Industrial Cleaning: Exposure to Dust Hazardous to Health

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A significant burden of occupational respiratory disease in Great Britain is caused by exposure to dusts which are hazardous to health. It is common in a number of industries such as woodworking, stone working, and waste and recycling, for the workplace to become heavily contaminated with dusty material emitted from the process. Employers are responsible for taking effective measures to control exposure and protect health. The priority is to control the exposure at source. Failure to do so results in the need for regular cleaning which can cause very significant worker exposure.

This report describes research to better understand the contribution that industrial cleaning activities make to overall exposure to dusts, which are hazardous to health (excluding asbestos), in the manufacturing, construction and waste and recycling industries.

Internal intelligence was 'mined' from HSE's library of in-house occupational hygiene reports which describe site visits conducted for inspections or research from the late 1990s onwards.

The work concludes that there is potential to significantly reduce dust exposures in several common industries by more widespread adoption of good practice for cleaning dust from production areas.

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Industrial Cleaning: Exposure to Dust Hazardous to Health

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Key Messages

Many activities in the construction, waste and recycling, and manufacturing industries generate dust. Exposures to dusts which are hazardous to health, include those containing respirable crystalline silica, wood, metals, bioaerosols, and flour, can lead to respiratory diseases. Employers are responsible for taking effective measures to control exposure and protect health. The priority is to control the exposure at source. Failure to do so results in the need for regular cleaning which can cause very significant worker exposure.

This study has been carried out to better understand exposure to dust which is hazardous to health (excluding asbestos), associated with industrial cleaning activities. Data was 'mined' from 160 of HSE's existing in-house occupational hygiene reports which describe site visits conducted for inspections or research from the late 1990s onwards. The study identified that:

- There is potential for very high inhalation exposures to dust during cleaning tasks, and a relatively short spell of cleaning can contribute more to a worker's daily dust exposure than several hours of production activity.
- Dry sweeping was the most prevalent cleaning technique across all industries, by a considerable margin (approximately 74 %), followed by vacuum cleaners (41 %), compressed air blowing (26 %) and wet mopping/wiping (5 %).
- Inhalation exposures during cleaning using compressed air are more than double those for dry sweeping, and more than six times those for vacuum cleaning.
- Industrial vacuum cleaners are not always used and where they are, often do not meet the standards set out in HSE guidance.
- Respiratory protective equipment is not always worn (or worn correctly) for cleaning tasks, even where dust exposures are very high.
- Consultants who were employed by companies to undertake exposure assessment included monitoring results that sometimes underestimated the health risk because cleaning exposures were not assessed.
- In many instances, the failure to adopt low dust cleaning techniques appears to be due to a failure to adequately consider the exposure risk, rather than technical barriers.
- There is potential to significantly reduce exposures to dust, which is hazardous to health, in many industries by more widespread adoption of good practice for cleaning dust from production areas.
- Relatively straightforward, low-cost improvements could potentially reduce the burden of respiratory disease associated with these industries.

Executive Summary

Background

A significant burden of occupational respiratory disease in Great Britain is caused by exposure to dust, which is hazardous to health. It is common in a number of industries such as woodworking, stone working, and waste and recycling for the workplace to become heavily contaminated with dusty material emitted from the process. Employers are responsible for taking effective measures to control exposure and protect health. The priority is to control the exposure at source. Failure to do so results in the need for regular cleaning which can cause very significant worker exposure.

Aim and Objectives

This report describes research to better understand the contribution that industrial cleaning activities make to overall exposure to dusts, which are hazardous to health (excluding asbestos), in the manufacturing, construction and waste and recycling industries. Specific objectives were:

1. Quantify the contribution that industrial cleaning activities can make to overall dust exposures.

2. Quantify the reduction in exposure that can be achieved by implementing good practice with relation to cleaning activities.

3. Estimate the prevalence of different cleaning methods. This provides a baseline to track future progress in influencing industry to employ good exposure control practice during cleaning activities.

4. Identify common exposure control failures pertinent to cleaning activities.

5. Identify barriers to the adoption of 'low dust' cleaning techniques.

6. Quantify exposure associated with relevant cleaning activity.

Methodology

Internal intelligence was ‘mined’ from HSE’s library of in-house occupational hygiene reports which describe site visits conducted for inspections or research from the late 1990s onwards. A total of 1415 reports from all industry sectors, from the late 1990s onwards, were searched for various “cleaning” keywords. Reports considering asbestos were removed as this was outside the scope of the study, along with any other reports found to be of little relevance to cleaning. A total of 160 reports were reviewed in full for this study, producing a focussed study on exposure to substances hazardous to health associated

with industrial cleaning activities. Although relevant information was identified from a wide range of industries in the initial data-mining exercise, the most prevalent were construction, waste and recycling, bakeries, woodworking, brickmaking, stone working, foundries and paper tissue manufacture. Also included were a small number of agricultural sites.

HSE's library of occupational hygiene reports was the data source mined for this work. It is important to note that a detailed study of cleaning techniques was not the primary purpose of any of the site visits from which information was harvested. Hence, data was often incomplete or inconsistent from site to site. Although the information provides an insight into how process-generated dusts are cleaned up in a range of industries, it does not represent a systematic, statistically representative study.

Main Findings

- There is potential for very high inhalation exposures to dust during cleaning tasks. Even a relatively short spell of cleaning can contribute more to a worker's daily dust exposure than several hours of production activity.
- Dry sweeping was the most prevalent cleaning technique across all industries, by a considerable margin, with approximately 74 % of the visit reports included in the study reporting some dry sweeping. Forty one percent of the reports related to worksites where vacuum cleaners were used, 26 % reported some use of compressed air blowing and 5 % reported some use of wet mopping/wiping. Often sites used a combination of cleaning techniques.
- Inhalation exposures during cleaning using compressed air are more than double those for dry sweeping, and more than six times those for vacuum cleaning.
- Industrial vacuum cleaners are not always used and where they are, often do not meet the standards set out in HSE guidance.
- Respiratory protective equipment is not always worn (or worn correctly) for cleaning tasks, even where dust exposures are very high.
- Consultants' monitoring results provided an underestimate of the health risk on occasion, by not assessing cleaning exposures.
- In many instances, the failure to adopt low dust cleaning techniques appears to be due to a failure to adequately consider the exposure risk, rather than technical barriers.

Conclusions

- There is potential to significantly reduce dust exposures in several common industries, including construction, waste and recycling, and manufacturing including

woodworking, bakeries, brickmaking, stone working and foundries, by more widespread adoption of good practice for cleaning dust from production areas.

- Relatively straightforward, low-cost improvements could potentially reduce the burden of respiratory disease associated with these industries.

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1 Introduction

1.1 Background

A significant burden of occupational respiratory disease is caused by uncontrolled exposure to dust in workplaces across Great Britain. It is common in a number of industries (e.g., woodworking, stone working, waste and recycling), for the workplace to become heavily contaminated with dusty material emitted from the manufacturing process. This gives rise to the need for cleaning up, which has the potential for significant worker exposure to dusts, which are hazardous to health, if the exposure control strategy for cleaning activities is deficient. Bad practice may include, for example, the use of compressed airlines to 'blow down' equipment, and dry sweeping. Exposure to dusts which are hazardous to health, are of concern for occupational respiratory disease.

Giving appropriate attention on cleaning up activities provides an opportunity to significantly reduce dust exposures in many workplaces without a need for significant financial investment in engineering controls.

HSE has accumulated a body of evidence on industrial cleaning activities from a number of scientific projects, conducted for research or other regulatory purposes. This includes intelligence on the prevalence of different cleaning approaches and some information on the barriers preventing the application of 'low dust' (that is lower exposure) cleaning techniques. In some cases, this is supplemented with task-specific exposure measurement data, which allows the exposure associated with various cleaning activities to be quantified. This data has not previously been collated and analysed to capture what is known about the associated exposures to dusts which are hazardous to health.

This report details the findings of an exercise to 'mine' this intelligence from relevant reports to determine what is known about dust exposure associated with industrial cleaning activities, and the potential for exposure control. The report provides estimates of the prevalence of good and bad practice, summarises exposure data associated with these, and discusses some of the barriers to the adoption of low dust cleaning techniques. This work may inform future HSE guidance and intervention activity.

