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# Deliverable D4.3

# Literature review and toxicity rating of exhaust and secondary aerosols

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**PAREMPI**
Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air

Funded by the European Union

**PAREMPI Particle emission prevention and impact: from real-world emissions of traffic to secondary PM of urban air**

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# Table of Contents

List of abbreviations ..... 4
1. Executive Summary ..... 5
2. Toxicity database and literature review criteria ..... 6
3. Toxicity rating ..... 7
4. Summary and experimental approach in PAREMPI campaigns ..... 8
5. References ..... 9
Appendix 1. Database – Readme tab ..... 10
Appendix 2. Database – Parameters tab ..... 11
Appendix 3. Database – Toxicity tab ..... 13

# List of abbreviations

| | |
|---|---|
| ALI | Air-Liquid Interface |
| C | Cytotoxicity (in toxicity rating) |
| D | Other endpoints |
| G | Genotoxicity |
| HD | Heavy-duty |
| LD | Light-duty |
| NRMM | Non-Road Mobile Machinery |
| NOx | Nitrogen oxides |
| $NH_3$ | Ammonia |
| O | Oxidative stress |
| OFR | Oxidation Flow Reactor |
| PM | Particulate matter |
| $PM_{aged}$ | Aged particulate matter (including secondary aerosol) |
| $PM_{fresh}$ | Fresh particulate matter |
| ROS | Reactive oxygen species |
| SecA | Secondary aerosol |
| $SO_2$ | Sulfur dioxide |
| VOC(s) | Volatile Organic Compound(s) |

# 1. Executive Summary

This deliverable presents a review of the toxicity of transport-related emissions based on the PAREMPI toxicity database (expanding **D5.1**), together with an overview of the experimental approach developed within the project.

The toxicity part of the database currently includes **186 literature-based entries, 180 for fresh exhaust and 6 for aged exhaust,** and enables a harmonised evaluation of toxicological responses across different transport sectors, fuels and technologies. The analysis showed that existing research is strongly focused on fresh exhaust emissions, while the toxicity of aged particulate matter (PMaged) and secondary aerosol (SecA) remains understudied. Although emission control technologies have reduced regulated pollutants, unregulated components such as ultrafine particles and semi-volatile compounds are becoming increasingly relevant as they may contribute to observed toxic effects.

A major limitation identified in the literature is the lack of studies that directly link emission characteristics with toxicological findings under the repeatable conditions. In addition, a significant share of otherwise relevant studies cannot be included in a harmonised assessment due to insufficient reporting of either emission characterisation or toxicological methodology missing.

To address these gaps, PAREMPI developed an integrated experimental approach combining emission measurements, atmospheric ageing simulation and toxicological assessment under well described conditions. The campaigns covered multiple transport sectors and included both laboratory and real-world measurements. The use of oxidation flow reactors enabled the generation of aged emissions, while *in vitro* Air–Liquid Interface exposure system allowed for physiologically relevant toxicity testing.

Overall, the project provides unique datasets linking emissions with biological responses and addresses the key knowledge gaps, particularly in relation to aged emissions and secondary aerosol toxicity. The dataset is used for improved assessment of health impacts from transport emissions and will be further expanded as new data become available.

Acknowledgement: The authors would like to acknowledge the key contributions of Hilkka Timonen and Luis Barreira (FMI) on emissions database (D5.1), and Päivi Aakko-Saksa (VTT) on the public PAREMPI toxicity database and the rating system.

# 2. Toxicity database and literature review criteria

The toxicology part of the PAREMPI database was established to enable a systematic and harmonised evaluation of toxicological data from transport emissions across different technologies, fuels, and operating conditions. It connects the emissions dataset by linking physicochemical characteristics of emissions with biological responses.

The database has been substantially expanded and currently includes **186 literature-based entries** covering various transport emissions and toxicity assessments. Despite this expansion, the available studies remain strongly focused on fresh particulate matter (PM), while investigation addressing the toxicity of aged PM and secondary aerosol (SecA) are still underrepresented.

Each entry in the toxicity database contains:

- Exposure class, including on-line exposure systems such as Air–Liquid Interface (ALI) setups, as well as studies using pre-collected particulate matter in submerged or ALI conditions
- Emission source like fresh exhaust PM, aged PM, secondary aerosol
- Transport sector and application, such as light-duty (LD), heavy-duty (HD), and non-road mobile machinery (NRMM), including vehicles, engines, generators
- Engine and combustion characteristics

To ensure consistency and scientific robustness, the database was compiled using clearly defined selection and quality criteria. Only studies based on **direct measurement results from single emission sources were included**, enabling source-specific interpretation of toxicological findings. Studies based on mixed ambient samples (e.g. roadside or tunnel measurements) or modelling approaches were excluded.

In addition, study quality and complexity were considered. Priority was given to studies assessing **multiple toxicological endpoints** (e.g. cytotoxicity, genotoxicity, oxidative stress, inflammation) and/or different exposure durations. Studies with insufficient methodological detail or evident inconsistencies were excluded to maintain the reliability of the dataset.

To enable comparison across studies a **standardised toxicity rating system was applied**. While the main focus was on studies from the past 10–15 years to reflect modern engine technologies, fuels, and aftertreatment systems, older **high-quality studies** were also included.

