ABOUT US

Our mission is to be your engine particulate emissions specialist. We give our customers throughout the world a complete engine PM emissions sampling solution using our flagship Model BG-3 as the hub of this effort.

Our goal is to develop world-class Particulate Partial Flow Sampling Systems (PPFSS) that provide the highest quality sample data, greatly increase testing efficiency, drastically reduce costs, and improve test-cell safety.

Sierra has a great track record. Throughout the 1990’s, Sierra’s Model BG-1® and Model BG-2® became the leading PPFSS in the world. We now support hundreds of BG systems used by customers located all over the world.

Sierra has forged unique partnerships with Caterpillar and CP Engineering. Together, engineers worked as a team to develop, design, and test the Model BG-3 to meet the stringent needs of engine manufacturers through cutting-edge technology and patented inventions.

These partnerships have allowed Sierra to design the most innovative and state-of-the-art PM product offering on the market. Sierra owns the exclusive worldwide license to Caterpillar’s patented micro-dilution technology Patent #5,058,440 and system flow control features described in United States patent #6,615,677 along with two additional US patents.

Our goal is to offer customers throughout the world a single choice for their particulate measurement needs, offering solutions from sample collection to final processing for customers using the gravimetric method currently written in the regulations. Our team is set up to rapidly provide any customer with standard or custom solutions.

www.sierraemissions.com

MODEL BG®-3

The Model BG-3® is a Particulate Partial Flow Sampling System (PPFSS) that provides accurate, repeatable Particulate Matter (PM) measurements for transient and steady-state engine and vehicle testing. More than three years of research, development and testing at Caterpillar, John Deere and other engine manufacturers, as part of the proven adherence to ISO 16183, have demonstrated the BG’s ability to maintain transient cycle PM correlation to within +/- 5% of full flow CVS results.

During a transient test cycle, engine speed, load, airflow and fuel flow values exhibit high rates of change over very short time frames. The magnitude of engine inlet air mass flow excursions can approach 10:1 within less than two seconds. The challenge for any PPFSS is to maintain constant proportional flow from an exhaust stream with a highly variable mass flow rate throughout a typical test cycle.

The primary purpose of the Model BG-3 is to control the flow rate of a representative sample of exhaust during an engine test cycle. In order to ensure that the total mass of particulate trapped at the filter is equivalent to that obtained by the use of a full flow CVS, the sample flow rate must be controlled in real-time to be proportional to the exhaust mass flow. Further, it is necessary to control this sample flow rate to ensure that the filter temperature does not exceed the regulatory defined limit while the dilution air temperature is maintained in the range required by the regulations.

The Model BG-3 is an integrated product that incorporates two flow devices supplying and extracting gas from patented radial inflow partial flow dilution technology used in the dilution tunnel design. The mass flow of raw exhaust sampled at the probe is the difference between the flow rates of the dilution and total mass flow meters.

This sample flow is calculated as the difference between the total and dilute flow. The magic of BG-3 is the patented dilution tunnel which eliminates the major Achilles heel of any PPFSS, the deposition of particulate on dilution chamber walls as the diluted exhaust sample is transferred to the filter from the raw exhaust stream. Zero particulate loss in the dilution tunnel and a very short equilibration zone before the filter set the BG apart from all other PPFSS.

Sierra’s patented dilution tunnel technology is a chamber under pressure. Conditioned dilution air permeates from the outside of the chamber in through the walls of a sintered metal tube carrying the diluted sample, creating a hydrocarbon-free air barrier. This eliminates the effect of the dilution system’s “history” on the test sample.
The Patented Transient Dilution Airflow Control (TDAC™) utilizes partial flow dilution tunnel design advances and a unique flow apportionment and control system to effectively execute proportional sampling. The flow delay at the particulate sample probe is considerably less than the 500-millisecond delay specification elaborated in ISO 16183. The Model BG-3 utilizes a real-time measurement of exhaust flow to ensure correlation with full-flow constant volume sampling measured and controlled by the system's dilution air mass flow controller located inside the TDAC™ module. A flow control valve system in a feedback loop with an ultra-fast response (<300 millisecond) provides control of the proportional flow control valve. The dilution air mass flow controller and its ancillary instrumentation are maintained in a thermally stable environment in close proximity to the dilution tunnel. TDAC™ input is provided by a 0-5 volt linear output from the engine with Sierra's Air-Trak™ (200 millisecond response-time thermal mass flow meter specifically designed for the application).

MODEL BG®-3 SOFTWARE

The BG-3 software is a user friendly application that allows the engineer to work independently of a host system or interfaced with a host. The BG-3 software was designed by test cell engineers, for test cell engineers. The BG-3 software allows the knowledgeable engineer the diversity of testing any size or fueled engine for particulates, calibration and troubleshooting of the system.

Main Status Screen

Tracker Screen

The status screen displays the system layout and all of the real-time parameters before and throughout the test. The operations display is a useful tool for the operator as the test is being performed and after completion.

