
Temperature			998	947	1041
Oxygen Content			3,6	3,3	4,5

Retention time		
Volume flow in boiler	m^3/h	129786
Oxygen content boiler	Vol.%	3,6
Moisture boiler	Vol.%	16,8
Pressure comb. boiler and air	hPa	1015
T ABZ Mean	°C	993
Volume flow boiler [operating state]	m^3/s	872286
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,1
delta H ABZ	m	-4,56
Plane of retention time 2 sec	m	9,44
Retention time	**Sec**	**4,13**





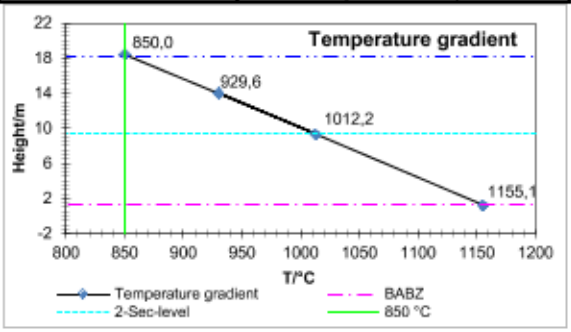
Industrie Service

Series of measurements 4, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **11:57** **End** **12:33**

Measured Values of Measuring Plane 1				
Metering Point		Axis 1	Axis 2	Axis 3
1	Temp. °C	889	907	871
	O2 Vol.%	3,5	3,1	3,8
2	Temp. °C	962	957	899
	O2 Vol.%	3,4	3,1	3,9
3	Temp. °C	985	969	915
	O2 Vol.%	3,6	2,9	3,7
4	Temp. °C	980	970	924
	O2 Vol.%	3,1	2,8	3,4
5	Temp. °C	975	971	932
	O2 Vol.%	2,5	2,7	3,1
6	Temp. °C	946	939	899
	O2 Vol.%	2,8	2,9	3,3
7	Temp. °C	872	888	871
	O2 Vol.%	2,9	3,0	3,2
Components		**mean**	**min**	**max**
Temperature		930	871	985
Oxygen Content		3,2	2,5	3,9

Measured Values of Measuring Plane 2				
Metering Point		Axis 1	Axis 2	Axis 3
1	Temp. °C	1047	1012	995
	O2 Vol.%	3,2	3,4	3,4
2	Temp. °C	1074	1024	991
	O2 Vol.%	3,0	3,2	3,3
3	Temp. °C	1103	1055	1023
	O2 Vol.%	3,1	2,9	2,9
4	Temp. °C	1100	1052	1036
	O2 Vol.%	2,9	2,9	2,6
5	Temp. °C	1098	1049	1049
	O2 Vol.%	2,7	2,9	2,3
6	Temp. °C	1067	1010	1002
	O2 Vol.%	2,9	3,5	2,8
7	Temp. °C	1036	981	986
	O2 Vol.%	3,2	3,7	3,1
Components		**mean**	**min**	**max**
Temperature		1038	981	1103
Oxygen Content		3,0	2,3	3,7



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	160,6
Primary air flow [HLA10CF001XJ61]	m³/h	67080
Secondary air flow [HLA50CF001XJ61]	m³/h	56592

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	828
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,9

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	206607
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,5
Temperature stack [HNA03CT001XQ01]	°C	117,0
Pressure stack [HNA03CP001XQ01]	hPa	1012,1
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,4

Temperature gradient		
Mean value of temperature MP 1	°C	930
Mean value of temperature MP 2	°C	1038
delta T1,2=T2-T1	°C	108
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	17,7

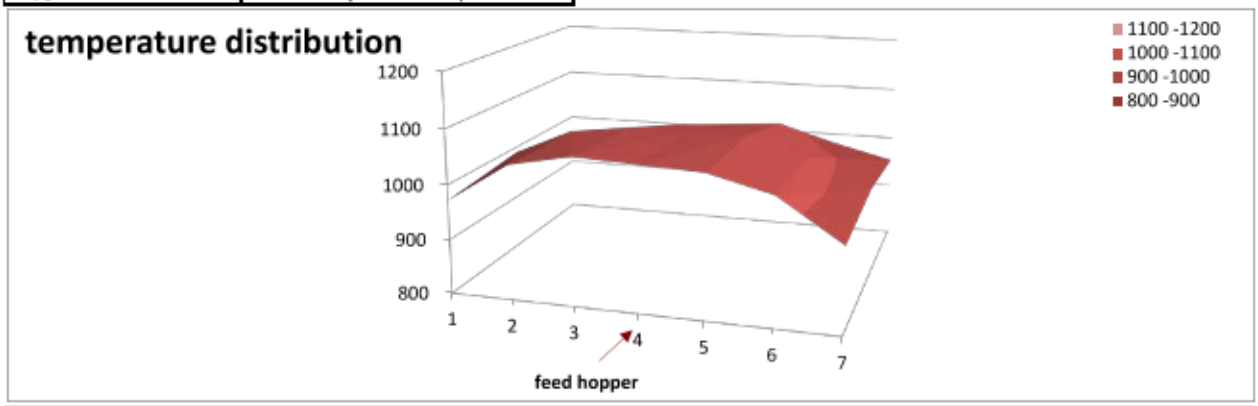
Industrie Service

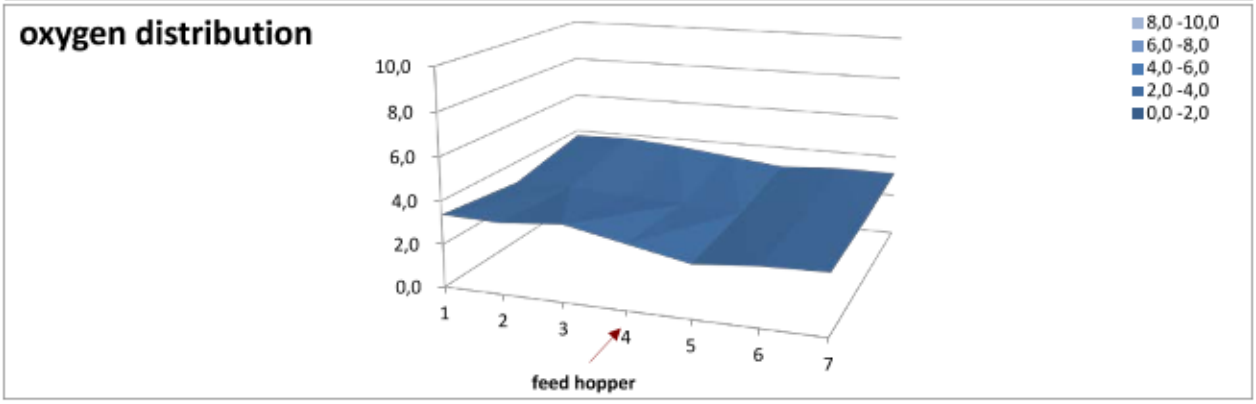
Series of measurements 4, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **11:57** **End** **12:33**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	972	990	954
	O2	Vol.%	3,4	3,0	3,7
2	Temp.	°C	1045	1040	982
	O2	Vol.%	3,3	3,0	3,8
3	Temp.	°C	1067	1052	998
	O2	Vol.%	3,5	2,8	3,6
4	Temp.	°C	1062	1053	1006
	O2	Vol.%	3,0	2,7	3,3
5	Temp.	°C	1057	1054	1015
	O2	Vol.%	2,4	2,6	3,0
6	Temp.	°C	1029	1022	981
	O2	Vol.%	2,7	2,8	3,2
7	Temp.	°C	955	970	953
	O2	Vol.%	2,8	2,9	3,1
Components			**mean**	**min**	**max**
Temperature			1012	953	1067
Oxygen Content			3,1	2,4	3,8

Retention time		
Volume flow in boiler	m^3/h	131060
Oxygen content boiler	Vol.%	3,1
Moisture boiler	Vol.%	16,7
Pressure comb. boiler and air	hPa	1015
T ABZ Mean	°C	1003
Volume flow boiler [operating state]	m^3/s	861007
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,0
delta H ABZ	m	-4,67
Plane of retention time 2 sec	m	9,33
Retention time	**Sec**	**4,18**





