EMERY OIL REMOVAL EFFICIENCY

APPLICATION NOTE CI-00070

Background

The Catalytic Stripper (hereon CS) is a vital component of a highly efficient Volatile Particle Remover (VPR) system (shown in the diagram below). Typically, the CS is placed between a two-stage (hot and cold) dilution system, to remove any non-solid particles and gas-phase hydrocarbons. The first dilution stage operates between 150 – 400 °C ±10 °C, and dilutes by a factor of at least 10. The sample then enters the CS whereby semi volatile organic compounds (SVOCs) in the aerosol and gaseous phase are converted into CO_2 and H_2O. Solid particles (e.g. fractal aggregates such as soot) remain unchanged and pass through the CS into the optional second dilution stage, typically operated at ≤ 35ºC, then the sample passes through to the Particulate Number Counter (PNC).

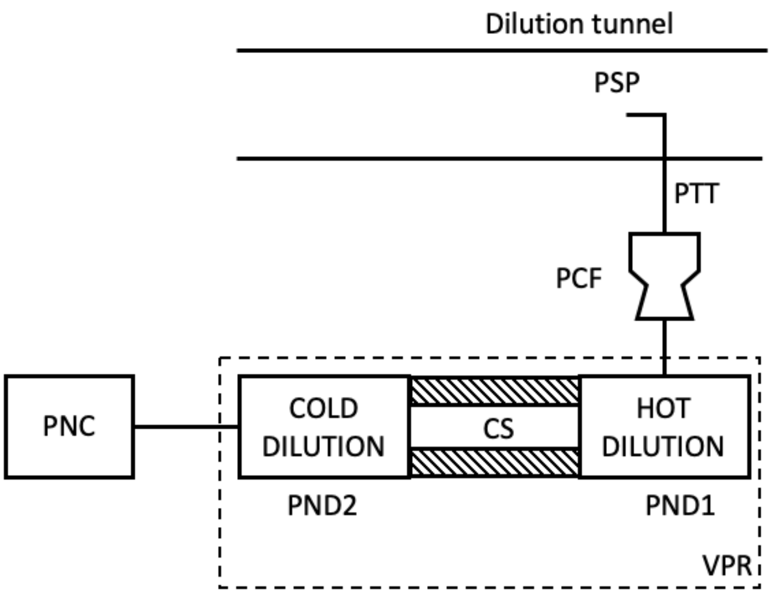

Figure 1: Schematic of the dilution tunnel measurement system in the PMP protocol

Acronym	Definition	Acronym	Definition
PSP	Particle Sampling Probe	VPR	Volatile Particle Remover
PTT	Particle Transfer Tube	PNC	Particle Number Counter
PCF	Particle pre-classifier	CS	Catalytic Stripper
PND	Particle Number Diluter	PND2	Particle Number Diluter 2

It is common to validate the effectiveness of the VPR system by examining the removal efficiency of a single semi-volatile species in a defined mass/size range. The Particle Measurement Programme (PMP) states that a VPR must achieve a > 99.0 % vaporization of 30 nm tetracontane ($CH_3(CH_2)_{38}CH_3$) particles, with an inlet concentration of ≥ 10,000 per cm^3, by means of heating and reduction of partial pressures of the tetracontane. Further, future PMP legislation is likely to include an additional challenge of > 99% removal efficiency of polydisperse alkane (e.g. Eicosane, decane or higher) or emery oil with count median diameter > 50 nm and mass > 1 mg/m^3.

Here, we show the removal efficiency of Emery Oil in the CS015 (1.5 L/min) unit.

***Note**: the PMP standard dictates the removal efficiency is for the **VPR system as a whole**, and thus will be [even] higher than the results we show here for the undiluted CS.*

Experimental Setup

The experimental apparatus is shown below. Emery oil was diluted in n-propanol at ~100 ppm in one instance, and ~1000 ppm in a second instance, to generate larger particles. Excess n-propanol was removed with an adsorbent before being diluted to create a sufficiently concentrated, steady, aerosol flow of 1.5 L/min.

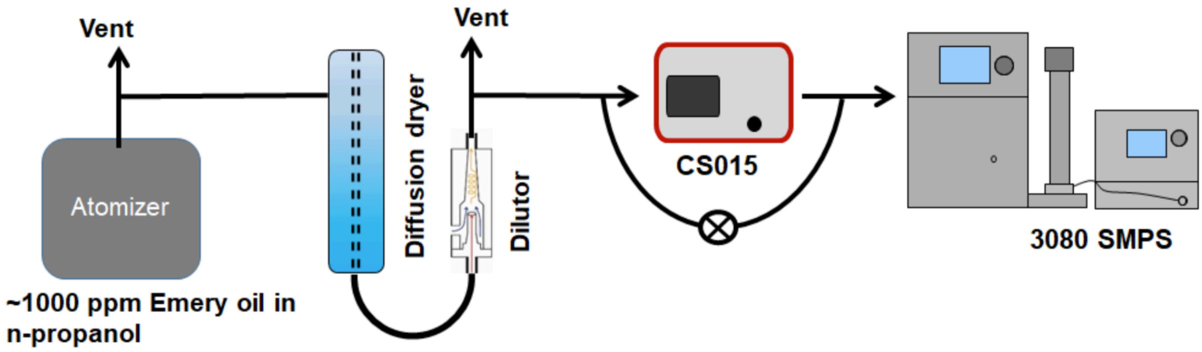

Figure 2: Schematic of the experimental setup

The Emery oil particles alternately passed through a CS015 (Catalytic Stripper with nominal flow rate of 1.5 L/min) and a bypass line, before the electrical mobility size distribution was measured by a TSI 3080 SMPS with long column DMA and 3776 CPC.

