INFLUENCE OF THERMODENUDER DIMENSIONS ON NANOPARTICLE MEASUREMENT

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7-42-27 Jindaiji-higashi-machi, Chofu, Tokyo 182-0012, JAPAN

Purpose of this study is to highlight the problems encountered during the use of thermodenuder (TD) for nanoparticle measurements and to suggest the respective solution. Though the thermodenuder influences both the solid and volatile particles, as a first report, only the effect of thermodenuder dimension on solid nanoparticle measurements is presented.

Slide 4 shows the photographs of nanoparticles produced in this solid particle genarate system, taken by a scanning electronic microscope. Left hand side figure shows the photograph of particles collected on ELPI's 7th impactor (615nm). Right hand side shows, the particles collected on a filter paper used in usual diesel particulate matter measurement. The left side frame shows that, many of the particles are accumulated in a manner similar to diesel particle.

Slide 9 shows a details of the absorption parts in two types of TD.

The two types of TD used in this study have the same dimensions for the heating part, but the absorption parts are different. The length of absorption part is 615 mm for TD-A type and 725 mm for TD-B type. The thickness of the charcoal filter of A type TD is 5 mm thicker than the B type having the filter thickness of about 12 mm. On the other hand the type A has a sample gas flow path area of about 12 cm^2 which is narrower than the B type having the flow path area of about 29 cm^2.

Slide 10 shows the shape of the flow gas impactors.

Its shows that, two types of TD have different configurations in the sample gas flow imapactor.

Type A has a cone shaped basket made of stainless steel mesh inside which the charcoal filter is filled up. Type B has similar shape but made directly from an aluminum block.

Slide 12 shows the nanoparticle concentrations measured with type-A and type-B TD having different configuration in the absorption part and without TD. Actually there exists some particle loss in the whole range of nanoparticle measurement while using both type-A and type-B TD. Especially the type-B TD shows a constant value of particle concentration within the particle size range of 29 nm to 164 nm, which is different from the sample gas particle distribution result measured without a TD. From the result it is clear that there always exist some loss of solid particles especially in case of type-B TD. The loss of small size particles is higher than the large size particles and therefore accurate measurement of nanoparticle distribution profile is difficult.

Slide 13 shows the comparison between two impactors used in two type-A TDs.

There is some loss of the large particles when the sample gas flow impactor was changed from stainless steel mesh to aluminum block. However, in this experiment no significant particle loss of smaller particles were observed. Hence, it can be said that the difference in flow impactor material is not mainly responsible for previously mentioned differences in measurement results between the type-A and type-B TD.

Next, we focus to the differences in charcoal filter thickness.

At the first stage an empty type TD was prepared by removing the charcoal filter from a type-A TD and tested. Slide 14 shows a comparative result of nanoparticle distribution between the empty type TD and without TD (ELPI only). The sample gas flow path area of the type-A TD increased by 2.5 times on removing the charcoal filter. The metal surface inside the TD was widely exposed. From this figure it is clear that the particle loss in the empty TD is significantly larger than the case of without TD. Especially the loss of the smaller particles were high as seen in the 1st-stage of the distribution graph where the particle size is 29 nm as central value.

In the next step, experiments were done with the empty TD and the type-A TD with charcoal filter. The results are shown in slide 15.

The result of empty TD also shows significant loss of smaller sizes in comparison with the normal TD. The peak of the particle distribution appears at the 1st stage (28 nm) for normal TD while it appears at the 2nd stage (56 nm) in case of the empty TD. The figure also shows that the particle loss by TD specially the loss of smaller particles having diameter less than 100 nm does not depend on the nanoparticles trap phenomena of the charcoal filter.

Slide 16 shows the comparison of thermophoresis effect between type-A and type-B TD.

At the early stage of TD nanoparticles are heated to 250°C and then flows to the absorption region of the TD. During this time a very high temperature gradient is produced between the high temperature sample gas and the low temperature wall of the absorption part of the TD. Type-B TD has sharper temperature gradient than the type-A TD, as can beseen in this figure. Therefore due to the thermophoretic effect particle loss can be high in type-B TD.

Slide 17 summarizes the conclusions drawn from this study.

The TD influences the nanoparticles that is loss of particles occurs even no volatile fractions exist in the sample gas. The loss occurs due to the sharp temperature gradient between the low temperature absorption part of TD and hot sample gas which causes thermophoresis effect.

In this study only the influence of TD on solid fraction of nanoparticle was attempted.

In future the influence of TD on volatile and semi-volatile particles will be considered. Especially TD influences the nuclei mode of particles which is thought to contain semi-volatile fraction. Therefore the particle loss mentioned in this study may contain the formation of nuclei mode of particles along with adhering on the TD wall. This will be considered in the next study.