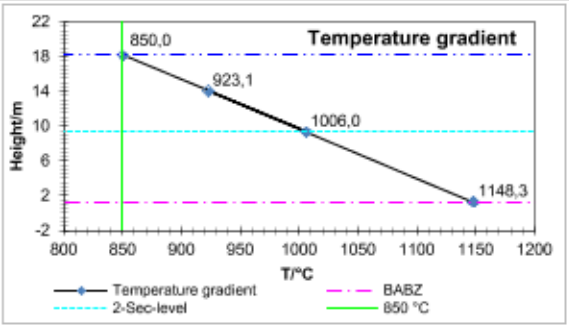
Industrie Service

Series of measurements 5, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **12:33** **End** **13:09**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	893	913	880
	O2	Vol.%	3,2	2,7	3,5
2	Temp.	°C	954	947	892
	O2	Vol.%	3,5	3,2	4,0
3	Temp.	°C	966	964	910
	O2	Vol.%	3,5	3,1	4,0
4	Temp.	°C	964	959	916
	O2	Vol.%	3,1	3,0	3,7
5	Temp.	°C	962	954	921
	O2	Vol.%	2,8	3,0	3,3
6	Temp.	°C	939	933	889
	O2	Vol.%	2,9	3,0	3,3
7	Temp.	°C	874	887	869
	O2	Vol.%	2,7	2,8	3,1
Components			**mean**	**min**	**max**
Temperature			923	869	966
Oxygen Content			3,2	2,7	4,0

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	1060	1024	1011
	O2	Vol.%	2,7	3,0	2,9
2	Temp.	°C	1067	1018	984
	O2	Vol.%	3,1	3,3	3,2
3	Temp.	°C	1094	1053	1013
	O2	Vol.%	3,0	3,1	2,9
4	Temp.	°C	1090	1042	1020
	O2	Vol.%	2,9	3,0	2,8
5	Temp.	°C	1086	1030	1027
	O2	Vol.%	2,8	3,0	2,6
6	Temp.	°C	1057	987	981
	O2	Vol.%	3,0	3,5	3,1
7	Temp.	°C	1033	981	987
	O2	Vol.%	3,0	3,7	2,9
Components			**mean**	**min**	**max**
Temperature			1031	981	1094
Oxygen Content			3,0	2,6	3,7



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	159,7
Primary air flow [HLA10CF001XJ61]	m³/h	66657
Secondary air flow [HLA50CF001XJ61]	m³/h	56688

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	829
Oxygen content [HNA01CQ901XJ61]	Vol.%	4,9

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	206825
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,5
Temperature stack [HNA03CT001XQ01]	°C	117,0
Pressure stack [HNA03CP001XQ01]	hPa	1011,5
Moisture stack [HNA03CQ001XQ01]	Vol.%	16,8

Temperature gradient		
Mean value of temperature MP 1	°C	923
Mean value of temperature MP 2	°C	1031
delta T1,2=T2-T1	°C	108
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	17,7

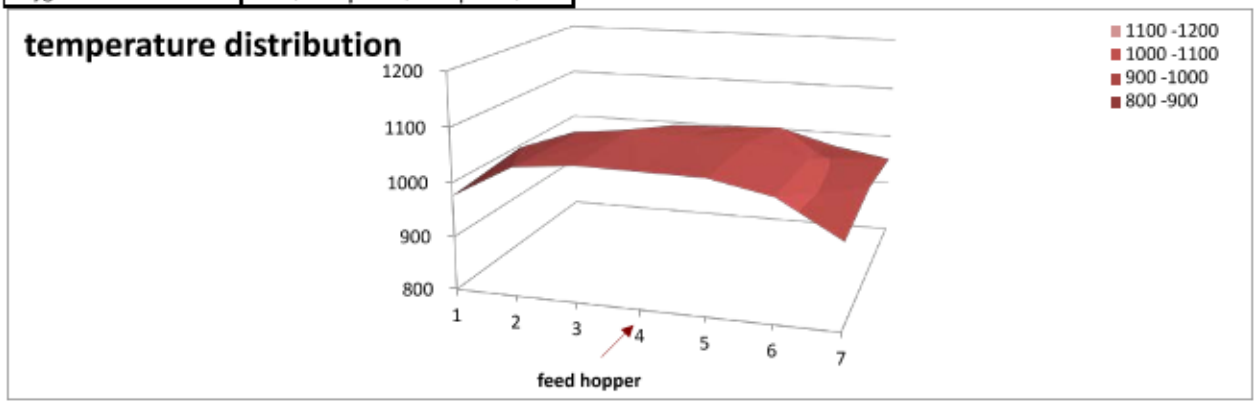
Industrie Service

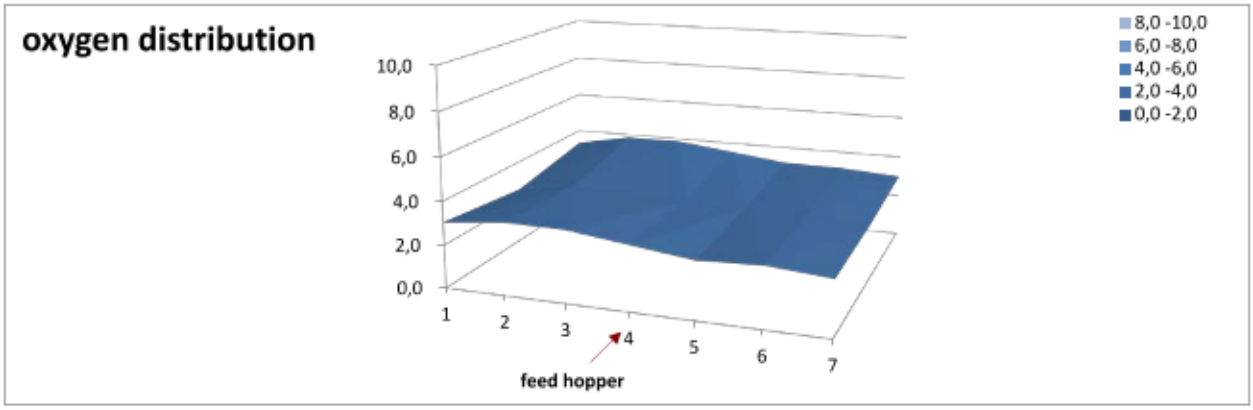
Series of measurements 5, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **12:33** **End** **13:09**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	976	996	963
	O2	Vol.%	3,1	2,6	3,3
2	Temp.	°C	1037	1030	975
	O2	Vol.%	3,4	3,0	3,9
3	Temp.	°C	1049	1047	993
	O2	Vol.%	3,3	3,0	3,9
4	Temp.	°C	1047	1042	998
	O2	Vol.%	3,0	2,9	3,5
5	Temp.	°C	1045	1037	1004
	O2	Vol.%	2,6	2,8	3,2
6	Temp.	°C	1022	1015	972
	O2	Vol.%	2,8	2,9	3,2
7	Temp.	°C	957	970	951
	O2	Vol.%	2,5	2,7	3,0
Components			**mean**	**min**	**max**
Temperature			1006	951	1049
Oxygen Content			3,1	2,5	3,9

Retention time		
Volume flow in boiler	m^3/h	130926
Oxygen content boiler	Vol.%	3,1
Moisture boiler	Vol.%	16,8
Pressure comb. boiler and air	hPa	1015
T ABZ Mean	°C	999
Volume flow boiler [operating state]	m^3/s	858290
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,0
delta H ABZ	m	-4,69
Plane of retention time 2 sec	m	9,31
Retention time	**Sec**	**4,19**





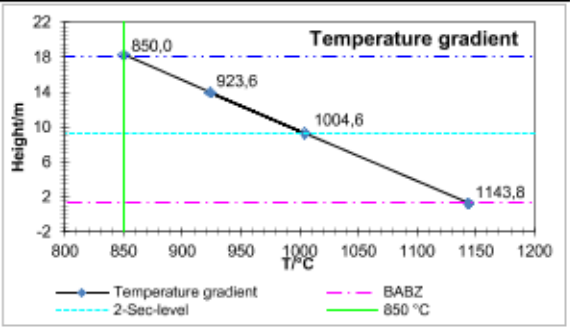
Industrie Service

Series of measurements 6, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **13:09** **End** **13:45**