At present, the toxicity database consists exclusively of published literature data. Toxicity results obtained within the PAREMPI project are not yet included, as they are not published yet. The database is maintained in an Excel format enabling traceability and continuous updatability as new literature and experimental results become available (**Appendix 1-3**)

# 3. Toxicity rating

The toxicity rating applied in the database uses a harmonized and transparent framework for evaluating the biological effects of transport-related emissions. The purpose of the rating system is to enable easy and systematic comparison of toxicity responses across different conditions. The rating system is based on key biological effects:

- **Cytotoxicity (C):** reduction in cell viability and damage following exposure to emissions
- **Genotoxicity (G):** DNA damage or mutations, which can contribute to long-term health risks such as cancer
- **Oxidative stress (O):** Measures oxidative stress responses, such as the generation of reactive oxygen species (ROS) or depletion of antioxidants
- **Other endpoints (D):** Covers other relevant cellular effects not included above such as immune response markers (e.g. cytokine release), changes in epithelial barrier integrity, or metabolic shifts

Each endpoint is scored using the rating presented in **Table 1**. In the final rating, each emission condition is summarised using a combined rating code (e.g. C.1–G.0–O.x–D.nd), enabling quick cross-comparison of results across different sources and technologies.

**Table 1. Standardized rating codes and their interpretations used in the database.**

| Rating Code | Description |
|---|---|
| nd | No data available |
| 0 | No harmful effects found |
| x | Unclear results |
| 1 | Potentially harmful ($p<0.05$) |
| 2 | Slightly harmful ($p<0.01$) |
| 3 | Clearly harmful ($p<0.001$) |
| 4 | Harmful in high confidence level ($p<0.0001$) |
| 5 | Very harmful in high confidence level |

# 4. Summary and experimental approach in PAREMPI campaigns

The literature review based on the PAREMPI toxicity database shows that transport emission toxicity research is **fragmented and uneven across emission types and technologies**. The dataset is clearly dominated by studies on fresh exhaust, while the toxicity of aged particulate matter (PMaged) and secondary aerosol (SecA) remains largely understudied. Although technological improvements have reduced regulated emissions, the importance of unregulated components such as ultrafine particles and semi-volatile compounds has increased as it may contribute to observed toxic effects. At the same time, there is a lack of high-quality studies connecting emission characteristics with toxicological outcomes under repeatable conditions.

Another limitation is that a large proportion of otherwise relevant studies cannot be included in a evaluation due to **missing or insufficient information**. In many cases, either the toxicological methodology (e.g. exposure conditions, endpoints, statistical treatment) or the emission characterization (e.g. particle composition, size distribution, or precursor gases) is not described in sufficient detail, which **prevents consistent application of the toxicity rating system**. In some studies, both aspects are incomplete or not directly comparable, making reliable interpretation impossible.

This significantly reduces the number of usable entries and limits comparability, while also introducing bias, as potentially relevant results must be excluded. It also reflects a broader challenge in this field, where **studies require a combination of expertise** in emissions measurement and toxicology. As a result, critical aspects may not always be sufficiently addressed during peer review, as it is difficult to fully evaluate all aspects within limited number of reviewers.

Overall, this highlights the need for more consistent and transparent reporting of both emission and toxicity data, as well as greater awareness of these interdisciplinary requirements in study design and review. The experimental approach in PAREMPI was designed to address these problems, in particular the lack of data integration and the limited information on aged emissions and SecA. The campaigns covered light-duty and heavy-duty vehicles, as well as simulated marine and aviation emissions, in both laboratory and real-world environments, with detailed descriptions provided in **Deliverables D2.2 and D5.3**.

An important addition was the use of oxidation flow reactors (OFRs) to simulate atmospheric ageing, enabling direct comparison between fresh and aged emissions. Toxicological assessment was done using in vitro Air–Liquid Interface (ALI) exposure systems (*Vojtisek et al. 2025*), including a portable incubator enabling controlled exposure under both laboratory and on-road conditions. The experimental setup combined measurements of particle properties (number, size, mass, composition) and precursor gases (e.g. NOx, $NH_3$, $SO_2$, VOCs) with multiple toxicological endpoints. **Further details on methodology and results are provided in Deliverables D2.3 and D4.2 and summarized in D5.3.**

Overall, PAREMPI provided integrated datasets linking emission properties with toxicological responses across transport sectors, fuels and technologies. Once published, data will be available in public database.

# 5. References

PAREMPI Deliverable D2.2, Rönkkö et al., Measurement results of emissions, secondary aerosol forming potential and methodology, Horizon Europe project PAREMPI, Available https://parempi.eu/, 2025.

PAREMPI Deliverable D2.3, Aakko-Saksa et al., Evaluation of robust measurement methods for estimating secondary aerosol mass, Horizon Europe project PAREMPI, Available https://parempi.eu/, 2025.

PAREMPI Deliverable D4.2, Cervena et al., Toxicity results for exhaust and secondary aerosols using basal and easily measured of toxicity markers and advanced microscopic methods, Horizon Europe project PAREMPI, Available https://parempi.eu/, 2025.

PAREMPI Deliverable D5.1, Timonen et al., Database of emissions, secondary aerosols and toxicity rating, Excel file, 2024, Horizon Europe project PAREMPI, Available https://parempi.eu/, 2025.

PAREMPI Deliverable D5.3, Timonen et al., Scientific evidence report, Horizon Europe project PAREMPI, Available https://parempi.eu/, 2025.

Vojtíšek-Lom, M., et al., 2025. Portable emissions toxicity system: Evaluating the toxicity of emissions or polluted air by exposure of cell cultures at air–liquid interface in a compact field-deployable setup. Science of the Total Environment. https://doi.org/10.1016/j.scitotenv.2024.178010

# Appendix 1. Database – Readme tab

The following table provides the content of the Readme tab of the current database.

