Designation: E2798 – 11

Standard Test Method for Characterization of Performance of Pesticide Spray Drift Reduction Adjuvants for Ground Application[1]

This standard is issued under the fixed designation E2798; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method is used to characterize the performance of pesticide spray drift reduction adjuvants with respect to spray droplet size spectra, volume of fines, and other use parameters under simulated field ground application conditions. This test method does not include any procedures to evaluate if pump shear degrades the performance of the spray drift reduction adjuvant.

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

NOTE 1—This method uses industry-standard units. The following conversions to SI units are provided for convenience: 1 mph = 1.61 kph; 1 in = 2.54 cm; 1 gal/acre = 9.36 L/hectare.

1.3 *This test method does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D3825 Test Method for Dynamic Surface Tension by the Fast-Bubble Technique

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E456 Terminology Relating to Quality and Statistics

E609 Terminology Relating to Pesticides

E799 Practice for Determining Data Criteria and Processing for Liquid Drop Size Analysis

E1260 Test Method for Determining Liquid Drop Size Characteristics in a Spray Using Optical Nonimaging Light-Scattering Instruments

E1519 Terminology Relating to Agricultural Tank Mix Adjuvants

E1620 Terminology Relating to Liquid Particles and Atomization

E2408 Test Method for Relative Extensional Viscosity of Agricultural Spray Tank Mixes

2.2 *ASABE Standards:*[3]

ASAE S572.1 Spray Nozzle Classification by Droplet Spectra, March 2009

2.3 *NFPA Standards:*[4]

NFPA 30 Flammable and Combustible Liquids Code

NFPA 33 Standard for Spray Application Using Flammable or Combustible Materials

3. Terminology

3.1 Definitions for terms used in this test method can be found in Terminologies E456, E609, E1519, and E1620.

4. Summary of Test Method

4.1 This test method provides guidelines for the measurement of parameters pertaining to the performance of drift reduction adjuvants under simulated field ground application conditions. The measurements can be made in a wind tunnel or spray chamber. The method describes the preparation, composition, and test/application conditions for droplet size and spray pattern measurements. Exact selection of application conditions, such as nozzle type and tank mix partners, may vary according to intended use conditions. This test method has not been verified for aerial and orchard airblast pesticide applications.

5. Significance and Use

5.1 Pesticide regulations for the minimization of drift during pesticide application often require active ingredient (a.i.) product use under defined droplet size conditions. Spray performance with respect to transport and deposition of droplets and particles at target surfaces and product efficacy for

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[1] This test method is under the jurisdiction of ASTM Committee E35 on Pesticides, Antimicrobials, and Alternative Control Agents and is the direct responsibility of Subcommittee E35.22 on Pesticide Formulations and Delivery Systems.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American Society of Agricultural and Biological Engineers (ASABE), 2950 Niles Rd., St. Joseph, MI 49085, http://www.asabe.org.

[4] Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, http://www.nfpa.org.

desired applications are also affected by droplet size spectra. The effect of drift reduction adjuvants on droplet size spectra should be understood in this context. The present test method describes standard tests that can be conducted to investigate the performance of pesticide spray drift reduction adjuvants under simulated field use conditions for drift management decisions in the context of the entire spraying process. The measured reduction in driftable fines and shift in spray droplet size distribution can be used to reduce the buffer zones mandated by regulatory agencies.

6. Apparatus

6.1 *Spray chamber or wind tunnel* of known air flow characteristics. Droplet size measurements may be made in a spray chamber or wind tunnel. Where a spray chamber is used for simulating ground application of pesticides, make provisions to have an air flow with a minimum 7 mph velocity in the direction of the sprayed fluid. The Spray Drift Task Force (http://www.spraydrift.com) has found that this minimum air flow will keep the small drops moving forward and prevent them from swirling back and getting measured multiple times. A diagram of an example test arrangement can be seen in Fig. 1 of Test Method E1260, but locate the exhaust vent at the bottom of the spray chamber so the ambient air is moving in the same direction as the sprayed fluid. Where a wind tunnel is used for simulating ground applications of pesticides, size the wind tunnel working section width to allow the spray to fully form without constriction. The minimum width for normal use with a wide range of nozzle and atomizer types will be 1 m. The height shall be sufficient to allow a full traverse (using either continuous or chordal measurement sampling) through the entire spray cross-section. Usually this will require a minimum height of 1 m.

