LINK'S BRAKE EMISSION SYSTEM 'M6330'

Measurement devices, sensors, and layout

Presented to PMP TF2

April 8th 2021

Link Engineering Company

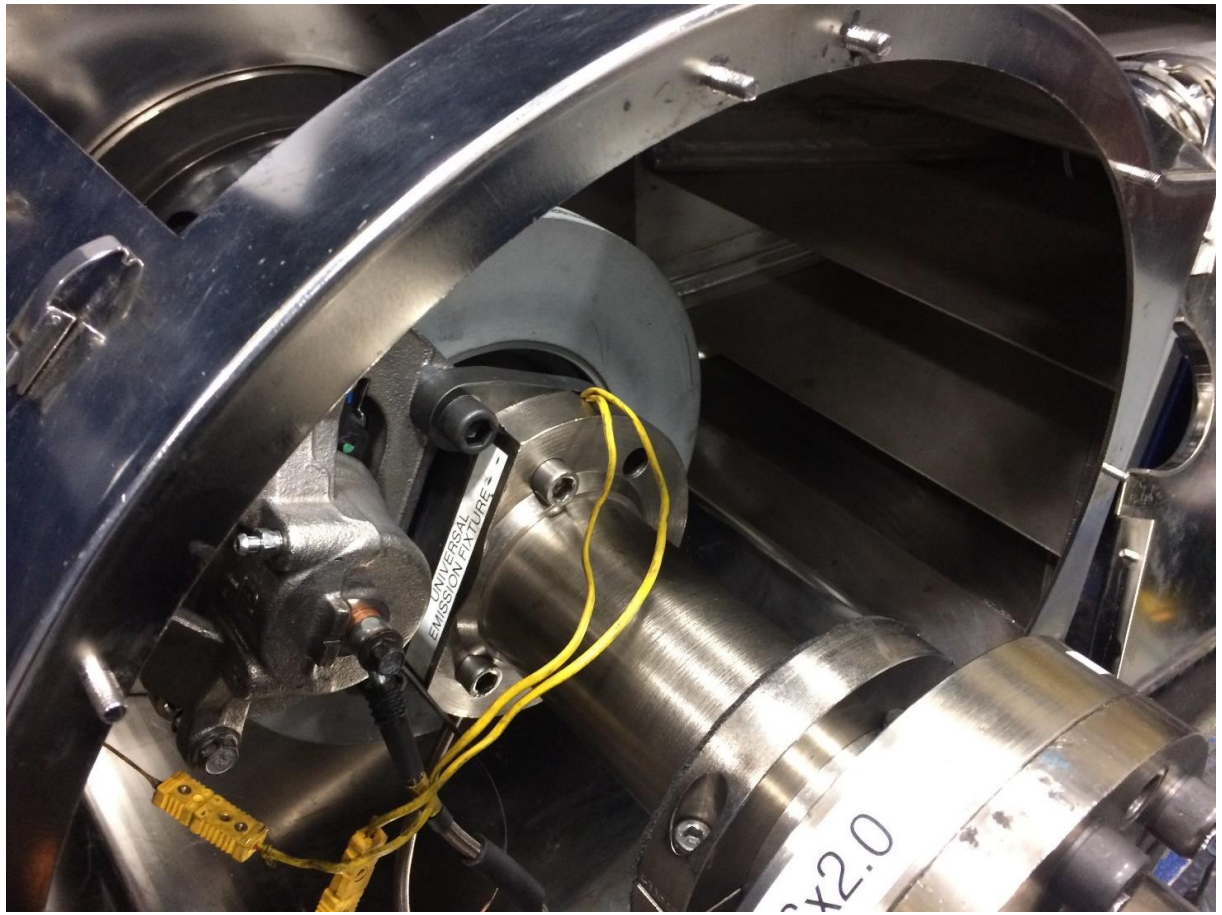
Testing facility location (U.S.A.)

