PROJECT: SMT4-CT97-2166

Pilot Studies of CEN Protocols for Evaluating the Emission of Airborne Hazardous Substances from Machines

SYNTHESIS REPORT
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Project Coordinator: David Mark

University of Birmingham, UK

Now at
Health and Safety Laboratory
Broad Lane, Sheffield S3 7HQ, UK

E mail: dave.mark@hsl.gov.uk:
Tel: +44 114 289 2601
Fax: +44 114 289 2732

PROJECT SUMMARY CONTRACT SMT4-CT97-2166

Background

The control of hazardous emissions (such as aerosols, dusts, gases and vapours) from machines is an important consideration in the design and operation of many industrial processes. For this to be based on valid scientific principles, it is necessary to have reliable information about the likely emissions rates of hazardous substances from the machines that are designed, installed and monitored. Emissions of hazardous substances from machines are an important part of European standards currently being developed to fulfil the requirements of the EU Directive on Safety of Machinery. The work described in this report involves the evaluation and further development of two complementary methods for the measurement of the emission rates of pollutants from machines. The two main methods for measuring the emission rates of pollutants from machines are: a) Test Bench Method, in which measurements of the emission rates of real pollutants from machines are made in specially built test rigs in test houses, and b) Tracer Gas method, where a tracer gas of known emission rate is injected into the pollutant source to mimic the transport properties of the pollutant. The latter method can be carried out in rooms or enclosures at the workplace.

Objectives

The main aims of this project are: a) to evolve the necessary methodology for Part 2 of EN 1093 (Tracer Method); b) to improve the emission rate measurements for all emitted particles especially the larger ones which dominate the inhalable fraction using the Test Bench Method as specified in Part 3 of EN 1093; c) to evaluate the reproducibility of the improved methods by means of preliminary tests using firstly a reference pollutant source, and secondly a simple machine (a cutting machine for aerosols; a cleaning machine for gases and vapours).

Work Programme

The work divided into two main sub-projects: a) Test Bench method, and b) Tracer Gas method. For both sub-projects a similar iterative work programme was adopted. The first step involved the development of simple reference pollutant sources (both dust and gas) to be used in the tests. The parameters which affect the results of both the Test Bench method (as outlined in the standard) and the proposed Tracer Gas method, were then investigated. The results were analysed and the protocols for both methods revised and improved. Preliminary tests of revised protocols using reference pollutant sources to determine the reproducibility of the two methods were then carried out. Tests with simple cutting and parts washing machines were then carried out to highlight any problems with the methods associated with the operation of machines, and to provide estimates of the accuracy of the final methods. The feasibility of applying tracer methods to the emissions of particles from machines was investigated. Publications, conference and meeting presentations have been prepared to disseminate the results from the research.

Results and Achievements

New or revised protocols have been produced for two complementary methods for measuring the emission rates of hazardous substances from machines. For the Test Bench method, tests were successively carried out to investigate the parameters that affect the emission rates of particles from machines when the protocol in EN 1093-3 is followed. From the findings of the study, improvements to the protocol for EN1093-3 were proposed. The accuracy of the final protocol was established. For the Tracer Gas method, a draft protocol for measuring the emission rates of gaseous pollutants from machines was produced and the accuracy of the protocol established. The use of tracer particles to predict the emission rates of particles from

machines was investigated and sufficient promise was shown to suggest further work should be carried out.

Keywords: Emissions from machines, airborne particles, gases and vapours, workplace pollution control

CONTENTS

1. INTRODUCTION

The control of hazardous emissions (such as aerosols, dusts, gases and vapours) from machines is an important consideration in the design and operation of many industrial processes. For this to be based on valid scientific principles, it is necessary to have reliable information about the likely emissions rates of hazardous substances from the machines that are designed, installed and monitored. Emissions of hazardous substances from machines are an important part of European standards currently being developed to fulfil the requirements of the EU Directive on Safety of Machinery. The work described in this report involves the evaluation and further development of two complementary methods for the measurement of the emission rates of pollutants from machines. The two main methods for measuring the emission rates of pollutants from machines are: a) Test Bench Method, in which measurements of the emission rates of real pollutants from machines are made in specially built test rigs in test houses, and b) Tracer Gas method, where a tracer gas of known emission rate is injected into the pollutant source to mimic the transport properties of the pollutant. The latter method can be carried out in rooms or enclosures at the workplace.

