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Accredited Inspection-
and certification body,
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Manufacturer: Zystm A/S

Project No.: LAB13-03

Report No.: 1/FC-Z81/P3/06/13

Type testing of bench-type fume cupboard ZYSTM ZAFE 81, W = 900 mm, according to EN 14175-3:2004

Aachen, 19.08.2013

Head of testing station: B. Konrath

Responsible tester: M. Winklehner

CONTENTS

1.0 Introduction

I.F.I. Institut für Industrieaerodynamik GmbH, Institut an der Fachhochschule Aachen, D- 52074 Aachen, has been commissioned by Zystm A/S., DK- 7430 Ikast to test the operational reliability of the bench type fume cupboard type **Zystm ZAFE 81 (W = 900 mm)**.

The type testing of the **ZAFE 81** fume cupboard has been executed in accordance with the test procedure of EN 14 175-3:2004.

Terms and dimensions of testing fume cupboards are given in EN 14 175-1:2003,. EN 14 175-2:2003 determines the safety and performance requirements of fume cupboards. These safety and performance requirements are tested and evaluated in accordance with the type testing procedure of part 3 of EN 14 175:2004.

The EN-standard specifies no limit values. In addition the requirements concerning the containment of the fume cupboard of the professional association of the chemical industry, technical committee chemistry, dated July 29, 2003, of the tested volume flows have been checked and evaluated with regard to the compliance of the valid limit values.

<table>
<tr><th colspan="2">Limit values of professional association of the german chemical industry (BG Chemie), technical committee chemistry, dated 29.07.2003
for testing fume cupboards according to EN 14175-3:2004
(Berufsgenossenschaft der chemischen Industrie, Fachausschuss Chemie)</th></tr>
<tr><th>Maximum tracergas average value φ_x</th><th>Maximum tracergas peak value</th></tr>
<tr><td rowspan="2">0,65 ppm</td><td>5 * 0,65 ppm = 3,25 ppm
(Containment: robustness φ_R and sash movement phases φ_3, φ_5 of outer measurement grid test)</td></tr>
<tr><td>3 * 0,65 ppm = 1,95 ppm
(Containment: static sash phases φ_2, φ_4 of outer measurement grid test)</td></tr>
</table>

For the measurement values on inner measurement plane, the French NF XPX 15-203 gives a limit value of 0,1 ppm for the average concentration value at each measuring point.

2.0 Description of the test specimen

2.1 Structural design and main dimensions

Figure 1 shows the tested bench-type **ZAFE 81** of nominal width 900 mm. The fume cupboard **ZAFE 81** consists mainly of a steel frame structure carrying the casing and containing the table leaf. A airfoil-profile is installed in front of the desktop. The profile is moveable and separately locked to prohibit the uncontrolled movement. The height of desktop was 900 mm.

The main dimensions of the test specimen are:

ZAFE 81	width (mm)	height (mm)	depth (mm)
External	900	2300	850
Internal	850	1110	575-640
Sash opening	850	500	-
Drawing no. of manufacturer	10380003-8100090.iam; ZAFE 81; Birgitte Videbæk Nielsen; 31.01.2013		

The fume cupboard **ZAFE 81**has a one-piece sash with a mechanical stopping device at 500 mm opening. These are resulting in the following test sash opening:

	width (mm)	height (mm)
Sash opening: vertical	850	500
Sash opening: horizontal, right	none	none
Sash opening: horizontal, left	none	none

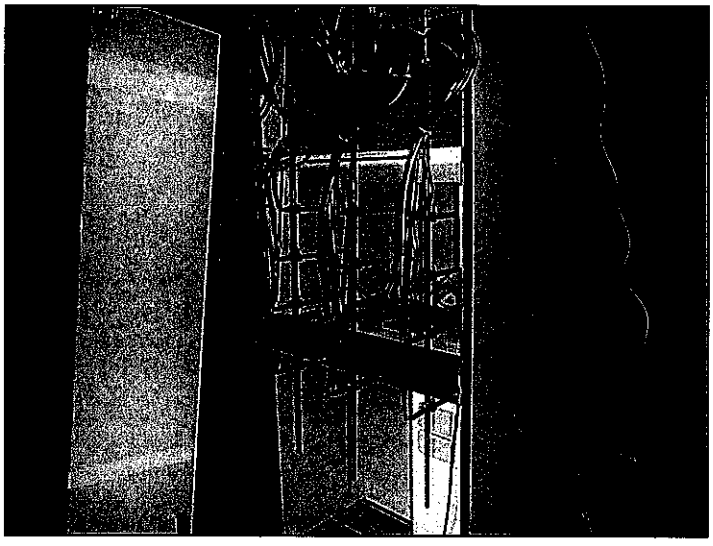


Figure 1: ZAFE 81 in test room

2.2 Extract air and test volume flow rate

An exhaust air socket of diameter d = 250 mm is fitted into the ceiling of the device. The fume cupboard **ZAFE 81** has been connected to the volume flow measuring system of the testing room via a hose of 1.5 m length and a diameter of d = 250 mm and the extract air has been discharged from the testing room into the atmosphere.

The fume cupboard **ZAFE 81** has been tested at the following face velocities and correspondent extract volume flow rates:

	Test 1	**Test 2**	**Test 3**
Tested face velocities	0.499 m/s	0.302 m/s	-
Correspondent extract volume flow rate	788 m³/h	481 m³/h	-

2.3 Control device

Not tested.

