Characterization of Smoke Machines in Testing Aircraft Smoke Detectors

Presented to: Systems Working Group

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Background

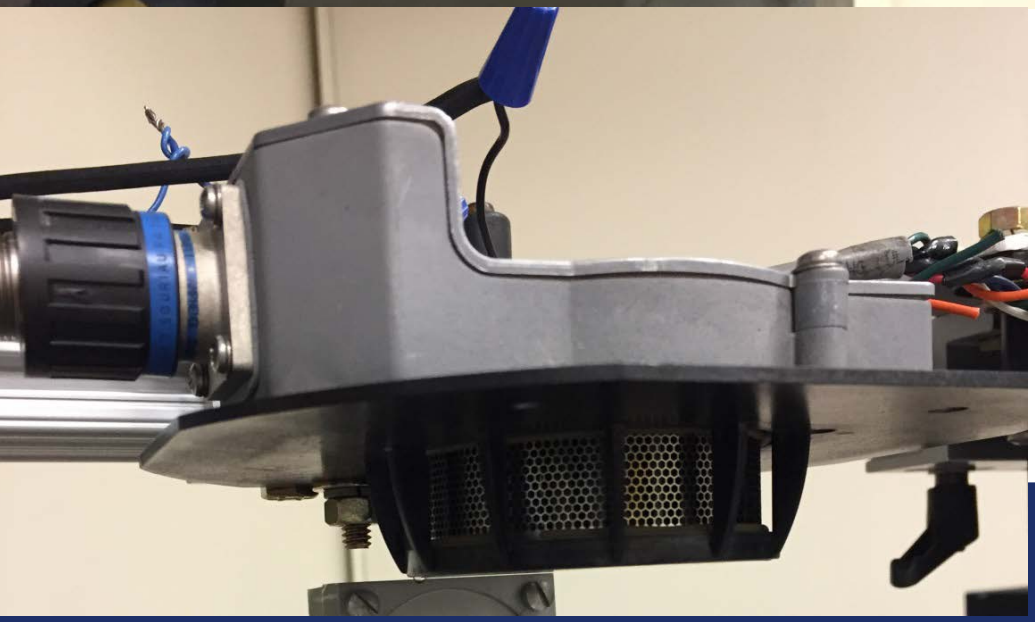
- **This study is based on characterizing the smoke from theatrical smoke machines to understand what alerts different types of smoke detectors, and what would best be used for testing them.**

New False Alarm Rejection Criteria

- Dust
- Insecticide
- Ambient Light (Dazzle)
- Combined Temperature, Pressure, and Humidity Cycling

Testing Equipment

Whittaker Smoke Detector



Kidde Smoke Detector

Testing Equipment

Rosco 1700 (water based fluid)

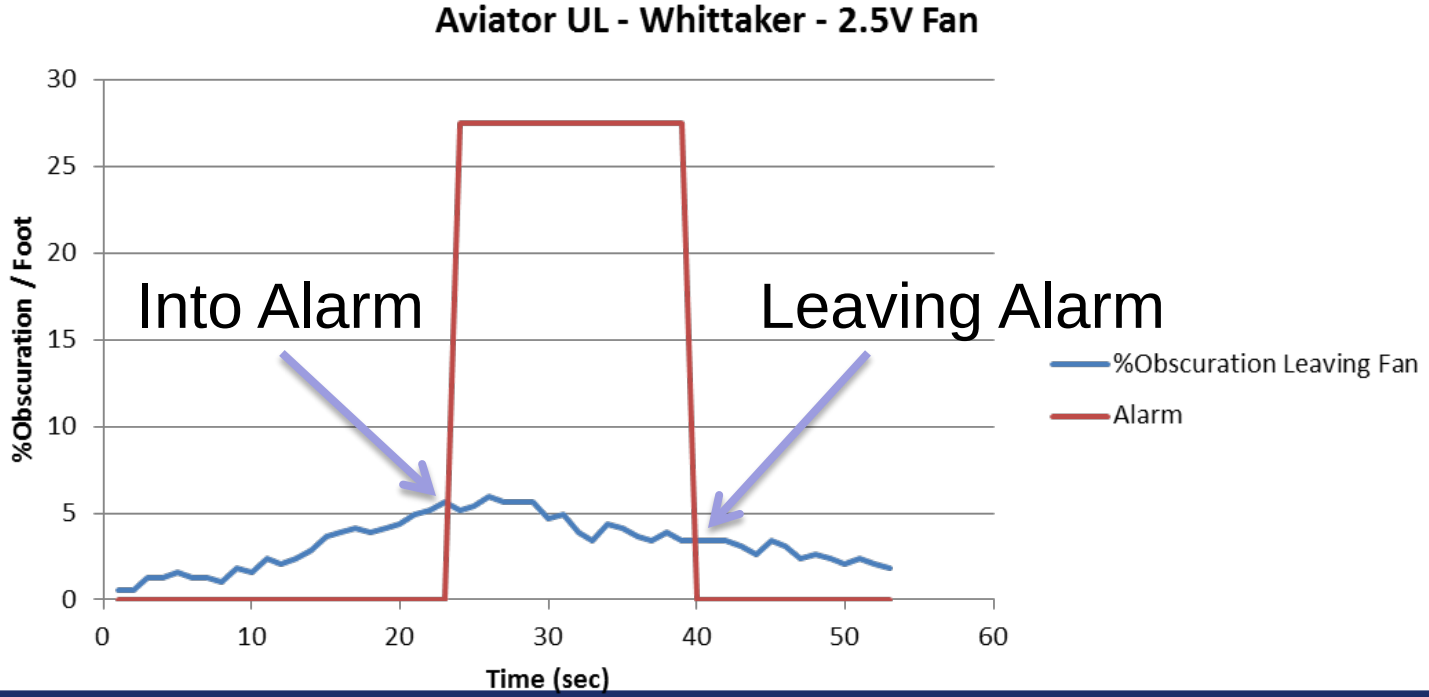
- Clear Fog Fluid
- Light Fog Fluid

Concept Aviator SDT Ultra Low (oil based fluid)

