



Berne University of Applied Sciences

Highschool of Engineering
and Information Technology, Biel-Bienne
IC-Engines and Exhaust Gas Control (AFHB)



Technical University
of Denmark



Particle Emissions of 2-S scooters & General Emissions Issues of 2- and 3-Wheelers

**4th Information Report for IEA Implementing Agreement AMF,
Annex XXXIII, international activities 2007/2009**

Ordered by :

ExCo Meeting AMF, Sao Paulo, Oct. 18-21, 2004
Swiss Federal Office of Energy, project nbr. 100510, Oct. 20, 2004

Report :

Jan Czerwinski, Dipl. Ing. Dr. techn.,
Professor for thermodynamics & IC engines
University for Applied Sciences, Biel-Bienne, CH

Annex XXXIII Assistant Operating Agent:

Jesper Schramm, M. Sc., Ph. D.
Professor for IC engines & Air Pollution
Technical University of Denmark, Lyngby, DK

CONTENTS

1. ABSTRACTS	3
2. INTRODUCTION	3
3. ACTIVITIES OF THE SWISS NETWORK	4
3.1. TOXICITY UNI BERN - AFHB *)	4
3.2. OTHER ACTIVITIES OF THE SWISS NETWORK	4
4. SAE – EC JRC JOINT CONFERENCE ON SCOOTER EMISSIONS	4
5. AECC	5
6. OTHERS	5
7. CONCLUSIONS	5
8. ACKNOWLEDGEMENT	6
9. REFERENCES	6
10. ABBREVIATIONS	7
11. ANNEXES	8

*) Abbreviations see at the end of report

1. ABSTRACT

The serious health effects of particle emissions from traffic are known from the discussions about diesel engines technology and legislation. In this context the particle emissions of small 2-S engines with lost oils lubrication cannot be neglected any more.

A particular concern is about the 2-S scooters, small motorcycles and 2-S 3-wheelers, which in several countries are used very much in congested city centers.

To promote the exchange of information and mutual collaborations and progress in this domain, the present report summarizes shortly the international technical activities and activities in the reporting institutes.

There are several possibilities to reduce emissions from 2-S engines by means of technical measures and application of the best available technology (BAT*). Nevertheless the technical efforts alone cannot solve the pollution problem in several countries. The information and involvement of the political, economical and legal authorities, as well as the awareness and education of the population (users) are very important factors.

Small 4-S engines, which are going to replace more and more the 2-S engines in several new fleets, also have large potentials of emission improvements. The engines for handhold machines 2-S & 4-S represent challenges of emission reduction both: from the point of view of cost and technology.

Some information about those engines is included in this report.

2. INTRODUCTION

At present there is a demand for improved knowledge about particulate emissions from 2-S Scooters. Since emissions from other type of vehicles have been dramatically decreased as a result of more stringent emission regulations in many countries, the focus on 2-S Scooter emissions is becoming more obvious. Furthermore, some Third World countries suffer from extreme emissions from 2-S vehicles, due to the large number of those vehicles.

Therefore projects on measuring and evaluation of the impact of emissions have been started up in many countries. The influence of factors like: fuel, lubricant, engine and aftertreatment technology is being investigated in the different projects. These are the main factors that can be adjusted in order to develop cleaner vehicles.

In order to obtain an overview of the investigations the IEA *) AMF Annex XXXIII with following objectives was started in autumn 2004 :

- an overview of the content of ongoing projects
- establishment of an information network between project leaders
- establishment of links between projects, where mutual progress can be obtained
- a summary report, describing the results from the projects

The present 4th report gives further overview of international activities on research of 2-S scooters in scope to promote further technical collaborations, exchange with authorities and general improvement of the critical air pollution.

A very important step is the organisation of an International Conference on (Particle) Emissions of 2-S Scooters (see pt. 4), which is a result of the international activities of the IEA AMF Annex XXXIII.