**Secondary emissions from transport – database**

| | |
|---|---|
| **Database compiled by** | Luis Barreira, Hilkka Timonen, Päivi Aakko-Saksa, Hana Barosova, Jan Topinka, Tereza Cervena |
| **PAREMPI SecA Database** | In the PAREMPI project (https://parempi.eu/ ) a new SecA database was developed. Database provides a comprehensive collection and analysis of data on the emission rates of secondary aerosol species, their precursors and toxicity of primary (PriA) and secondary aerosols (SecA) emitted from various transportation sources. The database is complemented with the other data available from the measurements including e.g. BC, PN, PM results. |
| **Data review process** | The database considered only direct measurement results from single sources, such as those from engines, passenger cars, and heavy-duty vehicles, while excluding mixed emissions like those from ambient roadside or tunnel measurements or results obtained through indirect calculation. |
| **Format** | The database is in the format of an excel table to ensure easy access and possibility to modify the resulting dataset as needed. |
| **Parameters** | See Parameters tab |
| **Contact info** | Hilkka Timonen, hilkka.timonen@fmi.fi, Päivi Aakko-Saksa, paivi.aakko-saksa@vtt.fi |
| **Date** | 30/03/2026 |

# Appendix 2. Database – Parameters tab

The following table provides the content of the parameters of the current database.

| List of parameters updated: | 30/03/2026 | |
|---|---|---|
| **Parameter** | **Explanation** | **Value (NA=Not available)** |
| Transport sector | Transport sector studied | LD=Light-duty; HD=heavy-duty (HD); NRMM= non-road mobile machinery; Marine; Aviation |
| Application | Transport application studied | Car; Bus; Truck; Tractor; Ship; Aircraft etc. |
| Emission class | Emission class of vehicle, engine, ship, aircraft | Euro 5; Euro 6d; Euro VI; Stage III etc. |
| Model year | Model year of the studied engine, vehicle etc. | Numerical |
| Engine combustion | Diesel (DI), Spark-ignited (SI), Dual-fuel (DF) | Main classification of internal combustion engine |
| Engine combustion technology | Engine combustion technology | FFV=Flex fuel vehicle; GDI=Gasoline direct injection; Common rail; Gasoline, Diesel, Turbine etc. |
| Engine combustion details | Turbo, injection etc. | Details if available |
| Engine size | Size of studied engine | Numerical |
| Engine size unit | Unit used to give the engine size | Liter (L); Power (kW) |
| Stroke / Cylinders | Stroke of an engine | Numerical / numerical |
| Engine speed (SSE/MSE/HSE) | Engine speed | SSE=Low-speed engine; MSE=Medium-speed engine, HSE=High-speed engine |
| Exhaust aftertreatment (EAT) | Emission control system | DOC=Diesel oxidation catalyst; SCR=Selective Catalytic Reduction; DPF=Diesel particulate filter; TWC=Three-way catalyst |
| Running hours/odometer | Running hours/odometer of an engine, vehicle etc. | Numerical |
| Unit of running hours/odometer | Unit for running hours/odometer of an engine, vehicle etc. | Hours (h), kilometers (km) |
| Lab/real-world/plume | The location of sampling | Laboratory; Real-world (on-road; on-board); plume |
| Temperature (°C) | Temperature of application during test | Numerical |
| Driving cycle | Driving cycle used in experiment | SSC= Steady state cycle, transient cycle (e.g. NEDC, WLTC, Artemis) |
| Load | Engine load (% of MCR) or roughness | Numerical or Low/Mid/High |
| Fuel | Specific fuel | EN228, EN590, E85, E10, E0, FAME, HVO etc. |
| Fuel sulfur content | Sulfur content of fuel | Numerical or Low (<10 ppm or <15 ppm) |
| Location | Geographical location of measurements | City; country |
| Leading organization | Organization in charge of campaign (or publication) | Institute; country |
| Alkanes, sum | C1-C22 alkanes (right-hand side) | Numerical |
| Alkenes, sum | C2-C6 alkenes | Numerical |
| Alkynes, sum | C2 alkyne | Numerical |
| OOC, sum | Oxygenated organic compounds | Numerical |
| Aromatics (1-ring), sum | Single-ring aromatics | Numerical |
| PAHs, sum in PM | Polyaromatic hydrocarbons in PM | Numerical |
| PAHs, sum in SVOCs | Polyaromatic hydrocarbons in SVOCs | Numerical |
| Total (S)VOC compounds | Sum from alkanes, alkenes, alkynes, alcohols, ethers, carbonyls, aromatics, PAHs | Numerical |
| NOx | Nitrogen oxides | Numerical |
| NO2 | Nitrogen dioxide | Numerical |
| N2O | Nitrous oxide | Numerical |
| CO | Carbon monoxide | Numerical |
| SO2 | Sulfur dioxide | Numerical |
| NH3 | Ammonia | Numerical |
| CO2 | Carbon dioxide | Numerical |
| NMOG/NMHC | Non-methane organic gases or hydrocarbons | Numerical |
| THC | Total hydrocarbons measured by flame ionisation detector (FID) | Numerical |
| CH4 | Methane | Numerical |
| Unit for gases | Unit for gases | mg/km, mg/kWh etc. |
| PM fresh (reg) | Particulate matter emission (fresh), regulated filter measurement | Numerical |
| PM fresh (mass impactor) | Particulate matter emission (fresh), measured by low pressure impactor | Numerical |
| PM fresh (PN-to-PM) | Particulate matter emission (fresh), PN to PM conversion | Numerical |
| PM fresh (AMS+BC) | Components (fresh) measured by AMS plus BC/EC | Numerical |
| Organics fresh (AMS) | Organic aerosol (fresh) from AMS measurement | Numerical |
| Nitrate fresh (AMS) | Nitrate aerosol (fresh) from AMS measurement | Numerical |
| | Ammonium aerosol (fresh) from AMS | |

