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OPERATING COSTS OF CHEMICAL AIR CLEANER FROM MUNTERS A/S IN A FINISHER UNIT

REPORT NO. 1513

Test shows that the chemical air cleaner MAC 2.0 used 18.2 kWh electricity; 2.1 kg acid; and 164 L water per finished pig when operating at full cleaning capacity in a finisher unit.

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Abstract

SEGES Pig Research Centre tested the chemical air cleaner MAC 2.0 from Munters A/S to document the consumption of electricity, acid and water and to evaluate operational stability over the course of one year. The air cleaner is an updated version of the MAC 1.0 air cleaner.

Results demonstrated that the MAC 2.0 used 18.2 kWh, 2.1 kg acid and 164 L water per finished pig. Based on the data collected in the investigation, operating costs amounted to DKK 18.5 per finished pig. The test period lasted a year in a finisher unit and the air cleaner operated at full capacity. It will probably be possible to lower the power consumption by changing the settings of the exhaust capacity

of the air cleaner to more energy-friendly levels. There were no service stops and no repairs were made during the test period, ie. an uptime of 100% was recorded. Ammonia concentrations in the ventilation air, recorded as point measurements before and after the air cleaner, dropped by averagely 93%.

Background

Air cleaning using acid is an environmental technology that has been used for years when designing new pig houses where reductions in ammonia emissions are a requirement.

Munters A/S has developed a chemical air cleaning system that uses sulphuric acid to lower the ammonia concentration in ventilation air from livestock facilities. SEGES Pig Research Centre tested the air cleaner for a one-year period in 2010-2011 [1] and again for one year in 2012-2013 [2] where its efficiency in terms of reduction of ammonia and odour and the operational stability and operating costs were evaluated in relation to the VERA protocol [3]. Munters A/S subsequently developed a version 2.0 of the chemical air cleaner. The new MAC 2.0 differs from the MAC 1.0 by having a horizontal design rather than a vertical design and the mist eliminators are now easy to slide out, which makes cleaning very easy.

The aim of the test was to document the operating costs and operational stability of the horizontal chemical air cleaner MAC 2.0 from Munters A/S in a finisher unit.

Materials and method

The air cleaner was set up in a finisher section with 525 place units. The pens were 5.75 m long and 2.50 m wide. The floor consisted of 1.75 m slatted floor from the back wall, 2.0 m drained floor in the middle and 2.0 m slatted floor towards the inspection aisle.

Slurry pits below the pens were roughly 60 cm deep. Slurry pits were emptied when slurry height reached approximately 40 cm. Pigs were fed meal feed ad lib in dry feeders.

Construction of the air cleaner

The removal of a wall element and the subsequent construction of a box around this helped direct the air that was to be cleaned into the air cleaner. The air was directed into the air cleaner through an opening measuring 2.8 m x 1.4 m. Nozzles placed on a nozzle bar in front of the two mist eliminators sprayed the acidic water into the air stream in a chamber measuring 4.5 m x 1.8 m x 1.5 m. The air was subsequently led through two mist eliminators to retain the acidic water in the cleaner. It was possible to manually slide the two mist eliminators out (see figure 2) which made cleaning very easy.

The acidic liquid (process water) in the air cleaner consisted of water to which 96% sulphuric acid solution was routinely added. The processing water recirculated in the air cleaner 24 hours a day. The addition of pH was regulated to maintain a pH of 2.0. Once a day, part of the process water was drained and transferred to the storage tank. Discharge of process water was controlled by a timer that activated the discharge pump in fixed intervals.

Figure 1. MAC 2.0, the air cleaner with acid from Munters A/S installed in a finisher unit.

Two suction units (Ø820 mm) were installed after the two mist eliminators that directed the air out of the cleaner. The air cleaner had a maximum cleaning capacity of 25,000 m^3/h.

Figure 2. The two mist eliminators can be slid out manually when cleaning the system.

