#### SPRAYING TECHNOLOGY SINCE 1997



## **ROTARY ATOMIZERS**

### TECHNICAL BULLETIN: DROPLET SPECTRUM AND UNIFORMITY OF SPRAY DISTRIBUTION



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## ZANONI EQUIPAMENTOS

TECHNICAL BULLETIN: ROTARY ATOMIZERS



®

EQUIPAMENTOS

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WWW.ZANONIEQUIPAMENTOS.COM.BR/EN





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# ZANONI ATOMIZERS

Knowledge and information are fundamental to quality in aerial applications. To ensure efficient spraying, it is essential that operators have access to scientific research and data to help them define which technologies best meet their needs.

With this in mind, we prepared this technical bulletin about our rotary atomizers, which present the results of a long research work. Although we started manufacturing this type of equipment only a few crop seasons ago, we are making constant investments to offer minimal references on the use of this technology, fulfilling our commitment to be transparent and to always seek the development of best quality products for application in the agriculture.

The document presents test results on the droplet spectrum offered by the M3 and M14 atomizers with the application of water in Air Tractors and in an Embraer Ipanema, respectively. In addition, we provide information about uniformity of spray distribution with different swath width for this second aircraft. In the end of the document, we also present some data about the use of Zanoni atomizers for mosquito control and spruce budworm control. Although these indicators vary considerably according to the characteristics of each type of application (including the type of aircraft, the type of product applied and the climatic conditions), they are a minimum reference to help our partners. It is recommended, however, that each operator carry out its particular tests to better suit the use of Zanoni rotary atomizers. The data provided here deal only with the results of agronomic tests. For technical information on maintenance, calibration and installation, consult the equipment manual or our team.

We thank each of the partners who place their trust in our work and have shared suggestions over the past few years, without which we would not have achieved the quality standards we have today. We also wish to thank all agronomists and other specialists in aerial application, who constantly contribute with their knowledge so that we can help in the development of agricultural aviation around the world.

#### **ROTARY ATOMIZERS**



#### INTRODUCTION

New developments in aerial spraying technologies have led to a tendency of reducing the spray volume in applications, due to the search for greater autonomy and greater operational capacity of aircraft. The decrease of water volume in applications, however, can lead to worse distribution and irregular deposition, influencing the effectiveness of agrochemicals and crop protection.

Need for greater flight autonomy.



Need for reduction and greater concentration of the spray volume.



Environmental risks and loss of efficiency due to drift.



Another concern in agricultural aviation are environmental issues and the loss of efficiency related to the drift of agrochemical products, with negative consequences for pest control and for the industry's image.

The two problems are closely related to the size and uniformity of the droplets sprayed, leading to the need for research and development of equipment that ensures greater control in the spectrum of droplets generated by the nozzles.



Need for greater control of the droplet spectrum.

#### ROTARY ATOMIZERS

**DROPLET SPECTRUM** 

#### DROPLET UNIFORMITY

Applications with thin and very thin drops in reduced volume tend to have a greater coverage on the target than thicker drops. The main problem with this type of application, however, is drift, as smaller drops can be carried by the wind due to their small volume.

Thus, it is important that the spectrum of droplets is as uniform as possible, avoiding that there are very thin droplets (with risk of drift) and very thick droplets that hinder the application (with risk of draining). The uniformity of the drops is measured by the relative span (RS), an indicator that points to a more uniform spectrum the smaller it is. That is, the closer to 0 the relative span, the more uniform the application and, consequently, the more efficient it tends to be.



#### DROPLET SIZE

In addition to uniformity, it is important to take into account the appropriate droplet size. Two indicators are important for this topic:

- The value that points out that 10% of the drops are less than or equal to it (Dv01);

- The value that indicates that 50% of the drops are less than or equal to it (the volumetric median diameter - VMD)

The ideal VMD varies according to each type of application and the nozzles can offer different types of VMD, depending on their calibration.

Dv01 cannot present very low values for any crop spraying (except for special applications, such as mosquito, locust and budworm control), as they are one of the main indicators of drift potential. An application with DV01 above 100 microns is recommended for insecticide and fungicide applications and 150 micron for herbicides.

