

ENGINE EXHAUST PARTICLE MEASUREMENT SYSTEM

3095 (3098 PTT PLUS 3090 EEPS™)

Measuring the transient response of new engine designs with advanced emission control devices can now be done seamlessly and accurately from a single user interface. The Model 3095 Engine Exhaust Particle Measurement System provides accurate dynamic dilution control and measures the size distribution of engine exhaust particle emissions from 5.6 to 560nm in 32 channels with the fastest system time resolution available (10 Hz).



Applications

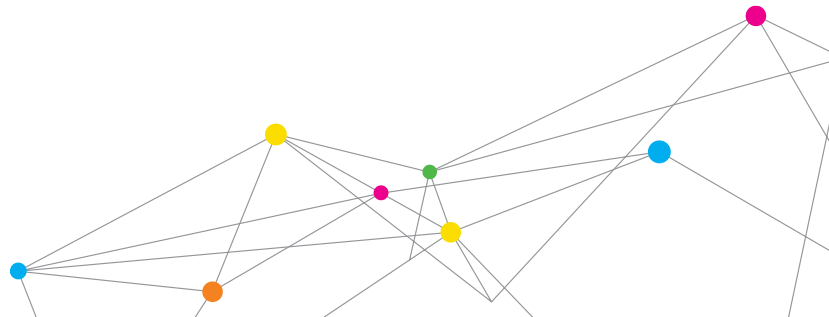
- + Sub-23nm solid particle emissions for post Euro 6 engines
- + Cold start engine emissions in Gasoline Direct Injection (GDI) engines
- + Exhaust after-treatment (DPF or GPF) characterization. Pre-DFF/GPF sampling with optional Pressure Reducing Module (PN 3098-PR)
- + Non-exhaust nanoparticle emissions (brake and tire wear)
- + Measurement of non-volatile PM emissions from aircraft turbine engines
- + Non-road mobile machinery emissions

Features and Benefits

- + Robust dilution design: porous tube diluters without moving parts to wear out or small orifices to clog
- + PMP-type (hot dilution-catalytic stripper-cold dilution) sample conditioning at ambient pressure for measurement of solid particles at 10Hz
- + Low thermophoretic and diffusional losses that are corrected for in the measured size distribution
- + Low cost of ownership with swappable flow controller module (only flow control module needs to be calibrated annually)
- + AK-serial command protocol for integration in test cell systems with host controller
- + Reliable and accurate dilution performance: well controlled/stable/accurate dynamic dilution ratio
- + Easy to use: Integrated control of PTT diluter and EEPS spectrometer from single user interface



