# Validation Testing of a Grain Dryer Exhaust Air Cleaner developed by Perry of Oakley LTD.


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PERRY CENTRIKLEEN

"NOTHING'S GETTING OUT"

## Introduction

On the 12th of November 2014 Dr Tomas Norton, Senior Lecturer in Agricultural Engineering at Harper Adams University visited the site of Cannington Grain in order to independently verify the validation test of a new cyclone-based air cleaner system developed for grain dryers at Perry of Oakley. The system was designed to minimise the amount of dust, chaff and husk being exhausted during drying. This technology will reduce the fire hazard around the drying/storage area and reduce the labour requirements to keep the area clean.

The cyclone-based air cleaner under investigation was designed and installed on the continuous mixed flow dryer at Cannington Grain. The working principle of the air cleaner is to induce swirl in the flow leaving the exhaust fan of the dryer, thereby directing the dust particles to outside of the conical-cylindrical ducting that connects the fan to the cyclone. These particles then feed into the cyclone solids/air inlet with the remaining “clean air” being exhausted to the atmosphere. The cyclone itself is based on principle that particles suspended in swirling air become disengaged with the airstream due to a combination of centrifugal and gravitational forces. Particles will drop out of the outlet at the base of the lower conical part of the cyclone whilst the clean air flows in the opposite direction through an outlet usually situated on top of the cyclone. The parameters describing the performance of a cyclone cleaner are pressure drop (gives the operating energy/cost) and collection efficiency (gives installation benefit). The intention of the present validation test was to focus on the “collection efficiency” of the air cleaner under standard operation conditions. This report outlines the methodology used during testing and the final calculated collection efficiency and compares the particle distribution of the dust collected from the two outlets of the cleaner.

## Method

### *Experimental set-up*

The total air cleaning unit including the cyclone was already built into the exhaust of a 20 tph mixed flow continuous drier at Cannington grain (Fig. 1a). A standard methodology for air cleaner collection efficiency testing was employed, and the experiment was designed and set up by the technical staff from Perry. This methodology was based on the placement of 2 collection boxes to capture particles leaving both the “clean air” exhaust and the solids exhaust of the cleaner (Fig. 1b&c). Both boxes were constructed so the sides and base were air-tight by lining them with polythene sheet (Fig. 1d). To allow air to flow through the boxes a “lid” was constructed of netting comprising a 0.3 x 0.6 mm mesh. This meant that particles less than 0.3 mm could leave the boxes if airborne.

Due to the high volumetric flow rate of the clean air being exhausted a large box (14.5 $m^3$) was required to try to drop the pressure so particles could more easily disengage with the air flow. However, given that the air velocity was still significantly higher in this box when compared with the smaller box at the solids exhaust (1.8 $m^3$) it was anticipated that the small suspended dust particles would leave the bigger box more readily. Therefore, the particle size distribution of the dust captured in this box are not completely representative of the actual distribution for particles below 0.3 mm.

Once all the boxes were fixed and sealed the dryer was set going at full capacity to dry the contents of partially full grain bin. The drying lasted a total of 4 hours, until such time as the bin collecting dust from the solids exhaust was deemed full enough for a representative sample to be taken.