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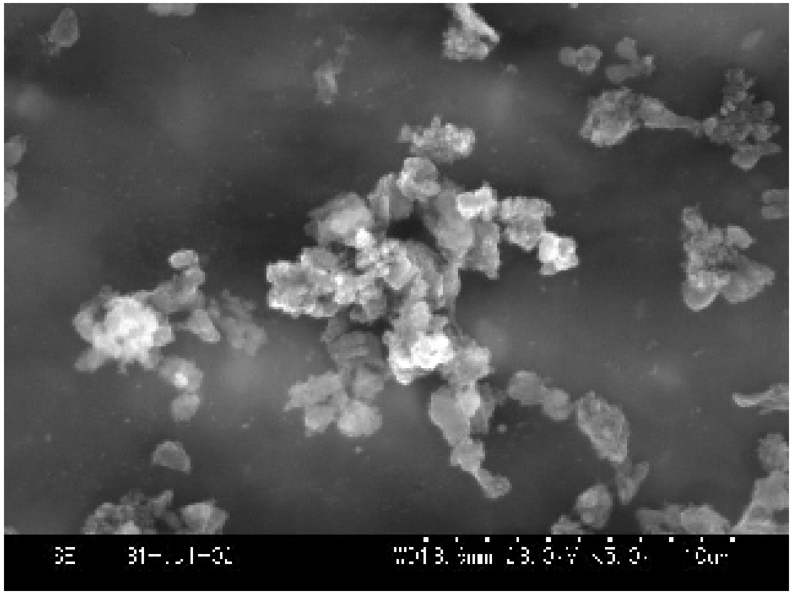
19. Aug. 2002
6th ETH Conference on Nanoparticle Measurement

Agenda

- 1.Introduction
- 2.Experimental Apparatus and Procedure
- 3.Experimental Result
- 4.Conclusions
- 5.in Future