1.2 Aim and Objectives

The aim of this work was to better understand the contribution that industrial cleaning activities make to overall exposure to dusts which are hazardous to health. Specific objectives were:

1. Quantify the contribution that industrial cleaning activities can make to overall dust exposures.
2. Quantify the reduction in exposure that can be achieved by implementing good practice with relation to cleaning activities.
3. Estimate the prevalence of different cleaning methods. This provides a baseline to track future progress in influencing industry to employ good exposure control practice during cleaning activities.
4. Identify common exposure control failures pertinent to cleaning activities.
5. Identify barriers to the adoption of 'low dust' cleaning techniques.
6. Quantify exposure data associated with relevant cleaning activity.

2 Methods

The work set out to identify intelligence on worker exposures to process-generated dusts during industrial cleaning activity, using HSE's library of occupational hygiene reports as the data source. This includes unpublished reports, relating to regulatory investigation ("reactive support") activity, as well as research reports.

An initial search was done to identify any reports containing information on dust exposures during workplace cleaning. The search included reports of site visits conducted for regulatory investigation purposes, and reports conducted for approximately 30 different research projects. These included site visits to assess the control of exposure to substances which are hazardous to health. A total of 921 "investigation" ("reactive support") reports covering the time period 2005 – 2015 were searched. A further 523 "research" reports were included, some of which dated back to the late 1990s. The database was not in frequent use before approximately 2005, all reactive support reports prior to this date had not been entered.

All documents were converted to PDF files and uploaded into an electronic (Endnote©) library. Within the library, the files were searched for keywords. This project was interested in current practice in construction, waste and recycling, and manufacturing, which were listed in the Health Priority Plan for Occupational Lung Disease[1].

Asbestos removal work was considered out of scope. Asbestos is also subjected to a strict set of regulations[2], where practices (including cleaning) are tightly regulated. Hence any reports from site visits with asbestos as the main topic were excluded from the search group.

The remaining files were then searched for any occurrence of the keywords listed in Table 1. Only files containing 'clean*' plus another of the listed keywords were included in the final search group. The inclusion of the asterisk (*) after 'clean*' in the search ensures that all reports containing words which begin with clean (e.g., cleaning, cleaner) would be identified.

Upon review of the remaining files, it was apparent that those containing both 'clean*' and 'wipe' often referred to 'clean areas' and the taking of 'wipe samples', without any reference to industrial cleaning processes or practices. To optimise extraction of files where industrial cleaning processes or practices were referred to, only those files which contained 'clean*' and 'wipe' plus another of the keywords were included in the final search group. Those files which did not contain another keyword, in addition to 'clean* and 'wipe' remained in a separate group and may be reviewed in future.

All PDF files in the final search group were reviewed for references to industrial cleaning practices or processes. Instances of all the keywords were highlighted on the PDF file and the context of the keyword was reviewed. If the context was in reference to an industrial

cleaning practice or processes, the relevant paragraph was copied into a data extraction table, along with details of the report.

Table 1 Keywords used in report search

Keyword searches	Secondary keywords	Number of files	Files included in final review
All files	-	1415	-
Asbestos	-	355	-
Clean*	-	612	-
Clean* AND	Brush*	152	Yes
-	Broom	55	Yes
-	Sweep*	126	Yes
-	Mop*	64	Yes
-	Vacuum*	164	Yes
-	Wiping	31	Yes
-	Compressed air	133	Yes
Clean* AND	Wipe (only)	158	Reviewed 2nd priority
Clean* AND	Wipe AND another keyword	10	Yes
Final combined search group	-	275	PDFs reviewed

In addition to the systematic search of HSE's library of occupational hygiene reports, a number of further reports were considered during this work. These were mainly from site visits conducted after the search was completed, but before final analysis of the data was

conducted, i.e., reports drafted between August 2015 and May 2016. A further 32 reports were added at this stage.

In reviewing the data extraction table, a number of reports were discounted as they contained information of little relevance, leaving 160 reports being reviewed in full. Of these, 153 were individual site visit reports. The remainder were project overview reports (n=7), which discussed information from a series of site visits. These were of some use in crosschecking that the electronic search had identified all relevant reports; site visit reports were the main source of information used for this work.

For the reports which were reviewed in full, relevant information was extracted on the cleaning techniques used, time spent cleaning and exposure controls employed; where available, quantitative exposure data relevant to cleaning was also extracted.

The information was collated into a series of Excel spreadsheets for analysis. A number of exposure examples were created using the intelligence from these reports; however, these are for illustrative purposes only. No systematic criteria were applied to select reports which contained information suitable for these examples.

It is important to note that a detailed study of cleaning techniques was not the primary purpose of any of the site visits from which information was harvested. Hence, data was often incomplete or inconsistent from site to site. Although the information provides an insight into how process- generated dusts are cleaned up in a range of industries, it does not represent a systematic, statistically representative study.

3 Results

Summary information on the prevalence of different cleaning techniques, segmented by industry sector, is presented in Table 2.

Table 2 Search of reports: number of reports in each industry sector

Industry	Number of reports [1]	Number with exposure data	Dry sweeping: Number (% of total)	Vacuum cleaners: Number (% of total)	Compressed air: Number (% of total)	Wiping / Mopping: Number (% of total)	"Other" cleaning technique [2:] Number (% of total)
Waste & Recycling	29	12	16 (55)	3 (10)	8 (28)	1 (3)	17 (59)
Woodworking	26	11	21 (81)	22 (85)	7 (27)	0 (0)	0 (0)
Stone working	21	0	14 (67)	3 (14)	5 (24)	2 (10)	5 (24)
Brickmaking	15	5	14 (93)	10 (67)	0 (0)	0 (0)	12 (80)
Foundry	14	2	12 (86)	3 (21)	6 (43)	0 (0)	3 (21)
Bakery	12	7	10 (83)	8 (67)	2 (14)	2 (17)	6 (50)
Construction[3]	9	3	6 (67)	4 (44)	0 (0)	0 (0)	3 (33)
Tissue	6	5	5 (83)	4 (67)	5 (83)	0 (0)	3 (50)

Industry	Number of reports [1]	Number with exposure data	Dry sweeping: Number (% of total)	Vacuum cleaners: Number (% of total)	Compressed air: Number (% of total)	Wiping / Mopping: Number (% of total)	"Other" cleaning technique [2:] Number (% of total)
Other industry	28	9	20 (71)	10 (36)	8 (31)	3 (11)	16 (57)
All	160	54	118 (74)	66 (41)	41 (26)	8 (5)	65 (41)

[1] Each report generally relates to one site although in some cases there was more than one report for a single site (i.e., more than one visit was undertaken to a single site).

[2] A variety of "other" techniques were reported, and are discussed, where relevant, later in this report.

[3] There was a strong bias in the construction reports towards visits done to assess wood dust exposure.

A variety of contaminants were measured across the different industry sectors. Inhalable dust was most frequently measured, and analysis of quantitative exposure data focussed mainly on this, to allow consistency across the industry sectors. This included flour dust in bakeries, and wood dust in woodworking and construction. Respirable dust and respirable crystalline silica (RCS) were included only where additional information was included in the reports. For the purposes of this report, “dust” is inhalable dust, unless otherwise specified.

Many companies employed a combination of cleaning methods at the time they were visited, and so the total for each industry sector is greater than 100 %.

Dry sweeping was the most prevalent cleaning technique across all industries, by a considerable margin (~74 %), 41 % reported using vacuum cleaners, 26 % reported some use of compressed air blowing and 5 % reported some use of wet mopping/wiping.

3.1 Breakdown by Industry Sector

3.1.1 Woodworking

Woodworking activities typically create particulate material in a wide range of particle sizes, from dust which would fall into the ‘inhalable’ category to large chips and shavings, which would not become airborne unless subjected to a high degree of air movement. There are separate Workplace Exposure Limits (WELs) for hardwood and softwood dust, which both stood at 5 mg/m^3 (8-hour time weighted average (TWA)) at the time this work was conducted[3]. As both hardwood and softwood dusts are respiratory sensitisers, and hardwood dust is a carcinogen[4], the Control of Substances Hazardous to Health Regulations 2002 (as amended) (COSHH)[5] requires wood dust exposures to be controlled to a level which is as low as reasonably practicable (ALARP). It should be noted that since this work was completed the hardwood dust WEL[4] has been reduced to 3 mg/m^3. The softwood dust WEL[4] has remained at 5 mg/m^3; however, if softwood dusts are mixed with hardwood dusts, the WEL for hardwood dusts shall apply to all the wood dusts present in that mixture.

