Odour Impact Assessment

Odour Emissions from the Maelor Foods Poultry Processing Facilit, Pickhill Lane, Wrexham

Date: 29th May 2018

Submitted to:

Mulkh Mehta

Maelor Food Limited

Prepared by:

Steve Peirson BSc CEng CEnv MIAgrE

ADAS,

Unit 1, Rubicon Square

4205 Park Approach

Thorpe Park

LEEDS

LS15 7BD

Contents

Executive Summary **2**

1 Introduction & Plant Description **5**

1.1 Background *5*

2 Odour Sampling & Analysis **9**

2.1 Open Tank Area Source *9*

2.2 Odour Control Scrubber *10*

2.3 Odour Sample Analysis *11*

3 Results **13**

3.1 Odour Analysis Results *13*

3.2 Discussion – Effluent Plant Emission Rates *13*

3.3 Odour Offensiveness *18*

4 Conclusions **20**

Quality Assurance

Authors:	Checked by:	Issued by:
Steve Peirson BSc, CEng, CEnv, MIAgrE	William Franklin MSc, MRSC, MIEnvSc, MIAQM	Steve Peirson BSc, CEng, CEnv, MIAgrE

Disclaimer

This report has been commissioned for the exclusive use of the commissioning party unless otherwise agreed in writing by RSK ADAS Ltd; no other party may use, make use of or rely on the contents of the report. No liability is accepted by RSK ADAS Ltd for any of this report, other than for the purposes for which it was originally prepared and provided.

Opinions and information provided in this report are on basis of RSK ADAS Ltd using due skill, care and diligence in the preparation of this report and no explicit warranty is provided as to its accuracy. It should be noted that no independent verification of any of the documents supplied to RSK ADAS Ltd has been made.

Executive Summary

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to undertake odour sampling and analysis at the recently opened poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE to assess odour emissions for comparison with odour emission rates modelled by ADAS in 2017 in an odour impact carried out before the plant was constructed.

The pre-operational Odour Impact Assessment was undertaken on the basis of estimated odour emission rates and this report sets out the results of odour sampling and analysis which was undertaken to validate the modelled odour emissions rates and/or to identify areas where improvements may be required to reduce odour emissions.

Findings - Effluent Plant

The results of odour sampling and emission rates, compared to previously modelled data are summarised in Table 1.

Area Source Emission Rates from Effluent Treatment Plant

	Modelled in 2017				Measured (May 2018)	
Source	Diameter (m)	Area (m^2)	Area Specific Emission Rate ($ou_E/m^2/s$)	Tank Emission Rate (ou_E/s)	Area Specific Emission Rate ($ou_E/m^2/s$)	Tank Emission Rate (ou_E/s)
Balance Tank	18	254.5	20	5,090	4,896	1,246,286*
Sediment Tank 1	13	132.7	1	133	0.25	33
Aeration Tank	18	254.5	10	2,545	0.54	137
Anoxic Tank	5	19.6	20	392	49	960

* Peak rate - assumes entirety of tank surfaces is vigorously mixed and aerated, which is NOT the case.

DAF Plant & Covered Sludge Tank - Emissions were negligible as these facilities vent through passive carbon filters and no odours were detected by the sampling team.

Aeration Tank and Final Settlement Tank - The measured emission rates for the final settlement tank and the aeration tank were substantially lower than previously modelled. The emission rates represent 25% and 5% of the 2017 modelled emission rates for the final settlement and aeration tanks respectively. These findings of very low emissions for these sources are entirely consistent with ADAS experience of effective effluent treatment plants elsewhere in the rendering and slaughterhouse sectors, and demonstrate that these facilities have negligible potential to cause off-site odour impacts.

Anoxic Tank - the measured specific emission rate of 49 $ou_E/m^2/s$ is appreciably higher than the modelled emission rate of 20 $ou_E/m^2/s$, but the surface area of this tank is relatively small, so that the anoxic tank is unlikely to make a material contribution to off-site odours with this emission rate. The relative unimportance of this tank can be illustrated by multiplying this emission rate up by the surface area of the tank, resulting in a tank emission rate of 960 ou_E/s, which is only around 13% of the previously modelled emissions from the aeration and balance tanks.

The higher than previously estimated anoxic tank emission odour rate suggests that there was some transfer of odorous effluent from the balance tank. Therefore, if septicity and odour emissions can be reduced/controlled from the balance tank, there can be expected to be some reductions in emissions from the anoxic tank.

Balance Tank - The balance tank is aerated and mixed by use of a venturi system. This mixer was seen to create an area of very vigorous mixing and effluent disturbance over a minor proportion of the surface of the tank, whilst the remainder of the tank surface was covered in a foam. There are therefore significant uncertainties about the measured emission rates for this tank because of potentially large variations in surface emission rates from at one extreme the highly turbulent conditions with air "bubbling" off the venturi mixer where the odour samples were collected, to more stable conditions at the opposite side of the tank where there was an undisturbed layer of naturally occurring foam. The emission rate in Table 1 therefore does NOT represent emissions from the tank surface as a whole, but is a worst case for the most vigorously mixed area of the tank.

However, it can be concluded that the balance tank is a potentially important source of elevated odour emissions, even if some cautious interpretation is applied to the results of the odour measurements to take account of uncertainty factors including:

a) The high emission rates were measured at the most aggressively aerated area of the tank,
b) Only approximately one third of the tank surface is vigorously aerated and more than half of the tank surface was covered with a "natural" foam which will suppress emissions.
c) The measured emission rates resulting from the three odour samples varied quite exceptionally by a factor of 5.7 (from 349,460 to 1,985,984 ou_E/m^3)

There are a number of important points that emerge from both the very high measured odour concentrations and the high indicative hydrogen sulphide concentrations in the odour samples:

a) High hydrogen sulphide concentrations measured in the odour samples (approximately 70ppm to 300ppm) are indicative of significant anaerobic decay within the balance tank, possibly within solids settled in the base of the tank (if the venturi mixer is not resulting in "scouring" the tank base), or possibly from anaerobic decay within the effluent itself.
b) The venturi mixer was quite evidently not keeping the contents of the tank aerobic.
c) The venturi mixer was almost certainly increasing odour emissions by stripping odorous gases out of the effluent with fine air bubbles.

