The Affect of Flat-fan Nozzle Angle on Aerial Spray Droplet Spectra

Paper # AA05-003

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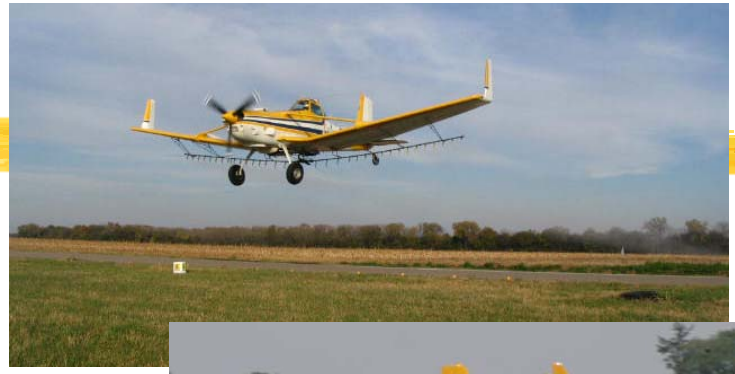
Objective:

The objective of this study was to evaluate the affect of spray angel on flat-fan droplet spectrums for fixed wing aerial applications.

Patterns?

Compared to USDA Models?

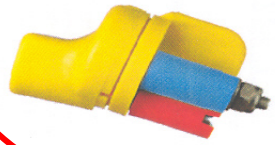
Materials and Methods:



- ✓ Multiple studies KS, CO, IL
- ✓ Multiple Aircraft
  - Cessna 188 - 2
  - AT 502
  - AT 802 - 2
  - 510 Thrush
- ✓ CP11TT with CP aerial flat-fan nozzles
- ✓ Multiple Angle Tests
- ✓ Collected Spray Droplets on WSP
- ✓ Compared to USDA Model

CP®'s NOZZLES and CHECK VALVES

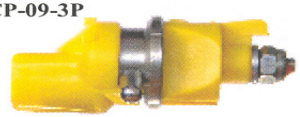
NEW! CP's 11TT

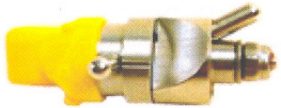


CP-03

CP-04

CP-09-3P



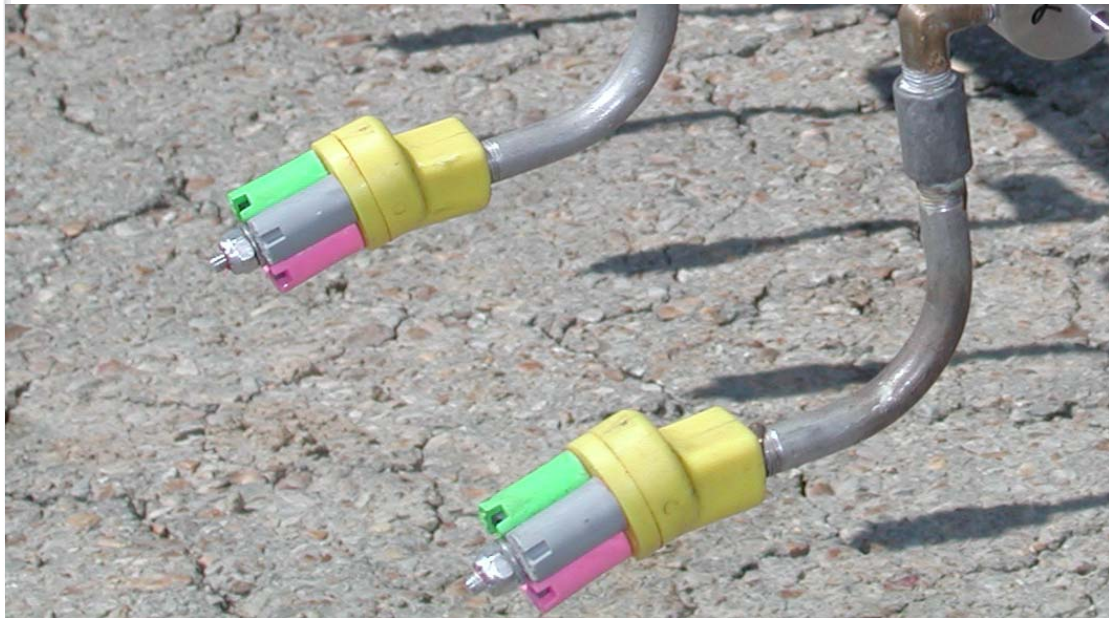


CP-09-3E

CP-02

CP-01-3

THE CP PRODUCTS® COMPANY, INC.



Materials and Methods:

- ✓ Kansas Trial – Wamego Airport
  - CP11TT with flat-fan nozzles
  - 2 GPA (35-4008 nozzles)
  - 5 GPA (35-4020 nozzles)
  - 40 psi
- ✓ Average speed - 115 mph by GPS
- ✓ Sprayed into head wind
- ✓ Application height 10-12 feet
- ✓ Multiple angles of orientation
  - 8,15,30,45,60,75
  - CP-06 Swivel

CP Swivel:

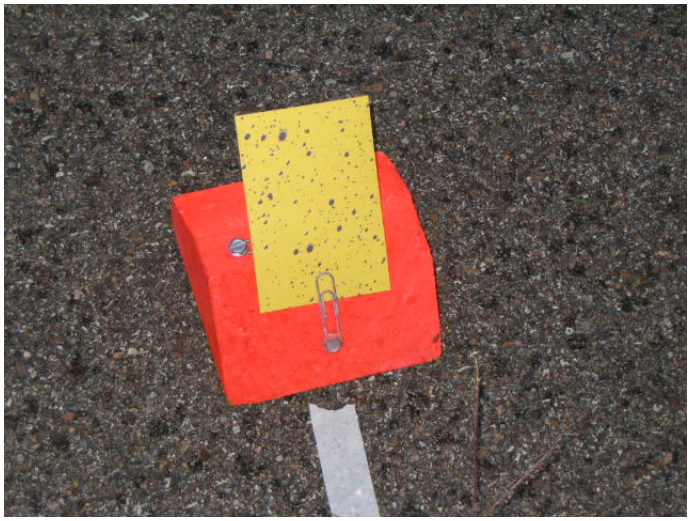
- ✓ Quick change angle device
- ✓ 15 degree increments
- ✓ Flexibility to increase the angle of attack
- ✓ Will this influence the droplet spectrum?