Measured Values of Measuring Plane 1					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	863	883	852
	O2	Vol.%	4,1	3,7	4,4
2	Temp.	°C	955	954	897
	O2	Vol.%	3,5	3,2	4,1
3	Temp.	°C	976	972	921
	O2	Vol.%	3,1	2,9	3,7
4	Temp.	°C	976	970	928
	O2	Vol.%	2,8	2,8	3,3
5	Temp.	°C	975	967	934
	O2	Vol.%	2,5	2,6	2,9
6	Temp.	°C	940	936	895
	O2	Vol.%	3,0	3,1	3,4
7	Temp.	°C	859	878	864
	O2	Vol.%	3,4	3,4	3,6
Components			**mean**	**min**	**max**
Temperature			924	852	976
Oxygen Content			3,3	2,5	4,4

Measured Values of Measuring Plane 2					
Metering Point			Axis 1	Axis 2	Axis 3
1	Temp.	°C	1009	980	959
	O2	Vol.%	3,7	4,0	4,1
2	Temp.	°C	1069	1018	982
	O2	Vol.%	3,2	3,4	3,3
3	Temp.	°C	1104	1060	1023
	O2	Vol.%	2,9	2,9	2,7
4	Temp.	°C	1101	1052	1035
	O2	Vol.%	2,7	2,8	2,4
5	Temp.	°C	1098	1045	1046
	O2	Vol.%	2,5	2,7	2,1
6	Temp.	°C	1064	998	996
	O2	Vol.%	3,2	3,6	3,1
7	Temp.	°C	1030	967	974
	O2	Vol.%	3,5	3,9	3,4
Components			**mean**	**min**	**max**
Temperature			1029	959	1104
Oxygen Content			3,1	2,1	4,1



Minimum conditions		
Minimum temperature	°C	850
Retention time	Sec	2,0

Boiler specifications		
Beginning of ABZ	BABZ	1,26 m
Plane of operating temperature	OMP	18,13 m
Measuring plane 1	MP1	14 m
Measuring plane 2	MP2	7,9 m
Area ABZ	A	59,25 m²

Operational data of boiler		
Steam flow [LBA10CF901XJ61]	t/h	158,2
Primary air flow [HLA10CF001XJ61]	m³/h	67394,6
Secondary air flow [HLA50CF001XJ61]	m³/h	56409,5

Operational measuring values in ABZ		
Temperature operating plane [average]	°C	825
Oxygen content [HNA01CQ901XJ61]	Vol.%	5,1

Operational measuring values at the stack		
Volume flow stack [HNA03CF001XJ62]	Nm³/h	206977
Oxygen content stack [HNA03CQ040XQ01]	Vol.%	6,6
Temperature stack [HNA03CT001XQ01]	°C	116,9
Pressure stack [HNA03CP001XQ01]	hPa	1013
Volume flow stack [calculated]	Vol.%	16,5

Temperature gradient		
Mean value of temperature MP 1	°C	924
Mean value of temperature MP 2	°C	1029
delta T1,2=T2-T1	°C	105
delta H 1,2	m	6,10
delta T1,2/delta H1,2	°C/m	17,3

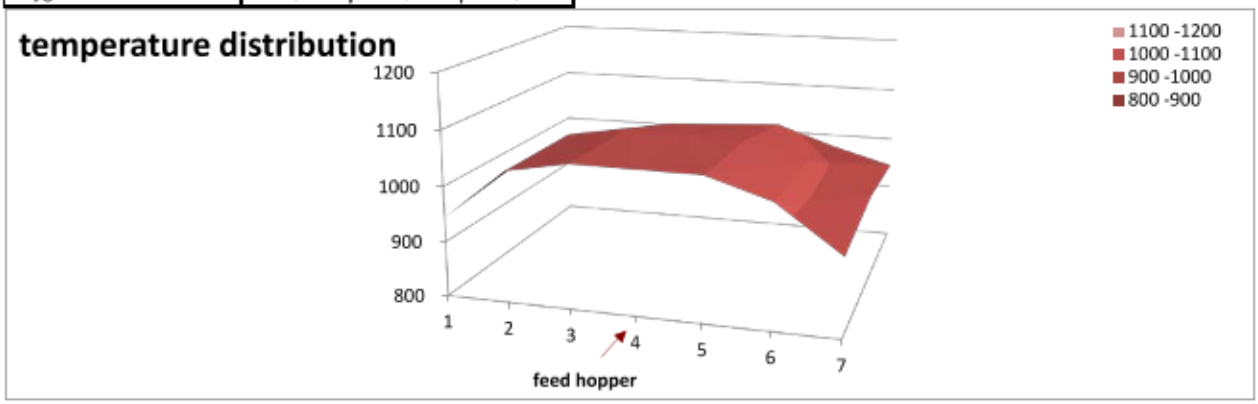
Industrie Service

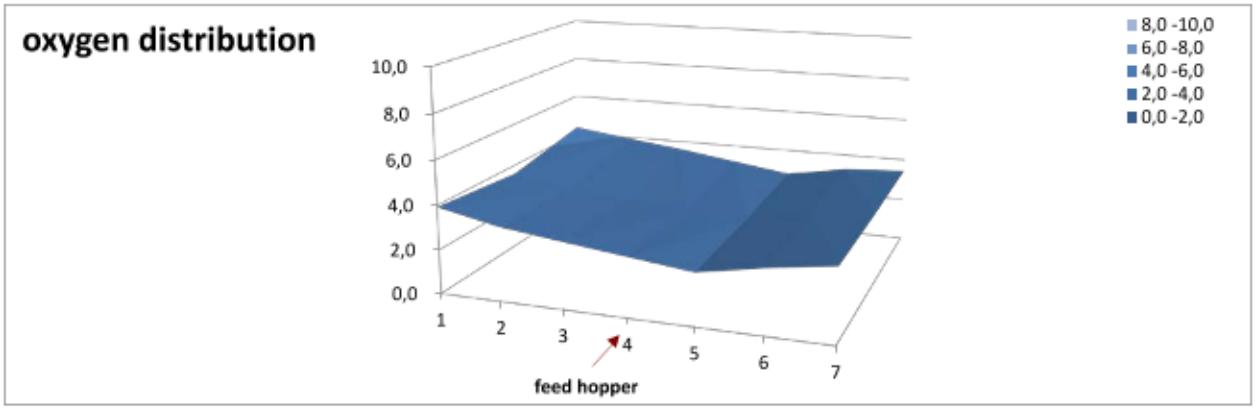
Series of measurements 6, nominal thermal load 100 % MCR
Normal operation without Interference
measured value

Date of Measuring **01.03.2019** **Beginning** **13:09** **End** **13:45**

Measured Values evaluated to the Plane in which the Retention Time of 2 sec. is just kept					
Output 1			Axis 1	Axis 2	Axis 3
1	Temp.	°C	944	964	933
	O2	Vol.%	3,9	3,6	4,3
2	Temp.	°C	1036	1035	978
	O2	Vol.%	3,3	3,1	3,9
3	Temp.	°C	1057	1053	1002
	O2	Vol.%	3,0	2,8	3,6
4	Temp.	°C	1057	1051	1009
	O2	Vol.%	2,7	2,6	3,2
5	Temp.	°C	1056	1048	1015
	O2	Vol.%	2,3	2,5	2,8
6	Temp.	°C	1021	1017	976
	O2	Vol.%	2,9	3,0	3,3
7	Temp.	°C	940	959	945
	O2	Vol.%	3,3	3,3	3,4
Components			**mean**	**min**	**max**
Temperature			1005	933	1057
Oxygen Content			3,2	2,3	4,3