Figure 3. Nozzle bar that moisturized the air using sulphuric acid mixed in water.

The pig house was ventilated with negative pressure ventilation with air intake via wall inlets and air outtake through three ventilation fans placed in the ceiling. In the test period, one of the fans in the ceiling was closed and the system was subsequently adjusted so that the remaining two fans in the ceiling directed half of the air outside and the remaining part was directed through the air cleaner. The fans in the ceiling and in the air cleaner operated parallel with each other. The air cleaner was thereby operated according to the principle of full cleaning (100% air cleaning) even though it only cleaned half of the air in the unit.

The test period ran from July 18, 2014, until July 31, 2015, and comprised four batches of finishers.

Recordings

Once a month, technical staff from SEGES Pig Research Centre visited the farm to collect data and to monitor the operation of the air cleaner.

The primary recordings were as follows:

Consumption of acid, electricity and water

Consumption of water and electricity was recorded every time the technician from SEGES Pig Research Centre. The consumption of acid was recorded by weighing the acid tank at each visit. The electricity consumption covered the overall consumption for pumps and fans in the air cleaner.

pH and conductivity

pH of the liquid recirculating in the air cleaner was recorded manually using the Metrohm 826 Ph Mobile at each visit as was pH on the pH meter of the air cleaner. Conductivity was also recorded manually using the Eutech Cyberscan con 400.

Service check and farm check

It was agreed with the herd owner and SEGES Pig Research Centre that Munters A/S performed the inspection of the air cleaner, the so-called farm check. All inspections and repairs of the air cleaner and the time spent on these activities were recorded in the log.

Pressure drop over the air cleaner

The pressure drop over the air cleaner was recorded on each visit.

Pigs and weight

At each day of measurement, the number of pigs in the section was noted and their weight visually evaluated.

Secondary recordings comprised the following parameters:

Ammonia and carbon dioxide

At all visits, ammonia and carbon dioxide concentrations were recorded with gas detector tubes (Kitagawa 105 SD and 126 SF). Recordings were made in the air before the air cleaner and in both exhausts after the air cleaner.

Air output

The air output was recorded continuously in the two exhausts in the finisher unit using Fancom measurement wings (Ø800). The air output in the air cleaner was recorded using measurement wings of the type Reventa (Ø820).

Temperatures in the pig house and outdoors

Temperatures in the finisher unit and outdoors were also recorded at each day of measurement throughout the test period. The results are shown in figure A5 in Appendix.

Fouling

Fouling in the lying areas was visually assessed on a scale from 0 to 100% fouling on each day of measurement.

Results and discussion

A total of 2,082 pigs were finished in the section. Annually, an average of 10,400 m^3/hour, corresponding to 50% of the ventilation air, was directed through the air cleaner.

Operating costs

Operating costs are calculated per finished pig and are shown in table 1.

The overall operating costs amounted to DKK 18.5 per finished pig. This figure does not include set up, labour, costs for service and maintenance, costs for storage of bilge water in the slurry tank and subsequent spreading. Assuming that water costs DKK 3.50 per m^3; acid costs DKK 2.0 per kg; and electricity costs DKK 0.76 per kWh, total operating costs amounted to DKK 22.8 per finished pig. From this amount, one must deduct the costs for ventilation that would have incurred if the herd did not use an air cleaner. Power consumption for ventilation of finisher unit where air cleaning is not practised typically constitutes roughly 5.5 kWh per finished pig [4].

The fans in the ceiling and in the air cleaner operated parallel with each other. The air cleaner was thereby operated on full cleaning (100% air cleaning) even though only half of the ventilated amount of air in the pig unit was directed through the air cleaner. It may be possible to lower power consumption if the settings of ventilation system are adjusted so that the first 12,500 m^3/hour of the air is directed via the first exhaust in the air cleaner and then exhaust two starts.

Table 1. Operating costs for air cleaning with acid using the MAC 2.0 from Munters A/S with 100% air cleaning in a test that ran for one year.