401 Southfield Rd

Dearborn, MI 48120

Testing services accredited to ISO 17025:2015

Engineering and lab processes, weighing room, and fully-integrated test reports

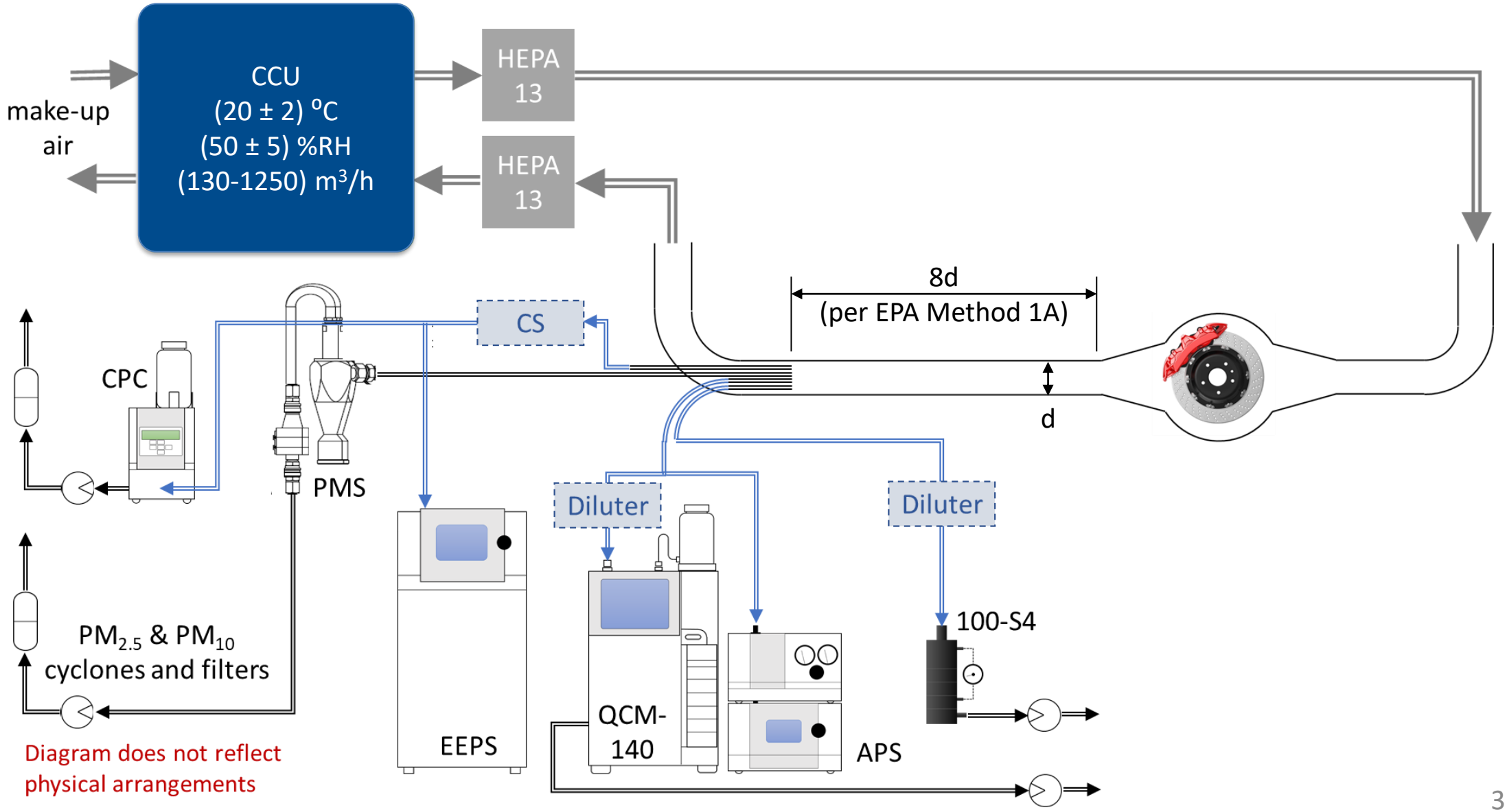


dedicated dynamometers

filter weighing

M6330 comprehensive configuration for PM, PN, and PSD

Conditioned air, aerodynamic enclosure, isokinetics, 6 nm-20 µm range

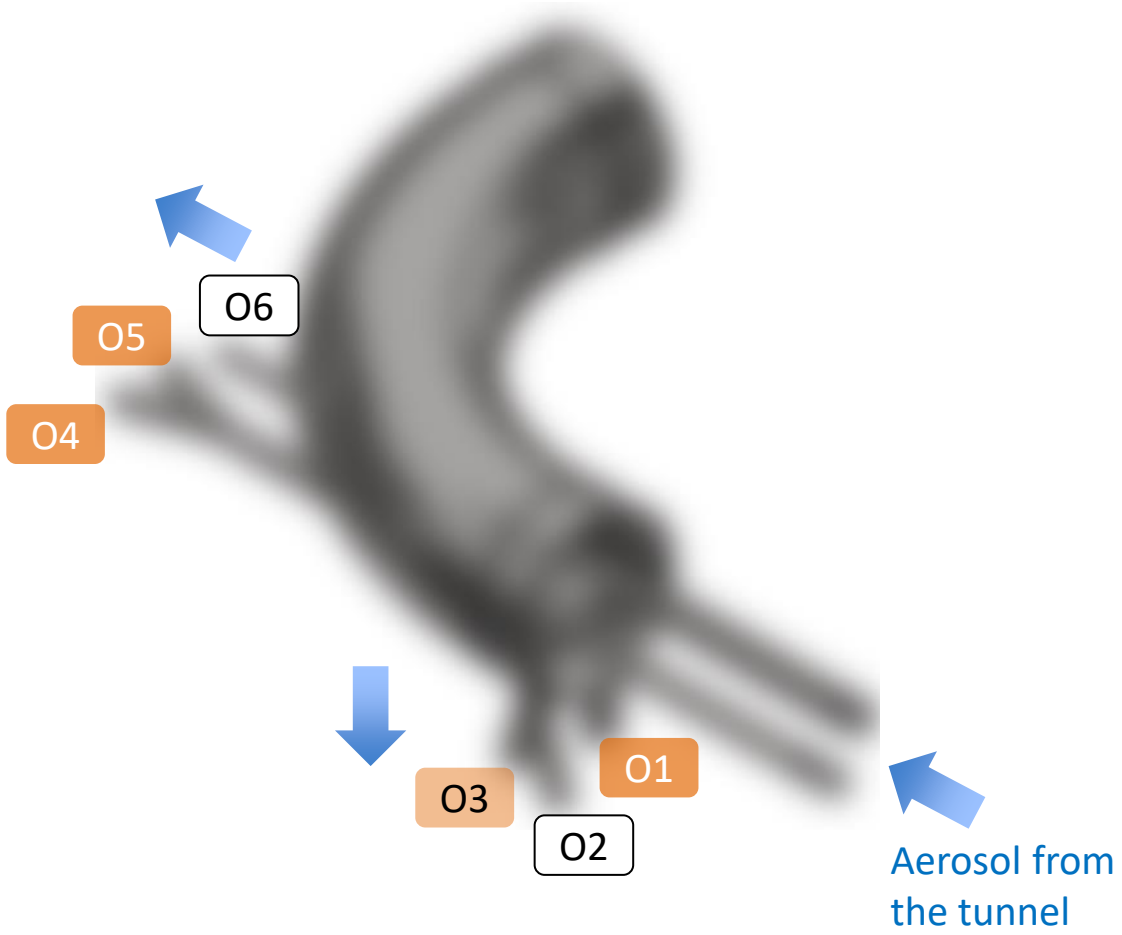


Instrumentation cluster

PM, PN, and PSD

Particulate sampling elbow

Multiple inlets and outlets



Filled blocks represent outlets for PM sampling

Outlet	Instrument Model	Instrument Supplier	Flow (L/min)	Measurand
O1	MOUDI 100S4	TSI (MSP model)	30.0	PM
O2	APS 3321 + Diluter	TSI	5.0	PSD
O3	MOUDI QCM 140	TSI (MSP model)	10.0	Time-based PM
O4	PM filter holder 2000-30FVT PM_{10} cyclone 2000-30EI	URG	16.7	PM
O5	PM filter holder 2000-30FVT $PM_{2.5}$ cyclone 2000-30EHS	URG	16.7	PM
O6A*	EEPS 3090	TSI	10.0	PSD
O6B*	CPC 3790A-10	TSI	1.0	PN

