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Test report N°289 – part 1 **Date : 14/12/2018**

FLOWRATE AND DROPLET SIZE MEASUREMENTS OF SKY BLUE NOZZLE (FOGGER)

REFERENCES : *CONFORMITY WITH NF ISO 5682-1 §7.6.*

Tested Material :	
Nature :	Nozzle (Fogger)
Manufacturer :	Automat World
Type :	Sky Blue

Company :	
Name :	Mr Dinesh M/s
Address :	Automat Industry PVT. Ltd 182, F.I.E. Patparganj Dehli 110092 India
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1. GENERAL

Name and address of the customer :
Mr Dinesh M/s
Automat Industry PVT. Ltd
182, F.I.E. Patparganj
Dehli 110092 India

Date of tests : Juillet 2012
Place : Testing facility of Irstea - Montpellier

Operator : Mr. Cyril TINET

2. IDENTIFICATION AND SPECIFICATION OF TESTED MATERIEL

Trade Mark **:** **Automat World**
Type **:** **Nozzle (fogger)**
References : **Sky Blue**

3. PROTOCOLS

3.1. DROPLET SIZE MEASUREMENT

Droplet size measurement is operated by using a PDA (Phase Doppler Analyser).
Each fogger was tested at 400 kPa (4 bar).

Measurements were operated vertically at a distance of 10 cm from the fogger outlet.

4. METHODOLOGIES & MEASUREMENT DEVICE

4.1. FLOW RATE MEASUREMENT.

Mass flowrate is achieved through a balance Mettler PB8100S (d = 0.1 g – scale 5000 g) linked to a PC via RS232 interface.
Time reference is the internal clock of the computer. Flowrate is calculated for a time lag of 4 minutes and repeated 3 times.
Raw values are corrected with respect to the real pressure value during the test.
Mean flowrate for each nozzle is calculated as the mean of 3 replicates of corrected flowrates.
Mass flowar is converted to volumetric flowrate considering teh density of water :1kg/L.

4.2. DROPLET SIZE MEASUREMENTS.

Foggers are fed with deionized water under pressure. A pressure controller allows the adjustment of the pressure at a given value. A pressure sensor Keller® is used with a measurement range of 0-10 bar and a precision of ± 0.01%.

The test bench is composed of a droplet sizer and velocimeter DANTEC® and a CHARLYROBOT® displacement device. Droplet sizer is a PDA (Phase Doppler Analyser) equipped with a laser generator of maximum power of 6 Watt. An optical device (prism + separator) generates 2 possible wavelengths 514 nm et 488 nm. Droplet velocity is calculated through Doppler Effect. Droplet diameter measurement is based on a principle of signal phase detection; the reflected light excites 3 different photodetectors with a time delay as function of the particle size. Moreover this device controls the sphericity of droplets.

This equipment is able to measure individual droplets in size and in velocity.

4.3. METHODOLOGY

This measurements complies with NF ISO 5682 –1 §7.6.

The fogger is placed on the displacement robot arm. 2D displacement is controlled by the robot software. Precision in the position of the fogger is 1 mm.

Displacement grid on the two axis and the acquisition time at each point are defined by using the software.

The position (0,0) corresponds to the point located at the vertical axis under the fogger and situated on the measurement plan. The fogger is immobile during measurements.

5. RESULTS

5.1. CALCULATION FORMULA FOR DROPLET SIZE

Assuming : n_i : number of droplets in the range of diameter *i*
d_i : Mean diameter of the range i

Arithmetic Diameter :

$$D_a = \frac{\sum_{i=1}^{n} n_i . d_i}{\sum_{i=1}^{n} n_i}$$

Volumetric Diameter :

$$D_v = \sqrt[3]{\frac{\sum_{i=1}^{n} n_i . d_i^{\,3}}{\sum_{i=1}^{n} n_i}}$$

Sauter Diameter : (D3/2)

$$D_{32} = \frac{\sum_{i=1}^{n} n_i . d_i^{\,3}}{\sum_{i=1}^{n} n_i . d_i^{\,2}}$$

Homogeneity (H) :

$$H = . \frac{\left(\sum_{i=1}^{n} n_i . d_i^{\,2} \right)^2}{\sum_{i=1}^{n} n_i . d_i . \sum_{i=1}^{n} n_i . d_i^{\,3}} \times 100$$

Number Median Diameter (NMD) : Numerical median of the population (the population is split in 2 groups representing the same number of droplets)