Materials and Methods:

- ✓ Illinois Trials – Mattoon, Lincoln
  - CP11TT with flat-fan nozzles
  - 2, 3, 4, and 5 GPA
  - 4015, 4020, 4025, 4030
  - 28 - 46 psi
- ✓ AT502, AT802's, 510 Thrush, Cessna 188
- ✓ 130, 150, 188 mph GPS measured
- ✓ Sprayed into head wind
- ✓ Application height 10-12 feet
- ✓ Orientation – 8 and 30 degrees
  - Determined by rotating the nozzle body and the nozzle

Collection Procedure:

- ✓ 1 pass per angle
- ✓ Water sensitive paper on each collector
  - 1 x 3 or 2 x 3 inch
- ✓ Collectors evenly spaced across the swath width
- ✓ Analyzed with DropletScan and composite statistics reported
- ✓ DV0.1, VMD, DV0.9
- ✓ Compared to USDA Model



USDA Aerial Nozzle Atomization Models

FIXED-WING

40-DEGREE FLAT FAN NOZZLE (LARGE ORIFICE)

FOR USE ON FIXED-WING AIRCRAFT

AERIAL APPLICATORS SPRAY NOZZLE HANDBOOK

USDA ARS AH-726

I. W. Kirk, Agricultural Engineer, Areawide Pest Management Research Unit,

Southern Plains Agricultural Research Center, Agricultural Research Service, U. S. Department of Agriculture, 2771 F&B Road, College Station, TX 77845-4966, USA.

Directions: Enter 40 DEGREE FLAT FAN nozzle settings, pressure, and airspeed in the cells highlighted below.
(Atomization parameters are valid only with nozzle and operational settings specified in the Acceptable Range.)

	Nozzle Tip Size, (Enter 15 for 4015, etc.)	Nozzle Angle, degrees	Pressure, psi	Airspeed, mph
Acceptable Range:	10 to 30	0 to 90	20 to 60	100 to 160
	20	8	40	150

Atomization parameters are displayed in the box below.

CAUTION: Do not enter or clear data in the cells in this box!

$D_{V0.1}$ =	205 µm	= Droplet size such that 10% of the spray volume is in droplets smaller than $D_{V0.1}$.
$D_{V0.5}$ =	289 µm	= Volume median diameter
$D_{V0.9}$ =	441 µm	= Droplet size such that 90% of the spray volume is in droplets smaller than $D_{V0.9}$.
RS =	0.82	= Relative Span
%V<100µm =	0.45 %	= Percentage of spray volume in droplets smaller than 100 µm diameter.
%V<200µm =	9.44 %	= Percentage of spray volume in droplets smaller than 200 µm diameter.
$DSC_{V0.1}$ =	COARSE	= Droplet Spectra Classification based on $D_{V0.1}$.
$DSC_{V0.5}$ =	MEDIUM	= Droplet Spectra Classification based on $D_{V0.5}$.
$DSC_{V0.9}$ =	FINE	= Droplet Spectra Classification based on $D_{V0.9}$.
DSC =	FINE	= ASAE S572 AUG99 Droplet Spectra Classification

F I X E D - W I N G

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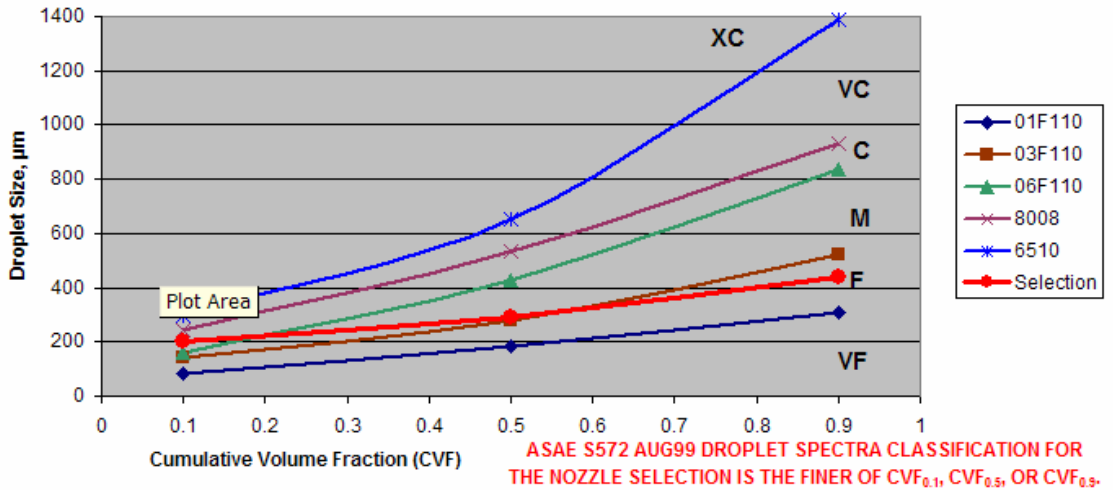
The Red Curve Shows Data for the Selected Nozzle Operation.
The Other Curves are for the ASAE S572 AUG99 Reference Nozzles.