- Concept Smoke Oil

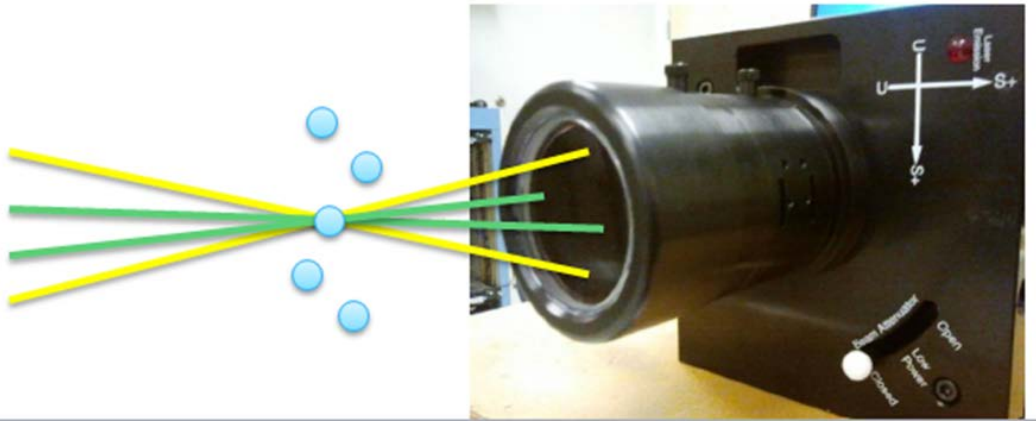
Characteristics to Measure

- **Particle size of smoke**
- **Percent obscuration of smoke initially alarming the detectors**
- **Percent obscuration of smoke “leaving alarm”**

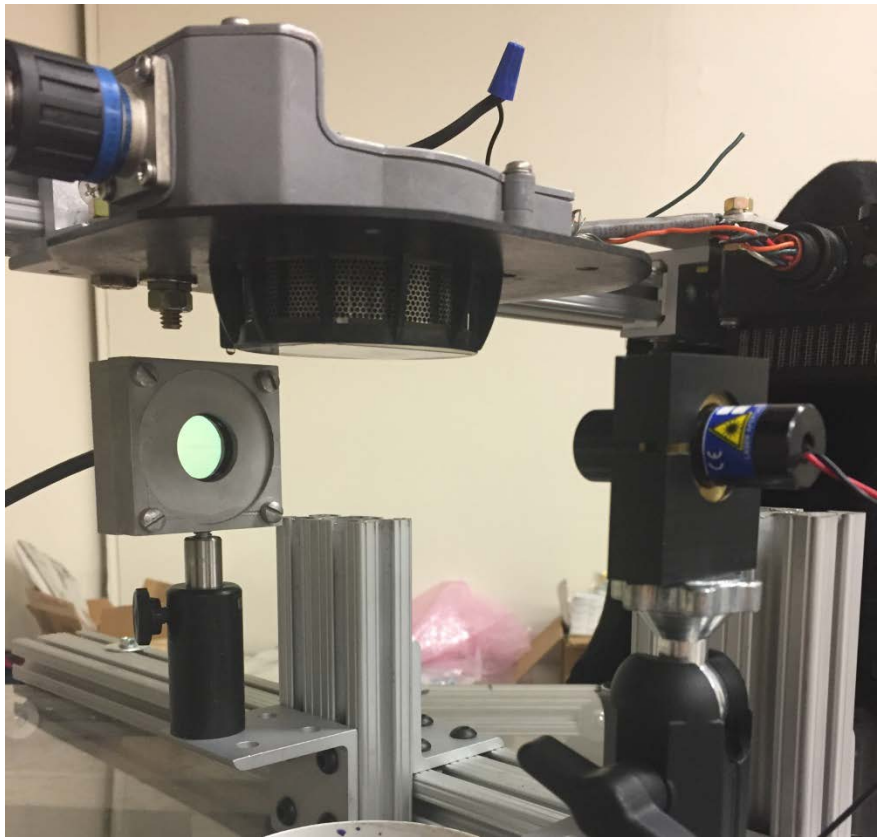


PDPA

- **Laser intersection point is measurement point. Light is refracted from here into the PDPA receiver.**
- **Test setup made to reduce noise and produce best data.**

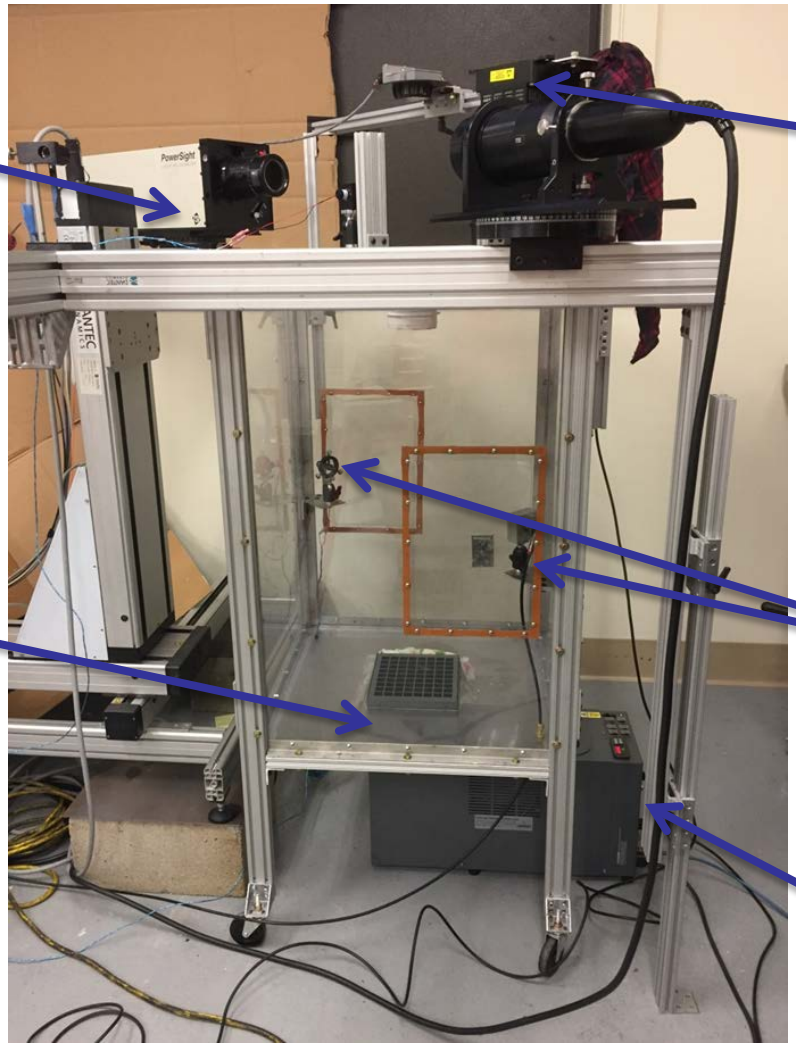


Optical Density Meters



- Meters are placed on the same plane as the PDPA lasers
- Measure percent obscuration of light per foot