6.2 *Droplet size analyzer* with calibration verification for tests. The droplet size analyzer selected for the tests shall be appropriate for the type of measurement being conducted and have a dynamic size range configuration capable of measuring the entire droplet size range produced by the sprays under investigation. Appropriate techniques include, but are not limited to, laser diffraction, Phase-Doppler particle size analyzers and imaging systems. Sympatec[5] and Malvern[6] make instruments capable of measuring spray droplet size using laser diffraction analysis. Test Method E1260 outlines the procedure for determining liquid drop size using these instruments.

6.3 *Liquid preparation and delivery system,* including agitation mechanism for tank mixes.

6.4 *Nozzle and spray application system* for ground application platforms.

7. Hazards

7.1 *Safety Precautions*—Before testing, read the precautionary statements on the product label, and the Material Safety Data Sheet, or both. Take proper precautions to prevent skin contact and inhalation of the fines, or the vapors, or both. Take care to prevent contamination of the surrounding area. Always wear the appropriate safety equipment and, where indicated, wear respiratory devices approved by NIOSH for the product being tested.

7.1.1 **Warning—**A spray of flammable liquid dispersed in air presents the risk of explosion and fire. Refer to NFPA 30 or NFPA 33 for information about safe practices for storage and handling of flammable liquids and for spray processes involving sprays of flammable liquids.

7.1.2 **Warning—**Exposure to drops of various liquids by inhalation, ingestion, and skin contact may constitute health hazards.

7.1.3 **Warning—**Emission of some sprayed liquids into the atmosphere may be harmful to the environment or may pose a health risk.

7.1.4 **Warning—**Laser-based instruments contain lasers or other strong light sources which may pose a hazard to persons in their vicinity.

7.2 Contain all sprayed material and be sure to dispose of this material and remaining test substances properly.

8. Selection of Test Substances

8.1 Select test substances that reflect the intended end-use of the drift reduction adjuvant. While water can provide a useful baseline for range-finding tests, it must not be the sole system tested. Use the active ingredient pesticide formulation spray tank mixture as one of the test substances with the adjuvant. For example, commercial herbicides may be selected for adjuvants intended for use in herbicide applications. The use rate for the tests shall reflect commercial label use rates. It may be desirable to select several test substances for the evaluations, to compare performance between products. It may be appropriate to include other adjuvants such as surfactants, crop oils, or fertilizers, as the label allows. For example, ammonium sulfate (AMS) is recommended on many pesticide levels. Compatibility agents will be included if necessary to create a physically stable system.

8.2 Where possible, measure the physical properties of the test substance, particularly the dynamic surface tension at a surface lifetime age of 20 ms, shear and extensional viscosities. Test Method D3825 provides a technique for measuring dynamic surface tension. Test Method E2408 provides a technique for measuring extensional viscosity.

8.3 Use WHO 342 ppm hardness water in all sample preparations.

9. Preparation of Test Substances

9.1 *Mixing Order*—Mix the test substance components in the manner described in their respective mixing instructions. In

[5] The sole source of supply of the apparatus known to the committee at this time is Sympatec GmbH, System-Partikel-Technik, Am Pulverhaus 1 D-38678 Clausthal-Zellerfeld, Germany. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[6] The sole source of supply of the apparatus known to the committee at this time is Malvern Instruments Ltd, Enigma Business Park, Grovewood Road, Malvern, Worcestershire WR14 1XZ, United Kingdom. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

some cases, this may involve the preparation of a pre-mix of adjuvant(s) and active ingredient formulation. The samples must be mixed until homogeneous. Compatibility agents must be added to mixtures that do not form physically stable samples.