Dv01 > 100µm





Dv01 > 150µm



HERBICIDES

INSECTICIDES

FUNGICIDES

#### **ROTARY ATOMIZERS**

EQUIPMENT FUNCTION

#### ROTARY ATOMIZER OPERATION

One of the solutions created by the agricultural aviation sector to control the droplet spectrum is the so-called rotary atomizers. This type of nozzle rotates at high speed, breaking the sprayed load into uniform drops, eliminating small drops (which run the risk of drifting) and very thick drops (which are lost by draining), making it possible to work with low volumes. The equipment works according to the regulation of a valve (Variable Restriction Unit - VRU) that, together with the pressure adjustment of the airplane's spray pump, controls the flow of the product that will be sprayed on the crop.



The regulation of the drop size is obtained according to the rotation speed of the atomizer gauze, which varies according to the aircraft speed and the angle of the equipment's blades. The operator can therefore adjust the size of the drops according to the need for a particular application.





#### EFFICIENCY IN AERIAL SPRAYING

The spray atomization stands out as a tool that, during the application of low volume loads, allows a better uniformity of drops in relation to other types of nozzles. In this way, they can contribute to the reduction of the risks of drift of agrochemical products, provided that all guidelines of good practices for aerial application are followed and that the equipment is properly regulated.

#### SCIENTIFIC EVIDENCE

As highlighted by Antuniassi et al. (2011), a comparative evaluation of the spectrum and uniformity of droplets on rotary nozzles and hydraulic nozzles (depending on the volume of pesticides under laboratory conditions) concluded that rotary atomizers produce greater uniformity and a lower percentage of droplets susceptible to drift. Reis et al. (2010) points out that rotary atomizers produce drops with a lower coefficient of variation, that is, with greater uniformity than other types of nozzles. Da Cunha et al. (2017) also points out that it is possible to infer that atomizers are the most interesting tools to reduce drift when compared to conventional nozzles. Guedes et al. (2012), in turn, points out that «in relation to the application technologies, it was found a greater efficiency in the control of treatments applied with rotary atomizers ... resulting in greater deposition of the drops in the lower part of the canopy»

Thus, by making it possible to adjust the size of the droplets and guarantee uniformity to them, the atomizers can offer a more efficient application and greater productivity to the crop.



Greater uniformity of droplets.





#### ZANONI ATOMIZERS



#### ROTARY ATOMIZERS



After years of study, Zanoni Equipamentos<sup>®</sup> rotary atomizers were developed through high quality and precision procedures, using materials resistant to the most corrosive products used in aerial spraying. They are equipped with a cylindrical stainless steel atomizer gauze and are available in several mesh sizes, capable of producing the spectrum of drops required for each type of operation, with a high quality application.



- Stainless steel resistance and Zanoni Equipamentos<sup>®</sup> durability;
- Larger bearings than those of other manufacturers;
- Strong atomizer gauzes, which facilitate equipment cleaning;
- Easy maintenance;
- Efficiency in application, with appropriate uniformity of drops.

For information on the operation of the Zanoni rotary atomizer, access its technical manual on our website: <a href="http://www.zanoniequipamentos.com.br/uploads/products/manual/2020/06/atomizer-technical-manual-1593283497.pdf">www.zanoniequipamentos.com.br/uploads/products/manual/2020/06/atomizer-technical-manual-1593283497.pdf</a>

COMPONENTS

#### ROTARY ATOMIZERS Z 20224-1/2 and Z 40224-1/2

High-quality components that guarantee durability to the equipment.

Easy cleaning and simplified maintenance.

Zanoni rotary atomizers are produced with wire meshes in M2,5; M3 and M14. The proper size depends on the type of droplet spectrum desired by the operator. They are interchangeable in the same equipment and the operator can replace them according to the application's needs.

ITEM	PN	PRODUCT		
1	Z 20224-05-04	RING, SECURING		
2	Z 20224-05-02	САР		
3	Z 20224-05-05	VITON DIAPHRAGM		
4	Z 20224-05-01	DIAPHRAGM CHECK VALVE BODY		
1/2"	DIAPHRAGM CHECK V	ALVE (COMPLETE): Z 20224-05-1/2"		
5	Z 20224-01-09	BRASS NUT		
6	Z 20224-02-05	WASHER		
7	Z 20224-02-04	POLYURETHANE BUSH		
8	Z 20224-02-03	BUSH PIPE		
•	Z 20224-02	MOUNTING CLAMP (1 <sup>1</sup> / <sub>2</sub> " BOOMS)		
9	Z 40224-02	MOUNTING CLAMP (2" BOOMS)		
10	Z 20224-01-10	BRASS BUSHING		
11	Z 20224-01-01	HUB BODY ASSEMBLY		
	Z 20224-01-08	FAN BLADES (WIDE)		
12	Z 50224-01-08	FAN BLADES (MEDIUM)		
	Z 80224-01-08	FAN BLADES (SHORT)		
13	Z 20224-01-02-04	SNAP RING I-35		
14	Z 20224-01-01-03	GREASE NIPPLE		