** O6 is connected to a flow splitter leading to multiple outlets*

Particulate measurement range

PM, PN, and PSD

Bubbles along the lines are cutpoint diameters

Particle Mass

PMS_{10} – Cyclone + 47-mm filters

$PMS_{2.5}$ – Cyclone + 47-mm filters

100S4 – Low-pressure impactor

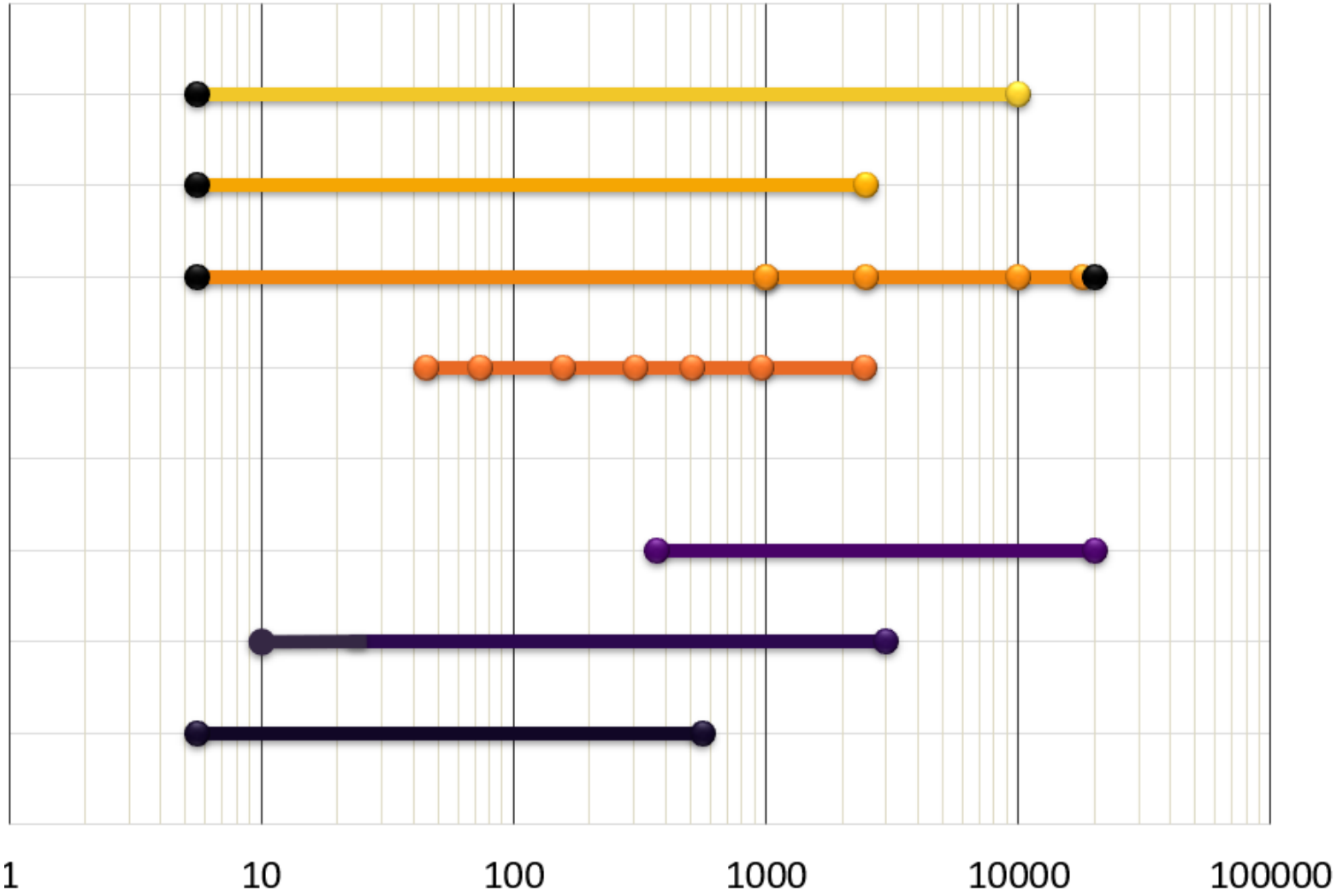
QCM – Quartz-crystal microbalance

Particle Count

APS – Aerodynamic Particle Spec.

CPC – Condensation Particle Counter

EEPS – Engine Exhaust Particle Spec.