| | | |
|---|---|---|
| Ammonium fresh (AMS) | measurement | Numerical |
| Sulfate fresh (AMS) | Sulphate aerosol (fresh) from AMS measurement | Numerical |
| Chloride fresh (AMS) | Chloride aerosol (fresh) from AMS measurement | Numerical |
| Black carbon (BC) | Black carbon or elemental carbon (EC) | Numerical |
| BC instrument/method | Instrument or method for measuring BC or EC | Instrument MSS, MAAP, aethalometer, TOA, AMS |
| Unit, fresh aerosol | Unit of fresh aerosol components | mg/m3 (temperature, pressure), mg/km, mg/kWh etc. |
| PM aged (PN-to-PM) | Particulate matter emission (aged), PN to PM conversion | Numerical |
| PM aged (AMS+BC) | Components (aged, secondary) measured by AMS plus BC/EC | Numerical |
| Organics aged (AMS) | Organic aerosol (aged, secondary) from AMS measurement | Numerical |
| BC | Black carbon | Numerical |
| BC instrument/method | Instrument or method for measuring BC | Instrument MSS, MAAP, aethalometer, AMS |
| Unit, aged aerosol | Unit of aged aerosol components | mg/m3 (temperature, pressure), mg/km, mg/kWh etc. |
| OH-exposure (days) | OH exposure used in studies of aged aerosol | Numerical |
| Oxidation device | Instrument for oxidation, oxidation flow chamber type | Instrument e.g. OFR (type) |
| PN fresh total 2.3 | Particle number emissions, fresh, total, above 2.3 nm | Numerical |
| PN aged total | Particle number emissions, aged, total | Numerical |
| PN total instrument | Instrument used for measuring total particle number emissions | ELPI, SMPS etc. |
| PN nv 23 | Particle number emissions, non-volatile, above 23 nm | Numerical |
| PN nv 10 | Particle number emissions, non-volatile, above 10 nm | Numerical |
| PN nv instrument | Instrument used for measuring non-volatile particle number emissions | DEED+CPC etc. |
| PN unit | Unit of particle number emissions | #/m3 (temperature, pressure), #/km, #/kWh etc. |
| Exposure class | Exposure method | ALI, PM pre-collected, SVOC |
| Emission source | Source of emissions studied | PM fresh exhaust, PM aged, Non-exhaust |
| Particle specification | ? | ? |
| Model | Model for toxicity testing | Human TCCC etc. |
| End points tested | Testing for toxicity | LDH, OxyDNA adducts etc. |
| Repetitions | Number of repetitions of the toxicity tests | Numerical |
| C | Cytotoxicity effects | nd=No data; 0=no harmful effects found; x=unclear; 1=potentially harmful (p<0.05); 2=slightly harmful (p<0.01); 1=potentially harmful (p<0.05); 3=clearly harmful (p<0.001); 4=harmful in high confidence level (p<0.0001); 5=Very harmful in high confidence level |
| G | Genotoxicity effects | nd=No data; 0=no harmful effects found; x=unclear; 1=potentially harmful (p<0.05); 2=slightly harmful (p<0.01); 1=potentially harmful (p<0.05); 3=clearly harmful (p<0.001); 4=harmful in high confidence level (p<0.0001); 5=Very harmful in high confidence level |
| O | Oxidative stress effects | nd=No data; 0=no harmful effects found; x=unclear; 1=potentially harmful (p<0.05); 2=slightly harmful (p<0.01); 1=potentially harmful (p<0.05); 3=clearly harmful (p<0.001); 4=harmful in high confidence level (p<0.0001); 5=Very harmful in high confidence level |
| D | Other endpoints | |
| Toxicity rating | Combined toxicity rating code of C, G, I, O, D | |
| Other info | Other relevant information | |
| DOI | DOI number of reference | |
| Reference | Reference with author, journal/report identification and publication year. | |

# Appendix 3. Database – Toxicity tab

The following clips provide examples of the content contained in the database.

