final report

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Modular biofiltration unit concept review

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1 Introduction

Teys Bros (Teys) owns and operates a beef abattoir at Beenleigh, in an area that is rapidly being encroached upon by residential development. The abattoir operates an odour control system in which all significant odour streams are collected at the source and directed to a chemical scrubbing unit where odour is reduced before discharge of treated air to atmosphere through a tall stack.

The Company is seeking to supplement this odour control system with a 'modular' biofilter that will receive and treat the high strength processing streams from the continuous high temperature cooker unit and related ancillary processing units.

Because these air streams are typically low in volume, a relatively compact biofilter is envisaged, capable of being mounted within the processing room, above the main processing units. As will be explained in Section 4, the treatment of these high strength air streams in isolation from other higher volume, lower strength streams is an innovation for the red meat industry in Australia. In this respect funding support is being sought by Teys from Meat Livestock Australia (MLA) for a trial application of this modular biofilter concept, at the Beenleigh plant.

This report by The Odour Unit Pty Limited (TOU) reviews the concept proposed by Teys, and focuses on the following issues:

- Technical soundness;
- Adequacy of the 'shipping container' biofilter module
- Expected performance; and
- Cost effectiveness.

Due to its preliminary nature the report does not address detailed design issues for the biofilter, nor does it examine the specific process units from which it will draw its air stream. It relies on information provided by Teys in the form of airflow, temperature and odour concentration data gathered by another consultant (MLM Environmental) in an earlier study.

2 Biofiltration – a general process overview

Biofiltration is a widely used and effective process for removing odour from air streams, using biological processes. It has been used for several decades in Europe and has been used in Australia for at least 20 years. The first major installation of a biofilter-based odour control system is believed to be the biofilter installed at the (then) Uncle Bens (now Masterfoods) plant at Bathurst, NSW in the early 1980s.

A biofilter consists of a bed of an organic medium, typically comprising a bark/compost blend, through which foul air is passed. The bed is kept moist to encourage the growth of aerobic micro-organisms, and to facilitate the transport of the odorous compounds from the gas phase to the liquid phase, where the micro-organisms biodegrade the compounds. The activity is rapid – typical gas residence times of 30 to 40 seconds are used, and virtually complete odour destruction is achieved in this time.

The treated air will typically contain some odour derived from the compost medium (an earthy/bark smell) but little or none of the original foul odour character.

Biofilters are used in a wide variety of industries. They are most suitable where the odour stream is derived from 'organic' sources, i.e. where organic material has degraded or where products are cooked or heated. In these applications the odorous compounds will typically consist of aldehydes, ketones, esters, hydrocarbons and reduced sulphur compounds. All of these compounds are readily biodegradable and sufficiently soluble to make them candidates for biological treatment. Biofilters are widely used in the red and white meat industries where they are the preferred method of odour treatment. Other suitable industries include edible oils, food processing, pet food processing, and the solid and liquid waste treatment sectors.

Because the principle of operation involves the contact of a foul air stream with a moist biologically-active medium, biofilter designs can vary considerably, since there are several ways to achieve this objective. The biofilter vessels can vary in shape, depth and flow direction. Early biofilters tended to have a medium depth of 1 metre and distribute the foul air beneath the biofilter bed through a series of slotted pipes in a gravel matrix. This upward flow direction resulted in the discharge of the treated air to atmosphere at the exposed surface of the bed. Later biofilters have tended to have deeper beds (up to 2 metres) and there is an increasing use of a full cavity/plenum chamber beneath the bed for foul air distribution. The deeper beds have been made possible by the growing use of more-open, air-permeable biofilter media, and the lower pressure losses through plenum chamber designs.

Key design parameters for biofilters are biofilter bed moisture control and effective air distribution. The main reasons for poor odour removal performance are uneven or patchy moisture across larger biofilter beds, due to a dry foul air stream and inadequate surface irrigation, and poor air distribution system design, resulting in short-circuiting and/or uneven air flows across the bed. The key to solving these problems is the ability to maintain the relative humidity in the foul air stream at 85-90% and above.

Biofilters are typically sized using a volumetric surface loading rate criterion, expressed as cubic metres per hour of airflow per square metre of biofilter bed area (m3/m2/hr). Some designers express this loading as an Empty Bed Residence Time (EBRT), expressed in seconds. The two criteria are directly linked, in that a bed depth of 1 metre and a loading rate of 120 m3/m2/hr are equivalent to an EBRT of 30 seconds, as is a loading rate of 180 m3/m2/hr for a bed depth of 1.5 metres. Both correspond to a volume loading of 120 m3/m3/hr. The higher loading rate of 180 m3/m2/hr is typical for modern, open bed, up-flow biofilter designs in Australia.

The above discussion relates to the bulk of biofilters installed in Australia that are custom-designed and built. There is also a smaller market for compact, spaceefficient proprietary biofilters. These biofilters are sold as turn-key units that are equipped with all ancillary air humidification and control systems, and are ready to install. While they resemble a shipping container in their dimensions (typically 12mx2.4mx2.2m), they are relatively more complex than simple open bed designs, and are loaded at least twice as heavily. They use a mostly-inorganic medium (polystyrene beads plus compost), and have a down-flow air direction, resulting in the biofilter vessel being fully enclosed and under slight pressure. The most common of these biofilters is marketed by a company called CleanTeq. The modular bioflter proposed by Teys will be compared with this design in Section 3.