Volume Median Diameter (VMD ou Dv_{50}) : Volumetric Median of the population (the population is split in 2 groups representing the same total volume)

Dv_{10} : Diameter equivalent to 10 % of the volume population (smaller droplets)

Dv_{90} : Diameter equivalent to 90 % of the volume population

Span : $(Dv_{90} – Dv_{10}) / Dv_{50}$

5.2. FLOWRATES OF 20 FOGGERS AT 3 – 3.5 AND 4 BAR

	3.0 bar		3.5 bar		4.0 bar	
	Flowrate (L/h)	Deviation to the mean	Flowrate (L/h)	Deviation to the mean	Flowrate (L/h)	Deviation to the mean
	4.53	-2.81%	4.85	-2.26%	5.17	-2.61%
	4.53	-2.66%	4.87	-1.90%	5.19	-2.24%
	4.55	-2.40%	4.88	-1.61%	5.19	-2.20%
	4.59	-1.48%	4.89	-1.58%	5.22	-1.65%
	4.59	-1.42%	4.90	-1.23%	5.24	-1.32%
	4.59	-1.34%	4.91	-1.17%	5.26	-0.98%
	4.60	-1.23%	4.91	-1.08%	5.26	-0.97%
	4.62	-0.75%	4.91	-1.03%	5.26	-0.94%
	4.63	-0.49%	4.93	-0.72%	5.28	-0.53%
	4.64	-0.41%	4.93	-0.70%	5.28	-0.49%
	4.64	-0.28%	4.93	-0.66%	5.29	-0.37%
	4.65	-0.18%	4.95	-0.21%	5.31	-0.04%
	4.66	0.14%	4.97	0.09%	5.32	0.30%
	4.69	0.62%	4.98	0.28%	5.32	0.31%
	4.69	0.77%	4.98	0.29%	5.33	0.33%
	4.74	1.73%	5.02	1.10%	5.35	0.81%
	4.74	1.74%	5.05	1.71%	5.41	1.84%
	4.75	2.06%	5.08	2.38%	5.46	2.80%
	4.85	4.12%	5.15	3.72%	5.50	3.66%
	4.85	4.25%	5.19	4.59%	5.54	4.30%
Mean flowrate (L/h)	**4.66**		**4.96**		**5.31**	

5.3. DROPLET SIZE RESULTS - GENERAL

Sky Blue nozzle Pressure : 4 bar	
Number of particules	608 448
Arithmetic Diameter (µm)	51
Volumetric Diameter (µm)	69
Sauter Diameter (µm)	90
Homogeneity	79.9%
NMD (µm)	46
Dv10 (µm)	59
Dv50 (VMD) (µm)	100
Dv90 (µm)	161
Span relatif	1.01
VMD / NMD	2.21
Number of droplets <100 µm (%)	92.1%
Volume of droplets <100 µm (%)	49.6%

5.3.1. Graphical representation of droplets in number

5.3.1.1.Caption

<1	1 à 2	2 à 3	3 à 6	6 à 10	10 à 18	18 à 32	32 à 56	56 à 100	100 à 178	178 à 316	316 à 562	562 à 1 000	1 000 à 1 778	1 778 à 3 162	3 162 à 5 623	5 623 à 10 000	>= 10 000

