XVII^th World Congress of the International Commission of Agricultural and Biosystems Engineering (CIGR)

Hosted by the Canadian Society for Bioengineering (CSBE/SCGAB)
Québec City, Canada June 13-17, 2010

EQUIPMENT FOR DUST REDUCTION IN GRAIN HANDLING: EVALUATION OF DUST AND CHAFT EXTRACTOR AND ASPIRATOR

QIUQING GENG[1], GUNNAR LUNDIN[1]

[1]Swedish Institute of Agricultural and Environmental Engineering, Box 7033, SE-750 07 Uppsala, Sweden, qiuqing.geng@jti.se
[1]G. Lundin, gunnar.lundin@jti.se

CSBE100899 – Presented at Section II: Farm Buildings, Equipment, Structures and Livestock Environment Conference

ABSTRACT Exposure to hazardous dust is a serious problem for farmer's working environment during handling of grain. The working environment in extreme dusty tasks should be improved through some effective technical approaches. The most common method for dust reduction is the use of equipment for cleaning grain with airflow that can be assembled in the grain flow from conveyors. This study aimed at investigating the level of dust reduction with such equipment. Two types of equipment for dust reduction, namely, dust and chaff extractor and aspirator, were evaluated, respectively. The evaluation was carried out at six occasions in drying plants of farms. The concentration of airborne particles in a size range of 0,1-10,0 μm was continuously collected and stored with a digital instrument. The results show that the average dust concentration varied among the measured occasions. Furthermore, a significant difference between the average dust concentrations with and without the evaluated equipment appeared. With the equipment, the dust concentrations were reduced by almost 50 % on average. The dust concentration without equipment for dust reduction exceeded substantially a health risk threshold value, 5 mg/m^3, for half of the occasions studied. A lower grain flow had a more dominant impact on the dust reduction rather than the type of equipment used. In addition, the dust in grain plants could be reduced through restricting the distance between conveyor outlet and grain surface in the bin.

Keywords: Aspirator, dust & chaff extractor, dust reduction, health risk threshold, grain handling, working environment.

INTRODUCTION

During grain handling on farms, the personnel are often exposed in a great concentration of harmful dust with a subsequent risk for work related disease. In recent years, the amounts of grain that are handled on farm level in Sweden have been increased. This means that the farmers can suffer from an increased exposure for grain dust in the plants, thereby resulting in a greater health risk for Organic Dust Toxic Syndrome (ODTS). It has been reported that work-related symptoms of the ODTS have occurred up to 44% of farmers in grain handling (Darke, 1976; Warren and Manfreda, 1980; Manfreda and Warren, 1998; Swan and Crook, 1998).

The level on such a harmful dust exposure can be affected by the method of grain drying used, the dryer's capacity, storage times and technical solutions selected for the grain handling. Furthermore, there are different methods to decrease the dust quantities. The most common method for removing dust from grain is to blow air through the grain when flowing from conveyors. The most common commercial equipment for such a dust reduction are dust & chaff extractors and aspirators. They are both assembled in the grain flow from conveyors.

The dust & chaff extractor, made of galvanized sheet steel, is designed to clean grain and other granular materials. In the purification process, the grain is blown through by a strong airflow while it runs in a thin and wide flow over an inclined plane. The cleaning distance approximate amounts to the interval between the air intake and the air damper that is the vertical distance where the grain kernels are exposed for the airflow (Figure 1). However, the commercial dust & chaff extractor does not have a sufficient cleaning distance to get an accurate cleaning of the grain. On the other hand, the dust & chaff extractor has a high capacity, takes small place and is relatively cheap.

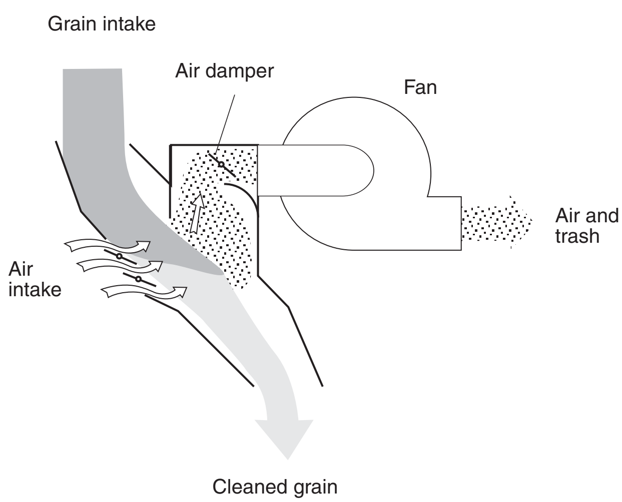

Figure 1. Dust & chaff extractor for dust reduction (Strand Mirza al. et. 1998; Qiuqing Geng, photo 2009).