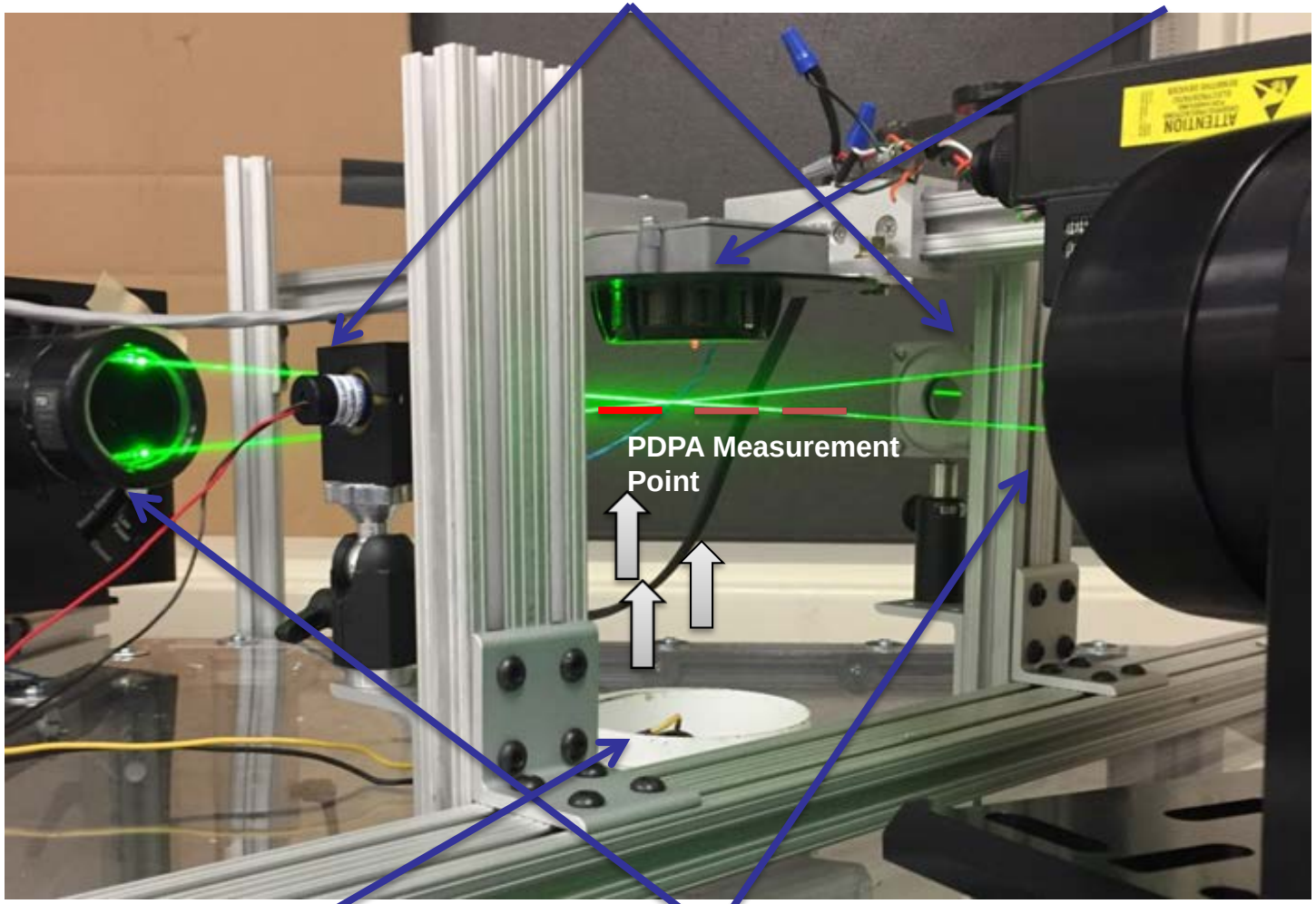
Experimental Setup



Experimental Setup

Optical Density Meter

Kidde Smoke detector

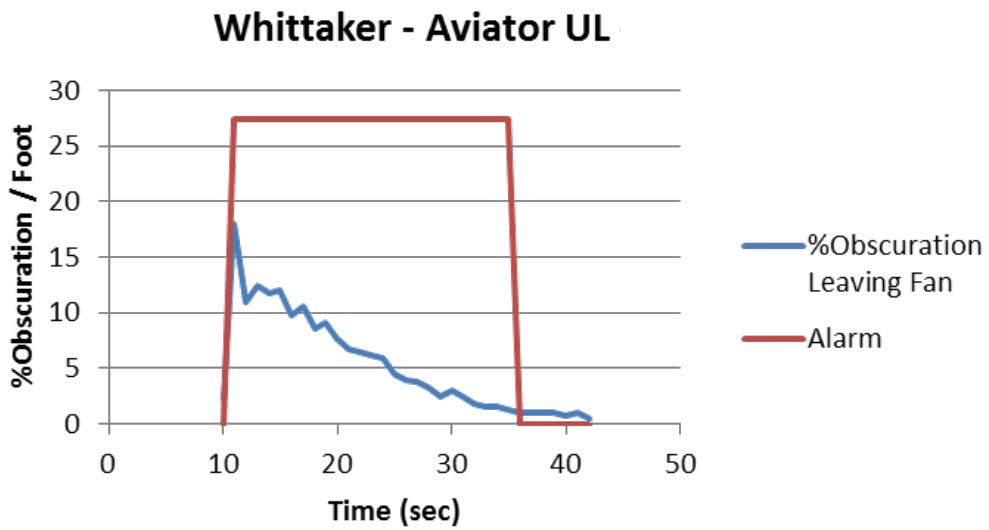


Exit fan

PDPA Laser

Detectors Leaving Alarm (%Obscuration Per Foot) *Whittaker Detector*

Aviator UL – Whittaker	
	Fan Exit Meter
RUN	Min % Obsc
Feb7 001	4.4
Feb7 002	2.8
Feb7 003	2.0
Feb7 004	2.5
Average	**2.9**