Retention time		
Volume flow in boiler	m^3/h	130334
Oxygen content boiler	Vol.%	3,2
Moisture boiler	Vol.%	16,8
Pressure comb. boiler and air	hPa	1015
T ABZ Mean	°C	997
Volume flow boiler [operating state]	m^3/s	858941
Area of boiler	m^2	59,25
Velocity of flow	m/s	4,0
delta H ABZ	m	-4,69
Plane of retention time 2 sec	m	9,31
Retention time	**Sec**	**4,19**



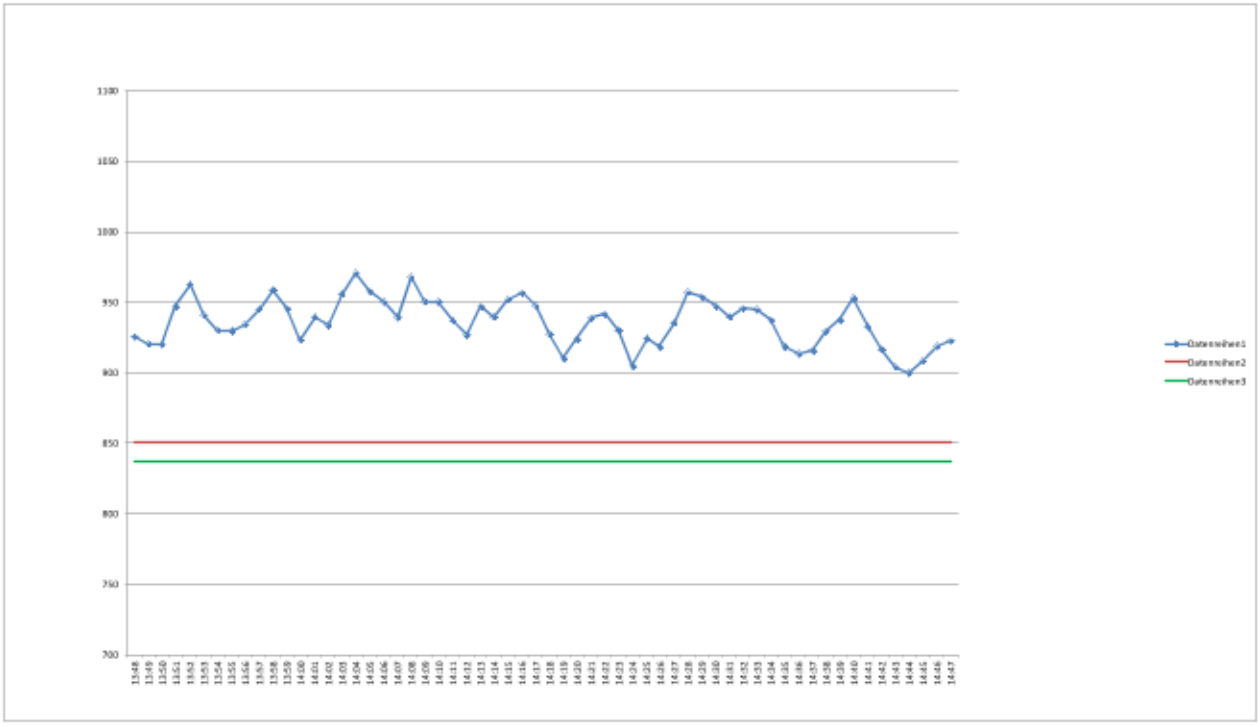


Industrie Service

100 % MCR, measurement 6, measuring point C1:
Confirmation that 95 % of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

date	time	temperature 2 Sec °C	temperature °C	volume flow Nm³/h (wet)	moisture ABZ Vol.%	oxygen containt Vol.% (dry)	recirculation flow Nm³/h (wet)	volume flow cor. Nm³/h (dry)	oxygen stack Vol.% (dry)	moisture stack Vol.%	volume flow cor. m³/s	delta H m	delta H max	temp gradient °C/m
01.03.2019	13:48	925	854	210422	16,8	4,8	20997	127804	7,1	18,7	255,8	-4,1	-4,1	17,3
	13:49	920	851	207797	16,8	4,5	20533	131361	6,3	17,5	258,5	-4,0	-4,0	17,3
	13:50	920	850	205468	16,8	4,4	20488	131070	6,2	17,8	257,1	-4,1	-4,1	17,3
	13:51	947	865	210852	16,8	3,1	20906	130798	6,7	17,2	237,6	-4,7	-4,7	17,3
	13:52	963	877	206979	16,8	3,0	20464	127836	7,0	18,7	230,7	-5,0	-5,0	17,3
	13:53	941	867	210128	16,8	4,3	20535	129171	6,9	18,8	251,7	-4,2	-4,2	17,3
	13:54	931	863	213436	16,8	4,3	20583	134296	6,4	17,3	261,6	-3,9	-3,9	17,3
	13:55	930	863	207624	16,8	4,4	20496	130742	6,1	17,6	262,9	-3,9	-3,9	17,3
	13:56	934	863	206141	16,8	4,2	20495	131518	6,2	17,4	254,4	-4,2	-4,2	17,3
	13:57	945	868	208828	16,8	3,8	20474	130260	6,7	16,8	246,0	-4,4	-4,4	17,3
	13:58	959	877	207024	16,8	3,3	20470	128427	6,8	16,5	236,7	-4,7	-4,7	17,3
	13:59	946	871	205476	16,8	4,2	20487	128234	6,7	16,5	248,3	-4,4	-4,4	17,3
	14:00	924	859	211768	16,8	4,8	20508	133374	6,5	16,6	267,6	-3,7	-3,7	17,3
	14:01	940	864	203179	16,8	3,9	20502	130437	6,3	17,0	248,2	-4,4	-4,4	17,3
	14:02	934	861	206236	16,8	4,1	20454	131327	6,4	16,8	252,3	-4,2	-4,2	17,3
	14:03	956	872	205670	16,8	2,9	20448	129910	6,8	16,4	233,1	-4,9	-4,9	17,3
	14:04	970	884	207871	16,8	2,7	20488	129217	6,8	16,3	230,0	-5,0	-5,0	17,3
	14:05	958	882	207903	16,8	3,6	20512	131887	6,5	16,6	247,2	-4,4	-4,4	17,3
	14:06	950	875	206519	16,8	3,6	20506	133267	6,1	17,0	249,7	-4,3	-4,3	17,3
	14:07	939	869	199225	16,8	4,5	20521	130444	5,9	17,4	257,9	-4,0	-4,0	17,3
	14:08	968	881	200407	16,8	2,5	20487	130267	6,1	17,1	229,2	-5,0	-5,0	17,3
	14:09	951	876	206896	16,8	3,6	20436	130019	6,3	16,5	249,3	-4,3	-4,3	17,3
	14:10	950	875	206285	16,8	3,8	20498	130659	6,6	16,2	247,8	-4,4	-4,4	17,3
	14:11	937	870	212180	16,8	4,0	20492	136903	6,2	16,7	262,4	-3,9	-3,9	17,3
	14:12	927	864	210373	16,8	4,3	20544	136304	5,8	17,1	259,1	-3,7	-3,7	17,3
	14:13	947	870	207699	16,8	3,3	20534	133403	6,3	16,7	245,5	-4,5	-4,5	17,3
	14:14	939	869	207795	16,8	4,2	20513	132329	6,4	16,5	256,5	-4,1	-4,1	17,3
	14:15	952	874	210194	16,8	3,2	20496	133388	6,5	16,4	244,0	-4,5	-4,5	17,3
	14:16	957	880	209788	16,8	3,1	20474	134492	6,3	16,4	245,3	-4,5	-4,5	17,3
	14:17	947	875	206877	16,8	3,7	20511	134127	6,3	16,4	252,8	-4,2	-4,2	17,3
	14:18	928	861	210353	16,9	4,3	20548	134890	6,3	16,6	262,7	-3,9	-3,9	17,3
	14:19	910	848	200331	16,9	5,4	20551	129905	6,2	16,7	271,3	-3,6	-3,6	17,3
	14:20	924	851	201964	16,9	4,3	20428	130201	6,3	16,6	253,5	-4,2	-4,2	17,3
	14:21	939	861	203084	16,9	3,8	20444	129430	6,5	16,4	244,8	-4,5	-4,5	17,3
	14:22	942	863	205141	16,9	4,0	20467	128857	7,0	15,8	243,4	-4,5	-4,5	17,3
	14:23	931	856	206717	16,9	4,3	20537	127946	7,0	15,8	249,4	-4,3	-4,3	17,3
	14:24	905	846	209280	16,9	5,3	20594	130582	6,3	16,7	277,0	-3,4	-3,4	17,3
	14:25	924	855	206762	16,9	4,4	20530	131519	6,4	16,5	258,5	-4,0	-4,0	17,3
	14:26	918	853	206665	16,9	5,0	20436	130243	6,6	16,3	265,2	-3,8	-3,8	17,3
	14:27	936	857	208856	16,9	3,7	20433	128863	7,0	15,9	243,2	-4,5	-4,5	17,3
	14:28	957	878	210337	16,9	3,5	20498	129543	7,0	15,8	241,2	-4,6	-4,6	17,3
	14:29	954	876	208556	16,9	3,8	20478	128475	6,9	15,9	243,5	-4,5	-4,5	17,3
	14:30	947	872	210219	16,9	3,8	20540	131912	6,7	16,2	249,5	-4,3	-4,3	17,3
	14:31	940	872	206249	16,9	4,5	20551	132168	6,4	16,4	261,4	-3,9	-3,9	17,3
	14:32	946	870	202380	16,9	3,9	20351	130039	6,3	16,4	248,0	-4,4	-4,4	17,3
	14:33	944	871	202412	16,9	4,1	20385	129993	6,4	16,3	250,9	-4,3	-4,3	17,3
	14:34	938	867	209254	16,9	4,1	20416	132519	6,6	16,1	256,1	-4,1	-4,1	17,3
	14:35	919	855	208281	16,9	5,0	20474	130982	6,5	16,2	267,4	-3,7	-3,7	17,3
	14:36	913	848	203211	16,9	5,1	20486	129401	6,5	16,3	264,9	-3,8	-3,8	17,3
	14:37	915	850	205550	16,9	5,1	20372	129458	6,6	16,1	265,2	-3,8	-3,8	17,3
	14:38	929	855	199627	16,9	4,6	20474	125005	6,8	16,0	248,0	-4,3	-4,3	17,3
	14:39	938	862	207780	16,9	3,9	20418	129939	6,7	16,2	248,2	-4,4	-4,4	17,3
	14:40	953	872	207243	16,9	3,7	20487	128844	7,1	15,7	239,1	-4,7	-4,7	17,3
	14:41	933	863	214288	16,9	4,4	20476	131796	7,0	16,0	258,7	-4,0	-4,0	17,3
	14:42	917	851	211695	16,9	4,7	20520	132252	6,7	16,4	264,3	-3,8	-3,8	17,3
	14:43	904	846	210049	16,9	5,5	20506	132577	6,5	16,7	278,2	-3,4	-3,4	17,3
	14:44	899	837	209612	16,9	5,5	20514	128956	6,5	16,9	270,6	-3,6	-3,6	17,3
	14:45	908	841	214890	17,0	4,4	20507	133493	6,7	16,6	262,5	-3,9	-3,9	17,3
	14:46	919	849	208402	17,0	4,9	20448	127000	7,1	16,1	257,8	-4,0	-4,0	17,3
	14:47	923	850	209354	17,0	4,8	20446	125529	7,3	16,0	252,5	-4,2	-4,2	17,3