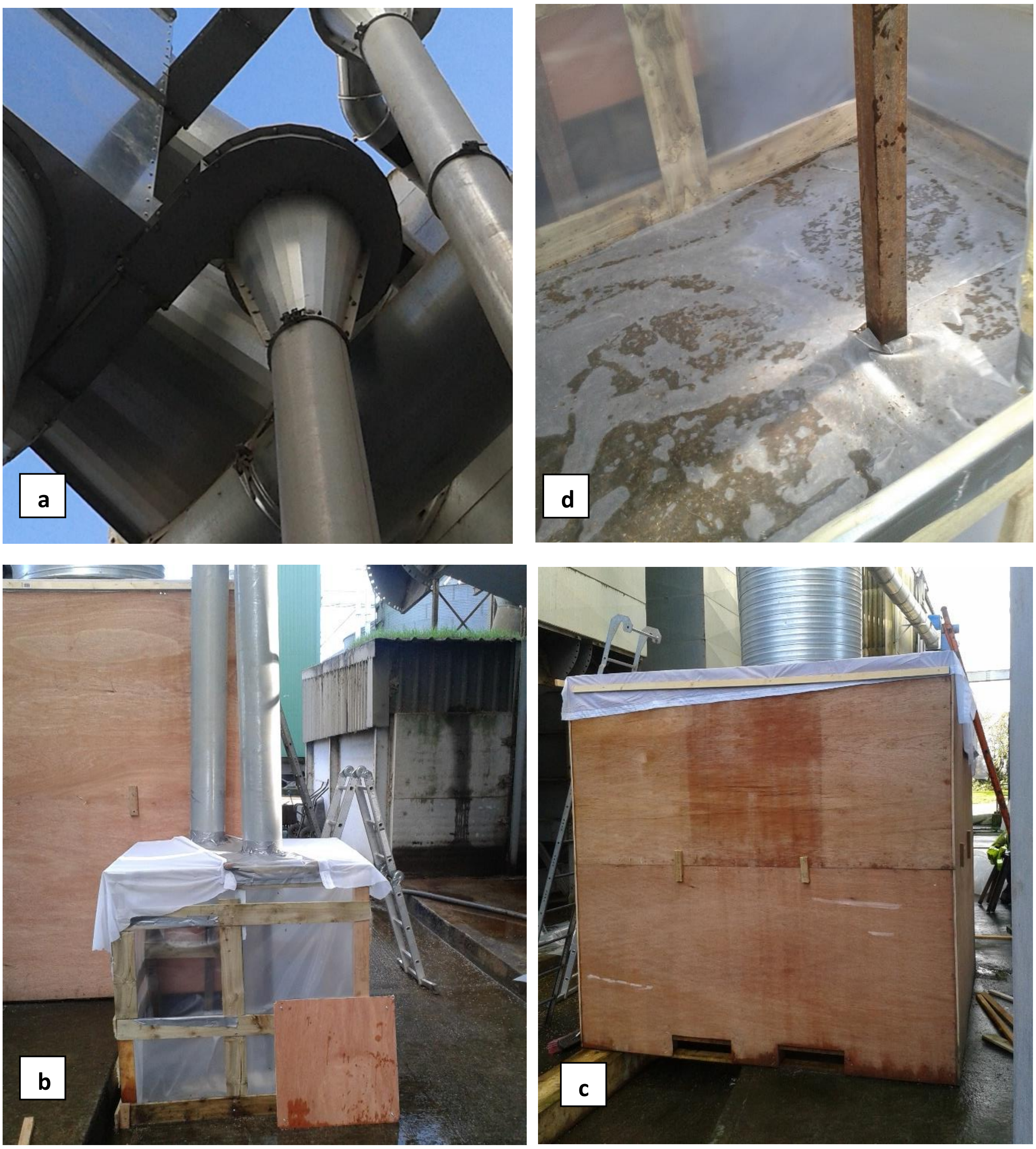


Fig. 1. Experimental set-up for the validation test. The air cleaning system (a). The box capturing particles from the solids exhaust (b). The box capturing the particles from the clean air exhaust (c). The lining of the boxes with polythene.

*Analysis*

The collection efficiency was determined by weighing the quantity of dust collected in each box and then calculating the proportion (percentage weight) of the total dust captured by the box at the solids exhaust of the cyclone. Further analysis was done to determine the distribution of the particle size in the dust collected by both bins. For this analysis a series of 7 test sieves with aperture size ranging from 78 µm to 4 mm were employed. To get a representative distribution the dust was placed in a pile and 3 samples were taken at different points in the pile. Each sample was put through the test sieves and weighed accordingly. As the total weight of dust collected from the clean air exhaust box was small all of what was collected was sieved. Fig 2 shows the range of particle sizes derived from the collected grain dust.


Fig. 2. Range of particle sizes in the grain dust as collected by the air cleaner (a). The 3 samples taken from the dust pile (b).

**Results**

*Collection Efficiency*

The total mass of dust collected in each bin is given in Table 1. Using these figures the collection efficiency of the air cleaning system was found to be 98%. However, this calculation doesn't include the fine particles were not trapped in the clean air exhaust bin.

Table 1. The total mass of dust collected in each bin

| Bin Identifier | Weight of collected dust (kg) |
|---|---|
| Clean air exhaust | 0.11 |
| Solids exhaust | 5. 05 |

*Particle size distribution*

Analysing the particle size distribution in the grain dust could provide a basis for further optimisation of the cleaner if required in the future. The distribution of the particle sizes in the dust (as a proportion of sample weight) collected from the solids exhaust (Fig 3) shows that most of the particles captured are in the 212-600 µm range. On the other hand the box at the clean air exhaust captured the greatest proportion in the 850 µm -2 mm of particle range (Fig. 4). It would also be expected that a great proportion of particles < 100 µm would be captured in the clean air exhaust bin but this could not be demonstrated in the current test. Moreover, the larger amount of dust would be recommended for a better representation of the particles sizes, and this wasn't possible due to time constraints.

