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HEALTH & SAFETY LABORATORY

Improved Dust Sampling Methods for Mines: Final Report

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An agency of the Health and Safety Executive

SUMMARY

Objectives
New Respirable Dust Regulations for UK coal mines are currently being drafted, and will introduce new dust sampling instrumentation, monitoring strategies, permissible exposure limits and enforcement practices into the coal industry. The aim of this project was to identify suitable instruments for measuring respirable, thoracic and inhalable dust concentrations (and respirable quartz concentrations) in a mining context, and capable of being approved for use in gassy mines. This report gives an overview of the work carried out, the main findings and the outputs of the project.

Main findings
After investigating the range of available instruments, the CIP10 sampler was identified as the best choice overall for routine, accurate measurement of respirable coal mine dust. It can generally be used without difficulty for both static and personal monitoring, and practical procedures for dust sampling in the UK mining context have been developed. Methods for determining both respirable dust and quartz concentrations have been investigated. The other samplers tested in this project were either less easy to use in the mining context, or gave less precise results than the CIP10.

A survey of dust and quartz concentrations in a range of UK mining situations was carried out, in order to inform the discussions on exposure limits for coal mine dust and quartz. The results obtained were written up for publication and presented to a range of audiences.

Main recommendations
The project successfully identified instruments and procedures suitable for dust measurement in the UK mining context. The project has provided technical and scientific support to the review of the Respirable Dust Regulations. Further work to familiarise the mining industry with the instruments and measurement methodology was recommended, and is now in the planning stage.

This project was commissioned and supported by HM Mines Inspectorate, and by the Safety Policy Directorate, of the Health and Safety Executive.

1 INTRODUCTION

At present, the Respirable Dust Regulations (RDR) require the concentrations of respirable dust in UK coal mines to be measured on a regular basis using a fixed-point sampler, the MRE 113A. As part of the review of RDR, consideration has been given to the introduction of alternative dust measuring instruments and monitoring strategies. The principle aim of project R42.108 was to provide scientific and technical information to back up these regulatory revisions. Specific objectives at the outset of the project were as follows:

- To evaluate both personal and static sampling instruments for inhalable, respirable and thoracic dust fractions, identifying those suited for use in the particular conditions of the UK mining environment;
- To validate the performance of selected samplers against the existing approved MRE 113A sampler and against CEN standards, under conditions applicable to mining;
- To advise on any performance considerations that might affect the choice of monitoring strategy.

The scope of the project was later expanded to include the following additional objectives:

- To carry out a representative survey of both personal and static respirable dust measurements in UK coal mines, along with occupational hygiene survey in each mine;
- To develop validated methods for the analysis of quartz in CIP10 samples obtained underground.

To achieve these objectives, the project incorporated a number of subcontracts with various organisations, detailed below.

2 Phase 1: IDENTIFYING POTENTIALLY SUITABLE DUST SAMPLING INSTRUMENTS

Contacts were established with agencies in different countries in order to identify options for dust sampling in coal mines. The aim was to identify modern instruments available for measuring dust and quartz concentrations in a mining context, and capable of being approved for use in gassy mines. Information was sought primarily on instruments that were already commercially available and in routine use in mines, however some information on instruments under development in other countries was obtained.

Instruments were identified for each of the different types of measurement tasks that may be needed within an overall monitoring strategy for coal mine dust. It was recommended that the HSL passive sampler and the NIOSH dust detector tube should be evaluated for assessment measurements; the CIP10 sampler be evaluated for compliance measurements; and the Respicon sampler be evaluated for special investigatory measurements.

3 Phases 2-5: LABORATORY TESTS OF SAMPLER PERFORMANCE

HSL carried out laboratory comparisons of three samplers with the MRE113A, under simulated mining conditions. The three candidate samplers selected were the Higgins and Dewell respirable cyclone, the CIP10, and the IOM personal inhalable sampler with foam size-selective insert. Nominal MRE113A filter loadings of 1, 5 and 10 mg, and external windspeeds of 1,2 and 4 m/s, were chosen to represent a realistic range of conditions found in UK mines. All tests were carried out in a small wind tunnel with the samplers isolated to simulate static sampling. Of the candidate samplers tested the CIP10 proved to have the most reliable selection of the respirable fraction, in terms of dust loading and performance at different windspeeds. The relationship to the MRE 113A results was stable and predictable over the entire parameter space. On the basis of these results the CIP10 sampler was recommended for field testing in UK mines as a static sampler (as well as a personal sampler, for which purpose it had already been validated). The Higgins and Dewell cyclone and the IOM sampler were not considered suitable for fixed-point sampling, although their performance for personal sampling of respirable dust is acceptable.