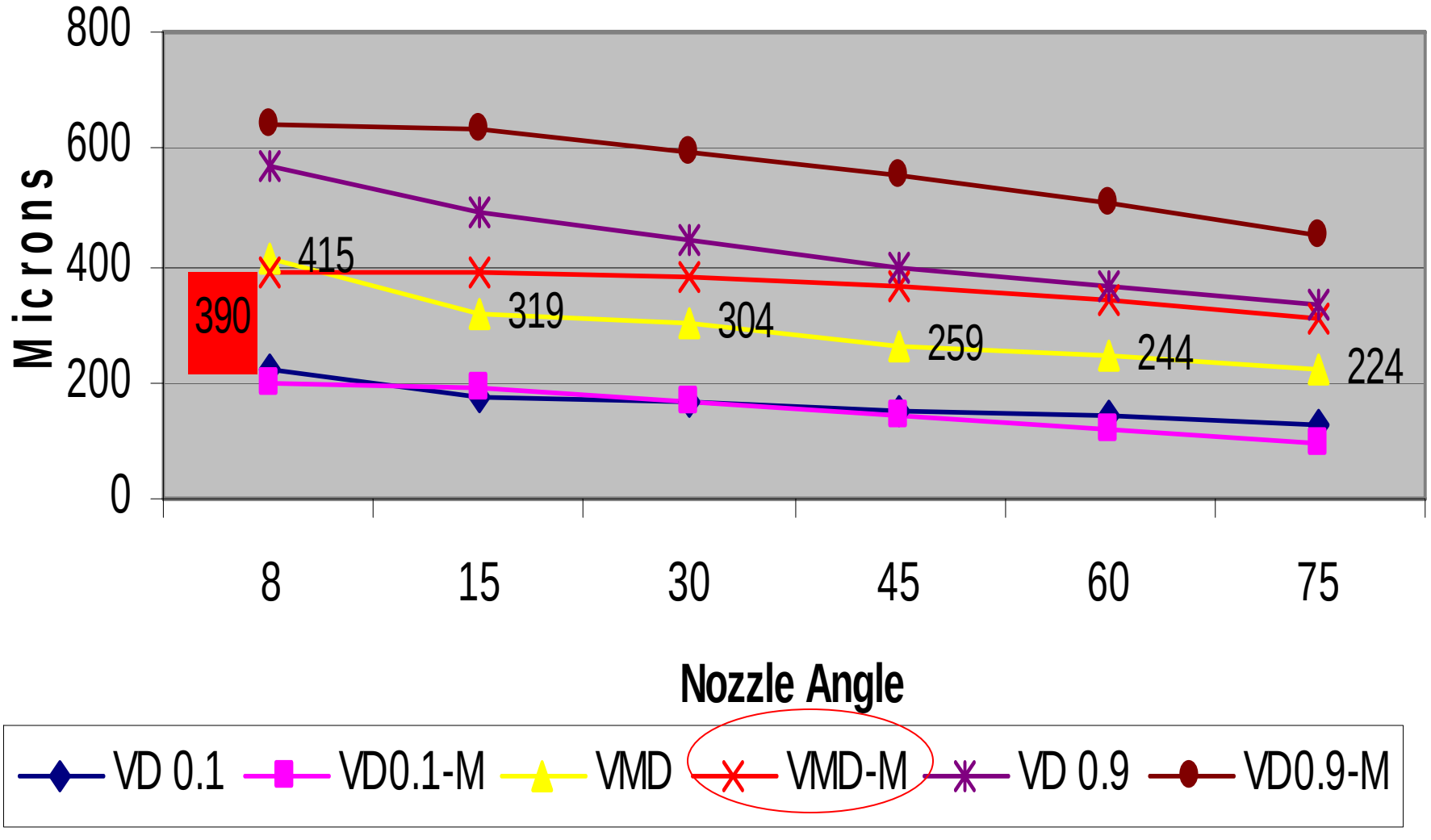
ASAE S572 AUG99 DROPLET SPECTRA CLASSIFICATION FOR THE NOZZLE SELECTION IS THE FINER OF $CVF_{0.1}$, $CVF_{0.5}$, OR $CVF_{0.9}$.

Values and classifications reported here are least-squares best-estimate predictions from experimental data collected in a wind tunnel.
Values reported from other laboratories may not yield the exact same values, but similar trends would be expected.
The ASAE droplet spectra classification category is based on droplet sizes in the mid-80% of the spectrum and not a single data point.

Wamego

Model compared to Measured @ 2 GPA

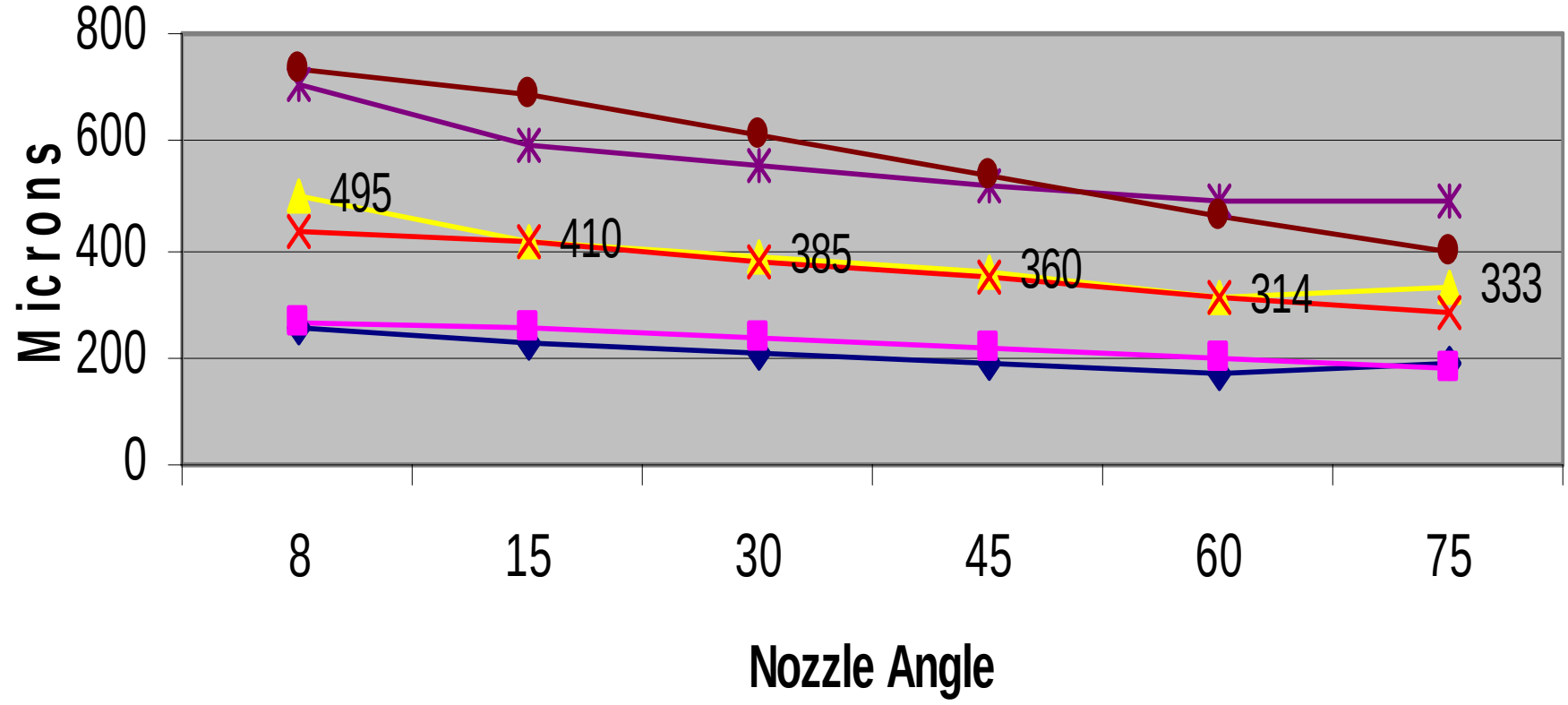
Cessna 188 (CP11TT-4008 @40 PSI, 35 nozzles, 115 MPH)