ITEM	PN	PRODUCT
15	Z 20224-01-02-03	BEARING
16	Z 20224-01-02-06	BEARING SPACER (INSIDE)
17	Z 20224-01-02-05	BEARING SPACER (OUTSIDE)
18	Z 20224-01-02-07	BEARING HOUSING
19	Z 20224-01-05	V'RING
20	Z 20224-01-04	DEFLECTOR RING
21	Z 20224-01-03-01	SHAFT
22	Z 20224-01-03-05	SPRING CLIP
23	Z 20224-01-03-04	TEFLON GUIDE
24	Z 20224-01-03-03	SPRING
25	Z 20224-01-03-02-03	VITON RING
26	Z 20224-01-03-02	RETENTION VALVE
27	Z 20224-01-07	DEFLECTOR DISC
	Z 20224-01-06-M2,5	ATOMIZER GAUZE M2,5
28	Z 20224-01-06-M3	ATOMIZER GAUZE M3
	Z 20224-01-06-M14	ATOMIZER GAUZE M14
29	Z 20224-01-13	DEFLECTOR CAP

The mounting clamp varies according to the aircraft's boom profile. For the correct product, please inform the dealer which type of boom the equipment will be installed on.

The propeller blades of the equipment vary according to the average speed of the aircraft. For more information, see the technical manual available on our website or contact the Zanoni team.

#### ZANONI ATOMIZER



#### 1/2" VARIABLE RESTRICTOR UNIT (VRU) Z 20224-03-1/2

Stainless steel VRU: corrosion resistance and Zanoni Equipamentos<sup>®</sup> durability.



Zanoni VRU also fits other brands of rotary atomizers and they have a double feeding system (items 37 + 42), for applications with higher flow rates.

ITEM	PN	PRODUCT
30	Z 20208-01-04	5/16" HEX NUT
31	Z 20208-08	5/16" WASHER
32	Z 20224-03-09	DISC WITH LEVER
33	Z 20224-09	O'RING 2008
34	Z 20224-03-04	SHAFT
35	Z 20224-03-01	VRU BODY
36	Z 00093	NOZZLE FOR HOSE (3/8" X 1/8" NPT)
37	Z 00089	1/4" X 1/8" NPT NIPLE
38	Z 20224-03-05	MAIN SEAL (TEFLON)
39	Z 20224-03-03	STAINLESS STEEL BALL
40	Z 20224-08	O'RING 019
41	Z 20224-03-02	VRU CAP 1/2"
42	Z 00092	ELBOW (3/8" X 1/8" NPT)

#### CONSTANT RESEARCH AND DEVELOPMENT

Zanoni Equipamentos started manufacturing the atomizers a few years ago, at the request of some of our Brazilian agricultural aviation partners. After a few years of working in the field together with operators, the Zanoni rotary atomizer is gradually being improved to offer a precise and efficient application for the agricultural pilot, in a device with high durability and easy maintenance, as the company usually develops its line of products.

Constantly seeking to perfect its atomizer and listening to several complaints about the lack of uniformity in spraying (including the first prototypes of its own nozzles), Zanoni Equipamentos has endeavored to offer the most efficient equipment in terms of droplet size distribution.

As has been widely discussed in universities and in the entire agricultural aviation industry, we always need more information and scientific studies on the quality and efficiency in aerial application. Even though it took a long time to enter the rotary atomizer market, Zanoni Equipamentos has invested considerably in research to offer accurate and transparent data to its partners, improve spraying technologies and to collaborate for the development of agricultural aviation as a whole.

After an intense development work, the Zanoni rotary atomizers started to receive several positive feedback from agronomists and operators regarding uniformity (relative span), also presenting Volume Median Diameter (VMD) and Dv01 which are safe and suitable for fungicide and insecticide applications (since in Brazil, rotary atomizers are widely used for those types of crop spraying and the Zanoni equipment has offered the best performance in this job).

In this document we present some results obtained by field research with our M3 and M14 atomizers on Air Tractor and Ipanema aircraft. There is also some results about the application of Trumpet (for mosquito control) with the M14 by US operators. In addition to the information disclosed here, we have some other research scheduled to be carried out both in laboratories and in the field, maintaining our commitment to always provide accurate and transparent data to our partners.



