Further Challenge in Automobile and Fuel Technologies
For Better Air Quality

JCAP Health Effect WG Report

2002.2.22

Health Effect WG
Goal and Task of Health Effect WG

• Collect scientific information on health effect of automotive emission and summarize information on its probable effect on human health.
• Collect information on risk assessment.
• Study how automobile emission reduction measures and fuel quality improvement evaluated in JCAP improves health effect.
Purpose and Major Activities of Study

Purpose:
Collect/provide information on health effect of automotive emission as basic materials for public use through review by the experts.

Survey on the health effect of individual substances
Physical and chemical properties, pharmacokinetics, carcinogenicity, respiratory diseases, chronic toxicity, dose - response evaluation

Target:
Exhaust emission from diesel vehicles, especially particulate
Five unregulated substances listed below
Benzene  Formaldehyde  Acetaldehyde  1,3-Butadiene  Benzo(a)Pyrene
Purpose and Major Activities of Study
(Continued)

Survey on health risk assessment
Risk assessment methodology such as dose-response and exposure evaluations, as well as unit risk

Survey on experimental studies of diesel exhaust emission
Experimental findings of composition, property change, mutagenicity, etc. of exhaust emission with regard to the engine specifications and fuel properties
Review on Study

Considering the study results to be used as a public database, established a Review Committee comprising experts and submitted the study results to the committee for review.

Review Committee
Chairman:
Ryuuichi Kato, honorary professor at Keio University

Committee member:
Yuzo Hayashi, Guest professor, School of pharmaceutical sciences,
Kitasato University
Michihito Takahashi, Guest professor, School of pharmaceutical sciences,
Showa University
Haruhiko Sakurai, Director, National Institute of Industrial Health,
Ministry of Labour
Jun Kagawa, Professor, Tokyo Women’s Medical University

as of the year 2000
Risk Assessment Process

**Identification of toxicity**
Identify how the certain substance gives harmful effects on human health.
(1) Physical and chemical property
(2) Relation between molecular structure and the toxicity
(3) Pharmacokinetics (absorption, metabolism, etc)
(4) Toxicity data
(5) Data for human body (clinical, epidemiological data)

**Dose-response evaluation**
Clarify quantitative relation between exposure and health effect.
(1) Epidemiological study
(2) Animal experiment
(3) Extrapolation to human
(4) Calculation of unit risk

**Exposure assessment**
Clarify the degree of exposure to a certain population group.
(1) Characterizing emission
(2) Chemical reaction, diffusion and transfer in the environment
(3) Characterizing population group studied
(4) Calculation of exposure quantity

**Risk Estimation**
Estimate incidence of health hazard in certain population group from the information obtained through the above process
(1) Estimation of risks
(2) Importance of evidence
(3) Explanation of uncertainty
Assessment of Carcinogenicity of Diesel Emission

- Toxicity of diesel emission is commonly recognized in terms of carcinogenicity.
- On unit risk or risk estimation, uncertainty of epidemiological or exposure data is pointed out.

<table>
<thead>
<tr>
<th>Group</th>
<th>Carcinogenicity</th>
<th>Unit risk</th>
<th>Estimated risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO</td>
<td>Probably carcinogenic to humans.</td>
<td>3.4 X 10^{-5} (-µg/m³)^{-1}</td>
<td></td>
</tr>
<tr>
<td>U.S. EPA</td>
<td>Inhalation exposure is likely to be carcinogenic to humans.</td>
<td>_________</td>
<td>_________</td>
</tr>
<tr>
<td>CARB</td>
<td>The assumption that DE increase lung cancer risk is biologically plausible.</td>
<td>1.3 X 10^{-5} - 2.4 X 10^{-5} (-µg/m³)^{-1}</td>
<td>200 - 3600 X 10^{-6}</td>
</tr>
<tr>
<td>Ministry of Environment (JAPAN)</td>
<td>Epidemiological study suggests its carcinogenicity.</td>
<td>_________</td>
<td>_________</td>
</tr>
</tbody>
</table>
The Aim of Ames Test

- To confirm that introduction of future technologies for diesel vehicle and fuel is expected to improve the health effect of diesel exhaust emission based on Ames test for SOF (Soluble Organic Fraction) of particulate matter

- Not to aim at assessing and analyzing the effect which individual technological factor has on mutagenicity
Outline of Ames Test

What is mutagenicity?:
A certain property of chemical substances, etc. that damages DNA in a cell causing mutation.

Toxicity originating from damaged DNA comprises genetic toxicity to reproductive cells and carcinogenicity to somatic cells.

What is Ames test?:
One of mutagenicity test, and reversion mutation test using Salmonella typhimurium, used to screen carcinogenic substances.

It was clarified that there is a certain degree of correlation with carcinogenicity.

The strains used:
TA98 and TA100 were used generally applied for assessing diesel emission.

To examine the mutagenicity of metabolism activator, assessed the strain to which metabolic enzyme S9mix was added, as well.