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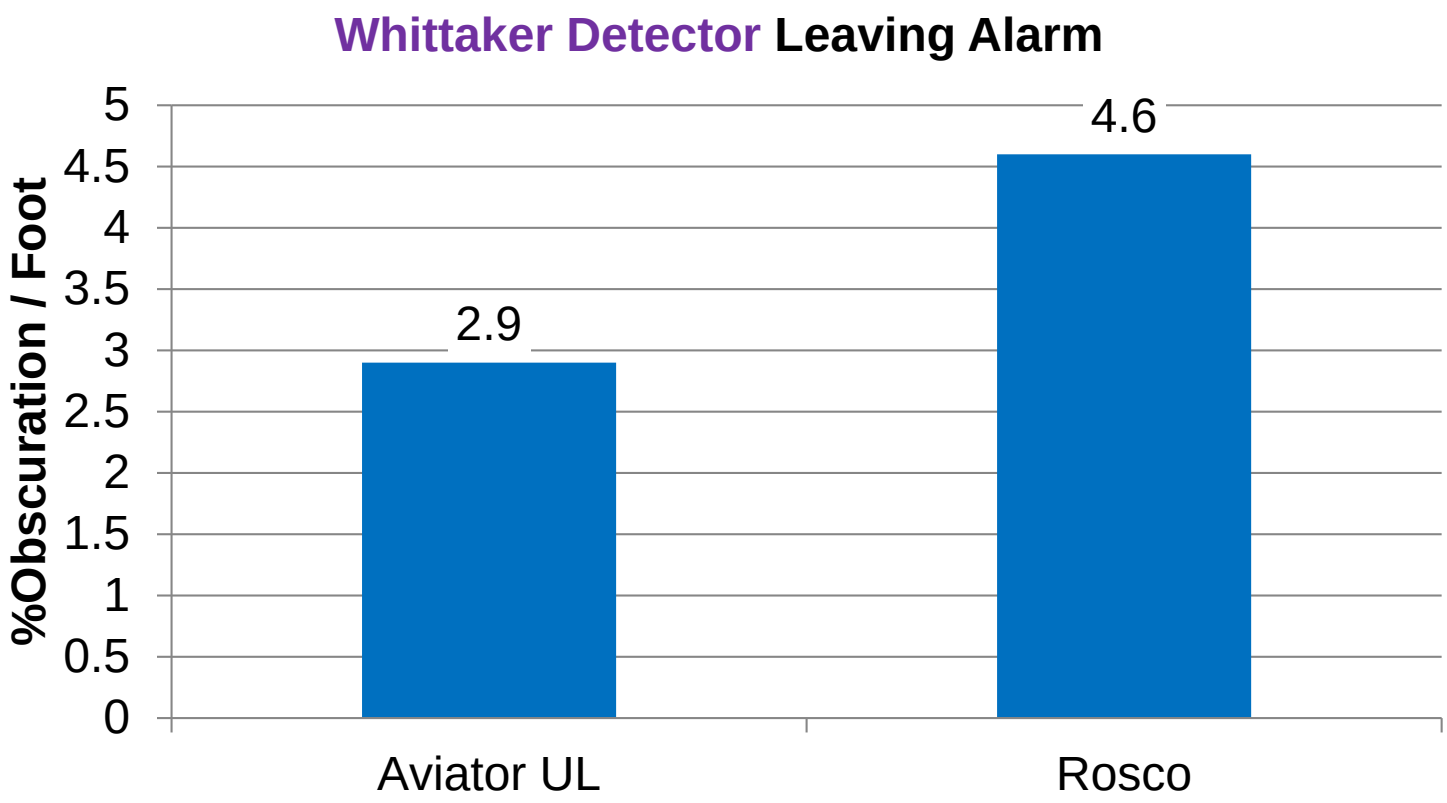
Average	**2.9**

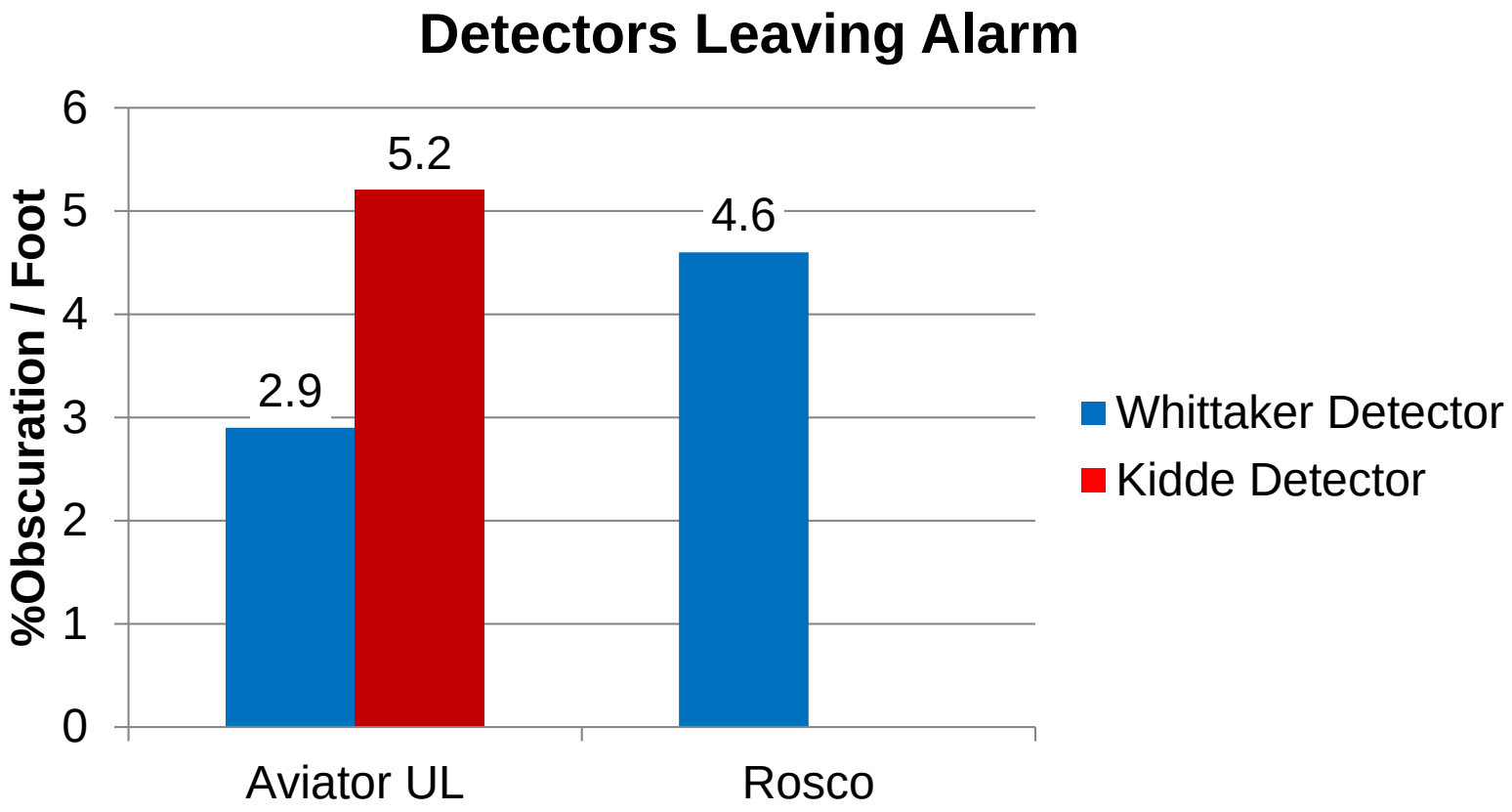
Rosco – Whittaker	
	Fan Exit Meter
RUN	Min % Obsc
Feb8 007	4.3
Feb8 008	3.4
Feb8 009	5.0
Feb8 010	5.8
Average	**4.6**