ZANONI M3 ATOMIZER



ZANONI M14 ATOMIZER

#### GENERAL PERFORMANCE

#### RESULTS

In a test carried out by the agronomist Rodrigo Franco Dias (UFSM, ConnectFarm) on an Air Tractor aircraft (with average speed of 140 mph) from DP Aviação (Air Tractor dealer), very appropriate relative spans were found, according to the parameters indicated by specialists in this area. The research conducted in Rio Grande do Sul state analyzed the droplet spectrum based on three flow rates (5L/Ha; 10L/Ha; and 15L/Ha) with water, under 3 different types of equipment settings (high, medium and low rotation). Offering a VMD between 130 $\mu$ m and 200 $\mu$ m (depending on the desired calibration), always with DV01s above 100  $\mu$ m, the Zanoni M3 atomizer presented the following relative amplitudes and VMDs:



AGRONOMIC TESTS WITH ZANONI M3 ATOMIZER



ZANONI M3 ATOMIZER ON AIR TRACTOR AIRCRAFT

	FLOW: 5L/HA		FLOW: 10L/HA		FLOW: 15L/HA	
	RS	VMD	RS	VMD	RS	VMD
LOW ROTATION	0,8	199µm	0,8	181µm	0,8	190µm
MEDIUM ROTATION	0,8	149µm	0,7	162µm	1,2	200µm
HIGH ROTATION	0,9	140µm	1	136µm	0,8	156µm

Note: the tests are preliminary and the results may vary according to climatic conditions, characteristics of the agrochemical, aircraft profile, etc.

The same model of equipment was featured at AgAir in September 2020. Tests with Zanoni M3 atomizer were carried out by Alan McCracken in an AT402 from Grupo Piaia, in Piauí state. The renowned agronomist, author of the magazine's cover story in that month, pointed out that there was "an almost perfect distribution of drop sizes for insecticides and fungicides using low volumes, with a minimum drop volume below 150 microns and a low percentage above ideal maximum of 350 microns". In addition to the published article, the expert sent a compliment to Zanoni Equipamentos regarding the uniformity of drops presented by the equipment and also for the quality of its Variable Restrictor Unit (VRU).

The two tests, thus, confirm the experiences reported by the various Brazilian partners of the company, that the Zanoni atomizers have shown a standard of excellence in relation to the uniformity of drops, with the traditional durability of the brand.

GENERAL PERFORMANCE

#### TESTS WITH EMBRAER IPANEMA

During the first week of August 2020, a series of agronomic tests were carried out in Pelotas (Rio Grande do Sul state) in the field of aerial application. The research, conducted by agronomist PhD Henrique Campos, evaluated three types of spray nozzles (conventional nozzles, Zanoni rotary atomizers and also the Zanoni-Spectrum electrostatic system - for more information about this technology, please see our website), analyzing the droplet spectrum, drift potential and uniformity of spray distribution with different swath width.

The application was carried out with an Embraer Ipanema 202 aircraft from the company Taim Aero Agrícola. Nine series of four to seven repetitions were carried out with the Zanoni M14 rotary atomizers, varying according to three flows and with three adjustments of the equipment: high rotation with flow rates of 5L/Ha, 10L/Ha and 15L/Ha; medium rotation with flow rates of 5L/Ha, 10L/Ha and 15L/Ha; and low rotation with flow rates of 5L/Ha, 10L/Ha and 15L/Ha. The rotation of the atomizer varies according to the regulation of the angle of its blades and the flow varies according to the regulation of the spraying system or the rotary atomizer variable restrictor unit (VRU).



FIELD TESTS WITH ZANONI M14 ATOMIZER



PHD HENRIQUE CAMPOS (SABRI), RESPONSIBLE FOR CONDUCTING THE RESEARCH



IPANEMA 202 EQUIPPED WITH ZANONI M14 ATOMIZER

The tests with rotary atomizers were carried out on August 8 between 9:20 am and 1:20 pm. The wind speed varied between 1 km/h and 12 km/h, the temperature between 16°C and 18°C and the relative humidity between 80% and 84%. The average speed of the aircraft varied between 144 km/h and 164 km/h, making, in all shots, an application with a pressure of 2.8 bar (or approximately 40.6 PSI). For each of the shots, hydrosensitive papers were used distributed along a wire positioned in the field, over which the aircraft flew by applying water and dye, which were placed under the reading of a DropScope microscope (SprayX).

