

A SAMPLE OF PHASE DOPPLER MEASUREMENT

APPLICATIONS PROVIDING FLEXIBILITY AND VERSATILITY

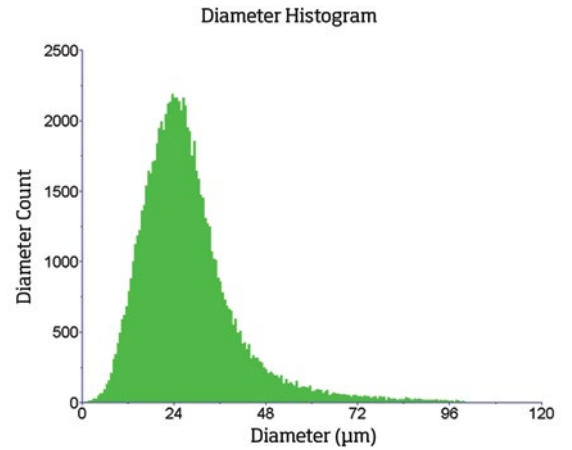


UNDERSTANDING, ACCELERATED

PDPA SYSTEMS PROVIDE SOLUTIONS

Finding Solutions

When you need to know how efficient a spray is operating, or if it meets performance specifications, the solution is a phase Doppler system from TSI. TSI's Phase Doppler Particle Analyzer (PDPA) has a long history of versatility, from agricultural sprays to zero-gravity sprays. TSI's PDPA system has even measured droplet size spectra in hurricanes using a special research aircraft.



UHPS spray being measured with a PDPA system. Diameter histogram is shown above. UHPS equipment courtesy of Rosenbauer America Inc.

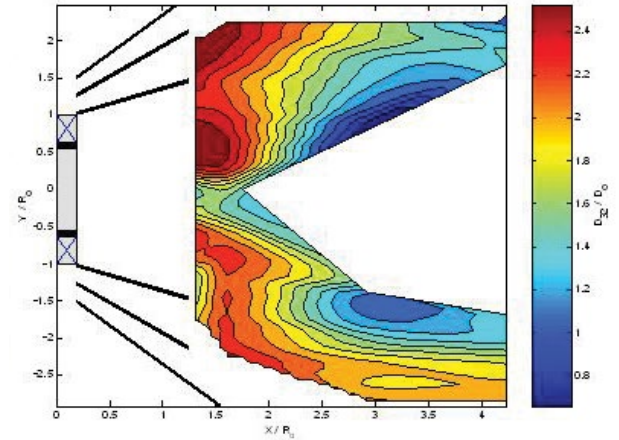
Please note: PDPA system arrangement depicted does not include the new PowerSight module, the latest in solid-state laser technology.



THE MOST ADVANCED ANALYSIS TOOLS

Aircraft Combustor Spray Measurements

TSI's Phase Doppler Particle Analyzer has a long history of measuring fuel sprays, even in the presence of combustion. Recent innovations in combustor design create the need for new measurements. Measurements have been made in a combustor test rig with a FSA signal processor based system, including a traverse to sample at many locations in order to generate contour plots of Sauter Mean Diameter (SMD) as shown at right. Results provide clues as to where the reaction zone is located and where fuel may be deposited on the walls. This information is important for understanding emissions characteristics, particularly under transient conditions.



Large Scale Fire Suppression Spray Measurements

Sprays touch our lives in many ways, from the morning shower to the fuel injectors in our car's engine. But for fire suppression sprays, achieving the right spray parameters can mean the difference between life and death. A new type of Ultra-High Pressure System (UHPS) was recently tested with a two-component PDDPA system using a FSA signal processor and RV-2070 Receiver Probe. Water and water plus 3% foaming agent sprays were tested. Results showed very good initial atomization and larger droplet sizes for the non-foaming agent spray (see picture below).

Premixed lean combustor in operation (bottom) and measured Sauter mean diameter (top). Courtesy Jonathan Colby and Georgia Institute of Technology - See AIAA2005-4143 and AIAA2006-4919 for more details.