Interpretation of the measurement data in the context of the 2017 modelling study suggests that the off-site impacts of odours from the balance tank may be in excess of 10 ou_E/m^3, and possibly even in excess of 20 ou_E/m^3 at the 98th percentile at some off-site residential receptors.

It can therefore be concluded that reductions in septicity and emissions from the balance tank are a high priority to reduce and minimise the odour impact of the poultry processing plant as a whole. Possible improvements which might be considered could include:

a) Draining the balance tank down to determine if there are accumulated solids in the base of the tank which are not being disturbed, mixed and aerated by the venturi system. If there are solids in the tank, then they should be removed and the tank should be completely cleaned out before being brought back into service. The effectiveness of the venturi mixer, in terms of both aeration and as a mixing system, could then be re-assessed.
b) Consideration should be given to maintaining the balance tank at a lower liquid level (to reduce residence times and the potential for anaerobic decay) and draining down the balance tank periodically, say at weekly intervals, to ensure that solid accumulations do not occur and/or are removed before significant anaerobic decay occurs.
c) Investigate the possible use of an alternative mixing system which will not result in the aggressive aeration seen with the venturi to avoid odour "stripping".

d) Consider using dosing chemicals to control septicity and odour generation in the balance tank.
e) As a final resort it may be necessary to considering covering and odour controlling the balance tank, but this would introduce additional health and safety risks for any maintenance and cleaning work, which is inevitable where mixers have to be used and where solids are likely to settle in the base of tanks.

Odour Scrubber Performance - The most striking aspect of the scrubbing system are the very low (<2,000 ou_E/m^3) untreated odour concentrations in air at the inlet to the scrubber.

The treated air odour concentrations were also very low (<1,000 ou_E/m^3). Typically treated air odour concentrations off single stage scrubbers are in a range of 1,000 to 2,000 ou_E/m^3, so that although the 60.7% percentage abatement does not appear high, the low treated air odour concentrations are very impressive, particularly given the risks of "chlorine" components of air odour dominating treated air odours.

Airflow through the scrubber was measured at 9.61 m^3/s, so that with a geometric mean odour concentration of 536 ou_E/m^3, the measured odour emission rate of 5,157 ou_E/s is materially less than the 2017 ADAS modelled emission rate of 17,000 ou_E/s. By proportion, the odour "contribution" of the scrubber emissions at the off-site receptors can be determined, and at receptor R1 the modelled impact with an emission rate of 5,157 ou_E/s would be approximately 0.19 ou_E/m^3, which is insignificant.

It can therefore be concluded that if similar levels of scrubber performance can be maintained the scrubber has very low potential to cause any off-site odour impacts. In terms of scrubber operating parameters, it is suggested that scrubber pH should be maintained close to 9.0 as an upper limit and redox should be controlled in a range from 700 to 750 mV.

1 Introduction & Plant Description

1.1 Background

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to undertake odour sampling and analysis at the recently opened poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE to assess odour emissions for comparison with odour emission rates modelled by ADAS in an odour impact assessment carried out before the plant was constructed.

Odours from a small number of sources on the site have some potential to cause increases in ground level odour concentrations. The pre-operational Odour Impact Assessment was undertaken on the basis of estimated odour emission rates and this report sets out the results of odour sampling and analysis which was undertaken to validate the modelled odour emissions rates and/or to identify areas where improvements may be required to reduce odour emissions. The odour emissions assessments carried out are described in this report, along with the results and interpretation in the context of the previous odour impact modelling assessment inputs, and the emission estimates and assumptions used in the impact assessment.

The plant is concerned with the slaughter and processing of broiler chickens to produce chicken meat and chicken meat products for the food and retail markets. The following paragraphs describe the key activities in each area of the plant which pose some risks of significant odour impacts and the odour measurements that have been carried out to assess emissions. Odour sampling was carried out on 9th May (on the effluent treatment plant) and 15th May 2018 (on the chemical scrubber).

1.2 Odour Sources Extracted to Abatement by Chemical Scrubber

Aero-Scalder & De-feather

The birds are slaughtered mechanically as they move around a conveying system. After bleeding, the birds will be conveyed in to a de-feather room where they are scalded by a saturated hot air system to loosen their feathers to facilitate mechanical plucking in the de-feather area. This new technology provides a non-immersion scalding method that minimises water and energy use and it is claimed has much lower odour emissions as it avoids the large volumes of water containing decaying organic matter that are normally involved in "tank" scalding.

Scald vapours are enclosed inside the unit and odorous air is extracted directly into the **chemical scrubber** for abatement before dispersion to atmosphere through a tall stack. Chemical scrubbers have been used in a number of other UK poultry processing plants to treat higher intensity odour streams.

Offal Bays – Loading & Removal Building

Feathers are transferred in a water flume to the offal bay building where they are separated from the flume water (which is recirculated) and the flume water is drained down to the effluent treatment plant at the end of each day. The pressed feathers are loaded into bulk trailers for transport off-site to a rendering plant. Feathers are removed from the site on a daily basis.

Offal which is not fit for human consumption is also transferred to the offal bay building where it is loaded into trailers and transported off-site to a rendering plant on a daily basis.

The offal bay waste removal building is fully enclosed and building headspace air is extracted directly to the **chemical scrubber and stack** odour mitigation systems.

Blood Storage Tanks

Blood from the bleeding area is transferred to a blood tank located inside the building housing the feather separation pit which has internal drains to the effluent treatment plant.

The blood tank is connected directly to extraction ducting to the **chemical scrubbing** odour treatment system.

Odour Sampling on Chemical Scrubber

Triplicate odour samples were collected concurrently from both the scrubber inlet duct (just upstream of the scrubber) and the scrubber outlet (after the fan so that mixed samples were obtained) on 15th May to assess odour concentrations in the untreated inlet air and the treated outlet air so that scrubber abatement performance could be assessed.