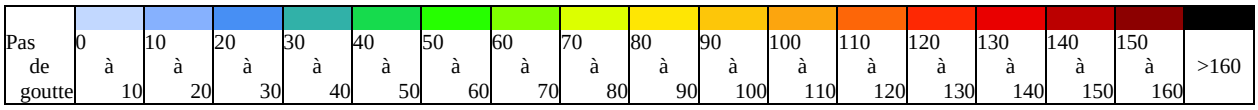
Number of droplets per second

5.3.1.2.Pressure 4.0 bar

X/Y	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
-100			0,2	0,2	2,4	3,8	0,8	0,8	2,0	2,2	3,6	2,4	2,8	2,0	1,2	0,8	1,2		0,4	0,4	
-90			0,2	2,0	12	5,8	6,4	7,8	14	18	16	17	20	14	9,4	3,2	2,6	2,2	0,6	0,6	0,4
-80	0,2	0,6	2,6	3,8	10	13	31	37	44	61	50	73	73	54	41	22	7,8	2,2	0,4	0,2	0,2
-70	0,6	1,0	5,2	11	26	47	84	100	125	129	152	139	164	136	100	47	19	8,2	3,0	1,0	0,4
-60	0,6	2,6	11	34	58	120	188	232	244	233	237	261	297	247	167	85	34	17	6,4	2,0	1,2
-50	1,6	6,6	17	73	132	215	336	413	411	396	385	393	495	394	239	120	53	26	14	4,4	2,2
-40	3,8	12	27	102	193	342	512	732	758	664	542	572	731	575	268	134	77	40	20	6,2	2,6
-30	2,6	18	56	133	225	432	713	1165	1251	1096	910	1145	1152	651	253	130	69	38	17	6,8	2,0
-20	5,4	18	64	111	270	728	809	1576	2252	1972	1814	1527	1075	637	170	84	46	25	15	6,4	2,4
-10	5,6	21	68	156	350	511	1003	2059	3170	3636	2145	1437	920	285	128	102	44	26	13	9,4	4,2
0	5,6	30	79	168	333	522	1081	2484	4341	6037	3431	978	397	201	122	78	46	24	17	8,4	3,0
10	5,0	21	62	137	319	526	996	1587	4076	7230	4993	2009	690	360	180	96	56	26	16	8,8	2,2
20	3,4	17	44	113	233	399	633	787	1540	2686	2649	1694	1016	500	249	127	56	32	10	5,0	3,2
30	3,0	11	30	80	223	251	320	456	665	870	1011	855	540	335	183	96	53	22	11	4,2	1,4
40	3,0	6,2	13	37	87	126	171	268	424	464	398	327	270	175	97	57	32	13	5,6	2,4	0,2
50	1,6	1,6	7,4	19	38	64	90	165	208	212	187	155	124	85	46	27	14	5,4	1,6	0,8	0,4
60	0,6	1,6	4,2	7,6	12	19	43	77	92	98	87	61	46	39	24	9,4	2,6	1,4	1,0	0,2	
70	0,4	0,6	2,0	2,4	4,4	8,6	23	33	36	41	32	22	15	14	7,6	3,2	0,4	0,2		0,4	0,2
80	0,2		1,2	1,0	2,2	2,6	7,8	8,2	11	11	8,6	6,4	6,2	3,8	2,6	1,0	1,4	0,4			
90		0,2		0,2	1,0	0,8	1,8	2,2	3,8	3,2	3,0	1,2	1,6	0,8		0,2		0,2			
100				0,4	0,4		1,0	0,6	1,0	1,4	0,8	0,8	0,4	0,4		0,4	0,2		0,2		

5.3.2. Graphical Representation of NMD

5.3.2.1.Caption



Diameter in micrometers (µm)

5.3.2.2.Pressure 4.0 bar

X/Y	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
-100			111	122	89	90	97	102	108	100	113	101	106	105	100	105	122		147	135	
-90			93	101	92	101	88	100	114	97	95	106	113	110	106	119	101	112	113	129	120
-80	88	90	89	87	88	97	97	97	98	97	95	99	102	110	108	106	113	114	123	128	143
-70	112	113	95	109	94	91	94	98	92	90	91	92	96	98	102	101	104	101	112	120	133
-60	90	114	100	94	96	93	83	84	83	84	83	85	86	88	92	98	98	99	105	112	118
-50	90	90	104	91	92	85	80	77	75	75	74	72	74	80	87	93	97	99	98	107	97
-40	101	88	95	94	86	77	72	67	64	61	62	62	60	67	81	89	97	99	97	94	123
-30	97	95	96	89	81	71	63	57	53	49	47	43	44	56	76	83	88	96	98	98	113
-20	96	96	97	90	78	65	55	40	31	35	29	30	35	47	73	81	89	93	95	102	116
-10	99	97	93	89	74	64	49	32	33	28	28	30	31	58	75	78	87	90	97	103	115
0	95	100	96	85	75	65	48	35	26	20	24	40	61	71	78	83	86	88	92	97	100
10	103	98	94	89	77	65	55	47	29	21	24	39	61	73	80	83	87	91	97	94	102
20	91	95	95	91	83	73	65	59	49	37	40	48	58	70	81	87	90	91	95	94	112
30	97	98	101	93	85	82	75	67	62	59	59	64	72	74	80	87	94	91	94	97	105
40	102	95	91	94	95	89	81	75	71	71	74	75	78	83	86	89	94	99	103	98	118
50	99	104	91	93	90	90	85	83	83	81	85	80	84	87	86	91	95	98	104	123	140
60	107	95	96	93	91	95	91	88	90	87	87	85	87	88	86	88	92	86	94	85	
70	93	90	90	88	91	94	93	91	90	91	90	90	88	89	93	108	94	83		132	96
80	100		101	88	105	95	95	92	88	92	95	99	87	93	88	91	96	111			
90		98		110	94	105	91	86	88	94	91	95	82	91		85		94			
100				128	122		102	96	94	91	95	91	81	104		99	86		3		