10. Nozzles, Atomizers, and Spraying System

10.1 *Nozzle Types and Use Conditions*—The nozzle selection will depend on the intended end-use for the adjuvant under evaluation. Section 10.2 lists resources for nozzles which should be used at a minimum for the tests, depending on application types. Additional nozzle types and use patterns may also be included if appropriate for the pesticide and use type. The performance of many adjuvants depends on the nozzle type and use conditions, as well as the initial droplet size range. For example, some adjuvants may cause an increase in the coarseness of the spray for sprays which are initially relatively fine, or for certain types of nozzle, while providing different behavior with sprays of different initial (that is, no adjuvant) conditions. Ground nozzles are usually operated at pressures around 40 psig. The exact pressure for a given test will depend on manufacturer recommended operating conditions and test requirements. Measure and record the effect of the adjuvant on spray pressure and liquid flow rate. Ground applications usually involve an airstream velocity up to 18 mph to facilitate sampling with number density sampling techniques.

10.2 *Ground Spraying Systems*—For ground-based applications, ASAE S572.1 provides flat fan reference nozzles of different designations between extremely fine (XF) and ultra coarse (UC). These are often used in standard droplet size tests in Europe, North America, and other regions. Include the reference sprays for the boundaries between fine/medium and medium/coarse sprays (which cover most commercial arable spray applications) to assess whether the adjuvants cause the sprays to shift toward finer or coarser sprays. If the desired test nozzle produces a coarser spray quality, then also include the reference nozzles for the coarse/very coarse and very coarse/ultra coarse boundaries. The actual test nozzle will be specified by the adjuvant manufacturer, but may include one or more of the following nozzle types for ground-based application tests at typical recommended use conditions: flat fan, air induction, and cone. If possible, include nozzles of at least two initial droplet size classes. Table 1 provides examples of test and reference nozzle/pressure combinations that are used in ground applications. All use a 50 mesh screen to prevent plugging and all yield about 0.2 gpm flow at the same given pressure.

11. Procedure

11.1 *Droplet Size Measurement*—Data criteria and processing examples are given in Practice E799. The droplet size analyzer shall be used in accordance with appropriate ASTM/ISO standard test methods. Methods for using laser diffraction instruments are given in Test Methods E1260.

11.1.1 *Precision*—Refer to Practice E177.

11.1.2 *Droplet Size*—Droplets shall be measured and characterized using an instrument having demonstrated accuracy in the range of droplet size produced by the nozzle being tested. The instrument shall have a calibration verification performed with a known source of droplets or other method. An alternative method would be to measure reference particles in a liquid suspension, as supplied by the instrument manufacturer.

11.1.3 *Volume Density Weighted (Spatial) Sampling Type Droplet Measuring Device*—Measurements can be made with a forward-light scattering (also called diffraction) instrument, imaging system, or other number density-weighted sampling technique. Spray measurements shall be collected across a plane perpendicular to the nozzle axis. Instrument calibration verification shall be checked before and after each series of tests. Manufacturer shall specify the method and technique for calibration. Additional information is provided in Test Method E1260.

11.1.4 *Number Flux Weighted (Temporal) Sampling Type Droplet Measuring Device*—Measurements can be made with a phase Doppler interferometer instrument, also called a PDPA,

TABLE 1 Test and Reference Spray Quality Nozzle Recommendations

Application	Spray Quality	Nozzle		Pressure (psig)
		Spraying Systems TeeJet[A]	Lechler[B]	
Adjuvant Drift Reduction Test Nozzles	Fine	XR11002	LU11002	40.0
	Medium to Coarse	TT11002	AD11002	40.0
	Very Coarse	AIXR11002	IDK11002	40.0
	Extra Coarse	AI11002	ID11002	40.0
ASAE S572.1 Spray Quality Reference Nozzles	Fine/Medium	XR11003	LU11003	43.5
	Medium/Coarse	XR11006	LU11006	29.0
	Coarse/Very Coarse	XR8008	LU8008	36.3
	Very Coarse/Extra Coarse	TP6510EVS	n/a	29.0