-S9 : without metabolic enzyme S9       +S9 : with metabolic enzyme S9
# Technology Packages for Assessment

<table>
<thead>
<tr>
<th></th>
<th>Future specification</th>
<th>Current specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vehicle</strong></td>
<td>New Long Term Emission Regulation</td>
<td>Long Term Emission Regulation</td>
</tr>
<tr>
<td></td>
<td>Adopted technologies : CR-DPF and de-NOX catalyst</td>
<td>Technologies evaluated in the step 1</td>
</tr>
<tr>
<td><strong>Engine</strong></td>
<td>New Long Term Emission Regulation</td>
<td>Long Term Emission Regulation</td>
</tr>
<tr>
<td></td>
<td>Adopted technologies : Cooled EGR, CR-DPF and de-NOX catalyst</td>
<td>Technologies evaluated in the step 1</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>Evaluated fuel : Low sulfur fuel Light diesel fuel</td>
<td>Current fuel</td>
</tr>
</tbody>
</table>
## Japan Clean Air Program

### Evaluated Technology packages for Ames Test

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine</td>
<td>O/Y</td>
<td>21.2</td>
<td>DI NA</td>
<td>Elect. In-Line</td>
<td>With</td>
<td>W/O</td>
<td>D1</td>
</tr>
<tr>
<td></td>
<td>X</td>
<td>8</td>
<td>DI NA</td>
<td>Common rail</td>
<td>W/O</td>
<td>W/O</td>
<td>D1</td>
</tr>
<tr>
<td>Chassis</td>
<td>EO</td>
<td>2.5</td>
<td>DI TI</td>
<td>Elect. VE</td>
<td>With</td>
<td>Oxidation catalyst</td>
<td>D1</td>
</tr>
<tr>
<td>Engine</td>
<td>YA</td>
<td>6.9</td>
<td>DI TI</td>
<td>Elect. In-Line</td>
<td>W/O</td>
<td>CR-DPF</td>
<td>2D-04,2D-07</td>
</tr>
<tr>
<td></td>
<td>YB</td>
<td>4.9</td>
<td>DI TI</td>
<td>Elect. VE</td>
<td>Cooled</td>
<td>CR-DPF</td>
<td>2D-04,2D-07</td>
</tr>
<tr>
<td></td>
<td>YC</td>
<td>15.7</td>
<td>DI TI</td>
<td>Common rail</td>
<td>W/O</td>
<td>CR-DPF + Urea SCR</td>
<td>2D-05,2D-07</td>
</tr>
<tr>
<td>Chassis</td>
<td>XB</td>
<td>2.5</td>
<td>DI TI</td>
<td>Elect. VE</td>
<td>Elect.</td>
<td>CR-DPF</td>
<td>2D-04,2D-07</td>
</tr>
<tr>
<td></td>
<td>XD</td>
<td>2.0</td>
<td>DI TI</td>
<td>Common rail</td>
<td>Cooled</td>
<td>CR-DPF+ De-NOx catalyst</td>
<td>2D-04,2D-07</td>
</tr>
</tbody>
</table>

### Fuel specs.
- D1: Average fuel in current market
- 2D-04: Low sulfur (50ppm)
- 2D-05: Low sulfur (50ppm) + lighter than diesel fuel
- 2D07: Extreme low sulfur (10ppm) + light as kerosene
Repeatability of Ames Test

- Prior to conducting Ames test, repeatability of Ames test results had confirmed using PM samples individually obtained in step 1.

- PM samples obtained through the following measurements using engine O/Y with same fuel.

<table>
<thead>
<tr>
<th>Test date</th>
<th>Fuel</th>
<th>Test Cycle</th>
<th>Emissions (g/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>NOx</td>
</tr>
<tr>
<td>5/7</td>
<td>D1</td>
<td>D13</td>
<td>4.30</td>
</tr>
<tr>
<td>5/19</td>
<td>↑</td>
<td>↑</td>
<td>3.97</td>
</tr>
<tr>
<td>6/1</td>
<td>↑</td>
<td>↑</td>
<td>4.08</td>
</tr>
<tr>
<td>8/31</td>
<td>↑</td>
<td>↑</td>
<td>4.53</td>
</tr>
<tr>
<td>9/14</td>
<td>↑</td>
<td>↑</td>
<td>4.14</td>
</tr>
<tr>
<td>10/1</td>
<td>↑</td>
<td>↑</td>
<td>3.99</td>
</tr>
</tbody>
</table>
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Repeatability test results

TA100-S9

TA100+S9

TA98-S9

TA98+S9
Comparison of Mutagenicity (Engine)

TA100-S9

Current Technology package

Future Technology package

TA100+S9

Current Technology package

Future Technology package

TA98-S9

Current Technology package

Future Technology package

TA98+S9

Current Technology package

Future Technology package
Comparison of Mutagenicity (Chassis)

- TA100-S9
- TA100+S9
- TA98-S9
- TA98+S9

PM emission (g/km)

Mutagenicity (rev/mgSOF)

- Current Technology package
- Future Technology package
Ames Test Results (3)

Dose-response relation on mutagenicity under current technological packages

TA100-S9

TA100+S9

TA98-S9

TA98+S9

Engine
O/Y
X
Test Cycle: D13

Chassis
EO
Test Cycle: 10 - 15
Ames Test Results (4)

Dose-response relation on mutagenicity under future technological packages (Engine)

Test Cycle: D13

Inhibition occurred in YC

Inhibition occurred in YC
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Ames Test Results (5)
Dose-response relation on mutagenicity under future technological packages (Chassis)

Test Cycle: 10-15
**Ames Test Results Summary**

● In both engine and vehicle combined with fuel, under the future technological packages, mutagenicity per unit SOF quantity (mg) shows larger decline than those under the current technological packages.

● Taking into consideration the decline in PM emission and the effect it gives, by introducing the future technologies, the mutagenicity is likely to improve further.
Review and Future Themes for Health Effect WG Activities

- Scientific information on health effect by automotive emission was accumulated to be as base data for health effect after getting the reviews by the experts.

- Ames tests were conducted in order to verify that the introduction of the future emission reduction technology improve the health effect focusing on diesel emission, particularly, PM. As the result, it confirmed the probability of mutagenicity to decline by the introduction of future emission reduction technology.

- Following actions still expected to be carried out by the government initiatives.
  Promote further assessment on new technology and enrich findings.
  Establish *in vitro* test method to assess health effect with easier method and in wider view.
  Establish and promote risk assessment methodology based on scientific findings.