Wamego

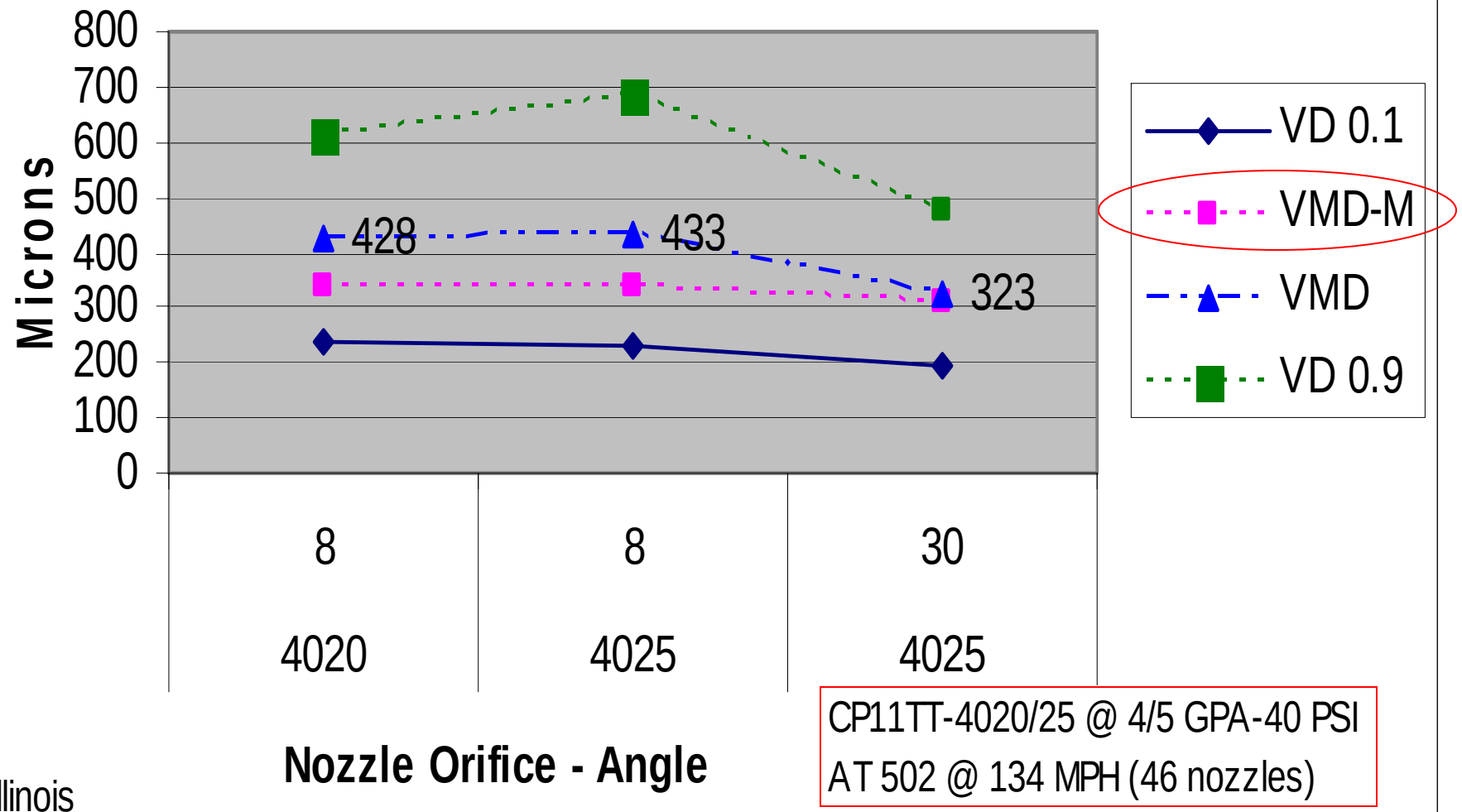
Model compared to Measured @ 5 GPA

Cessna 188 (CP11TT-4020 @40 PSI, 35 nozzles, 115 MPH)



