



Twinning Project IL/11
Implementation and Strengthening the Environmental Framework for
IPPC, Resource Efficiency and Eco-Management in Israel



Excel Template for EN 14181

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Scope

- Excel Template for Calculations that are part of EN 14181
 - The template is not a report! An EN 14181 report has to provide additional information
 - The following calculations are featured:
 - Determination of the best sampling point according EN 15259
 - QAL2 – Determination and validation of the calibration function
 - AST – Verification of the calibration function
 - AST – Linearity check of the AMS
 - QAL3 – Shewart Card
- Goal: Comparison with lab's template





Determination of the best sampling point

Best available measurement point in the measurement plane for the AMS (8.4, EN 15259)

Industrial Site: Powerplant
Emission Source:
Date :

Axis - depth	NO _x		Oxygen content		Temperature		Velocity		F _{rep} %	Info profile 1 abs (deviation)
	C _{grid} mg/m ³	C _{ref} mg/m ³	O _{grid} %	O _{ref} %	T _{grid} °C	T _{ref} °C	V _{grid} m/s	V _{ref} m/s		
Axis 1 - 0,16 m	516,0	492,0	7,8	8,6	363	346	28,9	20,9	123,5%	0,21
Axis 1 - 0,47 m	542,0	501,0	7,6	8,7	373	346	28,9	20,9	123,5%	0,21
Axis 1 - 0,78 m	540,0	499,0	7,9	8,8	380	346	29,3	19,9	135,1%	0,21
Axis 1 - 1,09 m	554,0	504,0	7,9	8,8	376	346	30,3	23,1	123,6%	0,10
Axis 2 - 0,16 m	429,0	493,0	10,5	8,9	343	346	16,9	19,6	87,2%	0,26
Axis 2 - 0,47 m	497,0	489,0	8,6	8,8	344	344	29,0	19,5	144,1%	0,30
Axis 2 - 0,78 m	505,0	486,0	8,3	8,8	373	346	27,2	20,5	136,1%	0,22
Axis 2 - 1,09 m	480,0	463,0	8,3	8,7	364	344	27,2	20,8	133,5%	0,12
Axis 3 - 0,16 m	440,0	468,0	9,4	8,7	332	342	5,7	20,9	114,0%	0,29
Axis 3 - 0,47 m	467,0	474,0	9,2	8,9	339	343	21,5	23,0	95,8%	0,29
Axis 3 - 0,78 m	492,0	472,0	8,6	8,8	364	342	31,2	21,0	143,2%	0,29
Axis 3 - 1,09 m	496,0	474,0	8,7	8,9	361	342	29,7	21,2	136,6%	0,23
Axis 4 - 0,16 m	460,0	467,0	9,4	8,9	333	341	7,1	21,7	34,4%	0,79
Axis 4 - 0,47 m	445,0	447,0	9,1	8,8	335	341	20,0	21,0	98,9%	0,15
Axis 4 - 0,78 m	466,0	455,0	9,0	8,8	347	341	28,3	20,6	140,6%	0,27
Axis 4 - 1,09 m	447,0	445,0	9,0	8,8	341	341	27,2	20,8	133,5%	0,20
Min value										0,10
Mean value	486,0	476,8	8,7	8,8	354,9	343,4	24,4	20,8	114%	28%

Results		
Best sampling point	Axis 1 - 1,09 m	
F _{rep} at the best available sampling point		123,6%
Ratios of measured values at the best available sampling point to mean value of all grid measurements for:		
NO _x	C _{grid} / C _{grid-mean}	114,0%
Oxygen content	O _{grid} / O _{grid-mean}	90,7%
Temperature	T _{grid} / T _{grid-mean}	106,0%
Velocity	V _{grid} / V _{grid-mean}	124,4%