Industrie Service



Evaluation according IPPC S5.01, measurement 6, 100 % MCR

- Measure worst case gas residence time using a time of flight method.
  (here used the plug flow method)

  residence time more than 2 seconds: yes

- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

  95% of the one-minute mean temperatures above 850 °C: yes

- above 850 °C for at least 2 seconds (IED Article 50(2)):

  above 850 °C for at least 2 seconds: yes

- IED does not specify oxygen concentrations for the combustion gases. It should however be noted that BAT requires sufficiently oxidising conditions at the final combustion stage to provide for good combustion, and the operator will be required to demonstrate this in his application. In many situations, the BAT oxygen concentration is likely to be about 6%.

  sufficiently oxidising conditions: yes

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7.3 Calibration function

7.3.1 Determination of the calibration function

Description of determination of the end of the afterburning zone:

The determination of the combustion chamber temperatures according to the procedure for calibration takes place in each case with full load and further authorized operating conditions. At least six grid measurements are to be accomplished at the same time in each case in measurement plane 1 and 2. For the periods of these grid measurements the average of measured values of the operational measuring instruments are to be determined, so that at least 3 data records (grid measurement / operational measurement) are available for each load point. On assumption of a linear temperature gradient between the planes of measurement 1 and 2, the end of the afterburning zone (ΔH_{ABZ}) is to calculate:

$$\Delta H_{ABZ} = \frac{t_{rt\,\min} \cdot \dot{V}_{cc}}{A} - \Delta H$$

with:

$t_{rt\,min}$	Minimum residence time = 2,0 s
ΔH_{ABZ}	Distance between end of afterburning zone and measuring plane 1
ΔH	Distance between beginning of afterburning zone and measuring plane 1
A	Cross-section area
$\dot{V}_{cc}$	Average value of volume flow of the exhaust gases in the combustion chamber

The mean temperature difference ($\Delta T_{1,2}$) is calculated after:

$$\Delta \mathrm{T}_{1,2} = \frac{1}{n} \sum_{i=1}^{n} (\mathrm{T}_{2i} - \mathrm{T}_{1i})$$

with:

T_{2i}	Average value of the temperature grid measurement in measuring plane 2
T_{1i}	Average value of the temperature grid measurement in measuring plane 1
n	Total number of the data records

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The mean temperature gradient ($\Delta T_{\frac{\Delta T_{1,2}}{\Delta H_{1,2}}}$) is calculated as follows:

$$\Delta T_{\frac{\Delta T_{1,2}}{\Delta H_{1,2}}} = \frac{\Delta T_{1,2}}{\Delta H_{1,2}}$$

with:

$\Delta H_{1,2}$	Distance between measuring plane 1 and 2
$\Delta T_{1,2}$	Mean temperature difference between measuring plane 1 and 2

Process description for calibration:

By the operating measured values for the temperature, the mean temperature difference (T_{ABZ_i}) and their lower confidence limit to the temperature values of the grid measurements in measuring plane 1 is to calculate:

$$T_{ABZ_i} = T_{1i} - \frac{\Delta T_{1,2}}{\Delta H_{1,2}} \Delta H_{ABZ}$$

with:

T_{1i}	Average value of the temperature grid measurement in measuring plane 1

Determination of the confidence limit V_B:

$$V_B = \frac{t_{n-2} \cdot s}{\sqrt{n}}$$

with:

t_{n-2}	Threshold value of the t-distribution (for n=n')
s	Dispersion around the regression line
n	Total number of the data records

$$\overline{T}_{ABZ} = \frac{1}{n} \sum_{i=1}^{n} T_{ABZi}$$

$$\overline{T}_B = \frac{1}{n} \sum_{i=1}^{n} T_{Bi}$$

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$$S_{T_B T_{ABZ}} = \sum_{i=1}^{n} (T_{Bi} - \overline{T}_B) \cdot (T_{ABZi} - \overline{T}_{ABZ})$$

$$S_{T_B T_B} = \sum_{i=1}^{n} (T_{Bi} - \overline{T}_B)^2$$

$$S_{T_{ABZ} T_{ABZ}} = \sum_{i=1}^{n} (T_{ABZi} - \overline{T}_{ABZ})^2$$

$$S^2 = \frac{S_{T_{ABZ} T_{ABZ}}}{n-2} \cdot (1 - \frac{S^2{}_{T_B T_{ABZ}}}{S_{T_B T_B} \cdot S_{T_{ABZ} T_{ABZ}}})$$

with:

$\overline{T}_{ABZ}$	Mean temperature at the end of the afterburning zone
$\overline{T}_B$	Mean temperature of the operational measurement
S	Standard deviation