Depending on the standard of engineering controls, large amounts of wood dust and debris can be deposited into the factory environment which requires frequent cleaning. Daily cleaning around woodworking machines is common and is typically done by production staff. The employment of dedicated cleaning personnel to clean production areas was not reported for any sites considered for this work.

Twenty-six reports were identified for the woodworking sector. The data in Table 2 indicates a similar prevalence of dry sweeping and the use of industrial vacuum cleaners (81 and 85 % of reports respectively); and 27 % of reports identified the use of compressed air blowing to remove dust. No occurrence of mopping/wiping methods was noted. At most sites, a combination of cleaning techniques was in use.

Twenty-two reports detailed sites were using portable, industrial vacuum cleaners; seven of which (32 %) were using equipment which did not meet the standard of class ‘M’

(Medium Hazard) or better, as set out in HSE guidance[6]. Thirteen reports detailed sites using flexible attachments fitted to a fixed local exhaust ventilation (LEV) system to vacuum clean.

Other cleaning methods reported in woodworking included wet/dry vacuum cleaners, shovels and squeegees.

3.1.1.1 Woodworking exposure examples

Exposure example WW1 – Comparison of dry sweeping with vacuum cleaning)

The task-specific exposure of two workers was monitored during cleaning. One of these workers spent 15 minutes cleaning using an industrial vacuum cleaner, with no measurable wood dust exposure (<3.6 mg/m^3). The second worker spent 17 minutes cleaning, using a combination of sweeping and compressed air blowing, resulting in an exposure of 13.9 mg/m^3. In this instance, the exposure associated with vacuum cleaning was at least 74 % lower than that associated with dry sweeping.

Exposure example WW2 – Comparison of vacuum cleaning exposures with a combination of vacuum cleaning and emptying LEV/general waste

The task-specific exposure of two workers was monitored during cleaning using vacuum cleaners, although no information on the type of equipment was noted. Away from the cleaning task, both workers were involved in production tasks. One worker spent 70 minutes cleaning, resulting in an exposure of 15 mg/m^3. This represented 30.8 % of the workers 8-hour TWA exposure. The second worker spent 36 minutes cleaning, resulting in an exposure of 43.6 mg/m^3; however, this cleaning task also included emptying LEV dust collection bags and emptying waste wood bins. This result represented 20 % of the workers 8-hour TWA exposure.

Exposure example WW3 – Dry sweeping exposures

The task-specific exposure of one worker was monitored during 27 minutes of dry sweeping. The measured exposure was 16.2 mg/m^3, which represented 48 % of the workers 8-hour TWA wood dust exposure.

These examples show that exposures during vacuum cleaning are much lower than when using other techniques. Full exposure data for these examples is found in Tables 4 – 6, Appendix 1.

3.1.2 Bakeries

Many bakery activities generate flour dust, which is a significant cause of occupational asthma and is subject to a WEL of 10 mg/m^3 (8-hour TWA)[4]. As a respiratory sensitiser, the COSHH Regulations[6] require flour dust exposures to be controlled to a level which is ALARP.

Regular cleaning is the norm in this sector, with workplaces being cleaned at least once per day. The employment of dedicated cleaning staff was reported at five sites, indicating that this is more common than other sectors, although cleaning is often done by production staff.

Twelve reports were identified for this sector. Cleaning techniques used were dry sweeping (83 % of reports), vacuuming (67 %), wiping/mopping (17 %) and compressed air blowing (14 %).

Other cleaning methods reported in bakeries included hose pipes, squeegees, scrapers, shovels, and mechanical wet-floor scrubbers.

3.1.2.1 Bakery exposure example

Exposure example B1 – Comparison of dry sweeping with vacuum cleaning

The task-specific exposure of two workers was monitored during cleaning. Both individuals worked on production tasks when not cleaning. One worker spent 64 minutes cleaning using a vacuum cleaner, resulting in a measured exposure of 4.3 mg/m^3. The second worker spent 15 minutes cleaning a dough brake using dry sweeping techniques, resulting in an exposure of 11.9 mg/m^3, almost three times higher than the measured exposure for vacuum cleaning. In this instance, the exposure associated with vacuum cleaning was approximately one-third of that associated with dry sweeping.

Full exposure data for this example is found in Tables 7a&b, Appendix 2.

3.1.3 Waste and Recycling

Waste and recycling (W&R) activities can give rise to dust of varying size fractions and composition, the latter being largely influenced by the nature of the material being processed. The reports included in this analysis mainly pertained to sites processing domestic and commercial general waste, electronic and electrical equipment, wood, and rubber tyres. Airborne dust at these sites can include metals, wood, minerals and bioaerosols. Some of the airborne dusts generated by some of these activities are subject to WELs.

More reports were identified for W&R activities than for any other industry sector, a total of 29 being considered in this study. 55 % of these reports detailed dry sweeping methods, and 28 % compressed air blowing. 10 % of reports detailed the use of industrial vacuum cleaners, and wet cleaning methods in 3 %. The employment of dedicated cleaning staff to clean production areas was reported in 21 %.

Other cleaning methods reported for this industry sector included the use of hose pipes, pressure washing systems, shovels, and dedicated attachments fitted to large vehicles, such as shovel loaders.

Nine task-specific exposures at or above 100 mg/m^3 were reported for cleaning across all sites. Three of these were associated with the use of compressed air to clean plant and equipment in the recycling sector.

3.1.3.1 Waste and Recycling exposure examples

Exposure example WR1 – Cleaning of wood chipping machinery

Cleaning of wood chipping machinery was studied at three sites as part of a project carried out in 2010. At each site, this task was done outdoors, with very little control in place to prevent or capture dust at source. As a result, the machinery became heavily contaminated, which necessitated frequent (daily) cleaning. This was typically done by production staff, using compressed air, with varying degrees of care, resulting in task-specific exposures varying from around 5 mg/m^3 to 150 mg/m^3. The company owning the site at which the highest exposures were recorded subsequently partnered HSE to explore the feasibility of other cleaning techniques. Although this exercise failed to identify viable alternatives to compressed air blowing, it confirmed that significantly reduced exposures could be achieved by the implementation of good working practices. These included (where possible) wetting down the dust prior to cleaning, the use of longer handled lances to increase the distance between the operator and the dust source, and only cleaning the parts of machines which were likely to fail through excess build-up of dust.

Exposure example WR2 – Cleaning air classifiers, domestic waste treatment plant

This short-term task, carried out daily, involved using a compressed air lance to remove dust from an air filtration system in a plant processing general domestic and commercial waste. The task took 12 minutes, resulting in an inhalable dust exposure of 108 mg/m^3, with correspondingly high bacteria, fungi and endotoxin exposures. This single task contributed 75 % of the worker's total 8-hour TWA exposure.

Exposure example WR3 – Implementation of vacuum cleaning system

A company which shredded and granulated truck tyres to produce rubber crumb was visited twice for research purposes. At the time of the initial site visit a number of workers were involved in the clean down of one area of the site. This activity was conducted weekly, and typically took several hours using a combination of dry sweeping and compressed air blowing. Task-specific exposures for four workers ranged from 9.7 mg/m^3 to 51.7 mg/m^3.

After the company installed a custom-built industrial vacuum system, task-specific exposures for two individuals were 3.6 and 15.5 mg/m^3. The higher of these two exposures was associated with working in cramped spaces, beneath machinery. Although the measurements indicate a substantial reduction in dust exposures through implementation of the vacuum cleaning system, there was potential to reduce these further

by better use of tools and extensions on the vacuum system, to reduce the need to work in cramped spaces and increase the distance between the worker and the dust source.

Full exposure data for these examples is found in Tables 8 – 11, Appendix 3.