| | Exposure class | Emission source | Transport sector | Application | Emission class | Model year | Engine combustion | Engine combustion technology | Engine combustion details | Engine size | Engine size unit | Stroke / cylinders | Engine speed (SSE/MSE/HSE) | After treatment technology (EAT) | Running hours/odometer | Unit of running hours/odometer | Laboratory/ real-world/ plume | Temperature (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 84 | ALI | PM aged | LD | Car | Euro 5 | N/A | SI | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 85 | ALI | PM aged | LD | Car | Euro 5 | N/A | SI | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 86 | ALI | PM mixed with volcanic ash | LD | Car | Euro 6? | N/A | SI | GDI | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 87 | ALI | PM mixed with volcanic ash | LD | Car | Euro 6? | N/A | SI | GDI | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 88 | Online exposure | PM fresh exhaust | HD | Marine engine | N/A | N/A | DI | Diesel | N/A | N/A | N/A | model AGC | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 89 | Online exposure | PM fresh exhaust | HD | Marine engine | N/A | N/A | DI | Diesel | N/A | N/A | N/A | model AGC | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 90 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | diesel | | 1598/85/250 | cm3/kW/Nm | | | DPF, SRC, DOC | | | Laboratory | cold |
| 91 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | diesel | | 1598/85/250 | cm3/kW/Nm | | | DPF, SRC, DOC | | | Laboratory | warm |
| 92 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | diesel | | 1598/85/250 | cm3/kW/Nm | | | DPF, SRC, DOC | | | Laboratory | cold |
| 93 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | diesel | | 1598/85/250 | cm3/kW/Nm | | | DPF, SRC, DOC | | | Laboratory | warm |
| 94 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | diesel | | 1598/85/250 | cm3/kW/Nm | | | DPF, SRC, DOC | | | Laboratory | warm |
| 95 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 1199/55/110 | cm3/kW/Nm | | | TWC | | | Laboratory | cold |
| 96 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 1199/55/110 | cm3/kW/Nm | | | TWC | | | Laboratory | warm |
| 97 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 1199/55/110 | cm3/kW/Nm | | | TWC | | | Laboratory | cold |
| 98 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 1199/55/110 | cm3/kW/Nm | | | TWC | | | Laboratory | warm |
| 99 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 999/81/200 | cm3/kW/Nm | | | TWC, GPF | | | Laboratory | cold |
| 100 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | GDI | | 999/81/200 | cm3/kW/Nm | | | TWC, GPF | | | Laboratory | warm |
| 101 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | CNG | | 1498/96/200 | cm3/kW/Nm | | | TWC | | | Laboratory | cold |
| 102 | Online exposure | PM fresh exhaust | LD | Car | Euro 6d | N/A | | CNG | | 1498/96/200 | cm3/kW/Nm | | | TWC | | | Laboratory | warm |
| 103 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | | | | Laboratory | |
| 104 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | | | | Laboratory | |
| 105 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | | | | Laboratory | |
| 106 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | | | | Laboratory | |
| 107 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | | | | Laboratory | |
| 108 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | a combined diesel oxidation catalyst (DOC) + | | | Laboratory | |
| 109 | Suspension | Methanol extracts | HD | Diesel engine | Euro 4 | 2005 | DI | diesel | direct injection, i | 11.7/310/6 | L/kW/cylinde | Scania diesel engine | | a combined diesel oxidation catalyst (DOC) + | | | Laboratory | |
| 110 | Suspension | Methanol extracts | HD | Bus | Euro 5+ | 2008 | DI | diesel | | 11.9L/6cylind | L/cylinder | Scania diesel engine | | | | | Laboratory | |
| 111 | online exposure | PM fresh exhaust | LD | Car | Stage IIIa | 2018 | | Diesel | N/A | 1.6 L/ 3 cylind | L/cylinder/K | N/A | N/A | no | N/A | N/A | Laboratory | Normal |
| 112 | online exposure | PM fresh exhaust | LD | Car | Stage V | 2019 | | Diesel | N/A | 2,3 L/ 4-cylin | L/cylinder/K | N/A | N/A | DOC+DPF | N/A | N/A | Laboratory | Normal |
| 113 | Online exposure + noise | Aerosol inhalation | LD | Car | Euro 2 | 1998 | TDI | Diesel | N/A | N/A | N/A | N/A | N/A | no | N/A | N/A | Laboratory | Normal |
| 114 | Suspension | Organic extracts from collected PM | HD | Small truck | N/A | N/A | N/A | Diesel | N/A | 176 | kW | N/A | N/A | N/A | N/A | N/A | Laboratory | 23°C |
| 115 | Suspension | Organic extracts from collected PM | HD | Small truck | N/A | N/A | N/A | Diesel | N/A | 176 | kW | N/A | N/A | N/A | N/A | N/A | Laboratory | 23°C |
| 116 | Suspension | Organic extracts from collected PM | HD | Small truck | N/A | N/A | N/A | Diesel | N/A | 176 | kW | N/A | N/A | N/A | N/A | N/A | Laboratory | 23°C |
| 117 | Suspension | Organic extracts from collected PM | HD | Small truck | N/A | N/A | N/A | Diesel | N/A | 176 | kW | N/A | N/A | N/A | N/A | N/A | Laboratory | 23°C |
| 118 | Suspension | Collected PM in media | N/A | unloaded diesel | according to Eur | N/A | N/A | Diesel | N/A | 2,2 L/4 cylind | L/cylinder/RF | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 119 | Suspension | Collected PM in media | N/A | diesel generator | according to Eur | N/A | N/A | Diesel | N/A | 113 | kW | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 120 | Suspension | Organic extracts from collected PM | LD | Car | N/A | N/A | GDI | Gasoline | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 121 | Suspension | Organic extracts from collected PM | LD | Car | N/A | N/A | GDI | Gasoline | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 122 | Suspension | Organic extracts from collected PM | LD | Car | N/A | N/A | GDI | Gasoline | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 123 | Suspension | Organic extracts from collected PM | LD | Car | N/A | N/A | GDI | Gasoline | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 124 | Suspension | Organic extracts from collected PM | LD | Car | Euro 6 | N/A | N/A | Gasoline | N/A | 92/6000 | kW/rpm | 1.0/3 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 125 | Suspension | Organic extracts from collected PM | LD | Car | Euro 6 | N/A | N/A | Gasoline | N/A | 92/6000 | kW/rpm | 1.0/3 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 126 | Suspension | Organic extracts from collected PM | LD | Car | Euro 6 | N/A | N/A | Gasoline | N/A | 92/6000 | kW/rpm | 1.0/3 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 127 | Suspension | Organic extracts from collected PM | LD | Car | Euro 6 | N/A | N/A | Gasoline | N/A | 92/6000 | kW/rpm | 1.0/3 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 128 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 129 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 130 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 131 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 132 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 133 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 134 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 135 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 136 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 137 | Suspension | Organic extracts from collected PM | HD | Engine | N/A | N/A | N/A | Diesel | N/A | 13L/6cyl | L/cylinders | 13L/6-cyllinder - modified operating with 1 cylinder | | | | | Laboratory | Normal |
| 138 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 2 | N/A | N/A | diesel | | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 139 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 2 | N/A | N/A | diesel | | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 140 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 2 | N/A | N/A | diesel | | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 141 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | diesel | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 142 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | diesel | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 143 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | diesel | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 144 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | CNG | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 145 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | CNG | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 146 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | CNG | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 147 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 148 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 149 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 150 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 151 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 152 | Suspension | Semi-volatile in DMSO/H2O | LD | Car | Euro 6 | N/A | N/A | gasoline | turbocharged di | N/A | N/A | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 153 | Aerosol exposure | PM fresh exhaust | LD | Car | Euro 6d | 2021 | N/A | GDI | TDI | 1 | N/A | N/A | N/A | 3 way catalyst + | N/A | N/A | Laboratory | Normal |
| 154 | Aerosol exposure | Aged pre-collected total aerosol, or gas | LD | Car | Euro 6d | 2021 | N/A | GDI | TDI | 1 | N/A | N/A | N/A | 3 way catalyst + | N/A | N/A | Laboratory | Normal |
| 155 | Aerosol exposure | PM fresh exhaust | LD | Car | Euro 6d | 2021 | N/A | GDI | TDI | 1 | N/A | N/A | N/A | 3 way catalyst + | N/A | N/A | Laboratory | Normal |
| 156 | Aerosol exposure | Aged pre-collected total aerosol, or gas | LD | Car | Euro 6d | 2021 | N/A | GDI | TDI | 1 | N/A | N/A | N/A | 3 way catalyst + | N/A | N/A | Laboratory | Normal |
| 157 | Online exposure | PM fresh exhaust | LD | car | N/A | N/A | N/A | Diesel | TDI | 6.5 | L | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 158 | Online exposure | PM fresh exhaust | LD | car | N/A | N/A | N/A | Diesel | TDI | 7.5 | L | N/A | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 159 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 160 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 161 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 162 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 163 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 164 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 165 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 166 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 167 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 168 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 169 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 170 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 171 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 172 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 173 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 174 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 175 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 176 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 177 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 178 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 179 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 180 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 181 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 182 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 183 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 184 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 185 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 186 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 187 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 188 | Suspension | PM fresh exhaust | HD | Marine engine | N/A | N/A | | single-cylinder c | N/A | N/A | N/A | 4 | N/A | N/A | N/A | N/A | Laboratory | Normal |
| 189 | | | | | | | | | | | | | | | | | | |

