Joint Research Unit
Information & Technologies for Agro-Processes
CENTRE of MONTPELLIER
361 rue J.F. Breton BP 5095
F-34196 MONTPELLIER Cedex 5 - France
Tel : +33 4 67 04 63 00 Fax : +33 4 67 16 64 40

Test report N°289 – part 2 **Date : 14/12/2018**

FLOWRATE AND DROPLET SIZE MEASUREMENTS OF DARK GREEN NOZZLE (FOGGER)

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

Tested Material :	
Nature :	Nozzle (Fogger)
Manufacturer :	Automat World
Type :	Dark Green

Company :	
Name :	Mr Dinesh M/s
Address :	Automat Industry PVT. Ltd 182, F.I.E. Patparganj Dehli 110092 India
Phone :	91-11-43036739
Fax :	91-11-43036739

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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 : **Dark Green**

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 on the basis of 4 minutes measurements 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 NOZZLES AT 3 – 3.5 AND 4 BAR

	3.0 bar		3.5 bar		4.0 bar	
	Flowrate (L/min)	Deviation to the mean	Flowrate (L/min)	Deviation to the mean	Flowrate (L/min)	Deviation to the mean
	5.85	-4.97%	6.24	-5.54%	6.66	-5.48%
	5.95	-3.43%	6.34	-4.02%	6.80	-3.44%
	5.96	-3.18%	6.35	-3.85%	6.80	-3.44%
	5.97	-3.12%	6.41	-3.02%	6.84	-2.84%
	6.00	-2.63%	6.43	-2.72%	6.92	-1.77%
	6.02	-2.33%	6.47	-2.13%	6.97	-0.97%
	6.06	-1.62%	6.53	-1.20%	6.97	-0.96%
	6.13	-0.51%	6.55	-0.86%	6.98	-0.86%
	6.13	-0.49%	6.59	-0.29%	6.99	-0.77%
	6.14	-0.31%	6.59	-0.28%	7.04	0.03%
	6.15	-0.10%	6.62	0.16%	7.08	0.53%
	6.17	0.24%	6.62	0.25%	7.10	0.82%
	6.23	1.12%	6.69	1.26%	7.12	1.08%
	6.26	1.68%	6.69	1.28%	7.13	1.31%
	6.27	1.74%	6.73	1.96%	7.18	2.03%
	6.28	1.93%	6.75	2.21%	7.20	2.28%
	6.32	2.57%	6.79	2.81%	7.21	2.45%
	6.37	3.42%	6.86	3.83%	7.25	2.99%
	6.43	4.41%	6.88	4.22%	7.27	3.28%
	6.50	5.56%	7.00	5.92%	7.30	3.71%
Mean flowrate (L/h)	**6.16**		**6.61**		**7.04**	

5.3. DROPLET SIZE RESULTS - GENERAL

Dark Green nozzle Pressure : 4 bar	
Number of particules	805 184
Arithmetic Diameter (µm)	50
Volumetric Diameter (µm)	68
Sauter Diameter (µm)	88
Homogeneity	79.3%
NMD (µm)	46
Dv10 (µm)	57
Dv50 (VMD) (µm)	98
Dv90 (µm)	167
Span relatif	1.12
VMD / NMD	2.14
Number of droplets <100 µm (%)	93.2%
Volume of droplets <100 µm (%)	51.8%