A

Orifice and Angle Effect on Droplet Spectra

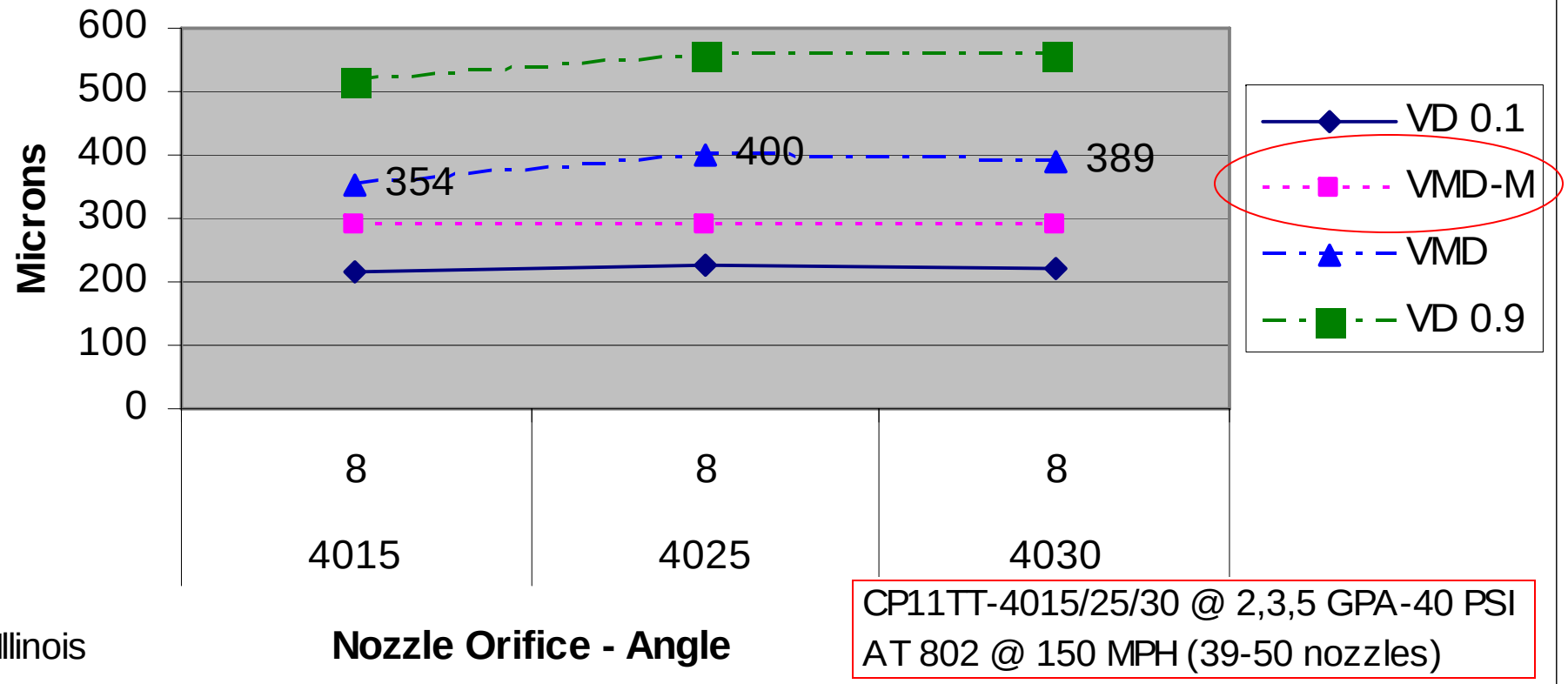


CP11TT-4020/25 @ 4/5 GPA-40 PSI
AT 502 @ 134 MPH (46 nozzles)

Illinois

B

Orifice Size Effect on Droplet Spectra

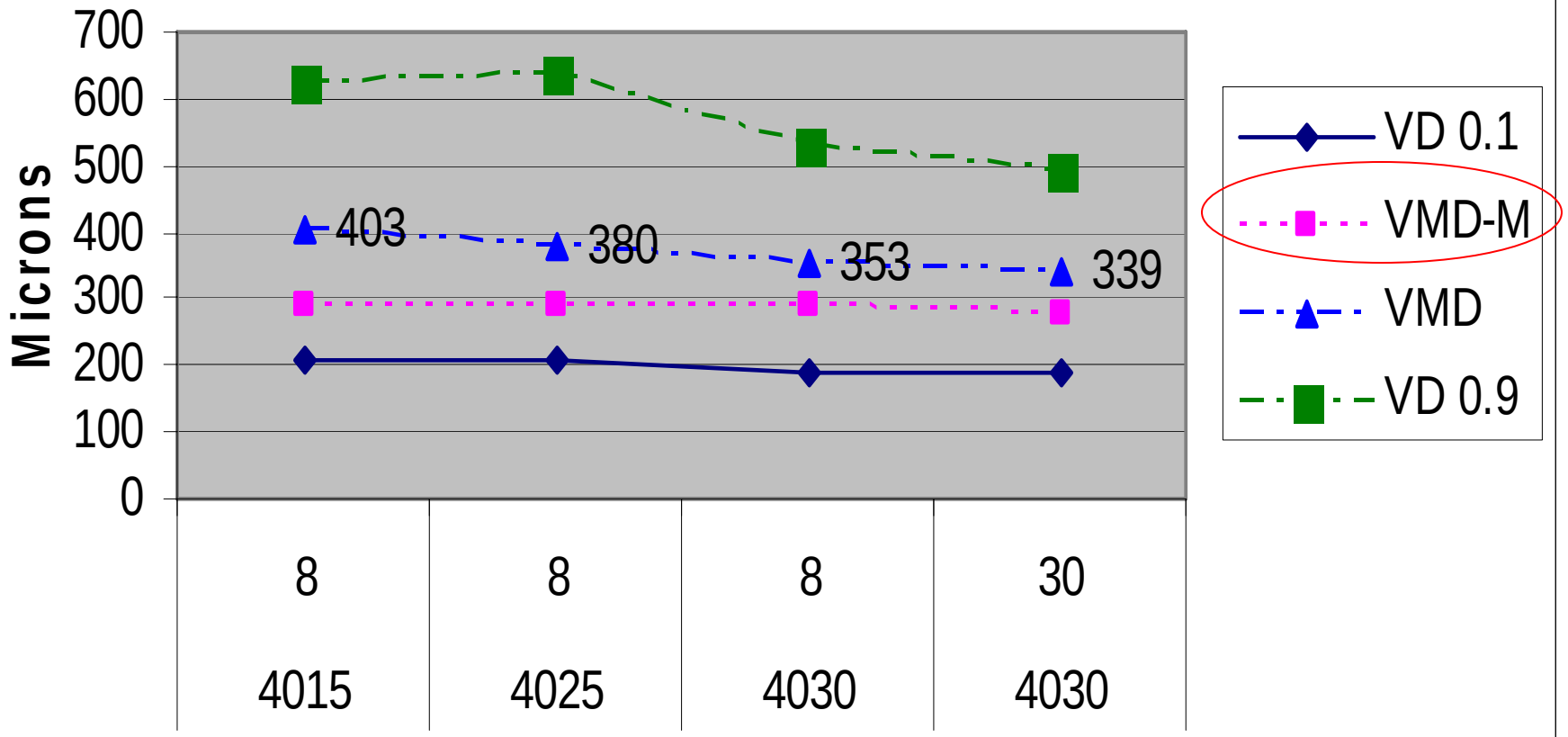


CP11TT-4015/25/30 @ 2,3,5 GPA-40 PSI
AT 802 @ 150 MPH (39-50 nozzles)