3. ACTIVITIES OF THE SWISS NETWORK

Annex A1 shows the Network, which started in 2004. Following works and cooperation can be mentioned:

- finish of project A (Feb. 2007)
- exchange of samples and analytical work at EU-JRC Ispra, Italy (project B)
- exchange of information and collaboration with the Toxicity Network France (project D)
- start of the research of toxicity 2007 with INSERM, Univ. Rouen, F; Univ. of Berne, CH; BAFU & TTM (organization chart see annex A2)
- leading of an annex of IEA AMF together with Techn. University Lyngby, DK (project G, present report).

The extensive research activities at AFHB are reported in references of [1], [2] & [3]. An executive summary report of Project A is given in [4].

3.1. TOXICITY UNI BERN - AFHB

A special cell-exposition chamber was prepared at AFHB and expositions of lung cells cultures were performed with different exhaust gas quality of a 2-S Scooter, [5], annex A3.

As actual conclusions can be remarked, that:

- there is a clear influence of exhaust gas quality on the cytotoxicity, oxidative stress and inflammatory reactions of cells,
- the influences on certain parameters are nevertheless not always with the expected tendency – there is further necessity of research,
- the exposition of cells to the combined aerosol (with gaseous and particulate toxic components) is a very useful method of research of toxicity; it is proposed to apply this method also for HD-engines with biofuels.

3.2. OTHER ACTIVITIES IN THE SWISS NETWORK

The proposition of the Swiss Network to organize an International Conference on (Particle) Emissions of 2-S Scooters was approved by SAE and by the EC-JRC in spring 2008. AFHB took contacts with different specialists, set up the technical program and forwarded it to the scientific committee, EC JRC & SAE.

4. SAE – EC JRC JOINT CONFERENCE ON SCOOTER EMISSIONS

Following attachments give the complete information about this Conference:

- annex A4 – preliminary announcement of the Conference
- annex A5 – Technical Program
- annex A6 – Abstracts of all technical presentations

The Conference will take place on the Autodromo Nazionale Monza, Italy, one of the oldest racing tracks for F1 worldwide.

The Conference addresses all concerned specialists from: authorities, rule makers, industry, environment & health protection and users.

In collaboration with IA HEV information about hybrid and/or electric 2-wheelers will be given.

The organizers hope to put with this event an important step towards general comprehension and improvements of the emission situations of 2-wheelers and in generally of small SI-engines.

5. AECC

Important information about international emission topics is to be found in the periodic newsletters of AECC (www.aecc.be).

In the newsletter March – April 2008 reports of the Belgian government about NP-Emissions of Two-Wheelers are mentioned, see annex A7. There is a remarkable international consciousness about nanoparticles, their health effects and high level emissions of 2-wheelers.

6. OTHERS

Performances of a small 2-stroke SI engine (50cc) with CNG propulsion were investigated at the University of Naples, [6], annex A8.

There are potentials of leaning the engine operation and lowering CO & NO_x. HC stays principally at the same level, as with gasoline, but is consist mostly of methane. There is lower maximum torque line with CNG due to a lower feeding ratio. There are no statements about lubrication and emissions from the lube oil.

An US-American company “Envirofit”, [7], sells in Asia a retrofit kit for 2- and 3-wheelers, which allows better dosing of fuel and lube oil, saves (according to the information source) the fuel consumption and lowers emissions (due to possibility of leaner operation). The system consists of low costs elements: fuel & oil injection, air pump, ECU, necessary sensors, cables and pipes, annex A9.

STIHL a German manufacturer of handheld machinery presents a development of stratified scavenging, which allows remarkable emissions reductions (CO, HC) without drawbacks of packaging, weight, costs, or power, [8], annex A10. There are no statements about lubrication-related unregulated emission components.

7. CONCLUSIONS

A lot of work is done yearly in the R&D of gasoline 2-S and 4-S engines for 2- and 3- wheelers.

Several improvements of engine- and exhaust gas aftertreatment technology are possible.