Detectors Leaving Alarm

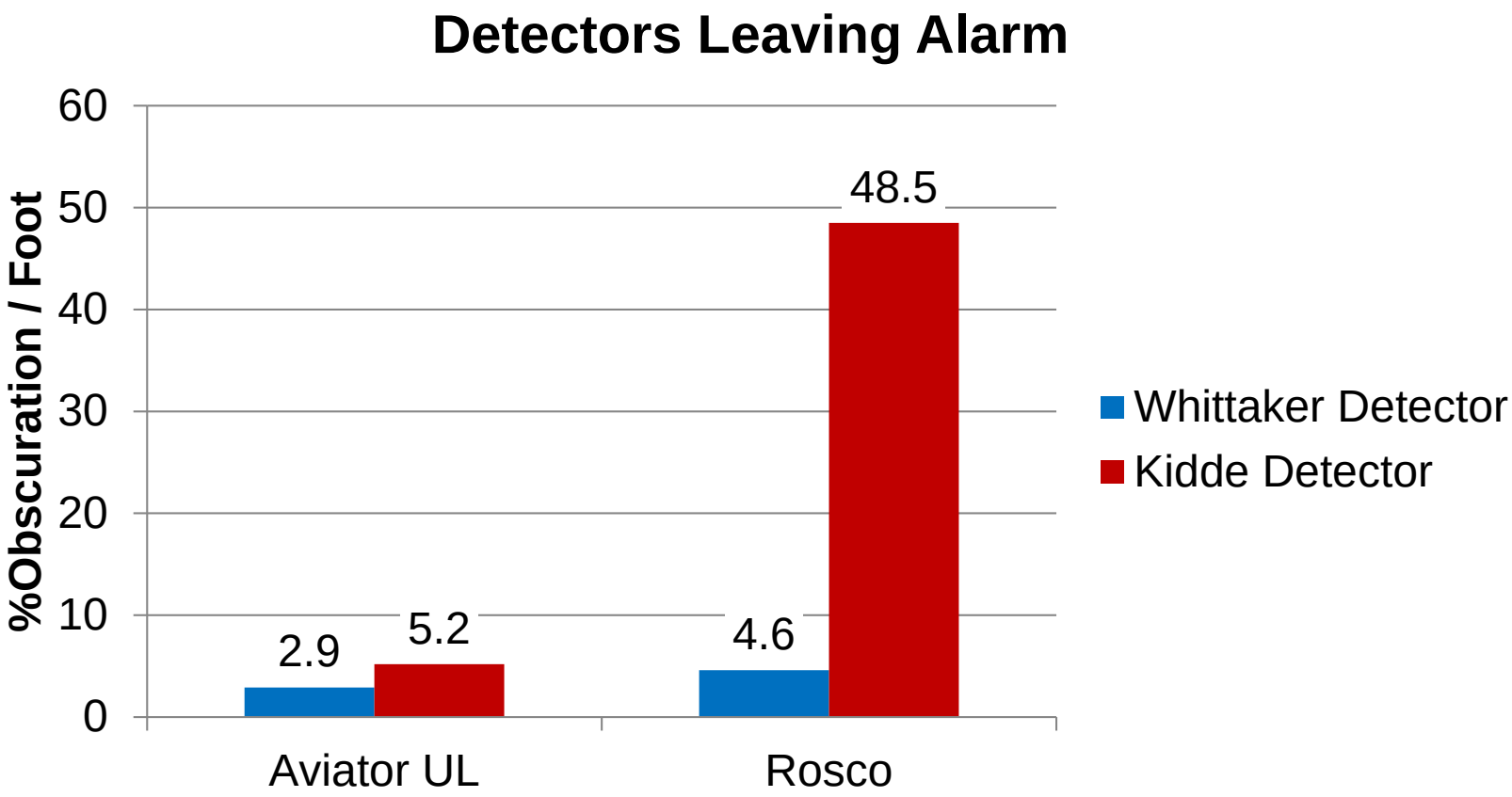
Whittaker Detector



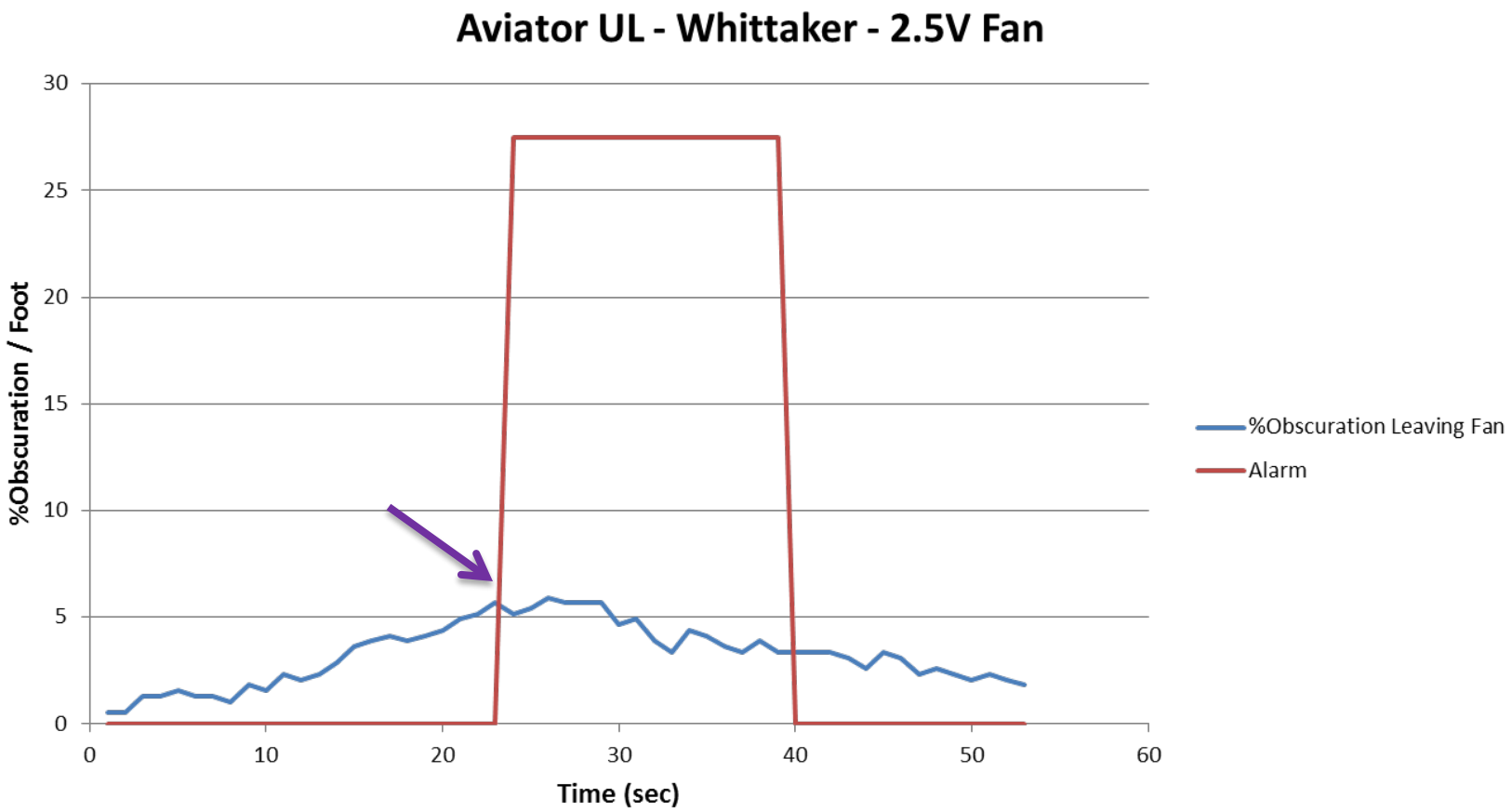