For calibration of the operational measurement will proceed as follows:

$$\Delta\overline{T}_{ABZ} = \frac{1}{6} \sum_{i=1}^{6} (T_{ABZi} - T_{Bi})$$

$$\Delta\overline{T}^*{}_{ABZ} = A \cdot x + B$$

$$T_{CalB} = T_{B10} + \Delta\overline{T}^*{}_{ABZ}$$

$$\Delta\overline{T}^*{}_{ABZ} = \Delta\overline{T}_{ABZ} - V_B$$

with:

A,B	Parameters of the general analysis function
x	Signal of the boiler load

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7.3.2 Evaluation of the calibration function

Evaluation 60 % MCR; Residence time 2,0 Seconds

ΔH_{ABZ} = -7,51 m

$\frac{\Delta T_{\Delta T_{1,2}}}{\Delta H_{1,2}}$ = 20,56 °C/m

meas. No.	steam flow t/h	T ABZ °C	temp. operating plane average (°C)	difference °C
1	92,4	952	715	238
2	93,1	956	712	243
3	93,7	962	717	245
4	92,7	963	717	246
5	92,8	962	715	246
6	96,5	973	727	246
Mittelwert	93,5	961	717	244

Evaluation 100 % MCR; Residence time 2,0 Seconds

ΔH_{ABZ} = -4,63 m

$\frac{\Delta T_{\Delta T_{1,2}}}{\Delta H_{1,2}}$ = 16,99 °C/m

meas. No.	steam flow t/h	T ABZ °C	temp. operating plane average (°C)	difference °C
1	160,5	1005	828	177
2	160,1	1009	829	180
3	156,6	1000	825	175
4	160,6	1008	828	180
5	159,7	1002	829	173
6	158,2	1002	825	177
Mittelwert	159,3	1004	827	177

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7.3.2.1 Coherence between boiler load and $\Delta\overline{T}_{ABZ}$

Requirement: The connection between the boiler load and the $\Delta\overline{T}_{ABZ}$ is to be determined by a regression analysis.

Method: The measured values of boiler load are compared to the calculated differences between operating temperature and temperature at the plane of the calculated retention time.

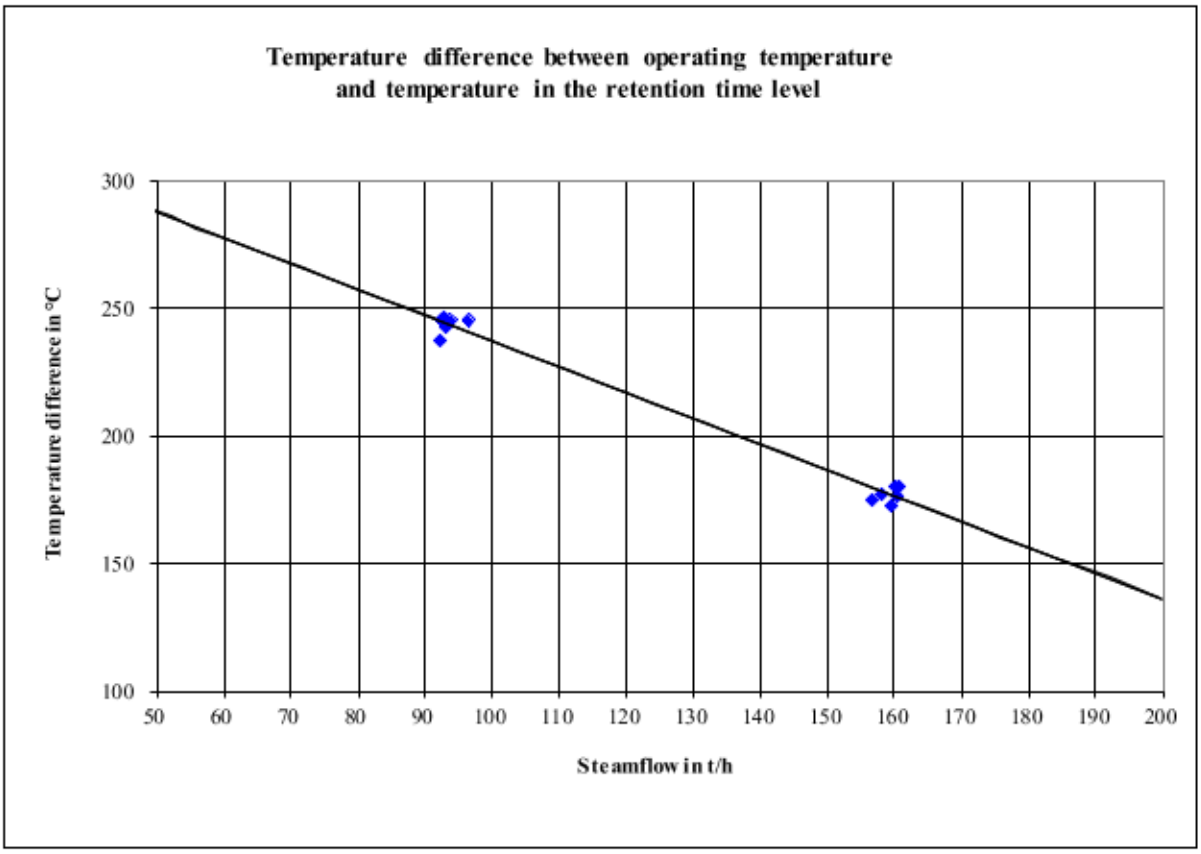
Result: A linear regression was determined, which can be described as follows:

$$\Delta\overline{T}^{*}_{ABZ} = A \cdot x + B$$

A,B Parameter of the general analysis function
x Signal of the steam flow measuring instrument in t/h

Temp. diffenence between retention time level and operating temp.

Meas. No.	Value Steam flow t/h	Temp. difference delta T ABZ K	T ABZ °C	T Operation °C	Loadpoint %
1	**92,4**	**238**	952	715	60
2	**93,1**	**243**	956	712	60
3	**93,7**	**245**	962	717	60
4	**92,7**	**246**	963	717	60
5	**92,8**	**246**	962	715	60
6	**96,5**	**246**	973	727	60
7	**160,5**	**177**	1005	828	100
8	**160,1**	**180**	1009	829	100
9	**156,6**	**175**	1000	825	100
10	**160,6**	**180**	1008	828	100
11	**159,7**	**173**	1002	829	100
12	**158,2**	**177**	1002	825	100



Results of the regression analyse for the minimung temperature

Coefficients of the calibration function	y = A x + B	1)	
	A	-1,013	(°C)/(t/h)
	B	338,5	(°C)

1) y = Temperature difference between operating temperature and 2 sec level
x = Steam flow in t/h

7.3.2.2 Confidence interval

Calculation of the confidence interval from the total number of the net measurements

Standard deviation	$S =$	7,3
Threshold value of the t-distribution	$t_{n-2} =$	2,228
Confidence interval	$V_B =$	5,4 °C

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8 Plausibility test

There is to make a plausibility test of the measurement results with regard to the plant load during the measurement period.

In this connection, the manner in which the plausibility test was carried out is to be described as well as those factors which were taken into account. Such factors might be:

- Previous knowledge of the plant
- Previous knowledge of comparable plants
- Comparison of various measurement values
- Correlation of signal patterns with varying operating states

In respect of the previous knowledge, the measuring results in this report are plausible.

Testing Laboratory / Calibration
Measuring Laboratory - DAkkS accredited according to DIN EN ISO/IEC 17025

Responsible person
Chalid Jonas Tawfik

Project manager
Gaylord Höß

signed *Höß*

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9 Appendix 1: Explanation of the used method for measurements

Requirements sector guidance IPPC 5.01

- Measure worst case gas residence time using a time of flight method.
- Use multiple traverse measurements of gas temperature to identify (or confirm) the lowest gas temperature location at, or shortly after, the qualifying secondary combustion zone.
- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.
- Use suction pyrometers to measure temperatures (acoustic pyrometers or shielded thermocouples may only be used if calibrated against suction pyrometers).