[A] The sole source of supply of the apparatus known to the committee at this time is Spraying Systems Co., P.O. Box 7900, Wheaton, IL 60187. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

[B] The sole source of supply of the apparatus known to the committee at this time is Lechler, 445 Kautz Rd., St. Charles, IL 60174. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,[1] which you may attend.

or an optical imaging system. Data shall be acquired along three (3) profiles through the spray, 120° apart. The size of the beam crossing or measurement region (waist) shall be made to be roughly equal or larger than the size of the largest droplet present. Selection of beam expander and transmitting lens determine the waist size. The instrument is 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 SNR. Typical values for experienced users can be expected to be within ±1 % 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.

11.1.5 *Spray Chamber or Wind Tunnel*—A chamber or wind tunnel shall be incorporated in a laboratory setup to provide a droplet measuring station. It may be round, rectangular, or prismatic in shape with suitable windows to accommodate the laser transmitter and receiver lenses without compromising the measurements. The duct shall accommodate the plume of the nozzle that is tested to allow full formation of the nozzle pattern. Upstream and downstream duct lengths shall be sufficient to minimize turbulence and vortices. A diagram of a suitable spray chamber is shown in Fig. 1 of Test Method E1260, with the modification that the vent draws air from the bottom of the spray chamber. This will provide a gentle air flow in the direction of the sprayed fluid to prevent vortices from carrying fine drops back up into the laser to be counted multiple times. The Spray Drift Task Force recommends a minimum 7 mph cocurrent air flow in wind tunnel measurements.

11.1.6 *Representative Cross-Section Average Sampling*—The spray patterns produced by most nozzles are not spatially uniform. It is therefore important to obtain a representative cross-section average sample for the sprays. This can be achieved through use of traverse or chordal measurement procedures. A stepper motor can be used to move the nozzle in a uniform manner from one side of the spray chamber to the other. The laser should sample the complete width of the spray plume. The nozzle height should be 9 to 12 in. above the laser for spray chamber measurements. If the droplet size distribution is measured at individual locations in the spray plume then all the data points should be averaged to determine the value used for the complete spray plume.

11.1.7 *Replication*—All measurements shall be replicated with at least three measurements. Average the measurements to provide a single value for data analysis. Make accommodations in the apparatus design to make sure the lenses stay clean throughout the experiment for both laser source and analyzer.

11.1.8 *Baseline and Adjuvant Measurements*—A series of tests shall comprise a measurement of the droplet size spectra and any other measurements (for example, dynamic surface tension, extensional viscosity, shear viscosity, liquid flow rate, spray angle, spray pattern uniformity/coefficient of variation) from the selected nozzle and application conditions for tank mixes with and without the adjuvants. These shall be referred to as the adjuvant and baseline tests, respectively. The only change between these two measurements will be the presence of the DRT adjuvant (and compatibility agent, if required). All other application conditions must remain constant for both measurements. The performance of the adjuvant shall be determined based on its effects on the baseline spray as given in the Report section below.

11.1.9 *Test Conditions*—The liquid and air temperature shall be measured at the time of the droplet size spectrum measurements and shall be within ±5°C of each other. The sample containing drift reduction adjuvant should be sprayed within 4 h of being made. Water should be sprayed between all test solutions to clean out the system. Every fifth time water is sprayed, droplet size measurements should be taken and compared to initial data to make sure apparatus is operating properly. One recommended spray rate dilution is 10 gal/acre. Other spray tank dilution rates may be required for special applications.