Airflow measurements were also made on a straight section of scrubber outlet ducting using a pitot tube and micro-manometer so that emissions could be quantified for comparison with the modelled emission rate. The sampling was undertaken towards the end of the slaughtering activity for the day, between 12:28 and 12:52, when odour loadings might be expected to be approaching a daily peak if there are any accumulations of solid/organic material in the scalding plant.

Some advice was provided to Maelor about scrubber operating conditions on the 9th May with respect to scrubber liquor pH (target should be around ≤9 to avoid generation of chloro-amines) and oxidising potential (target should be approximately 750mV) and this advice had been followed when the scrubber was sampled on 15th May.

1.3. Effluent Treatment Plant (ETP)

Odour emissions from the effluent plant open tank odour sources were measured on 9th May using an aspirated Lindvall hood as described below.

Effluent is generated predominantly as contaminated wash water from the abattoir and from the de-feather areas and the feather flume system. The ETP is located beyond the factory buildings, at some distance from potential receptors on Pickhill Lane.

Balance Tank

Raw effluent drains to a raw effluent pump sump and from there is pumped through an enclosed rotary drum screen on top of the balance tank to screen out larger solids from the effluent before treatment. The primary screenings fall into small containers (dolavs) and are transferred into the ABP's trailer in the offal bays.

The balance tank allows the effluent plant to be presented with more even and consistent pollutant load flows over 24 hours and seven days a week, rather than peak and more "concentrated" flows which only occur during and at the end of each production day on 5.5 days each week. There is also a diversion tank which may be used occasionally to segregate effluent in abnormal events such as spillages or to recycle out of specification treated effluent. It was not envisaged that the balance tank would be used other than very occasionally as a contingency, and it was empty at the time the odour survey was carried out.

The balance and diversion tanks are both mixed and aerated by venturi mixers with the intention of preventing the effluent becoming anaerobic/septic and odorous.

On the 9th and 15th May the balance tank was approximately half full and it was seen that the venturi system creates an area of vigorous disturbance over part of the tank surface and the remainder (majority) of the surface was covered with a layer of foam, as shown in Figure 4 below. Access to the tank to lower the Lindvall hood on to the surface is restricted to two areas below each of two platforms, with one adjacent to the effluent input from the screen, and the second above and adjacent to the venturi mixer. In the event sampling was carried out adjacent to the venturi mixer because the effluent inflow near the screens precludes sampling under the other platform. These constraints inevitably mean that the sampling location is subject to high rates of aeration and disturbance of the effluent so that the measured odour emission rates are highly likely to be unrepresentative of emissions from the tank as whole because other areas are more settled and covered by a foam. This factor has been discussed further in relation to the results.

DAF Plant

From the balance tank effluent is transferred to a Dissolved Air Flotation (DAF) system to flocculate and separate/remove suspended solids, fats, oils and greases, from where the separated solids are pumped to a covered sludge storage tank.

DAF plants can generate very limited volumes of quite intense and offensive odours, so that in this case the DAF plant has been fully enclosed with a stainless steel cover and vents directly to a passive carbon filter for odour removal. This filter was inspected closely during the sampling visit and there were no material odour emissions. Providing that the carbon filter is checked regularly as part of routine odour management practices, and that the filter element is periodically replaced when odour breakthrough occurs, the DAF unit represents a negligible odour source.

Activated Sludge Process - Anoxic Tank & Aeration Tank

The separated liquid from the DAF plant is transferred to an activated sludge system for aerobic (activated sludge) treatment, prior to final settlement and discharge to river.

The odour from activated sludge tanks is normally much less offensive than from DAF plants and sludge facilities, and odours are not usually attributable to them unless the effluent system has been overloaded and this has adversely affected the treatment.

In this case the activated sludge plant consists of an anoxic vessel followed by an aeration tank where the conditioned mixed liquor is injected with air via fine bubble air diffusion manifolds.

Both the anoxic tank and aeration tank were odour sampled with the Lindvall hood, with triplicate odour samples from each tank, accessed by a mobile scissor lift platform.

Final Settlement Tank

A final settlement or clarifier tank removes the activated sludge and remaining suspended solids from the effluent to achieve the final effluent quality. This was seen as a low odour risk source and therefore a single odour sample was collected with the Lindvall hood, accessed from the scraper bridge.

ETP Sludge Storage Tanks

A covered sludge holding tank stores the combined DAF and surplus activated sludge prior to transfer off-site for land spreading or injection by contractors. The sludge tank is covered and any gas from the tank headspace is vented through a passive activated carbon filter.

The filter was carefully inspected and “sniffed” by the sampling team and it was observed that there were no material odour emissions. Providing that the carbon filter is checked regularly as part of routine odour management practices, and that the filter element is replaced when odour breakthrough occurs, the sludge tank represents a negligible odour source.

2 Odour Sampling & Analysis

2.1 Open Tank Area Source

The measurement of odour emission rates was based on the collection of samples of odour in inert PET sample bags from a ventilated hood floated on the effluent in the tanks. A ventilated "Lindvall" hood was lowered on to the effluent surface and the hood ventilated with clean, odour free air provided by a battery powered fan and an activated carbon filter. The sampling hood is shown on the aeration tank in Figure 1. The underside of the hood includes a series of vanes to form seal on the airflow and direct the airflow back and forth across the effluent. The underside of a similar sampling hood is shown in Figure 2.

Triplicate odour samples were collected from the main sources sampled to help minimise the effects of statistical variability of olfactometric analysis.

Figure 1 Odour Sampling with Lindvall Hood on the aeration tank.

Figure 2 Underside of a Lindvall Hood showing the internal “vanes”

Once the hood is settled on the effluent, then odour free (filtered) air is blown into the hood through the clear polyethylene terephthalate (PET) ducting. This air traverses back and forth across the surface of the effluent under the hood, “collecting” odour, and then exhausts through ducting from the other end of the hood. The odour samples are collected from this air stream off the hood through an inert sampling tube to new PET (“Nalophane”) sample bags.