Detectors Leaving Alarm



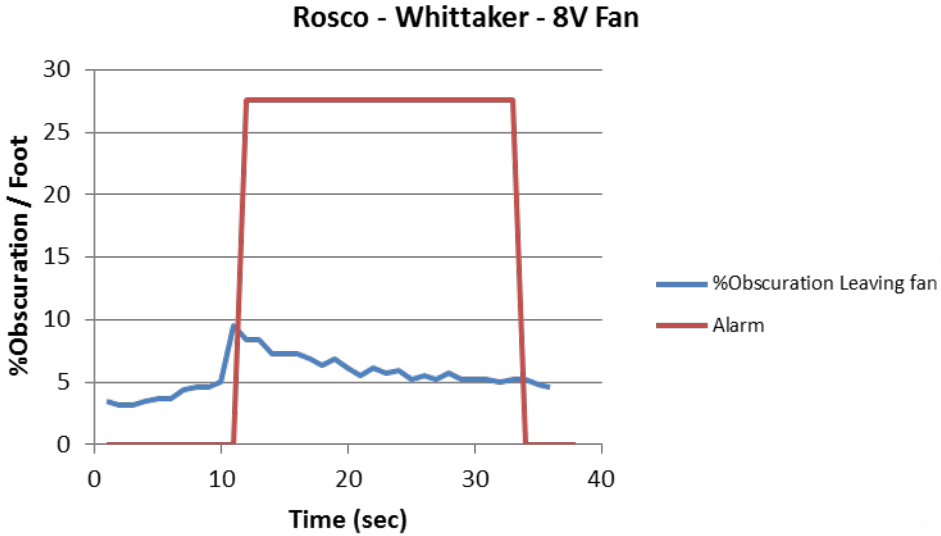
Detectors Leaving Alarm

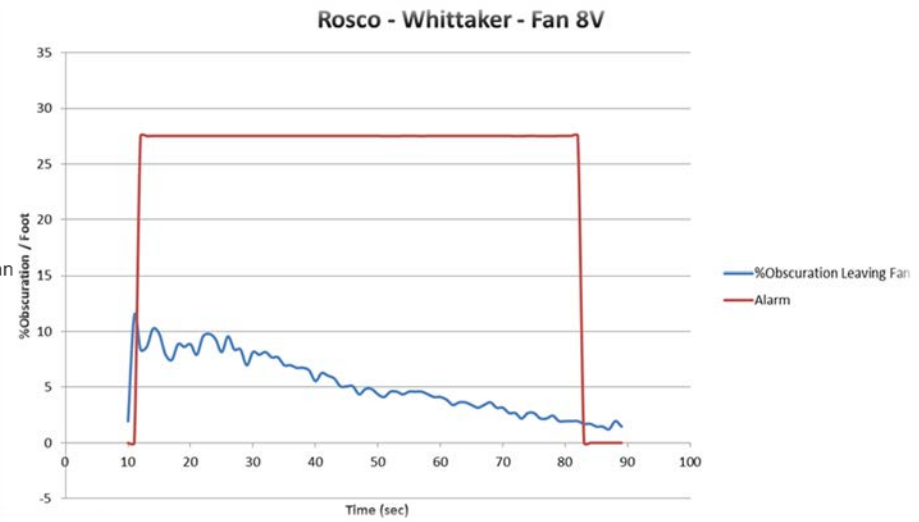