| | | | | | | | Toxicity testing | | | | To | | | | | Other info | References |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Driving cycle | Load | Fuel | Fuel sulfur content | Location | Leading organization | Particle specification | Model | End points tested | Repetitions | C | G | O | D | Rating code | | |
| 2 | | | | | | | | | | | | | | | | | |
| 84 | 3 separate start-up and idle | N/A | Gasoline | N/A | | Switzerland | Particle aging with ni | Cystic fibrosis humar | LDH, IL6, IL6, MCP1 | | 0 | nd | nd | 1 | C.0-G.nd-O.nd-D.1 | | https://doi.org/10.1038/srep11801 |
| 85 | 3 separate start-up and idle | N/A | Gasoline | N/A | | Switzerland | Particle aging with ni | Disstressed human p | LDH, IL6, IL6, MCP1 | | 1 | nd | nd | 0 | C.1-G.nd-O.nd-D.0 | | https://doi.org/10.1038/srep11801 |
| 86 | WLTC | N/A | Gasoline RON 95 | | Bern University for Applie | AMI Switzerland | combined exposure: | Human TCCC – A54 | Cytotoxicity, cell morpholog | 4 | 0 | nd | 0 | 0 | C.0-G.nd-O.0-D.0 | | https://doi.org/10.1016/j.envpol.2018.01.115 |
| 87 | WLTC | N/A | Gasoline RON 95 | ? | Bern University for Applie | AMI Switzerland | combined exposure: | Human TCCC – A54 | Cytotoxicity, cell morpholog | 4 | 0 | nd | 0 | 0 | C.0-G.nd-O.0-D.0 | | https://doi.org/10.1016/j.envpol.2018.01.115 |
| 88 | 1800 s long ISO 8178 rampe | N/A | Ar20* fuel meeting E | N/A | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation, | 3 | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.scitotenv.2023.16 |
| 89 | | | essentially aromatic | N/A | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation, | 3 | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.scitotenv.2023.16 |
| 90 | modification of WLTC test | N/A | EN590 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 91 | modification of WLTC test | | EN590 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 92 | modification of WLTC test | | HVO | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 93 | modification of WLTC test | | HVO | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 94 | modification of WLTC test | | HVO | | VTT, Finland | VTT, Finland | regen | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 95 | modification of WLTC test | | EN228 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 1 | 0 | nd | C.nd-G.1-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 96 | modification of WLTC test | | EN228 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 97 | modification of WLTC test | | Alkylate | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 1 | 0 | nd | C.nd-G.1-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 98 | modification of WLTC test | | Alkylate | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 99 | modification of WLTC test | | EN228 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 100 | modification of WLTC test | | EN228 | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 101 | modification of WLTC test | | CNG | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 102 | modification of WLTC test | | CNG | | VTT, Finland | VTT, Finland | N/A | Human carcinogenic | genotoxicity, inflammation | 3 | nd | 0 | 0 | nd | C.nd-G.0-O.0-D.nd | | https://doi.org/10.1039/D3EA00136A |
| 103 | Braunschweig cycle | | EN590 | 8 mg/kg | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 150+ u | https://doi.org/10.1186/1743-8977-9-37 |
| 104 | Braunschweig cycle | | RME (EN14214) | 8 mg/kg | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 300 uc | https://doi.org/10.1186/1743-8977-9-37 |
| 105 | Braunschweig cycle | | Hydro-treated vega | 5 mg/kg | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 0 | 1 | C.1-G.1-O.0-D.1 | for dose 50+ uc | https://doi.org/10.1186/1743-8977-9-37 |
| 106 | Braunschweig cycle | | 30/70 HVO/EN590 | | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 300 uc | https://doi.org/10.1186/1743-8977-9-37 |
| 107 | Braunschweig cycle | | 30/70% RME/EN590 | | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 300 uc | https://doi.org/10.1186/1743-8977-9-37 |
| 108 | Braunschweig cycle | | EN590 | | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 300 uc | https://doi.org/10.1186/1743-8977-9-37 |
| 109 | Braunschweig cycle | | HVO | | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 0 | 1 | C.1-G.1-O.0-D.1 | for dose 150+ u | https://doi.org/10.1186/1743-8977-9-37 |
| 110 | Braunschweig cycle | | CNG | | VTT, Finland | University of Eastern Finland | N/A | Murine macrophage | cytotoxicity (PI positive cell: | N/A | 1 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | for dose 150+ u | https://doi.org/10.1186/1743-8977-9-37 |
| 111 | cold start+load and idle wit | N/A | HVO | | Uni Lund | Uni Lund | N/A | Human exposure | spirometry, inspiratory and | 19 humans | nd | nd | 0 | | C.nd-G.nd-O.nd-D.0 | | https://doi.org/10.1186/s12989-021-00446 |
| 112 | cold start+load and idle wit | N/A | HVO | | Uni Lund | Uni Lund | N/A | Human exposure | spirometry, inspiratory and | 19 humans | nd | nd | nd | 0 | C.nd-G.nd-O.nd-D.0 | | https://doi.org/10.1186/s12989-021-00446 |
| 113 | N/A | N/A | Diesel | less than 10 p | Uni Lund | Uni Lund | N/A | Human exposure | Heart rate and endothelial f | 18 humans | nd | nd | nd | 0 | C.nd-G.nd-O.nd-D.0 | | https://www.tandfonline.com/doi/full/10.10 |
