

Development of Calibration Procedures for Non-Volatile Particulate Matter Mass Measurement Methods

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Problem Statement

Three candidate methods have been identified by the SAE E-31 Committee for possible use in an Aerospace Recommended Practice for non-volatile particulate matter (PM) mass emissions. However, none of these methods measure PM mass directly, have a standard procedure available to implement the method, or incorporate a technique to quality assure the data collected by means of an external standard. This program addresses this research problem.



2

Program Objectives

- Develop Standard Operating Procedures (including quality assurance/quality control checks) for three candidate non-volatile particulate matter (PM) mass measurement techniques including:
 - -Carbon burn-off (e.g., National Institute of Occupational Safety and Health [NIOSH] Method 5040)
 - -Multi-Angle Absorption Photometer (MAAP)
 - -Laser Induced Incandescence (LII)
- Validate all three methods against the filter gravimetric technique using a known aerosol source representative of turbine engine exhaust in a controlled laboratory environment
- Provide the above information to the SAE E-31 Committee for inclusion in an ARP for the measurement of non-volatile PM mass to be used in future new optime cortification
- to be used in future new engine certification



Potential Modifications to NIOSH 5040

- Development of specialized apparatus and methodology for sampling of gas turbine exhaust
- Validation against filter gravimetric technique



Thermo Scientific Model 5012 Multi-Angle Absorption Photometer



Model 5012 MAAP flow schematic



Schematic of the MAAP sensor unit showing the position of the light source and the photo detectors



MAAP in Use at Wright-Patterson Air Force Base (WPAFB)





Direct Output from MAAP (1-Minute Data) MAAP Data





Potential Modifications Needed for MAAP Instrument

- Real time data processing and analysis for data output stream at speeds <<< 1 minute
- Better flow control to allow sampling rates << 16.7 lpm
- Automation of switching valve on instrument inlet
- Incorporation of a secondary dilution system to condition sample flow prior to analysis
- Some means to independently verify proper instrument operation before starting measurements (i.e., QC check)



Artium Laser Induced Incandescence Instrument



Schematic of LII instrument optics layout, showing path of laser beam and detected particle incandescence



Artium Model LII 300 in Use at WPAFB





Potential Modifications to LII 300

- Incorporation of a flow meter to monitor sampling rate to the instrument
- Some type of independent QC check to verify proper instrument operation before starting measurements



Experimental Apparatus for Methods Validation Phase

- Low speed wind tunnel (one pass)
- Mini-CAST burner (aerosol generator)
- Catalytic stripper (remove volatile PM)
- Sample splitter
- Stainless steel filter holders for Teflon and quartz filters
- Sampler/instrument under evaluation



Wind Tunnel Schematic



From Section A.10.4 of SAE Aerospace Information Report 6037



Jing Mini-CAST 5200





Particle: Size range: Ouput: Exhaust Flow: Mass output:	
Flow Temperature Accuracy	
Repeatablility Weight:	

Combustion soot particle 20-200 nm Up to 10^8 particle/cm³ 30 l/min (1.8 m³/h) 20 mg/h (30 nm) - 550 mg/h (200 nm) 80-140°C 5% for mass & number 2% for particle size (± 3 nm) ± 5% 5 kg

13



Model 5202 RSG Mini-CAST Details (Simplified)



- Propane diffusion flame
- Portable, low cost (\$ 30K), easy to use
- Particle characteristics similar to engine emissions
- Ability to vary size and number
- Dilution system required
 - Eductor provides ~80:1 dilution at 40 psig





CAST Output Capabilities

Long-term stability of particle concentration



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15



Current Project Status

- Potential location for wind tunnel system has been identified
- Contact with instrument manufacturers and selected experts have been made preparatory to starting work
- Sources for the CAST burner and catalytic stripper have been identified and cost quotations obtained
- Quality Assurance Project Plan currently in preparation
- FAA/EPA Interagency Agreement to fund program in process