DRAFT

GENERIC VERIFICATION PROTOCOL

FOR THE VERIFICATION OF PESTICIDE SPRAY DRIFT REDUCTION TECHNOLOGIES FOR ROW AND FIELD CROPS

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List of Acronyms/Abbreviations

ADQ	audit of data quality
ANSI	American National Standards Institute
APCT Center	Air Pollution Control Technology Verification Center
ASABE	American Society of Agricultural and Biological Engineers
ASAE	American Society of Agricultural Engineers (precursor to ASABE)
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
BBA	Biologische Bundesanstalt für Land- und Forstwirtschaft (Germany's Federal Biological Research Center for Agriculture and Forestry)
ºC	degrees Celsius
cfm	cubic feet per minute
cm	centimeter
CV	coefficient of variance
DQIG	data quality indicator goal
DQO	data quality objective
DRT	drift reduction technology
$D_{v0.x}$	droplet diameter (µm) at which 0.x fraction of the spray volume is contained in smaller droplets
dyne/cm	dynes per centimeter
EC	emulsifiable concentrates
EPA	United States Environmental Protection Agency
ESTE	Environmental and Sustainable Technology Evaluations
ETV	Environmental Technology Verification
fpm	feet per minute
ft	foot
gal/acre	gallons per acre
Hz	hertz
ISO	International Standards Organization
kPa	kilopascal
L	liter
LERAP	Local Environmental Risk Assessment for Pesticides (UK scheme)
m	meters
mph	miles per hour
min	minute
mg	milligram
mL	milliliter
mm	millimeter
ms	millisecond
m/s	meters per second
µL	microliter
µm	microns
OPP	Office of Pesticide Programs
ORD	Office of Research and Development

PE	performance evaluation
PES	performance evaluation system
PMT	photo multiplier transistor
psi	pounds per square inch
QA	quality assurance
QC	quality control
QM	quality manager
QMP	quality management plan
QSM	quality system manual
RH	relative humidity
RTI	Research Triangle Institute
S	second
SNR	signal to noise ratio
SOP	standard operating procedure
TSA	technical systems audit
VMD	volume median diameter
v/v	volume/volume

Preface

This generic verification protocol was prepared by stakeholders and staff for the Environmental and Sustainable Technology Evaluations (ESTE) project *Verification of Pesticide Drift Reduction Technologies*. The protocol provides a detailed methodology for conducting and reporting results from a verification test of pesticide drift reduction technologies (DRTs). The plan was reviewed by U.S. Environmental Protection Agency (EPA) and interested stakeholders. These stakeholders are acknowledged below.

The EPA is charged with licensing the sale and use of pesticides and ensuring that when applicators use pesticides according to product label directions the pesticides will not cause unreasonable adverse effects to humans or the environment. To perform these important functions, EPA must rely, in part, on quality scientific data and other information to estimate a pesticide's potential hazards, exposures, and risks from its intended use. An important component of this scientific assessment is the potential risks to humans and the environment from pesticide droplets or particles that drift from the application target site (e.g., a corn field) during or shortly after application. Generally, applications of most if not all sprays result in some amount of drift; however, application equipment and technologies, as well as meteorological conditions and the applicator's behavior and use of the equipment and technologies, can all profoundly affect the amount of pesticide drift.

The pesticide industry and government have conducted considerable research and assessments in recent years to determine the sources, pathways, and exposure to the environment from airborne spray which can often drift off-target at the time of spray application. However, most of the research has focused on "conventional" technologies. A number of underutilized commercial technologies exist for managing drift; however, little information exists on their effectiveness in reducing spray drift levels. Verification of the effectiveness of pesticide spray drift reduction technologies is a focus of this EPA initiative.

EPA's Office of Research and Development (ORD) is partnering with EPA's Office of Pesticide Programs to complete this project under the ESTE program. The ESTE program is part of EPA's Environmental Technology Verification Program (ETV), which was created in 1995 to facilitate the commercialization of innovative or improved environmental technologies through performance verification and dissemination of information. In 2005, ETV established the ESTE program to focus these verifications specifically on Agency needs. Consistent with other ESTE efforts, a technical panel of knowledgeable and interested stakeholders representing application equipment manufacturers or vendors, pesticide applicators and government agencies, as well as research scientists, educators and others related to spray application technology and drift management prepared this test protocol to be used to evaluate the performance of technologies that reduce pesticide spray drift. This protocol describes the testing approach used to generate high-quality, peer-reviewed data for several drift reducing technologies, including test design and quality assurance aspects.

The ultimate goal is to accelerate acceptance and use of improved and cost-effective application technologies which, when used properly, have the potential to significantly reduce pesticide spray drift. The Agency will encourage equipment manufacturers to voluntarily use this test plan for testing their equipment. Initially, EPA will work closely with several vendors of DRTs to evaluate DRT performance. If proven significantly effective for reducing spray drift, DRTs will be considered in EPA's scientific review of pesticides and development of spray drift restrictions for product labels. Eventually, pesticide manufacturers can request EPA approval of product labels with these technologies and reduced application restrictions. These technologies will allow pesticide applications equally, or more, protective of the environment and the health of those in the vicinity than current methods. In addition, applicators will have more flexibility in making application decisions. Use of DRTs will allow more targeted, and therefore more effective, pesticide applications. The ETV APCT Center can conduct this testing and resulting datasets would be readily accepted by OPP as inputs in their review of pesticides and spray drift restrictions for product labels.

Acknowledgements

Stakeholder Technical Panel

Individuals selected for their technical expertise to participate on a Drift Reduction Technology Stakeholder Technical Panel are listed below. We want to thank the panel members for contributing their technical input to this protocol document.

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In addition to the STP members listed above, several other individuals provided technical input and resources in the development of this protocol. We would like to thank the following for making contributions to this protocol document.

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GROUP A: PROJECT MANAGEMENT

A4: Project/Task Organization

The U.S. Environmental Protection Agency (EPA) has overall responsibility for the Environmental Technology Verification (ETV) Program and for the *Verification of Pesticide Drift Reduction Technologies* project under the Environmental and Sustainable Technology Evaluations (ESTE) Program. The ESTE Program operates as part of the Agency's larger ETV Program. ETV develops testing protocols and verifies the performance of innovative technologies that have the potential to improve protection of human health and the environment. Both the EPA's Office of Pesticide Programs (OPP) and Office of Research and Development (ORD) are involved in the project.

In 2005, the EPA created a new program element, ESTE, under its current ETV. This program is designed to support the Agency's ability to address important environmental issues (and environmental sustainability) and to protect human health. As part of ESTE, innovative, commercial-ready technologies showing potential to significantly reduce risks may be selected for verification testing. Testing—conducted with the same commitment to quality assurance, cost-sharing, and stakeholder involvement fundamental to the larger ETV program—provides credible performance data needed for accurate assessment of the effectiveness of these technologies. The future verification testing program could be conducted by the APCT Center, under the sponsorship of EPA, with the participation of DRT manufacturers and vendors. The APCT Center's role as verification organization is to provide technical and administrative leadership and manage the conduct of verification testing and reporting. Subcontractors may have roles as testing organizations. Site specific test/QA plans are prepared to meet the requirements of the generic verification protocols (this document) and approved by the APCT Center.

Management and testing of pesticide DRTs within the APCT Center are performed in accordance with procedures and protocols defined by a series of quality management documents. The primary source for the APCT Center quality system is EPA's Policy and Program Requirements for the Mandatory Agency-wide Quality System, EPA Order 5360.1 A2 (May 2000). The quality system that will govern testing under this plan is in compliance with the following:

- EPA Requirements for Quality Management Plans (EPA QA/R-2)
- EPA Environmental Technology Verification Program, Quality Management Plan (EPA ETV QMP), for the overall ETV program
- APCT Verification Center's Verification Testing of Air Pollution Control Technology - Quality Management Plan (APCT Center QMP)[1]
- [Testing Organization's Standard Operating Procedures (SOP)][1]
- This protocol.

EPA's ETV QMP provides the definitions, procedures, processes, organizational relationships, and outputs that will ensure the quality of the data and the programmatic elements of ETV. Part A of the EPA ETV QMP includes the specifications and guidelines that are applicable to common or routine quality management functions and activities necessary to support the ETV program. Part B of the EPA ETV QMP includes the specifications and guidelines that apply to test-specific environmental activities involving the generation, collection, analysis, evaluation, and reporting of test data.

APCT Center QMP describes the quality systems in place for the overall APCT Center program. It was prepared by RTI and approved by EPA. Among other quality management items, it defines what must be covered in the generic verification protocols and test/QA plans for technologies undergoing verification testing.

Generic verification protocols are prepared for each technology to be verified. These documents describe the overall procedures to be used for testing a type of technology and define the critical data quality objectives (DQOs). The document herein is the generic verification protocol for pesticide spray DRTs. It was written with input from the technical panel and approved by EPA.

Test/QA plans are prepared by the testing organization. The test/QA plan describes in detail how the testing organization will implement and meet the testing requirements of the generic verification protocol. The test/QA plan also sets data quality objectives (DQOs) for supplemental non-critical measurements that are specific to the site of the test. The test/QA plan addresses issues such as the test organization's management organization, test schedule, documentation, analytical methods, data collection requirements, calibration, and traceability. It also specifies the QA and quality control (QC) requirements for obtaining verification data of sufficient quantity and quality to satisfy the DQOs of the generic verification protocol. A test plan addendum will also be developed that describes the specific DRT. For pesticide spray DRT, the critical measurements include the droplet size distribution, the spray flux (low speed wind tunnels only), and deposition (field testing only). Other supplemental, non-critical measurements may also be conducted (e.g., application rate, material usage, dose, worker exposure).

[1] Each ESTE project is required to have a QMP in place and is allowed to use the QMP of an existing ETV Center. This project has elected to use the QMP from the Air Pollution Control Technology Verification Center (APCT Center). The verification organization for DRT verifications that occur after completion of this ESTE project is anticipated to be the APCT Center and this document reflects that assumption. This does not preclude other testing organizations from using the protocol. The testing organization for this ESTE effort has not yet been identified.

Appendix A lists full citations for these documents. This protocol is in conformance with *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), *EPA Guidance for Quality Assurance Project Plans* (EPA QA/G-5), and the documents listed above.

A testing organization with a quality system in compliance with the EPA ETV and APCT Center QMPs and with the capability to carry out the methods and procedures contained in this plan will conduct the testing. The testing organization will verify the emissions reductions of drift reduction technologies. The testing organization will perform the testing, evaluate the data, and submit a report documenting the results. The APCT Center will use the data to prepare the verification reports and the verification statements. The various QA and management responsibilities are divided among the testing organization, APCT Center, and EPA key project personnel.

A5: Project Definition and Background

For the purpose of this document and associated testing projects, pesticide spray drift is defined as the movement of spray droplets through the air at the time of application or soon thereafter from the target site to any non- or off-target site, excluding pesticide movements by erosion, migration, volatility, or windblown soil particles after application. Spray drift management is of interest to pesticide and other chemical manufacturers, application equipment manufacturers, pesticide applicators, government agencies, advocacy groups, and the public. Spray drift risks are correlated to deposition in EPA risk assessment. To reduce exposure, DRTs that can reduce drift downwind are beneficial; the results of the testing to be conducted under the ETV program are to be used to estimate downwind deposition. For example, the testing results from wind tunnel testing (droplet size distribution and/or spray flux) will be used as inputs to models that will estimate deposition downwind. (Any model results will be determined outside of this ETV protocol, the test/QA plan, and results.) This test approach to evaluate DRT is one more approach in addition to other understood methods for testing DRT.

Industry, including pesticide applicators, and government researchers have over many years developed and employed a variety of pesticide application strategies and technologies to reduce spray drift. Examples include low drift spray nozzles and sprayers, drift control chemical adjuvants, barrier structures, and vegetation. Although these and other technologies have the potential to provide drift reduction, there is often uncertainty about their effectiveness or performance for this goal. Verification testing of DRTs provides objective, quality-assured data regarding the effectiveness of the tested technologies to reduce spray drift. Effective employment of these test results by EPA and pesticide and equipment manufacturers will enable pesticide applicators to make more informed and confident decisions for selecting and using DRTs. Use of these DRTs in the application of pesticides has the potential for significant benefits: reduced spray drift and the associated risks to humans and the environment; greater on-target deposition of pesticides applications; increased efficacy; and applications under a wider range of environmental conditions.