| 114 | WHTC | N/A | Diesel (B0) | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | Cytotoxicity, oxidative stres | 1 | 0 | 1 | 1 | nd | C.0-G.1-O.1-D.nd | Before samplin | https://doi.org/10.3390/ijms17111833 |
| 115 | WHTC | N/A | neat fuel-grade biodiesel (B100, n | | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | Cytotoxicity, oxidative stres | 1 | 0 | 1 | 1 | nd | C.0-G.1-O.1-D.nd | | https://doi.org/10.3390/ijms17111833 |
| 116 | WHTC | N/A | 70% B0 and 30% B100 (B30) | | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | Cytotoxicity, oxidative stres | 1 | 0 | 1 | 1 | nd | C.0-G.1-O.1-D.nd | | https://doi.org/10.3390/ijms17111833 |
| 117 | WHTC | N/A | pure hydrotreated vegetable oils s | | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | Cytotoxicity, oxidative stres | 1 | 0 | 1 | 1 | nd | C.0-G.1-O.1-D.nd | | https://doi.org/10.3390/ijms17111833 |
| 118 | 8 weeks of running unloade | N/A | Diesel EN590 | N/A | N/A | Norwegian Institute of Public | N/A | Human bronchial ce | Cytotoxicity, pro-inflammat | 3 | 1 | 0 | 1 | nd | C.1-G.0-O.1-D.nd | | https://doi.org/10.1002/tox.21884 |
| 119 | N/A | N/A | Diesel EN590 | N/A | N/A | | N/A | Human bronchial ce | Cytotoxicity, pro-inflammat | 3 | 1 | 0 | 1 | nd | C.1-G.0-O.1-D.nd | | https://doi.org/10.1002/tox.21884 |
| 120 | WLTC | N/A | E5 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | dried particles from o | Human bronchial ce | cytotoxicity, mucin product | 3 | 1 | 1 | nd | C.1-G.1-O.1-D.nd | | https://doi.org/10.1016/j.tiv.2022.105316 |
| 121 | WLTC | N/A | E5 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | dried particles from o | MucilAir | cytotoxicity, mucin product | 3 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1016/j.tiv.2022.105316 |
| 122 | WLTC | N/A | E20 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | dried particles from o | Human bronchial ce | cytotoxicity, mucin product | 3 | 1 | 0 | nd | C.1-G.1-O.0-D.nd | | https://doi.org/10.1016/j.tiv.2022.105316 |
| 123 | WLTC | N/A | E20 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | dried particles from o | MucilAir | cytotoxicity, mucin product | 3 | 1 | 1 | 1 | C.1-G.1-O.1-D.1 | | https://doi.org/10.1016/j.tiv.2022.105316 |
| 124 | Artemis | N/A | E0 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | cytotoxicity, p53 target gen | N/A | 0 | 2 | nd | 2 | C.0-G.2-O.nd-D.2 | | https://doi.org/10.1016/j.tiv.2018.02.002 |
| 125 | Artemis | N/A | E15 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | cytotoxicity, p53 target gen | N/A | 0 | 1 | nd | 1 | C.0-G.1-O.nd-D.1 | | https://doi.org/10.1016/j.tiv.2018.02.002 |
| 126 | Artemis | N/A | n-But25 (n-Butanol | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | cytotoxicity, p53 target gen | N/A | 0 | 2 | nd | 1 | C.0-G.2-O.nd-D.1 | | https://doi.org/10.1016/j.tiv.2018.02.002 |
| 127 | Artemis | N/A | i-But25 (i-Butanol 2 | N/A | Roztoky, Prague, CZ | IEM CAS, Prague, CZ | N/A | Human bronchial ce | cytotoxicity, p53 target gen | N/A | 0 | 1 | nd | 2 | C.0-G.1-O.nd-D.2 | | https://doi.org/10.1016/j.tiv.2018.02.002 |
| 128 | N/A | 6 bar | petroleum diesel (Sv | ultra low | Uni Lund | Uni Lund | 9.7% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 2 | nd | nd | C.nd-G.2-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 129 | N/A | 6 bar | petroleum diesel (Sv | ultra low | Uni Lund | Uni Lund | 9.7% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 130 | N/A | 6 bar | petroleum diesel (Sv | edish ultra lo | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 131 | N/A | 6 bar | petroleum diesel (Swedish ultra lo | | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 132 | N/A | 6 bar | petroleum diesel (Swedish ultra lo | | Uni Lund | Uni Lund | 17% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 133 | N/A | 6 bar | petroleum diesel (Swedish ultra lo | | Uni Lund | Uni Lund | 17% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 134 | N/A | 6 bar | Hydrotreated vegetable oil (HVO) | | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 135 | N/A | 6 bar | Hydrotreated vegetable oil (HVO) | | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 136 | N/A | 6 bar | Rapseed methyl esther (RME) | | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 137 | N/A | 6 bar | Rapseed methyl esther (RME) | | Uni Lund | Uni Lund | 13% intake O2 | female mice | genotoxicity, inflammation | 6–8 per cor | nd | 0 | nd | nd | C.nd-G.0-O.nd-D.nd | | https://doi.org/10.1186/s12989-020-00369 |
| 138 | N/A | N/A | EN 590 winter grade | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 139 | N/A | N/A | EN 590 winter grade | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 140 | N/A | N/A | EN 590 winter grade | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 141 | N/A | N/A | EN 590 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 1 | 0 | C.1-G.0-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 142 | N/A | N/A | EN 590 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 143 | N/A | N/A | EN 590 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 144 | N/A | N/A | CNG | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 145 | N/A | N/A | CNG | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 146 | N/A | N/A | CNG | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 147 | N/A | N/A | E10 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 148 | N/A | N/A | E10 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 149 | N/A | N/A | E10 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 1 | 0 | C.1-G.1-O.1-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 150 | N/A | N/A | E85 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 151 | N/A | N/A | E85 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 0 | 0 | 0 | C.1-G.0-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 152 | N/A | N/A | E85 | | VTT, Finland | VTT, Finland | N/A | RAW264.7 mouse m | cellular metabolic activity ( | 3 | 1 | 1 | 0 | 0 | C.1-G.1-O.0-D.0 | | https://doi.org/10.1039/D4EA00062E |