The aspirator is also designed to clean grain and other granular materials. Compared to the dust & chaff extractor, this equipment has a longer cleaning distance and a greater possibility to adapt the air speed to varying circumstances. Furthermore, the grain kernels are more exposed to the airflow as they are assembled over the spreader plate (Figure 2).

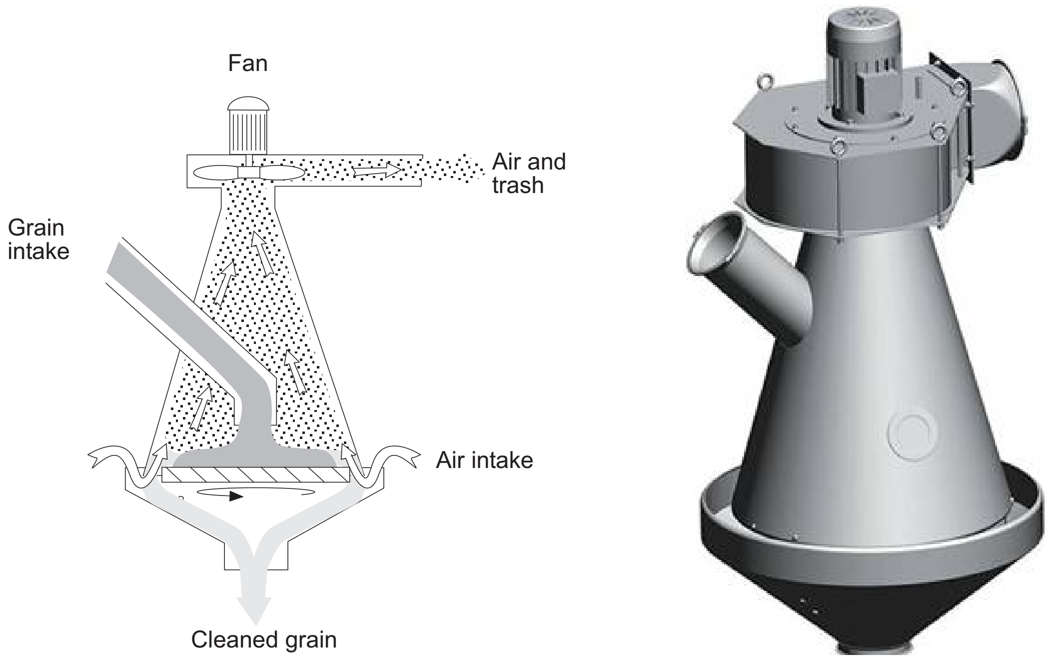

Figure 2. Aspirator for dust reduction (Strand Mirza al.et. 1998; www.tornum.se).

The function of dust reduction systems for cleaning grain with airflow described above has been inadequately evaluated. Also, the farmers have not sufficiently considered the risks for dust exposure in connection with investments in grain drying plants (Persson, 2005; Broberg, 2005).

It is known that the airborne dust is a serious work environment problem during grain handling on farms. This working environment should be improved through some effective technical solutions. It is important to know which sensible dust reductions are possible to achieve and the effect of the technical solutions on the health of the workers.

Therefore, the purpose of this introductory study was to evaluate the efficiency of dust reduction with the most common equipment such as dust & chaff extractors and aspirators.

MATERIAL AND METHOD

The study covered the measurements of dust occurrence during handling of grain with different technical solutions. The measurements were carried out on five different farms equipped with conventionally hot air dryer that is the most common dryer used in Swedish farms. Two types of equipment for dust reduction, namely, dust & chaff extractor and aspirator, were evaluated.

The measurements performed at six occasions in connection with filling/circulation of grain dryers and bulk loading bins during winter and spring 2008/2009 (Geng and Lunding, 2009). Factors that could affect the level of dust concentration were grain type, moisture content and feed rate of conveyor were registered during the measurements. Table 1 shows the specification of the measurement.

Table 1. Specifications of the measurement.

