

LATEST DEVELOPMENTS IN PARTICULATE MATTER MEASUREMENT

Horiba Engine Measurement Division

Mr. Les Hill

Mr. Rudolf Mörkl

HORIBA GmbH, Kaplanstrasse 5, A-3430 TULLN, AUSTRIA

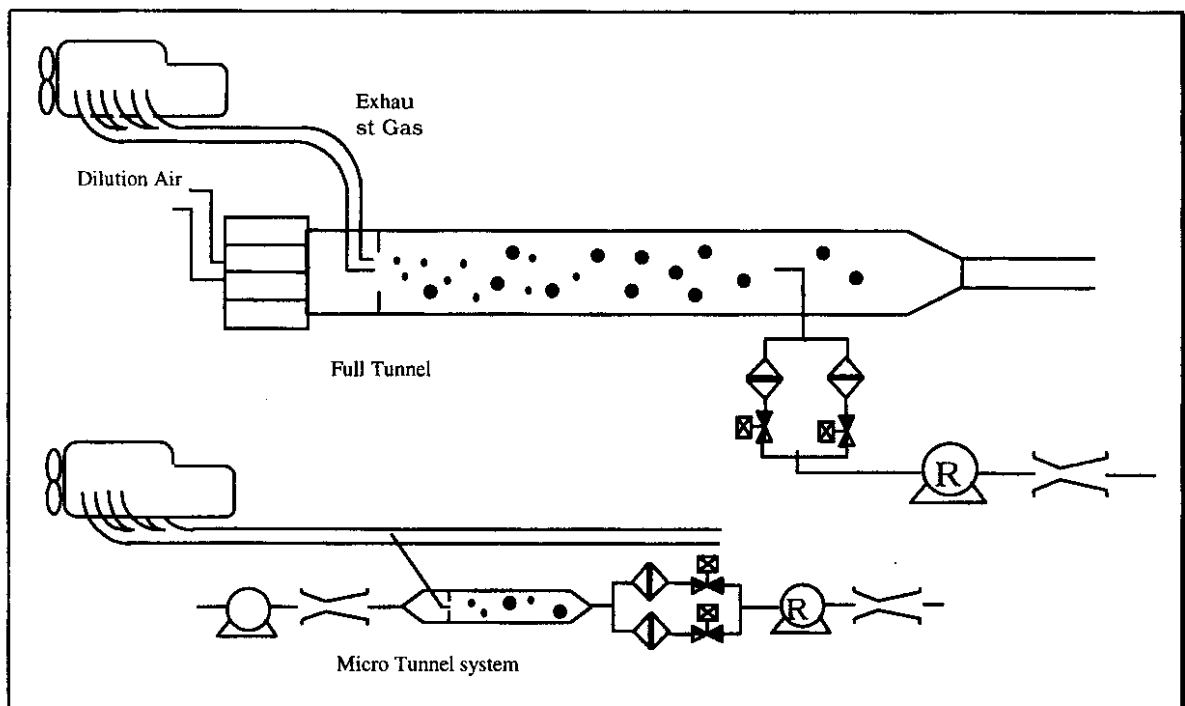
Tel.: + 43 2275 65225 , Fax: + 43 2275 65230

e-mail: moerkl@horiba.co.jp

MDLT-130X-T

A Partial Flow Dilution System For Particulate Measurements Under Transient Engine Operating Conditions