5.3.1. Graphical Representationof droplet numbers

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			0,4	0,8	5,6	8,4	6,0	5,6	8,6	5,6	1,8	2,0	1,0	0,8	0,6	0,2	0,4	0,2			
-90	0,2		0,8	1,8	2,8	8,2	18	22	23	24	13	6,2	6,4	2,6	1,6	1,4	0,6	0,2	0,2		
-80	0,6		0,4	1,2	5,0	13	44	75	67	42	35	29	19	10	8,4	3,4	0,6	0,6	0,2	0,4	
-70		0,2	1,0	3,2	6,0	24	101	180	148	124	99	78	55	34	13	5,0	2,6	1,2	0,6	0,2	
-60	0,6	1,0	2,4	7,2	20	39	148	388	408	313	240	178	113	63	33	14	4,4	1,4	0,8	0,2	
-50	0,4	1,4	3,6	11	21	70	183	585	952	679	559	460	276	133	55	23	9,4	4,8	1,4	0,4	
-40	0,6	1,6	4,6	12	33	103	247	755	2024	1688	1376	1064	626	297	110	44	17	4,2	1,8		
-30	0,2	1,6	3,6	14	45	116	403	1105	2922	6415	4371	3270	1454	612	248	74	26	7,6	1,6		
-20	1,0	1,4	4,4	13	41	115	343	1339	4430	11461	11335	8877	3210	1180	395	137	32	7,8	1,4	0,4	
-10	0,6	0,8	4,0	11	33	97	270	804	2527	6930	10033	8999	4406	1434	473	158	35	9,2	1,4	0,4	
0	0,2	1,6	4,2	8,0	24	61	145	354	841	2006	5956	2085	1018	703	395	152	36	6,4	1,4	0,2	
10	0,2	1,0	2,2	5,6	10	32	65	118	271	1392	5294	1371	365	269	213	110	28	5,4	2,0		
20		0,2		2,2	5,6	10	25	65	193	1955	4200	894	277	140	107	63	24	3,6	0,2	0,2	0,2
30	0,2		0,2	0,2	4,6	7,4	21	58	198	949	3177	554	239	121	76	34	18	2,6	0,2		
40		0,8	0,4	1,2	2,2	5,4	19	49	161	668	2106	566	169	99	60	22	6,0	1,6	0,4		
50		0,2	0,4	0,6	2,4	6,8	13	35	106	273	752	428	123	75	45	16	4,2	0,6	0,4		
60		0,2	1,2	1,2	1,6	5,0	13	22	68	143	271	387	106	43	21	9,2	2,6	0,6	0,2		
70				0,6	1,2	3,6	7,6	14	37	81	173	207	64	27	14	4,8	1,8	1,0			
80	0,4		0,2	0,6	0,6	1,0	3,8	10	23	47	108	101	39	15	5,2	1,8	1,2	0,6	0,2		
90			0,2	0,4		1,2	1,2	6,2	9,4	27	51	55	23	8,6	2,0	1,8	0,4	0,2			
100				0,2	0,2	0,4	2,2	2,4	7,0	17	26	21	13	4,6	1,8	0,4		0,2	0,2		

5.3.2. Graphical Representation of NMD

5.3.2.1. 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)

5.3.2.2.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			87	84	88	88	99	79	86	80	92	85	91	98	103	95	109	119			
-90	101		82	78	98	86	86	82	81	79	80	91	86	95	77	96	90	89	113		
-80	89		103	90	84	84	82	80	83	80	77	80	86	89	89	97	99	94	100	95	
-70		100	102	93	85	87	78	77	76	74	73	76	81	82	89	92	87	103	79	144	
-60	93	87	93	88	81	81	74	75	72	71	71	74	81	84	87	88	88	94	104	91	
-50	100	95	96	89	87	78	76	72	68	67	67	70	76	80	86	83	90	95	92	98	
-40	98	88	95	86	84	79	76	72	63	62	63	65	73	79	83	86	86	85	79		
-30	87	88	96	85	84	81	75	68	60	38	48	50	66	77	82	86	87	83	87		
-20	91	89	90	88	84	80	76	67	49	26	25	29	54	74	84	86	90	88	94	127	
-10	100	106	91	87	82	80	77	72	61	39	26	25	40	68	85	88	89	88	95	90	
0	85	88	86	81	84	82	77	72	67	59	33	47	59	70	83	89	88	92	94	84	
10	84	94	94	82	80	81	77	75	72	55	34	53	70	76	83	90	94	86	95		
20		85		87	81	82	78	76	73	45	37	60	72	76	84	89	92	93	71	71	95
30	92		98	67	86	84	80	78	74	62	39	68	72	77	83	85	94	92	83		
40		101	109	91	81	88	85	82	77	65	44	60	76	81	84	90	93	95	103		
50		115	98	82	93	91	86	83	80	76	62	60	78	85	87	88	89	104	111		
60		97	87	90	89	93	88	87	86	84	77	63	78	83	88	92	92	100	95		
70				110	100	90	92	90	87	85	85	76	84	87	92	94	89	107			
80	111		120	99	104	102	91	93	93	93	89	87	88	88	89	95	91	99	95		
90			123	101		95	111	94	96	104	98	94	92	98	88	93	105	104			
100				133	106	109	90	98	103	105	101	101	96	102	102	95		131	107		