2. THE CONSORTIUM

The project was carried out by the following partners:
UOB: Institute of Occupational Health, University of Birmingham, Birmingham, UK acting as coodinator
INRS: Institut National de Recherche et de Securité, Vandoeuvre Cedex, France
BIA: Berufsgenossenschaftliches Institut für Arbeitssicherheit, Alte Heerstrasse , Sankt Augustin, Germany
NIWL: National Institute of Working Life, Solna, Sweden
HSL: Health and Safety Laboratory, Sheffield, UK
FIOH: Finnish Institute of Occupational Health, Lappeenranta, Finland,
IFW: Institut für Werkzeugmaschinen, University of Stuttgart, Germany,
DAT: Datastat Consultants, London, UK (Subcontractor to UOB)
LECES: Maizieres-les-Metz Cedex, France (Industrial Partner)
JLC: John Liverton Consultants, Ladbroke, UK (Industrial Partner)

Brief organisational descriptions are given at the end of this report.

3. THE TECHNICAL WORKPROGRAMME (WP = WORK PACKAGE)

The work was organised into two main projects, associated with the two options for measuring the emission rates from machines – A) Test Bench Method, and B) Tracer Gas Method. Each project plan contains a number of separate work packages to fulfil the above project aims. However, as will be seen later in the report the plans were modified at certain stages during the work and there is definite linkage between the two methods.

3.1Test Bench Method

WP A1: Preliminary work for Test Bench : Procure and commission the equipment necessary for the project and to produce a statistically sound experimental protocol.

WP A2: Choice and validation of reference dust source: Select and validate a dust feeder suitable to serve as a simple reference dust source with known and reproducible emission rate.

WP A3: Evaluation of parameters affecting results of existing method: Study the effect of a range of experimental parameters on the measured emission rate.

WP A4: Standardisation of Equipment and revision of Protocol for Test Bench Method Produce the most suitable design of cabin and operational procedures for the test bench method.

WP A5: Tests of Test Bench Method with Reference Dust Source: Determine the reproducibility of the revised protocol for the test bench method.

WP A6: Tests of Test Bench Method with Simple Machine: Determine whether there are any practical problems with the methods associated with the operation of machines, and provide estimates of the accuracy of the method.

3.2Tracer Gas Method

WP B1: Preliminary work for Tracer Gas method: Procure and commission the equipment necessary for the project and produce a statistically sound experimental protocol.

WP B2: Tests of Tracer Gas Method with Reference Gas Source: Develop a reliable protocol for the tracer gas method, and determine the reproducibility of the proposed method

WP B3: Tests of Tracer Gas Method with Simple Gas Machine: Determine whether there are any practical problems with the methods associated with the operation of machines, and provide estimates of the accuracy of the method

WP B4: Determination of Transfer Coefficients of Gases and Aerosols: Determine the maximum particle size capable of being measured by the tracer gas technique

WP B5: Tests of Tracer Gas Method with Reference Aerosol Source: Determine the reproducibility of the tracer gas method for measuring the emission rate of simple aerosol sources.

WP B6: Tests of Tracer Gas Method with Simple Aerosol Machine: Determine whether there are any practical problems with the methods associated with the operation of machines and to provide estimates of the accuracy of the method

4. OVERVIEW OF THE RESULTS OF THE WORK

WPA1: Preliminary work for test bench method

Five partners were able to locate and deploy test cabins suitable for use in the project. These comprised an open test cabin of rectangular cross section 3 m wide, 2,4 m high and length 6 m and constructed of painted plywood or painted metal. This was connected via a tapered funnel to a square measurement duct of cross section 0.8 m by 0.8 m and 5 m long. A sketch of the test bench is given in Figure 1.