Measurement occasion, run code	Dust reduction equipment, type	Conveyor feed rate, ton/hour	Grain species	Moisture content (wet base), %	Working operation
D&C1	Dust & chaff extractor	30	Barley	12,7	Filling of bulk loading bin
D&C2	..	30	Winter wheat	12,8	Filling of bulk loading bin
D&C3	..	4	Barley	13,5	Circulation of grain dryer
D&C4	..	40	Winter wheat	13,0	Filling of bulk loading bin
ASP1	Aspirator	12	Oat	14,0	Filling and circulation of grain dryer
ASP2	..	40	Spring wheat	13,5	Circulation of grain dryer

The concentration of airborne particles in a size range of 0,1-10,0 µm was continuously collected and stored with a digital instrument named p*ersonalDataRAM* (*p*DR-1000AN, Thermo Electron Corporation, 2005). This instrument is appropriate for use in fields and records momentary values as time weighed mean (Figure 3). It can be used either to bring with the person during experiment or to install in equipment as a measure point. In the study, it was placed as a measure point in order to decrease the experimental deviation caused by varying work methods.

Figure 3. The measuring instrument, p*ersonalDataRAM,* was installed approximate one meter from the conveyor outlet.

RESULTS

Figures 4-9 show the variation of the dust concentration during the whole measurement period for each run. It is seen that the equipment for dust reduction were started and stopped in intervals of approximately 20 minutes.

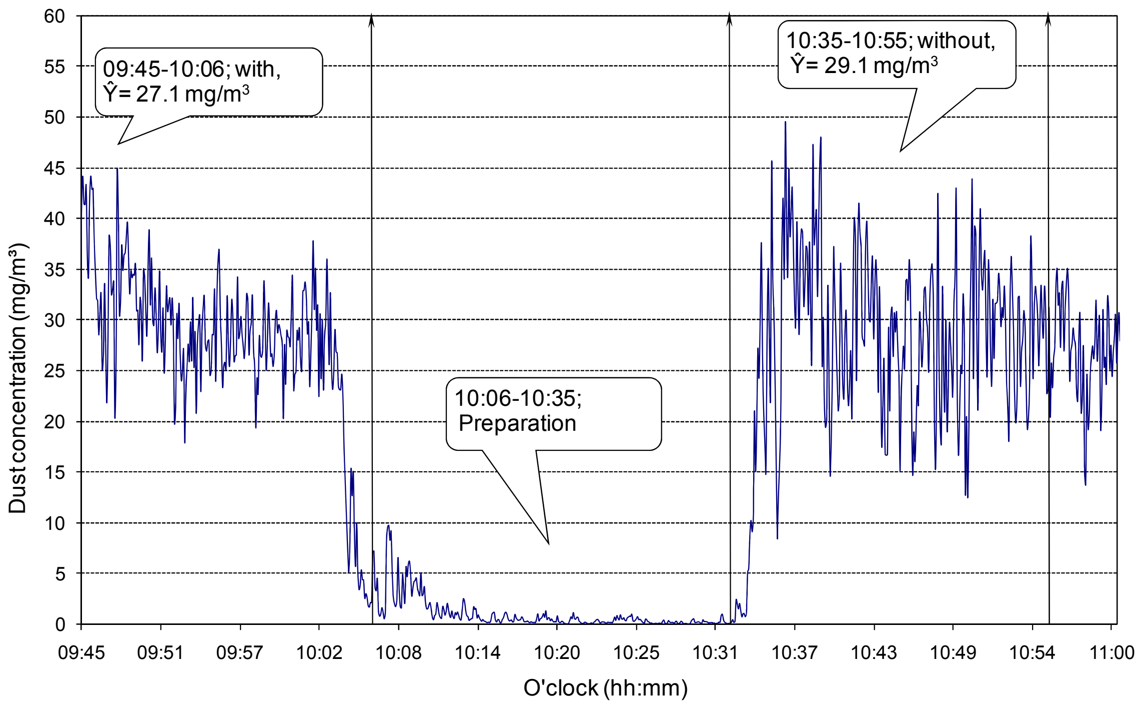

Figure 4. Run code D&C1. Dust concentration variation during filling of barley in bulk loading bin with and without dust & chaff extractor. Ŷ= mean.