#### DROPLET SPECTRUM

Based on the averages of each of the nine shots (based on the seven samples of each), the software reported the following results:

	FLOW: 5L/HA		FLOW: 10L/HA		FLOW: 15L/HA	
	RS	VMD	RS	VMD	RS	VMD
LOW ROTATION	0,8	170µm	1	175µm	0,9	185µm
MEDIUM ROTATION	0,7	154µm	0,8	164µm	0,9	159µm
HIGH ROTATION	1,1	122µm	1	138µm	1,1	174µm

Note: the tests are preliminary and the results may vary according to climatic conditions, characteristics of the agrochemical, aircraft profile, etc.

Despite presenting DV01s a little below 100 microns (standard established as safe for the application of fungicides and insecticides), the agronomist pointed out that applications with water tend to have thinner drops than the application with compound products and that the use of adjuvants tends to increase DV01 and VMD concluding that "the Zanoni nozzles have presented values of DVM and DV0.1 safe and suitable for the application of agrochemical products".

#### UNIFORMITY OF SPRAY DISTRIBUTION

In addition to the droplet spectrum, the agricultural aircraft research collected information to determine the best swath width. Such data is of great importance for aerial spraying, since the adequacy of the swath guarantees the absence of phytotoxicity in the crop (due to the overlapping of swath) and prevents flaws in the control of pests and diseases.

The data on the ideal swath for each type of regulation of the Zanoni M14 atomizers are available in the sequence of this document.

The ideal for uniformity of the spray distribution (which is calculated by the CV indicator - coefficient of variation) is that it is always less than 20% and, the smaller it is, the more uniform and efficient the application is. For each adjustment of the Zanoni M14 atomizer, CV information was collected, thus offering data so that the pilot can determine the most efficient swath for his work according to the type of application, both for racetrack (RT) and back and forth (BF) applications.

The agronomist, a profound expert on this topic, commented positively on the uniformity of spray distribution offered by the Zanoni M14 atomizer.

DROPLET SPECTRUM

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	5L/Ha - High Rotation		
Analysed Area	90.45 cm <sup>2</sup>	Covered Area	0.54%
Applied Volume on Paper	0.011µL/cm²	Density	31.39 N/cm²
Quantity of Drops	2839	<b>Relative Span</b>	1.09
Diameter Variation Coefficient	52.64%	Drift Potential	71.36%
VMD	122.51	D0.1	67.07
D0.9	200.36	NMD	61.25
Largest Drop	313.50µm	Smallest Drop	24.10µm
Average Diameter	69.82 μm		





DROPLET SPECTRUM

ANON

5L/Ha - Medium Rotation						
Analysed Area	78.77 cm <sup>2</sup>	Covered Area	0.90%			
Applied Volume on Paper	$0.021 \mu L/cm^{2}$	Density	33.97 N/cm²			
Quantity of Drops	2676	Relative Span	0.78			
Diameter Variation Coefficient	54.05%	Drift Potential	52.73%			
VMD	148.98	D0.1	84.17			
D0.9	200.36	NMD	72.83			
Largest Drop	260.08 μm	Smallest Drop	24.10µm			
Average Diameter	$83.32\mu{ m m}$					





DROPLET SPECTRUM

ANON

	5L/Ha - Low Rotation		
Analysed Area	88.37 cm <sup>2</sup>	Covered Area	1.15%
Applied Volume on Paper	$0.028\mu\text{L/cm}^2$	Density	32.80 N/cm <sup>2</sup>
Quantity of Drops	2898	<b>Relative Span</b>	0.80
Diameter Variation Coefficient	56.70%	Drift Potential	39.28%
VMD	169.75	D0.1	95.32
D0.9	230.44	NMD	84.17
Largest Drop	313.50µm	Smallest Drop	24.10µm
Average Diameter	91.26µm		





DROPLET SPECTRUM

ANON

	10L/Ha - High	Rotation	
Analysed Area	70.05 cm <sup>2</sup>	Covered Area	2.66%
Applied Volume on Paper	$0.057\mu\text{L/cm}^2$	Density	111.39 N/cm <sup>2</sup>
Quantity of Drops	7803	Relative Span	1.02
Diameter Variation Coefficient	53.29%	Drift Potential	59.20%
VMD	138.46	D0.1	84.17
D0.9	225.46	NMD	72.83
Largest Drop	351.72µm	Smallest Drop	24.10µm
Average Diameter	80.64 μm		