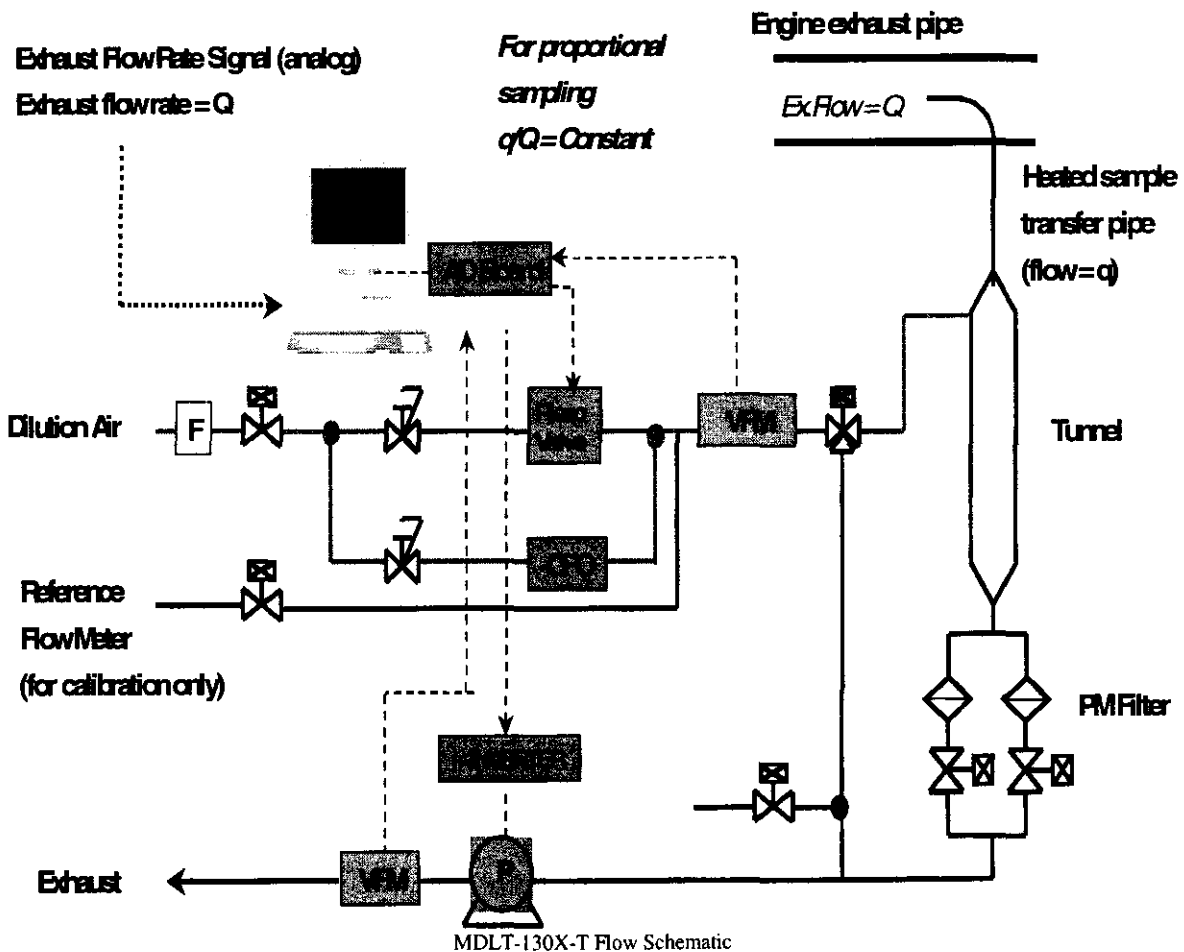
- The MDLT-130X-T is designed to meet the requirements of the new ISO regulations for Heavy Duty Diesel engine measurement currently under preparation. The regulations require the measurement of particulates under transient engine conditions. Existing legislation requires the use of full flow dilution systems for this measurement.
- The system operates as a partial flow dilution system, operating under flow proportional conditions controlled by exhaust flow rate signals from the engine test cell.



Conventional particulate measurement uses the full flow dilution tunnel. The MDLT measures particulate by diluting part of the exhaust flow. The volume of exhaust transferred from the exhaust is proportional to the total engine exhaust flow rate.