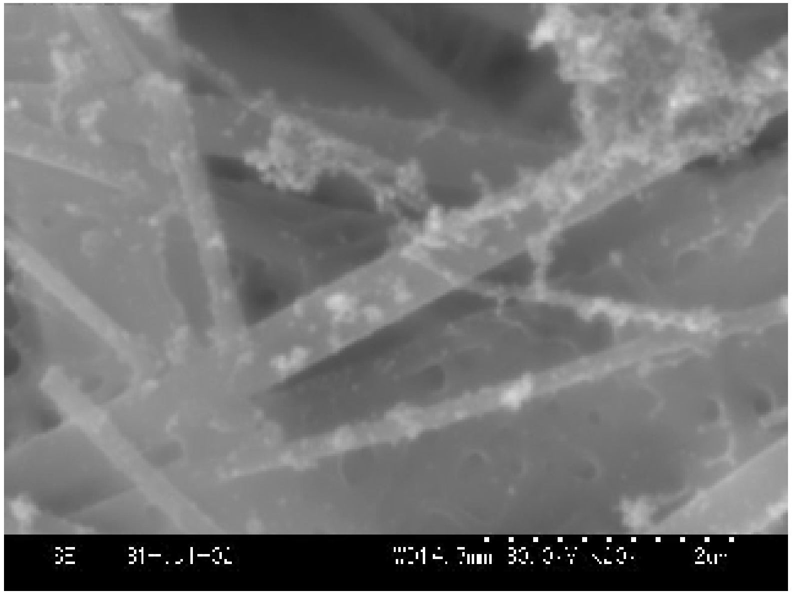
Carbon Particle Generator

SEM Photographs of Nanoparticles



Collected on ELPI's 7th Impactor

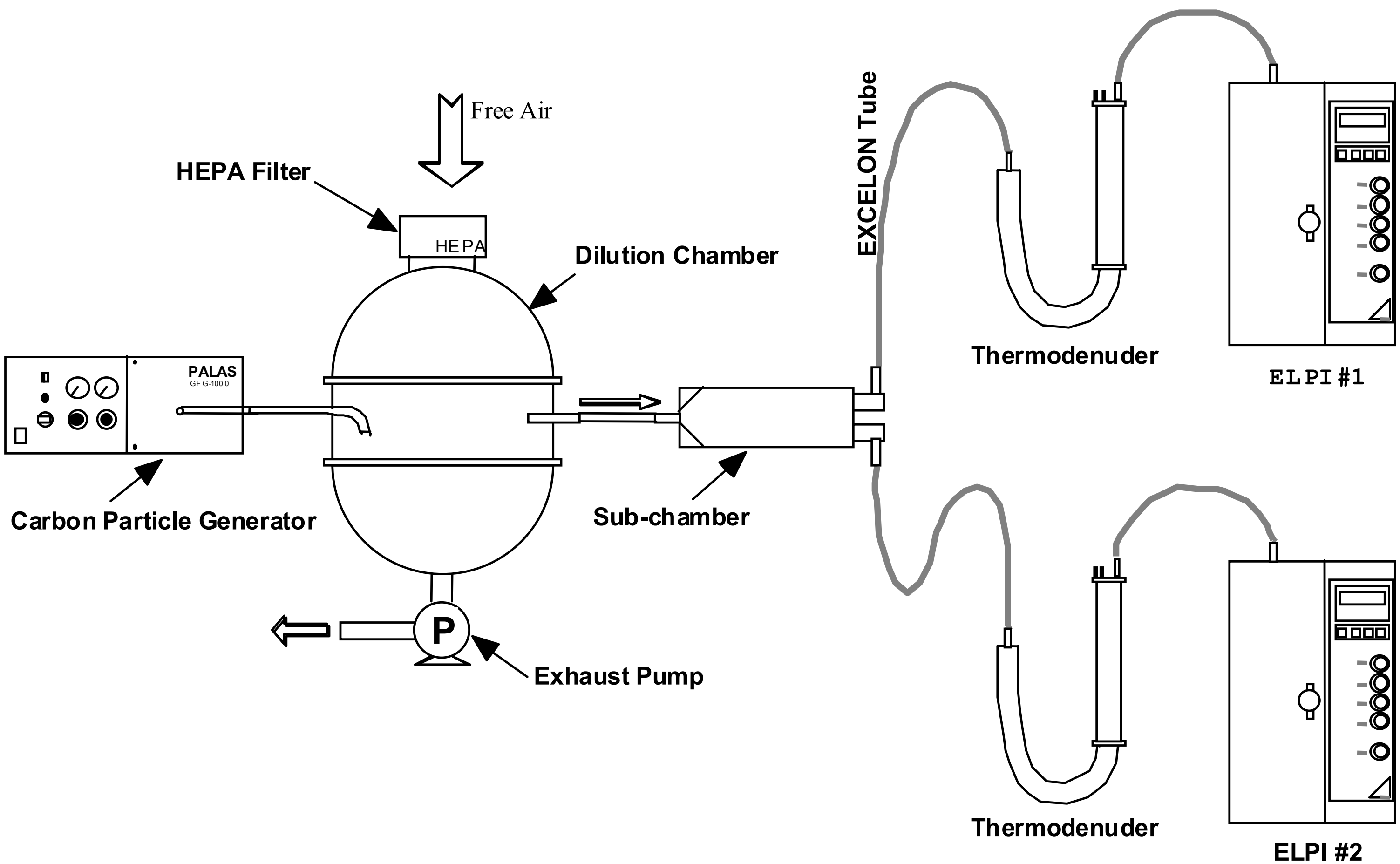
× 5000



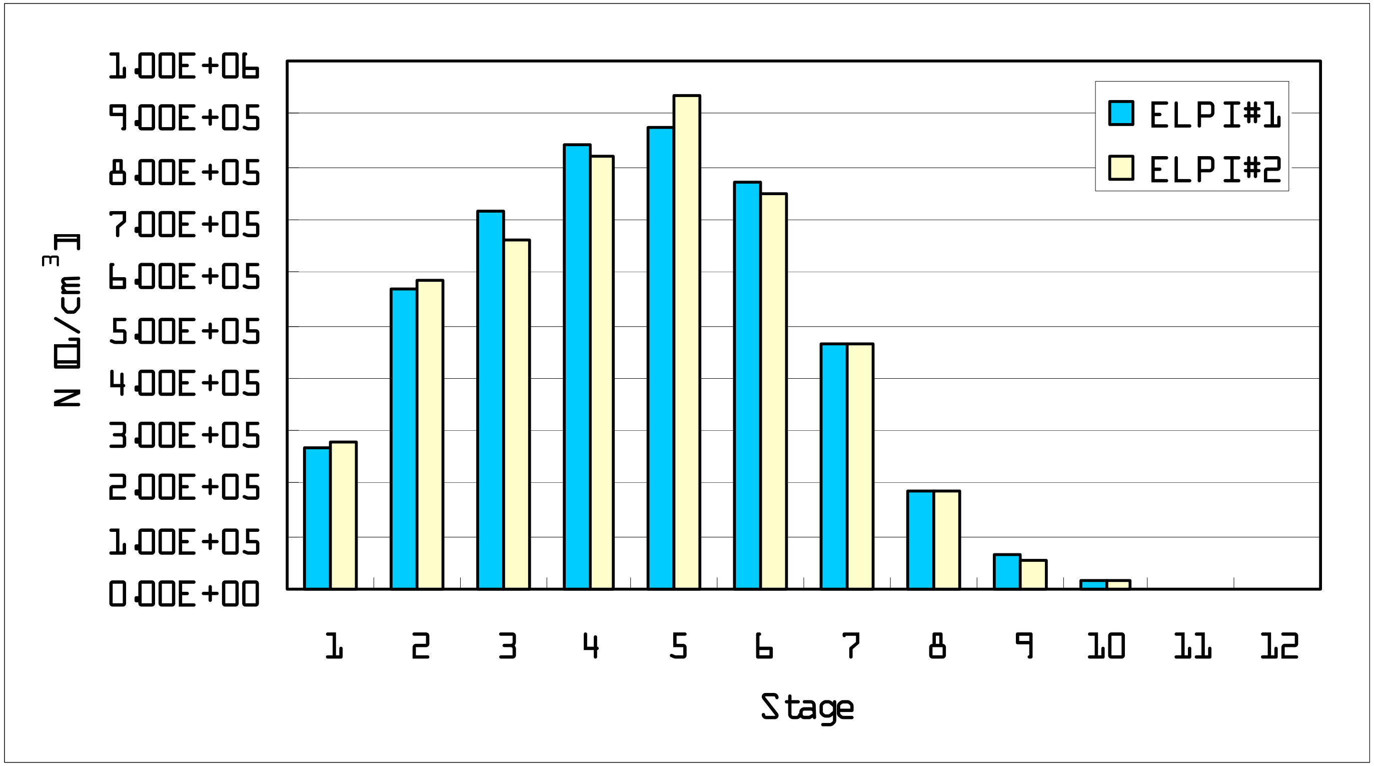