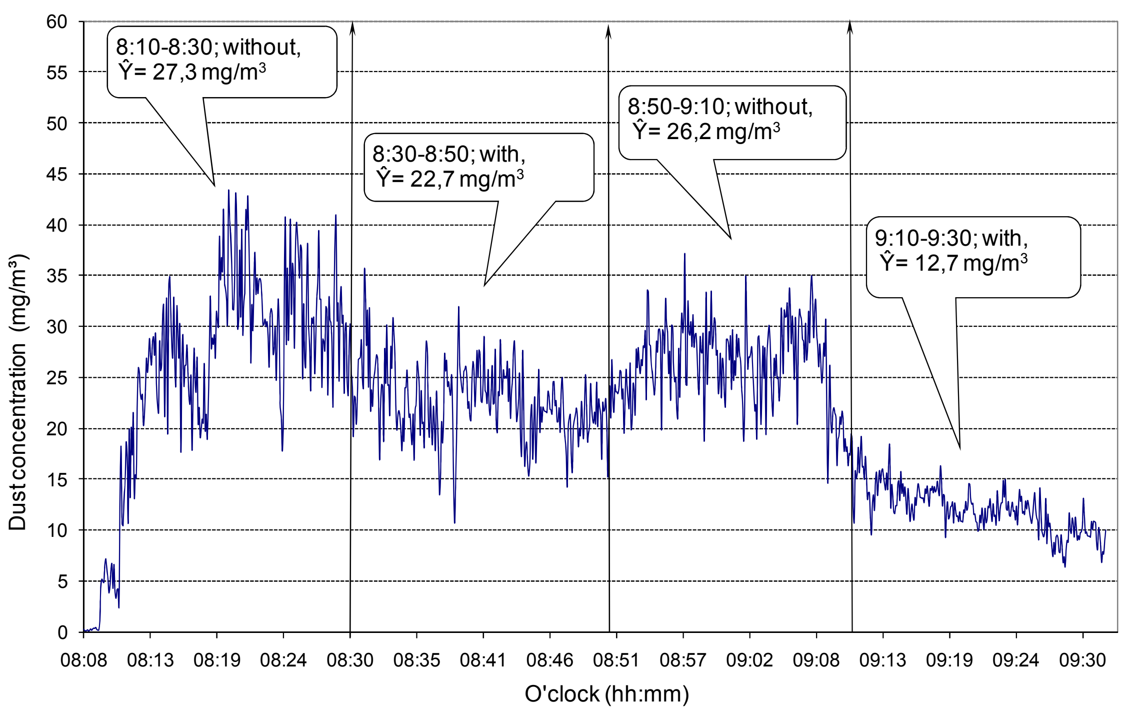

Figure 5. Run code D&C2. Dust concentration variation during filling of winter wheat in bulk loading bin without and with dust & chaff extractor. Ŷ= mean.

