Drift Reduction Technology (DRT)
Wind Tunnel Studies
Submission Review Guide

This guide is meant to aid in the review of drift reduction technology (DRT) reports for wind tunnel studies submitted under the Office of Pesticide Programs (OPP) DRT program.

Sections I, II, and III of this document provide additional details regarding data, formatting, and issues to consider in developing report reviews. Although this guide is not intended to strictly prescribe where and how to present the data, an example DRT report review template is provided in Section II for guidance. In general, reviewers should follow the example template. However, reviewers may modify the template as needed or disregard it in the case of multilateral reviews (*i.e.*, reviews with other agencies participating) in which an alternative format is agreed upon by the participating agencies. Lastly, a list of review considerations (Section III) is provided to help reviewers focus on critical DRT report issues and to identify any common deficiencies.

Section I. Data to Include in the DRT Review Template

Reviewers should include the following information to increase its utility to the Agency:

First page

- A statement should be included indicating whether the analyses were conducted in compliance with FIFRA GLP standards (and if not, how not or why not) and whether signed and dated Data Confidentiality, GLP Compliance, Quality Assurance, and Authenticity Certification statements were provided.

- The study classification and a concise statement of any deficiencies that impacted the classification should be provided on the first page of the review.

- A signature line(s) for the final reviewer(s) should be added to the first page of the report review. If this is unacceptable for other agencies participating in a multilateral review, then a cover page with the signature line(s) can be attached to each individual review submitted to EFED's files.

- An Executive Summary should be added to the review.

Principle of Method

- DRT characteristics and wind tunnel parameters should be summarized.

Results

- Results from study analyses should be tabulated for different technologies.

Deficiencies and Reviewer's Comments

- This section should list any deficiencies with the method, the validations, and the documentation.

References

- A References section should be added that lists any literature references other than the DRT reports cited in the study review.

Section II. Example DRT Report Review Template, Wind Tunnel Studies

Method for analyzing drift reduction technolgy via wind tunnel

Reports:	[Provide full citation. Provide the MRID (first) if the review is unilateral.]
Document No.:	[MRID xxxxxxxx]
Guideline:	Non-guideline
Statements:	[Indicate whether the study was conducted in compliance with FIFRA GLP standards and whether signed and dated Data Confidentiality, GLP Compliance, Quality Assurance, and Authenticity Certification statements were provided. If the validations were not conducted in compliance with FIFRA GLP standards, indicate why or how they deviated.]
Classification:	This study is classified as [provide classification and very concise statement of any deficiencies that impacted the classification] [E.g.: *"… acceptable for (application method). However, the study indicated this DRT is only applicable for nozzle pressures of XXX psi."*] [If study is considered acceptable, indicate the DRT * rating.]
PC Code:	[xxxxxx, if applicable]
Reviewer:	[Provide final reviewer(s)'s name and title.] **Signature:** **Date:** [Type date of signature.]

Executive Summary

A [low-speed, high-speed] wind tunnel study was conducted in support of [company and technology] classification as a drift reduction technology (DRT) under the Office of Pesticide Programs DRT program.

[Provide a brief discussion of the technology and the conduct of the study.]

[Insert one of the following]
This study has been found to be scientifically acceptable and the technology has been given a DRT rating of [star number].

Or

This study has not been found to be scientifically acceptable and, as such, the technology has not been given a DRT rating.

Table 1. Specifications of tested technology

Manufacturer	Technology Description	Model	Pressure Tested (psi)
Company A (example)	Nozzle	ABC11004XX	15
			30
			45

Manufacturer	Technology Description	Model	Pressure Tested (psi)

I. Principle of the Method

[Briefly describe the method used to assess the drift reduction potential of the technology, how spray droplet size was measured. Note any differences between the method used and those specified in the DRT protocol.]

[Provide brief description of testing facility: name, location, etc.]

[Briefly indicate whether study conditions were within protocol acceptance criteria requirements.]