	Total consumption	Consumption per finished pig	DKK per finished pig
Water	170 m^3	164 L	DKK 0.57
Sulphuric acid 96%	2,140 kg	2.1 kg	DKK 4.2
Electricity	24,649 kWh	23.7 kWh	DKK 17.9
Total operating costs per finished pig, minus costs for ventilation without air cleaning			DKK 18.5*
Production of bilge water for storage tank	23.8 m^3	22.9 L	N/A

*Total operating costs of DKK 20.6 exclude 5.5 kWh for ventilation without air cleaning, which amounts to DKK 4.2.

Results of a previous test where the air cleaner MAC 1.0 was tested at full air cleaning revealed a slightly higher power consumption (2.4 kWh per finished pig) than what was seen in this test. However, water consumption using the MAC 2.0 was slightly higher (42 L per finished pig) [2]. The consumption of acid was 0.15 kg higher per finished pig in this test compared with the MAC 1.0.

Operational status

There were no service stops of the air cleaner in this test and, besides scheduled inspections, no repairs were necessary. An uptime of 100% was therefore observed in this test.

The mist eliminator was cleaned once during the test period (October 6, 2014). The pressure drop above the air cleaner averaged 44 Pa, but varied throughout the test period, cf. figure A1 in Appendix.

The system was set to pH 2.0. pH recorded at every visit by the technician averaged 1.84 (see figure A2 in Appendix), while pH read on the air cleaner averaged 2.0. This reveals an average deviation of 8% on the air cleaner (higher values than recorded). Conductivity averaged 101 mS/cm, which is identical to the levels recorded with the MAC 1.0 [2]. Conductivity indicates the stability of the control strategy for discharge of process water. Figure A3 in Appendix shows the conductivity recorded on each day of measurement, and it is clear that conductivity was fairly throughout the test period.

Table A1 in Appendix lists the dates of farm inspections during the test where pH, acid supply, nozzles and air cleaner were checked. Time spent on all farmer inspection totaled 120 minutes with an average time of 5 minutes spent per farm inspection per visit.

Ammonia, carbon dioxide and fouling

The point measurements of ammonia concentrations before and after the air cleaner are shown in table 2. The results reveal an average reduction in ammonia concentrations of 93% when using the chemical air cleaner. The measurements are shown in figure A4 in Appendix. As expected, recordings revealed no differences in carbon dioxide concentrations before and after the air cleaner: before the air cleaner carbon dioxide averaged 1,630 ppm (± 560) and 1,670 ppm (± 605) after the air cleaner.

Table 2. Average ammonia concentration measured via point measurements in ventilation air before and after the air cleaner. 95 % confidence interval listed in parenthesis.

Observations	NH_3 concentration (ppm)		Reduction
N	Before air cleaner	After air cleaner	%
14	12.5 (8.3-16.7)	0.84 (0.59-1.1)	93

Fouling averaged 7% in the lying area throughout the test period. This indicates that there were no hygiene problems in the pens and demonstrates that the pigs used the pens as intended.

Conclusion

Operating costs of using Munters' MAC 2.0 air cleaner at a capacity of 100% air cleaning for a year amounted to DKK 18.5 per finished pig. This includes a consumption water of 164 L per finished pig, an acid consumption of 2.1 kg; and an additional power consumption of using the air cleaner of 18.2 kWh per finished pig, but does not include set-up costs, costs for service and maintenance and for storage and spreading of bilge water. There were no service stops or repairs on the air cleaner, and the air cleaner thus operated with an uptime of 100%. The air cleaner MAC 2.0 from Munters A/S lowered ammonia concentrations from the finisher unit by averagely 93%.

References

[1] Sørensen, K. (2013): Afprøvning af luftrenser med syre fra Munters. Meddelelse nr. 970, Videncenter for Svineproduktion.