Basic data of the emission source

Traverse points checked

Measurement results and reference values

Determination of the best sampling point





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QAL2 – Calibration Function

ELV and uncertainty

Analyzer data

Calibration function and variability

Reference material data pairs

QAL2 according EN 14181:2014

Component		NOx
Emission Limit Value (ELV)		
ELV (long-term)		300 mg/m ³
Max. Uncertainty @ 95% confidence p		20 % of ELV
σ_{ELV}		10,20 % of ELV
Reference oxygen		30,61 mg/m ³
σ_{ref}		6 vol.-%
Standard Reference Method (SRM)		
Method		Chemiluminescence
Standard		EN 14792
Number of measurements N		17
K_{SRM} value (App. I, EN 14181)		0,98
F_{SRM} (W-1) (App. I, EN 14181)		2,746
Automated Measurement System (AMS)		
Type of Analyzer		ENOX II AMS CEMS
Serial No.		0815
Output Signal from		4,00 mA
to		20,00 mA
Measurement range from		0 mg/m ³
to		405 mg/m ³
Zero Offset (only Type B calibration) Z		4 mA
Linear Regression		
Method		Type A
Slope b		22,53 (mg/m ³)/mA
Offset a		-63,56 mg/m ³
Calibration Range from		0 mg/m ³
to		362,94 mg/m ³
Standard deviation calibration functions s_{SRM}		26,23 mg/m ³
$s_{\text{SRM}} / \sigma_{\text{ELV}}$		Yes

SRM/AMS data - AMS-Conditions

SRM/AMS data - ELV-Conditions

AMS / SRM Data pairs																	
No. /	Date	Start	End	AMS measurements			AMS conditions / determined by AMS				SRM measurements			AMS conditions / determined by SRM			
				y_1	y_2	$y_{1.5}$	T	p	C_{O_2}	C_{CO_2}	y_1	$y_{1.5}$	$y_{1.5}$	T	p	C_{O_2}	C_{CO_2}
1	27.09.2016	08:00	08:30	5,51	285,95	329,94	0,00	1013,25	0,00	8,04	287,00	287,00	333,72	0,00	1013,25	0,00	8,10
2	27.09.2016	10:00	10:30	8,46	127,04	145,46	0,00	1013,25	0,00	7,94	132,00	132,00	151,15	0,00	1013,25	0,00	7,90
3	27.09.2016	12:00	12:30	7,96	115,79	133,60	0,00	1013,25	0,00	8,04	147,00	147,00	170,93	0,00	1013,25	0,00	8,10
4	27.09.2016	13:30	14:00	10,52	173,38	200,05	0,00	1013,25	0,00	8,04	154,00	154,00	175,00	0,00	1013,25	0,00	7,80
5	27.09.2016	15:30	16:00	8,17	120,46	136,89	0,00	1013,25	0,00	7,84	123,00	123,00	141,92	0,00	1013,25	0,00	8,00
6	28.09.2016	08:30	09:00	6,45	81,79	93,65	0,00	1013,25	0,00	7,94	87,00	87,00	98,86	0,00	1013,25	0,00	7,80
7	28.09.2016	10:30	11:00	6,94	92,82	107,10	0,00	1013,25	0,00	8,04	67,00	67,00	76,72	0,00	1013,25	0,00	7,90
8	28.09.2016	12:30	13:00	11,00	184,37	214,36	0,00	1013,25	0,00	8,14	192,00	192,00	218,18	0,00	1013,25	0,00	7,90
9	28.09.2016	14:30	15:00	14,78	269,43	310,89	0,00	1013,25	0,00	8,04	298,00	298,00	338,64	0,00	1013,25	0,00	7,80
10	28.09.2016	16:30	17:00	8,73	133,09	152,39	0,00	1013,25	0,00	7,94	123,00	123,00	141,92	0,00	1013,25	0,00	8,00
11	01.10.2016	08:00	08:30	10,99	184,05	209,14	0,00	1013,25	0,00	7,84	139,00	139,00	157,95	0,00	1013,25	0,00	7,80
12	01.10.2016	09:30	10:00	11,76	201,48	232,47	0,00	1013,25	0,00	8,04	172,00	172,00	200,00	0,00	1013,25	0,00	8,10
13	01.10.2016	11:00	11:30	14,00	251,79	290,53	0,00	1013,25	0,00	8,04	256,00	256,00	286,57	0,00	1013,25	0,00	7,60
14	01.10.2016	12:30	13:00	14,60	265,31	301,49	0,00	1013,25	0,00	7,84	247,00	247,00	289,45	0,00	1013,25	0,00	8,20
15	01.10.2016	14:00	14:30	12,99	229,15	262,39	0,00	1013,25	0,00	7,94	266,00	266,00	302,27	0,00	1013,25	0,00	7,80
16	01.10.2016	15:00	15:30	11,42	193,68	223,48	0,00	1013,25	0,00	8,04	187,00	187,00	214,12	0,00	1013,25	0,00	7,90
17	01.10.2016	16:30	17:00	7,72	110,43	125,48	0,00	1013,25	0,00	7,84	143,00	143,00	165,00	0,00	1013,25	0,00	8,00