3.1.4 Brickmaking

Brickmaking generates large quantities of dust which contains a proportion of RCS, for which a WEL of 0.1 mg/m^3 (8-hour TWA) is in place[4]. No short-term exposure limit (STEL) has been set. Task-specific monitoring of RCS exposure is not commonplace since typical workplace exposure levels are not detectable in short-term samples (i.e., generally for cleaning tasks).

Fifteen reports were identified for brickmaking. 93 % reported some use of dry sweeping, and 67 % reported some use of industrial vacuum cleaners, although these may not have been of an adequate standard (6 % of reports). There were no reported uses of either compressed air blowing or mopping/wiping. Dedicated cleaning staff were employed to clean production areas in 27 %.

Other cleaning methods reported for this sector included the use of shovels and wheelbarrows, pressure washing systems and mechanical wet-floor scrubbers.

3.1.4.1 Brickmaking exposure example

Exposure example BM1– Cleaning under de-hacking[A] machine

A number of workers spent just over an hour cleaning dust and other debris from beneath an automated de-hacking machine using brushes and shovels. Some attempt was made to damp down the area prior to starting this task, although insufficient water was used, which resulted in only the surface layer of the dust being damped. Respiratory protective equipment (RPE) was not worn by all workers involved in the task. The task-specific RCS exposure of one of the workers involved was 0.83 mg/m^3, sampled over a period of 70 minutes. For the remainder of the day, this worker operated the de-hacking machine, during which his measured exposure was 0.036 mg/m^3. On this occasion the 70 minute cleaning task contributed almost 45 % of the worker's 8-hour TWA RCS exposure, and resulted in the only measured exposure to exceed the RCS WEL on the day of the visit. The company subsequently informed the research team that an industrial vacuum cleaner would, in future, be used for this cleaning operation.

Full exposure data for this example is found in Table 12, Appendix 4.

3.1.5 Stone working

Stone working generates large quantities of dust which contains a proportion of RCS, for which a WEL of 0.1 mg/m^3 (8-hour TWA) is in place[4]. No STEL has been set. Task-

[A] De-hacking is the process of unloading the kiln after the bricks have cooled[7]

specific monitoring of RCS exposure is not commonplace since typical workplace exposure levels are not detectable in short-term samples (i.e., generally for cleaning tasks).

Twenty-one stone industry reports were identified, 67 % of which reported some use of dry sweeping. Other cleaning techniques were less prevalent with 14 % reporting some use of vacuum cleaners, 24 % reporting compressed air blowing and 10 % reporting use of (wet) mopping/wiping. All cleaning was done by production staff, and no sites reported employing dedicated cleaners to clean production areas.

Other cleaning methods reported for stone working included wet cleaning, the use of squeegees and pressure-washing systems.

No task-specific exposure data for cleaning in the stone working sector was identified, so no exposure examples have been created.

3.1.6 Foundries

Foundry work generates dust which contains a broad range of hazardous substances. The composition of foundry particulate is dependent on the nature of the materials in use in the foundry, and the wide range of foundry processes results in a high degree of variability from one foundry to another. Even within an individual foundry, the composition of the dust generated will vary at different stages of the process. It is highly likely that the dust will contain a proportion of RCS and metals, and a range of organic chemicals, some of which are subject to WELs.

Fourteen reports were identified for the foundry sector. 86 % reported some use of dry sweeping. 43 % detailed the use of compressed air blowing, and 21 % described the use of vacuum cleaners. There was no reported use of mopping/wiping. Only one foundry (7 %) reported employing dedicated cleaning staff.

Other cleaning methods reported in foundries included scraping and the use of shovels.

3.1.6.1 Foundry exposure example

Exposure example F1 – Dry sweeping exposure in comparison to production exposures

One worker undertaking cleaning activities for a full shift period using dry sweeping techniques, had a ferrous foundry particulate (as inhalable dust) exposure of 27.8 mg/m^3 for an 8-hour TWA. The WEL for ferrous foundry particulate (FFP) as an inhalable fraction, is 10 mg/m^3 (8-hour TWA). The measured exposure is nearly three times the WEL and was one of the highest exposures recorded at this site. Only one production exposure exceeded this cleaning exposure (fettling), with other production exposures (n=17) ranging between 2 and 22 mg/m^3.

Full exposure data for this example is found in Table 13, Appendix 5.

3.1.7 Construction

Construction dust is a general term used to describe different dusts associated with construction activities[8]. Construction dust can include three main types:

- Silica dust – created when working on silica- containing materials like concrete, mortar and sandstone (also known as RCS).
- Wood dust – created when working on softwood, hardwood and wood-based products like medium-density fibreboard (MDF) and plywood.
- Lower toxicity dusts – created when working on materials containing very little or no silica. The most common include gypsum (e.g., in plasterboard, limestone, marble and dolomite).

Nine reports were identified for the construction sector; six of these (67 %) detailed some use of dry sweeping. Other cleaning techniques were less prevalent; with 44 % reporting some use of vacuum cleaners. There were no reports detailing compressed air blowing or (wet) mopping/wiping. All cleaning was done by production staff, and none reported employing dedicated cleaners.

Other cleaning methods reported for the construction industry include raking, abrasive blasting, and damping / wet cleaning. No further information was available in the reports giving any further details on wet cleaning.

Three of the nine reports identified contained exposure data. All three of these reports were for wood dust on housebuilding sites. Two of the three reports contained exposure data for dry sweeping (6.5 – 8.5 mg/m^3), and the third for vacuum cleaning (3.8 mg/m^3).

3.1.7.1 Construction exposure example

Exposure example C1 – Cleaning by dry sweeping on a housebuilding site

One worker undertaking woodworking activities on a housebuilding site had a cleaning exposure, when using dry sweeping techniques, of 8.5 mg/m^3 over a 30 minute period. This task alone contributed 18 % of this worker's 8-hour TWA wood dust exposure.

Full exposure data for this example is found in Table 14, Appendix 6.

3.1.8 Tissue Making

Paper tissue manufacture can generate significant amounts of dust, which can accumulate on machinery, necessitating regular cleaning. Tissue dust is not subject to a specific WEL but is subject to the COSHH Regulations [6] as a substance hazardous to health.

The data for tissue making was taken from HSE research conducted in 1999/2000. It is not indicative of current work practice in this industry sector (no recent data was available) but has been included since it provides a clear illustration of the considerable exposure potential associated with industrial cleaning activities when using compressed air

(exposures up to 251 mg/m^3 were found). A summary of the results can be found in Table 15, Appendix 7.

Six reports were identified for the tissue making industry, five (83 %) of these reports identified some use of dry sweeping, and five (83 %) detailed the use of compressed air to remove dust from machinery. Four reports (67 %) detailed some use of vacuum cleaners (including ride on or manual controlled vacuum cleaners), but none reported (wet) mopping/wiping. Cleaning was done by a mixture of production staff and dedicated cleaners.

Other cleaning methods reported for this industry include scraping and (wet) hosing.

3.1.9 Other Industries

This category included a number of site visit reports from the agriculture sector (grain dust, poultry farming), quarrying (RCS), potteries (RCS), public services (wood dust from handling wood pellet biofuels) and others. A total of 28 reports were placed in this category, with no individual industry sector having more than five reports. The wide range of processes, dust sources, and cleaning approaches discussed in these reports mean that there is no value in conducting a detailed analysis for these reports.

3.2 Breakdown by Cleaning Method

A breakdown of task-specific exposure data for inhalable dust, categorised by cleaning method, is presented in Table 3.

Table 3 Summary statistics for task-specific inhalable dust exposures

	Number of reports	Number of data points	Median exposure mg/m^3	Average (arithmetic mean) exposure mg/m^3
Compressed air blowing	12	38	26.4	58
Dry sweeping	20	30	12.8	27.2
Vacuum cleaning	12	15	3.8	4.9

This analysis illustrates clear differences in dust exposures associated with these three cleaning techniques, with the median exposure for compressed air blowing being more than double that for dry sweeping, and more than six times that for vacuum cleaning. The averages (arithmetic mean) follow a similar trend, but in all cases are significantly higher

than the medians. This indicates the positively skewed nature of these data sets, which is typical of occupational exposure data. The full data sets are presented in Appendices 7 - 9.

