I. IDENTIFICATION DATA

<table>
<thead>
<tr>
<th>Thesis name:</th>
<th>Sample handling and proportional dilution for cell exhaust exposure in a toxicological incubator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Author’s name:</td>
<td>Rajesh Rameswaran</td>
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<tr>
<td>Type of thesis:</td>
<td>master</td>
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<tr>
<td>Faculty/Institute:</td>
<td>Faculty of Mechanical Engineering (FME)</td>
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<tr>
<td>Department:</td>
<td>Department of Automotive, Combustion Engine and Railway Engineering</td>
</tr>
<tr>
<td>Thesis reviewer:</td>
<td>Ing. Jakub Ondráček, Ph.D.</td>
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<tr>
<td>Reviewer’s department:</td>
<td>Laboratory of Aerosol Chemistry and Physics, Institute of Chemical Process Fundamentals, Czech Academy of Sciences, v.v.i.</td>
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II. EVALUATION OF INDIVIDUAL CRITERIA

**Assignment**

*Evaluation of thesis difficulty of assignment.*

The goals and the content of the submitted master thesis are consistent with common standards. The main aim of the thesis is very complex and requires high experimental skills. The successful design of the exposure chamber will have very high impact on research in the field of human exposure to air pollution closely connected to car emissions.

**Satisfaction of assignment**

*Assess that handed thesis meets assignment. Present points of assignment that fell short or were extended. Try to assess importance, impact or cause of each shortcoming.*

The main goals of the thesis were successfully addressed. The experimental part including the setup of the correct flows through the system, comparison of different dilution systems as well as design of temperature and relative humidity measurements were performed in very sound manner.

The results of the toxicity experiments performed during the study were not discussed, so cannot be commented. One remark can be raised towards the evaluation of particle losses in the system. Nevertheless, having in mind the available instrumentation, this problem was tackled in efficient way.

The data analysis could be better statistically analyzed and the presentation of measured data could be graphically better presented.

**Method of conception**

*Assess that student has chosen correct approach or solution methods.*

The main goals of the thesis were solved with available resources with a reasonable approach. Utilization of different types of dilution systems for individual parts of exposure chamber were well justified.

Experimental estimation of particle losses in the lines leading exhaust emissions to the deposition chamber was not ideal. Measurement of concentration in front and behind the tested part in different times can lead to high uncertainties in the particle loss estimation taking into account that the individual test cycles cannot be repeated with exactly reproducible manner. On the other hand, this approach was driven by the availability of measurement devices.

The control system for RH can be improved by setting the temperature control for deionized supply water for humidifiers. The temperature and relative humidity measurement system was developed taking into account the cost effective approach and was sufficient for current pilot exposure chamber setup.

**Technical level**

*B - very good.*

*Assess level of thesis specialty, use of knowledge gained by study and by expert literature, use of sources and data gained by experience.*

The presented master thesis deals with very up-to-date topics. The human health relevant threats are in the scope of many different research groups. Dealing with effect of airborne particulate matter produced by exhaust of vehicles is very important for assessment of adverse health effect. Finally, epidemiological and toxicological studies are the state of the art topics. And the design of exposure chamber is very unique.
Formal and language level, scope of thesis

Assess correctness of usage of formal notation. Assess typographical and language arrangement of thesis.

The reviewed master thesis has very high language standard and is written with minority of mistakes. From the point of view of the formal arrangement of chapters and logical structure of the whole thesis, the whole text fulfills the requirements for master thesis standards.

Selection of sources, citation correctness

Present your opinion to student’s activity when obtaining and using study materials for thesis creation. Characterize selection of sources. Assess that student used all relevant sources. Verify that all used elements are correctly distinguished from own results and thoughts. Assess that citation ethics has not been breached and that all bibliographic citations are complete and in accordance with citation convention and standards.

The literature review is reasonably comprehensive. The main topics are covered and appropriate number of literature resources was used in the thesis. The author used peer reviewed articles in the scientific journals as well as the sources available online. The only deficiency can be found in some of the sources cited. Some of the references are not listed in the list of references (Liem Pham et al., 2018; Mohsin et al., 2018; Robert, 1997) and some of the references found in the list of the references cannot be found in the text (Barter et al.; Raza et al., 2018). Also the format of the individual citations should be uniform throughout the list of references.

Additional commentary and evaluation

Present your opinion to achieved primary goals of thesis, e.g. level of theoretical results, level and functionality of technical or software conception, publication performance, experimental dexterity etc.

This section of the review includes some remarks and comments to the master thesis. They should be taken as suggestions for possible improvements and do not lower the quality of the presented work.

Some of the terms used in master thesis require better explanation.

Literature study on negative effects of particles on human health could be covered in more details.

Some of the abbreviations were explained after their first use in the text.

Some parts not detailed enough – e.g. principle of AVL SmartSampler is explained in insufficient way. The principle of operation is not clear from the description.

Some principles are not explained fully correctly – EEPS, CPC.

Problems and issues encountered during experimental work are common. The reviewer is not sure if they need to be mentioned in the master thesis.

The control system for RH can be improved by setting the temperature control for deionized supply water for humidifiers. The reviewer does not fully understand the concept of particle losses measurements presented in the work. The estimation of particle losses based on experiments done at different times are highly disputable. It is possible to estimate (with quite high precision) the particle losses in the tubings from theoretical calculations. Some discussions over particle losses require more thorough considerations of all possible effects and the ways how it was measured. Nevertheless, the estimation of the losses does not influence the overall main aim of the whole system which is exposure of the cells to the exhaust particles.

There are many mechanism causing particle losses in sampling tubing, as was correctly mentioned one is due to electrostatic charge on the walls of tubings, but there are more important mechanisms especially for nanoparticles – Brownian diffusion, which is not mentioned at all. Increasing flow rate helps to reduce effect of losses due to diffusion, but the flow can be increased only to the limit of laminar flow. Otherwise the particle losses will be increased when reaching turbulent flow regime.

With regards to the explanation of differences between results of measured particle concentration with different diluters. Nucleation can be the reason, but it depends on the dilution conditions, if the dilution air was cooling down the exhaust flow, then it could be the reason, otherwise most probably not. The conditions of the dilution are not mentioned in the text.

The suggested future improvements are relevant and could substantially improve the utilization of the exposure chamber for on road measurements.
III. OVERALL EVALUATION, QUESTIONS FOR DEFENSE, CLASSIFICATION SUGGESTION

Summarize thesis aspects that swayed your final evaluation. Please present apt questions which student should answer during defense.

The overall quality of the reviewed master thesis is very good. The literature review deals with all the most important aspects of the described problematics. The experimental part is very well written. There are just some small inaccuracies in the description of the used aerosol instruments. The obtained data were evaluated using standard approach. The results deduced from the data are correct. Also the end of the thesis shows the ability of the student to make the right conclusions and the future scope brings interesting ideas for further improvement of the exposure measurement chamber for field (on road) measurements.

The only objection is the way how the particle losses in the sampling tubing and the humidifier were measured and calculated. Nevertheless, this reviewer’s opinion does not diminish the overall quality of the thesis.

All the small remarks and comments of the reviewer were presented to the student in electronic copy of the master thesis.

Questions for the master thesis defence:

Which particles (approximate size range) stay suspended longest in the air and why?

What are the main mechanisms of particulate matter removal from the air?

What is the most relevant quantity in regards to adverse health effect of air pollution caused by PM (particle number, surface or volume/mass)?

What should be the conditions to inertial impact nanoparticles?

What type of nucleation process is utilized in CPC (homogeneous or heterogeneous)?

I evaluate handed thesis with classification grade **B - very good.**