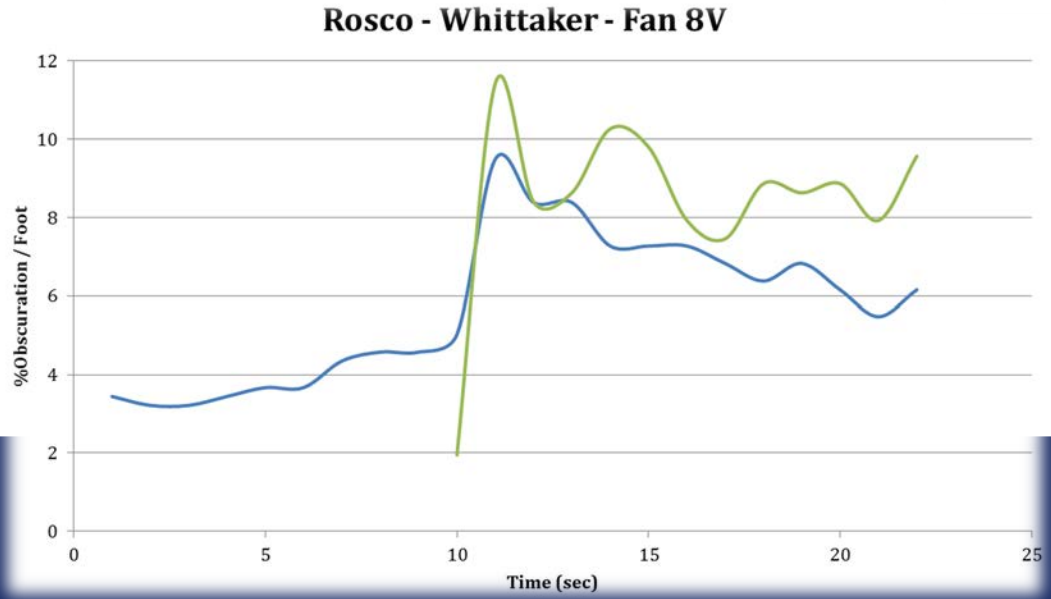
Detectors Going Into Alarm



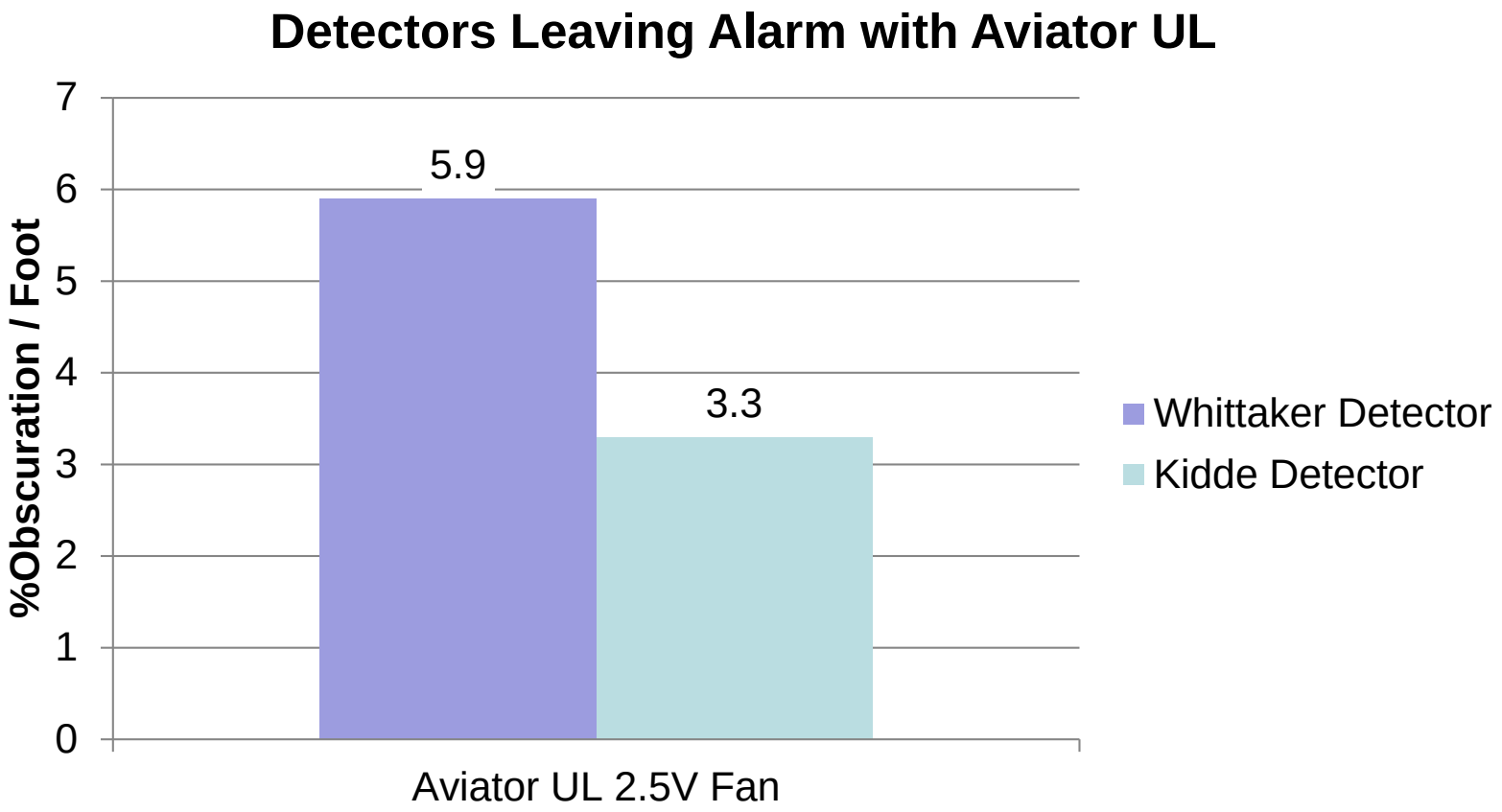
Detectors Going Into Alarm
Rosco – 8V Fan