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)

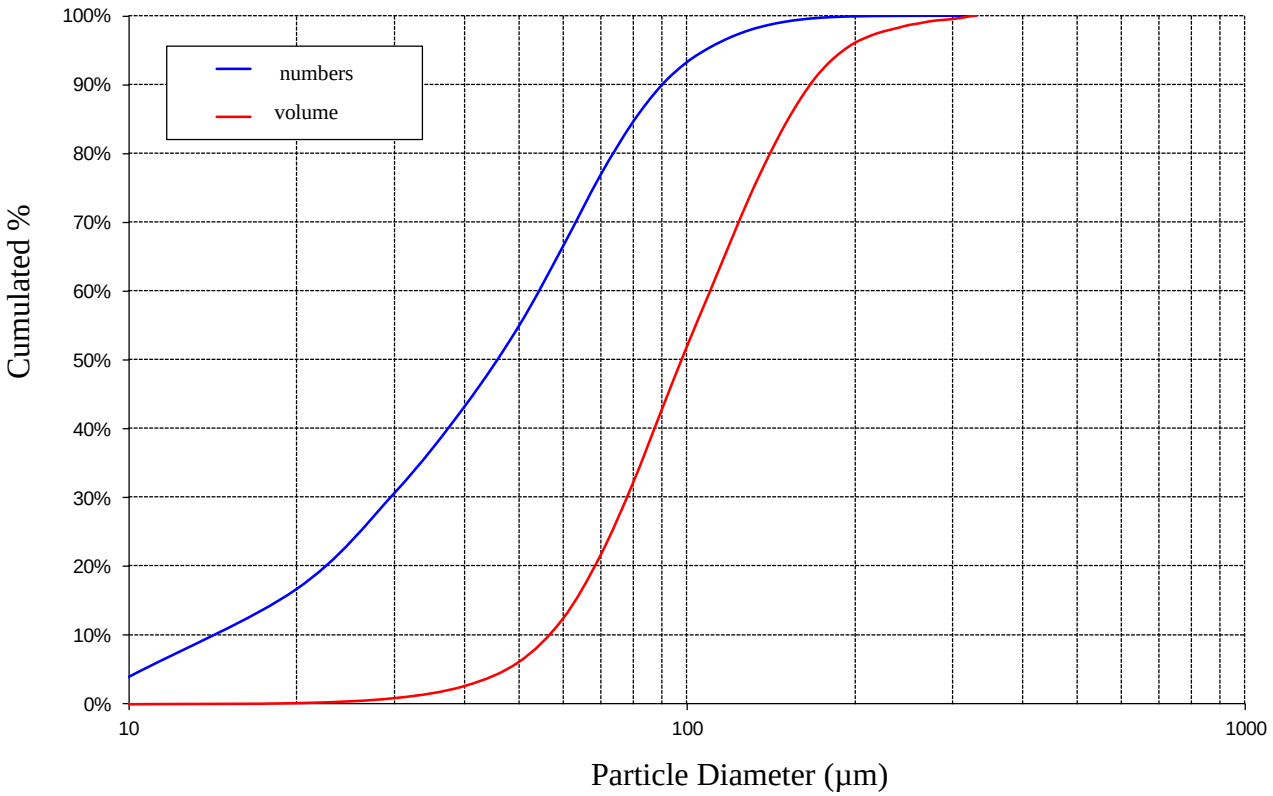
5.3.3.2. Pressure 4.0 bar

X/Y	-100	-90	-80	-70	-60	-50	-40	-30	-20	-10	0	10	20	30	40	50	60	70	80	90	100
-100			87	84	89	88	111	93	88	82	96	97	107	98	103	95	109	119			
-90	101		82	85	105	96	119	88	84	86	85	104	91	98	79	103	111	89	113		
-80	110		103	90	85	92	96	97	89	88	82	89	98	94	93	102	99	112	100	95	
-70		100	103	94	90	98	88	97	92	84	83	86	96	98	100	99	93	103	105	144	
-60	93	87	102	98	85	91	90	92	92	81	84	93	101	102	102	101	100	95	104	91	
-50	100	96	96	107	95	93	91	95	102	87	83	92	98	97	100	96	98	99	95	98	
-40	98	90	102	93	92	94	97	94	107	89	83	94	104	102	111	99	96	88	80		
-30	87	95	100	90	92	95	96	99	114	92	85	103	110	111	114	107	100	97	88		
-20	91	91	92	92	99	94	97	106	112	106	85	111	122	125	120	111	110	103	100	127	
-10	100	106	94	94	91	90	95	99	107	94	80	96	112	128	129	116	107	98	113	90	
0	85	97	89	86	90	89	88	91	88	86	67	77	89	113	117	115	109	97	166	84	
10	84	94	102	94	84	89	86	87	82	75	64	78	86	95	111	119	119	101	97		
20		85		95	87	86	86	85	83	73	74	89	86	87	97	109	106	102	71	71	95
30	92		98	67	88	93	85	86	83	84	86	94	88	92	94	99	106	108	83		
40		101	109	99	82	93	92	88	87	86	92	86	93	96	98	104	98	100	103		
50		115	98	103	95	93	93	90	90	91	90	87	91	94	101	96	93	130	111		