The "Tracker" function is a tool that every engineer will find irreplaceable. This screen can be used by the engineer to track any of the functions (diluted mass flow, delta pressure, engine exhaust flow versus sample mass flow) or other immediate test functions for immediate reference or archival of data.

Setup Screen

Calibration Screen

The BG-3 set-up screen is unique in that it can be modified for any test situation. Altering the units of measure is one of the easily adjustable features of the set-up screen. The easily accessed (tab) screen allows the engineer the rapid change of any test parameter.

The engineer will find the calibration of the system very manageable and efficient. The fully automated calibration routine can be performed at any time.
**MODEL BG®-3 SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Current ISO DIS 16183 Permissible Limit</th>
<th>MODEL BG-3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accuracy of Dilution Air Flow</td>
<td>+/- 2% of reading</td>
<td>+/- 1.5% of reading</td>
</tr>
<tr>
<td>Accuracy of Diluted Exhaust Gas Flow</td>
<td>+/- 2% of reading</td>
<td>+/- 1.5% of reading</td>
</tr>
<tr>
<td>System Response time</td>
<td>&lt;= 0.5 second</td>
<td>0.3 second</td>
</tr>
<tr>
<td>Input method of Exhaust gas mass flow</td>
<td>1. Direct method</td>
<td>Any of the 4</td>
</tr>
<tr>
<td></td>
<td>2. Air &amp; fuel measurement methods (@(G_{exh} = G_{air} + G_{fuel}))</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Tracer measurement method</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Air flow and air to fuel ratio measurement method</td>
<td></td>
</tr>
<tr>
<td>Proportionality</td>
<td>Correlation coefficient R² of the linear regression between (G_{p,i}) and (G_{EXH,i}) shall not be less than 0.9.</td>
<td>&gt;0.98</td>
</tr>
<tr>
<td></td>
<td>The standard error of estimate of (G_{p,i}) on (G_{EXH,i}) shall not exceed 5% of (G_{p,max}).</td>
<td>1-2%</td>
</tr>
<tr>
<td></td>
<td>(G_{p}) intercept of the regression line shall not exceed +/- 2% of (G_{p,max}).</td>
<td>Meets requirement</td>
</tr>
<tr>
<td>Filter size</td>
<td>Particulate filters must have a minimum diameter of 47mm. Larger diameter filters are acceptable.</td>
<td>47mm, 70mm</td>
</tr>
<tr>
<td>Sample filters</td>
<td>The diluted exhaust shall be sampled by a single filter media placed within the filter holder during the test sequence.</td>
<td>Meets requirement</td>
</tr>
<tr>
<td>Filter face velocity</td>
<td>A gas face velocity through the filter of 35 to 100 cm/s</td>
<td>Meets requirement</td>
</tr>
<tr>
<td></td>
<td>The pressure drop increase between the beginning and the end of the test shall be no more than 25kPa.</td>
<td></td>
</tr>
<tr>
<td>Filter loading</td>
<td>Minimum filter loading shall be 0.25 mg for filter size of 70mm and below.</td>
<td>Meets requirement</td>
</tr>
<tr>
<td>Accuracy of (G_{tot,w})</td>
<td>+/- 2%</td>
<td>+/- 2% or less</td>
</tr>
<tr>
<td>Accuracy of (G_{dil,w})</td>
<td>+/- 2%</td>
<td>+/- 2% or less</td>
</tr>
<tr>
<td>Additional specifications</td>
<td>All parts of the dilution system in contact with raw and diluted exhaust gas must be designed to minimize deposition or alteration of the particulates.</td>
<td>Meets requirement</td>
</tr>
<tr>
<td>SP Sampling probe</td>
<td>The minimum ID. shall be 4mm. The minimum diameter ratio between exhaust pipe and probe shall be 4.</td>
<td>Meets requirement</td>
</tr>
<tr>
<td>Type of probe</td>
<td>Open tube facing to upstream or downstream, or Multiple hole or hatted probe facing to upstream</td>
<td>All</td>
</tr>
</tbody>
</table>

**ISO 16183 INFORMATION**

The diluted exhaust shall be sampled by a single filter media placed within the filter holder during the test sequence.
The highest possible data quality is generated through sophisticated software and hardware in four key areas.

1) Patented TDAC™ Technology.
TDAC™ technology (Transient Dilution Airflow Control) allows engine manufacturers to collect extremely accurate data, very quickly. TDAC™ allows the speed of the dilute mass flow controller to correctly correlate the sample flow with the actual engine exhaust mass flow.

2) Sample Flow Rate Confirmation.
A third mass flow meter confirms the sample flow rate by comparing the measured flow to the set flow of the Model BG-3. This serves as a Go/No Go sample flow check before or after each test. For example: one can compare this to the zero/span function commonly performed on a gaseous analyzer.

3) Validation.
The Model BG-3 continuously controls and validates all critical operational and calibration data parameters and readings so that test engineers can make decisions during as well as after a test.

