

Exposure to Flour Dust in UK Bakeries: Current Use of Control Measures

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Objectives: In May 2001, a maximum exposure limit (MEL) for flour dust was set in the UK at 10 mg/m³ [8 h time-weighted average (TWA)] with a short-term exposure limit (STEL) of 30 mg/m³ (15 min reference period). The purpose of this study was to produce a benchmarking baseline of current control measures and exposure levels, in addition to assessing the provision of training and the knowledge of the UK regulations amongst the bakeries.

Methods: A total of 208 long-term personal inhalable dust samples (8 h TWA) were collected from workers in 55 bakeries (covering a wide range of industry types and sizes) between October 2002 and December 2003 in England, Wales and Scotland. Standardized occupational hygiene reports were produced for each establishment to provide information about the site (such as the size of the bakery) and the control measures employed (including ventilation, good working practices, knowledge of UK regulations and the extent of training provided).

Results: Median inhalable dust exposure (8 h TWA) for the bakery workers was 3.7 mg/m³ (75th percentile at 7.7 mg/m³) and 17% of the dust results exceeded the MEL. Although information about the MEL has been available in the trade press and through recognised trade associations, only 27% of the bakeries were aware of the MEL and STEL. Mixed model regression analysis suggested that determinants of higher exposure included the job category (particularly weighing/sieving or mixing), medium to large bakery size (50 or more employees) and bakeries being located in Scotland. However, having an appointed safety representative was associated with lower exposure.

Conclusions: The conclusions derived here are based upon the use of a statistical model, but clearly, if bakeries and individuals employ good working practices, with correct use of local exhaust ventilation, they should be able to comply with the MEL.

Keywords: control measures; exposure; flour dust

INTRODUCTION

Flour dust is an asthmagen and is known to cause sensitization, allergic rhinitis and occupational asthma amongst bakers and millers (Musk *et al.*, 1988; Jeffrey *et al.*, 1999). Subsequently, there have been many studies focusing on flour dust exposure in bakeries (Burstyn *et al.*, 1997; Elms *et al.*, 2003; Bulat *et al.*, 2004). Flour dust can also act as an irritant and may give rise to short-term respiratory, nasal and eye symptoms, or it may provoke an asthma attack in individuals with pre-existing disease. In the UK, flour and grain dust are the second most

commonly cited agents associated with occupational asthma (Ross *et al.*, 1997). Consequently, under the UK Control of Substances Hazardous to Health (COSHH) Regulations 2002, flour dust is defined as a hazardous substance.

Exposure to flour dust occurs across a range of food industries including plant bakeries, craft bakeries, cake and biscuit production, pastry production, in-store bakeries and pizza production. In May 2001, a maximum exposure limit (MEL) for flour dust was set at 10 mg/m³ [8 h time-weighted average (TWA)] with a short-term exposure limit (STEL) of 30 mg/m³ (15 min reference period). The flour dust MEL is a statutory limit under COSHH 2002 (HSE, 2002a). MEL takes socio-economic factors into account, and the rationale for the limit is set out in *EH64 Summary Criteria* (HSE, 2002b). This

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type of limit enables efforts towards reduction of the exposure as far below the MEL as reasonably practicable. Following the implementation of these limits, it is important to assess how effective control measures have been in complying with the MEL and whether knowledge of the regulations is related to lower exposure. Adequate control of exposure to flour and ingredients dust should help to reduce the incidence of occupational asthma in the baking industry, which is one of the priority objectives of the Health and Safety Commission (Curran and Fishwick, 2003).

This study forms part of an industry-wide survey of bakeries to benchmark current patterns and levels of exposure to flour dust. For the bakeries sampled, the study also provides information about the effectiveness of existing control measures, and how this relates to knowledge of the regulations and compliance with their other provisions.

METHODS

Bakery details

Fifty-five bakeries (Health and Safety Executive and Local Authority inspected) were sampled between October 2002 and December 2003 in England, Scotland and Wales. Facilities were randomly selected (by regional HSE inspectors) from HSE and Local Authority records to cover a wide range of industry types and sizes. Additionally, workers were randomly selected from different areas of the bakery where flour products were used and asked if they would agree to be monitored. Very few (if any) workers declined to participate in the study.