3.2.4 Compressed Air Blowing

Forty-one of the reports detailed some use of compressed air to remove dust from plant and machinery. Quantitative exposure data for compressed air blowing was obtained from twelve different sites, across three different industries. One site had been visited twice. Industries included tissue manufacture, waste and recycling, and “other” (including grain handling and bathroom manufacture).

The median exposure was 26.4 mg/m^3 and nine exposures (23 %) equalled or exceeded 100 mg/m^3. As might be expected for a process involving a near-field high energy exposure source, such as compressed air, exposures were highly variable and often potentially very high. The full data set is presented in Table 15, Appendix 7.

Of the forty-one sites, RPE was not worn at all for compressed air blowing in eight cases (21 %), and in a further eight cases, RPE use was inconsistent for this activity.

More than half the data points for compressed air cleaning were taken from HSE research conducted in 1999/2000 on the manufacture of paper tissues. It is not indicative of current work practice in this industry sector (no recent data was available) but does provide a clear illustration of the exposure potential associated with compressed air blowing.

3.2.5 Dry Sweeping

One hundred and nineteen reports detailed some use of dry sweeping to clean production areas. Twenty of these reports contained quantitative exposure data for dry sweeping, across seven different industries. Industries included construction, wood (manufacture), bakeries, foundry, brickmaking, recycling and “other” (grain handling).

A total of thirty data points were obtained. The median exposure was 12.8 mg/m^3 and two exposures (6 %) equalled or exceeded 100 mg/m^3. The full data set is presented in Table 16, Appendix 8.

RPE was not worn for dry sweeping at 26 sites (22 %), and in a further 17 (14 %) cases, RPE use for dry sweeping was reported to be inconsistent.

3.2.6 Vacuum Cleaning

Sixty-eight reports detailed reported some use of vacuum cleaners to clean production areas. Twelve of these reports contained quantitative exposure data for vacuum cleaning, across six different industries. Industries included construction, wood (manufacture), bakeries, brickmaking, recycling and “other” (grain handling).

A total of fifteen data points were obtained for inhalable dust. The median exposure was 3.8 mg/m^3. The full data set is presented in Table 17, Appendix 9, and includes a small amount of data for respirable dust and RCS.

A similar number of workers wore RPE during vacuum cleaning (26 %), as those who did not (28 %). RPE use was unknown or occasional in the remainder of the reports (minimal details were provided).

3.2.7 Mopping / Wiping

Exposure data for wiping and mopping was obtained from two different industries. Activities during the measurement period included other cleaning activities as well as mopping and wiping, so separate results for these cleaning methods alone cannot be identified.

3.3 Other Issues

The reports considered for this work contained indications that where dutyholders had commissioned exposure monitoring, there were occasions where cleaning activities were overlooked.

An assessment was made of seven consultants' exposure reports obtained for woodworking research purposes, for six sites. None of these reports measured cleaning exposures, only production exposures, which were often measured for periods which were significantly less than the full work hour shift. In many cases in this industry, cleaning was undertaken by production workers at the start or at the end of a shift, and not throughout the working day, and so cleaning exposures were missed from the production samples.

The consultants' reports often stated what cleaning methods were used at the site, but some did not detail recommendations on the adoption of low dust cleaning techniques. One report recommended the removal of a compressed airline which was used for blowing down clothing, and three reports recommended the use of vacuum cleaners instead of brushes. Only one report mentioned using M or H class vacuums. One report recommended the use of RPE for "uncontrolled dust release" during tasks such as cleaning.

3.3.1 Exposure example O1 - Failure to include cleaning in exposure assessment

HSE researchers visited a site processing pre-sorted, recyclable domestic waste in 2010. Personal sampling was conducted on 17 subjects, working in different areas of the site. Five 8-hour TWA total inhalable dust exposures above 10 mg/m^3 were measured, with the average measured exposure at 7.1 mg/m^3. A return visit in 2014 indicated higher exposures. On this occasion, 8-hour TWA exposures were determined for fifteen workers. Six of these exceeded 10 mg/m^3, with an average of 13.2 mg/m^3. Between these two visits the duty holder commissioned a monitoring survey by an external consultancy. The consultant conducted personal sampling on six workers. The highest measured exposure

was 1.9 mg/m^3, with an average of 1.2 mg/m^3. Working practices on this site included a number of production operatives conducting end-of-shift cleaning of the plant using compressed air. This activity was included in the two exposure assessments conducted by HSE but had not been included in the consultant's survey.

In this case, the consultants' monitoring results provided an underestimate of the health risk at this site. The need to include cleaning activities in exposure monitoring surveys is discussed in HSE guidance (see HSG 173, Appendix 2, Paragraph 19, '*You also need to ensure that start-up procedures at the beginning of shifts and end-of-shift tasks such as clean down operations are included.')*[11].

In addition to total inhalable dust, HSE researchers also measured a number of individual constituents of the dust. These were not measured by the consultant so the results for these agents cannot be compared.

The full data for this exposure example is found in Table 18, Appendix 10.

3.4 Barriers to the adoption of 'low dust' cleaning techniques

A variety of barriers to adopting low dust cleaning techniques were mentioned in reports. These can be segregated into physical and behavioural/organisational barriers:

- Physical:
  - Larger/heavy items cannot be vacuumed (wood, stone working, foundry).
  - Electrical equipment- no wet cleaning possible (stone working, wood recycling).
  - Efficiency of the air filters is compromised if cleaned with water (wood recycling).
  - Water-spray dust suppression- supply and drainage not arranged (quarry).
  - Electricity not available in outdoor environment (construction).
  - Need specialist adaptor to vacuum cleaners (brickmaking).
  - Expense of vacuum cleaners (other- pottery).
  - Electric cable to vacuum didn't reach end of room (bakery).
- Behavioural/organisational:
  - Manufacturer's instruction to clean machinery with compressed air (wood recycling).
  - Vacuum cleaner broken, awaiting repair (bakery).
  - Vacuum cleaning is time consuming (tissue).
  - Brooms are regularly removed from the workplace but are soon replaced as they are easy to obtain (brickmaking).

Several of the reasons listed above appear to be genuine technical barriers to the easy adoption of low dust cleaning techniques. These pertain to the size/weight of debris to be cleaned being too large for vacuuming, and the incompatibility of electrical equipment with wet cleaning methods. Others (unavailability of specialist vacuum adaptors, electrical cable too short, vacuum cleaner broken), suggest a failure to adequately consider the exposure risk associated with cleaning, i.e., inadequate risk assessment. The return of brooms into workplaces where they have previously been removed is suggestive of a lack of management control. Many of these problems could be easily remedied.

3.5 Comparison of project vs reactive visits

The information considered in this report was collated from HSE occupational hygiene site visit reports which were prepared either for research projects or other regulatory investigation purposes ("reactive visits"). Sites recruited for research projects are often selected with the aim of identifying good exposure control practice. Conversely, reactive visits tend to be conducted in support of HSE investigations and enforcement activity, which often indicates the potential for exposure control standards to be deficient in some way at these sites. Clearly, there is potential for systematic biases to exist within these two categories, with intelligence from project visits being skewed toward good practice, and vice-versa for reactive visits.

The initial search of all reports included 523 reports for site visits conducted for research purposes and 921 for "reactive" visits. Of these, specific information on cleaning activities was extracted from 96 of the research reports, and 63 of the reactive reports. The proportionally higher incidence of information on cleaning in reports for research visits reflects the more comprehensive nature of these reports.

Data on the prevalence of different cleaning techniques categorised by type of visit, is presented in Table 4.

Table 4 Data on the prevalence of different cleaning techniques in reports

Visit type	Number of reports	Number with exposure data	Dry sweeping: number of reports	Vacuum cleaners: number of reports	Compressed air: number of reports	Wiping / mopping: number of reports	Other*: number of reports
Project	96	40	74 (76.3 %)	46 (47.4 %)	32 (33 %)	4 (4.1 %)	61 (63.5 %)
Reactive	64	14	44 (68.8 %)	21 (32.8 %)	10 (15.6 %)	4 (6.3 %)	21 (32.8 %)

* A variety of “other” techniques were reported, and are discussed, where relevant, in this report.

Whilst the prevalence of bad practice (dry sweeping, compressed air blowing) was higher for companies recruited to research projects than for those visited for reactive purposes, the prevalence of vacuum cleaners was also higher at these companies. Overall, these results suggest no strong bias in either direction for the reports considered in this study.