There are two basic requirements for the partial flow dilution system

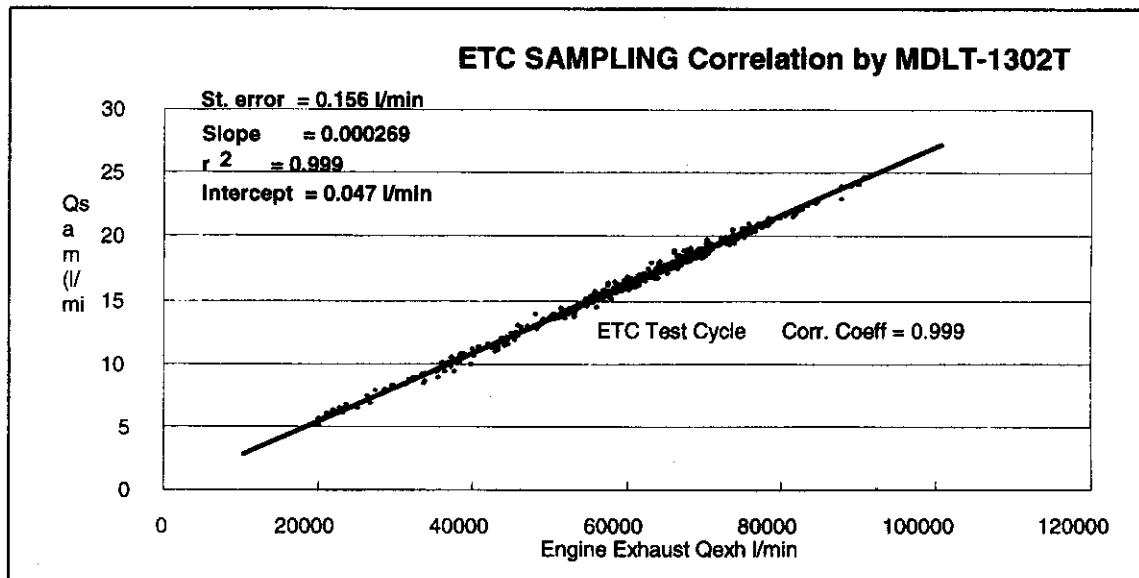
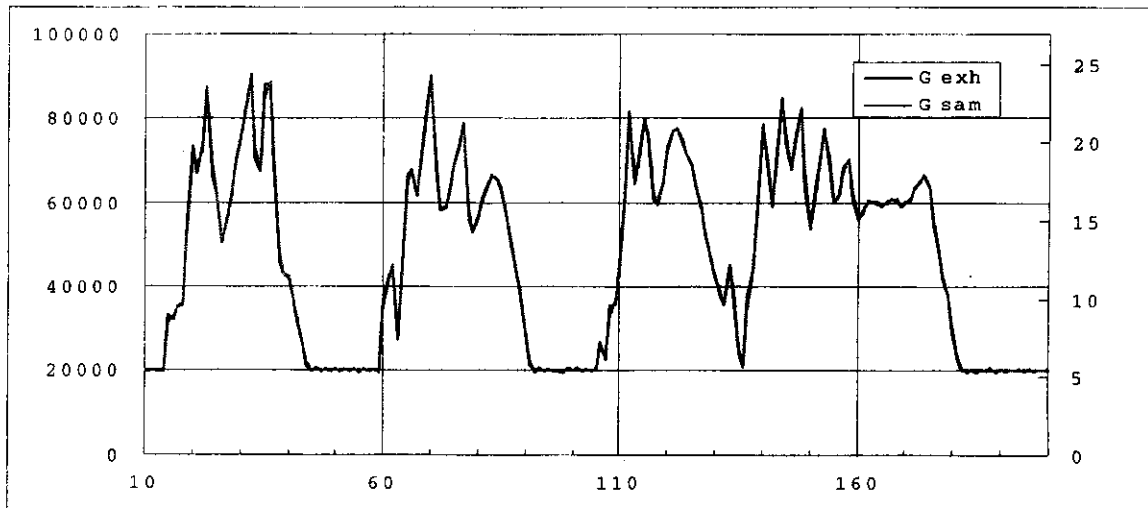
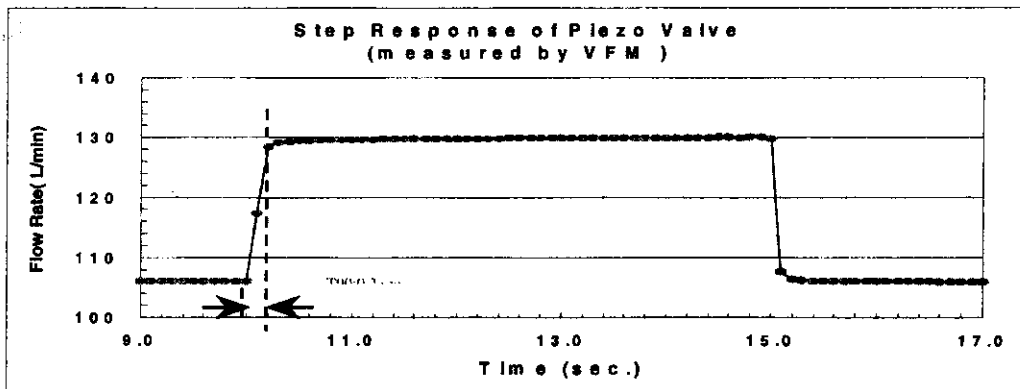
- Measurement and control of the proportion of engine exhaust taken for dilution. Methods include :
 - physical exhaust splitters
 - iso-kinetic flow sampling using sample probe pressure balancing
 - exhaust flow measurement or calculation controlling variable flow dilution systems (such as MDLT-130X-T)
- Transfer of exhaust sample with the minimum possible loss of particulate material (keep transfer line smooth, short, straight and high temperature)



