

## Flow Rate Correction for the Model 3790 Engine Exhaust Condensation Particle Counter (EECPC)

Application Note EECPC-001

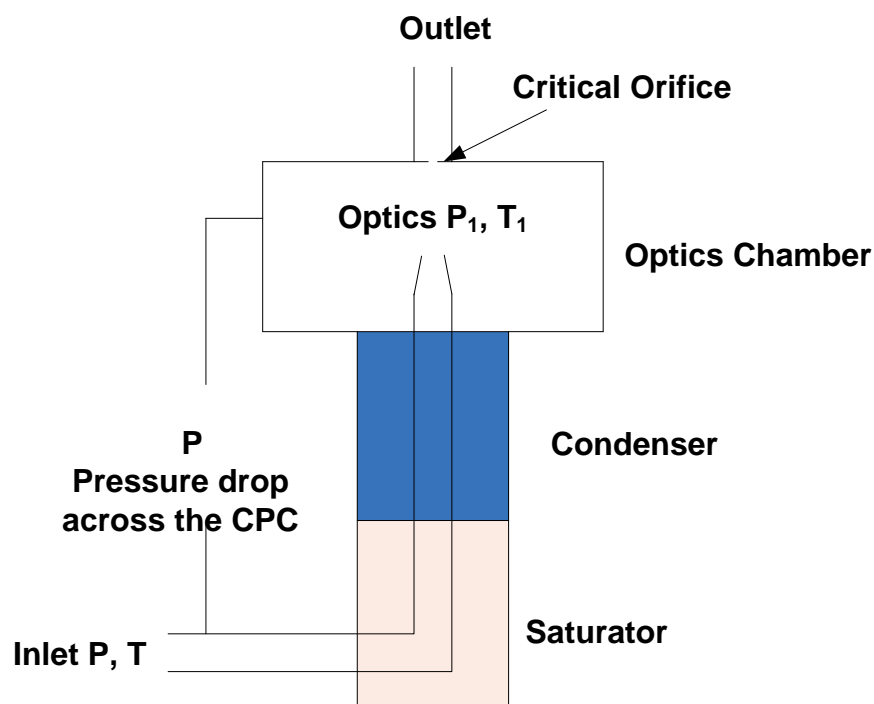
**Xiaoliang Wang**

TSI Incorporated, Particle Instruments,  
500 Cardigan Road, Shoreview, MN 55126, USA

**Hans-Georg Horn**

TSI GmbH, Particle Instruments,  
Neuköllner Str. 4, 52068 Aachen, Germany

(April 25, 2008)



The critical orifice in the Engine Exhaust Condensation Particle Counter (EECPC) is selected such that the inlet flow is 1 lpm at TSI standard conditions ( $T_0=294.3$  K and  $P_0=101.3$  kPa) when the EECPC is warmed up ( $T_1 = 313.2$  K). Typically the pressure drop from inlet to the nozzle outlet is 2.3 kPa. Therefore at TSI standard condition, the pressure upstream the critical orifice is  $P_0=101.3 - 2.3 = 99.0$  kPa, and the temperature upstream of the orifice is  $T_1 = 313.2$  K (optics temperature).

Next we calculate the volumetric flow rate at the critical orifice inlet, when the EECPC inlet conditions are  $T_0=294.3$  K and  $P_0=101.3$  kPa. Because the mass flow rate at the inlet is the same as that at the orifice  $Q_1$ , we have

$$1 \times \frac{P_0}{T_0} = Q_1 \times \frac{P_0 - \Delta P}{T_1}$$

$$\text{Then } Q_1 = 1 \times \frac{P_0}{T_0} \times \frac{T_1}{P_0 - \Delta P} = 1 \times \frac{101.3}{294.3} \times \frac{313.2}{99.0} = 1.089 \text{ lpm}$$

This is the volumetric flow rate set by the orifice, which ideally will always be constant, independent of EECPC inlet temperature and pressure.