Testing will be performed on application technologies with one or more of the following test methods: low speed wind tunnel testing, high speed wind tunnel testing, and field testing. Field testing is an acceptable method of testing all DRTs. Low speed would be the speed of the air in the wind tunnel crossing the spray nozzle for ground application, and high speed would be the speed of the air in the wind tunnel crossing the nozzle for aerial application; for example, low speed would be less than 20 mph and high would be greater than 20 mph. For certain DRTs, wind tunnel testing may be an appropriate test method. The verification tests will gather information and data for evaluating the performance of the strategies and technologies as claimed by the vendors and the technologies' associated environmental impacts and resource requirements. The scope will, in most cases, cover four principal study questions:

1. What is the performance of the technology in terms of the manufacturer/vendor's statement of capabilities for reducing downwind deposition? Answering this question is critical to determining the performance of the technology and thus the measurements made to address this question are critical. The specific DQOs for these measurements are included in Element A7.

2. What are the test conditions (a range for equipment conditions and ambient conditions) over which the performance is measured (e.g., spray pressure, formulation type, release height, crop canopy, ambient temperature, wind speed, relative humidity)? The range of conditions that the technology is evaluated will be used to determine the conditions required for performance in the field. The DQOs for the measurement the test conditions are described in Element A7.

3. What are the associated environmental impacts, if any, of operating the technology within this range other than drift reduction (e.g., effects on application rate/material usage, dose, other sources of environmental exposure, worker exposure)? Evaluation of the associated environmental impacts is a supplemental non-critical product of this test plan and as a result available instrumentation may be used to make measurements for this purpose. No DQOs are defined for this question.

4. What are the resources associated with operating the technology within this range relative to standard pesticide application equipment (e.g., energy, waste disposal, and product usage, as well as sprayer handling – for example, some technologies may affect the safety of operation of aircraft or other sprayers)? Measurement of consumption of resources is a supplemental non-critical measurement of this test plan and as a result, available instrumentation may be used to make measurements for this purpose. No DQOs are defined for this question.

This ETV protocol describes the overall procedures to be used. The test/QA plan for pesticide drift reduction technology will describe how test procedures will be specifically implemented for this testing program. Each test site or testing organization will need to develop a test/QA plan for its test facility. The plan will address application of pesticides to row and field crops (including bare ground) using aerial and ground spraying systems that spray swaths. (Other applications such as radial orchard and vineyard spraying may be addressed in the future.) Where the test procedures allow flexibility (e.g., "alternate methods ... may be used"), the specific implementation using this flexibility will be described by the testing organization. Where flexibility in test procedures is not stated, it is intended that the methods will be followed without deviation. Deviations from described protocols must be described by the testing organization in its test/QA plan and addenda.

A6: Project/Task Description

A6.1 Description

This ETV protocol describes the test and QA procedures that will conform to all specifications of *EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5*, the EPA ETV QMP, and the ETV APCT Center QMP. The test/QA plan will specifically describe the quality system required of the testing organization and the procedures applicable to meeting EPA quality requirements that are common to all ETV tests. Test/QA plans, developed for each test site, and test plan addenda, developed for each technology, will be reviewed and approved by EPA prior to testing.

The verification tests will gather information and data for evaluating the performance of the DRT. Also, any adverse environmental impacts of operating the DRT will be evaluated. The specific operating conditions used during the testing will be documented as part of the verification process. Table 3 in Element B2, Table 4 in Element C2, and Table 5 in Element D2 of this protocol, present a summary of all measurements that will be made to evaluate the performance of the DRT and document the test conditions.

A description of a specific technology, the test procedures to be used and test-specific details will be documented as a applicant-specific addendum to the test/QA plan that will be prepared and submitted for EPA review and approval prior to the start of testing. The applicant-specific addendum will provide additional information needed to conform to required Elements A5 (Problem Definition/Background) and A6 (Project/Task Description) of EPA QA/R-5.

Categories of DRTs include:

1. Spray nozzles (e.g., atomizers with fewer fines);
2. Sprayer (passive delivery assistance) modifications (e.g., shields and shrouds, wingtip devices);
3. Spray (active) delivery assistance (e.g., air assisted spraying);
4. Spray property modifiers (e.g., formulation/tank mix ingredients that modify spray solution physical properties);
5. Landscape modifications (e.g., artificial or natural hedges and shelterbelts).

A6.2 Test Facility Description

A description of the test facility will be included in the test/QA plan for each test site.

A6.2.1 Test Site Description

Three potential testing sites or approaches are covered in this protocol: low speed wind tunnel, high speed wind tunnel, and field testing. The low speed wind tunnel and the high speed wind tunnel test results will be used by EPA in conjunction with modeling to determine downwind drift deposition reduction. Low speed wind tunnel testing is appropriate for certain types of DRTs intended for use on or with some ground boom sprayers while high speed wind tunnel testing is for certain DRTs, such as nozzles and devices intended to reduce air shear, on aerial application equipment. Field testing is acceptable for testing all types of DRTs.

In **Table 1**, the DRT categories are matched to the potential testing approaches and a map to the testing procedures laid out in this document is provided.

Table 1. DRT versus Testing Approach

	Type of Drift Reduction Technology				
Test Method	**Spray Nozzle**	**Spray Material Property Modifiers**	**Sprayer Modification**	**Spray Delivery Assistance**	**Landscape Modification**
Low speed wind tunnel[1]	Acceptable	Acceptable	Questionable[4] and Supplemental[5]	Not Acceptable	Supplemental[5]
High speed wind tunnel[2]	Acceptable	Acceptable	Not Acceptable	Not Acceptable	Not Acceptable
Field testing[3]	Acceptable	Acceptable	Acceptable	Acceptable	Acceptable

1 For DRTs intended for use on or with ground boom spray equipment
2 For DRTs intended for use on or with aerial spray equipment
3 For DRTs intended for use with either ground boom or aerial spray equipment
4 It is advisable to confirm with the EPA ETV project manager that the test methods will be adequate for verification of these types of DRTs.
5 Low speed wind tunnel testing may provide information that can reduce the extent of field testing required for validation, or supplement field data; however, field testing is also required.

Low speed wind tunnel testing

A wind tunnel with the following characteristics will be used:

1. A wind tunnel with working section dimensions at least 1.75 meter (m) wide x 1.75 m high x 7 m long shall be used for measurement of the spray distribution vertically (“airborne drift potential”) and horizontally (“deposition drift potential”) and droplet size distribution for a spray.

2. An example of a suitable wind tunnel setup is shown on Figure 1.

3. The airflow characteristics of the wind tunnel shall be known and documented. The air speed at different horizontal and vertical locations in the wind tunnel must be documented in order to identify the distance from the tunnel’s surface that edge effects occur and document the space where air flows uniformly in the working section. The wind tunnel working section used for sampling shall have less than 8 percent turbulence and local variability of air velocity below 5 percent.

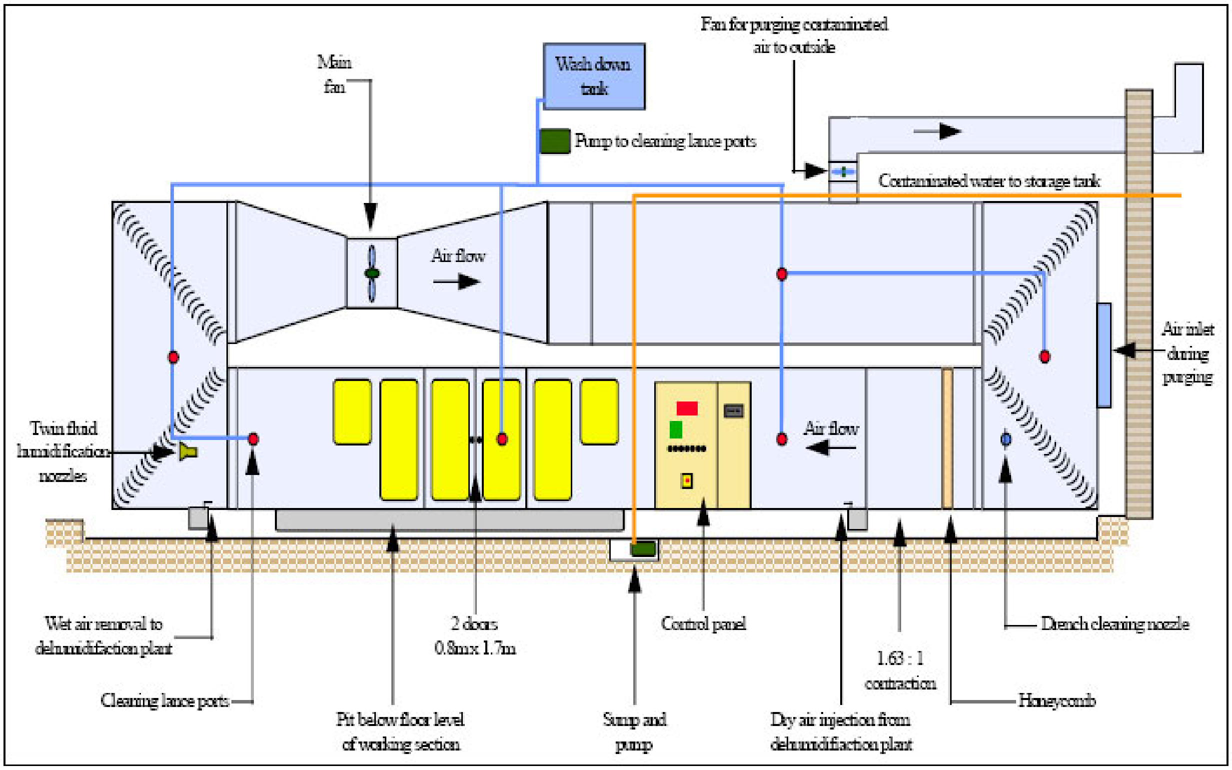

Figure 1. Example of a low speed wind tunnel
(by permission of Silsoe Spray Application Unit – part of The Arable Group).

High speed wind tunnel testing

For high speed wind tunnel testing, a wind tunnel of the following characteristics will be used:

1. A wind tunnel with working section dimensions at least 0.8 m wide x 0.8 m high x 2 m long shall be used for measurement of droplet size distribution for a spray.

2. An example of a suitable wind tunnel setup is shown on Figure 2.

3. The airflow characteristics of the wind tunnel shall be known and documented. The air speed at different horizontal and vertical locations in the wind tunnel must be documented in order to identify the distance from the tunnel's surface that edge effects occur and document the space where air flows uniformly in the working section. The wind tunnel working section used for sampling shall have less than 8 percent turbulence and local variability of air velocity below 5 percent.

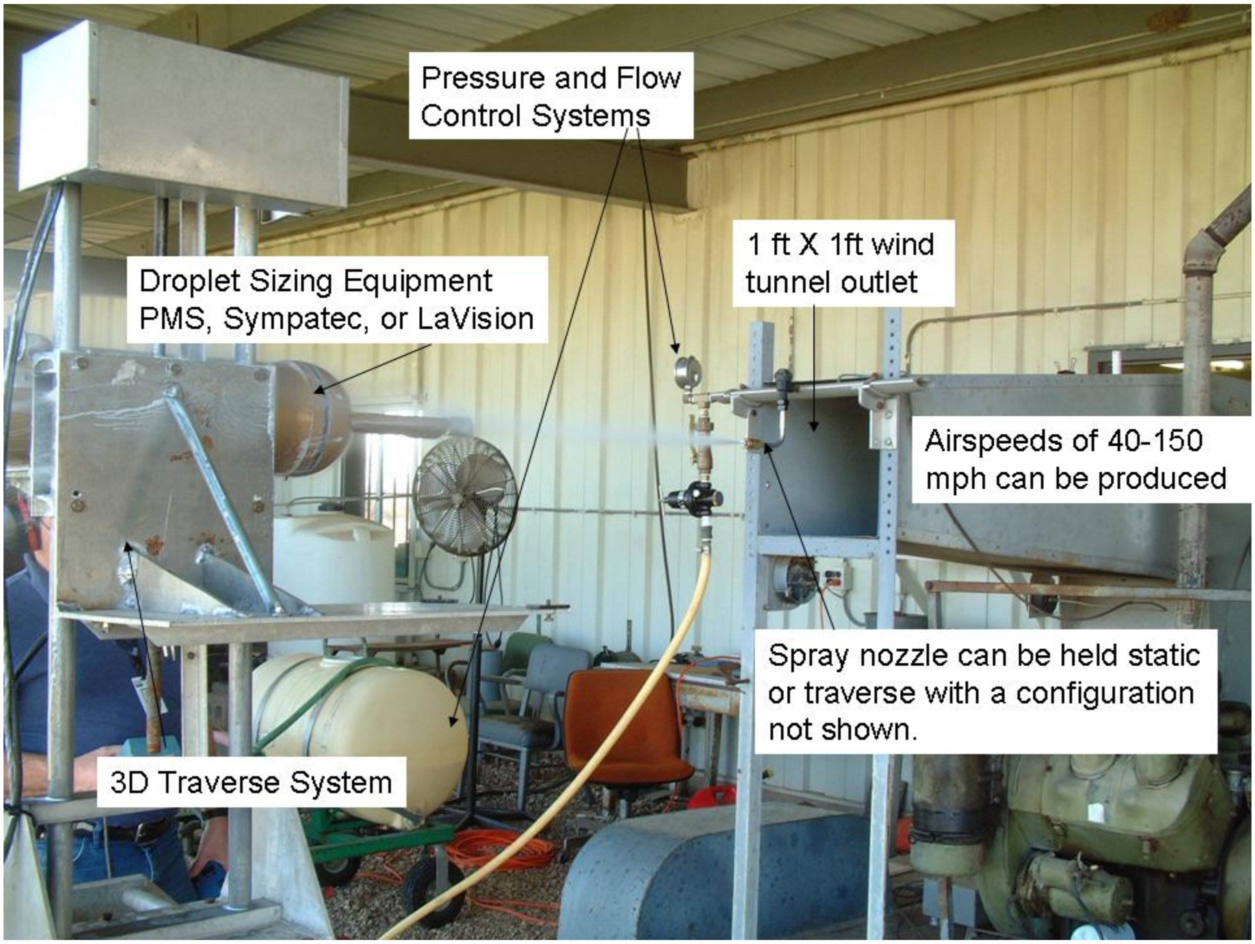

Figure 2. Example of a high speed wind tunnel.

