

Project Report

**HEALTH AND SAFETY EXECUTIVE  
RESEARCH AND LABORATORY SERVICES  
DIVISION**

**broad lane, sheffield, s3 7HQ.**

**Wet Removal of Asbestos: Final Report**

**by**

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**IR/L/MF/95/08**

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Issue authorised by B Tylee

28th April 1995

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File Ref 22CR/002/93

Project Number: R42.62

## **EXECUTIVE SUMMARY**

The project R42.62 /9112 " The Suppression of Dust During Removal of Fibrous Insulation Materials", was commissioned by the Field Operating Division of HSE to support and monitor it's initiative for the increased use of effective dust control methods, during licensed asbestos removal.

The aim of the project was to investigate the effectiveness of controlled wet removal methods to reduce airborne fibre levels inside enclosures and to measure the performance of commercially available systems and suppressants.

The project followed three lines of enquiry:

- 1) Laboratory tests on wetting agents and various asbestos containing materials.
- 2) Site visits to investigate wet removal procedures and to collect airborne samples.
- 3) A database collating information on airborne fibre concentrations from HSL sampling exercises and from other non -HSL sources.

This final report summarises the conclusions from the seven planned project reports which were planned and delivered to give the required data to the Customer as the earliest opportunity. In all some 25 specific conclusions and 8 overall conclusions are presented, along with a summary of the average fibre concentrations.

## **1. INTRODUCTION**

The Minerals and Fibres National Interest Group commissioned the project R42.62/9112 " The Suppression of Dust During Removal of Fibrous Insulation Materials", with HSL to investigate the effectiveness of controlled wet removal methods to reduce airborne fibre levels inside enclosures and to measure the performance of commercially available systems and suppressants. This project was designed to study the effect of the Field operating Divisions (FOD's) initiative in writing to all licensed asbestos contractors in July 1992 drawing their attention to FOD's concern about the lack of progress in the industry towards the use of dust suppression and control methods. The requirement to prevent exposure to employees during asbestos removal, or to implement dust control methods at source to reduce airborne levels to the lowest that are reasonably practicable; is an essential part of the Control of Asbestos at Work Regulations 1987 (amended 1993) and the Approved Code of Practice for work with asbestos insulation, asbestos coatings and asbestos insulating board (1993).

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- 1) Laboratory tests on wetting agents and various asbestos containing materials.
- 2) Site visits to investigate wet stripping practices and to collect airborne samples.
- 3) A database collating information on airborne fibre concentrations from HSL sampling exercises and from other non-HSL sources.

This final report draws together the conclusions from seven HSL project reports, which summarised and gave detailed analysis of the three main project areas to meet the Customer's requirement for information to be available from an early stage. All project reports were delivered to time.

## **2. Laboratory Investigations**

Preliminary laboratory investigations into methods of measuring the rate of penetration and wetting (IR/L/DI/93/01) established the experimental techniques on a standard plaster block which showed that :

- 1) That the rate of penetration was inversely related to temperature, and simple heating of water can make a significant difference.
- 2) The addition of some wetting agents slowed down the rate of penetration into the test block compared to water at the same temperature.
- 3) A chromatographic separation of the active agents was observed during the penetration under laboratory conditions so that the effect of any additive may be limited in influencing the penetration rate.
- 4) The commercially available dampness tester used by building surveyors was a useful instrument for checking the extent of the penetration of liquid.

These measurement techniques and protocol were then used to measure the penetration of six commercially available wetting agents, three commercially available encapsulating agents, tap water and soapy water on three different asbestos containing materials ((IR/L/DI/94/06). The main conclusions were:

- 5) The rate of penetration of different liquids through ACM depended on the nature of the ACM. Water for example, penetrated pipe lagging and loose amosite much faster ( $5 \text{ mm}\cdot\text{min}^{-1}$ ) than it penetrated pre-formed tiles ( $0.16 \text{ mm}\cdot\text{min}^{-1}$ ).
- 6) There was little difference in the penetration rates of water, wetting agents or encapsulating agents when applied to pre-formed tiles but wetting agents penetrated loose amosite faster than water or encapsulating agents.