These air samples are then analysed by olfactometry and the results used to measure the emissions of odour from the area of effluent covered by the sampling hood, by multiplying the odour concentration of the odour samples by the measured rates of ventilation through the Lindvall hood.

The sample hood was ventilated for 5 minutes before the first of each set of three samples was collected and then the three odours samples were collected sequentially, with each sample collected over a period of 4-5 minutes. Airflow exiting the sampling hood was measured with a vane anemometer and records were made of sampling times.

The odour concentrations results determined by the odour analysis are multiplied up by the measured airflow rate at the outlet of the Lindvall sampling hood to determine an odour emission rate, calculated as European odour units per second (ou_E/s). Geometric mean odour concentrations have been calculated for each set of three samples because the human response to odours is approximately logarithmic.

The emission rate for each set of measurements has then been divided by the area of effluent covered by the hood to provide and area specific odour emission rate, expressed as odour units per second per square metre of effluent surface ($ou_E/m^2/s$).

An odour sample collected off the surface of the balance tanks was submitted for hedonic tone analysis, to help determine the offensiveness of scrubber outlet emissions.

2.2 Odour Control Scrubber

Triplicate odour samples were collected concurrently from both the scrubber inlet duct and outlet duct. The inlet samples were taken after a bend immediately upstream of the scrubber with samples extracted through a new and inert PET sample tube using the lung method with a “barrel” and 12v pump. Outlet (treated air) samples off the scrubber outlet were collected after the fan at the base of the stack so that mixed samples were obtained.

Airflow measurements were made on a straight section of scrubber outlet ducting using a pitot tube and micro-manometer so that emissions could be quantified for comparison with the modelled emission rate.

The scrubber samples were collected between 12:28 and 12:52 on 15 May. These samples were collected towards the end of slaughtering for the day to ensure that near "peak" odour emissions could be captured as part of the performance assessment.

A scrubber outlet sample was submitted for hedonic tone analysis, to help determine the offensiveness of scrubber outlet emissions.

2.3 Odour Sample Analysis

The odour sample bags on site were transported to the UKAS accredited Silsoe Odours odour analysis laboratory and analysed within 30 hours of collection in accordance with the British/European Standard BS EN 13725. Odour concentrations are determined by presenting the samples to a panel of six human "sniffers" who sniff the diluted sample at a range of dilution rates, starting at a high dilution ratio so that the panellists don't initially detect the odour and then sequentially decreasing the dilution rations increasing until the odours are just detected. The presentations are carried out through a pair of sniffing horns, as shown in Figure 3, with the diluted sample randomly switched between the two sniffing horns for each different dilution presentation. The panellists select which sniffing horn they think is presenting the sample at each dilution rate and they also provide a response about the certainty of their decision, choosing from a "guess", an "inkling" or a "certain" choice. The objective is to determine the number of dilutions of a sample which is required to just make the sample detectable to 50% of the panel of sniffers and this number (or dilutions) equates to an odour concentration in European odour units per cubic metre of air (ou_E/m^3).

The odour laboratory also measured hydrogen sulphide (H_2S) concentrations in the sample bags using a Jerome 631 "hydrogen sulphide analyser" or gas indicator tubes. The Jerome meters have some cross sensitivity to other compounds, so the results do not provide an absolute measurement of H_2S, but they do give some indication of the extent to which there may have been septicity and anaerobic decay within the sampled odour sources. The H_2S measurements are indicative and not part of the Silsoe Odours UKAS accreditation.

Figure 3 – Odour Analysis (sample bag in foreground)

3 Results

3.1 Odour Analysis Results

The results of the odour and hydrogen sulphide concentration analyses are set out in Table 2.

Table 2 Odour Analysis Results for Effluent Tanks (9th May) and Scrubber (15th May)

Sample Nos.	Odour Source	H_2S (ppm)		Odour Concs. (ou_E/m^3)		Emission Rate ($ou_E/m^2/s$)
		Conc.	% Red.	Results	Geo. Mean	
	EFFLUENT TANKS					
W1 W2 W3	Aeration Tank	0.002 0.002 0.002	N/A	48* 71* 64*	**6.2**	**0.54**
W4 W5 W6	Anoxic Tank	0.18 0.20 0.24	N/A	5,522 6,893 8,525	**6,872**	**48.9**
W7	Settlement Tank	0.005	N/A	<35**	**N/A**	**<0.25**
W8 W9 W10	Balance Tank	c70 c130 c300	N/A	349,460 470,470 1,985,984	**688,802**	**4,897**
	SCRUBBER					
A1 A2 A3	Scrubber Inlet Air	0.12 0.12 0.13		1,207 1,681 1,252	**1,364**	
B1 B2 B3	Scrubber Outlet Air	0.008 0.017 0.020	**88.1%**	282 775 706	**536**	**5,157**
		Percent reduction over scrubber			**60.7%**	

*Odour concentrations so low that determination not complete because of limitation of sample volume in standard sample bag.
** Odour concentration below the 35 ou_E/m^3 limit of measurement

3.2 Discussion – Effluent Plant Emission Rates

Table 3 below provides a comparison of the measured emission rates and the odour emission rates previously modelled by ADAS.

Table 3 Area Source Emission Rates from Effluent Treatment Plant

	Modelled in 2017				Measured (May 2018)	
Source	Diameter (m)	Area (m^2)	Area Specific Emission Rate ($ou_E/m^2/s$)	Tank Emission Rate (ou_E/s)	Area Specific Emission Rate ($ou_E/m^2/s$)	Tank Emission Rate (ou_E/s)
Balance Tank	18	254.5	20	5,090	4,896*	1,246,286*
Sediment Tank 1	13	132.7	1	133	0.25	33
Aeration Tank	18	254.5	10	2,545	0.54	137
Anoxic Tank	5	19.6	20	392	49	960

* Peak rate - assumes entirety of tank surfaces is vigorously mixed and aerated, which is NOT the case.