Particulate mass sampling

Using impactors or cyclones

Feature	100S4	PMS
Size control	Cascade impaction	Cyclones
PM mass	Size-segregated mass PM1, PM1-2.5, PM2.5-10, PM10-18, PM>18	Cut-off sizing PM2.5 PM10
Filter media	Coated aluminum + glass fiber filters	PTFE (Teflon) Quartz-fiber
Filter size	47 mm	47 mm
Chemical analysis feasibility	Not feasible	Feasible
Inlet orientation	Vertical	Horizontal

100S4 (TSI/MSP)

PMS (URG)

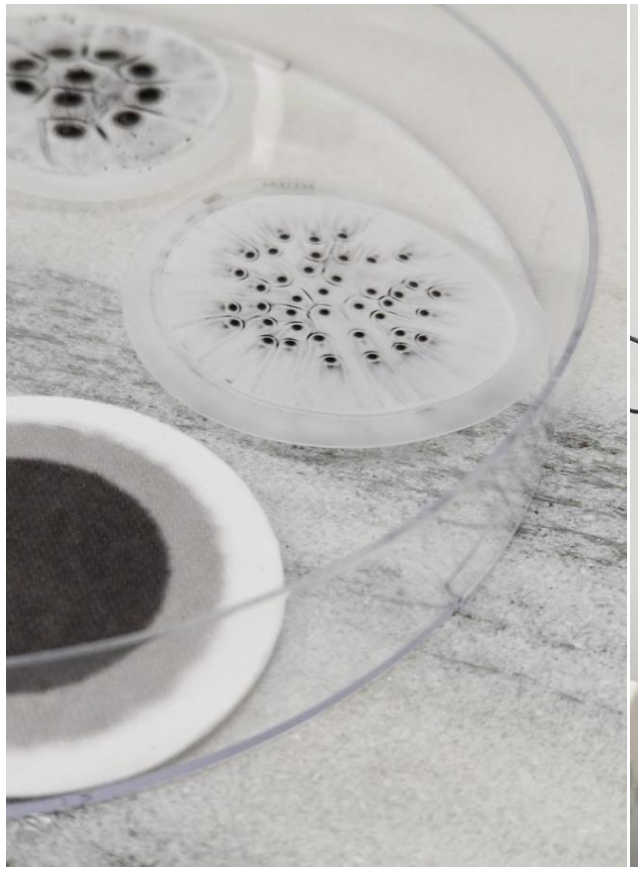
PM filter weighing room

Maintained per 40 CFR Part 1065 [T_{air} = (22 ± 1) ^{o}C; T_{dew} = (9.5 ± 1) ^{o}C]