Later laboratory work (IR/L/DI/94/10) looked at the dust suppressing capabilities of the three generic types of commercially available liquid suppressants (wetting, penetrating and encapsulating agents). This showed that:

- 7) The average evaporation rate of water and water based liquids was approximately the same,  $0.13 \text{ mm}\cdot\text{hour}^{-1}$  and only a high temperature oil based liquid had a significantly lower evaporation rate. ( $0.09 \text{ mm}\cdot\text{hour}^{-1}$ ).
- 8) The percentage of water and three wetting agents ("Astrip", "Wetstrip" and "Idenden 30-328") required to suppress fibre release from

asbestos containing pipe lagging (amosite in a calcium magnesium carbonate) were determined using a rotating drum dustiness tester. 16% by volume of water was required to suppress emissions, less than any of the three wetting agents tested. "Wetstrip", 29% by volume was the least efficient of the wetting agents. It should be noted that other ACM's may behave differently.

### **3. Database:**

A database was constructed from the results of the site sampling carried out by HSL and data supplied from two mailing requests to other NAMAS (IR/L/DI/93/03) and RICE (IR/L/MF/95/04) participating laboratories. By interrogating this database useful information regarding the fibre levels recorded during different fibre removal exercises could be compared. The latest report summarises results from 751 airborne fibre samples; 100 of these were from dry removals (all non-HSL) and 651 were from wet removal, of which 161 were collected by HSL. Table 1 summarises the arithmetic and geometric means for all data, which is broken down into six sub-groups: all dry removal data; dry removal data (personal only); all wet removal data; wet removal data (HSL only); wet removal data (personal only) and wet removal data (personal and HSL only). All sampling and analysis was carried out using the membrane filter - phase contrast microscopy method as detailed in MDHS 39 (3) to evaluate optically visible fibres > 5 um long. It should be noted that the dry removal samples are subject to counting errors and the reason for the dry removal personal samples being lower than all dry removal samples is due to overloading reducing the fibre count and the inability to analyse the more densely loaded filters.

Figure 1 shows the reduction in airborne fibre concentrations inside the enclosures at sites where "wet" removal techniques were employed, compared to sites where no wetting was carried out. Figure 2 compares the HSL wet removal data, with all wet removal data and Figure 3 compares wet removal data (personal and HSL only) to all wet removal data (personal only). The conclusions from the database (IR/L/MF/95/04) were:.

Table 1: Summary of database fibre concentrations by sub-groups

Data Group	Arithmetic Mean (f.ml <sup>-1</sup> )	Geometric Mean (f.ml <sup>-1</sup> )
All data	50.61	0.4
All dry removal data	358.56	40.97
Dry removal data (personal only)	219.84	25.52
All wet removal data	3.78	0.2
Wet removal data ( HSL only)	2.15	0.66
Wet removal data ( personal only)	6.88	0.53
Wet removal data ( HSL and personal only)	2.67	0.83

9) The arithmetic mean airborne fibre concentrations inside the enclosures at sites where wet removal was employed ( 3.78 f.ml<sup>-1</sup>) were some two orders of magnitude lower than those at dry removal sites (358.6 f.ml<sup>-1</sup>). More than 60% of the airborne samples taken at "dry sites" had fibre concentrations greater than 20 f. ml<sup>-1</sup>. By contrast at "wet removal" sites more than 70% of the samples had fibre concentrations less than 2 fibre ml<sup>-1</sup>.

10) HSL results were slightly higher than the results from other laboratories. It is thought that as HSL's sampling strategy which sampled precisely targeted work activities, rather than establishing 4 hour time weighted averages was the reason for the higher values.

A comparison of samples collected by HSL and by the contractor during one of HSL's site visits during wet removal supported the above conclusion. The HSL samples had four times the fibre levels of those reported by the contractors sampling team (IR/L/MF/95/01).