Field testing

For field testing, the test site with the following characteristics will be used:

For field testing, the designated trial/spray site should be an exposed area with no obstructions that could influence the air flow in the areas of application or measurement. There should be a bare ground (or stubble less than 7.5 cm high) treatment area and a similarly bare downwind area for sampling stations. The measurement area should be downwind of the treatment area. The length of the spray track should be at least twice that of the largest downwind sampling distance and should be symmetrical about the axis of the sampling array. All downwind distances should be measured from the downwind edge of the directly sprayed treatment area. The requirements for the field test site are consistent with requirements from United Kingdom's Local Environmental Risk Assessments for Pesticides (LERAP), Germany's Biologische Bundesanstalt für Land- und Forstwirtschaft (Federal Biological Research Center for Agriculture and Forestry [BBA]), the International Standards Organization (ISO), and the American Society of Agricultural and Biological Engineers (ASABE) (formerly known as the American Society of Agricultural Engineers [ASAE]).

A6.2.2 Application/Process Equipment Description

The description of the application and process equipment including photographs will be included in the applicant-specific addendum.

A6.2.3 Control Technology (i.e., DRT) Description

The technology to be verified must be described fully and concisely. The description, provided by the technology manufacturer/vendor, must include: technology name, model number, the DRT principle, key specifications, manufacturer's name and address, serial number or other unique identification, warning and caution statements, capacity or output rate, and other information necessary to describe the specific DRT. The performance guarantee coupled with operating conditions and instructions will be provided. Examples of an ETV verification statement are presented on the ETV Website [http://www.epa.gov/etv/]. If combinations of independent technologies are being submitted, the description of the combined technology should completely identify and describe those technologies being combined.

A6.3 Schedule

Figure 3 shows an example schedule for completion of a first draft verification report and statement. The test-specific schedule is expected to vary from technology to technology based on the scheduling needs of the applicant and the testing organization.

	MONTH					
TASK	**1**	**2**	**3**	**4**	**5**	**6**
APCT Center develops applicant-specific test/QA plan addendum	◆					
Applicant accepts addendum, signs Terms & Conditions	◆					
EPA approves applicant-specific test/QA plan addendum	◆					
Testing organization receives test items from applicant		◆				
Testing organization conducts testing			■	■		
Testing organization delivers test report to APCT Center					◆	
APCT Center completes first draft verification report and statement						◆

Figure 3. Example of schedule.

A7: Quality Objectives and Criteria

The DQOs of this testing focus on the direct or indirect measurements of spray drift deposition using field testing or wind tunnel testing. For field tests, measurements of spray drift on horizontal collectors are collected to directly measure spray drift deposition in the area downwind. For wind tunnel testing, the testing organization will measure droplet size and spray volume data (and will later use these generated data with spray drift models such as the dispersion models, AGDISP or WTDISP, capable of translating the droplet size and spray volume measurements made using this protocol to downwind deposition). Test requirements for low speed wind tunnels, high speed wind tunnels, and field testing are found in Groups B, C, and D, respectively.

For wind tunnel testing, the product of this test design will be the measurement of a droplet size distribution consisting of 32 or more droplet size bins (32 droplet size bins are necessary for input to the models). The degree of consistency of volume median diameter (VMD), droplet diameter (µm) at which 0.1 fraction of the spray volume is contained in smaller droplets ($D_{v0.1}$) and droplet diameter (µm) at which 0.9 fraction of the spray volume is contained in smaller droplets ($D_{v0.9}$) are used as a measure of data quality. Variation of less than ±3 percent is considered acceptable.

The rationale for the number of test runs will be included in the site-specific test/QA plans and the applicant-specific addenda, which will conform to required Element B1 of EPA QA/R-5. In general, the number of test runs would include: (1) a minimum of three test runs, (2) additional test runs indicated to meet certain statistical criteria, and (3) additional test runs desired by the applicant vendor or manufacturer. The number of test runs (or sample size) necessary depends on the variance of the data and the size of the difference that is to be detected. For the validation testing of this protocol, three test runs will be conducted. The data results from the validation testing of the protocol will be used to decide what additional test runs will be necessary to meet statistical criteria. In field testing, for example, it has been discussed that candidate test systems will be assigned a drift reduction bin of 25 to 50 percent, 50 to 75 percent, 75 to 90 percent, and greater than 90 percent. If the candidate test system is anticipated to achieve a drift reduction in the middle of a drift reduction bin, then it is likely that three test runs are necessary; however, for those candidate test systems with drift reduction near the edge of a drift reduction bin, it is likely that three test runs may be too few and additional test runs may be necessary to demonstrate the drift reduction bin with sufficient confidence.

The DQIG for individual measurements will conform to those specified in relevant sections of the test protocols and referenced procedures, as shown in Table 2. The DQOs for this testing are the Table 2 DQIG. Test-specific DQIG will be documented in the site-specific test/QA plans and its applicant-specific addenda.

Table 2. Data Quality Indicator Goals (DQIGs)

Parameter	Standard Operating Procedure (if applicable)	Acceptance Criteria
Section 1. Droplet Size Measurement at the atomizer for LSWT and HSWT and Droplet Size Measurement at 2 m for LSWT		
Spray material flow rate	ASAE S572	±0.04 L/min of values specified in the ASAE standard for reference and evaluation nozzles.
Spray pressure (nozzle operating pressure)	ASAE S572	±3.4 kPa of values specified in the ASAE standard for reference and evaluation nozzles.
Dynamic surface tension of spray liquid (not for use with drift retardant adjuvants)		40 ±4 dynes/cm at surface lifetime age of 10 to 20 ms
Spray volume in largest and smallest droplet size class bands in laser diffraction measurements		<1% of total volume in each case (i.e., < 2 percent total of the spray volume) – to be achieved through selection of appropriate lens and instrument configuration for the dynamic size range of the spray being sampled
Number of size class bands for reported data		≥ 32
Spray measurement chamber or wind tunnel cross-section diameter		Cross section at least three diameters larger than plume of nozzle (at measurement location)
Distance of farthest edge of spray from collecting lens (Malvern instruments)		<1 lens focal length to avoid vignetting sampling errors
Standard deviation around mean $D_{v0.5}$ for three replicate droplet size measurements		<7% for measurements with the same nozzle
Obscuration for spray measurements across a spray diameter (for laser diffraction systems)		<60% unless corrected for multiple scattering, whereupon the report shall include the measured obscuration, the algorithm used to correct for multiple scattering, and the manufacturer-stated limits of applicability for that algorithm.
Minimum obscuration for sampling to achieve cross-section average spray (e.g., start/ end trigger using traverse with laser diffraction systems)		2%
Spray material temperature	ASHRAE Standard 41.1	Measured within 0.1ºC
Ambient air temperature	ASHRAE Standard 41.1	Measured within 0.1ºC

Parameter	Standard Operating Procedure (if applicable)	Acceptance Criteria
Relative spray material and air temperatures		Spray material temperature must be within 2ºC of the air temperature to avoid atomization anomalies
Air speed		For low speed wind tunnels, between 2 m/s and 10 m/s, and measured to an accuracy within 0.1 m/s, close to nozzle location (with nozzle absent). For high speed wind tunnels, between 50 mph (22 m/s) and 180 mph (80 m/s), and measured to an accuracy within 5 mph (2 m/s), close to nozzle location (with nozzle absent)
Sample size per replicate measurement		>10,000 droplets for particle counting instruments or > 5 s for laser diffraction instruments
Diode suppression (laser diffraction systems)		Diodes may not be suppressed (no channels may be killed) in sampling. Correct selection of focal length lens, system alignment, avoidance of vibrations and cleanliness of optical surfaces should prevent the need for diode suppression (data loss). (If the laser is displaced during sampling, all diodes will measure incorrect scattering angles, and diode suppression is not an appropriate solution to such sampling problems.)
Replicate measurements		Measurements to be carried out with an atomizer 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.
Measured volume median diameter (VMD), $D_{v0.1}$ and $D_{v0.9}$ (i.e., the droplet diameter bounding the upper and lower 10% fractions of the spray)		Vary by less than ±3%
Section 2. Drift Potential Measurement in Wind Tunnel (Spray Flux and Deposition in LSWT)		
Ambient air temperature (dry bulb air temperature)	ASHRAE Standard 41.1	Measured to an accuracy within 0.1ºC
Wet bulb/dew point temperature or Percent relative humidity	Thermohygrometer equivalent to ASTM E337-84(1996)e1; or ASHRAE Standard 41.1	Measured to an accuracy within 0.1ºC or Within 5%

Parameter	Standard Operating Procedure (if applicable)	Acceptance Criteria
Air speed		Between 2 m/s and 10 m/s, and measured to an accuracy within 0.1 m/s, close to nozzle location (with nozzle absent)
Sampling rate for air speed	ASAE S561.1	Sampling should occur over a measuring period of 10 s
Wind tunnel working section width	ISO 22856	Minimum to avoid boundary layer and blockage effects
Wind tunnel turbulence	ISO 22856	< 8%
Consistency of air speed in wind tunnel working section	ISO 22856	< 5%
Spray nozzle and sampling height measurement		Within 5 mm (without airflow)
Spray material flow rate	ASAE S572	±0.04 L/min of values specified in the ASAE standard for reference and evaluation nozzles.
Spray pressure (nozzle operating pressure)	ASAE S572	±3.4 kPa of values specified in the ASAE standard for reference and evaluation nozzles.
Spray material temperature	ISO 22856	Measured within 0.1ºC
Ambient air temperature	ISO 22856	Measured within 0.1ºC
Relative spray material and air temperatures		Spray material temperature must be within 2ºC of the air temperature to avoid atomization anomalies
Percent relative humidity (low speed wind tunnel)	ISO 22856	80% ±5%
Solvent volume for extraction of tracer, if using collectors		Within 5% of volume required for analytical recovery and assessments (i.e., all samples should be washed with the same volume of solvent within 5% of the target volume)
Spray duration for replicate measurements		Minimum spray time of 5 s for each replicate measurement should be used, to allow stability of spray formation and to avoid under- or over-dosing of samplers or collectors. (Appropriate spray duration should be verified prior to measurement). Replicate measurements for a nozzle type should be within ±5% of mean time duration for a given setup.
Spray duration for similar nozzle types		Similar nozzle types from different vendors/manufacturers should be tested for a similar time duration, within ±5%.