AMS / Reference material Data pairs - Only Type C calibration!																	
No. /	Date	Time	Code	AMS measurements			AMS conditions / determined by AMS				Reference Material			AMS conditions / determined by SRM			
				y_1	y_2	$y_{1.5}$	T	p	C_{O_2}	C_{CO_2}	y_1	$y_{1.5}$	$y_{1.5}$	T	p	C_{O_2}	C_{CO_2}
R1																	
R2																	

Diagrams

SRM / AMS data pairs





AST Check of the calibration function

ELV and uncertainty

Analyzer data

Calibration function an variability

AST according EN 14181:2014

Component		Nox
Emission Limit Value (ELV)		
ELV (long-term)		300 mg/m ³
Max. Uncertainty @ 95% confidence p		20 % of ELV
σ_p		10,20 % of ELV
Reference oxygen		30,61 mg/m ³
		6 vol.-%
Standard Reference Method (SRM)		
Method		
Standard		
Number of measurements N		6
$k_{p,1}$ - value (App. I, EN 14181)		0,92
$t_{0,95} (N-1)$ (App. I, EN 14181)		2,132
Automated Measurement System (AMS)		
Type of Analyzer		
Serial No.		
Output Signal from		mA
to		mA
Measurement range from		mg/m ³
to		mg/m ³
Zero Offset (only Type B calibration) Z		mA
Linear Regression		
Slope b		22,53 (mg/m ³)/(mA)
Offset a		-63,58 mg/m ³
Calibration Range from		0 mg/m ³
to		362,94 mg/m ³
Std. dev. calibration function s_D		94,87 mg/m ³
$s_D \leq 1,5 \cdot k_{p,1} \cdot \sigma_D$		NO
$ D \leq t_{0,95} (N-1) \cdot s_D / \sqrt{N} + \sigma_D$		Yes

SRM/AMS data - AMS-Conditions

SRM/AMS data - ELV-Conditions

AMS / SRM data pairs

No. / i	Date	Start	End	AMS measurements			AMS conditions / determined by AMS				SRM measurements			AMS conditions / determined by SRM			
				x_i	\hat{y}_i	$\hat{y}_{i,5}$	T	p	c_{H2O}	c_{O2}	y_i	$y_{i,2}$	$y_{i,5}$	T	p	c_{H2O}	c_{O2}
				[mA]	[mg/m ³]	[mg/m ³]	[°C]	[hPa]	[vol.-%]	[vol.-%]	[mg/m ³]	[mg/m ³]	[mg/m ³]	[°C]	[hPa]	[vol.-%]	[vol.-%]
1				5,60	62,61	62,61	0,00	1013,25	0,00	6,00	112,61	112,61	112,61	0,00	1013,25	0,00	6,00
2				8,54	128,86	128,86	0,00	1013,25	0,00	6,00	28,86	28,86	28,86	0,00	1013,25	0,00	6,00
3				11,23	189,48	189,48	0,00	1013,25	0,00	6,00	289,48	289,48	289,48	0,00	1013,25	0,00	6,00
4				5,78	66,67	66,67	0,00	1013,25	0,00	6,00	16,67	16,67	16,67	0,00	1013,25	0,00	6,00
5				6,78	89,20	89,20	0,00	1013,25	0,00	6,00	189,20	189,20	189,20	0,00	1013,25	0,00	6,00
6				15,00	274,43	274,43	0,00	1013,25	0,00	6,00	174,43	174,43	174,43	0,00	1013,25	0,00	6,00
7																	
8																	
9																	

5



AST – Linearity Check

AST Linearity check according EN 14181:2014

Automated Measurement System (AMS)											
Type of analyzer	PG-350E (Horiba 2)										
Serial number	G8UX9Y4U										
Place of installation	Raum 259										
Date of test	10.03.2016										
Start and end time of test	09:56 - 11:18										
Person in charge	Fr										
Measurement unit	mg/m ³										
Upper measurement range limit [mg/m ³]	300										