4) Calibration.
- Fully automated daily calibration between each test.
- Fully automated leak check, zero/span check of the system.
- Filter face velocity (sample mass flow rate) for filter size.

The Air-Trak™ Model 628S was originally designed to work specifically with Sierra’s Model BG-3 engine emissions sampling system as an extremely fast, accurate, and repeatable engine air intake mass flow meter. The instrument has proven to be an excellent solution across the board in all engine testing applications.

Air-Trak™ is specifically designed to measure engine air intake mass flow rate. The meter uses Sierra’s Fast-Flo™ Sensor Technology for an extremely fast 200 millisecond response-time making it ideal for the toughest transient test cycles where flow excursion can approach 10:1 within less than two seconds.

Integral Dual-Plate laminar flow conditioning elements and wide 15:1 turndown make Air-Trak™ a flexible solution for the constrained piping environments commonly found in today’s engine test cells.

In addition, the versatile microprocessor-based instrument integrates the functions of flow-range adjustment, meter validation and diagnostics in a probe-mounted NEMA 4X (IP65) housing.

The Sierra BG-2 system has an installed base of several hundred systems and has been an excellent steady-state particulate partial flow sampler for engine test engineers since the early 1990’s. Although Sierra no longer manufacturers the Model BG-2, we do offer a hardware/software upgrade and continue to offer full support of the BG-2 systems through out the world.

Sample Flow Rate Confirmation
The Smart-Trak® Model 100 Digital Mass Flow Meter inside the BG-3 confirms sample flow rate before each test to assure the highest possible sample data quality.
AUTOMATIC FILTER CHANGER

Our Automatic Filter Changer allows the engineer to remain outside of the test cell during testing as several tests are done in succession. Our automatic filter changer works seamlessly with the Model BG-3 to fully automate particulate collection to greatly improve testing efficiency and more importantly, testing safety. The system can hold up to 17 (dependent on filter size, 47mm, 70mm, or 90mm) single filter cartridges. Sierra will customize the filter changer for 47mm, 70mm or 90mm applications. For example, Sierra has designed the changer to work interchangeably with both 47mm and 70mm.

FILTER HOLDERS

Sierra stocks 47mm, 70mm, and 90mm Filter Holders as well as filter media for use in our customers’ ongoing particulate testing. All filter holders are made of 316L Stainless Steel and meet requirements set forth in the Federal Register. Filter element cartridges are also available in 47mm and 70mm sizes. Cartridges are designed to fit into an individual filter holder or into Sierra’s automatic filter changer.

FILTER WEIGH CHAMBERS

Our filter post-processing Weigh Chamber is a compact, complete ready to run package that allows sample filter media to be accurately weighed per requirements set forth in the Federal Register. Our weigh station is a dual chamber design that allows the operator to stabilize and accurately weigh sample filter media from any size engine. A precision balance, such as the Sartorius, is supplied by Sierra as an option.

HEAT-PAK™

Our Heat-Pak™ is a heated and controlled particulate package built to the EPA CFR 1065 regulation. The Heat–Pak takes the diluted exhaust sample through a cyclonic separator, and controls the temperature and residence time to the filter face. It can be controlled and verified by the BG-3 used in a manual mode with other devices.

AIR-PAK™

Our Air-Pak™ is an air handling & scrubbing system designed to clean compressor air (used for dilution air in the BG-3) before it enters the BG system. The Air-Pak system can also be used for other analytical equipment within the test laboratory. Though the BG-3 has an adequate air purifying system (on-board) it has been found that many test facilities require this added measure of purification.
Sierra’s goal is to be your engine particulate emissions sampling specialist. We offer a complete array of customer support services for the BG-3 and all associated particulate measurement devices found in a typical engine test cell. Our staff of field engineers are ready to support customers on-site in any aspect of engine particulate emissions sampling.

We offer the following to every customer:

- Complete commissioning and training for all Sierra products
- Worldwide service & repair
- Spare & replacement parts for all products
- Yearly certification of all products
- Telephone support on all products
- On Site field support for all customers and all products
- Credible assistance and expert consultation on all emissions related equipment in a test cell

CUSTOMERS, APPLICATIONS & REGULATIONS

The BG® is a workhorse in emissions research and certification applications throughout the world. Aftertreatment and oil additive suppliers as well as automotive, on-road/off-road light & heavy duty diesel, motorcycle, locomotive, airplane, and marine engine & vehicle manufacturers depend on the Model BG-3.

Customers

- On-road/off-road light and heavy-duty engine & vehicle manufacturers
- Small engine, automotive and motorcycle manufacturers
- Locomotive and marine engine & vehicle manufacturers
- After treatment, oil & additive suppliers
- Universities and Government

Applications & Regulations

- Stationary Certification
- Steady-State
- Transient Certification
- Transient Engine Development
- ISO-16183
- ISO 8178
- EPA CFR 1065
- ETC (European Transient Cycle)