DROPLET SPECTRUM

ANON

	10L/Ha - Medium Rotation					
Analysed Area	86.95 cm <sup>2</sup>	Covered Area	1.48%			
Applied Volume on Paper	$0.035\mu\text{L/cm}^2$	Density	45.73 N/cm <sup>2</sup>			
Quantity of Drops	3976	Relative Span	0.82			
Diameter Variation Coefficient	57.26%	Drift Potential	39.84%			
VMD	164.58	D0.1	95.32			
D0.9	230.44	NMD	72.83			
Largest Drop	299.04 μm	Smallest Drop	24.10µm			
Average Diameter	88.13µm					





DROPLET SPECTRUM

ANON

	10L/Ha - Low Rotation		
Analysed Area	87.32 cm <sup>2</sup>	Covered Area	2.17%
Applied Volume on Paper	$0.056\mu\text{L/cm}^2$	Density	67.50 N/cm <sup>2</sup>
Quantity of Drops	5894	<b>Relative Span</b>	0.97
Diameter Variation Coefficient	60.17%	Drift Potential	35.91%
VMD	174.89	D0.1	95.32
D0.9	264.99	NMD	72.83
Largest Drop	361.21µm	Smallest Drop	24.10µm
Average Diameter	88.13µm		





DROPLET SPECTRUM

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	15L/Ha - High Rotation		
Analysed Area	89.23 cm <sup>2</sup>	Covered Area	8.12%
Applied Volume on Paper	0.216µL/cm²	Density	242.34 N/cm <sup>2</sup>
Quantity of Drops	21624	Relative Span	1.11
Diameter Variation Coefficient	58.97%	Drift Potential	36.41%
VMD	174.89	D0.1	95.32
D0.9	289.36	NMD	78.53
Largest Drop	468.56 μm	Smallest Drop	24.10µm
Average Diameter	90.30 µm		





DROPLET SPECTRUM

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	15L/Ha - Medi	um Rotation	
Analysed Area	91.09 cm <sup>2</sup>	Covered Area	3.10%
Applied Volume on Paper	$0.074\mu\text{L/cm}^2$	Density	98.08 N/cm <sup>2</sup>
Quantity of Drops	8934	Relative Span	0.94
Diameter Variation Coefficient	55.37%	Drift Potential	46.22%
VMD	159.40	D0.1	95.32
D0.9	245.31	NMD	78.53
Largest Drop	463.95 μm	Smallest Drop	24.10µm
Average Diameter	88.60 µm		





DROPLET SPECTRUM

ANOA

	15L/Ha - Low Rotation		
Analysed Area	86.40 cm <sup>2</sup>	Covered Area	2.50%
Applied Volume on Paper	0.067 μL/cm²	Density	63.66 N/cm <sup>2</sup>
Quantity of Drops	5500	<b>Relative Span</b>	0.89
Diameter Variation Coefficient	58.84%	Drift Potential	31.39%
VMD	185.13	D0.1	100.82
D0.9	264.99	NMD	84.17
Largest Drop	356.47 μm	Smallest Drop	24.10µm
Average Diameter	96.21µm		





SWATH UNIFORMITY



#### Swaths with greater uniformity

Swath (feet)	<u>56</u>	<u>57</u>	<u>58</u>	<u>59</u>	<u>60</u>	<u>61</u>	<u>62</u>	<u>63</u>	<u>64</u>	<u>65</u>	<u>66</u>	<u>67</u>	<u>68</u>	<u>69</u>	<u>70</u>	<u>71</u>	<u>72</u>
CV (RT)	11%	11%	11%	11%	10%	10%	10%	10%	11%	11%	11%	11%	11%	12%	12%	12%	13%
CV (BF)	10%	10%	10%	10%	10%	9%	9%	9%	10%	11%	12%	12%	13%	13%	14%	14%	15%



#### Swaths not suitable for work Swaths with greater uniformity

Swath (feet)	<u>43</u>	<u>44</u>	<u>45</u>	<u>46</u>	<u>47</u>	<u>48</u>	<u>49</u>	<u>50</u>	<u>51</u>	<u>52</u>	<u>53</u>	<u>54</u>	<u>55</u>	<u>56</u>	<u>57</u>	<u>58</u>	<u>59</u>	60	61
CV (RT)	29%	29%	29%	28%	25%	22%	18%	13%	12%	11%	11%	11%	11%	11%	11%	11%	11%	11%	11%
CV (BF)	17%	17%	17%	17%	17%	16%	15%	14%	13%	13%	13%	13%	13%	12%	12%	11%	10%	10%	10%