2.4 Test room conditions and atmospheric environment

Test room dimensions:		**Room climate (average):**		**Place of installation:**
Depth	: 5,6 m	Temperature	: 20 - 22 °C	
Width	: 4.6 m	Atmospheric pressure	: 1008 -1019 hPa	centred at a
Height	: 4.0 m	relative humidity	: 38 - 61 %	sound-reflecting rear wall
		air speed in test room	: < 0,1 m/s	
		Room differential pressure	: - 2.2 pa	

2.5 Test procedure

Gas outlets were mounted in the fume cupboard **Zystm ZAFE 81** in accordance with EN14175-3:2004 and placed in a distance of 200 (+-5) mm from the sash plane. As stipulated in EN 14175-3 the sash was set on a sash opening of 500 mm height.

A measurement pattern was mounted in front of the fume cupboard in a distance of 50 (+- 5) mm from the sash plane in accordance with EN14175-3:2004, 5.3.4.2.

The moved panel (1,9 x 1,4 m) for testing the **robustness of containment** was mounted in a distance of 400 (+-5) mm parallel to the sash plane of the fume cupboard in accordance with EN14175-3:2004, 5.4 (see Fig. 2). The range of moving was 3300 mm and was crossing six times with a velocity of v = 1 m/s (see EN14175-3:2004, 5.4). The total testing time was 275 seconds.

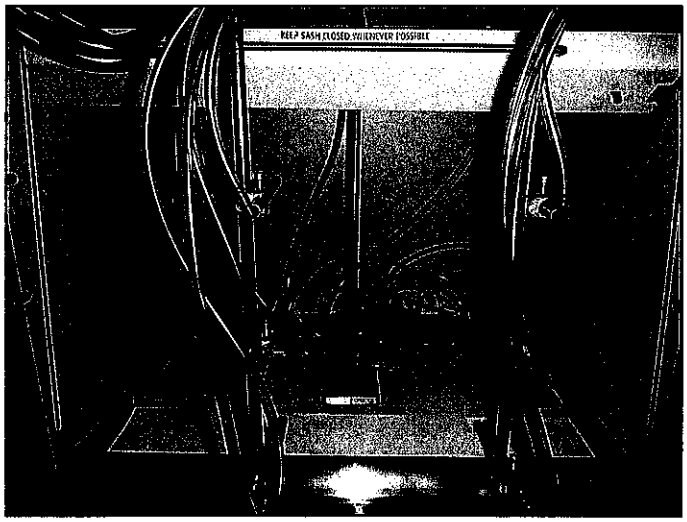


Fig. 2: Set-up of the testing facility in accordance with EN14175-3:2004, 5.4, robustness of containment

The test of the **outer measurement plane** was performed in accordance with EN 14175-3:2004, 5.3. The total testing time is 780 seconds, which are subdivided as follows: the first measurement cycle with open sash lasts 360 seconds (average concentration φ_2); after 360 seconds, the sash is closed in 1 second for the period of second 360 to 420 (average concentration φ_3) and remains closed for 240 seconds ((average concentration φ_4), before opening again at second 600 (average concentration φ_5 for the period of second 600 to 780).

The test gas was a mixture of 10% (per cent by volume) sulphur hexafluoride (SF6) in air. The tracer gas flow to test the fume cupboard was realized with a volume flow rate of 4,5 l/min (in accordance with EN14175-3:2004, 5.3.1.3).

The concentrations were measured using a Foxboro gas-infrared-absorption-spectrometer, Type MIRAN 1A. The measuring system was calibrated from 0 to 10 ppm. The measured values were entered and analyzed using a PC with a built-in A/D-converter, type DASH 16 of Keithley Instruments Inc..

The test gas coming from the fume cupboard was sucked by the probe samplers built in accordance with EN14175-3:2004 and conducted to the measurement instrument through 2 m long hoses and the probe collector also described in the Standard. The analog concentration signal was entered 5 times in the second, digitized, converted to a concentration value, then summarized to an average value and saved for further analysis.

If a test results in values above 0,01 ppm, EN 14175-3:2004 stipulates that 2 repeated measurements of this test are performed. However for the analysis, the measured values of the first 60 seconds are not taken into consideration in EN14175-3:2004 to realize balanced conditions.

The data and results were analyzed in accordance with EN14175-3:2004, 5.4.5.

The test of the **containment of the inner measurement grid** was performed in accordance with EN14175-3:2004, 5.3.

Again, the test gas was a mixture of 10% (per cent by volume) sulphur hexafluoride (SF6) in air. The amount of test gas was realized with a volume flow rate of 2,0 l/min in accordance with EN14175-3:2004, 5.3.5.2.

The measurement pattern, according to 5.3.3. of EN14175-3:2004, is installed to six positions in the inner measurement plane.

The total test time is 360 seconds. If a test results in values above 0,01 ppm, DIN EN14175-3:2004 stipulates that 2 repeated measurements of this test are performed.

However for the analysis, the measured values of the first 60 seconds are not taken into consideration in EN14175-3:2004 to realize balanced conditions.