- 11) Personal samples taken during wet removal were elevated compared to the average of all samples (personal and static combined) usually by a factor of two to three but sometimes by an order of magnitude.
- 12) Although there was some indication that the airborne fibre levels during the removal of amosite and amosite containing mixtures were higher, the overall conclusion was that the type of asbestos had relatively little influence on the results (level of airborne fibre release).
- 13) The type of asbestos product appeared to be highly important, the airborne levels produced from asbestos containing boards gave the lowest airborne fibre emissions (geometric mean = 0.04 f/ml) and sprayed products the highest (geometric mean = 1.78 f/ml). Pipe insulation (geometric mean = 0.3 f/ml) and lagging (geometric mean = 0.1 f/ml) falling between these values.
- 14) The best performance for dust suppression was obtained with the only complete removal system; where the wetting agent, application method and training are sold as a package and an assessment of competence with the system is also undertaken by the supplier. The low geometric mean and arithmetic means obtained with this system, showed that this was not only giving the greatest amount of suppression, but was consistent in doing so. The longer injection and soaking time used by this multiple-point injection system is critical in achieving consistent wetting of all the material to be removed. The longer time for injection and setting up mean that a structured approach to the removal must be undertaken, as several hundred needles must be placed in line and individual taps turned on. Overnight gravity injection was originally used for this system but due to removal contractors demands, a pressurised system was developed to speed up the injection to one - two hours.
- 15) The single needle, gun injection systems are more prone to operator variability and are not always supplied as a system. As each point is injected, it is up to the user to decide on how much liquid is supplied. A

Careful application may fully wet the material, but in many instances the material may not allow easy injection, and blow back and splashing liquid are frequent occurrences. The greater flexibility (set up time and pre-planning are minimal with this system) of the single gun systems has a ready appeal to many asbestos removal operators and saving in terms of time from injection to removal can be made, (in some instances the removal team follows the injection personnel with only a few minutes soaking time allowed). Therefore the economies of time, the need for little pre-planning and the judgement and consciousness of the person applying the fluid make this a much less reproducible and consistent method, even though it has the potential to achieve good suppression. Figure 4 shows the relative performances of the multiple-point injection and single needle (gun type) injection methods.

HSL observers at demonstrations and on site visits have witnessed a number of failures of pressurised systems, the wetting agent either blowing back through the injection point or taking the shortest path to nearest exit (injection) point and failing to be retained and wet the ACM.

16 Surface spray methods seem even more variable than single point inject methods and hand pumped sprays which limit the amount of liquid which can be easily supplied appear even less consistent in their ability to suppress airborne emissions.

17) The efficacy of individual wetting agents is highly dependent on the method of application so it is difficult to be confident on the relative performance of the liquids used. Other than the "Astrip", which consistently gave the best suppression, most other liquids (after comparing the geometric mean for all samples) appear to be better suppressants than water, but the difference is not very great. The performance difference between water and the specialised suppressant liquids is not perceptible from the geometric and arithmetic means of the personal samples.

These conclusions are in general agreement with the laboratory trials which suggested that there was little difference between the commercially available wetting agents and water. A possible exception was where the fibrous material was hydrophobic amosite, here wetting agents may be slightly better than water.[IR/L/MF/95/01]

- 18) It is important to emphasise that the database does not represent failed wet removal particularly well as the samples will be overloaded and not available for analysis. The best estimate is that at least 1 in 8 wet removal operations fall into this category.

#### **4. Field Visits and Surveys**

Site visits were an essential part of this project as they enabled the researchers to get a better insight into the way wet removal techniques were applied in practice. 16 visits to 12 different sites were carried out in 1993 and 9 visits to 2 sites were carried out in 1994. This pattern reflected the initial aim of the project to gain a breadth of experience in the different products and systems in use during the initial stages of the project; then to conduct a series of field trials at a "captive" site to confirm the laboratory observations. Unfortunately a good captive site was not located before the Minerals and Fibres NIG was wound up, but two sites were adapted to the purpose as far as possible and at one site a series of comparisons with different wetting agents was carried out. The conclusions from the first series of site visits were that:

- 19) The effectiveness of wet removal depends as much on the operators capabilities as to the wetting agents used, the type of asbestos or the form of the insulation.
- 20) The asbestos containing material (ACM) only has to be damp to make substantial reductions in the airborne fibre concentrations inside enclosures. Even poorly executed wet removal methods significantly reduce the fibre levels when compared to dry removal.
- 21) If sufficient amounts of any liquid (e.g. water) is applied to the ACM then airborne fibre release will be reduced.
- 22) At the captive site measurements of airborne fibre levels when inserting multiple needles showed that only very low levels of fibre release

occurred ( $<0.1$  fibre  $\text{ml}^{-1}$ ). Similar low airborne fibre levels were observed at the same site when drilling holes prior to the insertion of single needle guns.