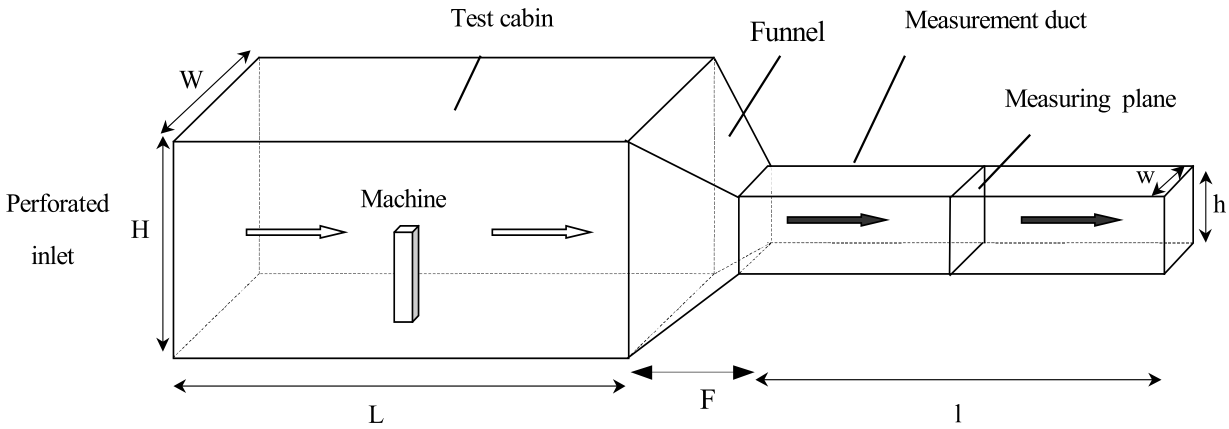

Figure 1: Schematic of Test Bench

Pollutants (particles or gases) emitted from the machine placed in the test cabin are conducted by the airflow into the measurement duct for assessment of the emission rate.

A considerable amount of time and effort was spent to commission the test benches. This involved in the first instance ensuring that the velocity profile of the airflow in the test cabin and measurement were as flat as possible. This was achieved in a number of different ways - some used a perforated inlet wall, others a fabric filter material, whilst others used aerodynamic means. Next, it was essential for accurate pollutant concentration measurements that the concentration profile in the measurement duct was as uniform as possible. After a series of tests with tracer gas and particles, this was achieved by the use of extra mechanical mixing between the machine and the measurement plane. Two approaches were found to be successful – a mixing fan placed in the funnel and a compressed air nozzle.

WPA2: Choice and validation of reference dust source

A reference dust source, for which the emission rate was known accurately, was required to enable the performance of the method, as described in the protocol in EN1093-3, to be examined. This comprised a PALAS RBG 1000 dust generator and a set of fused alumina (Aloxite) test dusts. The PALAS dust generator was chosen mainly because the emission rate could be determined from a number of simple weighings. In addition, it was fully controllable, could feed all sizes of dust required and was available for purchase off the shelf. Four grades of Aloxite were chosen for the project in the particle size range 6 to 74 μm mass median aerodynamic diameter (mmad).

A programme of testing and validation of the dust generators was carried out to develop an operating procedure for the dust generators, and to establish the level of similarity of dust emission amongst the six generators The mean variability between the emission rates for the six machines purchased was 5% for the four test dusts.

WPA3: Evaluation of parameters affecting results of existing method

The effects of a number of important parameters that may influence the measurements of the emission rates of dust from machines when following the protocol of EN 1093-3, were investigated using the simple reference source. Transport velocity (or wind speed) in the test cabin was found to be the most important parameter. The efficiency of the system increased with increasing transport velocity, especially for the larger particle sizes. The distance between dust source and measurement duct also affected performance, with the shorter distances giving higher efficiencies. The injection velocity and injection height had minor effects on performance, but low efficiencies were obtained when the particles were injected at orientations against the wind. These findings confirmed the predictions that had been made earlier about the performance of the current protocol and provided justification for the work.

WPA4: Standardisation of equipment and revision of protocol for test bench method

The results from WPA3 were analysed statistically and a set of the most suitable operating parameters for the method were agreed. These were incorporated in a revised protocol and used in the next stages of the work. All the test cabins were modified accordingly.

WPA5: Tests of test bench method with reference dust source

The aim of this phase of the work was to determine the accuracy of the revised method, using the reference dust source as a simple machine for which the emission rate is accurately known. Six partners took part in these tests, who carried out five replicate tests for each test dust. This enabled assessment of the intra- and inter-laboratory variability in determining the efficiency by which the emission rate of dust emitted from the reference dust generator can be measured by the test bench method.

The results were analysed statistically and it was found that the average efficiency in measuring the emission rate of dust from the reference dust source is dependent upon the size distribution of the dust emitted, varying from 91% for particles of mmad 6 μm to 44% for particles of mmad 74 μm. The intra-laboratory variability on measurement of the emission rate according to the given protocol is 4 to 5 %, and the inter-laboratory variability for measurement of the emission rate according to the given protocol is a maximum of 10 %.