Aeration Tank and Final Settlement Tank

This data demonstrates that the measured emission rates from the final settlement tank and the aeration tank are substantially lower than previously modelled. These findings of very low emissions for these sources are entirely consistent with ADAS experience of effective effluent treatment plants elsewhere, for example in the rendering and slaughterhouse sectors, and demonstrate that these facilities have negligible potential to cause off-site odour impacts. The emission rates represent 25% and 5% of the 2017 modelled emission rates for the final settlement and aeration tanks respectively.

Anoxic Tank

The area specific emission rate of 49 $ou_E/m^2/s$ is appreciably higher than the modelled emission rate of 20 $ou_E/m^2/s$, but the surface area of this tank is relatively small, so that the anoxic tank is unlikely to make a material contribution to off-site odours with this emission rate. The relative unimportance of this tank can be illustrated by multiplying this emission rate up by the surface area of the tank, resulting in a tank emission rate of 960 ou_E/s, which is only around 13% of the previously modelled emissions from the aeration and balance tanks.

The higher than previously estimated anoxic tank emission odour rate does suggest that there was some transfer of odorous effluent from the balance tank (and DAF unit), and therefore if septicity and emissions from the balance tank can be reduced there can be expected to be some reductions in emissions from the anoxic tank.

Balance Tank

The balance tank is aerated and mixed by use of a venturi system. This mixer was seen to create an area of very vigorous mixing and effluent disturbance over a fraction of the surface area of the tank, although there was a larger area of foam covering of the effluent surface on the remainder of the tank, as shown in Figure 4. The odour samples were collected by lowering the Lindvall hood from a platform adjacent to the venturi mixer so that the odorous samples were, by necessity, collected from the most "turbulent" area of the tank, and therefore from an area of the tank which is unlikely to be representative of the tank as a whole.

Figure 4 Balance Tank showing turbulent area under platform and foam covered area in the background

There are significant uncertainties about the measured emission rates for this tank for two key reasons: a) there are large variations in odour concentrations measured in air off the Lindvall hood as shown in Table 2 above (349,460 ou_E/m^3, 470,470 ou_E/m^3 and 1,985,984 ou_E/m^3), and b) there will inevitably be large variations in surface emission rates across the surface of the balance tank from at one extreme the highly turbulent conditions with air "bubbling" off the venturi mixer where the odour samples were collected, to more stable conditions at the opposite side of the tank where there was an undisturbed layer of naturally occurring foam.

These variables, and particularly variations in the surface of the effluent, are such that it is impossible to attribute any precision to the measured odour emission rates. However, there are a number of important points that emerge both from the high measured odour concentrations and also from the high indicative hydrogen sulphide concentrations in the odour samples:

a) The high hydrogen sulphide concentrations measured in the odour samples (approximately 70ppm to 300ppm) are indicative of significant septicity/anaerobic decay within the balance tank, possibly within solids settled in the base of the tank (if the venturi mixer is not resulting in "scouring" the tank base), or possibly from anaerobic decay within the effluent itself.
b) The venturi mixer was quite evidently not keeping the contents of the tank aerobic.
c) The venturi mixer was almost certainly increasing odour emissions by stripping odorous gases out of the effluent with fine air bubbles.

It can be concluded that the balance tank is a potentially important source of elevated odour emissions, even if some cautious interpretation is applied to the results of the odour measurements to take account of factors such as:

a) The high emission rates were measured at the most aggressively aerated area of the tank,
b) Only approximately one third of the tank surface is vigorously aerated and more than half of the tank surface was covered with a foam which will suppress emissions.

c) The measured emission rates resulting from the three odour samples varied quite exceptionally by a factor of 5.7 (from 349,460 to 1,985,984 ou_E/m^3)

As a "cautious" interpretation, even if the lowest measured odour concentration of 349,460 ou_E/m^3 is used to calculate an emission rate of 2,484 $ou_E/m^2/s$, and if this emission rate this is only applied to one quarter of the tank area, and if emissions from the remainder of the tank surface are ignored, then the overall tank surface emissions would equate to approximately 158,000 ou_E/s which is significantly higher than the total effluent plant emission rates (8,300 ou_E/s) modelled for all of the tanks by ADAS in 2017.

Although other factors such as the height of each emission source affect odour dispersion, if all other factors are equivalent, then offsite impacts are more or less proportional to emission rates, so that if effluent plant emission are assumed to be 158,000 ou_E/s, then 98th percentile off-site impact could be approaching a factor of 19 times higher than the modelled rates in Table 8 from the 2017 ADAS modelling report which is reproduced below.

Table 8 (in ADAS 2017 Modelling Report) Predicted Odour Concentrations

Receptor		Predicted Five year Average Mean 98th%-ile 1-hour mean Odour Concentrations (ou_E/m^3)		
		16m Stack and ETP	16m Stack Only	ETP Only
R1	Residential Properties to west-south-west	1.46	0.62	1.34
R2	Residential Properties to west-south-west	1.07	0.34	0.90
R3	Residential Properties to west-south-west	0.98	0.29	0.78
R4	Residential Properties to west-south-west	0.89	0.25	0.72
R5	Industrial premise to south	0.78	0.28	0.64
R6	Residential and agric. properties to north-east	1.43	0.37	1.42
R7	Whitegate Cottage	0.73	0.29	0.61
R8	Residential and agricultural property off A525	0.55	0.12	0.44
R9	Residential property off A525	0.49	0.12	0.35
R10	Residential property off A525	0.44	0.12	0.29
R11	Residential property off A525	0.41	0.12	0.28
R12	Residential property off A525	0.40	0.12	0.23
R13	School Farm	0.30	0.10	0.17
R14	Mayfield House	0.27	0.10	0.15
R15	Mangre Cottages	0.28	0.11	0.15

It can be seen that if the emission rate estimated from the balance tank and based on the measured odour emission rates is realistic, then the off-site impacts from the balance tank can be expected to have quite significant off-site impacts, which will be in excess of 10 ou_E/m^3, and possibly in excess of 20 ou_E/m^3 at some local receptors.