When the EECPC inlet pressure and temperature change to  $P$  and  $T$ , the volumetric flow rate at the orifice is still 1.089 lpm, but the volumetric flow rate at the EECPC inlet will change slightly. Again, according to constant mass flow rate, we can calculate the inlet volumetric flow rate as

$$Q \times \frac{P}{T} = Q_1 \times \frac{P_0 - \Delta P}{T_1}$$

$$\text{Then } Q = Q_1 \times \frac{P_0 - \Delta P}{T_1} \times \frac{T}{P} = 1 \times \frac{P_0}{T_0} \times \frac{T_1}{P_0 - \Delta P} \times \frac{P - \Delta P}{T_1} \times \frac{T}{P} = 1 \times \frac{P - \Delta P}{P_0 - \Delta P} \times \frac{T}{T_0} \times \frac{P_0}{P}$$

The flow rate at standard conditions (273.2 K and 101.33 kPa) is then

$$Q_{std} = 1 \times \frac{P - \Delta P}{P_0 - \Delta P} \times \frac{T}{T_0} \times \frac{P_0}{P} \times \frac{P}{T} \times \frac{T_{std}}{P_{std}} = 1 \times \frac{P - \Delta P}{P_0 - \Delta P} \times \frac{P_0}{T_0} \times \frac{T_{std}}{P_{std}}$$

In summary, when the EECPC inlet pressure is  $P$  and temperature  $T$ , the **volumetric flow rate** at the inlet is

$$Q(\text{lpm}) = 1 \times \frac{P - \Delta P}{P_0 - \Delta P} \times \frac{T}{T_0} \times \frac{P_0}{P}$$

and the **flow rate at standard conditions** (273.2 K and 101.33 kPa) is

$$Q_{std}(\text{slpm}) = 1 \times \frac{P - \Delta P}{P_0 - \Delta P} \times \frac{P_0}{T_0} \times \frac{T_{std}}{P_{std}}$$

where  $P_0 = 101.3$  kPa,  $T_0=294.3$  K,  $P_{std} = 101.33$  kPa,  $T_{std}=273.2$  K, "  $P$  is the nozzle pressure which can be read from the EECPC.

Note that "  $P$  is relatively small compared to  $P$  or  $P_0$  in most cases. Then the volumetric flow rate is independent of the inlet pressure, but proportional to the inlet temperature. The standard flow rate, on the other hand, is proportional to the inlet pressure, but independent of the inlet temperature because the optics temperature is constant.

---

TSI Incorporated – 500 Cardigan Road, Shoreview, MN 55126 U.S.A

USA	Tel: +1 800 874 2811	E-mail: <a href="mailto:particle@tsi.com">particle@tsi.com</a>	Website: <a href="http://www.tsi.com">www.tsi.com</a>
UK	Tel: +44 149 4 459200	E-mail: <a href="mailto:tsiuk@tsi.com">tsiuk@tsi.com</a>	Website: <a href="http://www.tsiinc.co.uk">www.tsiinc.co.uk</a>
France	Tel: +33 491 11 87 64	E-mail: <a href="mailto:tsifrance@tsi.com">tsifrance@tsi.com</a>	Website: <a href="http://www.tsiinc.fr">www.tsiinc.fr</a>
Germany	Tel: +49 241 523030	E-mail: <a href="mailto:tsigmbh@tsi.com">tsigmbh@tsi.com</a>	Website: <a href="http://www.tsiinc.de">www.tsiinc.de</a>
India	Tel: +91 80 41132470	E-mail: <a href="mailto:tsi-india@tsi.com">tsi-india@tsi.com</a>	
China	Tel: +86 10 8251 6588	E-mail: <a href="mailto:tsibeijing@tsi.com">tsibeijing@tsi.com</a>	
Singapore	Tel: +65 6595 6388	E-mail: <a href="mailto:tsi-singapore@tsi.com">tsi-singapore@tsi.com</a>	



TRUST. SCIENCE. INNOVATION.

Contact your local TSI Distributor or visit our website [www.tsi.com](http://www.tsi.com) for more detailed specifications.