Limited measurements were carried out to determine the mass of particles that had deposited on the internal walls of the test cabin between the dust source and the measurement plane. When these particles were added to the mass flux of particles reaching the measurement plane, the overall efficiency of the method was increased to 92% for particles of mmad 6 μm to 75% for particles of mmad 74 μm.

WPA6: Tests of test bench method with simple machine

With progress having been made in workpackages WPA1 to WPA5 to improve the accuracy of the method given in EN1093-3 by the use of a reference dust source and test dusts, the purpose of this final stage of the work was to investigate whether the new protocol worked. This involved the use of a simple machine designed and built by one of the partners. It consisted of a hand held circular saw and an angle grinder that were in turn attached to a simple automatic saw bench. Emission rate measurements were carried out for the machine when cutting slabs of three different materials: plaster, medium density fibreboard and concrete. Five replicate tests were performed and it was found that the intra-partner coefficients of variation within the laboratories were small at between 5 and 9 % for the three materials. However, the inter-partner variations for the three materials were larger (17 % for

MDF and 14 % for both the gypsum and the concrete), because the moisture content of the materials and the temperature at which the tests were carried out had a significant effect on the measured emission rate. It was recommended therefore that tests involving the cutting of materials should be carried out, if possible, under a specified set of environmental conditions to avoid uncontrollable differences between test houses. Again, when particles deposited on the internal walls were added to the measured particle fluxes, the overall efficiencies for the three materials were found to be greater than 90 % for all three materials

Production of draft revised standard method for Part 3 of EN1093

The final deliverable from the test bench project was a list of suggested changes to be put to CEN/TC114/WG15, for consideration in a revised version of the standard EN 1093-3. They were as follows:

- Mixing fans should be installed into the funnel of the test bench to ensure accurate sampling even for gaseous pollutants.
- The transport velocity in the test cabin should be increased to 0.5 m/s.
- The scope of the standard should include all airborne substances.
- There should be more detailed specification of samplers to be used, including the number of samplers or sampling positions required - one sampler in the centre may not be enough.
- The recommendations about the inlet to the test cabin can be more general. It is not necessary to specify use of perforated inlet, alternative methods could be used to ensure that there are no external influences on air inlet, and a uniform flat velocity profile is maintained in the test cabin.
- The use of surface monitoring techniques to estimate the dust deposited on the cabin, funnel and sampling duct floors should be considered as potentially useful additional information.

WPB1: Preliminary work for tracer gas method

One of the main benefits of using the tracer gas method, rather than the test bench method, to measure the emission rates of pollutants from machines is that in principle the measurements should be able to be carried out anywhere in the workplace. This means that it does not require a special facility. However, in order to allow the important parameters in the method to be studied and improved, the work was carried out in test rooms, chosen to have well defined consistent airflow patterns generated by one inlet and one outlet and ventilation rates of between 5 to 10 air changes/hr. Two partners provided tests rooms for the project, and despite having similar volume flowrates, one room had considerably better mixing characteristics than the other.

The principle of the tracer gas method is that if a tracer of known emission rate is injected into a gas machine, then by measuring the concentration of pollutant and tracer at a number of locations around the machine, the emission rate of the pollutant can be calculated. For this project, a combined pollutant/tracer gas generator that can operate as a reference gas source was produced by one of the partners. It comprised the controlled vaporisation of a known volume of acetone liquid. Two versions were produced – one a point source and one a plane source. Tracer gas was injected in a number of locations including in the pipe-work before emission. Three different tracer gases were tested – SF_6 mixed with nitrogen to give different densities, helium gas and nitrous oxide. The measurement and evaluation of the pollutant and tracer concentrations were similar for each of the test laboratories. The pollutant/tracer concentrations were allowed to build-up inside the test cabins until a steady state had been achieved (usually after approximately 2000 s). The gases were then sampled, in blocks of 600 seconds, at each sampling position at 1 second intervals. The mean concentrations of acetone and tracer at each of the sampling positions were then calculated.

WPB2: Tests of tracer gas method with reference gas source

The aim of this phase of the work was to develop the first draft protocol for Part 2 of EN 1093 (Tracer Method) using the combined expertise of the laboratories involved. The work comprised three phases, which were carried out sequentially to enable the method to be improved with the findings from each phase. The phases were: i) initial tests of emission rates of acetone using partners own methodology; ii) workshop at one laboratory to compare methods; iii) tests of reproducibility with revised protocol Each laboratory carried out three replicates of at least four different configurations for each phase of the work., and an agreed improved protocol was produced after the third phase, which would form the basis of the methodology for Part 2 of EN1093.