Detectors Going Into Alarm



Particle Size

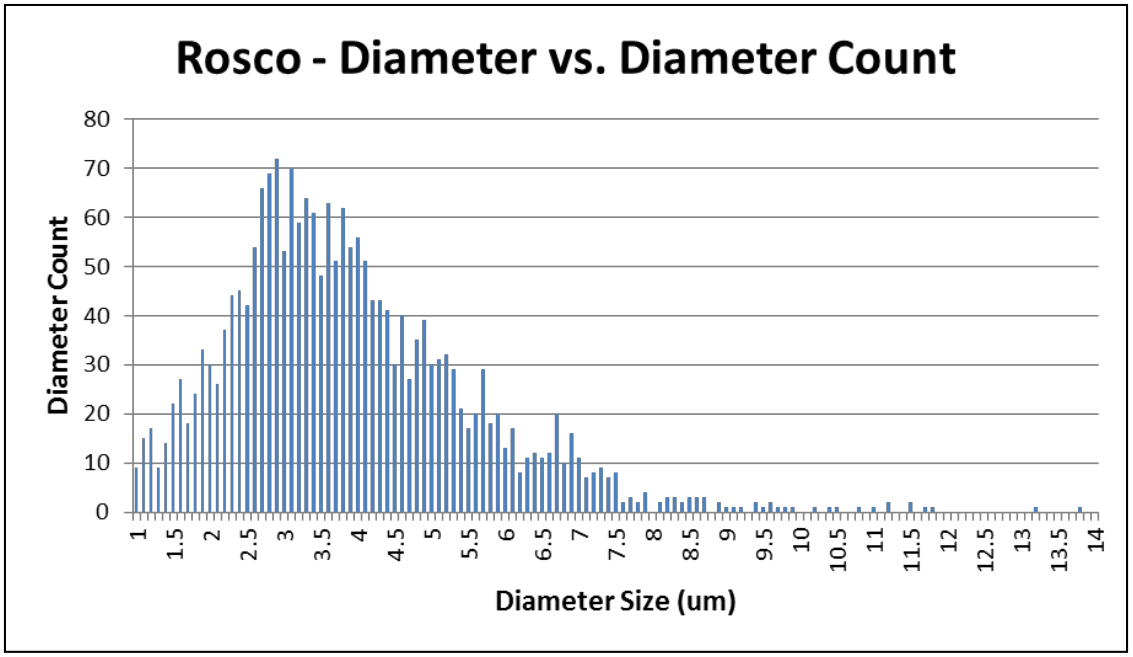
- Particle Sizes were measured while each detector alarmed to account for difference in alarm time
- Aviator UL recorded smaller particle sizes
- PDPA recorded significantly less amount of particles with the Aviator UL than with the Rosco

Rosco – Whittaker

RUN	D10 (um)	# Particles Averaged
March20 005	3.5	2079.0
March20 006	3.5	502.0
March20 007	3.5	2192.0
March21 001	3.3	9457.0
Average	**3.5**	

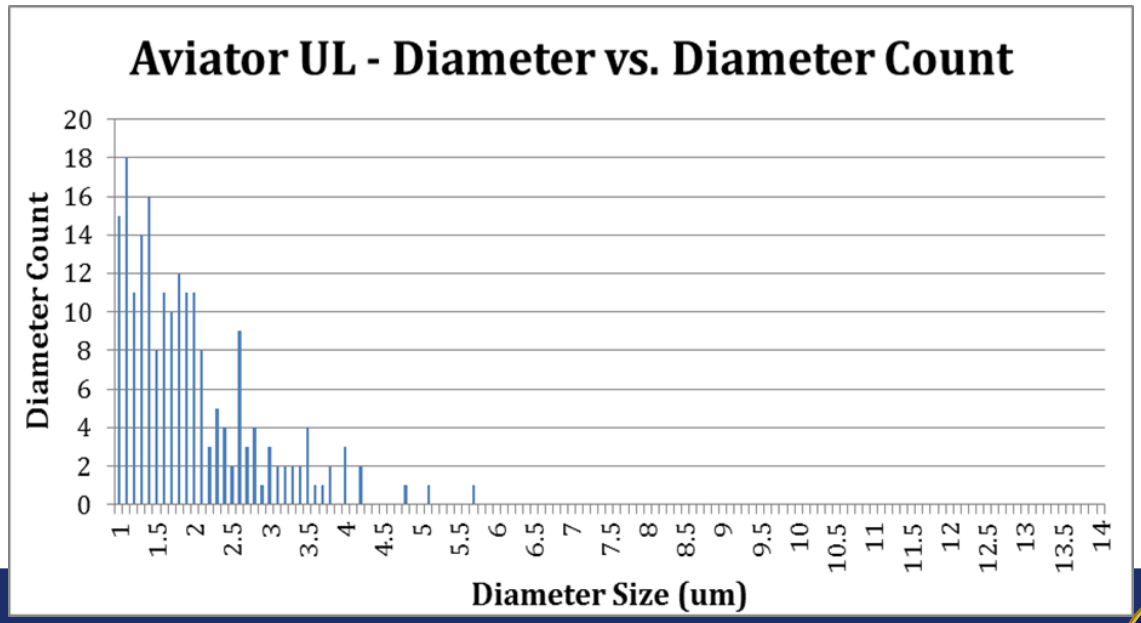
Aviator UL – Whittaker

RUN	D10 (um)	# Particles Averaged
March20 014	1.7	123.0
March20 015	1.6	189.0
Average	**1.7**	



Rosco

2147 Particles



Aviator UL

203 Particles

PDPA Limitations

- **The lowest diameter size that it can measure is 0.4 microns and for the configuration that we have, 0.5 microns.**
- **The minimum and maximum particle size bounds depend on the transmitter fringe spacing, the PDPA receiver focal length, the off axis angle of the receiver to the transmitter and the refractive index of the particle we are measuring.**

	Aviator UL	Rosco
Particle Sizing Off	662 particles	2592 particles
Particle Sizing On	287 particles	2530 particles

Particle Size

- Particle Size between detector alarms only differed by 0.1-0.2 microns
- Aviator UL showed to have smaller particle sizes than the Rosco

	Whittaker Detector (microns)	Kidde Detector (microns)
Rosco	3.5	3.6
Aviator UL	1.7	1.5

Rosco Light Fog Fluid

- **Rosco Light smoke is visually similar to Aviator UL smoke**
- **Rosco Clear fluid was able to alarm the Kidde detector at 48% Obscuration per foot.**
- **Average D10 Particle Size 4.0 microns**
- **Rosco Light fluid was unable to alarm Kidde detector, the %Obscuration per foot could not reach a high enough percent obscuration**
- **The Rosco Light has large particle size and doesn’t create smoke dense enough to alarm the false alarm resistant detector**

Summary

- **The Kidde detector is hypothesized to depend on particle size detection first and percent smoke obscuration second**
- **The oil based particles brought the Kidde detector into and out of alarm sooner than with the Whittaker.**
- **With water based particles, smoke needed to be very dense to alarm the Kidde detector but not the Whittaker.**

Aviator UL	Into Alarm	Leaving Alarm
Whittaker	5.9	2.9
Kidde	3.3	5.2

Questions or Comments?

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