Illinois

C

Orifice and Angle Effect on Droplet Spectra

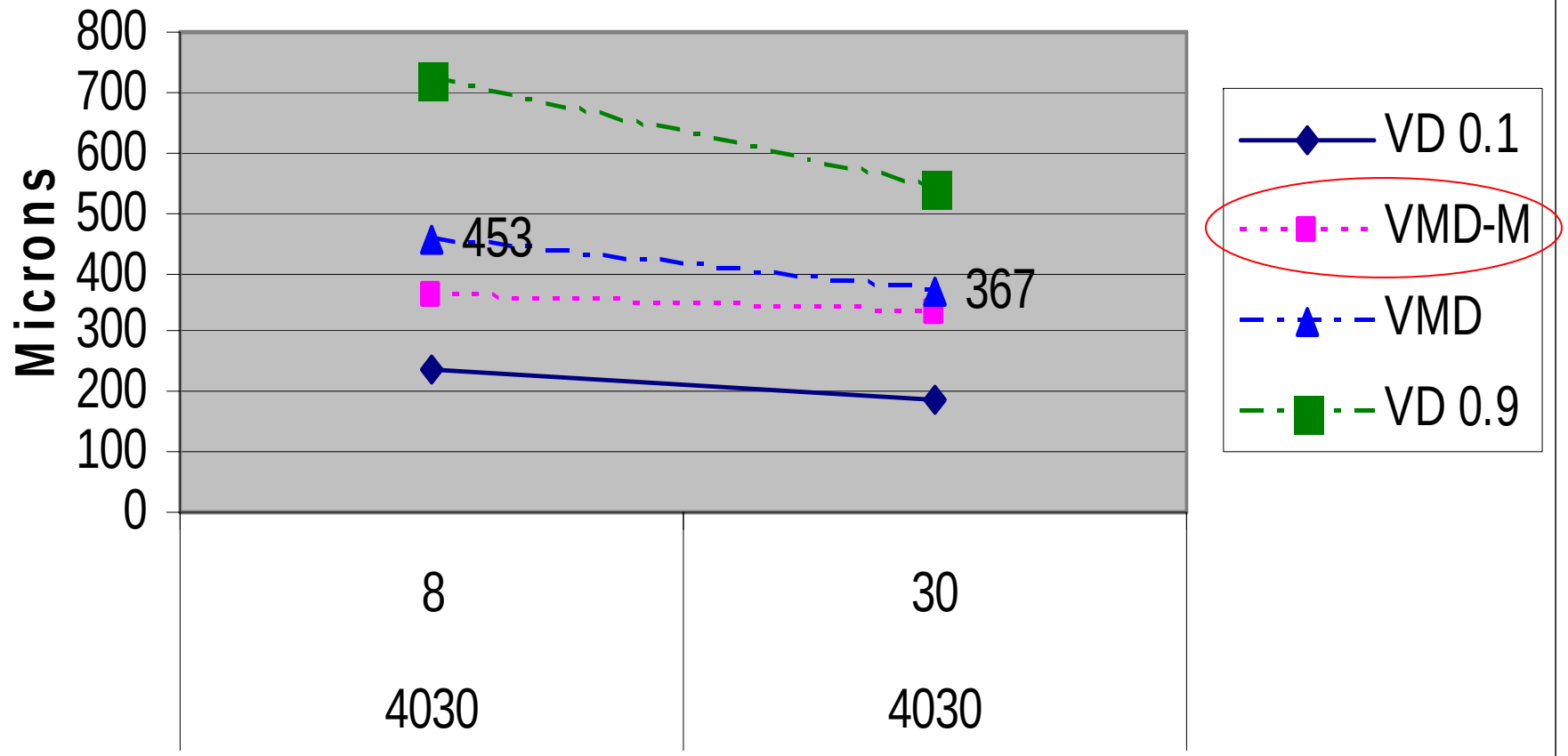


CP11TT-4015/25/30 @ 2,3,5 GPA-40 PSI AT 802 @ 150 MPH (39-49 nozzles)