5.3.3. Graphical representation of VMD

5.3.3.1.Caption

Pas de goutte	0 à 10	10 à 20	20 à 30	30 à 40	40 à 50	50 à 60	60 à 70	70 à 80	80 à 90	90 à 100	100 à 110	110 à 120	120 à 130	130 à 140	140 à 150	150 à 160	>160

Diameter in micrometers (µm)

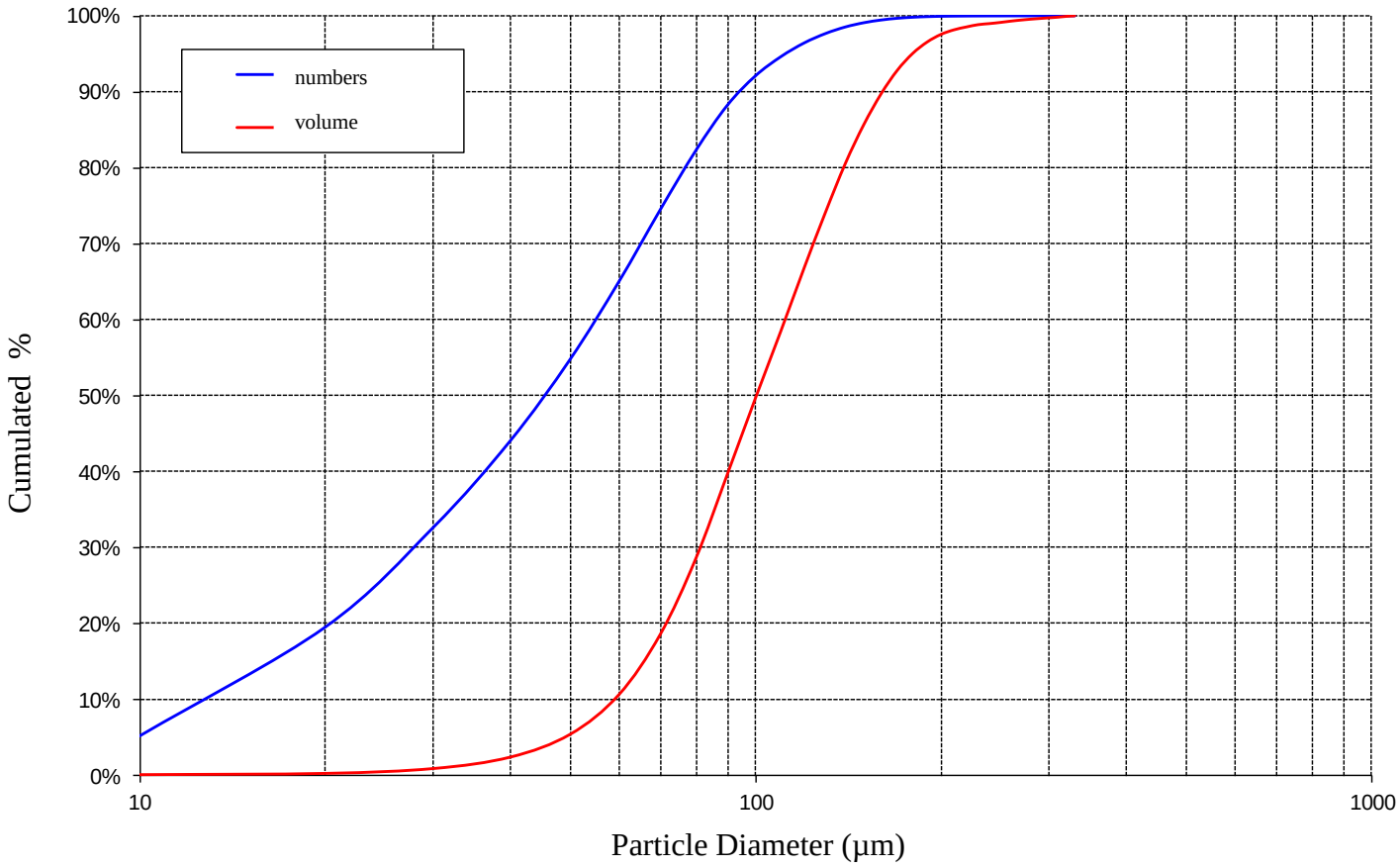
5.3.3.2.Pressure 4.0 bar

X/Y	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
-100			111	122	89	96	97	102	117	173	147	129	115	113	100	156	134		147	135	
-90			93	102	99	106	98	103	133	134	130	146	153	136	142	122	108	122	113	129	120
-80	88	90	93	101	114	119	150	138	139	141	113	128	133	143	137	130	120	116	123	128	143
-70	112	123	98	140	134	125	132	140	133	124	120	123	126	133	132	129	127	121	130	120	133
-60	90	115	119	130	133	129	122	129	122	114	114	116	124	121	126	123	117	125	125	146	118
-50	90	111	142	130	128	124	122	121	118	113	106	100	111	115	129	119	120	118	111	119	108
-40	115	99	126	125	115	110	105	111	107	99	90	89	106	119	112	113	118	117	113	115	144
-30	100	127	120	117	112	107	96	93	95	90	78	75	83	97	105	106	108	111	125	118	125
-20	133	121	127	120	108	96	91	90	90	90	64	60	64	78	92	95	100	104	110	123	121
-10	118	120	119	116	112	92	86	87	85	81	64	57	70	77	86	89	95	100	107	113	128
0	101	116	118	114	106	95	82	81	82	86	68	75	76	83	89	91	91	95	108	104	108
10	116	115	111	117	103	96	86	82	78	71	66	69	83	95	98	95	98	102	103	116	106
20	116	116	118	115	111	100	88	80	72	68	73	76	82	89	101	109	109	104	104	100	129
30	110	113	118	115	115	106	95	85	79	80	86	83	90	87	94	109	116	109	102	105	105
40	113	111	115	115	113	111	100	93	93	94	98	94	94	96	95	101	109	109	113	126	118