Dilution Air Flow Control For Transient Testing

- For transient testing, the speed of the dilution air flow control needs to be controlled quickly to maintain proportional sampling.
- The MDLT uses a fast response piezo-valve in combination with a CFO adjusted for the minimum dilution air flow

Example Data for ETC



MDLT-130X-T Feature Summary

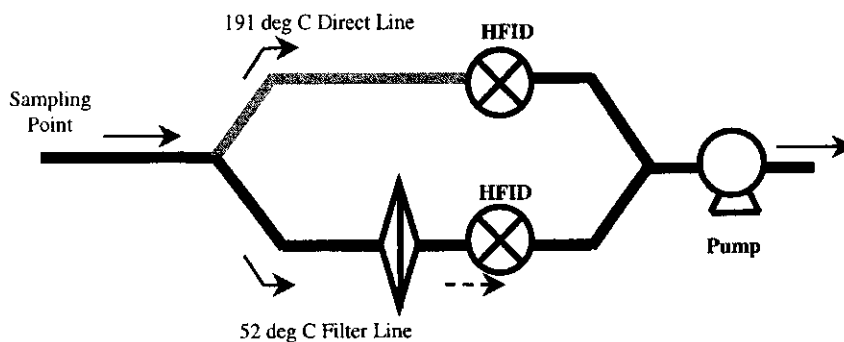
- Use of VFM (SAO) provides accurate, rapid flow rate measurement of diluted exhaust and dilution air flow rates
- Auto-calibration adjustment sequence maintains precision of the proportional sampling with minimal operator action
- Use of piezo-valve provides fast and accurate control of the dilution air flow rate for accurate proportional sampling on transient engine testing
- Exhaust flow “learning” routine can be used to improve the precision of the proportional sampling by applying “feed-forward” control
- MDLT-130X-T provides accurate proportional sampling from a real time exhaust flow measurement signal.

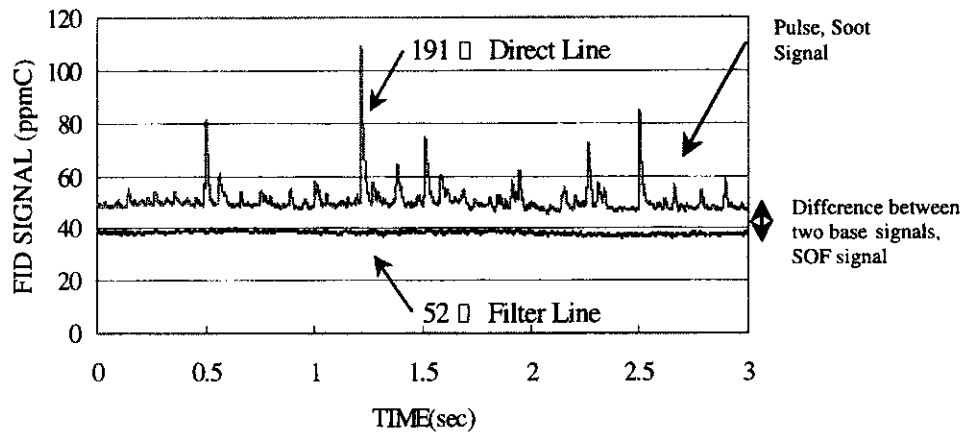
MEXA-1220PM Real-Time PM Analyzer

- Real-time PM measurement
Flame Ionized Detector(FID) is utilized to measure Soot and SOF(Soluble Organic Fraction) continuously.
- Soot, SOF separation measuring
Use of two different heated lines enables it to measure Soot and SOF separately.
- Gas sampling from direct engine line or diluted tunnel line
Particularly, direct gas sampling is more effective in developing engine system.