Many companies employed a combination of cleaning methods at the time they were visited, and so the total for each visit type is greater than 100 %.

4 Discussion

It is important to note that the information considered in this report was collated from HSE reports which were prepared for the purposes of planned scientific research or for other regulatory activity. In the majority of cases, the site visits were not conducted for the explicit purposes of studying the control of dust exposures during cleaning activities. Additionally, the analysis considers data from 160 site visit reports, which represents only a tiny fraction of GB work sites with potential dust exposure. Although the data illustrates a number of important points, it does not represent a systematic, statistically representative study of occupational exposures associated with dust cleaning activities.

The industries considered in this study generate varying, often relatively large, amounts of dust and debris which contaminate the workplace and necessitate regular cleaning. This is often done by production staff, and, in general, the exposure potential associated with cleaning activity did not appear to be fully recognised. In terms of reducing exposures associated with cleaning, the first priority should be improved containment of contaminants, via better enclosure and LEV, to minimise the amount of cleaning needed. This would provide productivity benefits to industry, since production staff would need to spend proportionally less time cleaning the workplace. Nevertheless, there will always be some degree of cleaning in production areas.

The study indicates that the application of good exposure control practice for dust cleaning tasks is not widespread. Almost three quarters (74 %) of the sites visited employed dry sweeping for dust cleaning. Dry sweeping was the most prevalent cleaning technique in all industry sectors except woodworking. Just over one quarter of the sites visited (25.6 %) reported some use of compressed air for dust cleaning. These techniques can give rise to excessive dust exposures but were found to be in common use.

The incidence of dry sweeping was lower in the waste and recycling sector than any other, with just over half the reports for this sector describing the use of this technique. There was a reasonably high incidence of ‘other’ cleaning techniques in this sector, including the use of cleaning attachments fitted to large vehicles such as shovel loaders. The relatively large scale of operations in this sector may go some way to explaining this. Large vehicles are frequently employed in the process and would appear to be utilised for cleaning operations also.

Although 41.2 % of reports detailed use of vacuum cleaners for cleaning, 32 % of these did not meet the standards set out in HSE guidance [6,8,9,10], which specifies hazardous dust vacuum cleaners of ‘M’ class (or better) rating for wood dust, construction dust and RCS. Domestic vacuum cleaners were in use at a number of sites. Some companies reported the use of high efficiency particulate (HEPA) filters in these; whilst this should provide a

high standard of dust filtration, it does not address the other features required to obtain formal ‘M’ (or ‘H’) classification.

Bakeries were the only industry sector identified where there was an appreciable incidence of (wet) wiping/mopping cleaning methods (16.7 %), although there was no exposure data available for this cleaning method alone.

There were clear differences in the use of compressed air blowing between industry sectors. Although this technique appears to be most prevalent in tissue manufacturing (83.3 %), the intelligence from this sector is much older than that from others, and there is a possibility that practices have changed since this data was collected. Other than tissue manufacture, compressed air blowing was most prevalent in foundries, occurring at just over 40 % of sites. Conversely, there was no use of this technique reported in brickmaking or construction.

Analysis of task-specific exposure data illustrates some clear differences in exposure potential between the main cleaning techniques studied. The median inhalable dust exposure for compressed air blowing (26.4 mg/m^3) is more than twice that for dry sweeping (12.8 mg/m^3), which in turn is more than three times higher than the median exposure for vacuuming (3.8 mg/m^3).

A number of reasons were recorded for failing to adopt low dust cleaning techniques. Whilst some of these do appear to be technically valid (e.g., incompatibility of wet methods with electrical equipment), in a number of cases the barriers mentioned by dutyholders would appear to easily overcome. It appears that often the failure to adopt low dust cleaning techniques appears to be due to a failure to adequately consider the exposure risk, rather than genuine technical barriers. A number of the contaminants handled at the sites in this study included asthmagens and/or carcinogens. Where they cannot be prevented, exposures to such substances are required to be controlled to a level which is as low as reasonably practicable, and this requirement extends to cleaning activities as well as production tasks.

The exposure examples also provide a useful insight into the contribution that relatively brief cleaning tasks can make to full-shift exposure. Woodworking example WW3 illustrates a situation where 27 minutes of dry sweeping have contributed almost half the workers total daily wood dust exposure. Waste and recycling example WR2 provides an even more extreme example, where a 12 minute cleaning task in a waste processing plant contributed 75 % of the full-shift exposure.

Anecdotally, there appears to be an increasing prevalence of high-pressure water washing (pressure washers) to clean dust in production areas. This may partially reflect the increased availability of pressure washers to non-specialist users. Pressure washers can create a large amount of fine water mist, and this will carry the material being cleaned into the airborne phase. The exposure risks associated with the use of pressure washers do not appear to be widely recognised in a number of the industries in which they are in use.

In many cases RPE was either not worn for cleaning activities or was worn inconsistently. Given the degree of dust exposure often associated with cleaning production areas, RPE is often required for these activities and especially in situations where technical barriers prevent the adoption of low dust cleaning techniques. The failure to utilise RPE consistently and correctly provides further indication that dust exposures associated with cleaning activities are not suitably addressed in the risk assessment process.

A very limited analysis has not identified any significant biases pertaining to the adoption of good practice for cleaning dust from production areas between site visits conducted for reactive purposes, and those conducted as part of research projects.

5 Conclusions

There is potential for very significant inhalation exposure to dust during cleaning activities, and this is often overlooked by dutyholders. Within the industries included in this study, there is potential to significantly reduce dust exposures, and hence reduce the incidence of respiratory disease, by implementation of good practice for cleaning dust in production areas.

Better implementation of engineering controls, such as containment and the use of LEV systems, would reduce the amount of cleaning needed in production areas and so reduce associated dust exposures by controlling exposure at source.

The prevalence of cleaning methods which generate significant levels of airborne dust, mainly dry sweeping, and the use of compressed airlines, is widespread. These techniques appear more common than the use of industrial vacuum cleaners. Task-specific exposure data illustrates clear differences between these cleaning methods, with exposures for compressed air blowing being more than double those for dry sweeping, and more than six times higher than exposures associated with vacuum cleaning.

In many instances, the failure to adopt low dust cleaning techniques appears to be due to a failure to adequately consider the exposure risk, rather than technical barriers.

In more than a third of cases where industrial vacuum cleaners are used, these do not meet the standards set out in HSE guidance.

Although cleaning activities are usually brief, where good practice is not applied, they can contribute more to a workers' 8-hour TWA dust exposure than several hours working on production tasks.

Failure to use RPE consistently and correctly is common when conducting dust cleaning activities.

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Appendix 1: Woodworking Exposure Examples WW1-WW3

Table 4a Exposure data for woodworking example: WW1: Worker 1

Sample Position	**Worker 1 Production**	**Worker 1 Cleaning with vacuum**	**Worker 1 Combined tasks**
Duration (mins)	403	15	-
Inhalable dust (mg/m^3)	13.4	<3.6	-
Inhalable dust (mg/m^3 8-hour TWA)	12.8	-	-
Percentage of time spent cleaning (%)	-	-	3.13
Exposure (%) #	-	-	1.00

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 4b Exposure data for woodworking example: WW1: Worker 2

Sample Position	**Worker 2** **Production & cleaning**	**Worker 2** **Production & Cleaning with compressed air**	**Worker 2** **Combined tasks**
Duration (mins)	342	17	-
Inhalable dust (mg/m^3)	1.5	13.9	-
Inhalable dust (mg/m^3 8-hour TWA)	1.4		-
Percentage of time spent cleaning (%)	-	-	3.54
Exposure (%) #	-	-	46.06

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 5a Exposure data for woodworking example: WW2: Worker 1

Sample Position	Worker 1 Production	Worker 1 Cleaning	Worker 1 Combined tasks
Duration (mins)	160	70	-
Inhalable dust (mg/m^3)	6.5	15	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	7.1
Percentage of time spent cleaning (%)	-	-	14.58
Exposure (%) #	-	-	30.81

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 5b Exposure data for woodworking example: WW2: Worker 2