The bakeries were categorised into four main groups: micro-bakeries (1–9 employees), small bakeries (10–49 employees), medium-sized bakeries (50–249 employees) and large bakeries (>250 employees). Industrial plant bakeries were not included in the study. In-store bakeries were allocated to the ‘small’ category. Six of the bakeries did not produce bread but produced pies, pastries or pizzas. The personal 8 h TWA for 208 workers were classified into four main groups (Table 1) by job task (bakers, mixers/weighers and sievers, cleaners and others). Of the 55 bakeries surveyed, 35 (65%, one missing response) were members of a recognized UK bakery trade association and approximately half of the bakeries (47%, one missing response) had an appointed safety representative.

Control measures assessment

The occupational hygienist undertook a comprehensive on-site hygiene survey. This included an initial walk-through survey to evaluate the bakery, followed by an exposure control assessment

including personal exposure to flour dust. Standardized occupational hygiene reports were produced for each establishment using information obtained from the bakery owner/manager. These reports provided information about the site (such as the size of the bakery) and the control measures employed [including ventilation and good working practices (HSBLC, 1998), knowledge of UK regulations and the extent of training provided] (Table 2). From the assessment, the occupational hygienist judged whether the control measures were adequate overall (i.e. will reduce exposure to well below the 8 h MEL and 15 min STEL).

Table 1. Job category and description of tasks

Job category	Number of samples	Description of tasks
Baker/table/dough brake	108	Undertakes general baking duties including shaping and dusting, operates dough cutting and dispensing machine
Mixer/siever/weigher	59	Operates mixer. Combines flour with other ingredients such as flour improver, yeast, fat and water. Sieves and weighs flour and other ingredients
Cleaner	6	Cleans machinery, utensils and surfaces
Other	35	Operates ovens. Packs bread and makes up orders, administration, driver, working on counter. May not be in main production area

Table 2. Site and process information

Main details	Description
Number of employees	—
Products baked	—
Knowledge of COSHH and MEL	Awareness that flour dust is a respiratory sensitizer, exposure limits, safety assessments and monitoring
Control measures	Presence and extent of local exhaust ventilation
Working practices	The way ingredients are blended, bags emptied and folded and whether hand dusting is undertaken or not
Cleaning processes	Use of vacuum, dry sweeping
Respiratory protective equipment (RPE)	If RPE is provided, whether it is used and maintained appropriately
Management of control measures	Are control measures adequate, reliable and sustainable
Training and supervision	Types and extent of training, information provided to employees, supervision and good working practices

Sampling methods

Personal long-term samples were collected in the workers' breathing zone using IOM sampling heads with glass fibre filters (GF/A, Millipore) at a calibrated flow rate of 2 l/min. Field blanks were included for each sampling visit. The filters were weighed twice in a preconditioned room (kept at a constant temperature and humidity) before and after sampling was undertaken and the personal dust exposure [8 h TWA (mg/m^3)] calculated.

Data analysis

The data analysis for the occupational hygiene reports was performed using SPSS software (Statistical Package for Social Scientists v10, SPSS Inc., Chicago, USA). Descriptive statistical analysis was performed on the data in addition to cross-tabulation with the Mantel–Haenszel common odds ratio estimate. One-way ANOVA and *t*-tests were used to compare natural logarithms of exposures for bakers classified by size and job task. To calculate determinants of flour dust exposure, analysis was performed using a linear mixed-effects regression model with fixed effects for covariates (such as bakery size, job task, knowledge of regulations and training, presence of an appointed safety representative and bakery location; Table 3, and random factory effects to account for repeated measurements taken from the same site. Because only one sample was taken for each worker, it was not possible to distinguish worker effect. Bakery location was viewed as a potential determinant, as it was proposed that bread products baked by the Scottish industry might differ from those in England and Wales because of regional differences in recipes and practices. The models were fitted using restricted maximum likelihood estimation in S-plus 6 (InSightful Corporation)