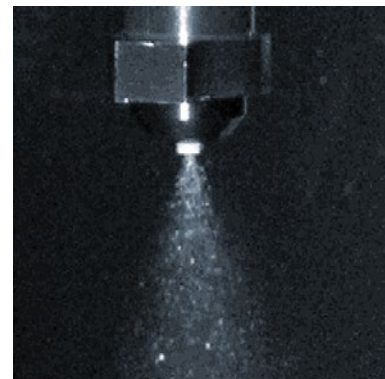
PDPA SYSTEMS SOLVE PROBLEMS

Refrigerant Spray Measurements

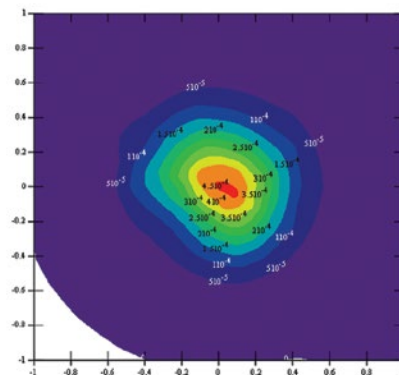
Refrigerants are constantly evolving into more efficient and environmentally-friendly formulations. When the properties change, however, we need to seriously consider measurement of any related spray processes within the refrigeration system.

High performance electronics use direct cooling by a refrigerant spray, and a standard FSA signal processor based PDPA was used for this study. Flux is a key parameter related to heat load offloaded by the refrigerant, so accuracy is important.

TSI's patented intensity validation and Probe Volume Correction (PVC) helped deliver the required accuracy while maintaining the widest possible dynamic diameter range.



Refrigerant spray (above) and volume flux map (below). Very high accuracy was achieved with the TSI system. See ICLASS paper 06-163 for more details. Photo courtesy ISR Inc.



Aircraft-based pesticide/herbicide applicator system and measured diameter distribution of a phosphorothioate spray (top right). Ground-based atomizers have also been measured with PDPA.

Mach 2 Spray Measurements

High-speed sprays and flows are another phase Doppler application area currently receiving attention. The continuous flow Mach 2 wind tunnel shown below is being used to study liquid hydrocarbon sprays with an FSA signal processor based PDPA system and RV2100 receiver. Different injection strategies are being tested to gain an understanding of droplet breakup and mixing. Further details are provided in AIAA paper 2004-0971.