50	106	108	116	119	106	107	104	103	110	105	108	99	97	101	100	100	109	104	108	123	140
60	107	95	113	127	102	108	103	105	112	107	107	101	103	98	96	99	95	110	102	85	
70	93	124	98	98	97	115	107	107	105	119	107	104	104	100	96	129	94	83		132	96
80	100		101	88	105	118	115	100	98	139	103	134	95	104	103	98	99	111			
90		98		110	94	105	97	90	110	106	95	95	91	91		85		94			
100				128	122		104	96	114	93	95	130	81	104		99	86		3		

5.3.4. Numerical distribution of droplets per class

Class	Number of droplets	Percentage
[0;10[µm	31 064	5.105%
[10;20[µm	87 130	14.320%
[20;30[µm	80 186	13.179%
[30;40[µm	69 385	11.404%
[40;50[µm	65 104	10.700%
[50;60[µm	62 246	10.230%
[60;70[µm	57 493	9.449%
[70;80[µm	47 672	7.835%
[80;90[µm	36 309	5.967%
[90;100[µm	23 677	3.891%
[100;110[µm	15 418	2.534%
[110;120[µm	10 995	1.807%
[120;130[µm	7 579	1.246%
[130;140[µm	5 250	0.863%
[140;150[µm	3 386	0.556%
[150;160[µm	2 186	0.359%
[160;170[µm	1 391	0.229%
[170;180[µm	829	0.136%
[180;190[µm	479	0.079%
[190;200[µm	274	0.045%
[200;210[µm	142	0.023%
[210;220[µm	77	0.013%
[220;230[µm	54	0.009%
[230;240[µm	22	0.004%
[240;250[µm	21	0.003%
[250;260[µm	21	0.003%
[260;270[µm	15	0.002%
[270;280[µm	11	0.002%
[280;290[µm	8	0.001%
[290;300[µm	7	0.001%
[300;310[µm	6	0.001%
[310;320[µm	7	0.001%
[320;330[µm	4	0.001%

5.3.5. Graphical Representation of cumulated numbers and cumulated volumes



Written and transmitted	Verified and transmitted		Approuved
Date :	Date	Date	Date
The operator C.TINET	Test manager J.P.DOUZALS	Quality manager G. DIOULOUFET	Head of UMR ITAP B. RUELLE