RESULTS

Knowledge of regulations and guidance

Under the COSHH Regulations 2002, employers need to prevent people from being exposed to hazardous substances and, where this is not reasonably practicable, to control the exposure. The details of the main steps of a COSHH assessment are given in Table 4. Of the 50 companies with five or more employees, only 13 (26% of companies) had completed a written COSHH assessment, which the regulations require. Approximately half of these assessments covered all the activities where there was exposure to flour dust and identified a need for health surveillance [7 (54%) and 6 (46%), respectively]. Employees need to be made aware of the hazards and risks at their place of work, the signs and symptoms of work-related ill-health and be

Table 3. Potential determinants of airborne flour dust concentrations

Potential determinant	Definition
Bakery size	Micro/small or medium/large ^a
Region	Bakery location, England/Wales or Scotland
Job category	Weighing/mixing/sieving jobs or other job tasks ^b
Guidance document	Does the bakery have a copy of the Health and Safety in Bakeries Liaison Committee guidance document? (Yes or no)
COSHH	Has the bakery completed a written COSHH assessment? (Yes or no)
Knowledge of regulations	Are the bakeries aware of the MEL and STEL for flour dust? (Yes or no)
Sensitiser	Does the bakery understand that flour dust is a sensitizer? (Yes or no)
Safety representative	Does the bakery have an appointed safety representative (Yes or no)
Training	Is there any training provided on flour dust, the associated health effects, control measures or the use of good working practices?

^aAnalysis of bakery size demonstrated a significant difference ($P < 0.001$) between exposures in micro/small bakeries and medium/large bakeries.

^bAnalysis of job category demonstrated that as a group weighers/mixers/sievers were exposed to the highest median flour dust concentration. For the mixed-model analysis, bakers were divided into two categories, which were significantly different from each other ($P = 0.003$).

Table 4. From COSHH in a hurry, www.hse.gov.uk

Step	Details
1	Work out what hazardous substances are used in the work place and find out the risks of using these substances to people's health
2	Decide what precautions are needed before starting work with hazardous substances
3	Prevent people being exposed to hazardous substances, but where this is not reasonably practicable, to control the exposure
4	Make sure control measures are used and maintained properly and that safety procedures are followed
5	If required, monitor exposure of employees to hazardous substances
6	Carry out health surveillance where your assessment has shown that this is necessary or COSHH makes specific requirements
7	If required, prepare plans and procedures to deal with accidents, incidents and emergencies
8	Make sure employees are properly informed, trained, and supervised

correctly trained in the use of controls (both mechanical and behavioural). These areas were not intensively investigated in this study, as worker interviews were not held. HSBLC has published *Guidance on Dust Control and Health Surveillance in Bakeries* and also produced an interactive training package/video ('Breathe easy') which gives information on improving work practices to prevent dust from becoming airborne and health surveillance. Only 12 (28%) of the 55 bakeries had a copy of the guidance booklet; 17 (31%) were aware of both the guidance document and the training package, and 22 (40%) had some form of training on flour dust for employees joining the company. In general, the bakeries had limited knowledge of the existence of the MEL and STEL for flour dust. Approximately a quarter of the bakeries [15 (27%)] were aware of the MEL and STEL and of these bakeries, the majority [12 (80%)] understood the difference between the two exposure limits. Companies that had an appointed safety representative were more likely to be aware of the MEL for flour dust [odds ratio = 7.69 (confidence interval 1.84–32.20)], to understand that flour dust is a respiratory sensitiser (odds ratio = 5.68 (confidence interval 1.10–29.48)], to have completed a written COSHH assessment (odds ratio = 10.21 [confidence interval 1.98–52.70]) and to have provided some form of training on flour dust (odds ratio = 8.69 [confidence interval 2.46–30.64]) compared with companies that did not have a safety representative. However, in the occupational hygienist's opinion, bakeries with an appointed safety representative were no more likely to have 'adequate' control measures [odds ratio = 1.01 (confidence interval 0.33–3.08)] than those bakeries without one.