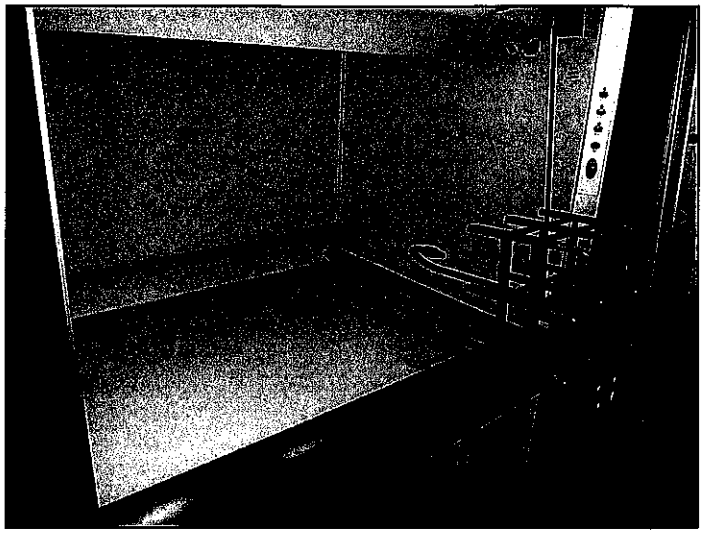


Fig. 3: Set-up of the testing facility in accordance with EN14175-3:2004, 5.3 (containment of inner measurement grid)

The determination of the face velocities was done according to EN 14175-3:2004, 5.2. The air velocities are measured at 15 points in the inner sash plane. The total test time is 60 seconds at each measurement point.

3.0 Measuring equipment used

Gas absorption spectrometer MIRAN 1 A CVF Ser. No. 4431 Foxboro; calibrated on: 03.12.2012

Propeller anemometer, MODEL 27106 , Young; calibrated on: 03.12.2012

Gas outlet in accordance with EN 14 175-3:2004

Personal Computer Pentium 333

BROOKS mass flow controller, Type 5850 E, Ser. Nr.: T20466

BROOKS controller, Type 5875

TSI-air velocity probe, Type 8475 , 0-2 m/s, Ser. no.: 0204211; calibrated on: 08.11.2012

Hygro-Thermo-Barograph, Type 8070 Nr. HK 4688 G. Lufft

A/D-Converter DAS16 Keithley

Test and evaluation software DIGISTO2, I.F.I. GmbH

ISEL tooth belt feeder BL1, No. 232101 0155

Testo Luxmeter 545, Ser.No.: 00711097/206

Spring balance Pesola, 0-5 kg, No. kra-002

Halstrup Multur, 0- 1000 Pa, Ser. No: 11970207, calibrated: 10-2012

Smoke tube, I.F.I. Gmbh

3.1 Averaged concentration detection limit of the measuring system

Date of tests: 14.- 21.06.2013	**ppm**
Detection limit (2 x σ)	< 0,005
Time constant	< 15 sec.

4.0 Results of testing the face velocities in accordance with EN 14 175-3:2004

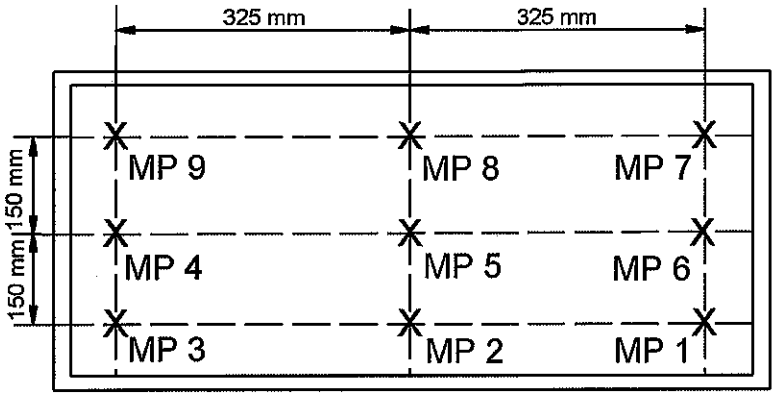
4.1 Averaged face velocity in accordance with EN 14 175-3:2004, 5.2.

	Test 1	Test 2	Test 3
	$V_{\text{In average}}$ (m/s)	$V_{\text{In average}}$ (m/s)	$V_{\text{In average}}$ (m/s)
Nominal	0.30	0.50	-
Tested	0.302	0.499	-

4.2 Individual results of the face velocities in accordance with EN 14 175-3:2004, 5.2.

Measuring point MP	Test 1		Test 2		Test 3	
	V_{In} (m/s)	Standard deviation (m/s)	V_{In} (m/s)	Standard deviation (m/s)	V_{in} (m/s)	Standard deviation (m/s)
MP 1	0.26	0.06	0.51	0.05	-	-
MP 2	0.32	0.02	0.49	0.02	-	-
MP 3	0.30	0.02	0.50	0.02	-	-
MP 4	0.31	0.03	0.54	0.05	-	-
MP 5	0.25	0.01	0.40	0.02	-	-
MP 6	0.32	0.02	0.54	0.01	-	-
MP 7	0.37	0.03	0.58	0.03	-	-
MP 8	0.28	0.01	0.44	0.01	-	-
MP 9	0.31	0.02	0.49	0.02	-	-

4.3 Measuring positions of the face velocities at the vertical sash opening in accordance with EN 14 175-3:2004, 5.2.



5.0 Results of the containment tests in accordance with EN 14 175-3:2004

5.1 Individual results of the containment of the inner measurement plane of the vertical sash opening (opening height 500 mm) in accordance with EN 14 175-3:2004, 5.3.