From the three-stage set of tests in which reference gas sources (both point and plane) were used, the requirements for accurate results were established. These included the ventilation requirements outlined above (in WPB1) and two recommendations for the tracer gas. They were: a) the tracer gas chosen should be neutrally buoyant, in order to have the same density as the diluted pollutant, and b) the tracer gas should be emitted as close to the source as possible, and should be emitted in a way similar to that of the pollutant.

WPB3: Tests of tracer gas method with simple gas machine

The aim of this phase of the work was to determine the mass emission rate of a gaseous pollutant from a real machine using the tracer gas method. From these measurements the accuracy and reproducibility of the proposed protocol for EN 1093-2 could be assessed.

WPB3 was intended to be a challenging test of the method, in which solvent vapour from a machine parts washer escaped fugitively through leaks in the washer lid. However, the injection of tracer gas was achieved simply into the compressed air tubing entering the machine and so this ensured that the pollutant and tracer were well mixed before release into the test room. Nevertheless, there were differences in the mean emission rates quoted between the three laboratories involved. Whilst the emission rate results from two partners were similar, those from the third were considerably higher. A possible reason for this was associated with the high air change rate of 25 per hour in the latter partner's test room. Whilst this did not appear to excessively affect the accuracy with which the measurements were made, it affected the rate of release of the acetone vapour from the machine. This provided an important additional recommendation for the successful application of the method – the air change rate in the room or enclosure should be between 5 and 10 air changes per hour (lower air changes are acceptable, but if air mixing is deemed to be poor, an additional fan should be used), and the room should be almost empty apart from the machine and the monitoring equipment.

With the findings form this work, a draft protocol for EN 1093-2 was written which represents the best methodology that we have developed from a systematic study of the parameters that may affect the measurement of the emission rate of gaseous pollutants from machines using the tracer gas method. However, before it becomes a standard there should be more inter-laboratory tests carried out to establish the accuracy of the method with more datasets.

WPB4: Determination of transfer coefficients of gases and aerosols

With the successful development of a protocol for measuring the emission rates of gaseous pollutants from machines in test rooms or work places, the next step was to investigate up to what size of particle the method could still provide usefully accurate results.The extension of the tracer gas methodology to particulate pollutants was considered at the outset to be problematic because of the difficulties of meeting the requirement of aerodynamic similarity between tracer and pollutant. This was borne out by the results from WPB4, in which the tracer gas method only gave reasonably good results for small particles of mmad of 1 µm. For particles of mmad of 6 µm, the tracer gas method underestimated the emission rate by around 50 %. At this stage in the project, the project team had to decide either to give up, or to investigate two different applications of the tracer technique. They were:

1) move the pollutant source into the test bench and investigate whether the method described in Part A could be improved by the use of tracer techniques,
2) investigate the use of particle tracers and follow the principle outlined for the tracer gas method.

The formal programme was therefore altered to allow the work dscribed above to procede.

WPB5 and WPB6: The use of tracer gas method in the test bench to enhance the methodology for measurement of emission rates of particles

The idea behind the first approach was in order to minimise the effect of the sedimentation of particles in test rooms with low air velocities, it was suggested that the particles and tracer gas should be transported in a piston-type airflow to a region of the test room where the concentrations can be reliably measured. This was the principle behind the test bench method, and so two partners investigated the use of the tracer gas method in the test bench to measure the emission rates of particles from the reference dust source and the simple machine following the protocols of WPA5 and WPA6, respectively. They found that similar accuracy could be achieved whether using the test bench method involving dust sampling through five isokinetic probes, or using the tracer gas method and sampling at one central points for both dust and tracer gas. The results from the simple machine gave mean errors of + 17.5, +9.9 and – 5.3 % for MDF, gypsum and concrete respectively, when comparing the single point/tracer gas method to the standard five sampling points method. The implication of this finding is that, if a test house has tracer gas equipment and expertise, and the emission rates from the machine are low, then a practical experimental set up would be to employ the single point/tracer gas method and use a large single central isokinetic probe. In this way, the mass of dust collected is maximised to reduce run time, and the accuracy of the method is improved by using the tracer gas. This may be suggested to the CEN/TC114/WG15 as a possible option to the five sampling point methodology.