Collected on Filter

× 20000

Experimental Apparatus

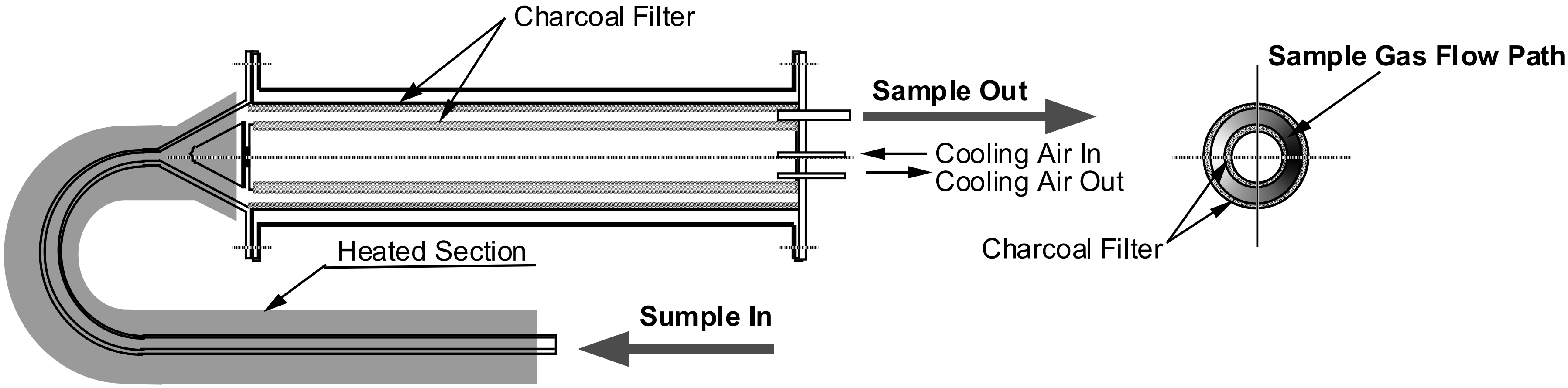


Comparison of Two ELPIs



Test Particle : DEHS (di-ethyl-hexyl-sebacate)
Concetration : 0.912 [g/cm^3]
Device : De Vilbiss nebulizer Model 1180