Table 2. Wind Tunnel Parameters

Parameter	Value	Acceptance Criteria
Spray measurement chamber or wind tunnel cross-section diameter (m)		Cross section at least three diameters larger than plume of nozzle (at measurement location)
Wind tunnel turbulence %)		< 8% (low speed only)
Air speed (m/s)		Between 2 m/s and 10 m/s (low speed) or between 22 m/s and 73 m/s (high speed), and measured to within 0.1 m/s (low speed) or 2 m/s (high speed) accuracy, close to nozzle location (with nozzle absent).
Sampling rate for air speed (#/s)		Sampling should occur over a measuring period of 10 s or less.
Consistency of air speed in wind tunnel working section (%)		< 5%
Ambient air temperature (dry bulb air temperature) (ºC)		Measured to an accuracy within 0.1 ºC 10 to 30 ºC with less than 5 ºC variation during test
Wet bulb and dew point temperature (ºC)		Temperature measured to an accuracy within 0.1 ºC
Relative humidity (%)		20 to 80% with maximum variation of 5% during test (low speed) or measured within 3% (high speed)

Parameter	Value	Acceptance Criteria
Dynamic surface tension of spray liquid (not for use with drift retardant adjuvants) (dynes/cm)		40 ± 4 dynes/cm at surface lifetime age of 10 to 20 ms
Spray material flow rate (L/min)		± 0.04 L/min of values specified in the ASABE[1] standard for reference nozzles and manufacturer recommended values for the test nozzles.
Spray pressure (nozzle operating pressure) (psi)		± 0.5 psi of values specified in the ASABE standard for reference and manufacturer recommended values for the test nozzles.
Spray material temperature (ºC)		Measured within 0.1 ºC
Relative spray material and air temperatures (ºC)		Spray material temperature must be within 5 ºC of the air temperature to avoid atomization anomalies
Spray Droplet Size Measurements		
Spray nozzle and sampling height measurement (m)		Within 5 mm (without airflow)
Standard deviation around volume median diameter (VMD, $D_{v0.5}$), $D_{v0.1}$ and $D_{v0.9}$ for three (minimum) replicate droplet size measurements		Vary by less than 10%.
Droplet size 2 m downwind from the nozzle		Less than 2% total of the spray volume should be contained in the uppermost or lowermost size classes.
Droplet size at the nozzle		Less than 2% total of the spray volume should be contained in the uppermost or lowermost size classes.
Replicate measurements		Measurements to be carried out with a nozzle or nozzle with a maximum deviation of output rate of ± 2.5% from the value specified by the manufacturer at the nominal rated recommended spray operating conditions. A randomly selected representative nozzle must be used.

1. ASABE – American Society of Agricultural and Biological Engineers

II. Results

Air Speed

Air speed measurements were taken [location] of the wind tunnel at a range of airspeeds from xxx to xxx miles per hour (mph). The mean measured airspeed was xxx mph, with a maximum variation of < x%.

Nozzle Flow Rate Measurement

The results of the nozzle flow rate measurements indicate that the average variation from nominal flow for all nozzles was x%, or, on an absolute basis, xx L/min (range - xx to xx L/min). An analysis of variance indicated no significant different of the % variation with nozzle orifice size ($\alpha = 0.05$). Analysis of variance of the absolute variations indicates a slightly higher and statistically significant increase of the variation at the largest orifice sizes.

Measurement of Percent of Fines (≤141 µm) Fraction

[Discuss the percent of fines ≤141 µm and how it compares to the reference nozzle results. An analysis of variance need to confirm significant different of the % variation with reference nozzle ($\alpha = 0.05$). Measurements should be presented separately (raw data) and as an average across repetitions for the following types of measurements: volume per droplet size category (*i.e.*, each of the 30 or more droplet size categories) at each height and volume per droplet size category and reference spray type.]

Quality Control Measurements

[Discuss if data quality was assessed using multiple test nozzles, blank samples, spiked samples, collocated duplicate samples, and duplicate analyses.]