Parameter	Standard Operating Procedure (if applicable)	Acceptance Criteria
For spray flux sampling using droplet size analyzers, also see Droplet Size Measurement section criteria in this table		Instrument criteria as listed in droplet size measurement section
Section 3. Field Study		
Dry bulb air temperature	ISO 22866	Between 5 and 35°C, measured to an accuracy within 0.5°C
Wet bulb/dew point temperature or Percent relative humidity	ASAE S561.1	Measured to an accuracy within 0.5ºC or Within 5%
Horizontal wind speed	ISO 22866	At least 1 m/s for all applications, measured at an accuracy within 0.2 m/s at nozzle height
Horizontal wind direction	ASAE S561.1	90° ± 30° to the spray track or the downwind edge of the sprayed area during the spray application. ≥ 70% of results shall be > 45° from the perpendicular of spray track when sampling at a frequency of 1.0 Hz within 2°
Nozzle flow rate	ASAE S561.1	Repeat measurements for individual nozzles within ±2.5%
Horizontal wind angle relative to sample line	ASAE S561.1	Mean angle between the sample line and the horizontal wind direction should not exceed 30º
Frequency of meteorological measurement sampling	ASAE S561.1	≥ 1.0 Hz sampling rate
Dynamic surface tension of spray liquid		40 ±4 dynes/cm at surface lifetime age of 10 to 20 ms
Surface vegetation height	ASAE S561.1	< 7.5 cm absolute height for all vegetation surface heights in drift sampling areas
Sample line and collection station locations		±2.5% of required location distances (at a minimum 2 m downwind of nozzle)
Sampling media area for individual collectors	ASAE S561.1	≥ 1000 cm^2 for deposition cards
Collector orientation for flat card/ plate/ cylindrical collectors		Horizontal ±15º relative to spirit level instrument or for vertical towers (optional additional collector), vertical ±15º
Diameter of cylindrical collectors (if used)	ASAE S561.1	2 mm ±5%
Number of samples at each sampling location		Determined from tests for the specific setup to produce confidence interval of ±10%

Parameter	Standard Operating Procedure (if applicable)	Acceptance Criteria
Boom length (swath width) and boom height above ground		Measured with accuracy within 1.0 cm when stationary
Application rate of tank mix in treated area		Within 2.5% of intended application rate
Forward speed of sprayer		Within 10% of target speed throughout entire application period. For aerial, at least 140 mph, and measured to an accuracy within 5 mph.
Solvent volume for extraction of tracer if using collectors		5% of volume required for analytical recovery and assessments (i.e., all samples should be washed with the same volume of solvent within 5% of the target volume)
Stability of tracer under conditions of study (light intensity, relative humidity, temperature, sampling media, storage conditions/ duration, etc.) measured as the amount recovered relative to the amount mixed for control samples		Tracer must exhibit adequate photostability (documented or published) allowing within 10% of the initial mixture detection values for all samples (note: samples should be collected in minimum possible time after exposure to drift sampling, stored in dark containers at <4°C and analyzed as soon as possible after collection)

Standards Cited

ANSI/ASHRAE 41.1 (1986) *Standard Method for Temperature Measurement*, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. 1791 Tullie Circle, NE, Atlanta, GA 30329.

ASAE S561.1 *Procedure for Measuring Drift Deposits from Ground, Orchard and Aerial Sprayers*. American Society of Agricultural and Biological Engineers, St. Joseph, MI.

ASAE S572 (1999) (sometimes referred to as ASABE S572) *Spray Nozzle Classification by Droplet Spectra*. Standard No. S572, American Society of Agricultural and Biological Engineers, St. Joseph, MI.

ISO Standard 22866 *Field Measurement of Spray Drift*. International Standards Organization.

ISO Draft Standard 22856: Equipment for Crop Protection – Laboratory Drift Methods Measurements. International Standards Organization.

A8: Special Training/Certifications

The testing organization may include any registrations, accreditations, qualifications, independently-assessed quality systems of the testing organization in the test site-specific test/QA plan.

A9: Documentation and Records

Test-specific documentation and records will be processed as specified in the testing organization's SOPs, protocols, etc.. See Element B10 for details of test data acquisition and management.

In accordance with Part A, Sections 5.1 and 5.3 of EPA's QMP, the testing organization will retain all test-specific documentation and records for 7 years after the final payment of the agreement between the testing organization and the APCT Center. RTI will retain all verification reports and statements for 7 years after final payment of the agreement between RTI and EPA.

GROUP B: DATA GENERATION AND ACQUISITION FOR LOW SPEED WIND TUNNELS

B1: Sampling Process Design (Experimental Design)

The measure of performance for the DRT for low speed wind tunnels will be derived from airborne droplet size distribution measurements and airborne liquid volume measurements. These values will be used by EPA to model deposition from 0 to 200 ft downwind. The basic experimental design will be to measure the droplet size spectrum under targeted test conditions with the DRT operating at specified spray pressure, air speed, boom height, and the "ambient" conditions. The measurement of droplet size spectrum and flux volume at 2 m distance downwind of the spray nozzle are the critical measurements for this verification test. Wind tunnel conditions and application conditions are important measurements for establishing the bounds of the verification test design. Deposition measurements in the wind tunnel are important for comparison to model estimates and evaluating model mass accountancy. Deposition measurements made in the wind tunnel and compared to near-field model predictions are an indicator of model accuracy.

In order to meet the DQOs, three replications will be used for each set of applications conditions intended for actual use in the field. For instance, three replications will be conducted for each combination of release height and nozzle pressure. As required by the DQO in Element A7, the product of this test design will be the measurement of a droplet size distribution consisting of 32 or more droplet size bins for the specified operating range. The DQIGs for appropriate parameters identified in sections 1 and 2 of Table 2 must be met. For example, the measured volume median diameter (VMD), $D_{v0.1}$ and $D_{v0.9}$ (the droplet diameter bounding the upper and lower 10 percent fractions of the spray) should vary by less than ±3 percent. The standard deviation around mean $D_{v0.5}$ should be less than 7 percent for three replicate droplet size measurements for the same nozzle.

Measurements of candidate test systems are compared to measurements from a reference spray system based on the ASAE S572 standard for droplet size. Before drift potential measurements are conducted, the candidate test system is categorized into droplet size category for very fine, fine, medium, coarse, very coarse, and extremely coarse using ASAE S572. The reference system should use the ASAE S572 reference nozzle associated with the lower (coarser) boundary of the droplet size category in which the candidate test system falls.

During drift potential measurements, the height of the reference nozzle (and nozzle spacing, if multiple nozzles are used) should be appropriate for the spray angle produced by the reference nozzle and does not need to be identical to the candidate test system. The reference nozzle should be directed straight down. The vendor may select the spray angle for the candidate test system nozzle.

B2: Sampling Methods for Measurement of Droplet Size, Deposit, and Test Conditions

Table 3 lists all the measurements required for this verification test. Measurements are categorized in the table as performance factors and test conditions. Performance factors are critical to verifying the performance of the DRT. Test conditions are important to understand the conditions of performance. Further detail is provided in Elements B2.1 through B2.4 and B4.

Table 3. Summary of Spray and Test Condition Measurements for Low Speed Wind Tunnels

Factors to Be Verified	Parameter to be Measured	Sampling and Measurement Method	Comments
Performance Factors			
Spray flux 2 m downwind from the atomizer	Tracer flux (µL or mg/cm^2/min) at the 6 (or more) measurement heights used in the downwind droplet size distribution measurement.	Multiple horizontal monofilament lines (or non-intrusive sampling methods appropriate for the spray material may be used).	If a method other than monofilament line is used, less than 2 percent total of the spray volume should be contained in the uppermost or lowermost size classes.
Droplet size 2 m downwind from the atomizer	At least six measurements of droplet size distribution corresponding to six or more heights.	Non-intrusive sampling methods appropriate for the spray material such as laser diffraction, phase-Doppler, laser imaging instruments	Less than 2 percent total of the spray volume should be contained in the uppermost or lowermost size classes.
Test Conditions Documentation			
Deposition	Deposition within 7 m downwind of the atomizer	Sampled using smooth horizontal surfaces such as filter paper. Measurement of extracted tracer using spectrofluorometer or other appropriate method.	Deposition should be described in terms of mass of tracer per unit area.
Droplet size at the atomizer	Droplet size distribution produced by the atomizer	Non-intrusive sampling methods appropriate for the spray material such as laser diffraction, phase-Doppler, laser imaging instruments.	Less than 2 percent total of the spray volume should be contained in the uppermost or lowermost size classes.
Spray pressure	Pressure of spray mix at the atomizer	See ASAE S572, section 3.	
Spray materials temperature	Temperature of the spray mixture	Calibrated thermometers accurate within 0.1ºC	Temperature of the ambient air and spray mixture should be within 2ºC
Spray nozzle height/ or boom height	Height of the atomizer above the floor of the wind tunnel		

Factors to Be Verified	Parameter to be Measured	Sampling and Measurement Method	Comments
Wind tunnel conditions	Air speed	An appropriate and calibrated anemometer such as hot wire or pitot-static tubes. Measurement should occur as close as possible to the atomizer without affecting its performance.	The air speed measured in the wind tunnel will be used to define acceptable field conditions of use. Testing organization conducts air speed, temperature, and humidity measurements simultaneously.
	Ambient air temperature	Calibrated thermometers accurate within 1ºC	
	Air humidity	Thermohygrometer equivalent to ASTM E337-84(1996)e1; ASHRAE Std 41.1; or other similar approach	

B2.1 Sampling Locations

Spray shall be sampled using one of several laser measurement systems: laser diffraction, phase-Doppler (excluding multi-phase droplets, e.g., air inclusion or emulsions), or laser imaging.

For droplet size distribution for determining the appropriate reference test system nozzle, the continuous traverse method is usually the optimal technique for sampling the spray plume, and data should be expressed as mass-balanced average droplet size data across the traverse. Multiple chordal measurements or (for phase-Doppler measurement systems), two- or three-dimensional mapping of droplet size and velocity throughout the spray plume, may also be used. Sampling should occur across a representative cross-sectional sample of the spray. Sampling should occur far enough from the atomizer to allow for both atomization of ligaments and secondary break up of droplets in the air stream to be complete. However, the sampling distance must be close enough to the atomizer that spray is not contacting the wind tunnel's surfaces. The sampling distance may need to be adjusted for different atomizers, flow rates, and test substances, but in general, the optimal sampling distance is between 20 to 50 cm from a nozzle.

For droplet size distribution and spray flux for drift potential, sampling will occur at the same locations for both, i.e., at 2 m downwind of the atomizer and at a minimum of six positions (or heights).

Measurement of air temperature and humidity should occur upwind of the atomizer and as close as possible to the atomizer without affecting its performance or the air speed at the atomizer.

B2.2 Process/Application Data Collection

1. Droplet size distribution sampling
   - Droplet size at the atomizer: Near the nozzles, see Element B2.4, Measurement of Droplet Size Spectrum Near the Nozzle (Determination of appropriate reference test system).

- Spray flux 2 m downwind from the atomizer and Droplet size 2 m downwind from the atomizer: For all measurements the downwind sampling distance will be 2 m from the nozzle orifice. The spray droplet size distribution and volume per unit time (i.e., spray flux) will be sampled at a minimum of six heights evenly distributed from the 0.1 m above the wind tunnel floor to a height equal to the nozzle height. The flux at the highest measurement height must be less than 1 percent of the cumulative flux measurements from lower heights. If amount of spray measured at the highest height exceeds 1 percent of the total volume measured at the lower heights, additional measurements at increments consistent with the lower measurement heights must be made. Alternatively, a continuous traverse spanning the specified height range may be used if the data droplet size distribution and spray volume data for specific heights can be recovered and it can be demonstrated that flux above the measured range accounts for less than 1 percent of the cumulative flux below. See Element B2.3, Wind Tunnel Measurement of Spray Drift Potential.

2. Horizontal samplers
   - Horizontal sampler location will be defined as the vertical distance below the atomizer's orifice and horizontal distance downwind of the atomizer.
   - Horizontal samplers will be placed directly downwind from atomizers.
   - Horizontal samplers will be placed at a height of 0.1 m above the wind tunnel floor to avoid boundary layer effects.
   - Horizontal samplers will be placed at 2, 3, 4, 5 and 6 m downwind of the atomizer.

3. Wind tunnel conditions
   - The following conditions shall be 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.

4. Sprayer conditions
   - Spray pressure shall be measured at the nozzle tip using a capillary connected to a pressure gauge (as is consistent with ASAE S572, section 3).

The sampling locations for these parameters are shown in Figure 4.