| 153 | 2x cold start and idling for 5 | N/A | E10 | N/A | ILMARI, Uni Eastern Finl | ILMARI, Uni Eastern Finland | fresh exposure | A549 | LDH, metabolic activity, IL8 | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1126/sciadv.adq2348 |
| 154 | 2x cold start and idling for 5 | N/A | E10 | N/A | ILMARI, Uni Eastern Finl | ILMARI, Uni Eastern Finland | 7 ppm O3 and UV ag | A549 | LDH, metabolic activity, IL8 | 3 | 1 | 1 | nd | nd | C.1-G.1-O.nd-D.nd | | https://doi.org/10.1126/sciadv.adq2348 |
| 155 | 2x cold start and idling for 5 | N/A | E10 | N/A | ILMARI, Uni Eastern Finl | ILMARI, Uni Eastern Finland | fresh exposure | BEAS-2B | LDH, metabolic activity, IL8 | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1126/sciadv.adq2348 |
| 156 | 2x cold start and idling for 5 | N/A | E10 | N/A | ILMARI, Uni Eastern Finl | ILMARI, Uni Eastern Finland | 7 ppm O3 and UV ag | BEAS-2B | LDH, metabolic activity, IL8 | 3 | 1 | 1 | nd | nd | C.1-G.1-O.nd-D.nd | | https://doi.org/10.1126/sciadv.adq2348 |
| 157 | 2x WHTC | N/A | EN590 | N/A | VTP, Roztoky, CZ | IEM CAS, Prague, CZ | N/A | primary human olfac | cytotoxicity, oxidative stres | 1 | 0 | 0 | 0 | 0 | C.0-G.0-O.0-D.0 | | https://doi.org/10.1002/alz.14347 |
| 158 | 2x WHTC | N/A | EN591 | N/A | VTP, Roztoky, CZ | IEM CAS, Prague, CZ | N/A | primary human olfac | cytotoxicity, oxidative stres | 1 | 0 | 0 | 1 | 1 | C.0-G.0-O.1-D.1 | | https://doi.org/10.1002/alz.14348 |
| 159 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 2 | 0 | 0 | 0 | C.2-G.0-O.0-D.0 | | https://doi.org/10.1016/j.envint.2025.10944 |
| 160 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 161 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 2 | 4 | nd | C.0-G.2-O.4-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 162 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 3 | 0 | nd | nd | C.3-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 163 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 164 | 20 kW and 40 kW were main | 25,50,75 | MGO | 0.001% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 165 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 166 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 167 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 4 | nd | C.0-G.0-O.4-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 168 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 169 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 170 | 20 kW and 40 kW were main | 25,50,75 | ULS-HFOAR | 0.048% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 171 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 172 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 173 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 2 | 0 | 0 | nd | C.2-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 174 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 175 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 176 | 20 kW and 40 kW were main | 25,50,75 | LS-HFO | 0.51% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 3 | 3 | nd | nd | C.3-G.3-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 177 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 178 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 1 | 1 | 0 | nd | C.1-G.1-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 179 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 3 | 4 | 0 | nd | C.3-G.4-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 180 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 181 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 1 | 3 | nd | nd | C.1-G.3-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 182 | 20 kW and 40 kW were main | 25,50,75 | HS-HFOSYN | 1.02% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 4 | 1 | nd | nd | C.4-G.1-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 183 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 184 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | 0 | nd | C.0-G.0-O.0-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 185 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 3 | 4 | nd | C.0-G.3-O.4-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 186 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 0 | 0 | nd | nd | C.0-G.0-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 187 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 1 | 1 | nd | nd | C.1-G.1-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 188 | 20 kW and 40 kW were main | 25,50,75 | HS-HFO | 2.16% m/m | University of Rostock | Helmholtz Zentrum Müncher | PM dispersion in 0.0 | A549 human alveola | trypan blue viability, colony | 3 | 4 | 2 | nd | nd | C.4-G.2-O.nd-D.nd | | https://doi.org/10.1016/j.envint.2025.10944 |
| 189 | | | | | | | | | | | | | | | | | |