Sample Position	Worker 2 Production	Worker 2 Cleaning	Worker 2 Combined tasks
Duration (mins)	154	36	-
Inhalable dust (mg/m^3)	15.6	43.6	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	16.2
Percentage of time spent cleaning (%)	-	-	7.50
Exposure (%) #	-	-	20.19

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 6 Exposure data for woodworking example: WW3

Sample Position	**Worker 1** **Production**	**Worker 1** **Cleaning by dry sweeping**	**Worker 1** **Combined tasks**
Duration (mins)	419	27	-
Inhalable dust (mg/m^3)	1	16.2	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	1.9
Percentage of time spent cleaning (%)	-	-	5.63
Exposure (%) #	-	-	47.96

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Appendix 2: Bakery Exposure Example B1

Table 7a Exposure data for bakery example: Worker 1

Sample Position	**Worker 1** **Production**	**Worker 1** **Cleaning using vacuum**	**Worker 1** **Combined tasks**
Duration (mins)	299	64	-
Flour dust (mg/m^3)	7.4	4.3	-
Flour dust (mg/m^3 8-hour TWA)	-	-	7.7
Percentage of time spent cleaning (%)	-	-	13.33
Exposure (%) #	-	-	7.45

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 7b Exposure data for bakery example: Worker 2

Sample Position	**Worker 2 Production 1**	**Worker 2 Production 2**	**Worker 2 Production 3**	**Worker 2 Cleaning using brush**	**Worker 2 Combined tasks**
Duration (mins)	113	248	15	15	-
Flour dust (mg/m^3)	20.5	13	17.8	11.9	-
Flour dust (mg/m^3 8-hour TWA)	-	-	-	-	Times overlap, not a combined TWA for all samples: Production 1 & 2: 15.4 Production 3: 17.8 Cleaning using brush: 11.9
Percentage of time spent cleaning (%)	-	-	-	-	3.13
Exposure (%) #	-	-	-	-	No result -times overlap. Not a combined TWA for all samples

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Appendix 3: Waste and Recycling Exposure Examples WR1- WR3

Table 8a Exposure data for waste and recycling example: WR1: Worker 1

Sample Position	**Worker 1** **Cleaning with compressed air**	**Worker 1** **Production & Cleaning**	**Worker 1** **Combined tasks**
Duration (mins)	76	345	-
Wood dust (mg/m^3)	149.96	18.36	-
Wood dust (mg/m^3 8-hour TWA)	-	-	Cannot use as production sample also involves some cleaning
Percentage of time spent cleaning (%)	-	-	n/a- cannot use production sample as includes some cleaning too
Exposure (%) #	-	-	n/a- cannot use production sample as includes some cleaning too

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 8b Exposure data for waste and recycling example: WR1: Worker 2

Sample Position	Worker 2 Production	Worker 2 Cleaning	Worker 2 Combined tasks
Duration (mins)	331	32	-
Wood dust (mg/m^3)	0.48	8.18	-
Wood dust (mg/m^3 8-hour TWA)	-	-	2.16
Percentage of time spent cleaning (%)	-	-	6.67
Exposure (%) #	-	-	25.25

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 8c Exposure data for waste and recycling example: WR1: Worker 3

Sample Position	Worker 3 Cleaning	Worker 3 Production	Worker 3 Combined tasks
Duration (mins)	73	322	-
Wood dust (mg/m^3)	5.12	3.47	-
Wood dust (mg/m^3 8-hour TWA)	-	-	5.51
Percentage of time spent cleaning (%)	-	-	15.21
Exposure (%) #	-	-	14.13

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 9a Exposure data for waste and recycling example: WR2: Worker 1

Sample Position	**Worker 1 Cleaning**	**Worker 1 Cleaning**	**Worker 1 Combined tasks**
Duration (mins)	327	143	-
Inhalable dust (mg/m^3)	14.2	5.8	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	11.6
Percentage of time spent cleaning (%)	-	-	100

Table 9b Exposure data for waste and recycling example: WR2: Worker 2

Sample Position	**Worker 2 Cleaning**	**Worker 2 Cleaning**	**Worker 2 Combined tasks**
Duration (mins)	66	63	-
Inhalable dust (mg/m^3)	0.6	3.6	-
Inhalable dust (mg/m^3 8-hour TWA)	0.6	3.6	-
Percentage of time spent cleaning (%)	-	-	100

Table 9c Exposure data for waste and recycling example: WR2: Worker 3

Sample Position	**Worker 3** **Cleaning using compressed air**	**Worker 3** **Cleaning using compressed air**	**Worker 3** **Combined tasks**
Duration (mins)	12	23	-
Inhalable dust (mg/m^3)	108	1.5	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	-
Percentage of time spent cleaning (%)	-	-	-

Table 9d Exposure data for waste and recycling example: WR2: Workers 4 and 5

Sample Position	**Worker 4** **Cleaning**	**Worker 5** **Cleaning**
Duration (mins)	481	429
Inhalable dust (mg/m^3)	81	29
Inhalable dust (mg/m^3 8-hour TWA)	0.7	1
Percentage of time spent cleaning (%)	100	100

Table 10a Exposure data for waste and recycling example: WR3(a): Worker 1

Sample Position	**Worker 1 Cleaning**	**Worker 1 Production**	**Worker 1 Combined tasks**
Duration (mins)	210	189	-
Inhalable dust (mg/m^3)	51.7	2.9	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	27.3
Percentage of time spent cleaning (%)	-	-	43.75
Exposure (%) #	-	-	82.85

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 10b Exposure data for waste and recycling example: WR3(a): Worker 2

Sample Position	**Worker 2 Cleaning**	**Worker 2 Production**	**Worker 2 Combined tasks**
Duration (mins)	221	198	-
Inhalable dust (mg/m^3)	25.8	8.1	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	17
Percentage of time spent cleaning (%)	-	-	46.04
Exposure (%) #	-	-	69.88

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 10c Exposure data for waste and recycling example: WR3(a): Worker 3

Sample Position	Worker 3 Cleaning	Worker 3 Production	Worker 3 Combined tasks
Duration (mins)	104	169	-
Inhalable dust (mg/m^3)	9.7	4.9	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	7.3
Percentage of time spent cleaning (%)	-	-	21.67
Exposure (%) #	-	-	28.79

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 10d Exposure data for waste and recycling example: WR3(a): Worker 4

Sample Position	Worker 4 Production	Worker 4 Production	Worker 4 Cleaning	Worker 4 Combined tasks
Duration (mins)	86	107	97	-
Inhalable dust (mg/m^3)	1.3	5.4	33.9	-
Inhalable dust (mg/m^3 8-hour TWA)	-	-	-	13.5
Percentage of time spent cleaning (%)	-	-	-	20.21
Exposure (%) #	-	-	-	50.75

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Table 11 Exposure data for waste and recycling example: WR3(b)

Sample Position	**Worker 1** **Cleaning**	**Worker 2** **Cleaning**
Duration (mins)	24	53
Inhalable dust (mg/m^3)	15.47	3.6
Inhalable dust (mg/m^3 8-hour TWA)	-	-
Percentage of time spent cleaning (%)	5.00	11.04

Appendix 4: Brickmaking Exposure Example BM1

Table 12 Exposure data for brickmaking example: BM1

Sample Position	**Worker 1 Cleaning**	**Worker 1 Production**	**Worker 1 Combined tasks**
Duration (mins)	70	284	-
Respirable dust (mg/m^3)	4.14	0.16	-
Respirable dust (mg/m^3 8-hour TWA)	-	-	1.3
RCS (mg/m^3)	0.83	0.04	-
RCS (mg/m^3 8-hour TWA)	-	-	0.27
Percentage of time spent cleaning (%)	-	-	14.58
Respirable dust exposure % #	-	-	46.4
RCS exposure % #	-	-	44.78

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Appendix 5: Foundry Exposure Example F1

Table 13 Exposure data for foundry example: F1

Sample Position	**Worker 1** **Cleaning by dry sweeping**
Duration (mins)	321
Inhalable dust / ferrous foundry particulate (FFP) (mg/m^3)	23.41
Inhalable dust / ferrous foundry particulate (FFP) (mg/m^3 8-hour TWA)	27.80
Percentage of time spent cleaning (%)	100

Appendix 6: Construction Exposure Example C1

Table 14 Exposure data for construction example: C1

Sample Position	Worker 1 Production	Worker 1 Production (router)	Worker 1 Cleaning by dry sweeping	Worker 1 Combined tasks
Duration (mins)	279	11	30	-
Wood dust (mg/m^3)	3.6	14	8.5	-
Wood dust (mg/m^3 8-hour TWA)	-	-	-	2.96
Percentage of time spent cleaning (%)	-	-	-	6.25
Exposure % #	-	-	-	17.95

This represents the proportion of the total dose attributable to the cleaning task. Calculated as task specific dose from cleaning dose (task specific cleaning exposure x minutes spent cleaning) divided by the total dose (8-hour TWA exposure x 480 (minutes)) x 100.