[2] Jørgensen, M. (2014): Afprøvning af kemisk luftrenser fra Munters A/S i en slagtesvinestald med fuld luftrensning. Meddelelse nr. 1006, Videncenter for Svineproduktion.

[3] Test Protocol for Air Cleaning Technologies, version 1, 2010-09-17.

[4] Landbrugsforlaget (2007): Håndbog i svinehold. Dansk Landbrugsrådgivning, Landscentret. ISBN: 978 87 7470 956 5

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Appendix

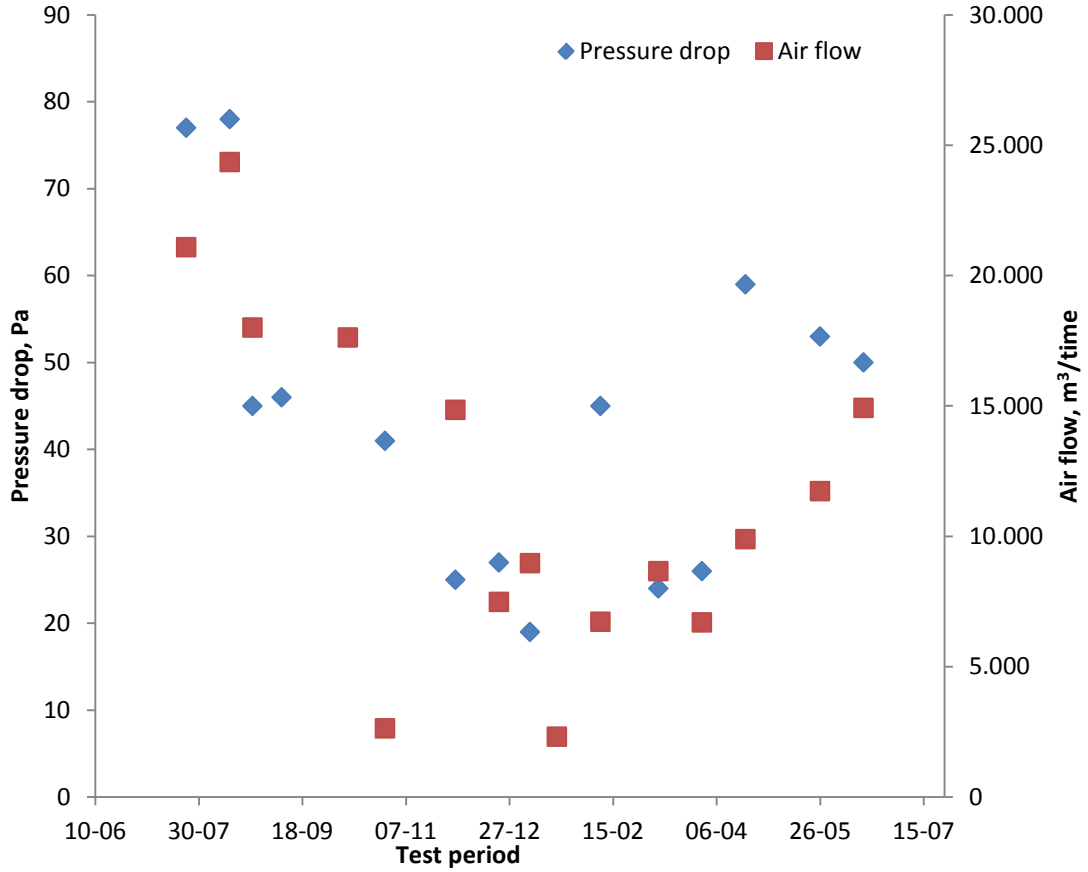

Figure A1. Pressure drop recorded above the air cleaner during the test period.