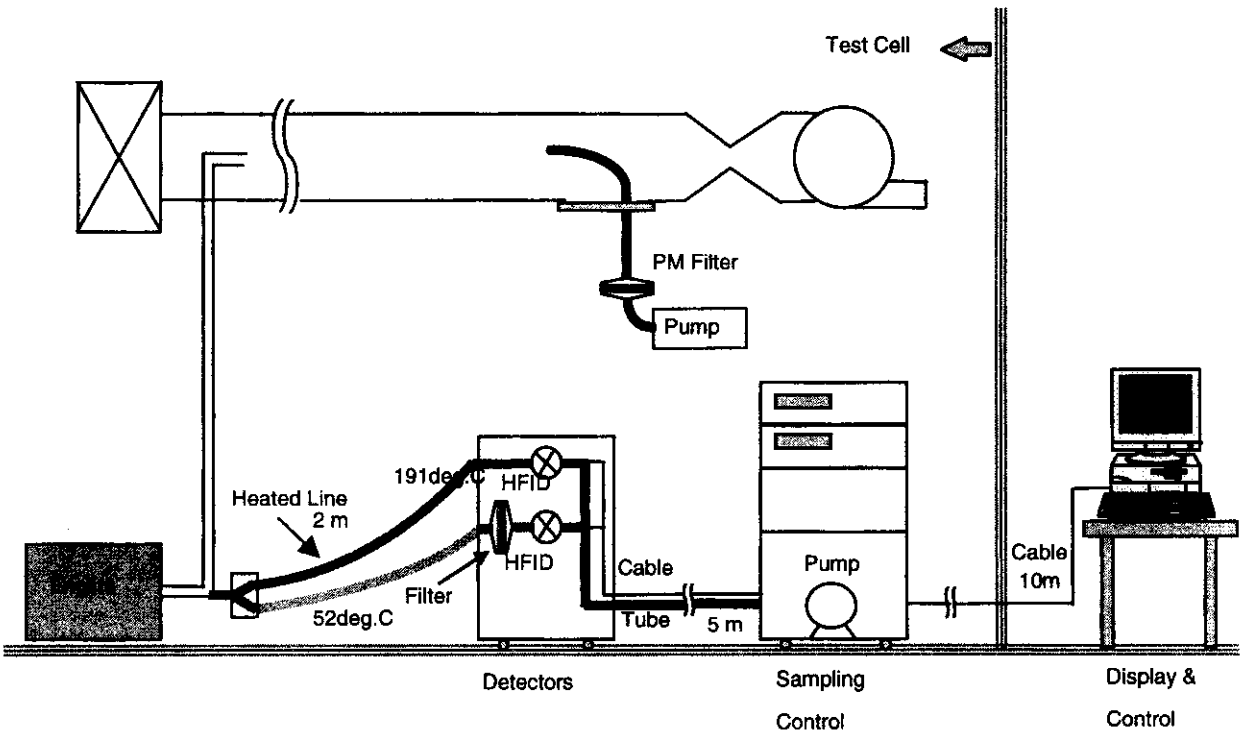


Principal of SOF (Soluble Organic Fraction) Measurement

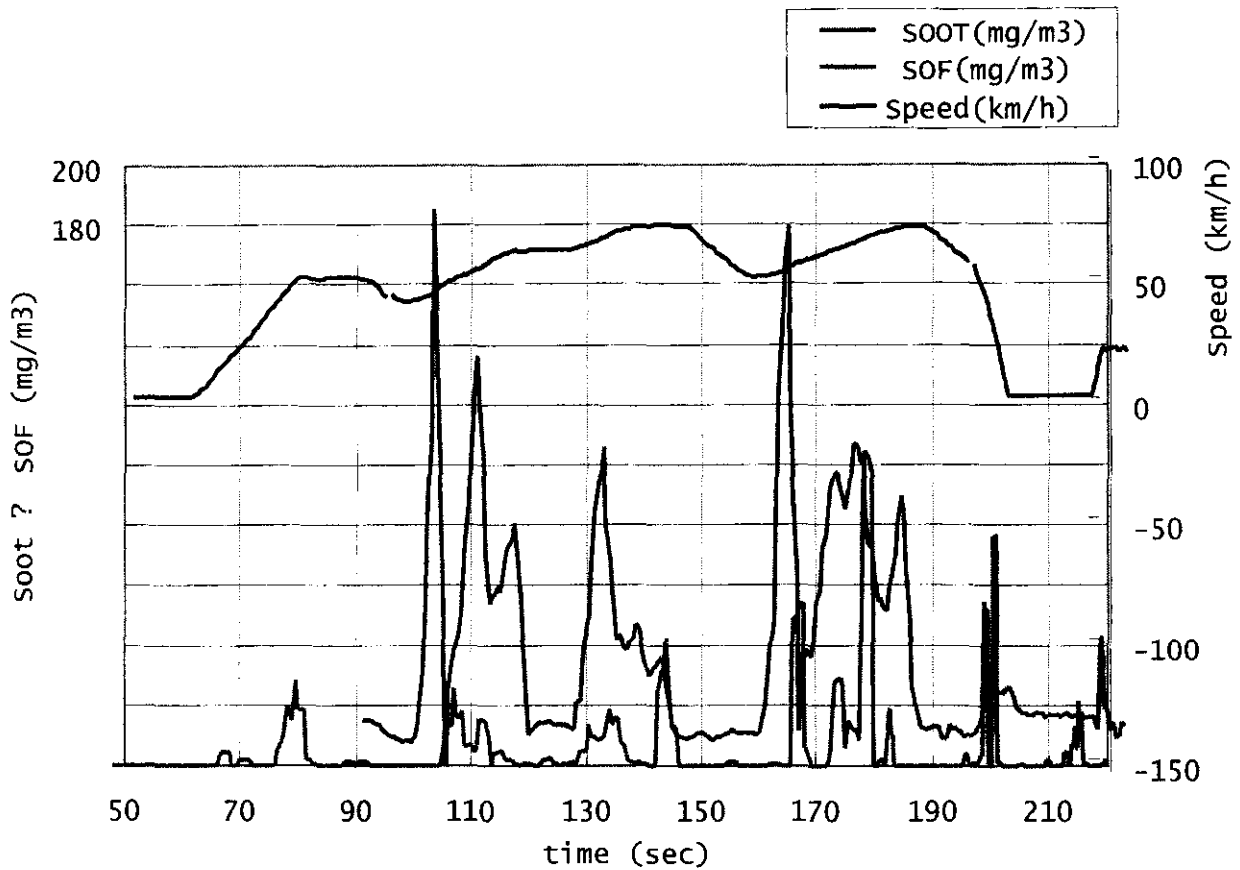