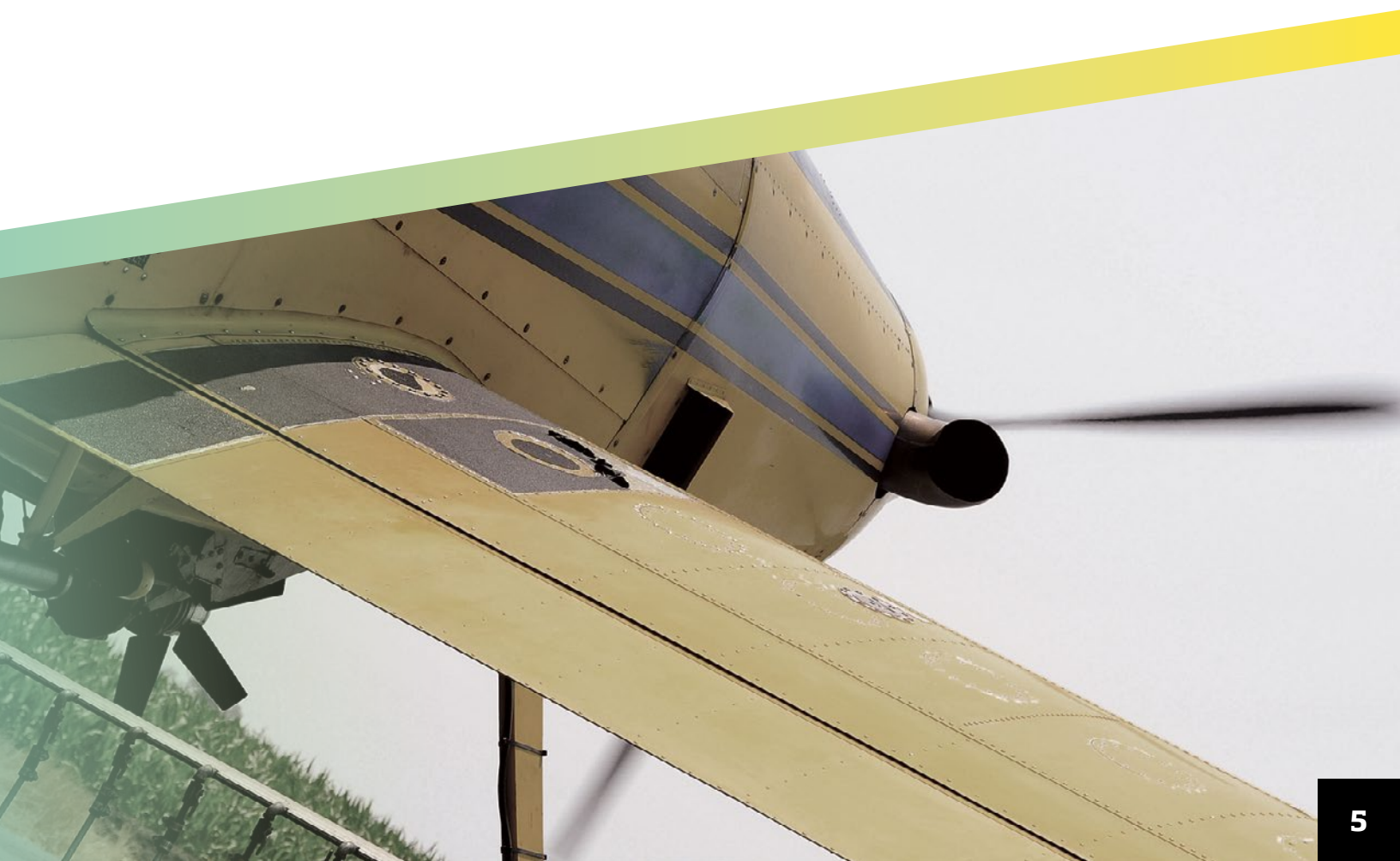
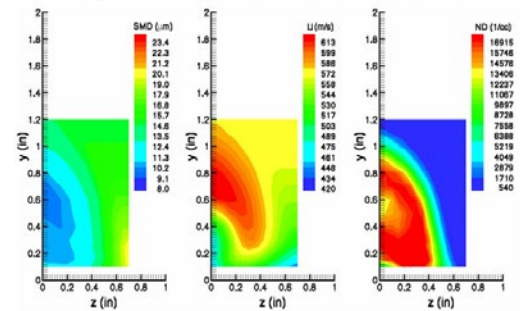
Pesticide Spray Measurements

TSI's Phase Doppler Particle Analyzer (PDPA) is also being used to measure agricultural sprays, such as insecticide sprays, herbicide sprays, and pesticide sprays. Environmental contamination is a top concern, as is applying the chemical to the intended target in the correct form. Spray analysis with a PDPA yields time-varying data, diameter-velocity correlations, and flux data – all invaluable to the spray analyst. For these measurements a standard FSA signal processor based PDPA system is typically used.

PDPA Measurements in Supersonic Wind Tunnel (Jet in Crossflow)

Mach 1.94
+ $d_0 = 0.5 \text{ mm}$
+ $q_0 = 7$
+ GLR +5%
+ $x/d_0 = 200$

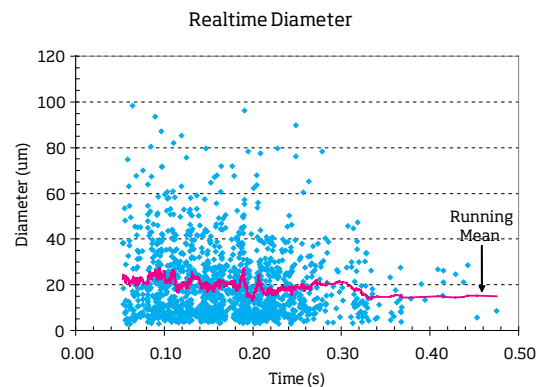
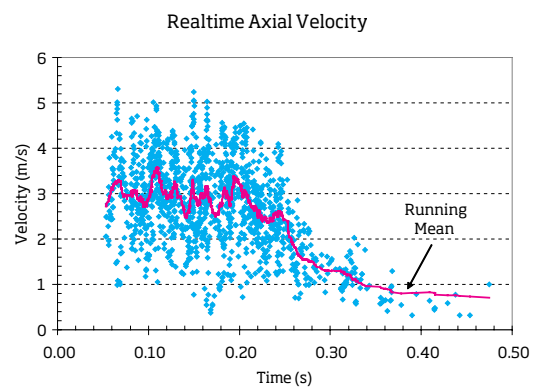
Sauter Mean Diameter (SMD), Streamwise Velocity (U), and Concentration (ND) for a Liquid Jet in Ma=2 Crossflow