III. Deficiencies and Reviewer's Comments

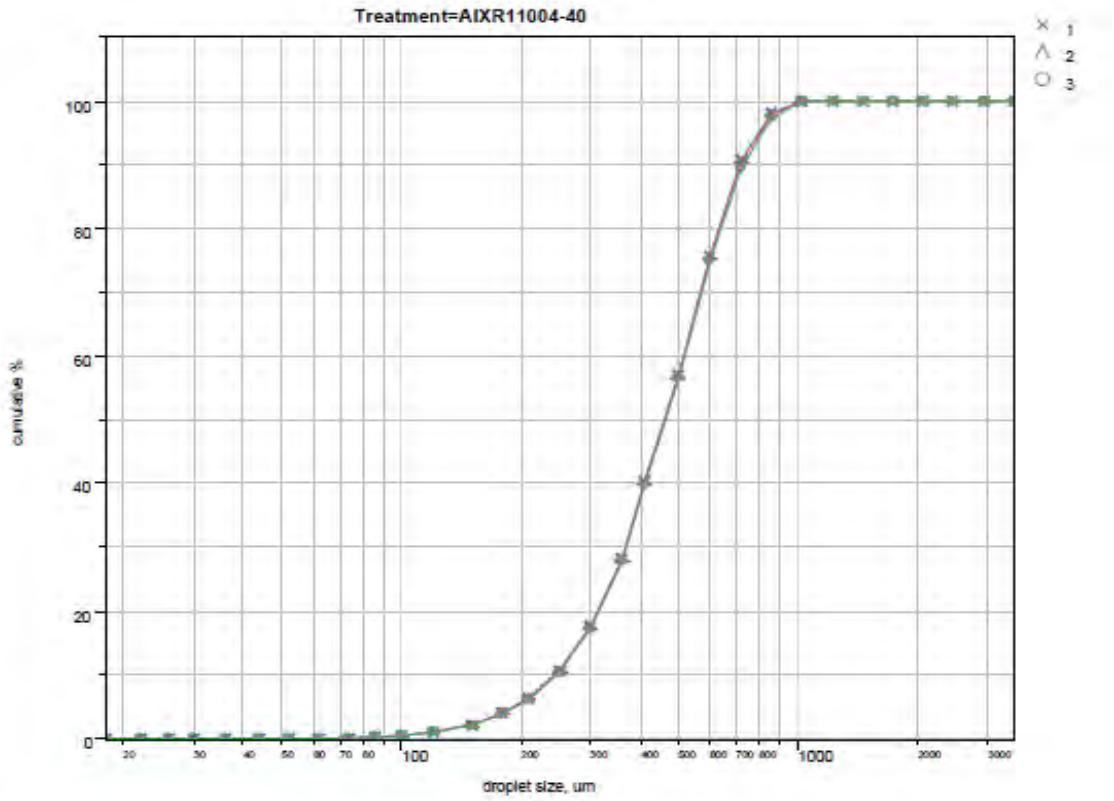
[List any deficiencies with study, particularly those that are not in line with the protocol.]

IV. References

[List any references cited in the review.]

Attachment 1: Drop Size Distribution Analysis

[Attach figures and tables depicting the drop size distribution(s) developed for the various DRT. The following is an example.]



Diam, um	cum vol%	stdev, abs	Diam, um	cum vol%	stdev, abs	Diam, um	cum vol%	stdev, abs
18	0.00	0.00	100	0.45	0.02	720	90.33	0.63
22	0.00	0.00	120	0.96	0.02	860	97.81	0.41
26	0.00	0.00	150	2.11	0.05	1020	99.95	0.02
30	0.00	0.00	180	3.87	0.07	1220	100.00	0.00
36	0.00	0.00	210	6.28	0.09	1460	100.00	0.00
44	0.00	0.00	250	10.50	0.13	1740	100.00	0.00
52	0.00	0.00	300	17.43	0.18	2060	100.00	0.00
62	0.00	0.00	360	27.92	0.23	2460	100.00	0.00
74	0.08	0.00	410	40.02	0.27	2940	100.00	0.00
86	0.20	0.01	500	56.74	0.31	3500	100.00	0.00
			600	75.34	0.46			

Section III. Drift Reduction Technology Report Review Considerations

This list of considerations is provided to help reviewers assess the acceptability of drift reduction technology reports. This list may be used as a screen, but is not meant to be attached to the report reviews. Listed considerations carry unequal weight. Evaluate them using best professional judgment. Consider all information from the reports and from reports for similar methods to determine whether any deficiencies affect the method report classification.

DRT Report – Wind Tunnel Studies

» The following conditions were measured at the same height as the nozzle, upwind of the nozzle in the wind tunnel working section at the time of spray release: ambient air temperature, air speed, relative humidity.

» Spray fluid temperature was measured with a calibrated thermometer.

» The spray pressure was measured at the nozzle tip using a capillary connected to a pressure gauge.

» Droplet size spectra for spray drift tests were made under the same conditions (*e.g.*, spray material, spray pressure, nozzle settings).