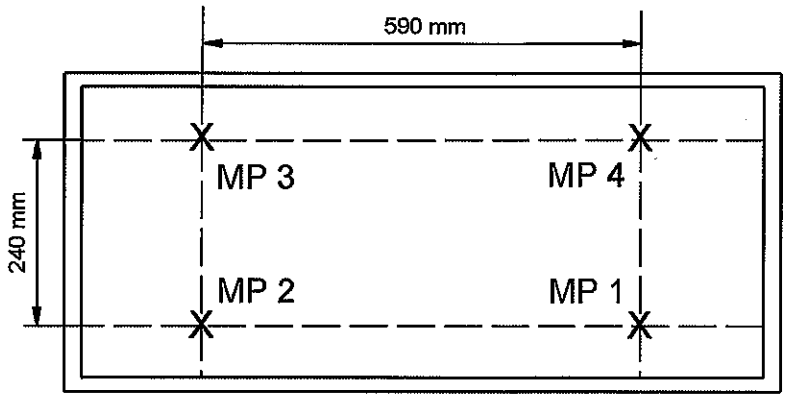
Face velocity: 0.3 m/s Sash opening	Measurement point No.	Test No.	φ_1 ppm	Containment factor C_{F1}	 $C_{F1\ mittel}$	$\varphi_{1\ average}$ ppm
500 mm vertical	1	1	<0.01	>5613	>5613	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	2	1	<0.01	>5613	>5613	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	3	1	<0.01	>5613	>5613	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	4	1	<0.01	>5613	>5613	<0.01
		2	-	-		
		3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-3:2004 (< 0.01)

Face velocity: 0.5 m/s Sash opening	Measurement point	Test	φ_1	Containment factor		$\varphi_{1\ average}$
	No.	No.	ppm	C_{F1}	$C_{F1\ mittel}$	ppm
500 mm vertical	1	1	<0.01	>3426	>3426	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	2	1	<0.01	>3426	>3426	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	3	1	<0.01	>3426	>3426	<0.01
		2	-	-		
		3	-	-		
500 mm vertical	4	1	<0.01	>3426	>3426	<0.01
		2	-	-		
		3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-2:2004 (< 0.01)

5.2 Measuring positions for the vertical sash opening of the inner measurement plane in accordance with EN 14 175-3:2004, 5.3



5.3 Averaged tracer gas concentration φ_1 and containment factors C_{F1} of the containment for the inner measurement plane in accordance with EN 14 175-3:2004, 5.3

Face velocity/ Sash opening	φ_1	Containment factor
	ppm	C_{F1}
0.3 m/s 850 x 500 mm vertical	<0.01	>5613
0.5 m/s 850 x 500 mm vertical	<0.01	>3426
- x - mm horizontal right	-	-
- x - mm horizontal left	-	-

5.4 Individual results of the tracer gas concentration φ_2 and the containment factors C_{F2} for the outer measurement plane in accordance with EN 14 175-3:2004, 5.3

0.3 m/s Sash opening	Test No.	φ_2 ppm	Containment factor C_{F2}	Containment factor $C_{F2\ average}$	$\varphi_{2\ average}$ ppm
500 mm vertical	1	<0.01	>5613	>5613	**<0.01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

0.5 m/s Sash opening	Test No.	φ_2 ppm	Containment factor C_{F2}	Containment factor $C_{F2\ average}$	$\varphi_{2\ average}$ ppm
500 mm vertical	1	<0.01	>3426	>3426	**<0 ,01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-2:2004 (< 0.01)

5.5 Individual results of the tracer gas concentration φ_3 and the containment factors C_{F3} for the outer measurement plane in accordance with EN 14 175-3:2004, 5.3

0.3 m/s Sash opening	Test No.	φ_3 ppm	Containment factor C_{F3}	$C_{F3\ average}$	$\varphi_{3\ average}$ ppm
500 mm vertical	1	<0.01	>5613	>5613	**<0.01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

0.5 m/s Sash opening	Test No.	φ_3 ppm	Containment factor C_{F3}	$C_{F3\ average}$	$\varphi_{3\ average}$ ppm
500 mm vertical	1	<0.01	>3426	>3426	**<0 ,01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-2:2004 (< 0.01)

5.6 Individual results of the tracer gas concentration φ_4 and the containment factors C_{F4} for the outer measurement plane in accordance with EN 14 175-3:2004, 5.3

0.3 m/s Sash opening	Test No.	φ_4 ppm	Containment factor C_{F4}	$C_{F4\ average}$	$\varphi_{4\ average}$ ppm
500 mm vertical	1	<0.01	>5613	>5613	**<0.01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

0.5 m/s Sash opening	Test No.	φ_4 ppm	Containment factor C_{F4}	$C_{F4\ average}$	$\varphi_{4\ average}$ ppm
500 mm vertical	1	<0.01	>3426	>3426	**<0 ,01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-2:2004 (< 0.01)

5.7 Individual results of the tracer gas concentration φ_5 and the containment factors C_{F5} for the outer measurement plane in accordance with EN 14 175-3:2004, 5.3

0.3 m/s Sash opening	Test No.	φ_5 ppm	Containment factor C_{F5}	$C_{F5\ average}$	$\varphi_{5\ average}$ ppm
500 mm vertical	1	<0.01	>5613	>5613	**<0.01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

0.5 m/s Sash opening	Test No.	φ_5 ppm	Containment factor C_{F5}	$C_{F5\ average}$	$\varphi_{5\ average}$ ppm
500 mm vertical	1	<0.01	>3426	>3426	**<0 ,01**
	2	-	-		
	3	-	-		
- mm horizontal right	1	-	-	-	-
	2	-	-		
	3	-	-		
- mm horizontal left	1	-	-	-	-
	2	-	-		
	3	-	-		

Measurement values < 0.01 ppm are below the minimum detection level of the test system used (< 0.005 ppm) and are replaced with the minimal detection value according to EN 14175-2:2004 (< 0.01)

5.8 Trace gas concentration φ_R and containment factor C_{FR} for the robustness of the containment in accordance with EN 14 175-3, 5.4.