11.2 *Supplemental Measurements*—The performance of a spray for effective delivery of a uniform dose of a chemical in agriculture or forestry is affected by many factors in addition to droplet size. It is recommended that additional performance criteria should also be assessed such as the effect of the adjuvant on spray angle and liquid flow rate at a given pressure and temperature through the same nozzles and application conditions used for the droplet size measurements. If the spray angle or liquid flow rate change significantly after addition of the drift reduction adjuvant, the applicator will need recommendations for adjustments required to retain uniform coverage in the field. Otherwise, the optimum drift reduction may not be produced. For drift management, there may be interest in measurement of spray drift potential using a wind tunnel or field sprayer.

12. Report

12.1 A report shall be prepared for water, water plus active ingredient formulation (baseline), and water plus a.i. plus adjuvant (plus compatibility agent if used) summarizing the test conditions and particle size distribution results. Test conditions to report include nozzle, pressure, dilution rate (spray volume), temperature, and nozzle distance to laser. Report the instrument manufacturer, model number, lens used, and software version. Report air velocity, which should be cocurrent in the direction of the sprayed fluid. The droplet size data shall include the volume median diameter (VMD) = $D_{V0.5}$, volume diameter for 10 % of total $D_{V0.1}$, volume diameter for 90 % of total $D_{V0.9}$, relative span ($D_{V0.9}$- $D_{V0.1}$)/ $D_{V0.5}$, and the volume% <105 µm. Optionally, the entire volumetric droplet size spectrum can be recorded. The standard unit of length measurement for liquid drop diameter shall be the micrometer (µm). The spray quality, or droplet size classification, shall be given according to ASAE S572.1 because this relates to pesticide labeling, modeling, and regulations. Spray volume contained in fine droplets below 105 µm will be used as the measure of the performance of the spray drift reduction adjuvant. This portion of the spray is considered most "driftable." The amount a Drift Reduction Technology (DRT) adjuvant reduces these fines will correspond to how much the adjuvant would reduce drift. Testing a tank mix adjuvant system includes testing water, water plus a.i. formulation, water plus a.i. plus drift reduction adjuvant, and, if required for physical stability, water plus a.i. plus adjuvant plus compatibility agent. A built-in drift control adjuvant can also be tested by comparing the pesticide formulation containing DRT adjuvant with the version that does not contain the adjuvant.

12.2 *Drift Reduction Technology Adjuvant Performance*—If the driftable fines are reduced significantly using the DRT adjuvant, then the DRT adjuvant will significantly reduce drift during spray application. Calculate the driftable fines reduction for each nozzle using the volume% < 105 µm measured using a.i. formulation dilution alone (V_{ai}) (baseline test) and a.i. formulation sprayed with DRT adjuvant (V_{DRT}) (adjuvant test) using Eq 1.

$$\text{Fines Reduction } (\%) = 100(V_{ai} - V_{DRT})/V_{ai} \quad (1)$$

Report if the DRT adjuvant reduces fines in one of these ranges: 0 to 25 %, 26 to 50 %, 51 to 75 %, or 76 to 100 %. These calculations should be performed for each nozzle tested for evaluation. At least one reference nozzle should also be tested from those listed in Table 1, such as the XR11003 nozzle, for example.

12.3 *Optional: Spray Quality*—Compare the droplet size classifications for the systems of active ingredient sprayed with and without drift reduction adjuvant. If the DRT adjuvant increased the droplet spectrum size classification to the next larger spray quality or even larger, then the DRT adjuvant is functioning to reduce drift equivalent to changing nozzles to achieve this corresponding larger spray quality. The generated spray quality reference chart using water can be compared to the sample reference chart shown in Fig. 1 of ASAE S572.1 to make sure the data generated in this test is reasonable. Some DRT adjuvants reduce driftable fines without significantly increasing VMD. Therefore, the calculation in 12.2 will be used to determine adjuvant drift reduction performance.

13. Precision and Bias[7]

13.1 This procedure yields comparative data. Precision and bias will depend on the measurement system and instrument used for a given test. A general discussion of the precision and bias for laser diffraction droplet size measurements is given in Test Method E799.

13.2 A round-robin test of laser diffraction instruments for measurement of spray drift reduction tank mix adjuvants was performed with the following results.