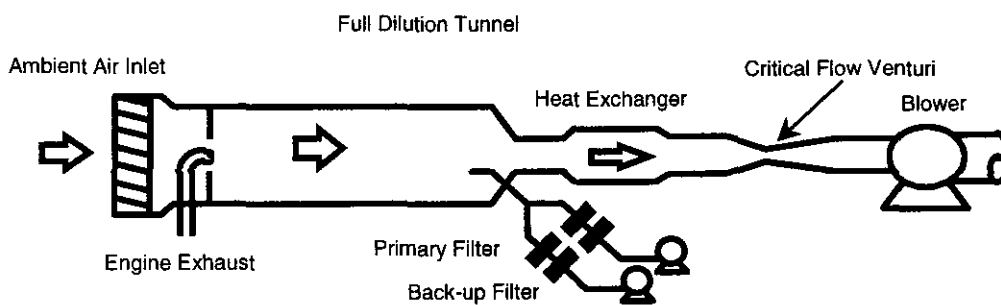
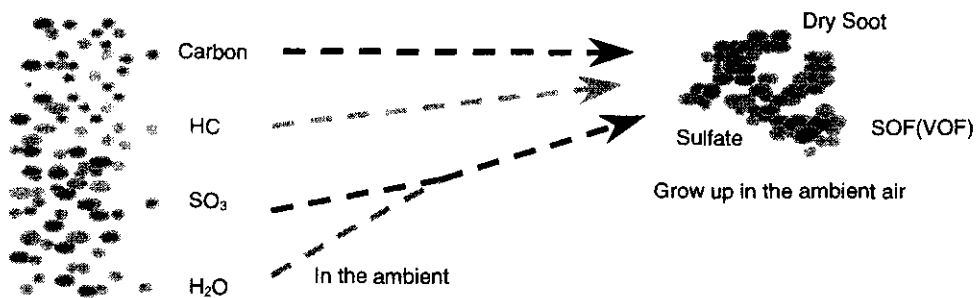
Setup for Direct Measurement