Sash opening 500 mm vertical	φ_R	Containment factor	φ_R average	Containment factor
	ppm	C_{FR}	ppm	$C_{FR\ average}$
1. Test, 0.3 m/s	**0.02**	2807	**0.02**	2807
2. Test, 0.3 m/s	**0.02**	2807		
3. Test, 0.3 m/s	**0.03**	1871		
1. Test, 0.5 m/s	**<0.01**	>3426	**<0.01**	>3426
2. Test, 0.5 m/s	-	-		
3. Test, 0.5 m/s	-	-		

5.9 Test of the air exchange efficiency in accordance with EN 14 175-3, 5.5.

Nominal face velocity (m/s)	Internal volume V_{fc} m^3	Air exchange rate N 1/s	Air exchange efficiency ε %
0.3	0.60	0.10	**44.4**
0.5		0.13	**35.4**

5.10 Test of the pressure drop in accordance with EN 14 175-3, 5.6.

Nominal face velocity (m/s)	Sash opening/ mm	Tube cross section Ø/ mm	Pressure drop Δp_V / Pa
0.3	500	250	**21**
0.5		250	**64**
0.3	0	250	**25**
0.5		250	**69**

5.11 Tracer gas peak values C_{max} (SF_6-peak value), 0.3 m/s

Sash opening	φ_R ppm	Containment factor C_{FR}	C_{max} ppm	Tracergas peak maximum (Berufsgenossenschaft der chemischen Industrie, Fachausschuss Chemie, 29.07.03)
500 mm vertical	0.03	1871	**0.13**	**5 * 0,65 ppm = 3.25 ppm**

6.0 Further tests in accordance with EN 14 175-3:2004

6.1 Sash supension test in accordance with EN 14 175-3:2004, 6.

After the release of one of the hoisting belts the sash of the fume cupboard **ZAFE 81** remains in the proximity of its starting position and fulfils the requirements of EN 14 175-3: 2004.

Sash position: 500 mm	Change of position after release/ cm
belt released	≈ 1

6.2 Sash forces in accordance with EN 14 175-3:2004, 6.

Moving direction	Test position at the handlebar		
	300 mm left	centre	300 mm right
	Kraft/ N	Kraft/ N	Kraft/ N
Sash opening: 500 mm vertical	23	21	22
Sash closing: 500 mm vertical	18	18	17

The EN 14175-2 requires a maximum of 30 N: the test is passed.

6.3 Protection against splashes in accordance with EN 14 175-3:2004, 6.

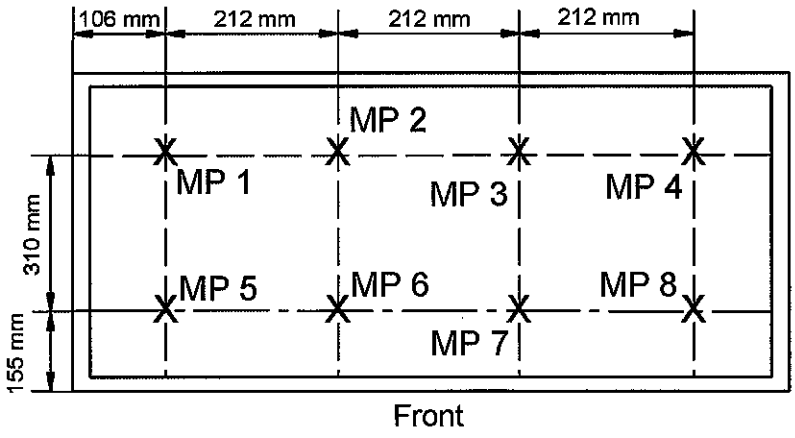
Very good: The protection against splashes of the fume cupboard **ZAFE 81**prevent the danger due to splinters and prevents spraying of liquids from the inner part of the fume cupboard into the laboratory with an overlap of 100%. The fume cupboard **ZAFE 81**therefore fulfils the demands of EN 14 175-3: 2004.

6.4 Intensity of illumination in accordance with EN 14 175-3:2004, 9.

The fume cupboard ZAFE 81is equipped with two neon tubes.. The neon tubes are dimensioned with a Length = 550 mm, and they are installed in a reflective-coated metal housing.

Measurement point	Intensity of illumination /Lux	Average intensity of illumination / Lux	Constancy of intensity of illumination
1	819	**858**	**0.95**
2	862		
3	869		
4	834		
5	856		
6	887		
7	895		
8	844		

6.5 Measuring positions of the intensity of illumination in accordance with EN 14 175-3:2004, 9.



6.6 Test of the desktop

According to EN 14175-3:2004, the desktop has been loaded with 2000 N at a area of 120 x 120 mm. The load has been positioned for 24 hours. After this, the load was removed and deformation was measured directly and additionally after further 24 h.

Test	bending	Limit value according to EN 13150, 6.2	Passed
Without load	0	-	-
Directly after removing load/ 24 h	- 1 mm	- 4.3	Yes
24h after removing load	- 0 mm	- 0.9	Yes

7.0 Results

The fume cupboard **ZAFE 81** has been tested in accordance with the type testing procedure for fume cupboards of EN 14 175-3: 2004. The requirements to the containment of the fume cupboard of the professional association of the german chemical industry (BG Chemie), technical committee chemistry, dated 29.07.2003, were fulfilled at the tested volume flow rates and the values measured were below the required limit values.
The test results and conditions at the tested face velocities are given in short form in the "Certificate No. 1/FC-Z81/P3/06/13" and the amendment to the certificate "Results of the type testing of a fume cupboard in accordance with EN 14 175-3:2004, No. 1/FC-Z81/P3/06/13".