Illinois

D

Angle effect on Droplet Spectra

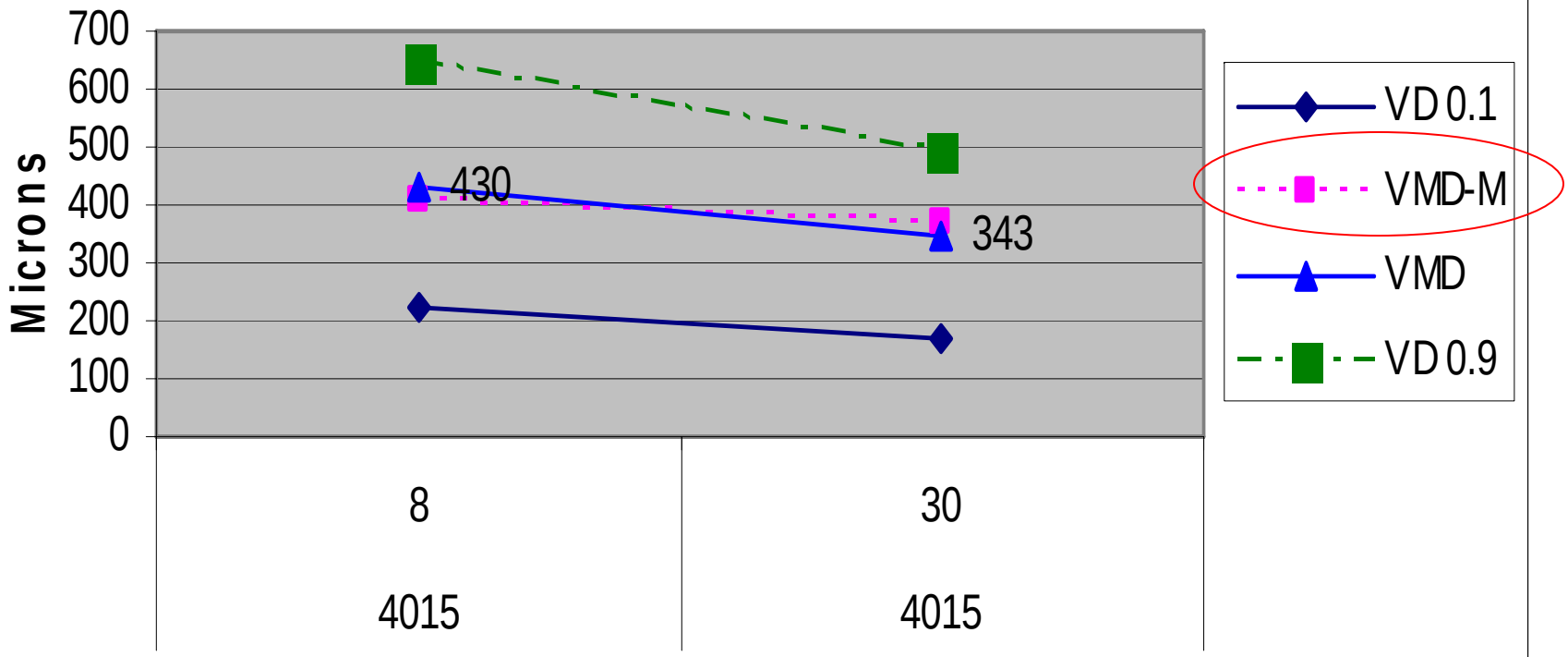


CP11TT-4030 @ 5 GPA-50 PSI
Thrush @ 130 MPH (37 nozzles)

Illinois

E

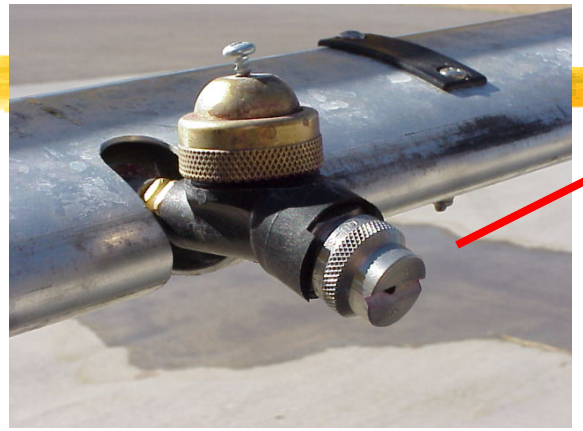
Angle Effect on Droplet Spectra

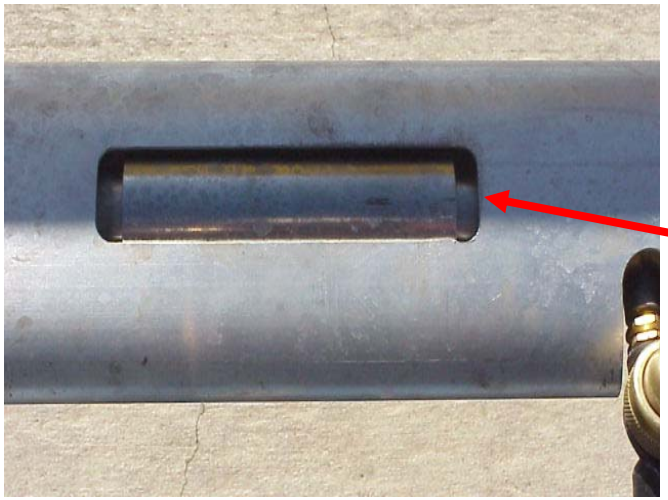


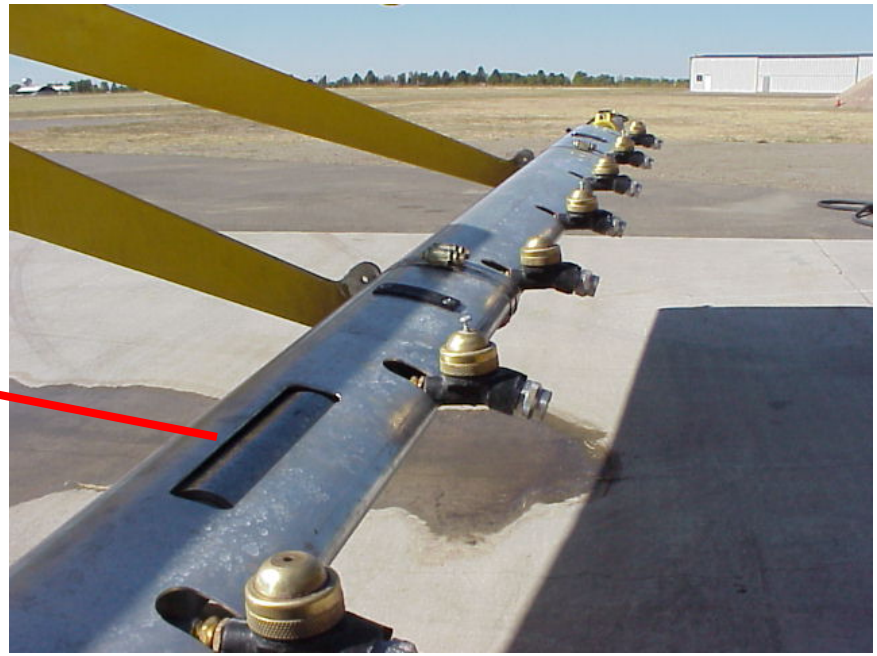
CP11TT-4015 @ 2 GPA-28 PSI
Cessna 188 @ 115 MPH (33 nozzles)