A subcontract to Deutsche Montan Technologie was set up to further evaluate the performance of the CIP10 and the Respicon samplers, under static sampling conditions. DMT carried out tests of the instruments in a wind tunnel under simulated mining conditions, but over an extended range of windspeeds, up to 8 m/sec. Each sampler was tested for its performance in collecting the respirable, thoracic and inhalable fractions. The inhalable performance proved problematic for all of the isolated samplers, particularly in high external winds. However both samplers were found to give good performance for collecting the respirable fraction, even in elevated winds.

A subcontract to the Institute of Occupational Health (IOH) was set up to evaluate the performance of the CIP10, Respicon and NIOSH detector tube samplers. Tests were carried out with manikin-mounted samplers, to simulate personal sampling under mining conditions. The CIP10 was tested for inhalable dust sampling (having already been extensively tested as a personal respirable dust sampler). In the time available it was only possible to carry out limited tests on the CIP10 inhalable sampler using a small number of particle sizes. The personal inhalable sampling performance appeared to be satisfactory over the limited range of conditions tested. The prototype NIOSH detector tubes proved unsuitable for laboratory testing owing to the small quantities of dust collected. It was decided therefore to defer testing these instruments until the field trials, described below.

4 Phase 5 – FIELD TRIALS OF SELECTED SAMPLING INSTRUMENTS

An extensive programme of field trials was carried out to assess the new dust monitoring instruments. Comparisons were made between different types of instruments, under both static and personal monitoring scenarios. The instruments included in the field trials were the MRE 113A, the CIP10, the NIOSH detector tube and the HSL passive sampler. The key objective of the underground trials was to evaluate the reliability and performance of these instruments, and the practicality of personal sampling in underground coal mines. The work also provided an opportunity to gather new exposure data, particularly personal exposure data, and data for small mines under-represented in previous surveys. Altogether, ten different mines were visited over a two-week period, with a repeat visit to one mine.

Procedures for mounting the samplers in both fixed locations and on miners themselves were developed, the latter in consultation with volunteers from the mining industry. Underground measurements were carried out in conjunction with the check sampling programme operated by TES Bretby, and with their assistance to provide and analyse MRE 113A samples via a subcontract. A further subcontract with the Institute of Occupational Medicine (IOM) was let to provide expert occupational hygiene input to the survey. IOM produced a comprehensive report that enabled the measured dust concentrations to be put into context with regard to dust control measures.

When dust monitoring was carried out with static samplers in fixed locations, the concentrations measured with the MRE 113A and CIP10 samplers were found to be highly correlated. The CIP10 concentrations were on average 20% lower than those measured using the MRE 113A, which is to be expected given that the instruments are optimised for different respirable sampling conventions (BMRC vs. CEN convention). Results from the NIOSH detector tubes were also correlated with the CIP10 results, but with a much lower degree of precision. The CIP10 and NIOSH detector tubes presented no serious practical problems when used as personal samplers, except in the case of very small mines where the workplace was very confined. The samplers were worn in mobile phone harnesses, which proved acceptable to the overwhelming majority of miners.

Observations that the CIP10 samplers sometimes switched off in the vicinity of conveyor magnets were investigated during a return visit to the mine where this problem had occurred. It was found to be a localised effect that would not be expected to interfere with routine dust monitoring, and requiring only vigilance by mine officials rather than special screening of the instrument.

Analysis of the mass of dust collected by the CIP10 samplers did not present any major difficulties provided blank weight correction procedures were used to correct for moisture uptake in the collecting foams and cups. The written procedures in MDHS 14/3 were used and proved suitable for determination of the respirable dust concentration using the CIP10. Quartz analysis was more difficult however, requiring a more involved procedure than the quartz analysis of MRE 113A filters. The results from the underground survey showed discrepancies between the quartz data from MRE and CIP10 samples, which required further investigatiom in the final phase of the project, as reported below.