#### 5L/Ha - High Rotation



#### Swaths with greater uniformity

Swath (feet)	<u>43</u>	<u>44</u>	<u>45</u>	<u>46</u>	<u>47</u>	<u>48</u>	<u>49</u>	<u>50</u>	<u>51</u>	<u>52</u>	<u>53</u>	<u>54</u>	<u>55</u>	<u>56</u>	<u>57</u>	<u>58</u>	<u>59</u>	60	61
CV (RT)	19%	18%	17%	17%	15%	11%	9%	9%	10%	10%	11%	11%	12%	13%	14%	14%	14%	13%	13%
CV (BF)	13%	13%	13%	12%	12%	12%	12%	13%	13%	13%	13%	13%	12%	12%	12%	12%	12%	13%	13%

CV (BF)

16%

17%

16%



ZANONI EQUIPAMENTOS - ROTARY ATOMIZERS

15%

15%

15%

14%

13%

12%

11%

10%

10%

10%

11%

12%

15%

16%

15%

15%

(RT) CV

(BF)

13%

14%

14%

15%

15%

15%

15%

SWATH UNIFORMITY



ZANONI EQUIPAMENTOS - ROTARY ATOMIZERS

15%

14%

14%

13%

12%

11%

11%

9%

9%

8%

8%

15%

#### TRUMPET APPLICATION

During the past year, Zanoni atomizers have also come to be used in mosquito control activities in North America. In addition to the positive results regarding the size of droplets, American operators praised the quality of the equipment due to its durability. As this type of application demands the maximum from the atomizer, it is ideal that the nozzles have a high resistance and, according to them, Zanoni products presented a "flawlessly operation", superior to that of other brands. Below you can find information about two applications with Trumpet using the Zanoni M14 atomizer.

#### VMD: 32.49 microns.



#### SPRUCE BUDWORM

The (eastern) spruce budworm (Choristoneura fumiferana) is a moth native to North America, which feeds on balsam fir, white spruce, red spruce and black spruce, killing those trees after four or five consecutive years of severe defoliation. During an outbreak cycle, which happens every three to four decades and may last several years, tens of millions of hectares of trees can be severely defoliated, with a significant impact on Canada's and USA's forests.



The eastern spruce budworm (top: adult moth; bottom: caterpillar). Natural Resources Canada (NRCAN)



Forest defoliation caused by the Spruce Budworm.

The Canadian government has a management program called Spruce Budworm Early Intervention Strategy (EIS) which aims to interrupt or slow the progression of a spruce budworm infestation, with research activities and operational insecticide applications. Some provinces run contracts for aerial application, like Quebec and Alberta. Some American states also have similar programs.

The pesticide used for spruce budworm control is called Bacillus thuringiensis (BT), a microbe naturally found in soil which is harmless to other animals, but it is toxic to the larvae of butterflies and moths. Those aerial forest spray operations use Ultra Low Volume (ULV), typically at 0.1 - 0.53 US gal/acre (1 – 5 l/ha), and requires a precise control of spray droplet size.

According to Valent BioSciences, the Foray 76B (one of the most popular BT formulations) is used against spruce budworm at 1.5 L/ha (approx. 0.16 gallon/acre) with a VMD of about 80 microns. The government agencies responsible for contracts require that the nozzles to be used in their application present safety, reliability and consistency in droplet sizes, what was achieved by the Zanoni M14 atomizer.



Aerial spraying against spruce budworm. USDA Forest Service.

#### WIND TUNNEL TESTING

Wind tunnel testing conducted at the Pesticide Application Technology Laboratory (University of Nebraska-Lincoln) demonstrated the suitability of the Brazilian nozzle for application of Foray 76B.





The tests that were run at the University of Nebraska's wind tunnel on January 13, 2021 assessed the Zanoni M14 atomizer performance in spraying Foray 76B at 100% v:v, with a Sympatec Helos Vario KR particle size analyzer. The nozzle was tested at wind speeds of 140 and 160 mph (thus simulating an Air Tractor 502 and an Air Tractor 802) with different blade angles and different flow rates per atomizer. Each treatment lasted 5 seconds and was replicated three times. The laboratory simulated a temperature of 69.8 °F and a relative humidity of 24.9%.