Specs of the analyzer

ID	Konzentration <i>i</i>	Reference Material Concentration y_i [mg/m ³]	Reading $x_{i,1}$ [mg/m ³]	AMS Reading $x_{i,2}$ [mg/m ³]	Reading $x_{i,3}$ [mg/m ³]	Average Readings \bar{x}_c [mg/m ³]	Auxilliary $S[Y_{ij} * (X_i - X_z)]$	Auxilliary $(X_i - X_z)^2$	Residuum d_c [mg/m ³]	rel. Residuum $d_{c,rel}$ [%]	Okay? $d_{c,rel} < 5\%$
1		0	0,30	0,30	0,40	0,33	-33,33	1111,11	-3,17	-1,06	
2		80	76,00	78,00	67,00	73,67	10313,33	2177,78	0,43	0,14	
3		20	23,00	23,00	22,00	22,67	-906,67	177,78	1,73	0,58	
4		40	46,00	54,00	48,00	49,33	986,67	44,44	10,97	3,66	
5		60	48,00	49,00	45,00	47,33	3786,67	711,11	-8,47	-2,82	
6		0	1,70	2,10	2,30	2,00	-200,00	1111,11	-1,50	-0,50	
7							0,00				
8							0,00				
9							0,00				
10							0,00				
11							0,00				
12							0,00				

Assessment

Average y_z	[mg/m ³]	33,33
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Linear Regressions

Equation	$x_i = A' + B \cdot (y_i - y_z)$	
Offset A'	[mg/m ³]	32,56
Slope B		0,87
Equation	$x_i = A + B \cdot y_i$	
Offset A	[mg/m ³]	3,50
Slope B		0,87

Readings

Result

Linearity check passed	Yes
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QAL3 – Shewart card

Analyzer specs

Thresholds

Results of the measurements

QAL3 Shewart Control Chart according Appendix C EN 14181:2014					
Automated Measurement System (AMS)			Reference Material		
Type of analyzer	PG-350E (Horiba 2)		Concentration zero reference material	mg/m ³	
Serial number	GBUX9Y4U		Concentration span reference material	200 mg/m ³	
Component	Nox		AMS Standard Deviations		
Calibration	Raum 259		Zero point standard deviation $s_{AMS,ZP}$	7,62 mg/m ³	
Measurement unit	mg/m ³		Zero point standard deviation $s_{AMS,ZP}$	3,8 %	
Long-Term ELV	200 mg/m ³		Span point standard deviation $s_{AMS,SP}$	7,62 mg/m ³	
Thresholds			AMS Standard Deviations		
Warning Threshold @ Zero Point	7,62 mg/m ³		Span point standard deviation $s_{AMS,SP}$	3,8 %	
Warning Threshold @ Zero Point	3,8 %				
Alarm Threshold @ Zero Point	15,24 mg/m ³				
Alarm Threshold @ Zero Point	7,6 %				
Warning Threshold @ Span Point	7,62 mg/m ³				
Warning Threshold @ Span Point	3,8 %				
Alarm Threshold @ Span Point	15,24 mg/m ³				
Alarm Threshold @ Span Point	7,6 %				
QAL3 Measurements					
No.	Date	Zero Point		Span Point	
		x [mg/m ³]	Δ [mg/m ³]	x [mg/m ³]	Δ [mg/m ³]
1		0	0	200	0
2		-0,5	-0,5	200	0
3		-0,8	-0,8	200,5	0,5
4		-0,7	-0,7	200,5	0,5
5		-0,5	-0,5	201	1
6		-1	-1	201	1
7		-1,5	-1,5	201,5	1,5
8		-1,5	-1,5	201,5	1,5
9		-1	-1	201,8	1,8
10		-0,5	-0,5	202	2
11		0	0	202,5	2,5
12		0,5	0,5	203	3
13		1	1	202,5	2,5
14		1,5	1,5	203	3
15		2	2	202	2
16		2,2	2,2	201	1
17		2,5	2,5	200	0
18		-3	-3	199	-1
19		4	4	198	-2
20		4,5	4,5	197	-3
21		5	5	196	-4
22		6	6	195	-5
23		7	7	194	-6
24		8	8	193	-7
25		9	9	192	-8

QAL3 - Shewart Card - Zero Point

QAL3 - Shewart Card - Span Point





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Questions and Remarks