Buoyancy-corrected mass

- Air temperature, pressure, dewpoint
- Microbalance with resolution of 1 µg

Store



Check

Weigh

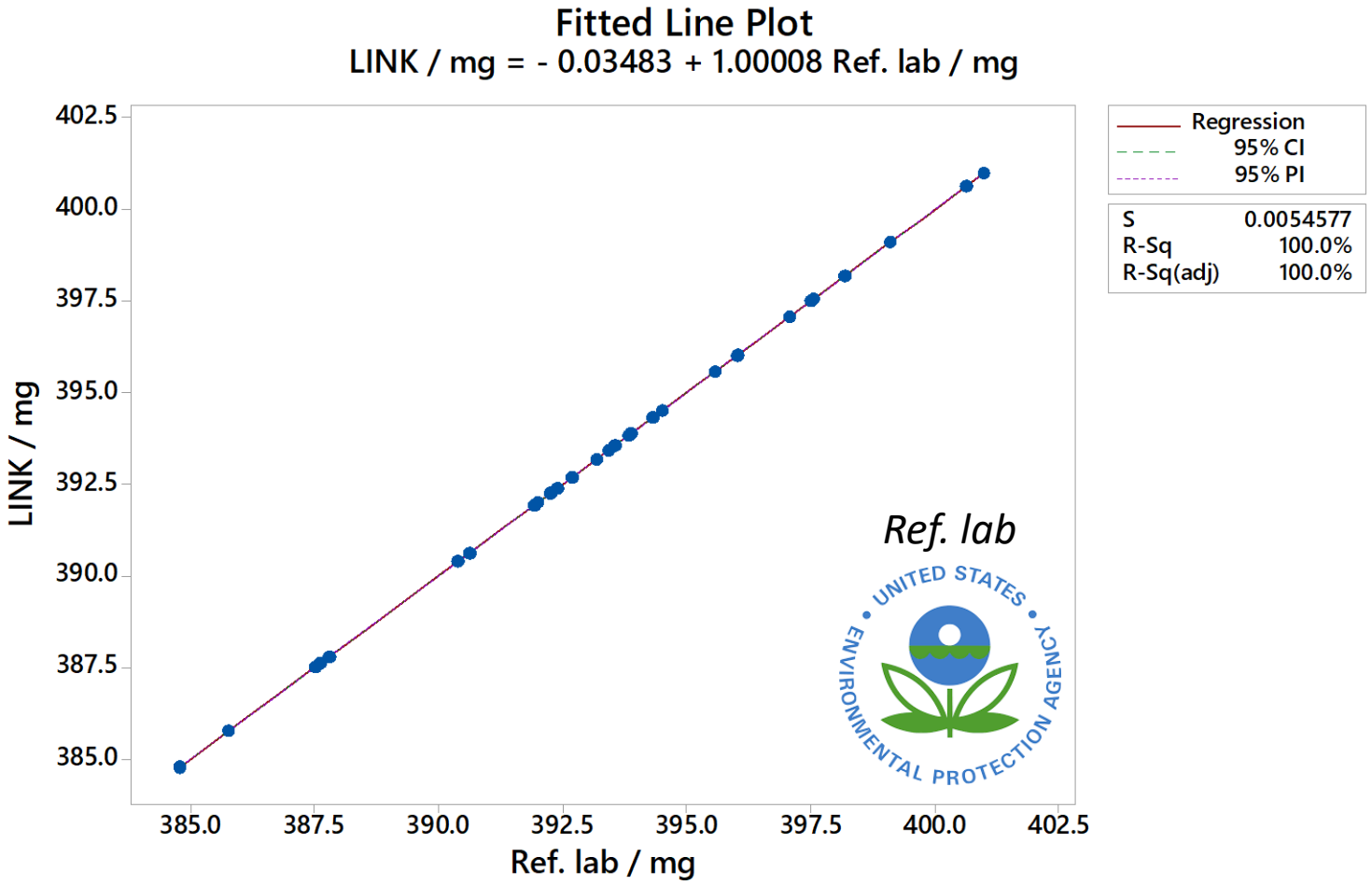
PM filter handling

Filter conditioning and storage per CARB/EPA/CFR

Feature	Coated Aluminum	Quartz Fiber	PTFE	Glass Fiber
Filter stock	TSI MSP Part# 0100-47-AF	Pallflex®, Part# 7194	Whatman 7592-104, Membrane filter with support ring	Pall A/E Glass Fiber Filter, 1µm, Part# 61631
Heat treatment	100 ^{o}C	550 ^{o}C	n.a.	n.a.
Storage (Pre- and post-test)	Weighing room	Freezer at -20 ^{o}C	Weighing room/ Freezer at -20 ^{o}C	Weighing room
Conditioning time (pre-test and/or weighing)	at least 1 hour	at least 4 hrs	at least 1 hour (4 hrs if stored in freezer)	at least 1 hour

Validation of weighing process

with 30 blank filters weighted three times each



buoyancy-corrected per 40 CFR Part 1065

THANK YOU

OEMs

Tier 1 & 2

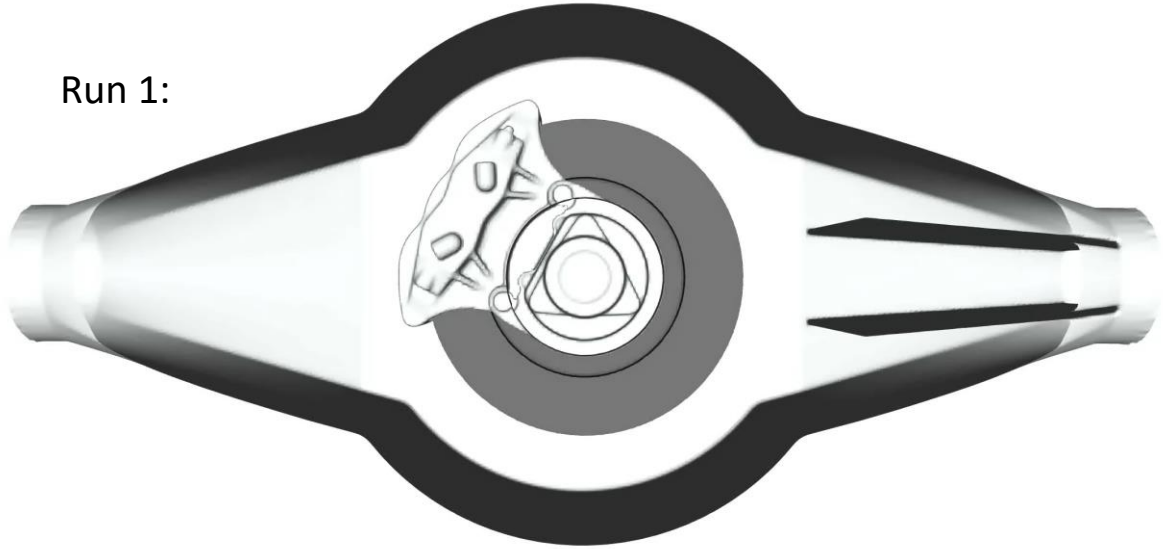
Additional slides based on inquiry about particle transport efficiency and PM mass collection efficiency