Control of exposure

Practicable measures to reduce exposure to flour dust were divided into two categories: (i) precautions involving changes to working practices and (ii) precautions involving changes to plant and equipment.

The use of dredgers or sprinklers rather than hand throwing of flour reduces exposure and although 51% of the bakeries employed these methods, 82% still undertook some flour dusting by hand. Another good working practice was to undertake cleaning using vacuum. In 44% of the bakeries, some or all of the cleaning was carried out using vacuum; however, 93% of the companies still used dry brushing.

Eighty-six per cent of the bakeries had some type of mechanical ventilation, and of these 77% had an extraction fan in the wall as general ventilation. Only 28% had local exhaust ventilation (LEV), and of these only three had records of maintenance examination and checks as required by COSHH regulation 9. There are essential activities (such as sieving) that are likely to lead to high short-term exposures to flour

dust, and while performing these short-term dusty tasks respiratory protective equipment (RPE) must be worn. Forty-two per cent of the bakeries surveyed provided RPE that generally met a recognized standard (74%). However, we do not have information on whether RPE was worn. Thirty per cent of the bakeries with RPE attempted to match the RPE to the level of exposure and/or the nature of the work. From the assessment, the occupational hygienist judged whether the control measures were adequate overall (i.e. will reduce exposure to well below the 8 h MEL and 15 min STEL). Forty-eight per cent (26) of the bakeries surveyed were judged to have adequate control measures, and, as a group, workers at the bakeries with control measures that were deemed 'adequate', were exposed to lower dust concentrations than those where control measures were deemed 'inadequate' ($P < 0.0001$).

Three-quarters [65 (76%)] of those individuals working in bakeries with adequate control measures were exposed to dust concentrations below 5 mg/m³, compared with half [51 (49%)] of those workers in bakeries without adequate control.

Exposure levels of inhalable dust

A total of 208 personal, 8 h TWA samples were collected from workers and inhalable dust exposures were determined. Inhalable dust exposures (8 h TWA) for the bakery workers ranged from below the limit of detection for gravimetric analysis (0.2 mg/m³) to 47 mg/m³, with a median exposure of 3.7 mg/m³ (75th percentile at 7.7 mg/m³). The majority of the samples (52%) were taken from bakers who undertook general baking duties (such as some element of dough shaping and dusting and operating dough cutting and dispensing machines) and as a group the median exposure to flour dust was 3.6 mg/m³ (minimum exposure below the limit of detection, maximum exposure 47 mg/m³) with the 75th percentile at 7.1 mg/m³ (Table 5). The highest median exposures were for the mixers/sievers and weighers (median exposure 5.2 mg/m³, 75th percentile at 9.7 mg/m³). The median dust exposures for micro and small bakeries were 3.0 and 2.2 mg/m³, respectively, whereas for the medium and large bakeries, this was 5.2 and 7.6 mg/m³, respectively (Table 6). Seventeen per cent of the personal 8 h TWA inhalable dust results exceeded the MEL.

Determinants of inhalable flour dust concentrations

The dust exposure data were normalized using natural logarithmic transformation. The data was analysed using a linear mixed-effects regression model. Table 7 shows the results for the determinants included in the analysis. The mixed-effects model accounted for repeated measures within bakeries, and

Table 5. Inhalable dust exposure for workers categorized by job grouping

Job category	<i>n</i>	Dust (mg/m ³)					
		Median	Geometric mean	SD	Min.	Max.	75th percentile
Baker/table/dough break	108	3.6	3.3	3.4	BLD	47.0	7.1
Mixer/siever/weigher	59	5.2	4.7	3.4	BLD	30.6	9.7
Cleaner	6	4.4	3.8	3.5	0.4	14.3	10.0
Other	35	2.1	2.2	2.8	BLD	30.8	4.1

BLD, below limit of detection.