To reduce sustainably the emissions of 2-wheeler fleet the technical improvements of new vehicles are not sufficient.

Further legal and political steps to increase the awareness of the users and to promote control and maintenance are necessary.

8. ACKNOWLEDGEMENT

The authors want to express their gratitude to:

- Swiss Federal Office of Environment (BAFU)
Swiss Association of Oil Manufacturers (EV)
Swiss Association of Lubricants Industry (VSS)
Swiss Federal Office of Energy (BfE)
for the financial support of the Swiss Network activities.
- Mr. Andreas Mayer, TTM
for leading and coordinating the Swiss Network activities
- Mr. Peter Finckh, EUWP Associate Chair for Transport
for promoting the activities of Annex XXXIII and for his constant engagement for energy, environment and economic development.
- Prof. Dr. Peter Gehr and Dr. Barbara Rothen-Rutishauser, Institute of Anatomy, University of Bern, for inspirations and support of the toxicity research.
- Dr. Giovanni De Santi and Dr. Maria Covadonga Astorga-Llorens EC-JRC Ispra for support and organization help of the International Conference on (Particle) Emissions of Scooters, Monza, Italy, June 11th-12th, 2009.

11. REFERENCES

- [1] Czerwinski, J.; Schramm, J.: Particle Emissions of 2-S Scooters. 1st information report for IEA Implementing Agreement AMF, Annex XXXIII, international activities 2004/2005, AFHB B169, Oct. 2005, DTU, BfE, www.iea-amf.vtt.fi -> download -> Annex XXXIII.
- [2] Czerwinski, J.; Schramm, J.: Particle Emissions of 2-S Scooters. 2nd information report for IEA Implementing Agreement AMF, Annex XXXIII, international activities 2005/2006 AFHB B189, Nov. 2006, DTU, BfE, www.iea-amf.vtt.fi -> download -> Annex XXXIII.
- [3] Czerwinski, J.; Schramm, J.: Particle Emissions of 2-S Scooters. 3rd information report for IEA Implementing Agreement AMF, Annex XXXIII, international activities 2006/2007 AFHB B209, Dec. 2007, DTU, BfE, www.iea-amf.vtt.fi -> download -> Annex XXXIII.
- [4] "Influences on Particle Emissions of Modern 2-Stroke Scooters. 4th report of the project Project A / 2004-2007. Lab. for Emission Control, Univ. of Appl. Sc. Biel, CH ; B198, Feb. 2007
- [5] Müller, L.; Rothen-Rutishauser, B.; Comte, P.; Czerwinski, J.; Kasper, M.; Mayer, A.; Morin, J.-P.; Gehr, P.: A New Exposure System to Evaluate the Toxicity of Scooter Emission in Lung Cells *In Vitro*. 12th ETH Conference on Combustion Generated Nanoparticles, Zürich, Aug. 2008, www.nanoparticles.ethz.ch
- [6] Gimelli, A.; Cascone, C.; Pennacchia, O. ; Unich, A. ; Capaldi, P. :Performance and Emissions of a Natural Gas Fueled Two-Stroke SI Engine. Università di Napoli "Federico II", SAE Techn. Paper SAE 2008-01-0318
- [7] www.envirofit.org; www.rolexawards.com
- [8] Möser, Ch. M.; Gegg, T.; Seidel, T.; Zwimpfer, M.: Emissions Reduction of Small Displacement High Power Engines. 8. Stuttgarter Symp.März 2008