Illinois

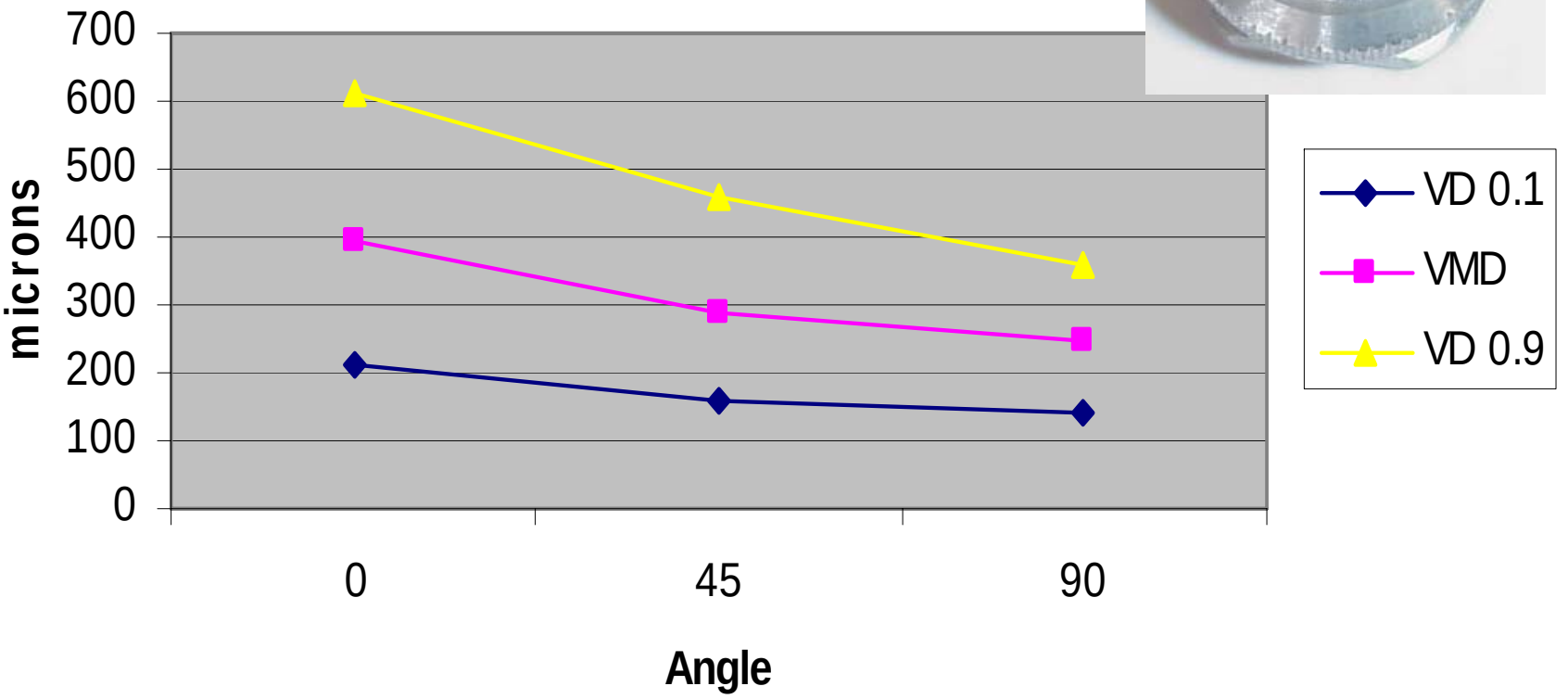
JARBA (Rotating Boom)







JARBA Rotating Boom
Spraying Systems 4015
AT 502 – 140 MPH - 45



Goodland 2003

Microsoft Excel - Jones Air Rotating Boom

File Edit View Insert Format Tools Data Window Help

100% Arial 10 B

A1 f_x

Droplet Size Prediction Model for the Jones Air Rotating Boom Assembly

Certified Environmental Management
C10224

ULV

Input data	
Air Speed (knots)	130
Nozzle Orifice size	4
Fan Angle (deg)	80
Nozzle Angle to Airstream (deg)	60

Predicted droplet size	
D[v,0.1]	47
VMD	126
D[v,0.9]	216
Span	1.34

The University Of Queensland
The Centre for Pesticide Application and Safety
"...for a safer environment"

Results Based on 100% DC-TRON at 3bar

Summary of findings - Kansas:

- ✓ Nozzle angle increase - results in smaller droplets
  - Wamego with Cessna 188 @ 115 MPH
  - At 2 and 5 GPA
  - For VD0.1, VMD, and VD0.9
- ✓ Nozzle orifice size increase - results in larger droplets
  - 2 GPA resulted in droplets smaller than the USDA Model
  - 5 GPA was better matched to the USDA Model

Summary of findings - Illinois:

- ✓ Nozzle orifice size increase - results in larger droplets
  - Not always true and not much effect
  - AT 502 – slight increase
  - AT 802's – increase and decrease
- ✓ Nozzle angle increase - results in smaller droplets
  - True for all tests
  - For VD0.1, VMD, and VD0.9
  - All the Air Tractors and Thrush droplets - larger than the USDA Model
  - Cessna 188 matched the USDA Model

Conclusions:

- ✓ Increasing the nozzle angle reduces the size of the droplet spectra
- ✓ These data sets indicate about 2-3 micron reduction in the VMD for each degree of downward slope
- ✓ Trends are consistent with the USDA Models
- ✓ At higher speeds the measurements tended to have a droplet spectra larger the USDA Model predicted
- ✓ Angle adjustment is an option for adjusting the droplet spectrum

Acknowledgements:

- ✓ Cary Rucker
- ✓ Rick Reed
- ✓ Harley Curless
- ✓ Don Haley
- ✓ David Kurtz
- ✓ Les Cady
- ✓ Carolyn Baecker

Thank you!