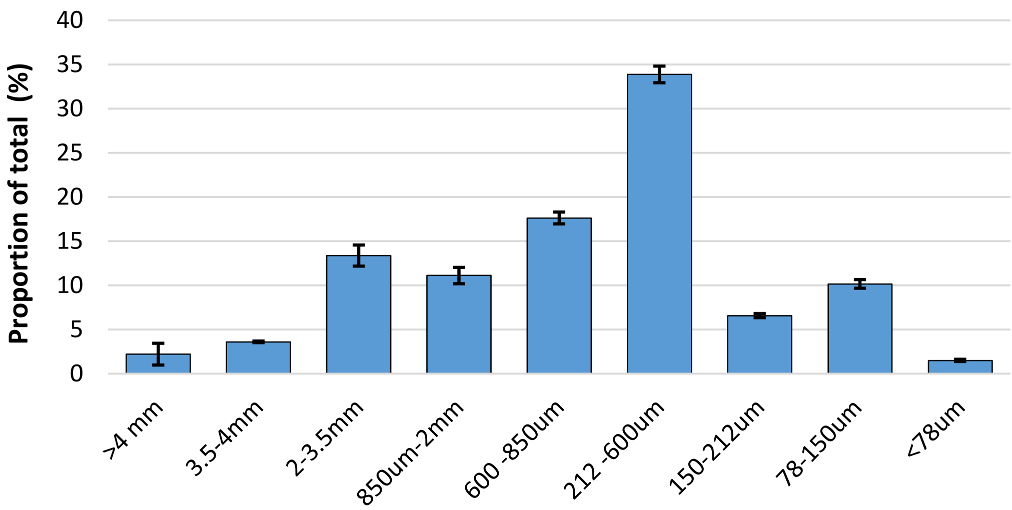


Fig. 3. Distribution of particle sizes as a proportion of the total sample weight at the solids exhaust

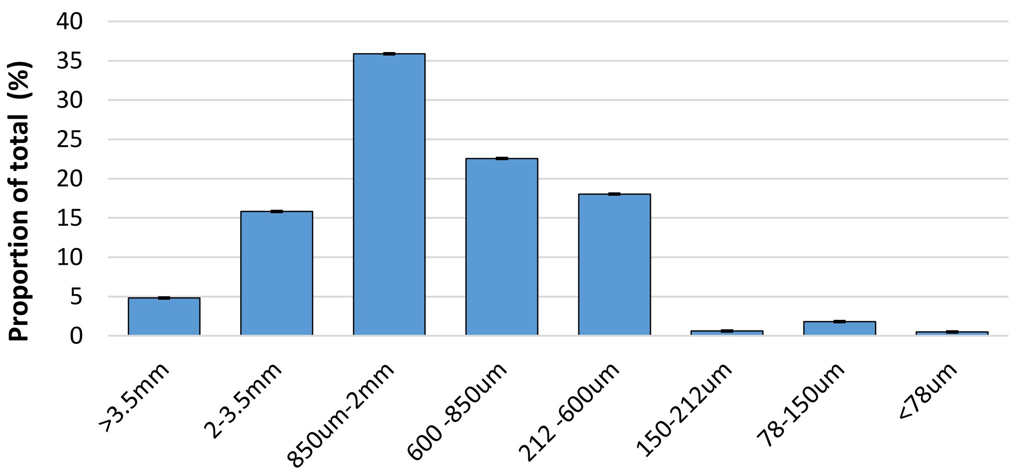


Fig. 4. Distribution of particle sizes as a proportion of the total sample weight at the clean air exhaust

**Conclusion**

The integrity of the validation test of a new air cleaner system designed by Perry of Oakley LTD to strip dust from the air exhausted from grain dryers was independently verified by Dr Tomas Norton of Harper Adams University. It was confirmed that (with the data collected) the collection efficiency of the cleaner was found to be 98%. However, because the fine particles in the clean air exhaust could not be included in the calculation it would be judicious to reduce the collection efficiency by 2-3% to take account of this element of uncertainty. An analysis of the particle distribution showed that the greater proportion of the dust captured from the clean air exhaust was made up of chaff and husk which likely didn't get captured by the cyclone due to its low density. However, the proportion of dust leaving the clean air exhaust which was finer than 300 µm could not be accurately measured.

# Appendix

Picture of the netting material used as the lid for the bins

Table listing the proportion of particle size in each grain dust sample taken

| Bin size (mm or um) | Particle proportion | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| >4 mm | 0.79 | 2.81 | 3.04 |
| 3. 5-4mm | 3.56 | 3.55 | 3.70 |
| 2-3.5mm | 14.64 | 12.30 | 13.15 |
| 850um-2mm | 10.25 | 11.00 | 12.08 |
| 600 -850um | 16.96 | 18.29 | 17.58 |
| 212 -600um | 34.80 | 33.92 | 32.91 |
| 150-212um | 6.75 | 6.68 | 6.30 |
| 78-212um | 10.66 | 10.10 | 9.68 |
| <78um | 1.59 | 1.35 | 1.55 |