particle inception

particles (AZ test dust ISO 12103:2016) injected at the outer edge of friction couple

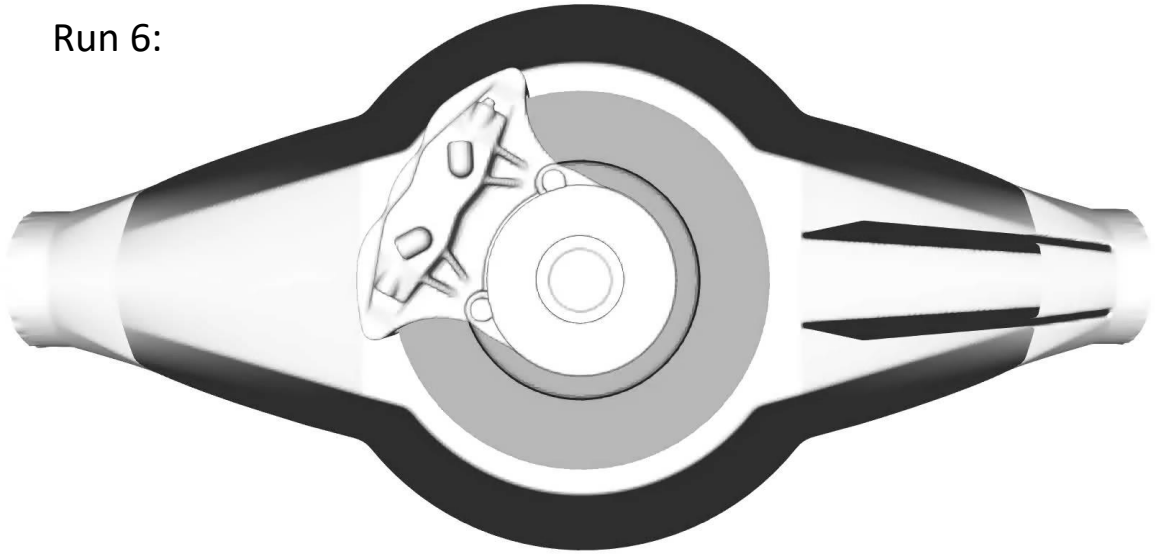
400 m³/h
Small brake
Solid disc
Aft position
CCW rotation
900 RPM
Post fixture

Run 1:

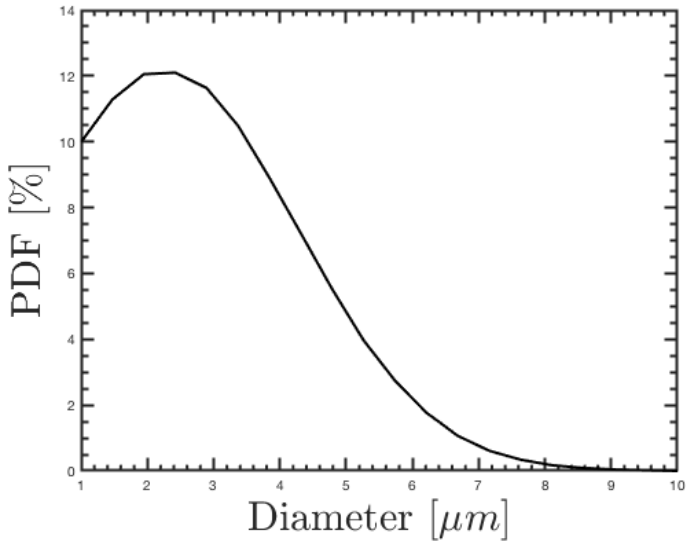


1000 m³/h
Large brake
Solid disc
Aft position
CW rotation
400 RPM
Post fixture

Run 6:

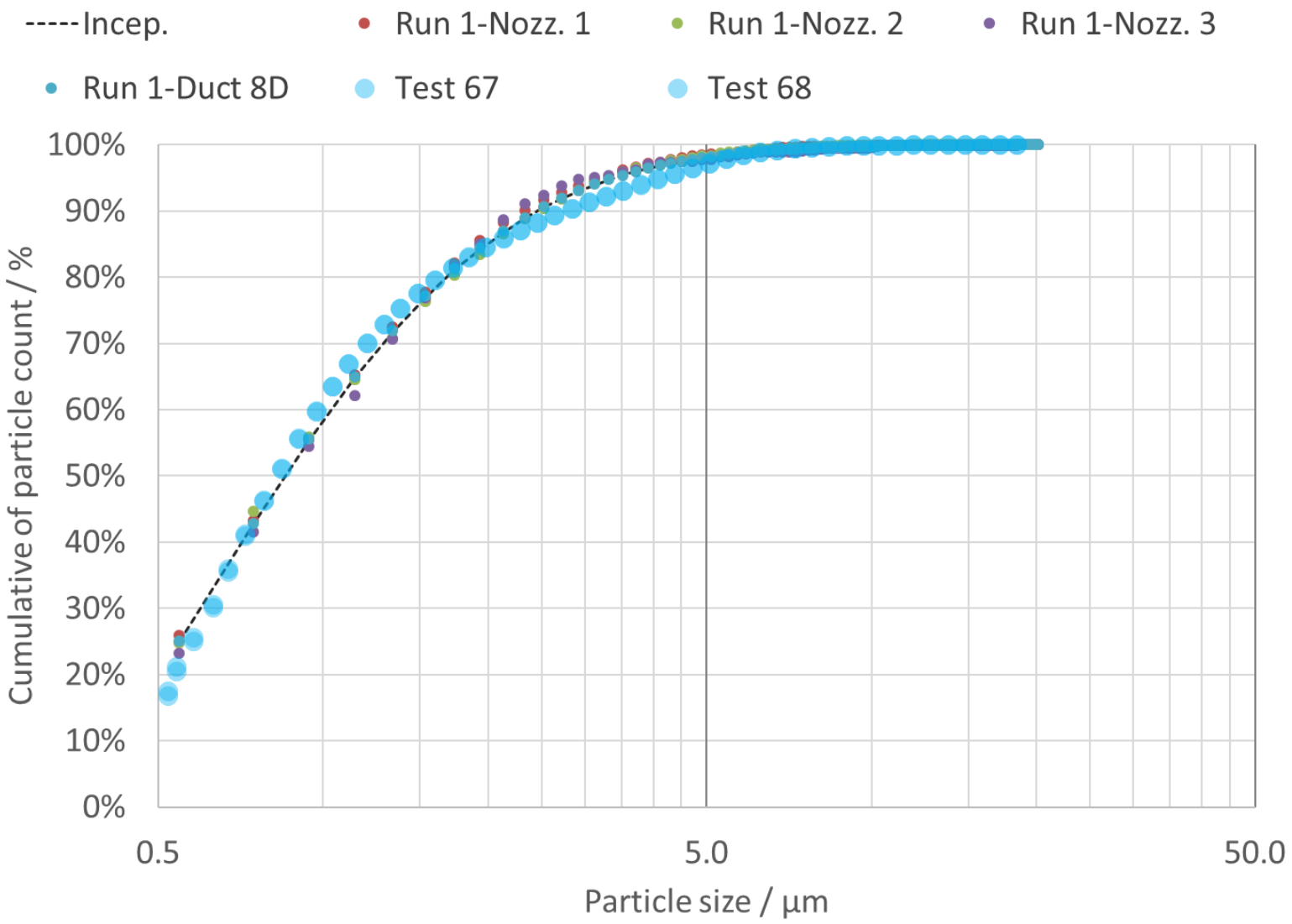


Particle Size Distribution (by mass)



particle count behavior in CVS for CFD v. experimental

Inception and nozzle CFD simulation do not deviate from experimental data



experimental validation using AZ fine dust (ISO 12103:2016)

transport efficiency was similar or higher than calculated with PALS Macro