The place of installation and the operation in and at the fume cupboard can lead to negative influence on the safe operation of the fume cupboard. Therefore, in practice substantially larger extract volume flow rates can be necessary for a safe operation of the fume cupboard than the extract volume flow rates adjusted for the tests.

Annex

1.0 Robustness of the containment in accordance with EN 14 175-3:2004

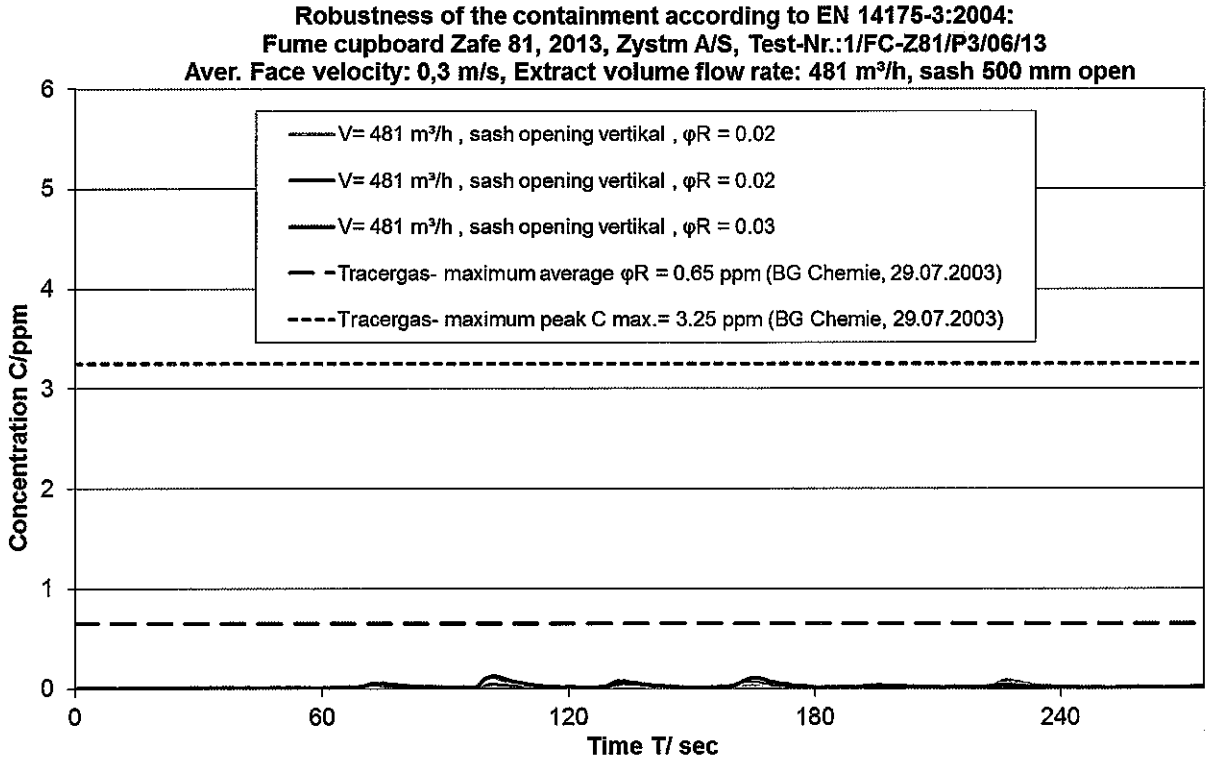


Diagram 1

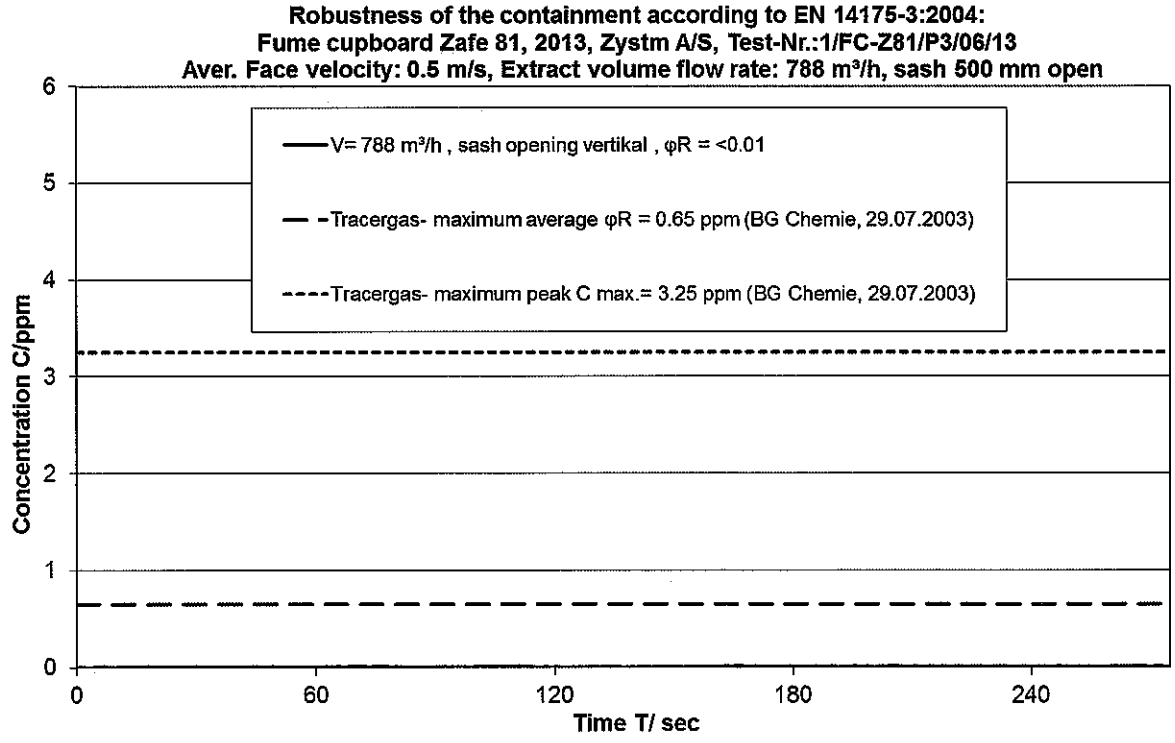


Diagram 2