It can therefore be concluded that reductions in septicity and emissions from the balance tank are a high priority to reduce and minimise the odour impact of the poultry processing plant as a whole. Possible improvements which might be considered could include:

a) Draining the balance tank down to determine if there are accumulated solids in the base of the tank which are not being disturbed, mixed and aerated by the venturi system. If there are solids in the tank, then they should be removed and the tank thoroughly cleaned out before being brought back into service. The effectiveness of the venturi mixer, in terms of both aeration and as a mixing system, could then be re-assessed.
b) Consideration should be given to maintaining the balance tank at a lower liquid level (to reduce residence times and the potential for anaerobic decay) and draining down the balance tank periodically, say at weekly intervals, to ensure that solid accumulations do not occur and/or are removed before significant anaerobic decay occurs.
c) Investigating the possible use of an alternative mixing system which will not result in the aggressive aeration seen with the venturi to avoid odour "stripping"
d) Consider using dosing chemicals to control septicity and odour generation in the balance tank.
e) As a final resort it may be necessary to consider covering and odour controlling the balance tank, but this would introduce additional confined space and health and safety risks for any maintenance and cleaning work, which is inevitable where mixers have to be used and where solids are likely to settle in the base of tanks.

Odour Scrubber Performance

The most striking aspect of the scrubbing system is the very low untreated odour concentrations at the inlet to the scrubber. As the samples were collected towards the end of the slaughter/processing shift these low odour concentrations suggest that the "Aero-scalder" scalding system generates low levels of odours.

The treated air odour concentrations are also very low. Typically treated air odour concentrations off single stage scrubbers are in a range of 1,000 to 2,000 ou_E/m^3, so that although the 60.7% percentage abatement does not appear high, the low treated air odour concentrations are very impressive, particularly given the potential for "bleach" or "chlorine" components of air odour dominating treated air odours with a sodium hypochlorite reagent.

Airflow through the scrubber was measured at 9.61 m^3/s, so that with a geometric mean odour concentration of 536 ou_E/m^3, the measured odour emission rate of 5,157 ou_E/s is materially less than the 2017 ADAS modelled emission rate of 17,000 ou_E/s. Again, by simple proportion the odour "contribution" of the scrubber emissions at the off-site receptors can be determined from Table 8 above, so that as an example at receptor R1 the modelled impact with an emission rate of 5,157 ou_E/s would be approximately 0.19 ou_E/m^3, which is insignificant.

It can therefore be concluded that if similar levels of scrubber performance can be maintained the scrubber has very low potential to cause any off-site odour impacts.

In terms of scrubber operating parameters, observations were made of scrubber liquor pH and redox potential throughout the odour sampling and these observations are summarised below in Table 4. This data shows that the scrubber dosing control system started to dose sodium hypochlorite during the sampling session at around 12:40, and suggests that abatement performance may have been better with the lower pH and lower redox potential levels at the start of the sampling session. If this is a real effect, then it is suggested that scrubber pH should be maintained close to 9.0 and redox should be controlled in a range from 700 to 750 mV.

Pressure drop through the scrubber was measured at 910 Pa from an inlet duct static pressure measured at -1,036 Pa and an outlet duct static pressure of -1,946 Pa. The inlet air was at 28.0^{0}C and the outlet was at 25.2^{0}C.

Table 4 Scrubber Operating Parameters

Time	Scrubber pH	Scrubber Redoc (mV)	Odours Samples & Collection Times	Odour and H_2S Concentrations (ou_E/m^3 & ppm)
12:33	9.06	745	B1 (12:28 to 12:33)	282 (0.008)
12:39	9.06	739		
12:44	9.12	750	B2 (12:35 to 12:41)	775 (0.017)
12:48	9.10	769		
12:52	9.09	775	B3 (12:42 to 12:52)	706 (0.020)
13:08	9.08	778		

3.3 Odour Offensiveness

Interpretation of the 2017 ADAS modelling assessment was based on the assumption that emitted odours from the scrubber and effluent treatment plant would be of medium offensiveness. The regulator of the installation (Natural Resources Wales or NRW) has requested that some assessment of odour offensiveness should be undetaken with the plant in use.

Hedonic tone analysis was undertaken by Silsoe Odours for samples with laboratory reference W5 from the scrubber outlet air (Sample B2) on 15 May, and sample W7 from the surface of the balance tank on 15 May. The results are presented below in Graph 1 for W5 (Scrubber Outlet Air) and Graph 2 for W7 (Balance Tank Surface).

Hedonic tone provides a measures of the offensiveness of odours through a scale from +4 (most pleasant) through to -4 (most offensive), but there is little guidance in the 2011 Environment Agency H4 odour guidance about the interpretation of hedonic tone scores and how offensiveness is to be assessed. Part 1 of the 2002 draft H4 provided hedonic tones for a range of odour/odour descriptors at Appendix 10, and for the “maximum” offensiveness gives a score of -3.75 for “cadaverous, dead animal”, and mid-range scores of -2.04 for “stale” odour and -1.98 for “fishy” odours.