10. ABBREVIATIONS

ACEM	Association des Constructeurs Européens de Motocycles (www.acem.eu)
ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie, France
AECC	Association for Emission Control by Catalyst (www.aecc.be)
AFHB	Abgasprüfstelle der Fachhochschule, Biel CH, (www.afhb.bfh.ch) (Lab.For Exhaust Gas Control, Univ. of Appl. Sciences, Biel-Bienne, Switzerland)
AMF	Advanced Motor Fuels
ANCMA	Associazione Nazionale Ciclo Motociclo Accessori, Milano, It.
BfE	Bundesmat für Energie, CH (SFOE)
BAT	best available technology
BAFU	Bundesamt für Umwelt, (Swiss EPA, FOEN)
C	Carburetor
Carb	Carburetor
CARB	Californian Air Resources Board
CERTAM	Centre d'Etudes et de Recherche Technologique en Aérothermique et Moteur
CPC	condensation particle counter
CVS	constant volume sampling
DC	diffusion charging sensor
DI	direction injection
DMA	differential mobility analyser
DTU	Technical University of Denmark, Lyngby DK
ECU	electronic control unit
EMPA	Eidgenössische Materialprüfungs- und Forschungsanstalt
ENEA	National Agency for New Technologies, Energy and Environment, Rome, Italy (Ente Nazionale per le Nuove Technologie, l'Energia e l'Ambiente)
EPA	Environmental Protection Agency
ETHZ	Eidgenössische Technische Hochschule Zürich
EV	Erdöl Vereinigung, CH
FL	full load
G-DI	gasoline direct injection
GRPE	Groupe Rapporteur Pollution et Energie
HEV	hybrid electric vehicles
IA	Implementing Agreement
ICCT	International Council on Clean Transportation (www.theicct.org)
IEA	International Energy Agency
I/M	inspection / maintenance
INSERM	Institut National de la Santé et de la Recherche Médicale, F
INSOF	insoluble fraction
JRC	EU Joint Research Center, Ispra It.
JASO	Japanese Automobile Standard Organisation
JSAE	Japanese Society of Automotive Engineering (www.jsae.or.jp)
ME	Matter Engineering, CH
NanoMet	minidiluter + PAS + DC (ev. + TC, or TD)
NMOG	non methan organic gases
NP	nanoparticulates
OP	ozon potential

PAH	polycyclic aromatic hydrocarbons
PAS	photoelectric aerosol sensor
PC	particles counts
PM	particulate matter, particulate mass
PMP	Particle Measuring Program of the UNO ECE GRPE
PN	particles number
PSD	particles size distribution
PSI	Paul Scherrer Institut, Switzerland
SAE	Society of Automotive Engineering (www.sae.org)
SAG	Swiss Aerosol Group (medical)
SAI	secondary air injection
SAS	secondary air system
SETC	Small Engines Technology Conference (www.sae.org)
SFOE	Swiss Federal Office of Energy
SI	spark ignition
SMPS	scanning mobility particles sizer
SOF	soluble organic fractions
SUVA	Schw. Unfall Versicherungs Anstalt, Swiss Occupational Insurance
SWRI	South West Research Institute
T	TSDI
TC	thermoconditioner, total carbon
TEF	Toxicity Equivalence Factor
TEQ	Toxicity Equivalence $TEQ = \sum (TEF_i \times concentration_i)$
TSDI	Two Stroke Direct Injection
TPN	total particle number
TTM	Technik Thermische Maschinen, Niederrohrdorf, CH
TUG	Technical University Graz, Austria
VSS	Verband der Schweizerischen Schmierstoffindustrie
VTT	Technical Research Center of Finland
WFC	wiremesh filter catalyst
WMTC	Worldwide Motorcycle Test Cycle

11. ANNEXES

A 1	2-S Scooters Swiss Project Network
A 2	Project D: Toxicity, organisation chart
A 3	Toxicity of Scooter Emissions
A 4	SAE-EC JRC Scooter Conference – preliminary announcement
A 5	SAE-EC JRC Scooter Conference – Technical Program
A 6	SAE-EC JRC Scooter Conference – Abstracts
A 7	AECC newsletter March – April 2008
A 8	CNG fuelled 2-S SI Engine SAE 2008-01-0318, [6]
A 9	Direct Injection Retrofit Kit for 2-S SI Engines, [7]
A 10	Emission Reduction of handheld machines, [8]