FLEXIBLE SYSTEMS RELIABLE RESULTS

Diameter & Velocity Trends of a Medical Inhaler Spray

When sprays are used to disperse a medicine in the nose or mouth, we need to pay particular attention to the spray characteristics in order to ensure the safety of this technique. Metered Dose Inhalers (MDI) are commonly used to deliver asthma medication to the nose or mouth, for example. The opening and closing process of the MDI atomizer could introduce abnormally large droplets and it is possible that the spray quality degrades as the plume stops, resulting in very large droplets. This could present a hazard in terms of the volume of medication within each drop. A standard FSA signal processor based PDPA was used to measure the medical inhaler. Diameter and velocity measurements were made on 10 to 20 spray events, as shown in the figure below.

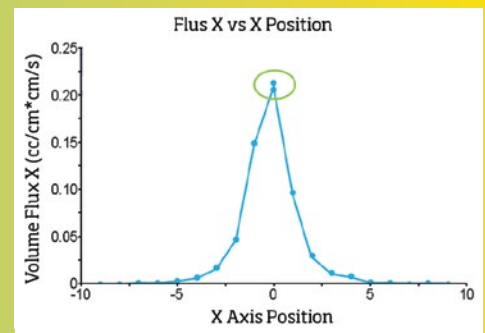
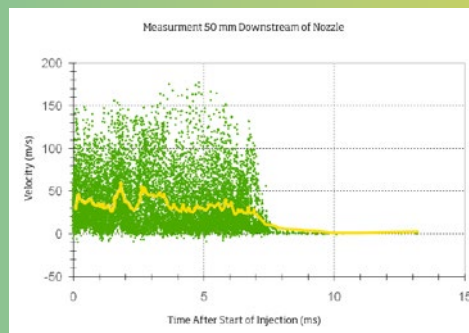
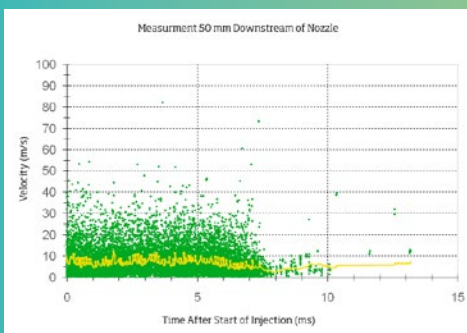


Direct Injection Gasoline Fuel Spray Measurements

Beginning in the late 1990's automobile companies began to take advantage of significant gains in fuel economy and engine power by moving to a direct injection strategy, whereby the gasoline is injected directly into the combustion chamber. Spray characteristics, like volume mean and volume flux, become extremely important to avoid pollutant formation and engine failure. That's why many engine manufacturers have begun intensive measurement campaigns with Dense Spray optimized phase Doppler systems from TSI. Time-resolved and average diameters are available. TSI's patented Intensity Validation and Probe Volume Correction (PVC) provide unmatched data reliability. Combine that with TSI's huge dynamic diameter range and you have the ideal Phase Doppler System for direct injection gasoline fuel sprays.

Biodiesel Fuel Spray Measurements

As a renewable energy source, biodiesel is very attractive in its overall energy efficiency. Measurements were recently made of a soy-based fatty acid methyl ester (FAME) spray with a TSI PDPA system. An appropriate beam expander and the FSA signal processor were used due to the high droplet density and short transit times. Results showed droplet diameters typical of petroleum based diesel fuel sprays for the injector used in this study. Further measurements are needed as injection equipment evolves into higher common rail pressures and piezo-injectors.



Velocity (left) and size (right) of a 100% biodiesel spray from a PLN type fuel injection system

FINDING SOLUTIONS

Use our many system components to customize your PDPA system to meet your application

- + Powersight Laser Module with 500mw laser power
- + FSA Signal Processor and Photo-Detector Module (PDM)
- + Transmitting Probe TM 250
- + Beam Expander XPD50-DPSS
- + Receiver RV 1070, 2070 Probes
- + Flowsizer 64 Software
- + Traverse Systems
- + DPSS laser
- + Fiberlight color separator module

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