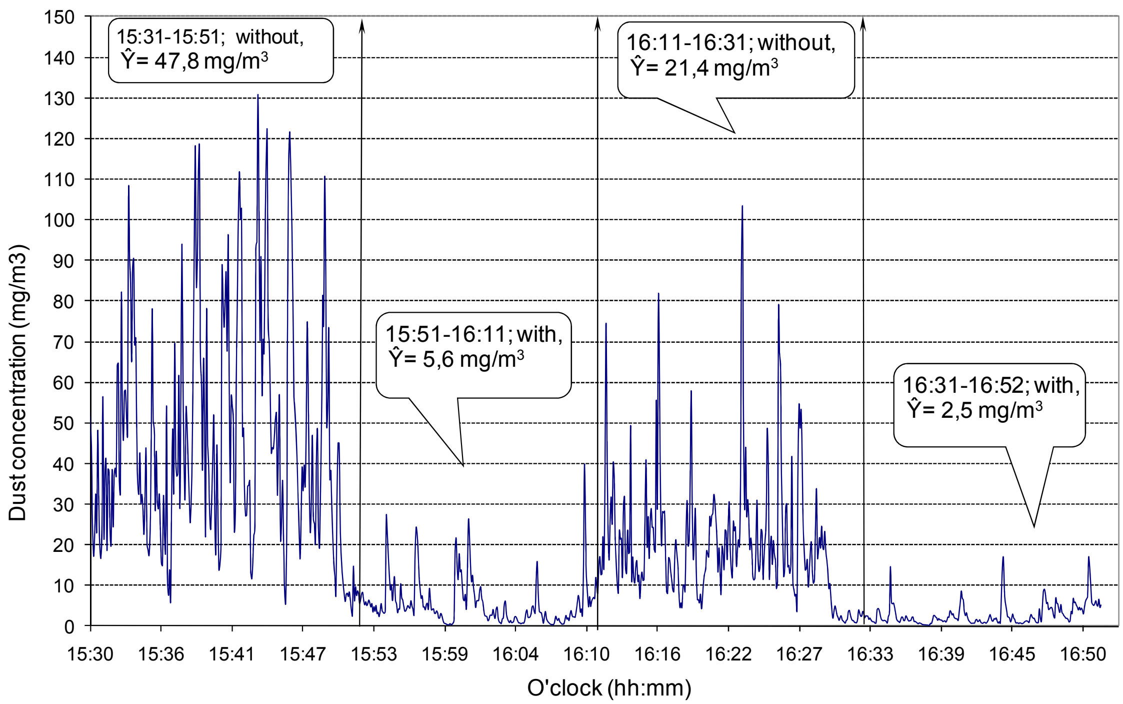

Figure 6. Run code D&C3. Dust concentration variation during circulation of barley in grain dryer without and with dust & chaff extractor. Ŷ= mean.

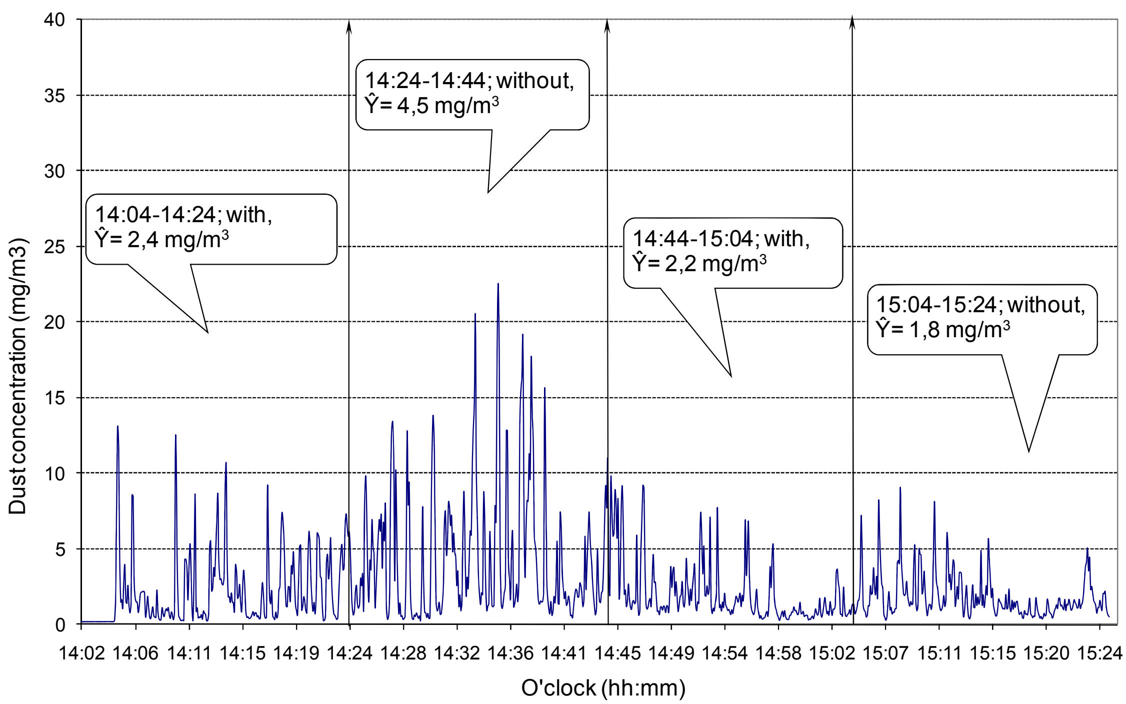

Figure 7. Run code D&C4. Dust concentration variation during filling of winter wheat in bulk loading bin with and without dust & chaff extractor. Ŷ= mean.