Table 6. Inhalable task-specific dust exposure for workers categorized by bakery size

Job category	Number of samples	Number of bakeries	Dust (mg/m ³)					
			Median	Geometric mean	SD	Min	Max	75th percentile
Micro	55	22	3.0	2.8	3.1	BLD	28.1	5.5
Small	74	20	2.2	2.2	3.8	BLD	30.6	5.7
Medium	35	6	5.2	5.7	2.6	1.2	47.0	10.4
Large	44	7	7.6	6.4	2.2	1.1	27.7	12.0

Table 7. Potential determinants of airborne flour dust concentrations included in the mixed-model analysis

	Value	SE	<i>t</i> -value	<i>P</i> -value
Intercept	0.582762	0.2807431	2.075784	0.0396
Safety representative	−0.667810	0.2982131	−2.239373	0.0301
Bakery size (medium to large)	1.361877	0.4048973	3.363511	0.0016
Region (Scotland)	0.932988	0.2777082	3.359598	0.0016
Job category (mixer/siever/weigher)	0.359852	0.1697114	2.120376	0.0356
Guidance document (HSBLC)	0.041751	0.1574091	0.265241	0.7920
Knowledge of regulations	0.250377	0.3550506	0.705186	0.4843
COSHH	−0.272583	−0.272583	−0.891236	0.3775
Training	0.192484	0.3100053	0.620904	0.5378

Table 8. Significant determinants of airborne flour dust concentrations included in the final model

	Value	SE	<i>t</i> -value	<i>P</i> -value
Intercept	0.671896	0.1892234	3.550810	0.0005
Safety representative	−0.699342	0.2741228	−2.551200	0.0138
Bakery size (medium to large)	1.555450	0.2853447	5.451126	<0.0001
Region (Scotland)	0.794551	0.2365998	3.358205	0.0015
Job category (mixer/siever/weigher)	0.354345	0.1670933	2.120643	0.0356

demonstrated that size of the bakery ($P < 0.001$), having an appointed safety representative ($P = 0.0138$), bakery location ($P = 0.0015$) and job task ($P = 0.0356$) were significant predictor variables in the model (Table 8). Bakery size appeared to be the major influencing factor on exposure levels (medium/large bakeries as a group demonstrating higher inhalable flour dust concentrations than micro/small bakeries), with the other three variables having a similar magnitude of effect. Having an appointed safety

representative at the bakery reduced the inhalable flour dust exposure. Bakery location and job task also affected exposure, with bakeries in Scotland and weighing/mixing/sieving being predictors of higher exposure.

DISCUSSION

Knowledge of regulations and guidance

This is the first report identifying the use of control measures in the baking industry and compliance with

the MEL. Under COSHH regulations, if a company has five or more employees, a record of the COSHH assessment of the hazards and risks identified in the company must be made and kept. From the analysis of the questionnaire data, approximately a quarter of the bakeries had completed a written COSHH assessment although we were not able to establish whether the bakeries that had not completed the assessment had begun the process of identifying hazards and risks. Although flour dust is defined as a respiratory sensitizer and under EH40/2002 (HSE, 2002a) has been given a 'sen' notation (therefore health surveillance is appropriate), only roughly half of the bakeries with a written assessment had identified a need for health surveillance.

Information about the MEL for flour dust has been available in the trade press and through bakery associations. However, only a small number of bakeries had knowledge of the MEL. In this study, bakeries that had an appointed safety representative were more likely to be aware of the MEL and STEL for flour dust, to have completed a written COSHH assessment and to have some form of training on flour dust. This indicates a potentially useful route for knowledge transfer from HSE and the bakery associations to the bakeries, although we do appreciate that it would not be possible for all bakeries to have an appointed safety representative. However, there was no association between having a safety representative and having 'adequate' control measures (in the occupational hygienist's opinion) suggesting that, in some situations, either information is not being passed to all of the employees, is not understood or is ignored or that exposures could potentially be reduced further. Unfortunately, no information was available regarding the employee's knowledge and understanding of risk and control, so it is impossible to resolve this issue. The mixed-model analysis demonstrated that one of the factors that generally led to lower exposures was having an appointed safety representative. This may appear contradictory. However, interpretation of the data suggests that although having an appointed safety representative did reduce the geometric mean concentration of flour dust, there was evidence to suggest that exposure could be further reduced to comply with the MEL. This is supported by data from bakeries highlighting some of the poor working practices.