Internal Construction of TD

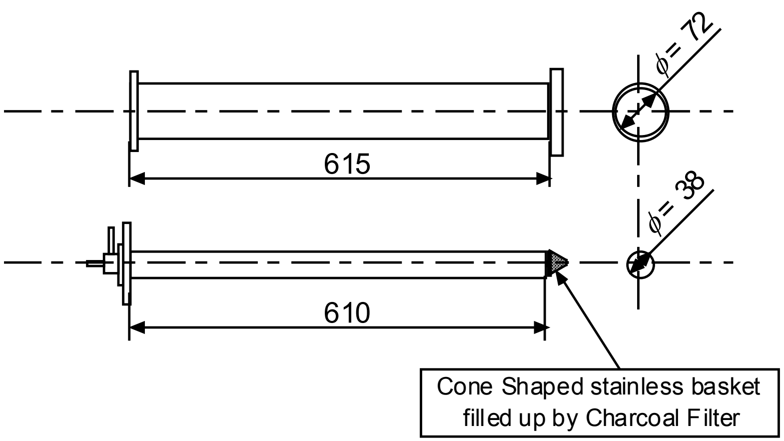


Two Type TDs

Appearance

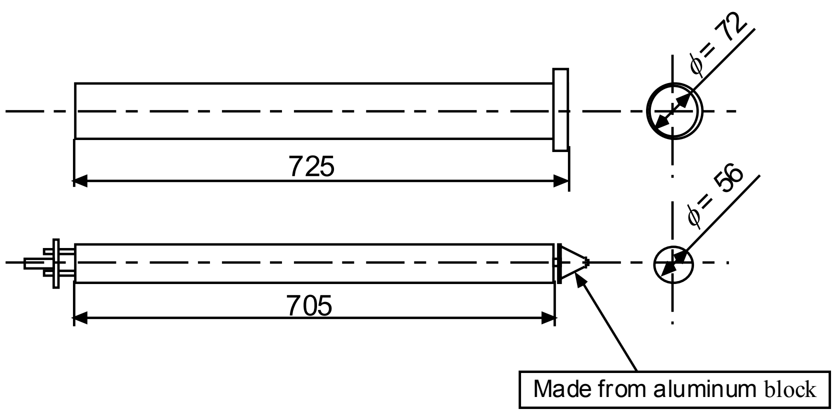
Parts Detail

Detail of Absorption Unit



Charcoal Filter Sheet t = 5.0 mm
Sample Gas Flow Path Area = 29 cm^2

TD-A type



Charcoal Filter Sheet t = 1.2 mm