5 Phase 6 – ANALYSIS, REPORTING AND PUBLICATION

Further work was carried out to investigate methodolody for the analysis of quartz in CIP10 dust samples, and produce validated analytical methods. HSL produced a set of CIP10 samples from known concentrations of reference 100% quartz powder. Half of the foams were removed from the collecting cups and sent to TES Bretby for analysis, and half were retained for analysis at

HSL. The quartz particles were recovered from the foams by either washing or ashing. With the wash recovery the particles are re-filtered onto a clean membrane filter prior to analysis and are also weighed on the pre-weighed filter. With the ashing method the particles are re-weighed after ashing the foam in a pre-weighed platinum crucible. Analysis can be carried out using either infra-red or XRD methods. Reports were produced by both organisations, describing the recommended procedures to recover the particles from the foams, and analysis of the recovered particles.

Although the procedures for washing the particles from the CIP10 foam and cup do not have 100% efficiency, it is reasonable to assume that they recover material of representative composition. The mass of quartz in the original CIP10 sample can thus be calculated by multiplying the mass of dust in the entire CIP collecting cup by the percentage of quartz, as determined by the analysis of the recovered dust. Note that the quartz analysis requires careful weighing of both the particles in the original CIP10 cup, *and* of the recovered particles. The validity of the method will be confirmed by comparison between a set of co-located CIP10 and MRE 113A samples, that have been collected in coal mines as part of TES check sampling procedures.

Reports were produced during the course of the project (see list below) at the end of the various key phases. The work was also written up for publication in the Transactions of the Institute of Mining and Metallurgy and the paper is currently in press. A detailed presentation on the work was given to a regional meeting of the IMM. Further presentations have been submitted and accepted for BOHS 2001 (York, UK) and for AIHA 2001 (New Orleans, USA).

5.1 Reports produced

Kenny, L.C (1998). Project R42.108 Phase 1 report. HSL report number IR/A/98/05.

Kenny, L.C and Stancliffe, J.D (1998) Comparison of respirable samplers for use in UK mines. Project R42.108 phase 2 report. HSL report number IR/A/98/11.

Kenny, L.C and Wake, D (2000). Improved dust sampling instruments for mines: Phase 5. Underground trials of samplers. HSL report number IR/EXM/00/06.

5.2 Publications

Kenny, L.C, Armbruster,L , Mark, D and Wake, D (2001). Evaluation of dust sampling instruments for UK coal mines. *Submitted to: Trans. IMM.*

5.3 Presentations

L C Kenny: Evaluation of instruments for dust monitoring in UK coal mines. IMM, November 2000.

L C Kenny, C Northage and G Gilmour . A survey of personal dust exposures in UK coal mines. BOHS 2001.

L C Kenny and D Mark. Proposed changes to dust sampling methodology in UK coal mines. AIHA 2001.

6 CONCLUSIONS AND RECOMMENDATIONS

Contacts with agencies in other coal-producing countries enabled a selection to be made of dust sampling instruments that have the potential to either replace or supplement the MRE 113A in UK coal mines. The CIP10 sampler was identified as potentially suitable for both fixed-point and personal sampling of respirable, thoracic and inhalable dust. Laboratory trials confirmed that it should have acceptable performance as a static or fixed-point sampler, under circumstances similar to UK mine dust sampling. Field trials of instruments confirmed that the CIP10 was indeed suitable as a replacement or supplement to the MRE 113A, subject to a satisfactory quartz analysis method being developed. This problem was later solved and the sampler evaluation satisfactorily concluded. Hence the aims and objectives of the project were met.

Further work is now planned to familiarise the mining industry with the instrumentation and sampling methodology developed during this project. Documented procedures will be produced for all aspects of the sampling and analysis of respirable dust and quartz. Efforts are also in hand to inform the mining industry, and occupational hygiene community, of the planned changes in dust monitoring methodology, through a programme of publications and presentations.

This project has contributed to the development of new regulations intended to further reduce health risks from dust exposure in the UK mining industry. The work was carried out collaboratively, with HSL managing the input of a number of other organisations – DMT, IOH,

IOM and TES. HSL benefited from a close and constructive relationship with the project officer, Mr Sellars, and are very grateful to him for his considerable input. Finally, the project would not have been possible without excellent cooperation from both management and workforce in the mining industry. In particular, HSL would like to thank all those who accompanied us on our visits to coal mines, for their care and consideration for our health, safety and welfare.