To define the flow rates per atomizer, we used the swath width (or "lane separation") recommended by Valent Biosciences in its <u>"Foray Technical Manual"</u> as a parameter, that is, a swath width of 175 feet (or 53 meters) for an Air Tractor 502 and a 200 feet (or 60 meter) swath width for an Air Tractor 802. In order to simulate an application of 1,37 L/ha to 1,47 L/Ha (approx. 0.146 gallon/acre to 0.157 gallon per acre), different flow rates per atomizer were used (as if the AT802 was equipped with 4, 6, 8 or 10 atomizers and as if the AT502 was equipped with 4, 6 or 8 atomizers), according to the following table:

	Foray 76B application:										
1,37 L/ha to 1,47 L/Ha (approx. 0.146 gallon/acre to 0.157 gallon per acre)											
<u>No.</u>	Hypothetical aircraft configuration:	<u>Rate per atomizer:</u>									
1	AT 802 with 4 atomizers (160mph, 200ft)	9.16 Liter/minute (or 2.42 GPM)									
2	AT 802 with 6 atomizers (160mph, 200ft)	6.02 Liter/minute (or 1.59 GPM)									
3	AT 802 with 8 atomizers (160mph, 200ft)	4.66 Liter/minute (or 1.23 GPM)									
4	AT 802 with 10 atomizer (160mph, 200ft)	3.52 Liter/minute (or 0.93 GPM)									
5	AT 502 with 4 atomizers (140mph, 175ft)	7.31 Liter/minute (or 1.93 GPM)									
6	AT 502 with 6 atomizers (140mph, 175ft)	4.66 Liter/minute (or 1.23 GPM)									
7	AT 502 with 8 atomizers (140mph, 175ft)	3.52 Liter/minute (or 0.93 GPM)									

SPRUCE BUDWORM CONTROL

In all those applications, the Zanoni M14 atomizer managed to offer the Volume Median Diameter (VMD) suggested by Valent Biosciences of around  $80\mu$ m, with a very satisfactory droplet size uniformity (that is, with low relative span – RS, which indicates a low number of very small and a low number of very large drops, providing security in the application), as shown in the table below:

Foray 76B application:											
1,37 L/ha to 1,47 L/Ha (approx. 0.146 gallon/acre to 0.157 gallon per acre)											
No.	<u>Blade Angle</u>	VMD	RS								
1	55°	82 <i>µ</i> m	1.30								
2	65°	83 <i>µ</i> m	1.25								
3	65°	82 <i>µ</i> m	1.25								
4	65°	79 μm	1.23								
5	55°	89 <i>µ</i> m	1.32								
6	55°	87 μm	1.32								
7	65°	85 μm	1.30								

Several applications other than those presented above were also carried out in the wind tunnel. They were not mentioned here because they do not fit the application standards of Foray 76B indicated by their manufacturer. It is important to highlight that, even so, the Zanoni M14 atomizer also managed to present a VMD of around  $80 \,\mu$ m (also with low relative span) with other flow rates per atomizer, both at 140 mph and 160mph. The Brazilian nozzle was also able to present other VMDs (bigger or smaller) according to the different blade angles, maintaining a low relative span in the same way. All data is available to interested parties and can be accessed by contacting Turbine Conversions, the exclusive dealer of Zanoni atomizers in North America.

Considering the above, the research conducted at the Pesticide Application Technology Laboratory (University of Nebraska-Lincoln) demonstrated that the Zanoni M14 atomizers offer a safe, reliable and consistent application of Foray 76B. This technology stands as a new option for the agricultural aviation contribute to the control of the spruce budworm in North America, being one of many innovations brought by the Turbine-Zanoni partnership to the aerial spraying industry.



furbine Conversions, Ltd.



# HOW TO FIND ZANONI

Zanoni Equipamentos has been dedicated to making its products available to agricultural pilots worldwide. The company believes that international cooperation, through dialogue and exchange of experiences, contributes to the evolution of the ag aviation industry in all countries and, above all, to the evolution of global agriculture. Just as several foreign technologies are used in Brazil and has helped make us one of the biggest food producers in the world, a great diversity of Brazilian innovations has contributed to crops in other countries.

Every pilot in each country does an essential job of taking care of crops, ensuring that the food reaches the mouths of the billions of people who live on the same planet. Believing in this responsibility that the agricultural aviation industry carries with itself, Zanoni Equipamentos seeks to fulfill its mission to offer the best quality aerial spraying systems around the world, by building relationships based on trust and integrity and constantly improving our products through research and the needs of each of our partners.

In this sense, we have strengthened our partnerships in Brazil, Latin America and North America, so that together we can offer the best technologies to all pilots. Below you will find more information about our distributors in North America. If you are interested in being our dealer, our door is always open and do not hesitate to contact the Zanoni team.

#### ZANONI'S DISTRIBUTORS IN NORTH AMERICA



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