Control of exposure

The occupational hygienist judged whether the control measures in place (including good working practices and ventilation) were adequate. Approximately half of the bakeries were thought to have adequate control measures that would reduce exposure to well below the MEL and STEL. This suggests that the other half of the bakeries did not understand

the value of 'reasonably practicable' control measures to reduce flour dust exposure or that these measures were being ignored.

Good working practices are known to reduce exposure to flour dust and can be found in the industry's HSBC guidance document (HSBC, 1998). Although most of the bakeries did not have a copy of this document, it was not established whether employers had previously read this document, followed any coverage in the trade press or obtained appropriate information some other way. However, activities such as dry sweeping and flour dusting by hand were still undertaken by the majority of bakeries, which may suggest that either there was limited knowledge of good working practices or that this was being overlooked by both employers and employees. Another control measure is for individuals to not spend all their time undertaking dusty job activities. This may in part account for the lower exposures in the micro/small bakeries, as many of the workers undertake general baking duties and subsequently their activities will vary.

In this study, median inhalable dust exposures (8 hour TWA) for the bakery workers were slightly higher than levels reported by Houba *et al.* (1997) and Nieuwenhuijsen *et al.* (1995). However, in this current survey the authors concentrated on those individuals working with flour products. The MEL for flour dust in the UK is 10 mg/m³ (8 h TWA reference period). In this study, 17% of the inhalable dust results exceeded the MEL, which is similar to that reported by Jeffrey *et al.*, (1999) and 38% were higher than 5 mg/m³. This study identified mixers/weighers/sievers as the category of workers exposed to the highest median dust levels, which is similar to previously reported data (Elms *et al.*, 2003). However, mixed-model analysis suggests that determinants of higher exposure include bakery size, regional location, job category and no appointed safety representative. From the observation that many of the bakeries surveyed did not employ good working practices, it can be proposed that with appropriate knowledge and use of good control practices, training and supervision, exposure levels (particularly in the medium- and large-sized bakeries) would be substantially reduced. The results of the 'control measures' questionnaire identified the bakeries that had 'adequate' control measures, which would reduce exposures to well below the 8 h MEL and 15 min STEL. Unsurprisingly, as a group, workers at bakeries with adequate control measures were exposed to lower dust concentrations than those where control measures were inadequate ($P < 0.0001$). Three-quarters (76%) of those individuals working in bakeries with adequate control measures were exposed to dust concentrations below 5 mg/m³, compared with half (49%) of those workers in bakeries without adequate control. Although this observation is not remarkable, it

does provide evidence that appropriate control measures can reduce flour dust exposure to well below the MEL; however, this may still not be as low as reasonably practicable.

Determinants of inhalable flour dust concentrations

A mixed-model analysis enabled the prediction of geometric mean flour dust exposures, taking into account bakery size, regional location, job category and having an appointed safety representative. Bakery size appeared to be the major influencing factor on exposure levels (medium/large bakeries as a group demonstrating higher inhalable flour dust concentrations than micro/small bakeries), with the other three variables having a similar magnitude of effect. The effect of the bakery having an appointed safety representative reduced inhalable flour dust exposure. Bakery location and job task also affected exposure, with bakeries in Scotland and weighing/mixing/sieving being predictors of higher exposure. It is not known why bakery location should affect the exposure levels; however, this could be because recipes may differ between the regions or there may be a higher production of hand-crafted floury dusted bread products and rolls in parts of Scotland (National Association of Master Bakers, personal communication). Further research would need to be undertaken to determine the regional differences. It is important to remember that all of these factors influence exposures; therefore, one could predict that an average weigher/mixer/siever working in a large Scottish bakery without a safety representative would be exposed to much higher levels than 'other' average bakers working in a small English/Welsh bakery with a safety representative. The conclusions derived here are based upon the use of a statistical model, but clearly if bakeries and individuals employ good working practices with correct use of LEV, then all categories of bakers should be able to comply with the MEL.

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