Sample Gas Flow Path Area = 12 cm^2

TD-B type

Cone-shape Part of Sample Gas Impactor on two type TD

TD-A type

TD - B type

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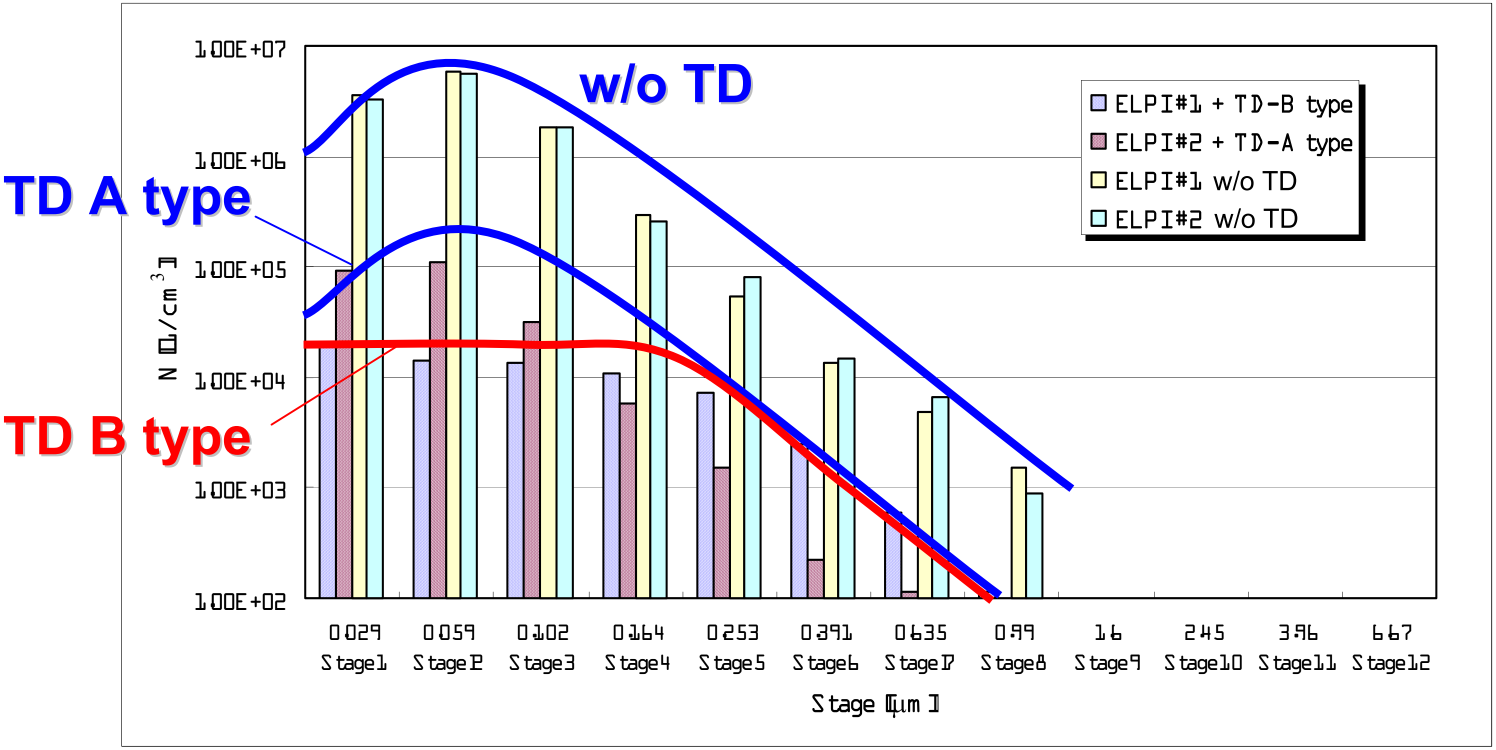
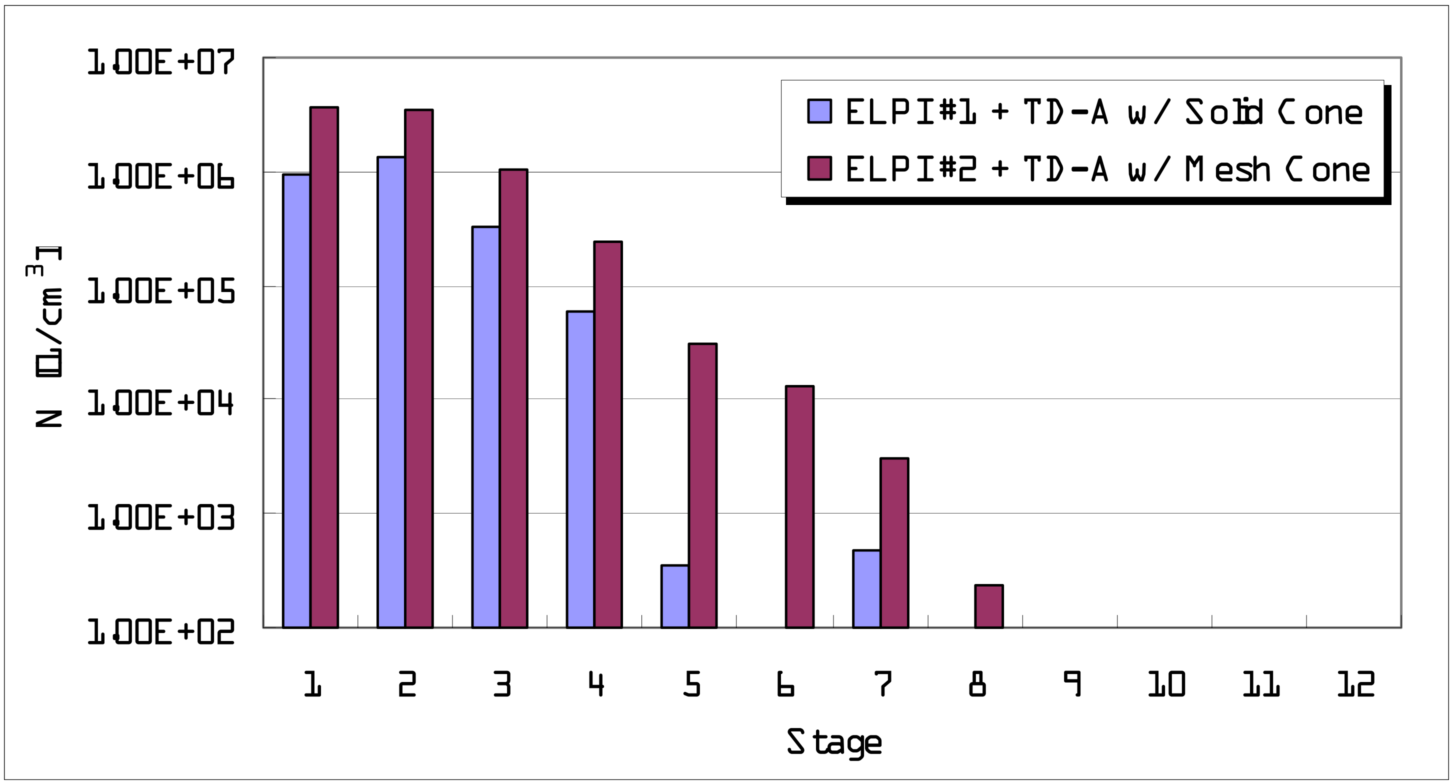
Influence of Two Types of TD