Multiple traverse measurement

- Use multiple traverse measurements of gas temperature to identify (or confirm) the lowest gas temperature location at, or shortly after, the qualifying secondary combustion zone.

  Selected method: multiple traverse measurements of gas temperature and oxygen contend time synchronized with the retention time.

  Execution: The furnace temperature was measured at 2 cross section positions using suction pyrometers. The cross sections will be as near as possible to the ABZ start and ABZ end. The temperature measurements at each location are taken in a traverse for 10 minutes each and at the centre of equal areas.

- Confirm that 95% of the one-minute mean temperatures (continuously monitored at the identified lowest temperature location over a period of at least one hour) exceed the stated minimum temperature requirement.

  Selected method: multiple traverse measurements of gas temperature and oxygen contend time synchronized with the residence time.

  Execution: The furnace temperature will be measured each point at a 10-minute intervals. After the grid measurement the lowest point is indicated and measured fix for one hour.
  That means three times the confirmation over the performance test period.

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- Use suction pyrometers to measure temperatures.

  Selected method: we use suction pyrometer with a triple ceramic shield and compressed air for the operating of suction.




The gases resulting from the combustion of non-hazardous wastes must be maintained at

- above 850 °C for at least 2 seconds (IED Article 50(2)).

  Selected method: The plug flow method is selected for a time equivalent determination of retention time. The furnace temperature will be measured at 2 cross section positions by using suction pyrometers.

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10 Appendix 2: Evaluations according to the guidelines

10.1 Determination of the temperature gradient

Grid measurements for the licensed operating states will be carried out on the same operating state of the plant on the measuring planes 1 and 2 at the same time.
The conditions of the measurements are described before. The average temperature difference $\Delta T_{1,2}$ between plane 1 and 2 for the respective operating state is formed out of the measured values.

$$\Delta T_{1,2} = \frac{1}{n}\sum_{i=1}^{n}(T_{2i} - T_{1i})$$

T_{1i}	Average value of the temperature grid measurement on measuring plane 1
T_{2i}	Average value of the temperature grid measurement on measuring plane 2
n	Number of the temperature grid measurements on measuring plane 1 or 2
$\Delta T_{1,2}$	Average temperature difference between measuring plane 1 and 2

The temperature gradient T_G can be determined out of the temperature difference $\Delta T_{1,2}$ and the difference in altitude $\Delta H_{1,2}$.

$$T_G = \frac{\Delta T_{1,2}}{\Delta H_{1,2}}$$

$\Delta T_{1,2}$	Average temperature difference between measuring plane 1 and 2
$\Delta H_{1,2}$	Distance between measuring plane 1 and 2
T_G	Average temperature gradient

On supposition of a linear course of temperature between measuring plane 1 and 2, or beyond it, the average temperature for each plane in the combustion chamber is determined by that. Inverse the plane in the combustion chamber, in which the minimum temperature of the exhaust gases is barely kept, can be determined arithmetically.

$$T_1 = \frac{1}{n}\sum_{i=1}^{n} T_{1i}$$

$$\Delta H_T = (T_1 - T_M)\frac{\Delta H_{1,2}}{\Delta T_{1,2}}$$

T_1	Average value of the temperature grid measurement measuring plane 1
T_M	Minimum temperature of the exhaust gases (850 °C)
$\Delta H_{1,2}$	Distance between measuring plane 1 and 2
$\Delta T_{1,2}$	Average temperature difference between measuring plane 1 and 2
ΔH_T	Distance between the plane in the combustion chamber, on which the exhaust gases still keep the minimum temperature on an average and measuring plane 1

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10.2 Determination of the residence time

To determine the residence time of the exhaust gases in the range above the minimum temperature, the exhaust gas volume flow will be measured and shall be converted to the exhaust gas conditions in the after burning zone.
The measurement of the volume flow shall be taken under consideration of the EN ISO 16911-1 isochronic to the grid measurements to prove the minimum temperature. When calculating the residence time the flow conditions in the after burning zone are taken as ideal plug flow.
According to the proof of the assumption of an ideal plug flow for the calculation of the residence time the RW TÜV has drafted an unpublished report, so far by order of the president of German Regional Council in Münster from the 14.07.1987.

To determine the residence time of the stack gas experimentally in the after burning chamber a noble gas tracer had been injected in 2 control planes at the gravity centre of the planes, which run through the after burning zone together with the exhaust gases. At the quitting of the last control plane the exhaust gas flow had been led to a transportable mass spectrometer by a partial sampling in the measuring grid. The residence time of the tracer had been determined out of the time difference between injection and the time of the signal rise at the mass spectrometer (corrected on the response time). The calculation, as it is described in this case, had also been carried out and compared with the tracer gas test.
The calculation of the residence time on the assumption of an ideal plug flow can be advocated because of the results.
The parameters like O_2, pressure and humidity in the after burning zone, which are necessary for the conversion, have to be recorded by measurements.
The temperature taken as a basis for the conversion is the average value from the temperature at beginning of the after burning zone T_{BABZ} and the minimum temperature.

Under consideration of the geometric conditions and the converted volume flow, it is possible to calculate the residence time in the after burning zone using the following formula.

$$t_{rt} = \frac{A \cdot (\Delta H + \Delta H_T)}{\dot{V}_{cc}}$$

A	Cross section area combustion chamber (for A = const.)
ΔH	Distance between beginning of after burning zone and measuring plane 1
ΔH_T	Distance between the plane in the combustion chamber at which the exhaust gases still keep the minimum temperature on average and measuring plane 1
$\dot{V}_{cc}$	Average value of volume flow of the exhaust gases in the combustion chamber (at operating state, humid) at $\frac{T_{BABZ} + T_M}{2}$
t_{rt}	Residence time of exhaust gases above minimum temperature

Criterion of quality is a retention time of 2 seconds.

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11 Appendix 2: Measurement uncertainties

The following example shows the theoretical maximum of uncertainties for measurements in the after burning chamber. The real uncertainties will be calculated after the measurements under care and attention of the local conditions at site.

When measuring the temperature, the measuring uncertainty is determined and calculated as follows shown as an example.

Accidental component of the measuring uncertainty
The more measurements are carried out the smaller becomes the accidental component of the measuring uncertainty of the average value of repeated measurements. The number of tests is determined by convention. In the present case the accidental component can be regarded as very small and therefore be ignored.

Well-known systematic component of the measuring uncertainty
Exactly well-known systematic measuring uncertainties are not known

Unknown systematic component of the measuring uncertainty
The measuring uncertainties have to be assigned to this group, but it is necessary to distinguish the two:
a, Measuring uncertainties caused by unknown systematic deviations which can be treated arithmetically like accidental deviations.
b, Measuring uncertainties caused by unknown systematic deviations which have to be treated by all means like systematic deviations.

Addition of measuring uncertainties
For a temperature measuring system the respective uncertainties are squarely added if they can be treated like accidental ones.
Deviations as specified to a, as well as to b, are known in the present case.
The deviations as specified to b, have the same direction of action and are first of all added linearly. The result is treated like an accidental deviation and added squarely.

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11.1 Measuring uncertainties of the measurement of minimum temperature

Uncertainties specified to a,: Precision of measuring of the thermocouples type K (Weights and measures regulations 14.2 PTB)	e_T	± 2,5 °C
Uncertainty by non-homogeneity of material (VDI3511 part 1)	e_M	± 5 °C
Uncertainty by the reference junction correction (VDI 3511 part 2)	e_V	± 3 °C
Uncertainty by analogue/digital conversion (data acquisition and control system (Estimated, ± 0,2 % of the final value of the measuring range)	e_{AD}	± 1,7 °C
Uncertainty by temporary variable measuring values (systemic inertia) (VDI 3511 part 2)	e_S	± 3 °C
Uncertainty by the spatial situation of the measuring points	e_L	± 3 °C
Uncertainties specified to b,: Drift dependence of the element of the temperature (Weights and measures regulation 14.2 PTB)	e_D	+ 2,3 °C
Radiation error by ceramics in dependence on the diameter of the element (VDI 3511 part 5, dependent on the temperature)	e_{St}	+ 5 °C
Increase of temperature in the air during the suction (VDI 3511 part 5, dependent on the speed)	eA	+ 2,5 °C

Calculation of the measuring uncertainty

$$e = \sqrt{e_t^{\,2} + e_M^{\,2} + e_V^{\,2} + e_{AD}^{\,2} + e_S^{\,2} + e_L^{\,2} + (e_D + e_{St} + e_A)^2}$$

$$e = \sqrt{2{,}5^2 + 5^2 + 3^2 + 1{,}7^2 + 3^2 + 3^2 + (2{,}3 + 5 + 2{,}5)^2}$$

The measuring uncertainty of the definition of the minimum temperature amounts to ± 12,5 °C.