Appendix 7: Exposure data for compressed air blowing

Table 15 Exposure data for compressed air blowing

Site	Duration (mins)	Inhalable dust (mg/m^3)
Tissue Manufacturer 1	228	12.2
Tissue Manufacturer 1	231	6.4
Tissue Manufacturer 1	230	19.3
Tissue Manufacturer 1	51	100
Tissue Manufacturer 1	100	100
Tissue Manufacturer 1	310	8
Tissue Manufacturer 1	16	74
Tissue Manufacturer 2	52	10.5
Tissue Manufacturer 2	46	251
Tissue Manufacturer 2	45	12.7
Tissue Manufacturer 3	32	123
Tissue Manufacturer 3	42	14.4
Tissue Manufacturer 3	243	48
Tissue Manufacturer 3	33	97
Tissue Manufacturer 3	31	210

Site	Duration (mins)	Inhalable dust (mg/m^3)
Tissue Manufacturer 3	27	235
Tissue Manufacturer 4	15	92
Tissue Manufacturer 4	13	49
Tissue Manufacturer 4	15	28
Domestic waste treatment	12	108
Domestic waste treatment	23	1.5
Wood recycling 1	175	5.38
Wood recycling 2	97	27.8
Wood recycling 3(a)	76	150
Wood recycling 3(a)	32	8.18
Wood recycling 3(b)	42	18
Wood recycling 3(b)	24	27
Wood recycling 3(b)	24	16
Wood recycling 3(b)	44	16
Wood recycling 3(b)	12	5.2
Rubber crumb manufacture 1	210	51.7
Rubber crumb manufacture 1	221	25.8
Rubber crumb manufacture 1	104	9.7

Site	Duration (mins)	Inhalable dust (mg/m^3)
Rubber crumb manufacture 1	97	33.9
Rubber crumb manufacture 2	28	188.9
Other 4 (grain)	8	14.2
Other 5 (bathroom manufacture)	391	7.2
Other 5 (bathroom manufacture)	383	2.8
All sites: Arithmetic mean	n/a	58.04
All sites: Median	n/a	26.4

Appendix 8: Exposure data for dry sweeping

Table 16 Exposure data for dry sweeping

Site	Duration (mins)	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)
Construction 1	30	8.5	-
Construction 2	7	6.56	-
Wood (manufacture) 1	27	16.2	-
Wood (manufacture) 2	32	31.7	-
Wood (manufacture) 3	393	<0.2	-
Wood (manufacture) 3	3	<23.1	-
Wood (manufacture) 4	17	13.9	-
Wood (manufacture) 7	15	109.1	-
Wood (manufacture) 8	41	1.63	-
Bakery 1	43	9.2	-
Bakery 2	15	11.9	-
Bakery 3	119	23.4	-
Bakery 4	14	4.9	-
Bakery 4	21	5.15	-

Site	Duration (mins)	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)
Bakery 4	58	12.43	-
Foundry 1	321	23.41	-
Other 1 (Grain)	64	75.5	-
Other 2 (Grain)	181	11.1	-
Other 2 (Grain)	179	54.5	-
Brickmaking 5	380	-	<0.011
Brickmaking 5	380	7.22	-
Recycling 1	60	12.9	-
Recycling 3	No sample duration listed	14.49	-
Recycling 3	No sample duration listed	6.77	-
Recycling 3	No sample duration listed	58.65	-
Recycling 3	No sample duration listed	18.27	-
Recycling 3	No sample duration listed	12.66	-
Recycling 3	No sample duration listed	15.68	-
Recycling 4	249	7.92	-

Site	Duration (mins)	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)
Recycling 5	5	208.6	-
Recycling 5	454	9.16	-
All sites: Average (arithmetic mean)	n/a	27.16	-
All sites: Median	n/a	12.78	-

Appendix 9: Exposure data for vacuum cleaning

Table 17 Exposure data for vacuum cleaning

Site	Duration (mins)	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)	RCS (mg/m^3)
Wood (manufacture) 3	12	<5.8	-	-
Wood (manufacture) 4	15	<3.6	-	-
Wood (manufacture) 5	385	>0.6	-	-
Wood (manufacture) 6	70	15	-	-
Wood (manufacture) 8	55	18.61	-	-
Bakery (Food) 2	64	4.3	-	-
Bakery (Food) 3	30	3.98	-	-
Bakery (Food) 3	63	3.88	-	-
Recycling 2	394	2.6	-	-
Construction 2	12	3.8	-	-
Other 2	26	0.51	-	-
Brickmaking 1	210	-	0.12	-
Brickmaking 1	210	-	-	0.025

Site	Duration (mins)	Inhalable Dust (mg/m^3)	Respirable Dust (mg/m^3)	RCS (mg/m^3)
Brickmaking 1	306	-	0.11	-
Brickmaking 1	306	-	-	<0.015
Brickmaking 2	70	4.14	-	-
Brickmaking 3	155	0.92	-	-
Brickmaking 3	302	0.43	-	-
Brickmaking 4	294	-	0.24	0.019
All sites: Average (arithmetic mean)	n/a	4.9	-	-
All sites: Median	n/a	3.84	-	-

Appendix 10: Exposure data for compressed air example O1 (inhalable dust)

Table 18 Exposure data for compressed air example O1

Area	HSL[B], 2010 mg/m^3 8-hour TWA	HSL, 2014 mg/m^3 8-hour TWA	Consultant, 2011 mg/m^3 8-hour TWA
Pre-sort cabin	10.6 22.6 7.7	12.5 14.8 20.8	Not measured
Main sorting cabin, Plastic line	10.3 4.9	11.9	Not measured
Main sorting cabin, newspaper line	9.0 10.3	6.6	1.2 1.9
Main sorting cabin, mixed paper line	6.3 10.1	3.2 9.5	Not measured
Tin sorting cabin	6.89	9.1	1.1
Quality control cabin	1.9 2.4	1.7	Not measured
Bailer operator	5.26	25.7	1
Bailer/trimmer	3.39	66.1	Not measured

[B] HSL- Health and Safety Laboratory. From 2018, HSL is known as HSE's Science Division.

Area	HSL[B], 2010 mg/m^3 8-hour TWA	HSL, 2014 mg/m^3 8-hour TWA	Consultant, 2011 mg/m^3 8-hour TWA
Shovel driver, reception hall	2.36	1.3	0.3
Forklift truck drivers	1.6 5.2	1.4 5.3	Not measured
Bin runner, main sorting cabin	Not measured	7.5	Not measured
Banksman	Not measured	Not measured	1.5
All: Number greater than 10 mg/m^3	5	6	0
All: Average (arithmetic mean)	7.1	13.2	1.2

A significant burden of occupational respiratory disease in Great Britain is caused by exposure to dusts which are hazardous to health. It is common in a number of industries such as woodworking, stone working, and waste and recycling, for the workplace to become heavily contaminated with dusty material emitted from the process. Employers are responsible for taking effective measures to control exposure and protect health. The priority is to control the exposure at source. Failure to do so results in the need for regular cleaning which can cause very significant worker exposure.

This report describes research to better understand the contribution that industrial cleaning activities make to overall exposure to dusts, which are hazardous to health (excluding asbestos), in the manufacturing, construction and waste and recycling industries.

Internal intelligence was 'mined' from HSE's library of in-house occupational hygiene reports which describe site visits conducted for inspections or research from the late 1990s onwards.

The work concludes that there is potential to significantly reduce dust exposures in several common industries by more widespread adoption of good practice for cleaning dust from production areas.

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