The database shows that the average airborne fibre levels were  $0.53$  f. $\text{ml}^{-1}$  when "injection" was the main work activity, which were considerably higher than the fibre levels observed at the 'captive' site. For some sub-groupings the fibre levels were even higher, for example HSL personnel samples had an average airborne fibre levels of =  $1.04$  f. $\text{ml}^{-1}$ .

- 23) Although effective dust suppression can and often is, achieved using single needle gun injection systems, failures can occur. At two sites airborne fibre concentrations inside the enclosures were measured/ estimated at  $60 - 100$  f. $\text{ml}^{-1}$
- 24) The commercially available "Protometer" proved a useful hand held device for checking the spread of the fluid in the ACM and detecting possible dry areas prior to removal work.
- 25) On-site tests by HSL using the same multiple-point injection system to apply the liquid found little difference in the dust/fibre suppression efficiency of various propriety additives and water alone, which agreed with the laboratory observations.

## 5 Overall Conclusions

- 5.1) This project looked at a representative range of the products and application systems being marketed and used by the asbestos removal industry. The three approaches used in this project (laboratory experiments, field surveys and data collection) were in good agreement and complemented each other to give a comprehensive evaluation of controlled wet removal, as it was currently being applied.
- 5.2) Controlled wet removal can dramatically reduce airborne fibre levels within the enclosure from hundreds of  $f.ml^{-1}$  to less than  $1 f.ml^{-1}$ . This places less burden on the performance and reliability of respiratory protective equipment and reduces the potential human exposures both inside and outside the enclosure.
- 5.3) It is clear that even poorly executed wet removal can reduce airborne fibre levels compared to dry removal techniques. However, proper well planned removal with careful application of the liquid is essential to achieve good suppression to below  $1 fibre ml^{-1}$ . The time spent on planning and careful application is often offset by the ease with which the surface can be cleaned and all the visible debris removed.
- 5.4) Some wetting and penetrating agents perform marginally better than water. However, the method of application of the liquid is of far greater importance to obtain good dust suppression
- 5.5) There is no correlation between airborne fibre concentration and the type of asbestos removed. The friability of the insulation does however relate to the measured airborne fibre releases.
- 5.6) The main cause for poor suppression was uneven wetting of the asbestos containing material due to limitations in the method of application or poor work practices. Multiple-point needle injection system generally gave the best performance. This was due to the combination of good initial training, a structured approach to the injection, which is inherent in the system and that the

cleaning up was made easier by the adequate and even application of liquid. Effective fibre suppression can be achieved using single needle injection systems but these systems are much more liable to operator error and variability and are more dependent on user competence and integrity. Spray application appears most suited for use as a supplement to injection methods (e.g. for local wetting when dry areas are found during removal).

5.7) The commercially available Protometer provided a useful tool for on site indications of wetting efficiency and the detection of dry areas, prior to removal. The addition of dyes to the wetting agent can also provide an useful indicator as to where penetration has failed.

5.8) The arithmetic ( $6.88 \text{ f.ml}^{-1}$ ) and geometric ( $0.53 \text{ f.ml}^{-1}$ ) means of personal samples taken inside enclosures during wet removal of asbestos containing materials, showed that the intended aim to reduce airborne fibre concentrations to single figure levels ( $<10 \text{ f.ml}^{-1}$ ) was achieved

## **6. Further work:**

A decision needs to be taken whether the work carried out under this project is sufficient to meet the informational and policy needs of HSE . Further sampling inside enclosures to support the increased number of site visits planned by FOD would appear justified along with further development and expansion of the database. The estimated failure rate; where the contractor being monitored failed to efficiently suppress fibre emissions by wet removal was 1 in 8 sites. Compliance rates for using controlled removal methods are not known and it would appear useful to further estimate and identify the upper quartile of airborne fibre concentrations during asbestos removal..

## **Acknowledgement**

The authors would like to acknowledge the help and support given by Mr John James and John Micklethwaite of the former Minerals Fibres NIG, Neil Evans of Leed FCG, the project officer and Mr R. Tyrer and Mr A. Addy of the Sheffield Area office and Mr J. Lawton of FOD HQ.

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Note: Figures not included in this electronic version.