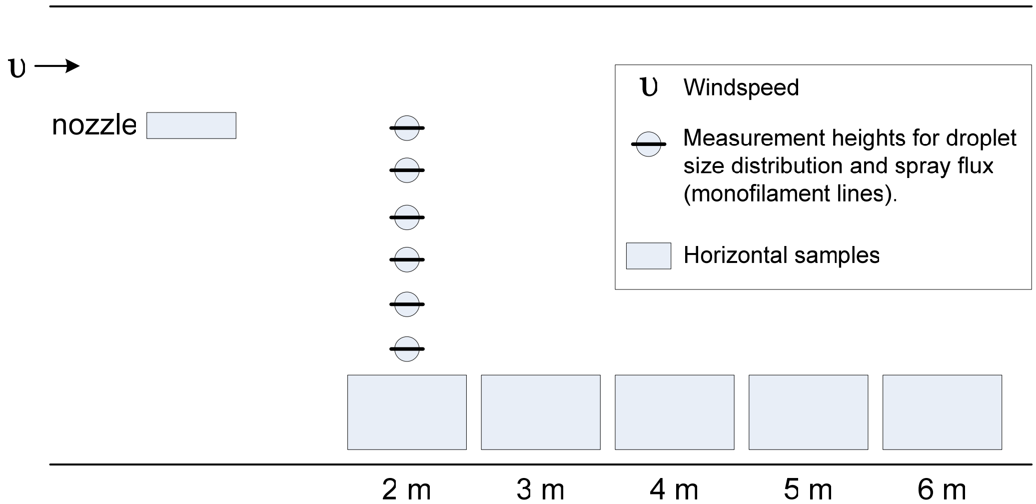

Figure 4. Low speed wind tunnel sampling locations.

B2.3 Wind Tunnel Measurement of Spray Drift Potential

All sampling will follow the requirements of the specific test method being used unless otherwise stated in this document or approved by EPA ETV project manager prior to the verification test. Laser-based measurement devices are used to measure droplet size distribution at 2 m and monofilament line is used to measure flux in the wind tunnel at 2 m at various heights. Horizontal sampling (for example, with filter paper) is used to measure horizontal deposition within the wind tunnel (see Element B2.5).

1. The spraying system shall be mounted to minimize effects on airflow.

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

3. Droplet size shall be measured using one of several laser or optical 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 shall be listed. Names, model numbers, serial numbers, scale ranges, software version number, and calibration verification shall be recorded.

4. The test spray nozzle(s) shall be mounted at a defined height not less than of 600 mm above the wind tunnel floor and not greater than a height 100 mm below the wind tunnel ceiling. Nozzles must be positioned in a place free from edge effects.

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

6. For each height, the sampling system must be configured to measure the entire dynamic size range of the instrument with less than 2 percent total of the spray volume contained in the uppermost or lowermost size classes.

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

8. For monofilament spray flux measurements, approximately 2 mm in diameter monofilament sampling lines should be used, extended horizontally across the wind tunnel, and cause minimal disruption to air flow in the wind tunnel.

9. For testing atomizers without using adjuvants, water containing surfactant may be used. Acceptable surfactants and surfactant concentrations are those that will provide a Newtonian tank mix with dynamic surface tension of 40 dyne/cm at surface lifetime age of 10 to 20 ms.
   - Use of other surfactants or concentrations should be approved by the EPA ETV project manager prior to testing.

10. When adjuvants are included as the DRT in the test spray material, emulsifiable concentrates (EC) formulations (blank or containing pesticide) must be included to make the results of the test extend to EC formulation. Water with surfactant (as described in Item 9 above) may be used if the results are only intended for aqueous solutions of 15 gal/acre or higher. An example of a commonly-used adjuvant in the U.S. is Triton X-77 in water at 0.25 percent v/v.

11. The spraying system shall be primed with spray prior to measurements to ensure that rinsing liquid is removed from the line and the liquid discharging from the nozzle is the actual intended tank mix. In addition, sprayer systems should be "run-in" for 5 min to ensure removal of machining burrs or plastic mold residue.

12. Spray material flow rate shall be measured at the operating pressure for the tests. The liquid flow rate measurement may include 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 should remain constant with a maximum deviation of ±2.5 percent. These liquid flow rate measurements are consistent with ISO 5682 part 1.

13. The wind tunnel shall be operated during sampling to provide a wind speed between 2 m/s and 10 m/s at the nozzle height.

14. To minimize evaporation effects, the relative humidity in the working section at the time of measurements shall be at least 80 percent ±5 percent.

15. The wind tunnel measurements of spray drift potential should comply with ISO Draft Standard 22856.

16. The type of nozzle being tested must be documented as follows:

- Flat fan, cone (hollow or full), impingement (deflector), and solid stream nozzles: manufacturer, fan angle at reference operating pressure, orifice size, material of manufacture.
- Other types of atomizers (e.g., rotary, electrostatic, ultrasonic): the type of nozzle must be described in the test/QA plan provided to EPA prior to testing in order to identify the appropriate parameters to be recorded.
- Include a close-up photograph of the nozzle and manifold and a cross-sectional drawing.
- Include the manufacturer nozzle part number.
- Document the type of nozzle body and cap used in the tests.

B2.4 Measurement of Droplet Size Spectrum Near the Nozzle (Determination of appropriate reference test system)

The droplet size of the test system near the nozzle is used to determine the appropriate reference test system. The droplet size measurement and classification shall be consistent with ASAE S572 in addition to the criteria below. The candidate test system is categorized into droplet size category for very fine, fine, medium, coarse, very coarse, and extremely coarse.

1. Droplet size spectra for spray drift tests shall be made under the same conditions (e.g., spray material, spray pressure, nozzle settings) and following the same procedures outlined in Element B2.3 except the measurements do not need to be made within a wind tunnel.

2. Droplet size may be 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 shall be listed. Names, model numbers, serial numbers, scale ranges, software version number, and calibration verification shall be recorded.

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

4. The sampling distance from the nozzle must be sufficient that the spray has atomized into droplets, for example through completion of breakup of sheets or ligaments of liquid following discharge from the nozzle.

5. The sampling system must be configured to measure the entire dynamic size range of the instrument with less than 2 percent total of the spray volume contained in the uppermost and lowermost size classes.

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

7. The droplet size measurements should include assessment of the droplet size category of the candidate test system and reference system according to ASAE S572.

B2.5 Measurement of Deposition within Wind Tunnel

Horizontal samplers (e.g., filter papers, strings, monofilament line) of known collection efficiency characteristics should be placed in the wind tunnel at the distances specified in Element B2.2. A representative photograph of a sampler placed in the wind tunnel should be provided.

B2.6 Wind Tunnel and Spray System Operation Data Collection

The following conditions shall be 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, and relative humidity. Spray pressure shall be measured at the nozzle tip using a capillary connected to a pressure gauge, as is consistent with ASAE S572, section 3. Spray material temperature shall be measured and shall be within ±2ºC of the ambient air temperature.

B3: Sample Handling and Custody Requirements

Procedures consistent with ISO 22856-1, Annex A should be followed. The samples collected during the test program will consist of horizontal samplers (filter paper) and monofilament line, if used. Analysis of these samples will be conducted using spectrofluorometers, as described in Element B4. To maintain sample integrity, the following procedure will be used. Each horizontal sampler and monofilament line will, prior to use, be stamped with a unique identification number or other numbering system to identify testing, test run, and position. A file folder or envelope will also be stamped with the identification number and the sampler will be placed in the corresponding folder.

The horizontal sampler filters and monofilament line containing tracer are placed in individual protective containers and then into numbered folders or envelopes. For transport, groups of samplers are sealed in heavy-duty plastic bags and stored in a heavy corrugated cardboard or plastic filing box equipped with a tight-fitting lid. All exposed and unexposed samplers are always kept separate to avoid any cross-contamination.

The date and time of sample collection and analysis must be recorded. Sample holding conditions (e.g., temperature, containers, light) must be noted for the period between sample collection and analysis.

If data collection and analysis is to be done on-site and no samples will be transported to a laboratory, sample custody requirements are not a required part of this verification test program.

B4: Analytical Methods

Measurement of deposited material will occur by extracting tracer from the horizontal samplers and monofilament lines followed by measurement of the amount of tracer in the extract. Tracer measurements should be expressed as the amount of material per unit area. Instruments used to measure tracer (e.g., spectrofluorometers) should be of adequate sensitivity to measure deposition at the most distant sampler.

B5: Quality Control

Air speed should vary by less than 5 percent within a trial and less than 5 percent across replicates.

Horizontal samplers and monofilament lines should be spiked with tracer at levels below that observed at the largest sampling distance in order to demonstrate adequate (>93 percent) recovery at the lowest measured deposition levels. Linearity of deposition relative to measurement instrumentation response should be demonstrated in the deposition range measured.

B6: Instrument/Equipment Testing, Inspection, and Maintenance

The site-specific test/QA plan resulting from this protocol needs to reference the testing organization's SOP for testing, inspection, and maintenance of instruments and equipment.

B7: Instrument/Equipment Calibration and Frequency

Calibration verification of some laser diffraction particle size analyzers can be achieved using ASTM Standard Test Method E 1458 "Test Method for Calibration Verification of Laser Diffraction Particle Sizing Instruments using Photomask Reticles."

Alternative techniques include reference particles and sprays of known size distribution.

Phase-Doppler instruments are optically calibrated during production – this is a lifetime calibration. Electronic phase calibration is normally done for each set of instrument settings, particularly photo multiplier transistor (PMT) voltage, sampling rate (pass band), and laser power level. This is done using a built-in calibration diode that generates a Doppler burst-like signal. Calibration values may also be obtained for various PMT voltages, for example, and recorded for later input during testing.

The accuracy depends on instrument settings, mainly through the signal to noise ratio (SNR). Typical values for experienced users can be expected to be within ±1 percent of the reading + 2° phase. The resolution in phase is 1/4096, or 0.0878906°.

The repeatability also depends on instrument settings, and with experience an operator may be expected to achieve typical values of ±2° phases. Single particle counting/imaging systems should measure at least 10,000 droplets per sample for statistical validity. Calibration can be achieved using reference materials of known size and/or following instrument manufacturer instructions such as lens focal length/size factor relationships.

B8: Inspection/Acceptance of Supplies and Consumables

The primary supplies and consumables for this exercise consist of the horizontal samplers, monofilament lines, and tracer materials. Prior to labeling, each sampler is visually inspected and is discarded for use if any damage is found. The tracer selected should allow for adequate sensitivity to measure deposition at all test distances. The tracer should be stable and nonvolatile in the test frame for testing and analysis. Background measurement samples from the testing site should demonstrate negligible levels of tracer or other interfering compounds.

Water used in spray tanks should have a hardness of less than 300 ppm.

B9: Non-Direct Measurements

If applicable, data that are not gathered directly by the testing organization may be used, however, the testing organization must describe these measurements in the test/QA plan or the applicant-specific addendum.

B10: Data Management

Results will be calculated as droplet size distribution and flux [i.e., volume or mass per unit area per unit time] at 2 m downwind from the nozzle at six heights and horizontal deposition at 2, 3, 4, 5, and 6 m for each set of sampling conditions (e.g., air speed, nozzle pressure, nozzle orientation). Droplet size distributions will be described by 32 categories of droplet diameter. Higher resolution distributions (more categories of droplet diameter) may be presented in addition to the 32-category description. Requirements for the verification test report, verification statement, and data storage and retrieval are provided in Group E, Data Reporting.

B10.1 Data Flow

Data measurement and collection activities are shown in Figure 5. This flow chart includes all data activities from the initial pretest QA steps to the passing of the data to EPA.