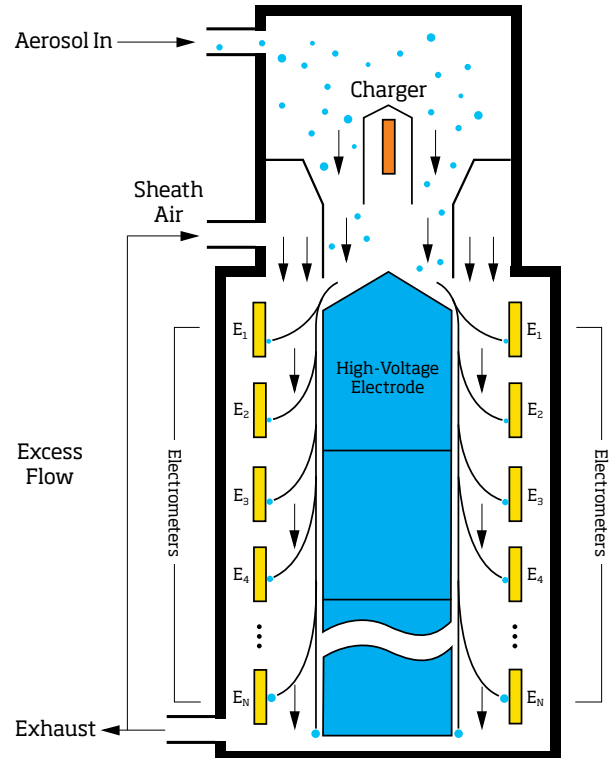
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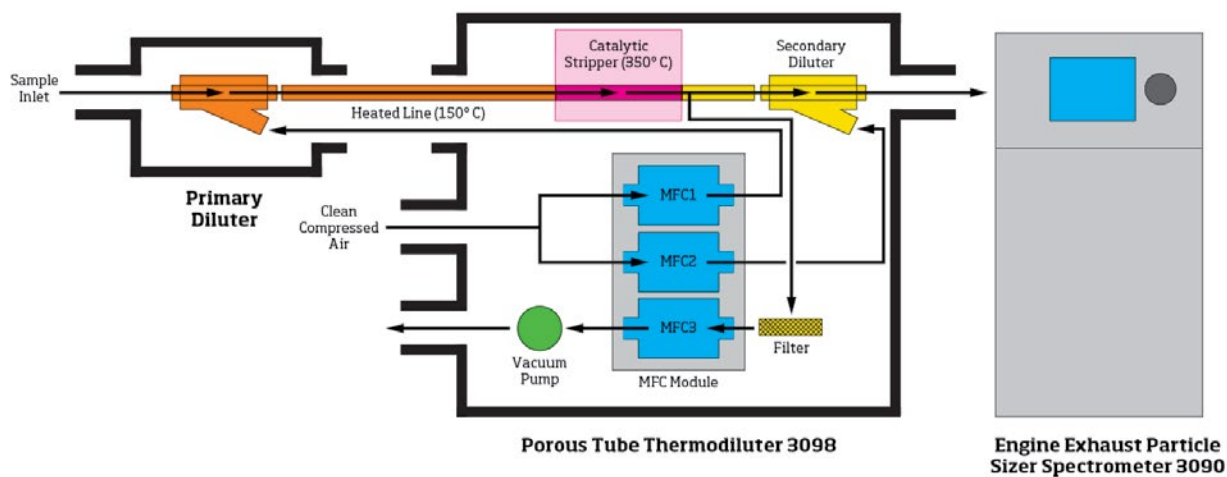
Based on more than 15 years of experience in the characterization of transient particle size distributions from internal combustion engines, TSI has combined the well-known 3090 Engine Exhaust Particle Sizer (EEPS™) with the 3098 Porous Tube Thermodiluter, to work as one integrated system known as the 3095 Engine Exhaust Particle Measurement system. The new 3095 system addresses the industry's need for robust and repeatable measurements that are in excellent agreement with PMP-compliant measurement instruments. This is achieved by an integrated sample conditioning system consisting of two porous tube diluters and a volatile particle remover with full characterization and integration of the particle size dependent losses from the point of sampling to the EEPS spectrometer. Based on the emerging requirements to measure particles below 23 nm in diameter, the system has been optimized to substantially reduce particle losses. It can either be addressed through the user friendly EEPS-Software that has been extended to fully control the complete system, or it can be integrated in the test bench host system through AK-protocol. In both cases, the full time resolution of 10 Hz is provided. The sampling system provides full control, whether the point of sampling is at 500°C, and up to 3 bar or at ambient temperature and pressure. Ease of use and simple maintenance were the main drivers during instrument development in order to offer maximum up-time for measurements, and minimum time for preventive maintenance. Two porous tube diluters in combination with a catalytic stripper allow the user to select a dilution ratio from as low as 10:1 to as high as 500:1 with well-defined low particle losses. The diluters do not have any moving parts and have very low particle losses thanks to the clean air wall flow. The clean dilution air is supplied by high-accuracy mass flow controllers that are referenced to each other by a patent pending, proprietary mirroring technique.

A heated sample line supplied with the system transports the exhaust sample from the primary diluter to the catalytic stripper. A high total penetration of more than 40%, even at particle sizes below 10 nm, result in very accurate size distribution measurements without post-data processing over the full particle size range from 5.6 nm to 560 nm, and over the full concentration range from $> 10,000 \text{ #/cm}^3$ to $< 1 \times 10^9 \text{ #/cm}^3$.

