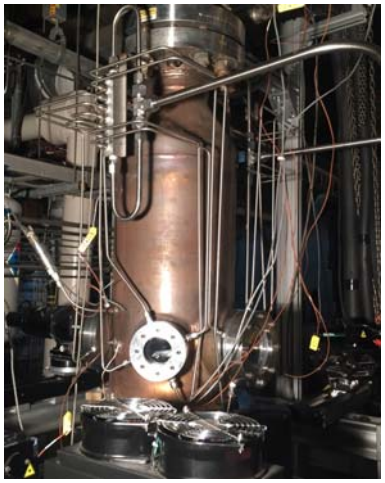
NJFCP Project 29A
Atomization Tests and Models

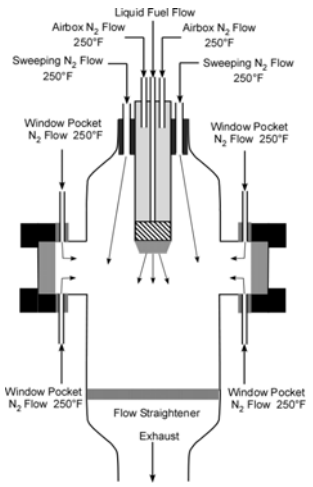
Motivation and Objectives

- Perform detailed diagnostic investigations of spray properties (e.g. fuel droplet size distributions, fuel spray break up lengths, and cone angles) for conventional and aviation fuels.
- Use advanced diagnostics such as phase Doppler anemometry (PDA) to investigate sprays generated by the Area 6 referee rig nozzle at a wide range of operating conditions (e.g., fuel temperature, fuel pressure, swirler pressure drop) using Purdue Variable Ambient Pressure Spray rig.
- Interact closely with the Stanford group (Area 5, Project 29B) and UTRC group who are performing advanced spray modeling and the Georgia Tech group (Area 3) investigating fuel effects on combustion, and the UDRI group (Area 6) who are operating the referee rig.

Methods and Materials

Variable Ambient Pressure Spray (VAPS) rig was designed for spray measurements at chamber pressures from 0.3 to 30 atm. PDA and diffraction methods (e.g. Sympatec) can be applied for droplet size and velocity measurements.



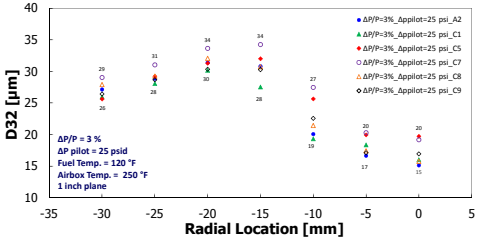


Summary

Researchers at Maurice J. Zucrow Laboratory/Purdue University are collaborating with Matthias Ihme of Stanford, Nader Rizk, formerly of Rolls Royce, Suresh Menon of GTI, Vaidya Sankaran of UTRC, Jeff Lovett of P&W, Andrew Corber of C-NRC, and other team members of the National Jet Fuel Combustion Program (NJFCP) to conduct atomization and spray measurements. The measurements below were performed on the referee rig nozzle at LBO conditions.

PDA Sauter Mean Diameter (D_{32}) Measurements from the VAPS rig at LBO Conditions for Different Fuels:

D_{32} Variation Between A2, C1, C5, C7, C8, and C9 at LBO conditions



Operating Conditions	LBO		Chilled	
	SI	English	SI	English
Vessel Pressure	2.07 bar	30 psia	1.01 bar	14.7 psia
Air Box Temp.	394 K	250 °F	278 K	40 °F
Fuel Temp.	322 K	120 °F	239 K	-30 °F
Fuel Mass Flow Rate	9.07 kg/hr	20 lbm/hr	9.07 kg/hr	20 lbm/hr
Injection Pressure	1.72 bar	25 psid	1.72 bar	25 psid

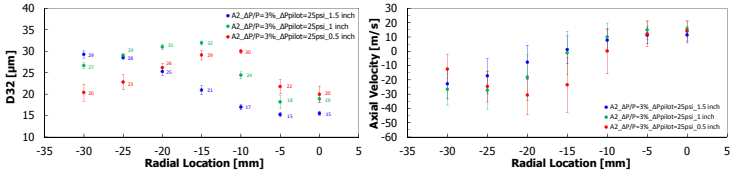
Lead investigators: Robert Lucht, Jay Gore, and Paul Sojka, Purdue University
Project manager: Cecilia Shaw, FAA

September26-27, 2017

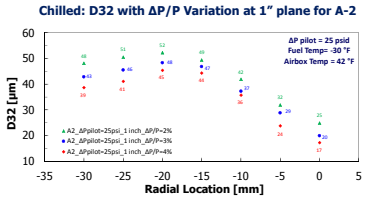
Results and Discussion

- Completed PDA measurements at LBO conditions for down-selected fuels (A-2, C-1, and C-5) as well as the X-fuels (C-7, C-8, and C-9).
- Obtained PDA measurements at three measurement planes: 0.5 inch, 1.0 inch, and 1.5 inch from injector.
- Obtained chilled fuel measurements.
- Installed LN2 line on VAPS rig to reduce air temperature from 278K (40^{0}F) to 239K (-30^{0}F) for operation with chilled air and fuel conditions.

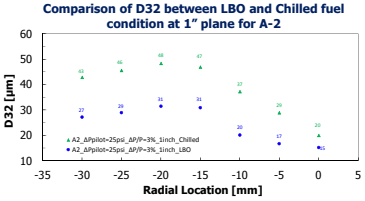
LBO: D32 and Axial Velocity at 0.5", 1", and 1.5" plane for A-2



Chilled: D32 with ΔP/P Variation at 1" plane for A-2



Comparison of D32 between LBO and Chilled fuel condition at 1" plane for A-2



Conclusions and Future Steps

- *Minimal variation in D_{32} between all fuels investigated at LBO operating conditions.*
- *Large droplets travel towards to the edge of the spray as the measurement plane increases.*
- *D_{32} for chilled fuel conditions demonstrated similar ΔP/P effects observed for LBO conditions.*
- *D_{32} for chilled fuel conditions are significantly larger ~~higher~~ than those for LBO conditions.*
- *Confirm amount of LN2 required to reach -30°F GN2 in the air box for chilled conditions.*
- *Obtaining additional data for the chilled fuel conditions starting with ΔP/P variation for the three fuels.*
- *Prepare to move the VAPS rig to ZL8 early next year.*

This work was funded by the US Federal Aviation Administration (FAA) Office of Environment and Energy as a part of ASCENT Project 29A under FAA Award Number COE-2014-29A, Grant 11752255 . Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the FAA or other ASCENT Sponsors.