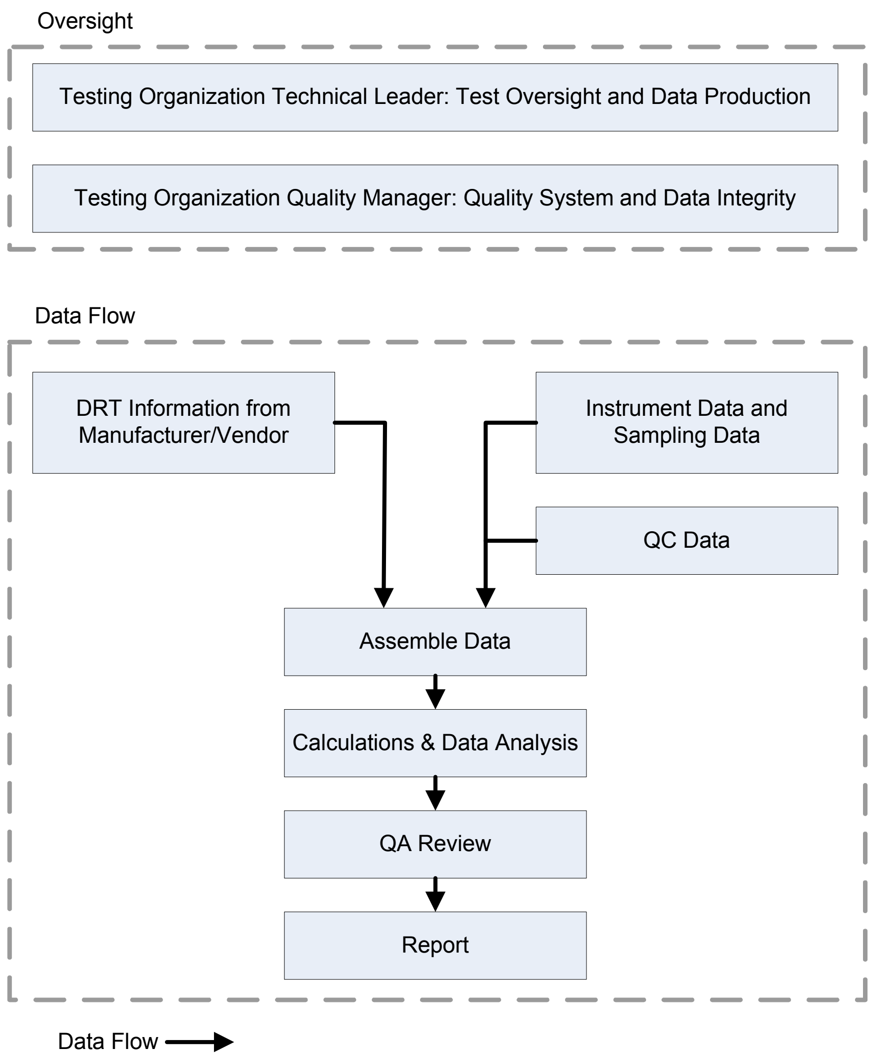

Figure 5. ETV data management system.

B10.2 Data Reduction

Data from each measurement for droplet size from the verification test will be reported as the incremental and cumulative volumes of 32 appropriately spaced and described bins of droplet diameter (microns). The $D_{v0.1}$, $D_{v0.5}$, $D_{v0.9}$, and relative span will also be presented. An example of a presentation of the output data is shown in Table B-1 in Appendix B. Raw data of droplet sizing instrument output should be provided as an appendix.

Data from measurements for flux (i.e., volume/unit area/unit time) from the verification test will be reported as "mL/cm^2/min" and labeled with the height at which the flux measurement was taken.

B10.3 Analysis of Verification Data

Measurements should be presented separately (raw data) and as an average across repetitions for the following types of measurements.

1. Downwind measurements:
   - Flux at each height
   - Volume per droplet size category (i.e., each of the 32 droplet size categories) at each height
   - Deposition on horizontal samplers at each downwind distance
2. Droplet size at the nozzle: Volume per droplet size category and reference spray type.

GROUP C: DATA GENERATION AND ACQUISITION FOR HIGH SPEED WIND TUNNEL TESTS

C1: Sample Process Design (Experimental Design)

The measure of performance for the DRT for high speed wind tunnels will be derived from droplet size distribution measurements. These values will be used by EPA to model deposition from 0 to 200 ft downwind. The basic experimental design will be to measure the droplet size spectrum under targeted test conditions with the DRT operating at specified spray pressure, air speed, and the "ambient" conditions. Droplet size spectrum is the critical measurement for this verification test. Wind tunnel conditions and application conditions are important measurements for establishing the bounds of the verification test design. Unlike the low speed wind tunnel testing, no deposition measurements are made with high speed wind tunnel testing.

In order to meet the DQOs, at least three replications will be used for each set of application conditions intended for actual use in the field. For instance, at least three replications will be conducted for each combination of air speed and nozzle pressure. As required by the DQO in Element A7, the product of this test design will be the measurement of a droplet size distribution consisting of 32 or more droplet size bins for the specified operating range. The DQIGs for appropriate parameters identified in sections 1 and 2 of Table 2 must be met. For example, the measured volume median diameter (VMD), $D_{v0.1}$ and $D_{v0.9}$ (the droplet diameter bounding the upper and lower 10 percent fractions of the spray) should vary by less than ±3 percent.

Measurements of candidate test systems are compared to a reference spray system based on the ASAE S572 standard for droplet size. Before drift potential measurements are conducted, the candidate test system is categorized into droplet size category for very fine, fine, medium, coarse, very coarse, and extremely coarse using ASAE S572. The reference system should use the ASAE S572 reference nozzle associated with the lower (coarser) boundary of the droplet size category in which the candidate test system falls.

During drift potential measurements, the angle of the candidate test system does not need to be identical to that of the reference spray system. The vendor may select the spray angle for the candidate test system nozzle. Acceptable nozzles, associated wind tunnel air speeds, and nozzle angles relative to air direction are identified below.

C2: Sampling Methods for Measurement of Droplet Size and Test Conditions

Table 4 lists all the measurements required for this verification test. Measurements are categorized in the table as performance factors and test conditions. Performance factors are critical to verifying the performance of the DRT. Test conditions are important to understand the conditions of performance. Further detail is provided in Elements C2.1 through C2.4.

Table 4. Summary of Spray and Test Condition Measurements for High Speed Wind Tunnels

Factors to Be Verified	Parameter to Be Measured	Sampling and Measurement Method	Comments
Performance Factors			
Droplet size at the atomizer	Droplet size distribution produced by the atomizer	Non-intrusive sampling methods appropriate for the spray material such as laser diffraction, phase-Doppler, laser imaging instruments.	The range of droplet size categories measured must account for at least 99% of the spray volume.
Test Conditions Documentation			
Spray pressure	Pressure of spray mix at the atomizer	See ASAE S572, section 3.	
Spray materials temperature	Temperature of the spray mixture	Calibrated thermometers accurate within 0.1ºC	Temperature of the ambient air and spray mixture should be within 2ºC
Wind tunnel conditions	Air speed	An appropriate and calibrated anemometer such as hot wire or pitot-static tubes. Measurement should occur as close as possible to the atomizer without affecting its performance.	The air speed measured in the wind tunnel will be used to define acceptable field conditions of use. Testing organization conducts air speed, temperature, and humidity measurements concurrently.
	Ambient air temperature	Calibrated thermometers accurate within 0.1ºC	
	Air humidity	Thermohygrometer equivalent to ASTM E337-84(1996)e1; ASHRAE Std 41.1; or other similar approach	

C2.1 Sampling Locations

Spray shall be sampled using one of several laser measurement systems: laser diffraction, phase-Doppler (excluding multi-phase droplets, e.g., air inclusion or emulsions) or laser imaging.

For both droplet size distribution for determining the appropriate reference test system nozzle and for determining drift potential, the continuous traverse method is usually the optimal technique for sampling the spray plume, and data should be expressed as mass-balanced average droplet size data across the traverse. Multiple chordal measurements or (for phase-Doppler measurement systems), two- or three-dimensional mapping of droplet size and velocity throughout the spray plume may also be used. Sampling should occur across a representative cross-sectional sample of the spray. Sampling should occur far enough from the atomizer to allow for both atomization of ligaments and secondary break up of droplets in the air stream to be complete. However, the sampling distance must be close enough to the atomizer that spray is not contacting the wind tunnel's surfaces. The sampling distance may need to be adjusted for different atomizers, flow rates, and test substances but in general the optimal sampling distance is between 20 to 50 cm from a nozzle.

Measurement of air temperature and humidity should occur upwind of the atomizer and as close as possible to the atomizer without affecting its performance or the air speed at the atomizer.

C2.2 Process/Application Data Collection

1. Droplet size distribution sampling
   - Droplet size at the atomizer, for classification: Near the nozzles, see Element C2.4, Measurement of Droplet Size Spectrum Near the Nozzle, Without the Effects of Flight Speed Air Flow (Determination of appropriate reference test system).
   - Droplet size at the atomizer, drift potential: Near the nozzles, see Element C2.3, Wind Tunnel Measurement of Spray Drift Potential (Droplet Size Distribution at Aerial Application Air Speeds at the nozzle).
2. Wind tunnel conditions
   - The following conditions shall be 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.
3. Sprayer conditions
   - The Spray pressure shall be measured at the nozzle tip using a capillary connected to a pressure gauge (as is consistent with ASAE S572, section 3).

C2.3 Wind Tunnel Measurement of Spray Drift Potential (Droplet Size Distribution at Aerial Application Air Speeds at the nozzle)

All sampling will follow the requirements of the specific test method being used unless otherwise stated in this document or approved by EPA ETV project manager prior to the verification test. Laser-based measurement devices are used to measure droplet size distribution at the nozzle in the wind tunnel.

1. The spraying system shall be mounted to minimize effects on airflow.
2. The orientation of the nozzle (predominant spray direction or axis of rotation) that the fan sprays discharge relative to the air flow direction must be measured with a protractor and recorded.
3. Droplet size shall be measured using one of several laser or optical 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 shall be listed. Names, model numbers, serial numbers, scale ranges, software version number, and calibration verification shall be recorded.
4. Nozzles must be positioned in a place free from edge effects.

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

6. The sampling system must be configured to measure the entire dynamic size range of the instrument with less than 2 percent total of the spray volume contained in the uppermost or lowermost size classes.

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

8. The droplet size measurements should include assessments of the droplet size category of the candidate test system and reference system according to ASAE S572.

9. For testing atomizers without using adjuvants, water containing surfactant may be used. Acceptable surfactants and surfactant concentrations are those that will provide a Newtonian tank mix with dynamic surface tension of 40 dyne/cm at surface lifetime age of 10 to 20 ms.Use of other surfactants or concentrations should be approved by the EPA ETV project manager prior to testing.

10. When adjuvants are included as the DRT in the test spray material, emulsifiable concentrates (EC) formulations (blank or containing pesticide) must be included to make the results of the test extend to EC formulation. Water with surfactant (as described in item 9 above) may be used if the results are only intended for aqueous solutions of 15 gal/acre or higher. An example of a commonly-used adjuvant in the U.S. is Triton X-77 at 0.25 percent v/v.

11. The spraying system shall be primed with spray prior to measurements to ensure that rinsing liquid is removed from the line and the liquid discharging from the nozzle is the actual intended tank mix. In addition, sprayer systems should be "run-in" for 5 min to ensure removal machining burrs or plastic mold residue.

12. Spray material flow rate shall be measured at the operating pressure for the tests. The liquid flow rate measurement may include 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 should remain constant with a maximum deviation of ±2.5 percent. These liquid flow rate measurements are consistent with ISO 5682 part 1.

13. The air speed in the working section of the wind tunnel must be measured as close as possible to the nozzle without affecting nozzle performance or allowing the atomizer to influence the air speed measurement. Air speed must be maintained between 50 and 180 mph.

14. The type of nozzle being tested must be documented as follows:

- Flat fan, cone (hollow or full), impingement (deflector), and solid stream nozzles: manufacturer, fan angle at reference operating pressure, orifice size, material of manufacture.
- Other types of atomizers (e.g., rotary, electrostatic, ultrasonic): the type of nozzle must be described in the test/QA plan provided to EPA prior to testing in order to identify the appropriate parameters to be recorded.
- Include a close-up photograph of the nozzle and manifold and a cross-sectional drawing.
- Include the manufacturer nozzle part number.
- Document the type of nozzle body and cap used in the tests.

C2.4 Measurement of Droplet Size Spectrum Near the Nozzle, Without the Effects of Flight Speed Air Flow (Determination of appropriate reference test system).

The droplet size of the candidate test system near the nozzle is used to determine the appropriate reference test system. The droplet size measurement and classification shall be consistent with ASAE S572 in addition to the criteria below. The candidate test system is categorized into droplet size category for very fine, fine, medium, coarse, very coarse, and extremely course.

1. Droplet size spectra for spray drift tests shall be made under the same conditions (e.g., spray material, spray pressure, nozzle settings) and following the same procedures outlined in Element C2.3 except the measurements do not need to be made within a wind tunnel.

2. Follow methods in Element B2.4, items 2 through 7.

C2.5 Wind Tunnel and Spray System Operation Data Collection

The following conditions shall be 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, and relative humidity. Spray pressure shall be measured at the nozzle tip using a capillary connected to a pressure gauge (as is consistent with ASAE S572, section 3). Spray material temperature shall be measured and shall be within ±2ºC of the ambient air temperature.

C3: Sample Handling and Custody Requirements

If data collection and analysis is to be done on-site and no samples will be transported to a laboratory, sample custody requirements are not a required part of this verification test program.

C4: Analytical Methods

No analytical methods are used.