The feasibility of developing a tracer particle method to measure particulate emission rates from machines

The work of WPB4 showed that the extension of tracer gas techniques to measuring the emission rates of particles failed because one of the main assumptions for the tracer gas method to work was not being met – the tracer and pollutant do not have similar transport properties. The aim of this part of the project was to investigate the use of particulate tracers to predict the emission rates of dust particles from machines.

The use of tracer particles to measure the emission rates of particles from machines is fraught with problems, but is the logical extension of the successful tracer gas techniques for gaseous emissions. The main problems are; how to differentiate between the tracer and the pollutant, how to generate the tracer particles and inject them close to the pollutant source, how to cover the range of particle sizes likely to be emitted from different machines. These problems were addressed in the feasibility study carried out by one of the partners. After considering various options, they derived a method that involved the use of sodium fluorescein powder, dispersed into the pollutant dust stream at a known emission rate via a metered dust disperser. Sodium fluorescein readily dissolves in water and so can be separately analysed by fluorescence spectrometry. Dusts of two different size ranges were produced by sieving, and preliminary results showed efficiencies were greater than 80 %. The method is still in the early stages of development, and there are a number of important problems still to solve, but we believe that it shows sufficient promise to warrant further work to develop the method into a practical and accurate method for measuring the emission rates of particles from machines in the workplace.

5. CONCLUSIONS

In this large two-part project, we have investigated and developed a number of methods for measuring the emission rates of pollutants from machines covering particulate and gaseous pollutants, a wide range of machines, in both test houses and the real workplace. We have achieved the following main objectives:

1. An assessment of the performance of the methodology for the current test bench standard EN 1093-3 has been carried out. It was found that the resultant emission rate measurements depending upon; the size distribution of the emitted dust, the transport velocity and transport distance in the test cabin, the degree of mixing in the test bench funnel and sampling duct.
2. A revised protocol for EN 1093-3 has been proposed. This incorporates the suggested changes made in light of the assessment carried out, and includes a number of possible options. If particle deposits on the test bench floor are included, then the biases in the measured emission rate measurements were limited to about 10 %. Intra and inter-laboratory variabilities were on average less than about 10 and 15 % respectively.
3. A draft protocol for EN 1093-2 for measuring the emission rates of gaseous pollutants from machines using tracer gas techniques, has been produced. It incorporates in the methodology, many of the important requirements that the laboratory tests had shown were essential for accurate results. The results from two laboratories had shown that the overall variability in the results was ± 11 %, with the mean bias in the range –10 to + 5 %.
4. The feasibility of extending the tracer gas technique to tracer particles has shown promise. Using two different sizes of sodium fluorescein, the emission rates of particles of mmad 46 μm and 105 μm, have been predicted with a bias of less than -17 %.

6 PUBLICATIONS AND CONFERENCE PRESENTATIONS

Conference presentations made

Mark D, Dessagne J-M, Fletcher B, Godja A, Heimann M, Jansson A, Welling I and Chalmers C (2000). Pilot studies of CEN protocols for evaluating the emission of airborne hazardous substances from machines – a review of progress. Paper presented at Ventilation 2000, Helsinki June 5 –7 2000, and published in the proceedings of the conference.

Publications in preparation

Mark D, Dessagne J-M, Heimann M Johnson A, Jansson A, Welling I, Fronius J and Chalmers C (2003) The role of machinery emissions testing for minimising exposure to hazardous substances in the workplace. To be submitted to Annals of Occupational Hygiene.

Fronius J, Mark D, Dessagne J-M, Heimann M, Jansson A, Welling I, Liverton JL and Chalmers C (2003) A study of the performance of EN 1093-3 - the test bench method for measuring the emission rates of particles from machines, and suggestions for improvement. To be submitted to Annals of Occupational Hygiene.

Dessagne J-M, Johnson A, Jailler M, Jansson A, Mark D, Chalmers C (2003) Development and evaluation of the tracer gas method for measuring the emissions rates of gases and vapours from machines. To be submitted to Annals of Occupational Hygiene.

Conference presentations planned

Mark D, Dessagne J-M, Johnson A, Fronius J, Heimann M, Jansson A, Welling I and Chalmers C (2002) Pilot studies of CEN protocols for evaluating the emission of airborne hazardous substances from machines. To be presented at Ventilation 2003, Sapporo Japan, 5-8 August 2003.