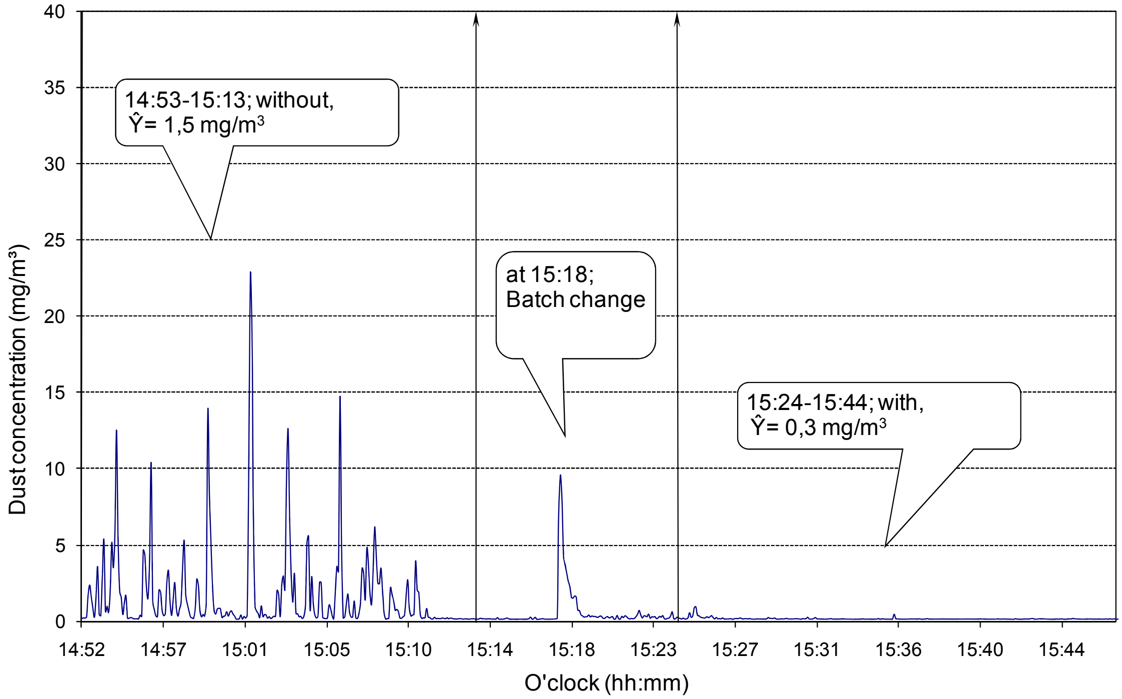

Figure 8. Run code ASP1. Dust concentration variation during filling and circulation of oat in grain dryer without and with aspirator. Ŷ= mean.

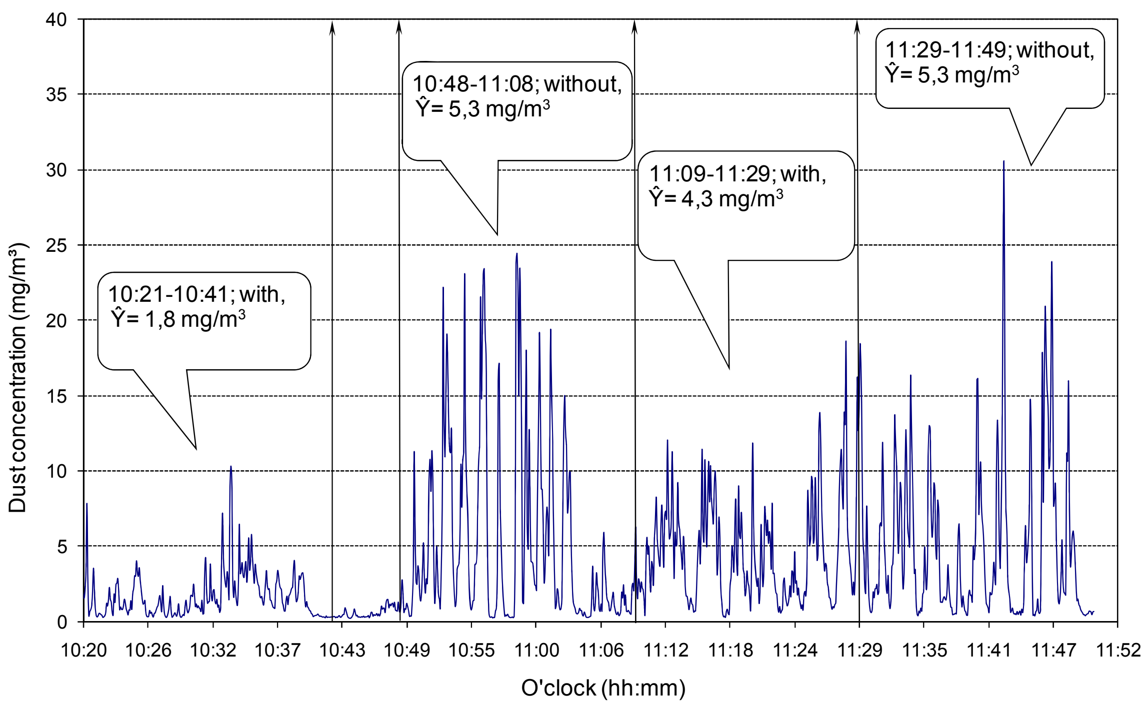

Figure 9. Run code ASP2. Dust concentration variation during circulation of spring wheat in grain dryer with and without aspirator. Ŷ= mean.