C5: Quality Control

At least three replicates for each set of test conditions should be conducted. Measured volume median diameter (VMD), $D_{v0.1}$ and $D_{v0.9}$ (the droplet diameter bounding the upper and lower 10 percent fractions of the spray) should vary by less than 3 percent.

Air speed should vary by less than 5 percent within a trial and less than 5 percent across replicates. Air speed must be maintained between 50 and 180 mph. If the air speed is less than 140 mph, there may be constraints on the application use label conditions.

C6: Instrument/Equipment Testing, Inspection, and Maintenance

The site-specific test/QA plan resulting from this protocol needs to reference the testing organization's SOP for testing, inspection, and maintenance of instruments and equipment.

C7: Instrument/Equipment Calibration and Frequency

Calibration verification of some laser diffraction particle size analyzers can be achieved using ASTM Standard Test Method E 1458 "Test Method for Calibration Verification of Laser Diffraction Particle Sizing Instruments using Photomask Reticles."

Alternative techniques include reference particles and sprays of known size distribution.

Phase-Doppler instruments are optically calibrated during production – this is a lifetime calibration. Electronic phase calibration is normally done for each set of instrument settings, particularly PMT voltage, sampling rate (pass band), and laser power level. This is done using a built-in calibration diode that generates a Doppler burst-like signal. Calibration values may also be obtained for various PMT voltages, for example, and recorded for later input during testing.

The accuracy depends on instrument settings, mainly through the signal to noise ratio (SNR). Typical values for experienced users can be expected to be within ±1 percent of the reading + 2° phase. The resolution in phase is 1/4096, or 0.0878906°.

The repeatability also depends on instrument settings, and with experience an operator may be expected to achieve typical values of ±2° phases. Single particle counting/imaging systems should measure at least 10,000 droplets per sample for statistical validity. Calibration can be achieved using reference materials of known size and/or following instrument manufacturer instructions such as lens focal length/size factor relationships.

C8: Inspection/Acceptance of Supplies and Consumables

Water used in spray tanks should have a hardness of less than 300 ppm.

As there are no other supplies and consumables, additional inspection and acceptance requirements are not a required part of this verification test protocol.

C9: Non-Direct Measurements

If applicable, data that are not gathered directly by the testing organization may be used, however, the testing organization must describe these measurements in the test/QA plan or the applicant-specific addendum.

C10: Data Management

Results will be calculated as droplet size distribution at the nozzle for each set of sampling conditions (e.g., air speed, nozzle pressure, nozzle orientation). Droplet size distributions will be described by 32 categories of droplet diameter. Higher resolution distributions (more categories of droplet diameter) may be presented in addition to the 32-category description. Requirements for the verification test report, verification statement, and data storage and retrieval are provided in Element E, Data Reporting.

C10.1 Data Flow

Data measurement and collection activities are shown in Figure 5 in Element B10. This flow chart includes all data activities from the initial pretest QA steps to the passing of the data to EPA.

C10.2 Data Reduction:

Data from each measurement for droplet size from the verification test will be reported as the incremental and cumulative volumes of 32 appropriately spaced and described bins of droplet diameter (microns). The $D_{v0.1}$, $D_{v0.5}$, $D_{v0.9}$, and relative span will also be presented. An example presentation of the output data is shown in Table B-1 of Appendix B. Raw data of droplet sizing instrument output should be provided in an appendix.

C10.3 Analysis of Verification Data:

Measurements should be presented separately (raw data) and as an average across repetitions for the following types of measurements. Measurements would include droplet size at the nozzle: volume per droplet size category (i.e., each of the 32 droplet size categories) and reference spray type.

GROUP D: DATA GENERATION AND ACQUISITION FOR FIELD STUDIES

D1: Sampling Process Design (Experimental Design)

The measure of performance for the DRT in field studies will be directly determined by deposition measured on horizontal fallout collectors according to either ASAE 561.1 APR04 or ISO/DIS 22866:2005(E) standard methods with modifications specified in Element D below. The specific placement of collectors will allow for an estimate of the integrated deposition from 0 to 61 m (200 ft) and the point deposition at 30.5 m (100 ft) downwind of the application site.

The treatment area/spray track must be at least 100 m long and perpendicular to wind direction. If samplers are placed beyond 61 m downwind, the length of the treatment area should be at least the product of the outermost sampler distance and 1.15 plus the distance between the outermost samplers in the sampling array.[2] This arrangement allows for the outermost samplers to be downwind of the treatment area when the wind direction approaches ± 30 degrees relative to the length of the treatment area.

The conditions of the study will be selected to allow for the measurement of the DRT and the reference spray systems under identical or similar conditions (e.g., wind speed, wind direction, temperature, relative humidity, release height). The measurements of deposition are the critical measurements for this verification test. Measurements of field and application conditions are important for establishing the limitations of the verification test design. As required by the DQO in Element A7, the DQIGs for the parameters identified in section 3 of Table 2 must be met.

Measurements of candidate test systems are compared to a reference spray system based on the ASAE S572 standard for droplet size. The reference system should use the ASAE S572 nozzle model associated with the lower (coarser) boundary of the droplet size category (very fine, fine, medium, coarse, very coarse, and extremely coarse) in which the test system falls. The height and spacing of the standard nozzle should be appropriate for the spray angle produced by the reference nozzle and does not need to be identical to the candidate test system. The reference nozzle should be directed straight down.

D2: Sampling Methods for Measurement of Droplet Size, Deposit, and Test Conditions

Table 5 lists all the measurements required for this verification test. Measurements are categorized in the table as performance factors and test conditions. Performance factors are critical to verifying the performance of the DRT. Test conditions are important to understand the conditions of performance. Further detail is provided in Elements D2.1 through D2.3 and D4.

[2] [Outermost sampler distance] x [2 tan(30)] + [distance between outmost array of samplers]

Table 5. Summary of Spray and Test Condition Measurements for Field Testing

Factors to Be Verified	Parameter to Be Measured	Sampling and Measurement Method	Comments
Performance Factors			
Deposition	Tracer deposit at multiple locations downwind of the treatment area	Sampled using smooth horizontal surface collectors such as filter paper.	Deposition should be described in terms of mass of nonvolatile tracer per unit area
Test Conditions Documentation			
Spray pressure	Pressure of spray mix at the atomizer	See ASAE S572, section 3.	
Spray materials temperature	Temperature of the spray mixture	Calibrated thermometers accurate within 1ºC	Temperature of the air and spray mixture should be within 2ºC
Flow rate	Volume per unit time produced by the nozzle under test conditions.	See ASAE S561.1	Repeat measurements for individual nozzles within ±2.5%
Release height	Height above the ground the spray materials are released		
Travel speed	Rate of speed for the equipment used to apply the spray material		
Meteorological conditions	Wind speed	See ASAE S561.1, section 3.2.3	
	Wind direction	See ASAE S561.1, section 3.2.4	
	Ambient air temperature	See ASAE S561.1, section 3.2	
	Ambient pressure	See ASAE S561.1, section 3.2	
	Relative humidity	See ASAE S561.1, section 3.2.2	

D2.1 Sampling Locations

Three parallel lines of horizontal collectors within the sampling array should be used. Collector lines in the sampling array should be spaced at least 15 m apart. The center collector line in the sampling array should be in the center of the application area. Horizontal deposition samplers should be placed at a minimum of 4 m, 8 m, 16 m, 30.5 m, and 61 m from the downwind edge of the treated area. At least one collector should be placed in the swath and upwind of the treatment area.

The placement of the station(s) for measuring meteorological conditions should be located in the open within 30 m of the treatment area and away from any obstruction or topographical irregularities.

A map should be provided showing the treatment area, sampler placements, position of the meteorological station(s), and any obstructions or identifying features of the test area.

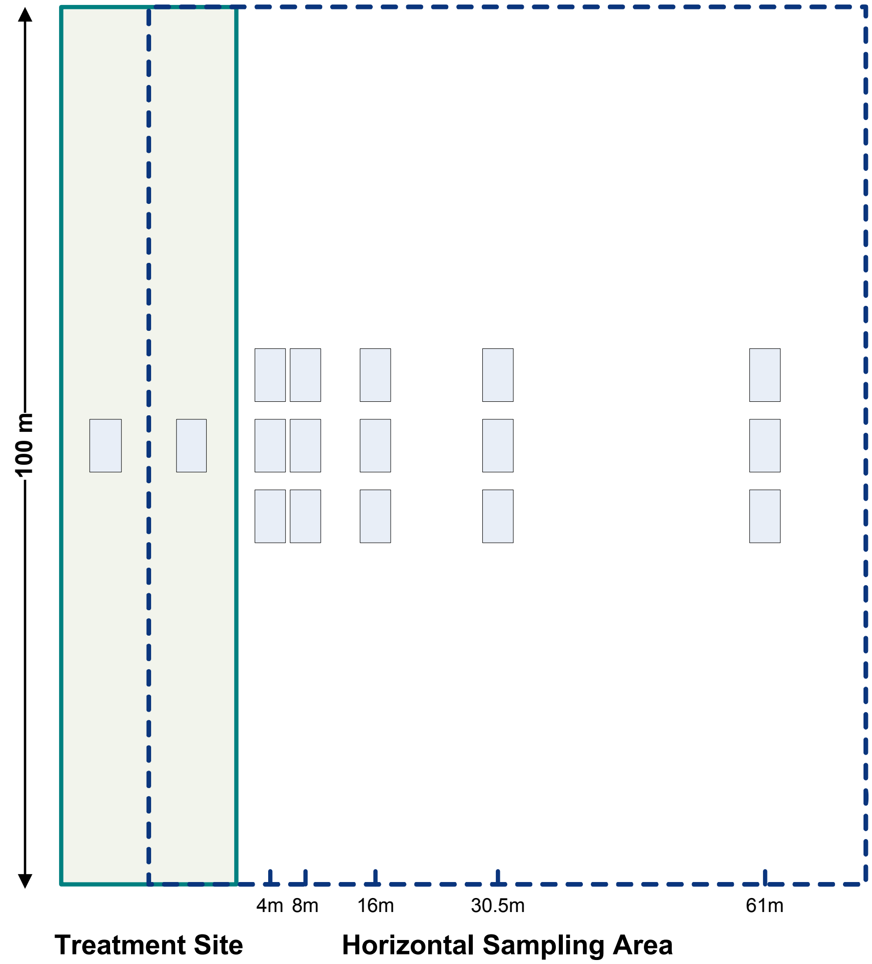

Figure 6. Sampling locations for field testing.

D2.2 Process/Application Data Collection

All sampling will follow the requirements of the specific test method being used, either ASAE 561.1 APR04 or ISO/DIS 22866:2005(E) standard methods, unless otherwise stated in this document or approved by EPA prior to the verification test. Example sampling locations for field testing are shown in Figure 6.

D2.3 Ambient Data Collection

Meteorological conditions will be measured with at least one weather station during applications. The sampling rate for wind speed and direction should be at least 4 samples per minute. The wind speed must be at least 1 m/s for all applications.

D3: Sample Handling and Custody Requirements

The date and time of sample collection and analysis must be recorded. Sample holding conditions (e.g., temperature, containers, light) must be noted for the period between sample collection and analysis.

The samples collected during the test program will consist of horizontal samplers (filter paper). Analysis of these samples will be conducted using gas chromatography, as described in Element D4. To maintain sample integrity, the following procedure will be used. Each horizontal sampler will, prior to use, be stamped with a unique identification number or other numbering system to identify testing, test run, and position. A file folder or envelope will also be stamped with the identification number and the sampler will be placed in the corresponding folder.

The horizontal sampler filters containing tracer are placed in individual protective containers and then into numbered folders or envelopes. For transport, groups of samplers are sealed in heavy-duty plastic bags and stored in a heavy corrugated cardboard or plastic filing box equipped with a tight-fitting lid. All exposed and unexposed samplers are always kept separate to avoid any cross-contamination.

The date and time of sample collection and analysis must be recorded. Sample holding conditions (e.g., temperature, containers, light) must be noted for the period between sample collection and analysis.

If data collection and analysis is to be done on-site and no samples will be transported to a laboratory, sample custody requirements are not a required part of this verification test program.

D4: Analytical Methods

Measurement of deposited material will occur by extracting tracer from the horizontal sample collectors followed by measurement of the amount of tracer in the extract. Tracer measurements should be expressed as the amount of material per unit area of sampler. Instruments used to measure tracer (e.g., gas chromatographs) should be of adequate sensitivity to measure deposition at the most distant sampler.