Technical Report available from the Coordinator

Mark D, Dessagne J-M, , Heimann M, Johnson A, Welling I, Fronius J, Jansson A and Chalmers C (2002) Pilot Studies of CEN Protocols for Evaluating the Emission of Airborne Hazardous Substances from Machines, Final Report on Project SMT4-CT97-2166

7. DETAILED INFORMATION ON THE CONSORTIUM

7.1 Overview of the consortium

Table 1 Participants and roles

No.	Organisation	Type	Role	Country	Business activity	Function in project
P.1	UOB	EDU	C	GB	Research/training in workplace health and medical services	Coord., Inv., Dev., Test., Steer.
P.2	INRS	ROR	P	FR	Research/services in workplace health and safety	Inv., Dev., Test., Steer.
P.3	BIA	ROR	P	DE	Research/services in workplace health and safety	Inv., Dev., Test., Steer.
P.4	NIWL	ROR	P	SE	Research/services in workplace health and safety	Inv., Dev., Test., Steer.
P.5	HSL	OTH	P	GB	Research/services in workplace health and safety	Inv., Dev., Test., Steer.
P.6	FIOH	ROR	P	FI	Research/services in workplace and environmental health and safety	Inv., Mod., Cons., Steer.
P.7	IFW	EDU	P	DE	Research/services in workplace health and safety	Inv., Dev., Test., Steer.
P8	DAT	IND	S to P1	GB	Consultant in experimental design and statistical analysis	Stats, Steer
P9	LECES	IND	Ind P	FR	Research/services in workplace and ambient air quality	Test
P10	JLC	IND	Ind P	GB	Consultant in machine tool design	Test

Key to abbreviations:
C = Co-ordinator; P = Partner; Ind P = Industrial Partner; S = Subcontractor (all subcontractors are major, and are thus included also as partners).
Coord. = Co-ordination; Inv. = Investigation; Dev. = Development; Test. = Testing; Experimental design and statistical analysis = Stats; Steer. = Steering Committee.

7.2 Profile of individual partners and subcontractors

7.2.1. PARTNER 1: University of Birmingham (UOB), UK

Technical team leader: Mr David Mark
Address: Institute of Occupational Health, University of Birmingham, Edgbaston, Birmingham, B15 2TT, UK.
Telephone: +44 121 414 6024*
Fax: +44 121 414 6217*
E-mail: dave.mark@hsl.gov.uk*

The Institute of Occupational Health is a multidisciplinary department within the Faculty of Medicine, University of Birmingham (UOB). UOB has an international reputation for work in occupational health and hygiene research and specialises in large multi-partner and/or multi-site international studies. It has wide experience in the measurement of airborne dust in workplaces for epidemiological research.

* David Mark is now at HSL, Sheffield UK.

7.2.2 PARTNER 2: Institut National de Recherche et de Securité (INRS), France

Technical team leader: Mr Jean-Michel Dessagne
Address: INRS, BP 27, 54501 Vandoeuvre Cedex, France.
Telephone: +33 83502072
Fax: +33 83502184
E-mail: dessagne@inrs.fr

INRS carries out work, under the aegis of the Ministry responsible for Social Security, to help to prevent occupational accidents and disease and to improve working conditions. INRS conducts research and studies, to provide training and to collect, analyse and disseminate information in the relevant fields. It acts as technical and medical advisor to State authorities, National and Area health insurance funds, trade associations, trade unions, etc. and is a notified body for the Machinery Directive. The Ventilation Department of INRS.has over 25 years experience in the field of chemical and fluid dynamics experimentation concerning the assessment of ventilation systems and their improvement.

7.2.3 PARTNER 3: Berufsgenossenschaftliches Institut für Arbeitssicherheit (BIA), Germany

Technical team leader: Mr Manfred Heimann
Address: BIA, Alte Heerstrasse 111, D-53757 Sankt Augustin, Germany
Telephone: +49 2241 231 580
Fax: +49 2241 231 234
E-mail: m.heimann@hvbg.de

BIA is the central research institute of the German professional associations, the statutory accident prevention and insurance institutions. It investigates causality in connection with occupational accidents and diseases. The BIA assists the professional associations by research, testing, technical advice and standardisation. It received accreditation as a testing and certification body for a number of test fields. The BIA activities are focused on chemical and biological hazards, toxicology and epidemiology, physical hazards, personal protective equipment and safety of machinery according to the requirements of the Machinery Directive.