Table 2 summarizes the mean and maximum values of the dust concentration with and without equipment for dust reduction as well as the percentage of dust reduction by these equipments. Figure 10 also shows the corresponding mean values.

Table 2. The mean and maximum values for dust concentration without and with the equipment for dust reduction.

Measurement occasion,	Dust concentration					
	Mean value[1]			Maximum value[2]		
Run code	Without (mg/m³)	With (mg/m³)	Reduction (%)	Without (mg/m³)	With (mg/m³)	Reduction (%)
D&C1	29,1	27,1	7	49,5	44,5	10
D&C2	26,8	17,7	34	43,1	35,5	18
D&C3	34,6	4,1	88	130,6	27,0	83
D&C4	3,2	2,3	27	22,5	13,0	42
ASP5	1,5	0,2	89	22,7	0,9	96
ASP6	5,3	3,1	43	30,3	18,5	39
Mean value			*47,5*			*48,1*

[1] Mean value is a time weighed mean over the measured period.
[2] Maximum value is a peak value during the measured period

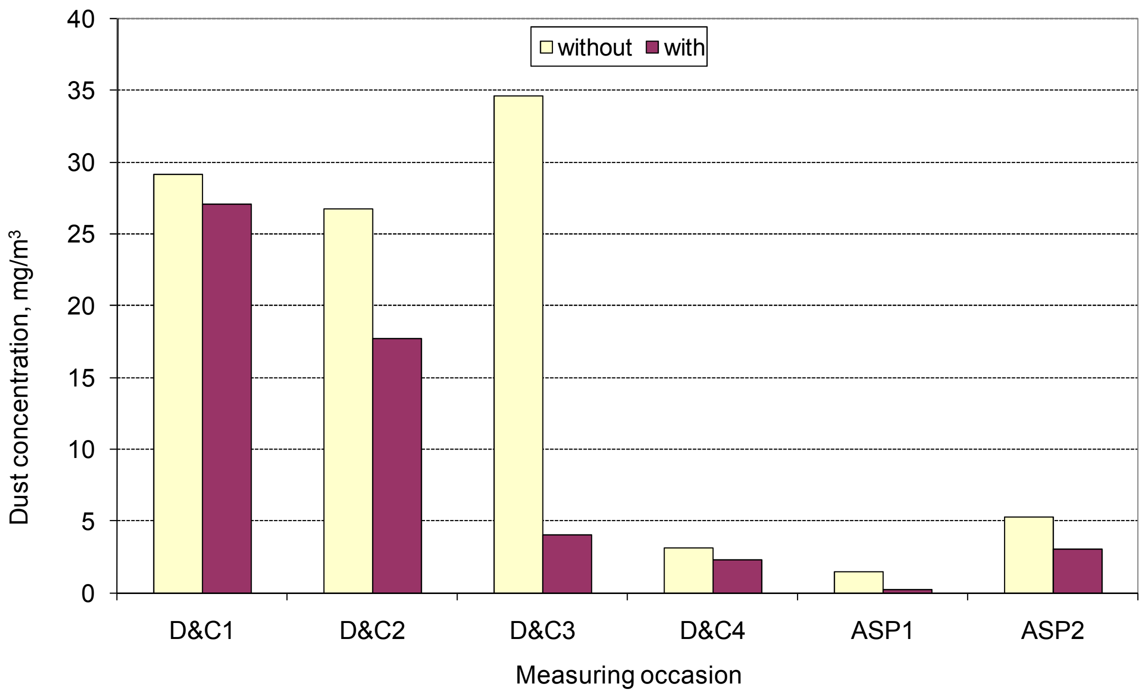

Figure10. Mean value for the dust concentration without and with equipment for dust reduction.

DISCUSSION

The results show that the dust concentrations varied to a large extent between the measuring occasions. Without the equipment for dust reduction, the mean values of the dust concentration varied from 3 mg/m^3 up to 35 mg/m^3 (Figure 10). This could presumably be explained by extraneous factors during the plant cultivation season, harvesting and subsequent handling. Of importance could for example be to what extent the grain had been transported internally in each plant before the measurement and if the equipment for dust reduction had been used during these activities.