60		97	87	90	89	96	96	92	93	102	100	89	92	90	94	99	98	100	95		
70				110	100	103	98	100	94	99	110	98	94	94	100	105	100	108			
80	111		120	99	104	107	93	95	102	111	118	107	104	97	94	110	91	99	95		
90			123	101		95	123	304	105	132	140	115	104	106	94	94	105	104			
100				133	106	109	98	101	106	122	118	114	111	136	109	95		131	107		

5.3.4. Numerical Distribution per class

Class	Number of droplets	Percentage
[0;10[µm	30 508	3.789%
[10;20[µm	102 974	12.789%
[20;30[µm	113 012	14.036%
[30;40[µm	100 793	12.518%
[40;50[µm	93 765	11.645%
[50;60[µm	93 441	11.605%
[60;70[µm	83 238	10.338%
[70;80[µm	62 062	7.708%
[80;90[µm	43 197	5.365%
[90;100[µm	27 452	3.409%
[100;110[µm	17 387	2.159%
[110;120[µm	12 190	1.514%
[120;130[µm	8 538	1.060%
[130;140[µm	5 647	0.701%
[140;150[µm	3 853	0.479%
[150;160[µm	2 558	0.318%
[160;170[µm	1 692	0.210%
[170;180[µm	1 046	0.130%
[180;190[µm	651	0.081%
[190;200[µm	408	0.051%
[200;210[µm	234	0.029%
[210;220[µm	158	0.020%
[220;230[µm	94	0.012%
[230;240[µm	71	0.009%
[240;250[µm	64	0.008%
[250;260[µm	33	0.004%
[260;270[µm	35	0.004%
[270;280[µm	21	0.003%
[280;290[µm	12	0.001%
[290;300[µm	12	0.001%
[300;310[µm	13	0.002%
[310;320[µm	16	0.002%
[320;330[µm	9	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