Example data for direct measurement



**Ultra Low Mass PM Analyzer
Oxidization & Deoxidization Method
MEXA-1370PM**



PM Mass = Filter Mass After Sampling - Filter Mass Before Sampling



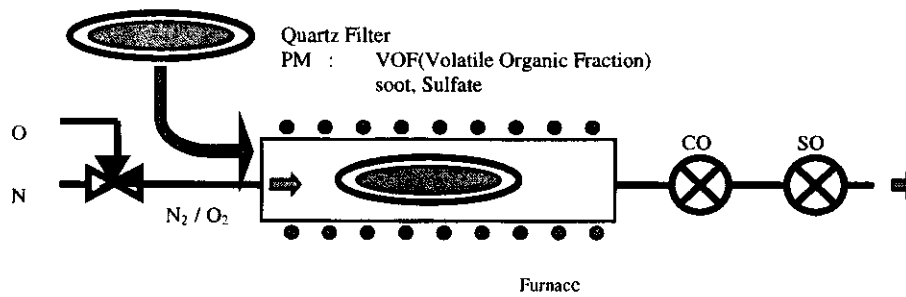
Problem of the Filter Weighing:

- **Light PM on Heavy Filter**
 70 mm Filter: 200 mg
 Particulate: 0.2 mg
 Particulate: Filter = 1 : 1.000
 The error of the filter weighing will cause very large error for the particulate mass measurement
- **Need to know SOF(VOF), Soot and Sulfate contents**
 for analysis of engine combustion
 for catalyst converter or particulate trap developing

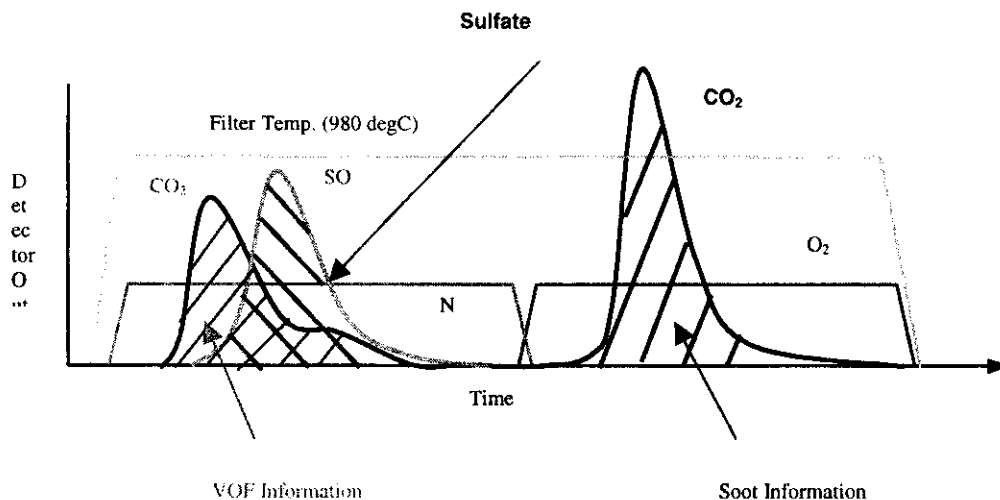
What is needed for the alternatives ?

- Dilution tunnel is still necessary;
- to represent the actual atmospheric dilution process
- to convert gas to particle
- to correlate PM measurement with the conventional method
- High Sensitivity
- Easy handling
- SOF(VOF), Soot and Sulfate Measurement
- for the development and the improvement of diesel engine and the after treatment systems

Principle of MEXA-1370PM



VOF, soot and Sulfate Calculation I



1. Fixed Volume Gas (CO_2 , SO_2) Calibration
Known mass. Integration of gas detector output
2. Generated CO_2 & SO_2 mass Measurement
3. Determination of VOF, soot and sulfate using the mass relations

- **There is very strong correlation between MEXA-1370PM and gravimetric method even for low PM mass.**
- **SOF(VOF), soot and sulfate mass analysis in 4 minutes is available.**

MEXA1370PM has the ability to become an alternative method for conventional gravimetric method.