Without the equipment for dust reduction, the average dust concentration exceeded a hygienic threshold value of 5 mg/m^3 (AFS, 2005:17) at three measuring occasions (Figure 10). At one of these occasions (D&C3), the equipment used could reduce the dust concentration to a level below the threshold value. However, it is noted that the measuring instrument was assembled nearby the conveyor outlet. Normally, the personnel stay just temporarily close to this dust source, which means that the average exposure for the dust could be substantially lower.

Also, the achieved reduction of dust concentration varied to a large extent between the measuring occasions. On average, the dust concentration could be reduced by approximately 48 % of the mean and maximum values (Table 2).

It could be expected that the performance between the investigated equipment for dust reduction would be different. The more sophisticated aspirator might achieve a greater dust reduction rather than dust & chaff extractor. This could be because the aspirator has a longer cleaning distance and the grain kernels are disseminated over a greater surface, resulting in more exposure to air. However, the difference between the equipment constructions did not give different results on the dust reduction. In Table 2, the greatest dust reduction rate, almost 90 %, could be obtained at one occasion either with aspirator or with dust & chaff extractor at lower feed rates (12 or 4 ton/hour, respectively). Obviously, the superior performances for dust reduction with the equipment used could be obtained at a lower feed rate. This is because a lower feed rate could cause a thinner grain layer, resulting in a more extensive exposure of the grain kernels to the airflow.

For the assessment of achieved performance should be held in mind that this introductory experiment was carried out at different occasions and with unequal opportunities. The results are thus not directly comparable with each other.

The measured dust concentrations proved to be dependent of the grain level in the grain dryer or bulk loading bin into which the grain was transported. Namely, the shorter distance for the fall of grain, the lower amount of airborne dust could be (Figure 5). This illustrates that the distance between the conveyor outlet and the grain surface could affect the dust diffusion from the grain.

CONCLUSIONS

The dust concentrations varied to a large extent between the measuring occasions with and without the equipment for dust reduction (i.e., dust & chaff extractors and aspirators).

The aspirator and the dust & chaff extractor could improve the air quality. On average, the dust concentrations with these equipments were reduced by almost 50 %.

The dust concentration nearby the conveyor outlet without the equipment for dust reduction exceeded substantially a health risk threshold value of 5 mg/m^3 for a half of the occasions investigated. However, the dust exposure to the operating personnel in practical working situations would be lower than the measurement values since the personnel usually could not work frequently nearby the dust source.

A lower grain flower had more dominant impact on the dust reduction than the type of the equipments used.

Dust in grain plants could be reduced through deceasing the distance between the conveyor outlet and the grain level in the dryer/bin.

Acknowledgements This work was financed by The Royal Swedish Academy of Agriculture and Forestry.

REFERENCES

AFS, 2005:17. Hygieniska gränsvärden och åtgärder mot luftföroreningar. Arbetsmiljöverkets föreskrifter om hygieniska gränsvärden och åtgärder mot luftföroreningar samt allmänna råd om tillämpningen av föreskrifterna (in Swedish). Swedish Work Environment Authority, Solna.

Broberg U, 2005. Oral information, Tel: 0512-291 00, Tornum AB, Kvänum.

Darke C.S., J. Knowelden, J. Lacey and A.M. Ward, Respiratory diesease of workers harvesting grain, Thorax, 1976, 31, pp. 294-302.

Geng Q. and G. Lundin, 2009. Dammreducerade utrustning vid spannmålshantering - utvärdering av damm- och bossavskiljare samt aspiratörer (in Swedish). Project repport, SLO-978. JTI - Swedish Institute of Agricultural and Environmental Engineering, Uppsala.

Manfreda J. and C. P. W. Warren, 1998. The effect of grain dust on health. Rev. Environ. Health, 66, pp. 239-267.

Persson S.J. 2005. Oral information. Tel: 0510-914 00, Akron-maskiner, Järpås.

Strand Mirza L, G, Lundin and J, Sampson 1998. Spannmålsrensning på gårdsnivå. Tillämpningar inom det ekologiska lantbruket (in Swedish). Teknik för lantbruket nr 67. Swedish Institute of Agricultural Engineering. Uppsala.

Swan, R. M. and B. Crook, 1998. Airborne microorganisms associated with grain handling, Ann. Agric. Environ. Med., 5, pp. 7-15.

Thermo Electron Corporation, 2005. Model pDR-1000AN/1200, personal DataRAM, Particulate Monitor, Instruction Manual, P/N (100181-00).

Warren C. P. W. and J. Manfreda, Respiratory symptoms in Manitoba farmers: association with grain and hay handling, Can. Med. Assoc. J., 1980, 122, pp. 1259-1264.