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11.2 Calculation of the measuring uncertainty of the residence time

The uncertainty, relative to the residence time, is based on the measuring uncertainties of the single measured values which enter into the calculation. To each of these values a range of uncertainty has to be assigned. For those values which are measured in the clean gas the confidence range statistically found out by calibration was used. For those values measured in the after burning zone: the minimum temperature and the minimum content of oxygen, there are enclosed separate uncertainty calculations whose result is taken into consideration in the present case. The uncertainties for all further values are known (for example literature etc.) or have to be estimated. The evaluation was, among other things, carried out according to the following guidelines:

General technical measuring terms	DIN 1319 part 3	08/83
General technical measuring terms	DIN 1319 part 4	12/85
Progression of error limits	VDE/VDI 2620 part 1	01/73
Progression of error limits	VDE/VDI 2620 part 2	01/73

The single measuring values which enter into the calculation are listed in the following.

-Clean Gas
volume flow after boiler
temperature after boiler pressure at the measuring point
content of moisture after boiler
oxygen content after boiler

-After Burning Zone
volume flow of stack gas
mean temperature NBZ
mean oxygen content NBZ
pressure at the measuring point
content of moisture

-Geometry

area	A
height	ΔH
height	ΔHT

-Symbols

G:	limits of error
x_1, x_2:	measured values
A:	area
H:	height
Ht:	difference in altitude
V_{FR}:	volume flow in m³/h
t:	temperature of stack gas in °C
p:	ambient air pressure in hPa
f:	moisture of exhaust gas in Vol. %
O_2:	mean oxygen content of the exhaust gases in Vol. %

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Measuring Uncertainty of the Residence Time

Statistic Result of the Error Limit G when Connecting by means of Addition:

$$G = \pm\sqrt{G_1^2 + G_2^2}$$

Relative Statistic Result of Error Limit G when Connecting by means of Multiplication:

$$G = \pm\sqrt{\left(\frac{|G_1|}{x_1}\right)^2 + \left(\frac{|G_2|}{x_2}\right)^2}$$

Relative Statistic Result of Error Limit G when Connecting by means of Division:

$$G = \pm\sqrt{\left(\frac{|G_1|}{x_1}\right)^2 + \left(\frac{|G_2|}{x_2}\right)^2}$$

Conversion Formula of Volume Flow:

Standardization:

$$\dot{V}_{Norm,O_2} = \frac{\dot{V}_{Betr.}}{\frac{273,15 + t}{273,15} * \frac{1013}{p} * \frac{100}{100 - f} * \frac{21}{21 - O_2}}$$

Destandardization:

$$\dot{V}_{Betr.} = \dot{V}_{Norm_{O_2}} * \frac{273,15 + t}{273,15} * \frac{1013}{p} * \frac{100}{100 - f} * \frac{21}{21 - O_2}$$

Formula of Calculation of the Residence Time t_{rt}

$$t_{rt} = \frac{A * (H + H_1)}{\dot{V}_{cc}}$$

Error limit of the Volume Flow Measuring:

$$\left|G_{\dot{V}}\right| = \left|\frac{\Delta\dot{V}}{\dot{V}}\right|$$

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Calculation of Measuring Uncertainty of the Residence Time

Error Limit of the Measurement of Temperature:

$$|G_t| = \left| \frac{273,15 + (t + \Delta t)}{273,15} - \frac{273,15 + t}{273,15} \right|$$

Error Limit of the Measurement of Pressure

$$|G_p| = \left| \frac{1013}{p + \Delta p} - \frac{1013}{p} \right|$$

Error Limit of the Measurement of Moisture:

$$|G_f| = \left| \frac{100}{100 - f} - \frac{100}{100 - (f + \Delta f)} \right|$$

Error Limit of the O_2 Measurement:

$$|G_{O_2}| = \left| \frac{21}{21 - O_2} - \frac{21}{21 - (O_2 + \Delta O_2)} \right|$$

Error Limit of Planimetry

$$|G_A| = |(a + \Delta a) * (b + \Delta b) - (a * b)|$$

Error Limit of Altitude Measuring

$$|G_H| = \left| \sqrt{\Delta H^2 + \Delta H_t^{\,2}} * (H + H_t) \right|$$

Relative Statistic Result of the Error Limit of the Residence Time G_{rt}

$$|G_{rt}| = \pm \sqrt{\left(\frac{|G_A|}{A}\right)^2 + \left(\frac{|G_H|}{H}\right)^2 + \left(\frac{|G_V|}{\dot{V}_{FR}}\right)^2}$$

The measuring uncertainty for the determination of the retention time is essentially dependent on the range of tolerance of the measurement of the volume flow. The mean error of the residence time amounts to about 10 % (≈ 0,2 sec.) of the measured value.

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11.3 Calculation of measuring uncertainty of the measuring system for the minimum oxygen content

The measuring uncertainty in measuring systems for the minimum oxygen content is determined and calculated as follows.

Accidental component of the measuring uncertainty

The more measurements are taken the smaller the accidental component of the measuring uncertainty of the average value of repeated measurements gets. The number of tests is determined by convention. In the present case the accidental component can be regarded as very small and therefore be ignored.

Well-known systematic component of the measuring uncertainty

Exact well-known systematic measuring uncertainties are not known.

Unknown systematic component of the measuring uncertainty

The measuring uncertainties have to be assigned to this group but it is necessary to distinguish:

a, Uncertainties caused by unknown systematic deviations which can be treated arithmetically like the two:

b, Uncertainties caused by unknown systematic deviations which have to be treated like systematic deviations by all means.

Addition of measuring uncertainties

For a measuring system for the minimum oxygen content the respective uncertainties are added squarely if they can be treated as accidental ones.
Deviations as specified to a, as well as to b, are known in the present case.
The deviations as specified to b, have the same direction of action and are first of all added linearly. The result is treated like an accidental deviation and added squarely.

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Measuring uncertainties of the definition of the minimum oxygen content

Measuring uncertainties specified to a,:

Precision of measuring of the analyzer (Probation guideline)	e_T	± 0,20 Vol. %
Uncertainty by calibration gas mixture (Certification)	e_M	± 0,06 Vol. %
Uncertainty by analogue/digital conversion (data acquisition and control system) (statement of the constructor, ± 1% of the final value of the measuring range)	e_{AD}	± 0,25 Vol.%
Uncertainty by temporary variable measuring values (systematic inertia) (Dead-time and 90%-time)	e_S	± 0,10 Vol. %
Uncertainty by local situation of the measuring points (Deviation of the measuring grid x)	e_L	± 0,60 Vol. %
Drift dependence of the analyzer from the temperature (type approval guideline)	e_D	± 0,10 Vol. %

Uncertainties specified to b,:

After burning effect in the non-cooled part of the probe (Catalytic after burning of CO (tube furnace effect))	e_{NV}	± 0,05 Vol. %

Calculation of the measuring uncertainty

$$e = \sqrt{e_t^{\,2} + e_M^{\,2} + e_{AD}^{\,2} + e_S^{\,2} + e_L^{\,2} + e_D^{\,2} + e_{NV}^{\,2}}$$

$$e = \sqrt{0{,}2^2 + 0{,}06^2 + 0{,}25^2 + 0{,}1^2 + 0{,}6^2 + 0{,}1^2 + 0{,}05^2}$$

The measuring uncertainty of the definition of the minimum oxygen content amounts to ± 0,7 Vol. %