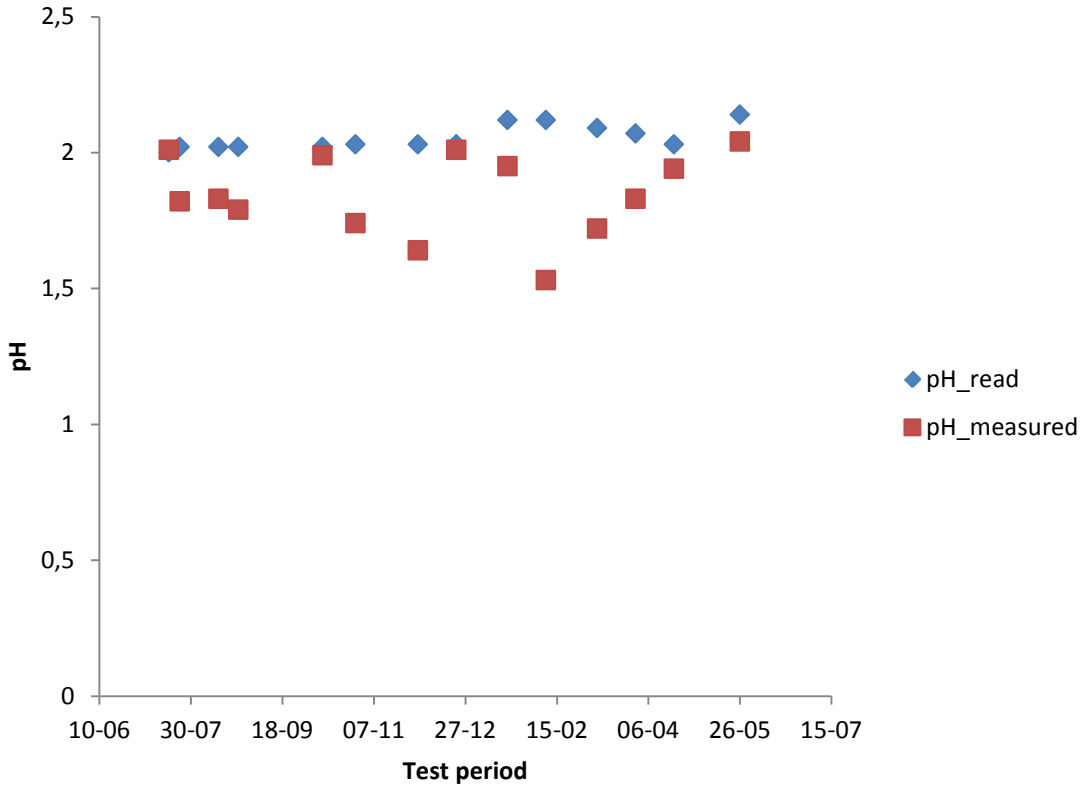

Figure A2. pH recorded and read throughout the test period.