7.2.4 PARTNER 5 National Institute of Working Life (NIWL), Sweden

Technical team leader: Dr Anders Jansson
Address: NIWL, S-171 84 Solna, Sweden
Telephone: +46 8 7309100
Fax: +46 8 275307
E-mail: anders.jansson@itm.su.se*

The Swedish National Institute for Working Life is the governmental institute for research into, and development of, several aspects of working life. The institute covers occupational health and safety as well as labour markets and work organisation
* Now at Institute for Applied Environmental Research, Stockholm University

7.2.5 PARTNER 6 Health and Safety Laboratory (HSL), UK

Technical team leader: Mr Arthur Johnson
Address: HSL, Health and Safety Executive, Broad Lane, Sheffield, S3 7HQ, UK.
Telephone: + 44 114 2892512
Fax: + + 44 114 2892372
E-mail: arthur.johnson@hsl.gov.uk

The Health and Safety Laboratory (HSL) is an agency of the UK Health and Safety Executive (HSE), which is responsible for enforcing workplace health and safety laws in the UK. HSL carries out research leading to the establishment of standards in the field of workplace health and safety.

7.2.6 PARTNER: 7 Finnish Institute of Occupational Health (FIOH), Finland

Technical team leader: Dr Irma Welling
Address: FIOH, Laserkatu 6, FIN-53850 Lappeenranta, Finland
Telephone: + 358 5 6243209
Fax: + 358 5 4120949
E-mail: irma.welling@ttl.fi

The Finnish Institute of Occupational Health is a research institute promoting occupational health and safety. The ultimate goal of the research is the generation of new knowledge which can be utilised in the recognition, reduction and elimination of occupational health hazards, as well as in the creation of healthier, safer, and more satisfactory working conditions.

7.2.7 PARTNER 8: Institut für Werkzeugmaschinen (IfW), University of Stuttgart, Germany

Technical team leader: Mr Jurgen Fronius
Address: IfW, University of Stuttgart, Holzgartenstrasse 17, D-70174 Stuttgart, Germany.
Telephone: + 49 711 1213875
Fax: + 49 711 1213858
E-mail: juergen.fronius@po.uni-stuttgart.de

The IfW has been engaged in dust measurements at woodworking machines and electric tools for several years. A certified test laboratory exists at IfW for these measurements. The laboratory has a test cabin for measuring emission rates and a range of dust samplers including static, personal and isokinetic samplers. It also has a tracer gas capability.

7.2.8 SUBCONTRACTOR: Datastat Consultants (DAT), UK

Principal Consultant: Mr Colin Chalmers
Address: 192 Doyle Gardens, Willesden, London, NW10 3SX, UK
Telephone: +44 181 965 4303
Fax: +44 181 933 9759
E-mail: c.chalmers@lse.ac.uk

Datastat Consultants is a consortium of independent statisticians who have held senior academic posts whilst carrying out consultancy work for industry and commerce. Two of the members of the consortium have had considerable experience in the modelling and analysis of data relating to airborne particulate matter.

7.2.9 INDUSTRIAL PARTNER: LECES Environnement (LECES), FR

Technical team leader: Mse Marie Jailler
Address: Voie Romaine, BP 40223 – 57282 Maizieres-les-Metz Cedex, France
Telephone: +33 3 87511628
Fax: +33 3 87704107
E-mail: m.jailler@leces.fr

LECES Environnement is an environmental technical services centre theat specialises in the study and control of air quality in the iron and steel industry. LECES has wide experience in testing the efficiency of ventilation systems and has used tracer gas techniques for this purpose since 1992.

7.2.10 INDUSTRIAL PARTNER: John Liverton Consultants (JLC), UK

Principal Consultant: Dr John Liverton
Address: Bridge Cottage, Ladbroke, Warwickshire, CV47 2BY, UK
Telephone: +44 1926 810657
Fax: +44 1926 810657
E-mail: jlc@johnliverton.com

John Liverton Consulting is a newly established specialist engineering consultancy which is able to advise on and investigate many aspects of machine tool and manufacturing technology. Their main expertise lies in the successful application of pecision grinding, but they have wide experience in working on UK and European machining research projects and bring an industry-based approach to the project.