Results

The aerosol sample comprised a nominal concentration of 2.2×10^6 emery oil particles of geometric mean diameter 64nm as measured by the DMA. The electrical mobility diameter is the same as the GMD as the particles are spherical and electrical mobility measurement is independent of particle density.

Two different concentrations were measured to test the mass removal efficiency of the CS015. shown in Figure 3. The new PMP legislation is likely to include: "> 99% removal efficiency of polydisperse alkane (e.g. Eicosane, decane or higher) or emery oil with count median diameter > 50 nm and mass > 1 mg/m^3" for the VPR removal efficiency, *as a whole*. This means that the expected mass at the CS is 0.1 mg/m^3.

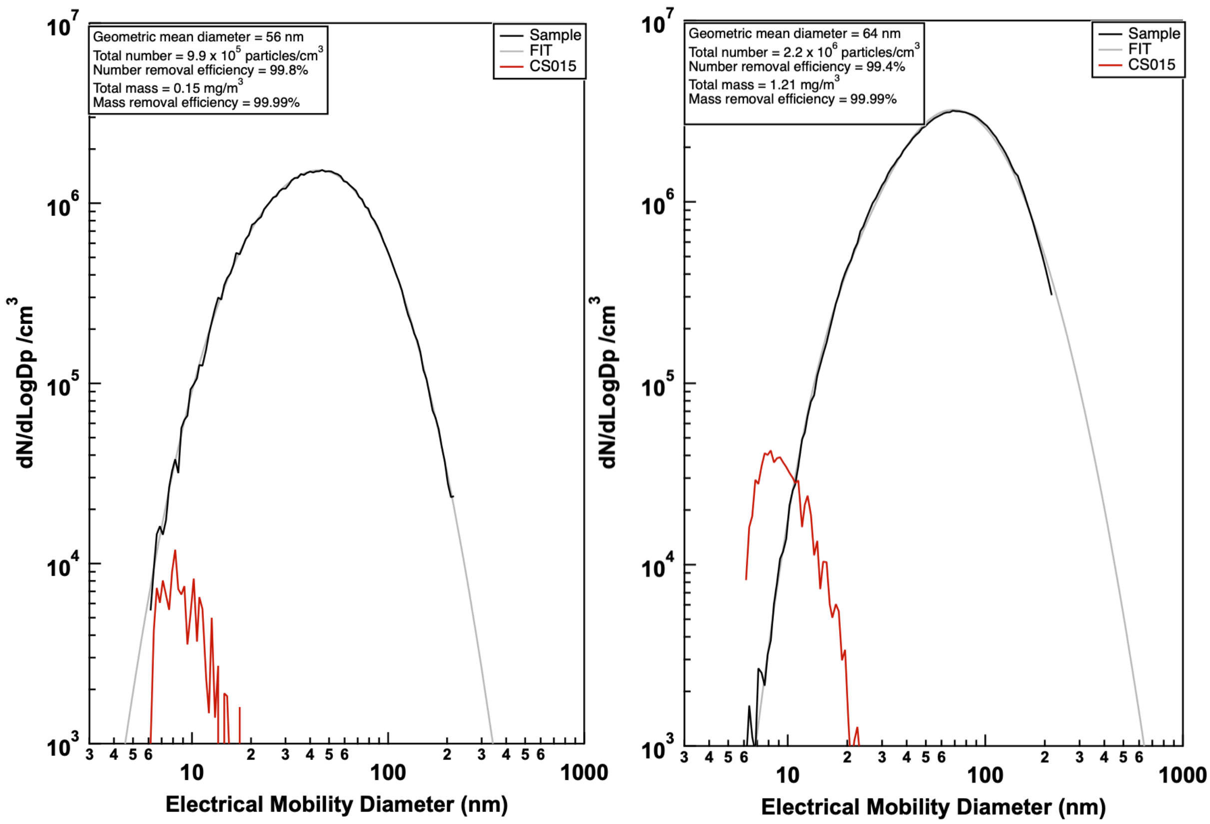

Figure 3: Aerosol size distributions as measured by the SMPS or the raw sample (black) and downstream of the CS (red) for low (left) and high (right) concentration Emery Oil samples. Note the log-log scale.

Summary

The results show that consistently, the CS removes over 99.99% by mass of the test aerosol. The number removal efficiency is also constantly over 99%. The “low” concentration experiment is directly applicable to the VPR test standard in the proposed PMP legislation. The “high” concentration test is that of the raw sample; i.e. if the primary dilutor failed or was not present. Further, a secondary dilution system would further increase the mass removal efficiency. Being as the CS passed *both* tests with over 99.99% mass removal efficiency, we can conclude that the CS is a very robust solution for use in a VPR system.

Further Reading

PMP legislation, documentation, and presentations:
https://wiki.unece.org/display/trans/PMP+50th+Session

References

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