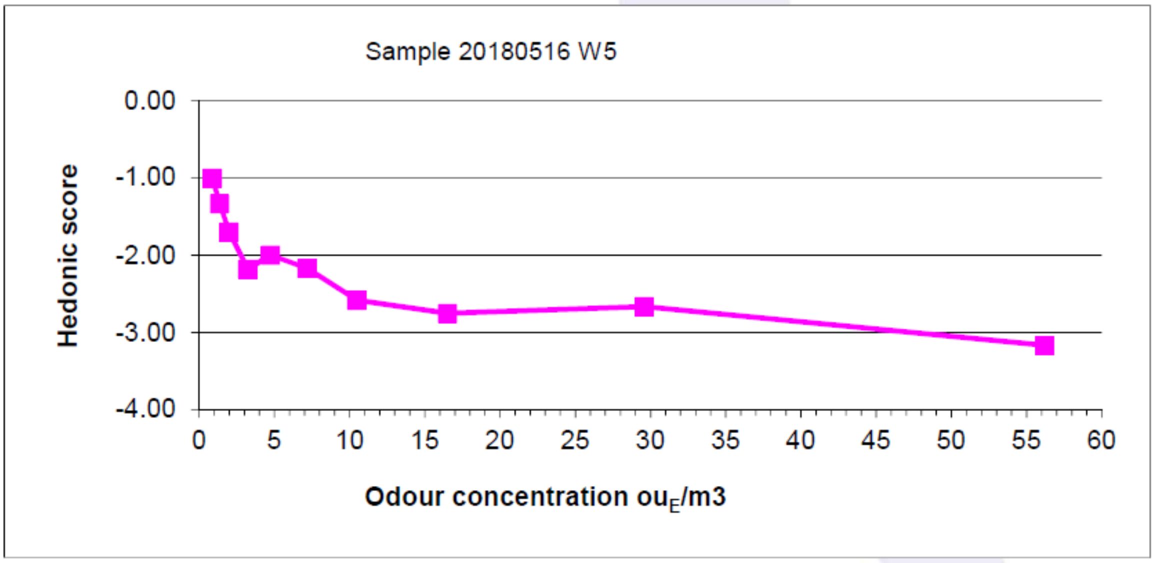
The data in Graph 1 shows that the scrubber outlet air (W5) passes through a medium offensiveness score of -2 at odour concentrations of between 3 and 5 ou_E/m^3, and this suggests that odour exposures at this range of concentrations might be detected as moderately offensive. This odour does not cross the -3 hedonic score threshold until the concentration exceeds 40 ou_E/m^3, which is well in excess of the detection threshold and also well in excess of the 3.0 ou_E/m^3 benchmark level used in the odour modelling study. It is concluded that this hedonic score data is consistent with a 3.0 to 5.0 ou_E/m^3 98th percentile modelling benchmark range for scrubber outlet air.

The data in Graph 2 shows that the balance tank odours are more offensive with the “transition” to a hedonic score of -2 at around 1.0 to 2.0 ou_E/m^3, although this is unlikely to be a true reflection of offensiveness because the odour would only just be at the detection threshold at 1.0 ou_E/m^3, even within the controlled conditions of the odour laboratory. This odour crosses the -3 hedonic score threshold at a concentration between 5 and 10 ou_E/m^3, which is above the detection threshold and also in excess of the 3.0 ou_E/m^3 benchmark level used in the odour modelling study.

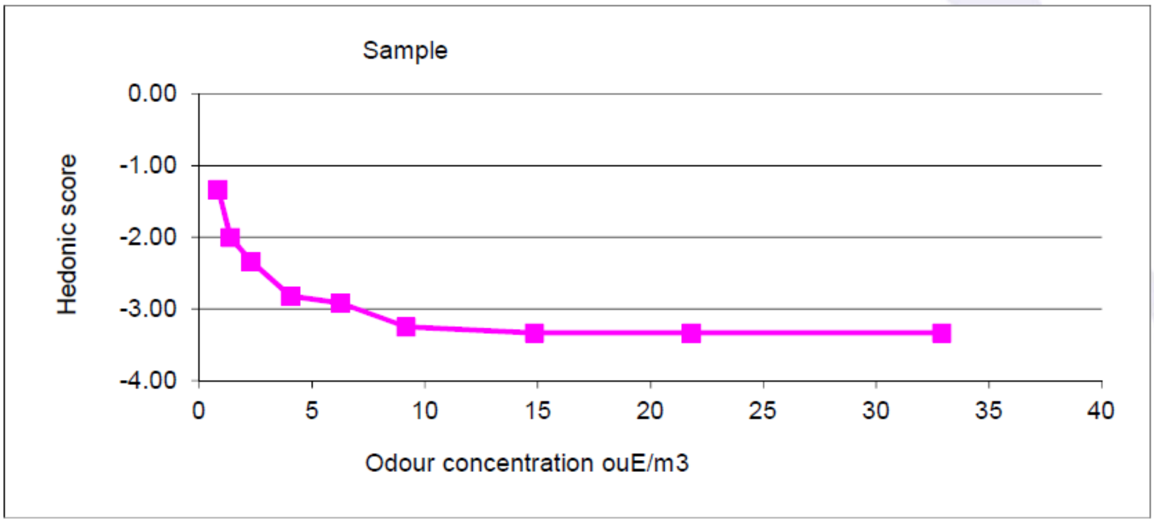
It is concluded that this hedonic score data suggests that a 3.0 ou_E/m^3 98th percentile benchmark may be only just tolerable for the “septic” balance tanks odours sampled on 9th and 15th May. If management of the balance tank can be modified to avoid septicity, then a 3.0 ou_E/m^3 98th percentile benchmark may appropriate, but otherwise a benchmark of 1.5 ou_E/m^3 could be more appropriate for the balance tank and effluent plant odours generally which are dominated by the balance tank and the anoxic tank.

Hedonic Analysis

Graph 1. Hedonic tone from Wrexham sample 20180516 W5



Graph 2. Hedonic tone from Wrexham samples 20180516 W7



4 Conclusions

ADAS has been instructed by Mr Mulkh Mehta of Maelor Foods Ltd to measure odour emissions from key elements of the poultry processing facility at Pickhill Lane, Wrexham, LL13 0UE in the context of an odour modelling study carried out by ADAS in 2017. The findings of this work are:

DAF plant & Covered Sludge Tank

Emissions through the passive carbon filters were negligible.

Aeration Tank and Final Settlement Tank

The measured emission rates for the final settlement tank and the aeration tank were substantially lower than previously modelled, representing 25% and 5% of the 2017 modelled emission rates for the final settlement and aeration tanks respectively. These findings of very low emissions for these sources are entirely consistent with ADAS experience of effective effluent treatment plants elsewhere, for example in the rendering and slaughterhouse sectors, and demonstrate that these facilities have negligible potential to cause off-site odour impacts.

Anoxic Tank

A measured specific emission rate of 49 $ou_E/m^2/s$ is appreciably higher than the modelled emission rate of 20 $ou_E/m^2/s$, but the surface area of this tank is relatively small, so that the anoxic tank is unlikely to make a material contribution to off-site odours with this emission rate. The relative unimportance of this tank can be illustrated by multiplying this emission rate up by the surface area of the tank, resulting in a tank emission rate of 960 ou_E/s, which is only around 13% of the previously modelled emissions from the aeration and balance tanks.