» Droplet size was measured using one of several laser measurement systems: laser diffraction, phase-Doppler (excluding multi-phase droplets, e.g., air inclusion or emulsion) or laser imaging. The instruments and apparatus used in the test were listed. Names, model numbers, serial numbers, scale ranges, software version number, and calibration verification were recorded.

» A representative cross-section average sample was obtained, using a mass-weighted traverse or multiple chordal measurements of the full spray (or half spray for axi-symmetric spray plumes).

» The sampling distance from the nozzle was sufficient to ensure that the spray atomized into droplets, for example through completion of breakup of sheets or ligaments of liquid following discharge from the nozzle. This distance is typically 20-60 cm.

» The sampling system was configured to measure the entire dynamic size range of the instrument with less than 2% total of the spray volume contained in the uppermost and lowermost size classes.

» If a number-density weighted ("spatial") sampling system was used, the setup minimized the development of a size-velocity profile within the spray (*e.g.*, by using a concurrent airflow if spray discharge was in the horizontal plane) to avoid data bias toward slower-moving (usually smaller) droplets.

» The droplet size measurements included assessment and confirmation of the droplet size category of the candidate test system and reference system according to ASABE S572.1, respectively.

» The spraying system was mounted to minimize effects on airflow.

» The orientation of the nozzle (predominant spray direction or axis of rotation) that the fan sprays discharge relative to the air flow direction was measured with a protractor and recorded.

» The test spray nozzle(s) was mounted at the height defined by the manufacturer's operating conditions and was at least 100 mm below the wind tunnel ceiling. Nozzles were positioned in a place free from edge effects.

» The wind tunnel floor was covered with an artificial turf surface to minimize droplet bounce and mimic stubble vegetation for field conditions.

» For testing nozzles without using adjuvants, water containing surfactant was used, such that a Newtonian tank mix with a dynamic surface tension of 40 dyne/cm at surface lifetime age of 10 to 20 ms was achieved.

» When an adjuvant was included with a nozzle as the DRT combination in the test spray material, a pesticide formulation and spray equipment reflecting the adjuvant's proposed end use was evaluated during testing (refer to ASTM E2798-11 for further details).

» The spraying system was primed with spray prior to measurements to ensure that rinsing liquid was removed from the line and the liquid discharging from the nozzle was the actual intended tank mix. The sprayer system was "run-in" for 5 min to ensure removal of machining burrs or plastic mold residue.

» Spray material flow rate was measured at the operating pressure for the tests. Measurements included techniques using liquid collected for a known duration, using Coriolis mass flow sensors, calibrated flow turbine, oval displacement meter, weighing system for the spray mix tank, or other method. Nozzle output remained constant with a maximum deviation of ± 2.5%.

» For low speed wind tunnel studies, the wind tunnel was operated during sampling to provide an air speed between 2 m/s and 10 m/s at the nozzle height with a default value of 2 m/s. For high speed wind tunnel studies, the wind tunnel was operated during sampling to provide an air speed between 22 m/s and 73 m/s at the nozzle height.

» The relative humidity in the working section at the time of measurements was 20 to 80% with a maximum variation of 5% during each test.

» The type of nozzle being tested was documented, including a close-up photograph of the nozzle and manifold, a cross-sectional drawing, the manufacturer nozzle part number, the type of nozzle body and cap used in the tests, and a description of the manufacturer-recommended nozzle settings, including spray height and angle.

» At least three replicates for each set of test conditions were conducted. Measured volume median diameter (VMD) varied by less than 10%. $Dv_{0.1}$ and $Dv_{0.9}$ (the droplet diameter bounding the upper and lower 10% fractions of the spray) varied by less than 10%.

» The hardness of water used in spray tanks was documented. Adjuvants were in the original manufacturer's packaging.

» For data not gathered directly by the testing organization, the testing organization described these measurements in their protocol or the applicant-specific addendum.

» Paper datasheets were signed by the technician responsible for collecting the data. The datasheet was reviewed for completeness and approved by the testing organization technical leader immediately after an experiment. The testing organization technical leader reviewed electronic data for compliance with data quality goals immediately after an experiment. Data from paper datasheets and electronic data were consolidated into a single database with reference to the DRT tested and all experimental conditions.

» Data from each measurement for droplet size from the verification test were reported as the incremental and cumulative volumes of 30 appropriately spaced and described bins of droplet diameter (micrometers). The $Dv_{0.1}$, $Dv_{0.5}$, $Dv_{0.9}$, and relative span were presented.