2.0 Containment of the outer measurement plane in accordance with EN 14 175-3:2004

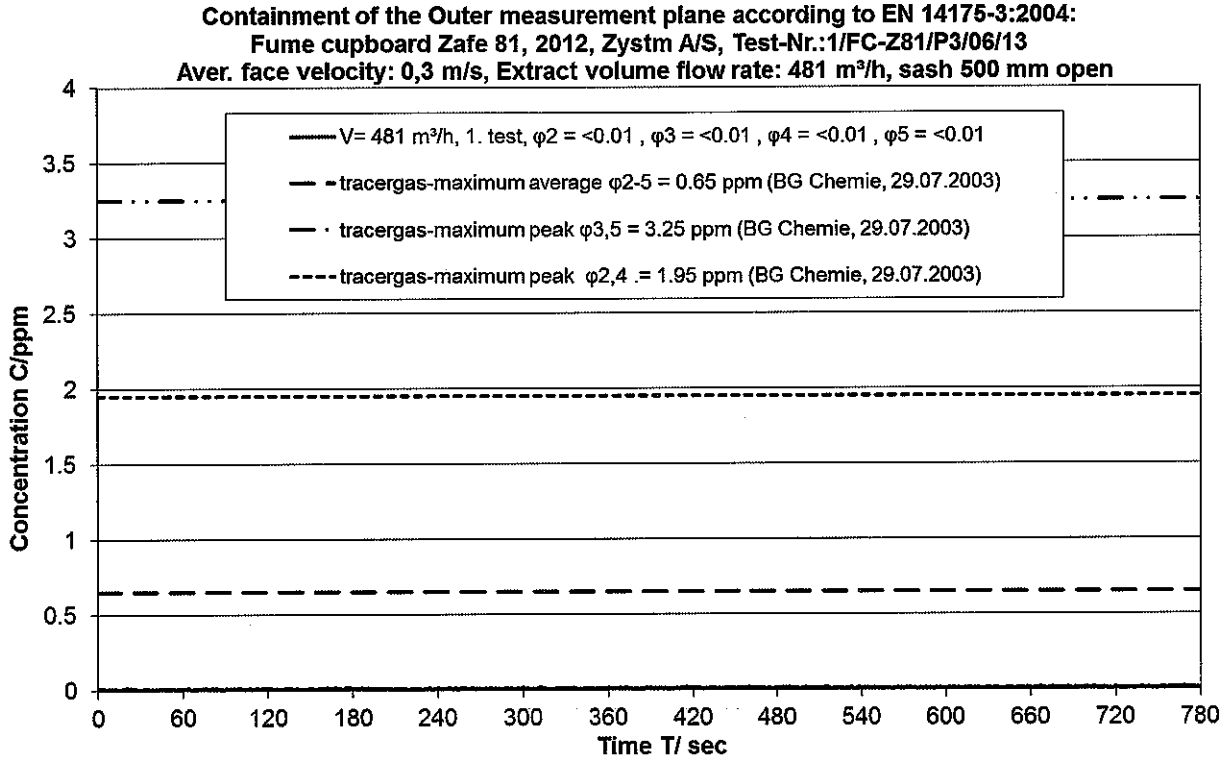


Diagram 3

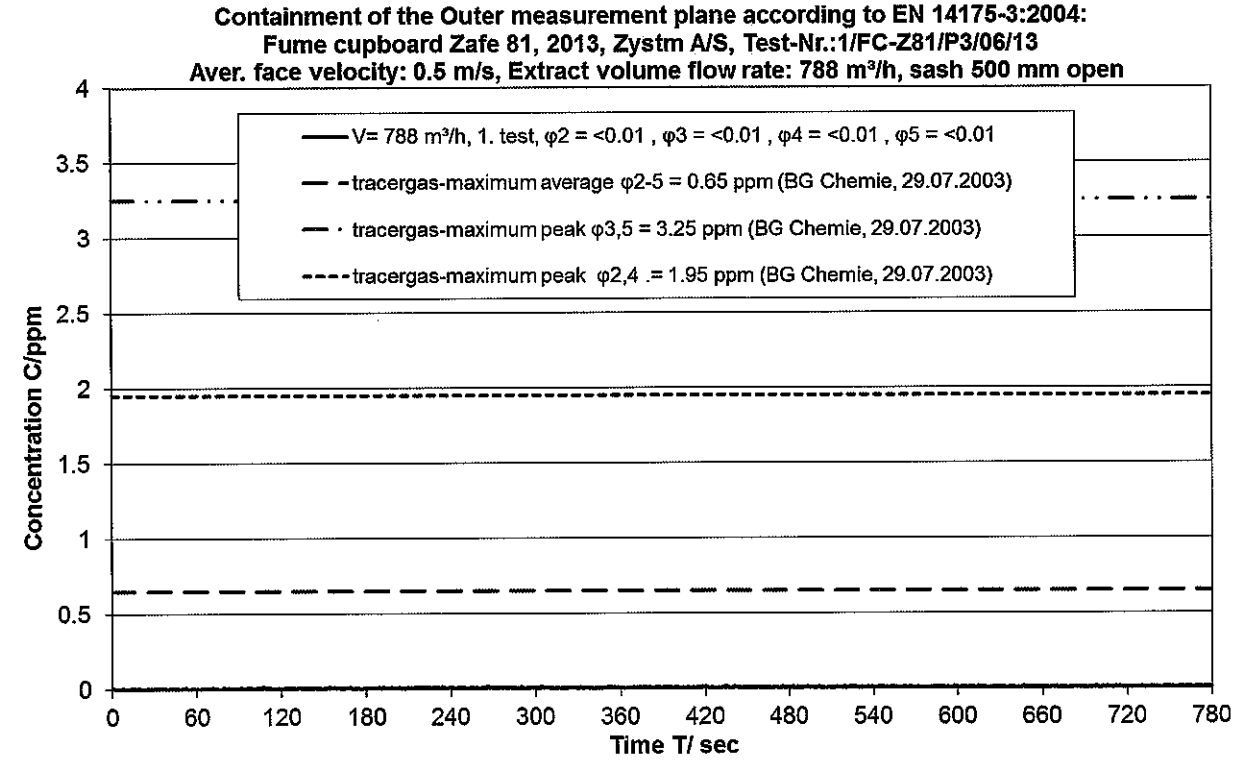
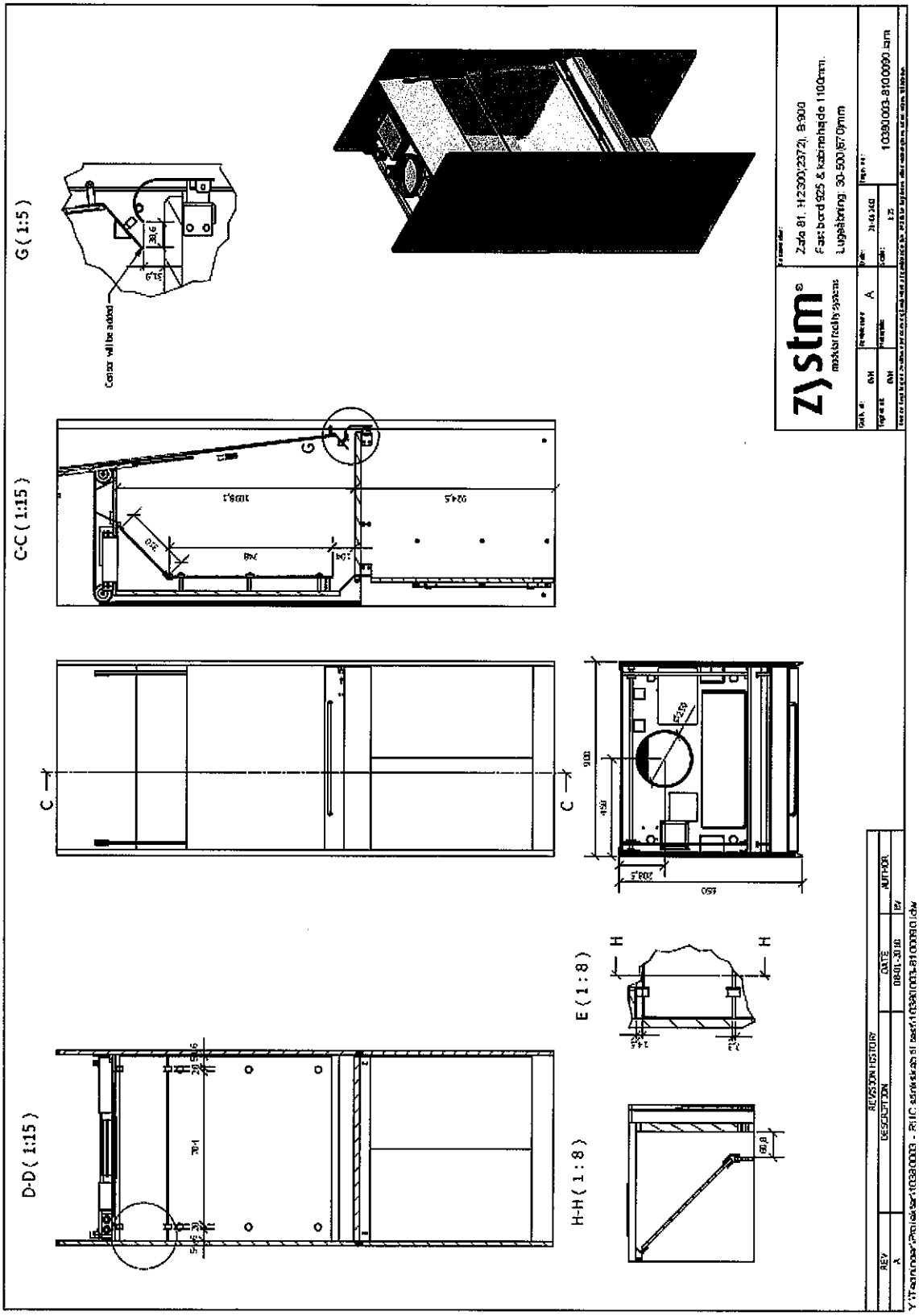


Diagram 4



Manufacturer drawing: Zystm ZAFE 81, W = 900 mm