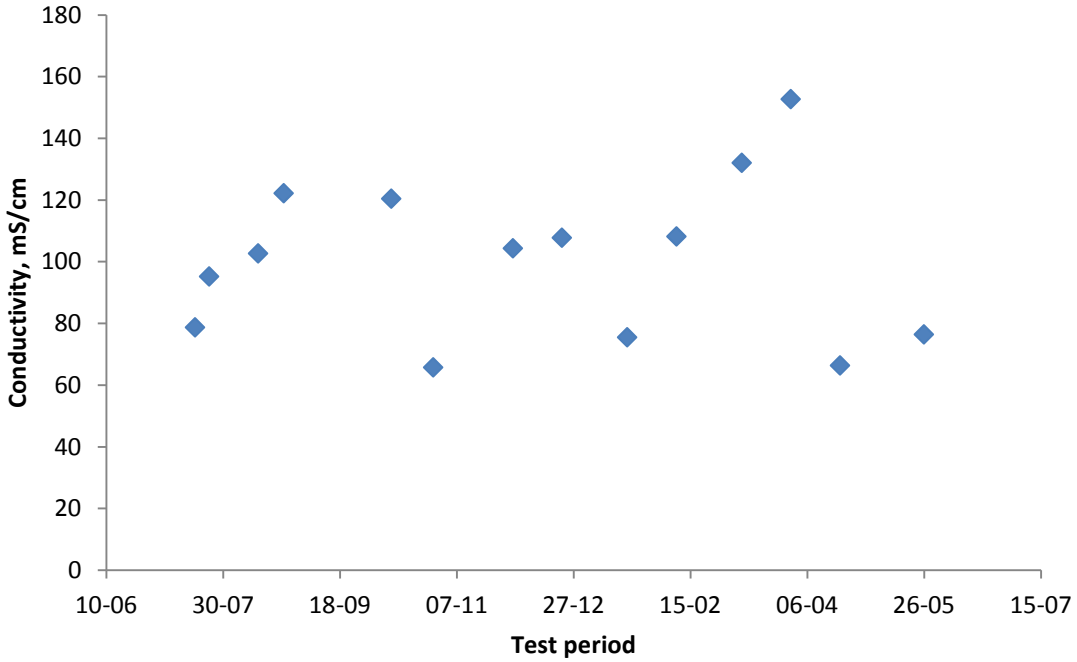

Figure A3. Conductivity recorded throughout the test period.

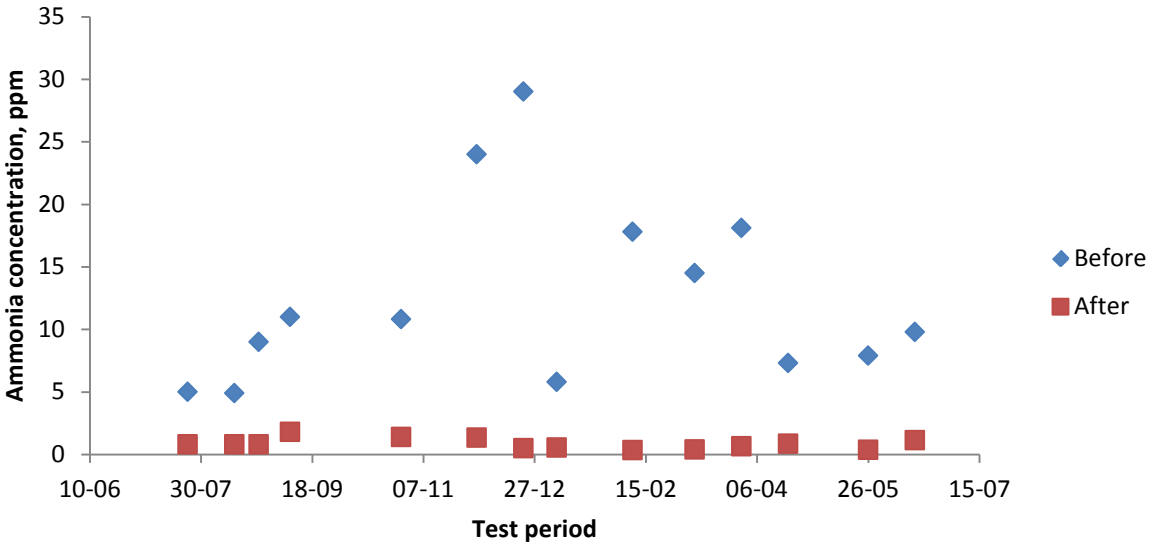

Figure A4. Ammonia concentration before and after the air cleaner recorded with Kitagawa detection tubes.