13.2.1 *Intralaboratory Variability*—The intralaboratory variability results using a Sympatec HELOS/KF with R6 lens spraying water at 40 psig using a flat fan nozzle XR11001 are shown in Table 2. The variability of the intralaboratory particle size distribution is less than 2 %, which is consistent with the expectations reported in similar experiments.

13.2.2 *Interlaboratory Variability*—The interlaboratory variability results using two nozzles, XR11002 and TT11002, are shown in Table 3. The variability of the interlaboratory particle size distribution is around 15 % or less, which is consistent with the expectations reported in similar studies.

14. Disposal of Sample

14.1 After testing, store all materials in a safe manner and dispose of used material in accordance with product label directions, or the Material Safety Data Sheets, or both.

15. Keywords

15.1 adjuvant; aerosol spray drift; drift control; drift reduction; droplet size spectrum; ground application; tank mix

[7] Elsik, C. M., "ASTM Test Method for Evaluation of Spray Drift Reduction Adjuvants," *Journal of ASTM International*, Paper JAI103719, www.astm.org, 2011.

TABLE 2 Intralaboratory Variability

Meas.	DV0.1 (µm)	DV0.5 (µm)	DV0.9 (µm)	Span (µm)	Rel Span	Vol% Fines <105 µm
1	58.35	150.8	239.2	180.9	1.20	26.59
2	57.90	148.9	238.6	180.7	1.21	27.50
3	59.62	151.5	245.1	185.5	1.22	26.63
4	56.76	151.1	243.4	186.7	1.24	27.36
5	57.74	147.2	231.0	173.2	1.18	27.48
6	56.16	147.5	240.2	184.0	1.25	28041
7	57.38	145.2	237.6	180.2	1.24	29.44
8	57.83	149.5	240.7	182.9	1.22	27.29
AVG	57.72	149.0	239.5	181.7	1.22	27.59
STDEV	1.04	2.2	4.2	4.2	0.02	0.94
CV(%)	1.8	1.5	1.8	2.3	1.9	3.4

TABLE 3 Interlaboratory Variability

XR11002 K-Glyph	DV0.1 (µm)	DV0.5 (µm)	DV0.9 (µm)	Span (µm)	Rel Span	Vol% <105µm	Vol% <150µm	Vol% <210µm
LAB 1	74.2	149.5	300.4	226.2	1.51	25.03	49.75	74.15
LAB 2	52.9	121.5	244.7	191.8	1.58	36.1	66.5	85.1
LAB 3	69.7	145.0	289.4	219.8	1.52	27.85	52.67	74.22
LAB 4	81.9	166.7	302.4	220.5	1.32	17.2	42.1	68.2
LAB 5	63.3	143.3	299.5	236.3	1.65	32.25	52.86	72.10
AVG	68.4	145.2	287.3	218.9	1.52	27.7	52.8	74.8
STDEV	11.0	16.2	24.4	16.5	0.12	7.2	8.8	6.3
CV (%)	16.1	11.1	8.5	7.6	8.0	26.1	16.7	8.4
TT11002 K-Glyph	DV0.1 (µm)	DV0.5 (µm)	DV0.9 (µm)	Span (µm)	Rel Span	Vol% <105µm	Vol% <150µm	Vol% <210µm
LAB 1	97.8	230.5	584.9	487.1	2.11	12.02	26.43	44.80
LAB 2	83.9	203.7	487.5	403.6	1.98	15.1	33.3	51.7
LAB 3	109.0	251.0	469.5	360.5	1.44	9.02	21.22	39.07
LAB 4	126.7	271.9	537.4	410.7	1.51	4.7	15.7	33.1
LAB 5	102.0	247.3	489.5	387.5	1.57	10.75	23.89	43.36
AVG	103.9	240.9	513.8	409.9	1.72	10.3	24.1	42.4
STDEV	15.7	25.5	47.1	47.3	0.30	3.8	6.5	6.9
CV (%)	15.1	10.6	9.2	11.5	17.7	37.3	27.0	16.3