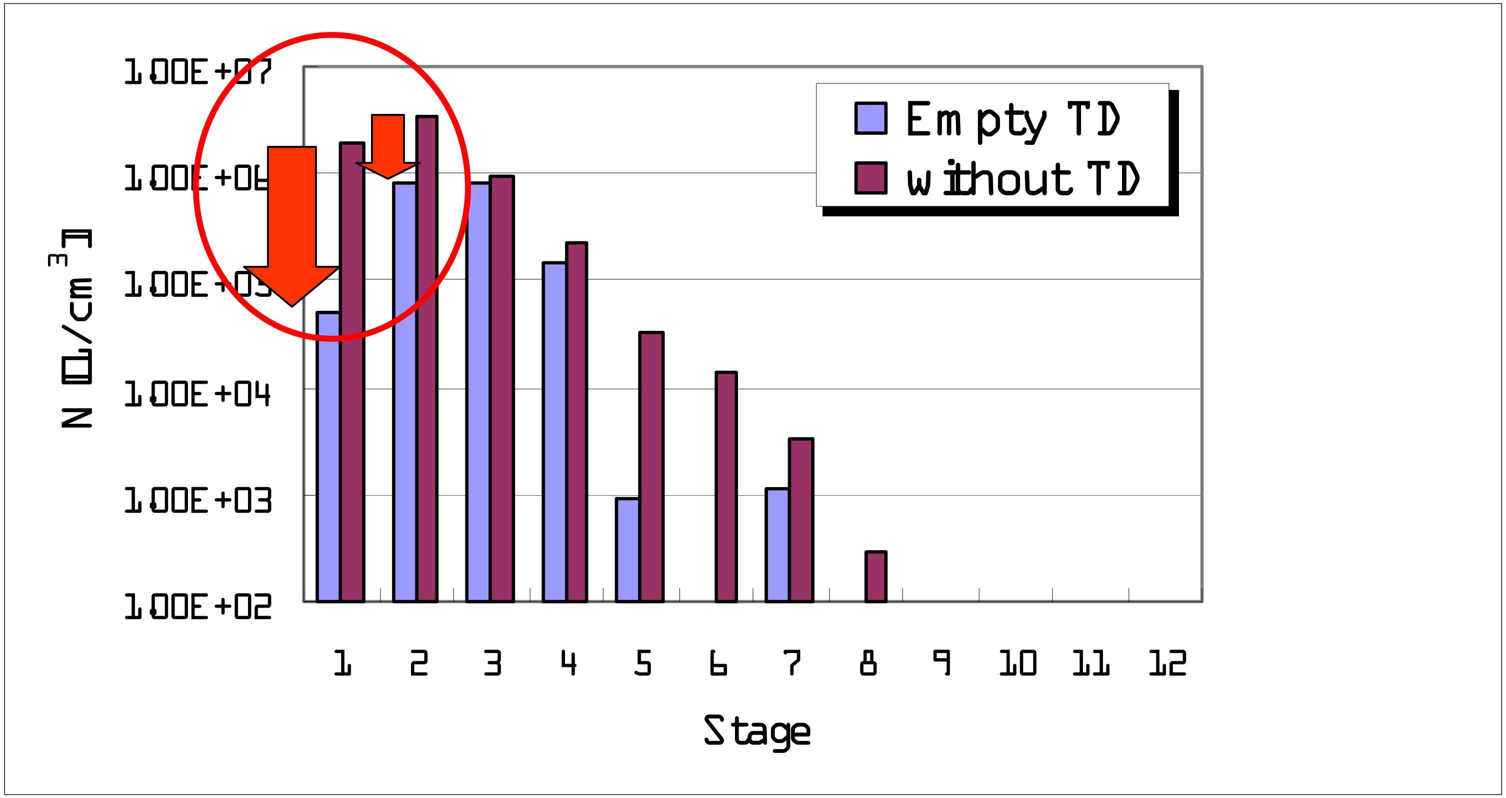


Effect from Differences of Sample Gas Flow Impactor

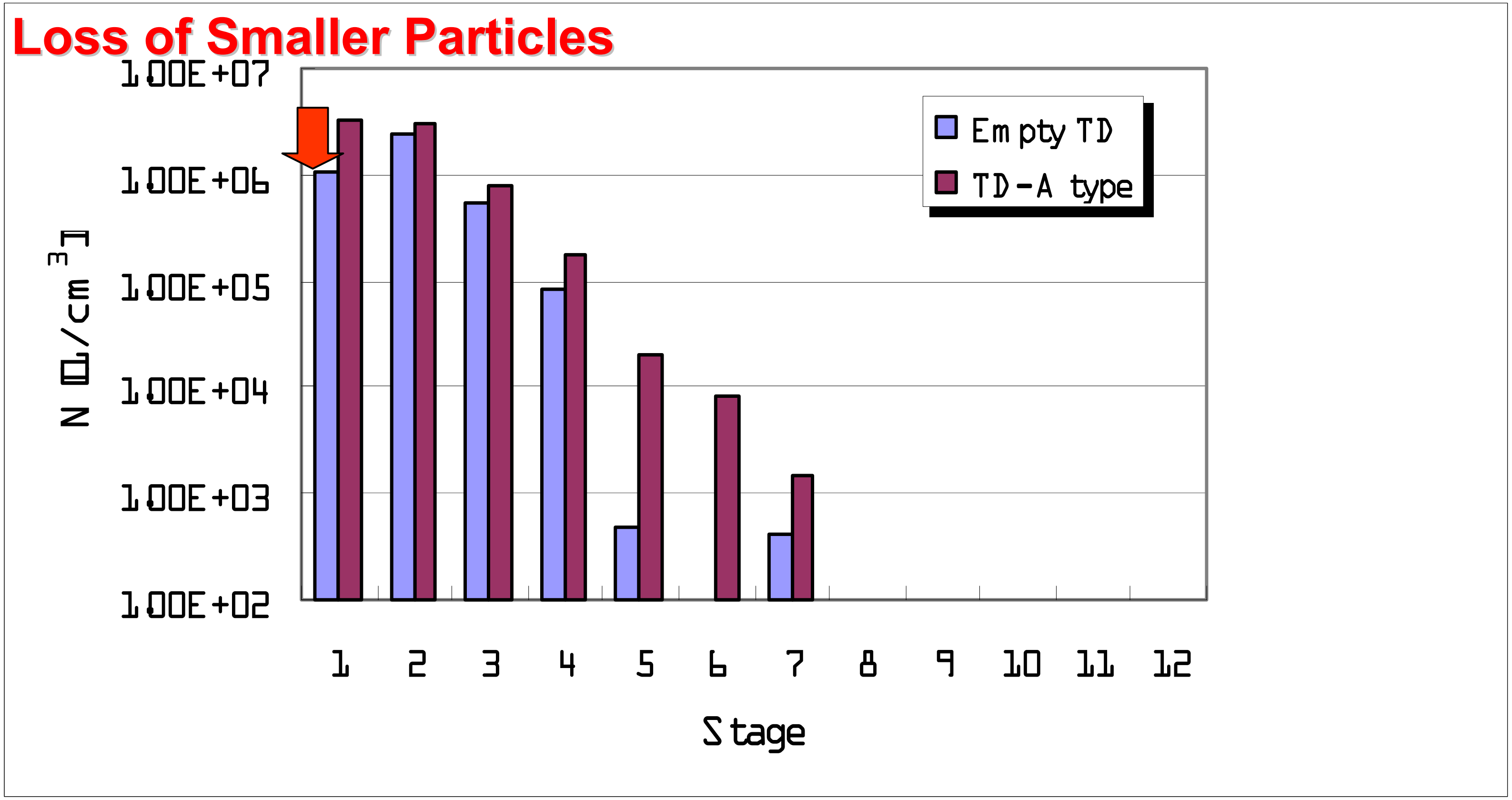


Comparison between ELPIs with Empty TD and without TD

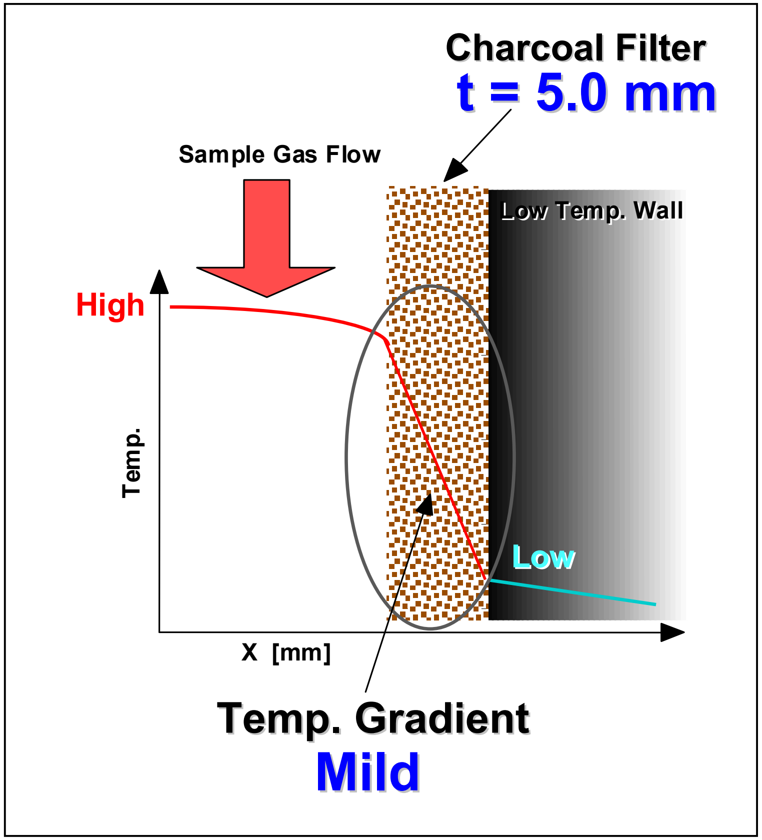
Particle Loss by Empty TD

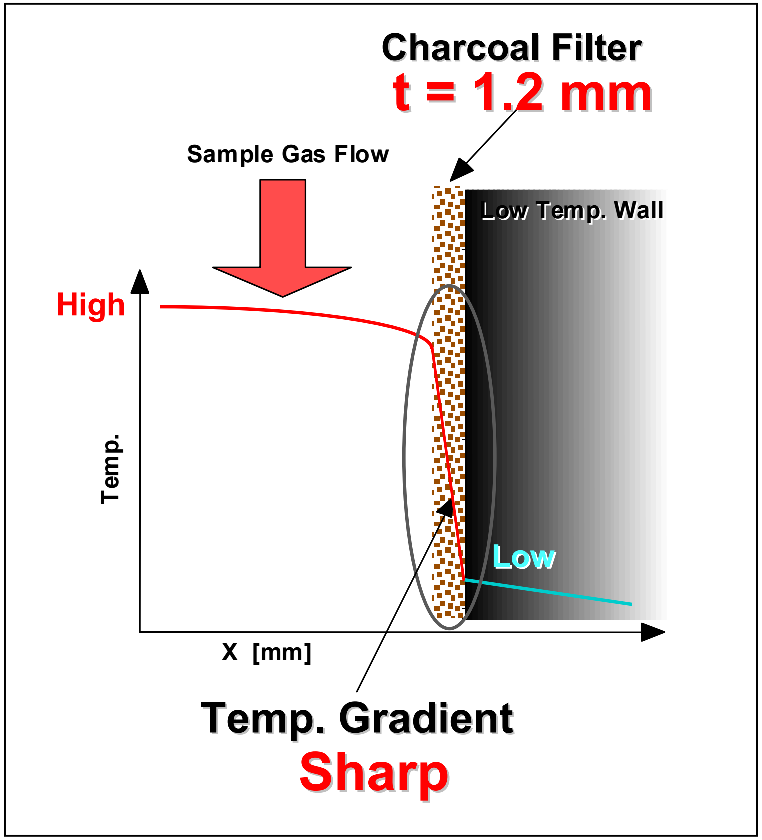


Comparison between ELPIs with Empty TD and Normal TD



Temperature Gradient





Type-A TD **Type-B TD**

4.Conclusions

- TD influences the nanoparticles i.e. loss of particles occurs **even no volatile fractions exist in the sample gas**.
- **A sharp temperature gradient between the low temperature absorption part of TD and hot sample gas causes particle losses due to thermophoresis effect.**
- Especially the smaller particles are trapped due sharp temperature gradient between the law temperature surface and hot gas and causes measurement error.

- *Dimension and internal construction of the TD should be selected very carefully when using the TD, so that no sharp temperature gradient will be promoted inside the TD and in all flow lines.*

5.In Future

- The influence of TD on volatile and semi-volatile particles will be considered. **Especially TD influences the nuclei mode of particles which is thought to contain semi-volatile fraction**.

- The particle loss mentioned in this study may contain the formation of nuclei mode of particles along with adhering on the TD wall. This will be considered in the next study.