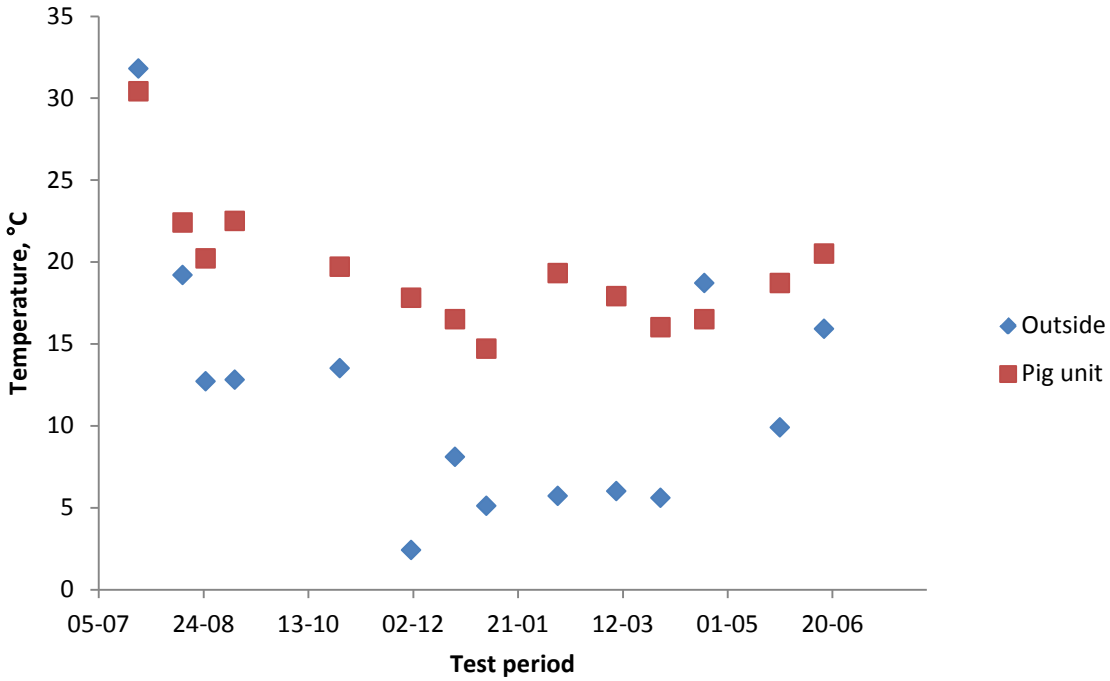

Figure A5. Point measurements of temperatures outdoors and in the pig unit on every day of measurement.

Table A1: Farmer inspection of Munters A/S chemical air cleaner MAC 2.0.

Date	Note	Activity
August 15, 2014	Farm inspection	Maintenance of air cleaner
August 22, 2014	Farm inspection	Maintenance of air cleaner
August 28, 2014	Farm inspection	Maintenance of air cleaner
September 3, 2014	Farm inspection	Maintenance of air cleaner
September 17, 2014	Farm inspection	Maintenance of air cleaner
September 25, 2014	Farm inspection	Maintenance of air cleaner
October 6, 2014	Farm inspection	Preparation and cleaning of filters between two batches of pigs
Oktober 31, 2014	Farm inspection	Maintenance of air cleaner
November 18, 2014	Farm inspection	Maintenance of air cleaner
December 4, 2014	Farm inspection	Maintenance of air cleaner
December 9, 2014	Farm inspection	Maintenance of air cleaner
December 22, 2014	Farm inspection	Maintenance of air cleaner
January 5, 2015	Farm inspection	Maintenance of air cleaner
January 19, 2015	Farm inspection	Maintenance of air cleaner
January 27, 2015	Farm inspection	Maintenance of air cleaner
February 4, 2015	Farm inspection	Maintenance of air cleaner
February 12, 2015	Farm inspection	Maintenance of air cleaner
February 17, 2015	Farm inspection	Maintenance of air cleaner
March 27, 2015	Farm inspection	Maintenance of air cleaner
April 16, 2015	Farm inspection	Maintenance of air cleaner
May 8, 2015	Farm inspection	Maintenance of air cleaner
May 20, 2015	Farm inspection	Maintenance of air cleaner
May 27, 2015	Farm inspection	Maintenance of air cleaner
June 4, 2015	Farm inspection	Maintenance of air cleaner
June19, 2015	Farm inspection	Maintenance of air cleaner

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