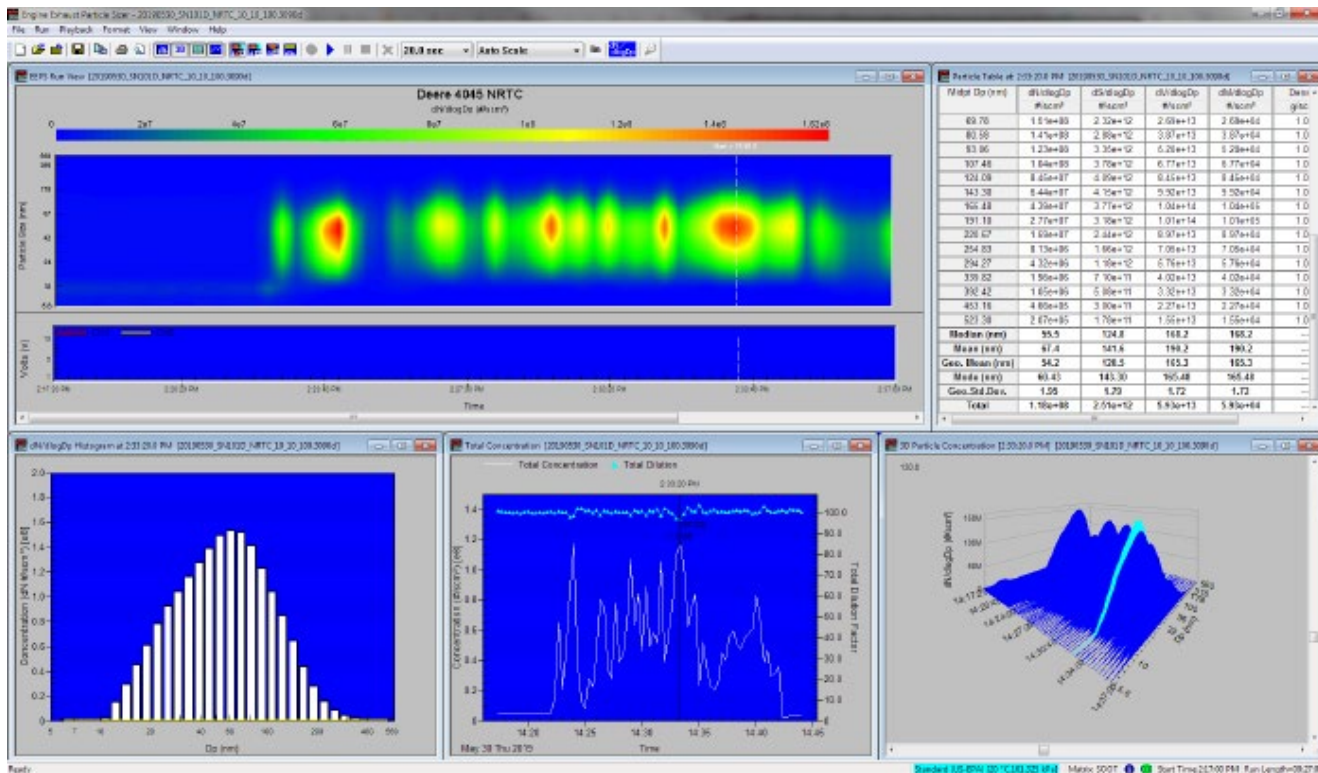
Characterize Particle Emissions in Real-Time



Flow schematic for 3090 EEPS™ Spectrometer



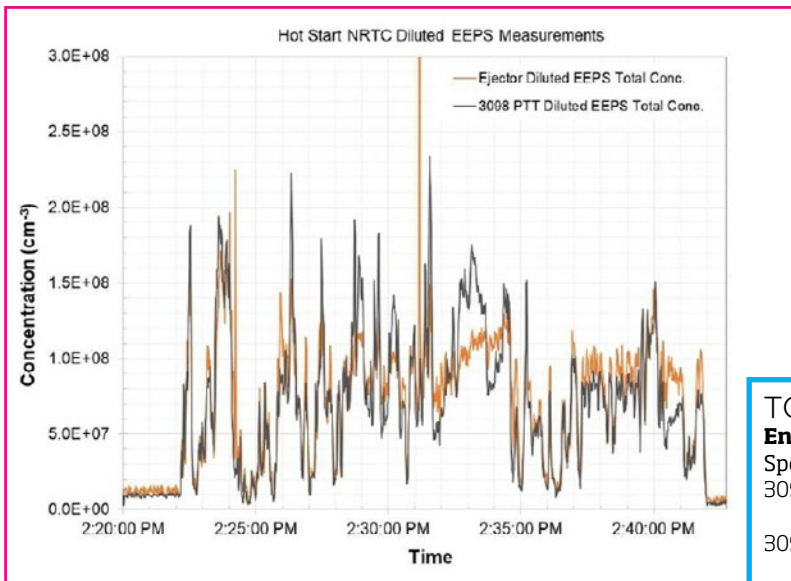
Flow schematic for 3098 Porous Tube Thermodiluter



The EEPS™ software offers five main views of the data including the measured dilution ratio in real time

	Set Point	Process Value
Primary Dilution Factor	10.0	9.0
Secondary Dilution Factor	5.0	4.8
Total Dilution Factor	50.0	43.7
Primary Diluted Sample	150	150 (°C)
Catalytic Stripper	350	352 (°C)
Dilution Factor Method		
Method: Standard flow		

User defined operation parameters for 3098 PTT



Measurements of diesel engine exhaust during a hot start of a transient cycle comparing the 3095 Particle Measurement System with a conventional ejector dilution system and the EEPS™ spectrometer