The higher than previously estimated anoxic tank emission odour rate suggests that there was to some transfer of odorous effluent from the balance tank (and DAF unit). Therefore, if septicity and odour emissions can be reduced from the balance tank, there can be expected to be some reductions in emissions from the anoxic tank.

Balance Tank

The balance tank is aerated and mixed by use of a venturi system. This mixer was seen to create an area of very vigorous mixing and effluent disturbance over a proportion of the surface of the tank, whilst the remainder of the tank surface was covered in a foam. There are therefore significant uncertainties about the measured emission rates for this tank because of potentially large variations in surface emission rates from at one extreme the highly turbulent conditions with air "bubbling" off the venturi mixer where the odour samples were collected, to more stable conditions at the opposite side of the tank where there was an undisturbed layer of naturally occurring foam.

It can nevertheless be concluded that the balance tank is a potentially important source of elevated odour emissions, even if some cautious interpretation is applied to the results of the odour measurements to take account of uncertainty factors including:

a) The high emission rates were measured at the most aggressively aerated area of the tank,
b) Only approximately one third of the tank surface is vigorously aerated and more than half of the tank surface was covered with a foam which will suppress emissions.
c) The measured emission rates resulting from the three odour samples varied quite exceptionally by a factor of 5.7 (from 349,460 to 1,985,984 ou_E/m^3)

There are a number of important points that emerge from both the very high measured odour concentrations and the high indicative hydrogen sulphide concentrations in the odour samples:

a) High hydrogen sulphide concentrations measured in the odour samples (approximately 70ppm to 300ppm) are indicative of significant anaerobic decay within the balance tank, possibly within solids settled in the base of the tank (if the venturi mixer is not resulting in "scouring" the tank base), or possibly from anaerobic decay within the effluent itself.
b) The venturi mixer was quite evidently not keeping the contents of the tank aerobic.
c) The venturi mixer was almost certainly increasing odour emissions by stripping odorous gases out of the effluent with fine air bubbles.

Interpretation of the measurement data in the context of the 2017 modelling study suggests that the off-site impacts of odours from the balance tank may be in excess of 10 ou_E/m^3, and possibly even in excess of 20 ou_E/m^3 at the 98th percentile at off-site residential receptors.

It can therefore be concluded that reductions in septicity and emissions from the balance tank are a high priority to reduce and minimise the odour impact of the poultry processing plant as a whole. Possible improvements which might be considered could include:

a) Draining the balance tank down to determine if there are accumulated solids in the base of the tank which are not being disturbed, mixed and aerated by the venturi system. If there are solids in the tank, then the tank should be cleaned out before being brought back into service. The effectiveness of the venturi mixer, in terms of both aeration and as a mixing system, could then be re-assessed.
b) Consideration should be given to maintaining the balance tank at a lower liquid level (to reduce residence times and the potential for anaerobic decay) and draining down the balance tank periodically, say at weekly intervals, to ensure that solid accumulations do not occur and/or are removed before significant anaerobic decay occurs.
c) Investigate the possible use of an alternative mixing system which will not result in the aggressive aeration seen with the venturi to avoid odour "stripping"
d) Consider using dosing chemicals to control septicity and odour generation in the balance tank.
e) As a final resort it may be necessary to cover and odour control the balance tank, but this would introduce additional confined spaces and health and safety risks for any maintenance and cleaning work, which is inevitable where mixers have to be used and where solids are likely to settle in the base of tanks.

Odour Scrubber Performance

The most striking aspect of the scrubbing system are the very low (<2,000 ou_E/m^3) untreated odour concentrations in air at the inlet to the scrubber.

The treated air odour concentrations were also very low (<1,000 ou_E/m^3). Typically treated air odour concentrations off single stage scrubbers are in a range of 1,000 to 2,000 ou_E/m^3, so that although the 60.7% percentage abatement does not appear high, the low treated air odour concentrations are very impressive, particularly given the risks of "chlorine" components of odour dominating treated air odours.

Airflow through the scrubber was measured at 9.61 m^3/s, so that with a geometric mean odour concentration of 536 ou_E/m^3, the measured odour emission rate of 5,157 ou_E/s is materially less than the 2017 ADAS modelled emission rate of 17,000 ou_E/s. By proportion, the odour "contribution" of the scrubber emissions at the off-site receptors can be determined, and at receptor R1 the modelled impact with an emission rate of 5,157 ou_E/s would be approximately 0.19 ou_E/m^3, which is insignificant.

It can therefore be concluded that if similar levels of scrubber performance can be maintained the scrubber has very low potential to cause any off-site odour impacts.

In terms of scrubber operating parameters, it is suggested that scrubber pH should be maintained close to 9.0 as an upper limit and redox should be controlled in a range from 700 to 750 mV.

Offensiveness/Hedonic Tone Data

The **scrubber outlet air** passes through a medium offensiveness score of -2 at odour concentrations of between 3 and 5 ou_E/m^3, and this suggests that a 3.0 to 5.0 ou_E/m^3 98th percentile is an appropriate modelling benchmark range for scrubber outlet air.

The **balance tank odours** are more offensive with the "transition" to a hedonic score of -2 at around 1.0 to 2.0 ou_E/m^3. This odour crosses the -3 hedonic score threshold at a concentration between 5 and 10 ou_E/m^3, which is above the detection threshold and also in excess of the 3.0 ou_E/m^3 benchmark level used in the odour modelling study. It is concluded that this hedonic score data suggests that a 3.0 ou_E/m^3 98th percentile benchmark may be only just tolerable for the "septic" balance tanks odours sampled on 9th and 15th May. If management of the balance tank can be modified to avoid septicity, then a 3.0 ou_E/m^3 98th percentile benchmark may appropriate, but otherwise a benchmark of 1.5 ou_E/m^3 could be more appropriate for the balance tank and effluent plant odours generally because they are dominated by the balance tank and the anoxic tank.