D5: Quality Control

The boom width, intended swath width, nozzle placement, and nozzle orientation of the application equipment will be reported. Wind direction during and for 2 minutes after application should be ±30 degrees perpendicular to the swath. Drive speed for ground equipment will be between 4 and 24 km/h (2.5 to 15 mph). Aerial application equipment speed must be at least 140 mph. If the aerial application equipment speed is less than 140 mph, there may be constraints on the application use label conditions.

Randomly selected, unused horizontal sample collectors should be spiked with tracer at 2 and 200 times the level of quantitation for the analytical equipment to be used for measuring tracer. Tracer recovery should be within 80 to 120 percent of the spiked amount. Stock solutions used in testing should also be tested. Linearity of deposition relative to measurement instrumentation response should be demonstrated in the deposition range measured.

Tracer concentration in the spray material tank will be measured and reported before and after testing on each test day and for each tank mix used.

D6: Instrument/Equipment Testing, Inspection, and Maintenance

The site-specific test/QA plan needs to reference the testing organization's SOP for testing, inspection, and maintenance of instruments and equipment.

D7: Instrument/Equipment Calibration and Frequency

Analytical instruments used to measure tracer extracts from collectors will be calibrated on the same day of analysis. Calibration will use a standard curve consisting of at least three points spanning the level of quantitation and the highest measured concentration level. The standard curve should be linear (r^2 greater than 0.95).

D8: Inspection/Acceptance of Supplies and Consumables

The primary supplies and consumables for this exercise consist of the horizontal samplers and tracer materials. Prior to labeling, each sampler is visually inspected and is discarded for use if any damage is found. The tracer selected should allow for adequate sensitivity to measure deposition at all test distances. The tracer should be stable and nonvolatile in the test frame for testing and analysis. Background measurement samples from the testing site should demonstrate negligible levels of tracer or other interfering compounds.

Water used in spray tanks should have a hardness of less than 300 ppm.

D9: Non-Direct Measurements

If applicable, data that are not gathered directly by the testing organization may be used, however, the testing organization must describe these measurements in the test/QA plan or the applicant-specific addendum.

D10: Data Management

Results will be calculated as deposition for each set of sampling conditions at downwind positions at 4 m, 8 m, 16 m, 30.5 m, and 61 m, including a summary of meteorological conditions and application conditions. Requirements for the verification test report, verification statement, and data storage and retrieval are provided in Group E, Data Reporting.

D10.1 Data Flow

Data measurement and collection activities for deposition are shown in Figure 5 of Element B10. This flow chart includes all data activities from the initial pretest QA steps to the passing of the data to EPA.

D10.2 Data Reduction

Data from each measurement for deposition from the verification test will be reported in units of mass/area for each downwind distance and the meteorological and application conditions will clearly be reported.

D10.3 Analysis of Verification Data

Measurements should be presented separately (raw data) and as an average across repetitions for each downwind measurements for the deposition on horizontal samplers at each downwind distance.

GROUP E: DATA REPORTING

E1: Outline of the Verification Test Report

- Verification statement
  - DRT manufacturer/vendor information
  - Summary of verification test program including testing location and type (LSWT, HSWT, or Field)
  - Results of the verification test
  - Droplet size classification, using ASAE S572.
  - Any limitations of the verification results
  - Brief QA statement
- Introduction
- Description and identification of the DRT
- Procedures and methods used in testing
  - The instruments and measurement apparatus used for droplet size measurement (including name and type, model number, serial number, scale ranges, software version number, and date of most recent calibration verification)
  - Spray flux and deposition sampling (including description of monofilament lines, size and type of horizontal samplers, placement of monofilament lines and samplers, and photograph of samplers place for collection)
- Statement of operating range and testing conditions over which the test was conducted including:
  - Nozzle orifice height
  - Spray pressure at nozzle
  - Volume/unit time produced by nozzle
  - Test spray material composition
  - Source of spray materials (including water)
  - Sampling locations
  - Temperature
  - Humidity
  - Wind speed – wind tunnel testing only
  - Flight speed or ground equipment speed – field testing only
  - Wind speed/direction – field testing only
  - Atmospheric stability (Pascal) – field testing only
  - Results of the ASAE S572 droplet size measurement

- Summary and discussion of results
  - Results supporting verification statement
  - Deviations and explanations from test plan
  - Discussion of QA and QA statement
- References
- Appendices
  - QA/QC activities and results
  - Raw test data
  - Equipment calibration results
  - Sample handling

E2: Draft Report Preparation

At the conclusion of the field and wind tunnel testing effort, a copy of all electronic and paper data will be made and retained by the testing organization task leader.

The testing organization will develop a verification report that verifies and summarizes the DRT test results.

E3: Data Storage and Retrieval

This section describes the handling and storage of the data. After the completion of a verification test, labeled three-ring binders containing manually recorded information and data output generated from instrumentation will be stored with a copy retained by the testing organization. This is called the 'Data Notebook' in the ETV and APCT Center QMPs. After the completion of a verification test, a computer diskette containing spreadsheet data files will be stored with a copy retained by the test analyst.

All data, verification reports, and verification statements will be retained for a period of not less than 7 years per Part A, Section 5.3 of the EPA ETV QMP.

GROUP F: ASSESSMENT/OVERSIGHT

F1: Assessments and Response Actions

F1.1 Internal Audits

Internal audits by the testing organization are conducted as specified in the testing organization's SOP, which must conform to required Element C1 (Assessments and Response Actions) and C2 (Reports to Management) of EPA QA/R-5. The testing organization SOP documents must be identified in the site-specific test/QA plan.

F1.2 Audits of Data Quality

In accordance with Table 9.1 of the EPA ETV QMP, the testing organization QM will conduct an ADQ of at least 10 percent of all of the verification data. The ADQ will be conducted in accordance with EPA's *Guidance on Technical Audits and Related Assessments for Environmental Data Operations, EPA QA/G-7*, including:

- a written report detailing the results of custody tracing,
- a study of data transfer and intermediate calculations,
- a review of QA and QC data, including reconciliation to user requirements, e.g., DQOs and DQIGs, and
- a study of project incidents that resulted in lost data, and a review of study statistics.

The ADQ report ends with conclusions about the quality of the data from the project and their fitness for their intended use.

F1.3 External Audits

The testing organization will cooperate with any external assessments by the EPA. EPA assessors will conduct a single mandatory quality and technical systems assessment of the testing organization before the start of the first test for each test facility. They may conduct optional witness assessments during the first test or any subsequent test. The external assessments will be conducted as described in EPA QA/G-7.

F1.4 Corrective Action

Corrective action to any audit or assessment is performed according to the testing organization's SOPs, which must conform to required Elements B5 (Quality Control) and C1 (Assessments and Response Actions) of EPA QA/R-5.

F2: Reports to Management

Internal assessment reports will be reviewed by the testing organization QM, who will respond as noted in Element C1 of EPA QA/R-5. The written report of the ADQ will be submitted for review as noted in Element F1.2 of this protocol.

GROUP G: DATA VALIDATION AND USABILITY ELEMENTS

G1: Data Review, Verification, and Validation

Data review and validation will primarily occur at the following stages:

- On site following each test run – by the test technician
- On site following completion of the test program – by the testing organization technical leader
- Before writing the draft verification test report – by the testing organization QM
- During QA review of the draft report and audit of the data – The criteria used to review and validate the data will be the QA/QC criteria specified in each test procedure, protocol, guideline, or method (see Table 2) and the DQIG analysis of the parameter test data. Those individuals responsible for onsite data review and validation are noted in Figure 5, Element B10, and above. The testing organization technical leader is responsible for verification of data with all written procedures. Finally the testing organization QM reviews and validates the data and the draft report using the site-specific test/QA Plan, test methods, general SOPs, and project-specific SOPs.

The data review and data audit will be conducted in accordance with the testing organization's SOP.

G2: Verification and Validation Methods

The process for validating and verifying data has been described in Elements B, C, and D of this protocol. Results of the testing are conveyed to the data users through the ETV verification statements and verification reports. Examples of an ETV verification statement are presented on the ETV Web site [http://www.epa.gov/etv/].

G3: Reconciliation with Data Quality Objectives

DQO requirements have been defined [in Table 2]. This reconciliation step is an integral part of the test program and will be done at the test site. Attainment of the DQO is confirmed by analyzing the test data as described in Element A7 and will be completed by the testing organization test technician and testing organization technical leader at the conclusion of the scheduled test runs. The DQO is defined as meeting the DQIG in Table 2.

The reconciliation of the results with the DQO will be evaluated using the data quality assessment process. This process started with the review of the DQO and the sampling design to assure that the sampling design and data collection documentation are consistent with those needed for the DQO. When the preliminary data is collected, the data will be reviewed to ensure that the data are consistent with what was expected and to identify patterns, relationships, and potential anomalies. The data will be summarized and analyzed using appropriate statistical procedures to identify the key assumptions. The assumptions will be evaluated and verified with all deviations from procedures assessed as to their impact on the data quality and the DQO. Finally, the quality of the data will be assessed in terms of precision, bias, and statistical significance as they relate to the measurement objectives and the DQO.

Results from verification testing of the DRT will be presented in a verification statement and a verification report as described in Element B10.2.

APPENDIX A: APPLICABLE DOCUMENTS AND PROCEDURES

1. EPA Documents

EPA. Policy and Program Requirements for the Mandatory Agency-wide Quality System. EPA Order 5360.1 A2. U.S. Environmental Protection Agency. May 2000.

EPA. *EPA Requirements for Quality Management Plans*. *EPA QA/R-2*, EPA Publication No. EPA/240/B-01/002. U.S. Environmental Protection Agency, Office of Environmental Information. Washington, DC. March 2001.

EPA. *Environmental Technology Verification Program, Quality Management Plan.* EPA Publication No. EPA/600/R-03/021. Office of Research and Development, U.S. Environmental Protection Agency. Cincinnati, OH. December 2002.

EPA. *EPA Requirements for Quality Assurance Project Plans. EPA QA/R-5*, EPA Publication No. EPA/240/B-01/003. Office of Environmental Information, U.S. Environmental Protection Agency. March 2001.

EPA. *Guidance for Quality Assurance Project Plans. EPA QA/G-5,* EPA Publication No. EPA/600/R-98/018. Office of Environmental Information, U.S. Environmental Protection Agency. February 1998.

EPA. *Guidance on Technical Audits and Related Assessments for Environmental Data Operations. EPA QA/G-7,* EPA Publication No. EPA/600/R-99/080. Office of Environmental Information, U.S. Environmental Protection Agency. January 2000.

2. Verification Organization Documents

RTI International. Verification Testing of Air Pollution Control Technology - Quality Management Plan, Revision 2.2. RTI International. Research Triangle Park, NC. February 2005.

APPENDIX B: EXAMPLE FORMAT FOR TEST DATA

Table B-1. Example of Test Data Report Format

Droplet Size Bin No.	Measures of droplet size categories (μm)			Mass Fraction	
	Largest	Arithmetic Mean	Smallest	Incremental	Cumulative
1	1504	1400.5	1297	0	0
2	1297	1208.5	1120	0	0
3	1120	1042.5	965	0	0
4	965	899	833	0	0
5	833	776	719	0	0
6	719	669.5	620	0.01	0.01
7	620	577.5	535	0.01	0.02
8	535	498	461	0.02	0.04
9	461	430	399	0.03	0.07
10	399	371.5	344	0.01	0.08
11	344	320	296	0.06	0.14
12	296	276	256	0.05	0.19
13	256	238	220	0.06	0.25
14	220	205.5	191	0.09	0.34
15	191	177.5	164	0.09	0.43
16	164	152.5	141	0.08	0.51
17	141	131.5	122	0.12	0.63
18	122	113.5	105	0.11	0.74
19	105	97.95	90.9	0.08	0.82
20	90.9	84.7	78.5	0.06	0.88
21	78.5	73.1	67.7	0.03	0.91
22	67.7	63.05	58.4	0.02	0.93
23	58.4	54.4	50.4	0.03	0.96
24	50.4	46.95	43.5	0.01	0.97
25	43.5	40.5	37.5	0.01	0.98
26	37.5	34.95	32.4	0.01	0.99
27	32.4	30.15	27.9	0.01	1.0
28	27.9	26	24.1	0.0	1.0
29	24.1	22.45	20.8	0.0	1.0
30	20.8	19.35	17.9	0.0	1.0
31	17.9	16.7	15.5	0.0	1.0
32	15.5	9.75	4.0	0.0	1.0
$Dv_{0.1}$ (μm)	74				
$Dv_{0.5}$ (μm)	160				
$Dv_{0.9}$ (μm)	335				
Relative Span	0.82				