TO ORDER

Engine Exhaust Particle Measurement System

Specify	Description
3095S	Engine Exhaust Particle Measurement System, w/2.5m sample line
3095M	Engine Exhaust Particle Measurement System, w/4.0m sample line
3095L	Engine Exhaust Particle Measurement System, w/6.0m sample line

Optional System Accessories

Specify	Description
3074B	Filtered Air Supply
3098-KIT	Accessory Kit for Model 3095 (filters)
3098-PR	Pressure Reducing Module
3098-MFC	Mass Flow Control Module (3 MFCs)
3098-2.5MHSL	Heated Sample Line, 2.5m
3098-4.0MHSL	Heated Sample Line, 4.0m
3098-6.0MHSL	Heated Sample Line, 6.0m

Computer must be purchased separately

SPECIFICATIONS

ENGINE EXHAUST PARTICLE MEASUREMENT SYSTEM MODEL 3095 (3098 PTT PLUS 3090 EEPS™)

Operating Features

Particle Size Range	5.6 to 560 nm
Particle Size Resolution	16 channels per decade (32 total)
Particle Concentration Range	Up to 1×10^9 P/cc at inlet of primary diluter with 500:1 dilution ratio
Particle Penetration	Size dependent penetration determined experimentally from 5.6nm to 560nm for the complete system at nominal operating conditions (heated sample line at 150 °C and catalytic stripper at 350 °C). Particle penetration correction applied to EEPS spectrometer size distribution.
Charger Mode of Operation	Unipolar diffusion charger with current control
Inlet Cyclone	
50% Cutpoint	1 μ m
Time Resolution	10 size distributions/sec
Response Time	<1.8 sec T10 to T90 (complete system; response time based on total number concentration response)

Flow Rates	
PTT diluter	0.25 to 5 L/min (determined by dilution ratio and temperature/pressure conditions)

EEPS Sample Flow	10 L/min
EEPS Sheath Air	40 L/min
Dilution Ratio Range	10:1 to 500:1
Volatile Particle Remover	Catalytic Stripper with >99% removal at 30nm with tetracontane aerosol

Heated Sample Line Temperature	OFF to 200 °C (default is 150 °C)
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Environmental Conditions

Raw Gas Temperature Range	0 to 500 °C (consult with factory for higher temperatures)
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EEPS Inlet Sample Temperature	10 to 50 °C
Sample Inlet Differential Pressure	+100 to -80 mbar without pressure reducing accessory < 3 bar with optional pressure reducing module

Operating Temperature	0 to 40 °C
Storage Temperature	-20 to 50 °C
Atmospheric Pressure	70 to 103 kPa (700 to 1034 mbar)
Humidity	0 to 90% RH (non-condensing)

Communications

User Interface	Rotary knob and display (limited functionality)
EEPS software	(full control of measurement system, PTT diluter and EEPS spectrometer)
Front Panel Display	6.4-inch, color, VGA LCD
Computer Requirements	Pentium® 4 processor, 2 GHz speed or better, > 512 MB RAM
Operating System Required	Microsoft Windows 10 (32-bit or 64-bit) operating system
Communications	9-pin RS-232 PTT diluter to EEPS spectrometer 9-pin RS-232 from PTT to USB (TSI Software - Laptop) AK-Protocol via Ethernet (to PTT diluter)

Electrical Features

EEPS Analog Input	Two analog input channels, 0 to 10 V
EEPS Analog Output	Four user-configurable analog outputs (see Application Note EEPS-001 for details)
EEPS Trigger Input	Two trigger input channels, potential free contact closure or 3.3 V pulled to GND
EEPS Trigger Output	Trigger output channel, potential-free contact closure

Physical Features

PTT Dimensions (H x W x D)	165 x 55 x 82 cm (at base)
EEPS Dimensions (H x W x D)	70.4 x 34.3 x 43.9 cm
PTT weight	140 kg (308 lb)
EEPS Weight	32 kg (70 lb)
Sample Inlet	1/4-in for raw undiluted gas; 3/8-in OD for EEPS inlet
Exhaust/Outlet	3/8-in OD

Power Requirements

EEPS	100 to 240 VAC, 50/60 Hz, 250W
PTT	100-120 VAC, 50/60Hz or 200-240 VAC, 50/60Hz; <1500W

Dilution Air Supply Requirements	Dry Air or N ₂ @ 80 psi and 25 °C; ~30 SLPM; dew point < 0 °C
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Specifications reflect typical performance and are subject to change without notice

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