To summarise, biofilters are proven technology in the odour field, and are the de facto standard across the meat industry. Their relative advantages and disadvantages are as follows:

Advantages Excellent odour destruction performance

Robust performance if well designed

Moderate to low capital cost

Low operating cost

No chemicals needed

Simple construction.

Disadvantages Space inefficient compared to other technologies

Pre-humidification needed for most climates in Australia

Biofilter medium needs replacement every 3-4 years

3 Australian meat industry biofilters

TOU has been associated with a number of biofilter systems that have been installed in Australian meat industry plants in recent years. Many other biofilters have been installed by others. The majority of these biofilter systems have been installed in the by-products/rendering plants.

One feature common to the biofilter systems installed in the meat industry is that these systems treat a combined foul air stream drawn from all of the point-source processing units. All of the TOU-designed systems collect point-source process air from rendering sources, treat this air in a biofilter, and bulk-ventilate the ventilation air within the building directly to atmosphere. Other systems combine point-source process air with ventilation air and treat this larger volume of air in a biofilter. The significance of combining the process air streams to the modular biofilter approach proposed by Teys is that the Teys biofilter will be required to treat a more concentrated (higher odour concentration) air flow. The biofilter design and performance will reflect this effect.

The following biofilters have been designed and installed for TOU's Australian meat industry clients in the last 7 years:

- E C Throsby, abattoir/rendering plant, Singleton, NSW (360 m2 bed area);
- Cargill Beef, Australia abattoir/rendering plant , Wagga Wagga, NSW, (280 m2);
- Harvey Beef, abattoir/rendering plant, Harvey, WA, 500 m2);
- Baiada Poultry, rendering plant, Tamworth, NSW;
- Cargill Beef, Australia abattoir/rendering plant , Tamworth, NSW, (280 m2);
- Fertal Holdings, rendering plant, Pert, WA, (200 m2).

Other large biofilter installations known to TOU include:

- Talloman, rendering plant, Perth, WA, four totalling 2,000 m2; and
- Baiada Peerless Limited, Rendering plant, Melbourne, Victoria, seven totalling 2,000 m2.

There are numerous smaller biofilter-based biofilters in other meat industry plants.

4 Modular biofilter concept review

4.1 General

The proposal by Teys is to divert a portion of the foul air currently being treated in the scrubber to a small, modular biofilter, as a means of decreasing the odour loading on the scrubber and thereby improving its performance and reliability.

The odour stream that has been identified for diversion is the processing stream from the cooker exhaust and feed areas . Experience at other rendering plants suggests that this air stream will contain a very high proportion of the total odour loading from the plant, by virtue of the noncondensible gas content arising from the condensation of the cooking vapours. When combined with process air drawn from the raw materials feed end of the cooker the combined air stream will still be high in odour but relatively low in volume, such that treatment in a compact, modular biofilter is proposed.

It is proposed to fabricate a modular biofilter using a shipping container, and to mount this biofilter above the DAF unit. The treated air from the biofilter will vent to atmosphere from the biofilter surface. It is understood that a standard shipping container will be used, with dimensions 12 m long and 2.4m wide. The height of the container should allow a bed depth of at least 1.6m. It can be seen from these dimensions that a bed area of 28.8 m2 is achievable. The entire unit will be mounted in a manner than enables it to be removed when replacement of the medium is needed. This is expected to be every 2 to 3 years, given that the expected elevated temperature of the foul air stream will accelerate the decomposition and compaction of the medium.

4.2 Cooker exhaust quality/quantity

Information provided to TOU by Teys, covering testing carried out in October 2005, indicates that the volumetric flow rate of the cooker exhaust stream is 2.1 m3/s (7,600 m3/hr). The measured temperature of this stream was 35 0C. The data provided to TOU contained a calculation error, to the extent that the actual measured airflow was 0.54 m3/s (1,940 m3/hr). Subsequent measurements taken by Teys and TOU on 28/2/2008 indicated an airflow of 1.1 m3/s (3,900 m3/hr) and a temperature of 46 0C. It is understood that the temperature of this air stream can vary between 35 0C and 46 0C. Since foul air temperature is a critical factor in biofilter performance and medium life it is recommended that the gas stream be re-tested before proceeding further with the modular biofilter proposal.

The same air quality information indicates that the cooker exhaust air stream will have an odour concentration of les than 150 ou (142 ou and 84 ou were recorded). Again, these concentrations are not in keeping with TOU data, and general experience within the rendering industry, which suggest that the odour concentration should be at least 12,000 ou, and possibly much higher. The implications of a higher odour loading on the biofilter are discussed below. Again, further odour testing of this air stream is recommended.

4.3 Design issues

4.3.1 Materials of Construction

A used shipping container will be suitable as an enclosure for a biofilter. The weight of the plenum floor and biofilter medium (bulk density of 700 kg/tonne) is expected to a maximum of 50 tonnes and, with suitable bracing, should be within the capability of the structure. Not withstanding this opinion a check with a structural engineer is recommended. The steel floor and walls of the container will need to be protected against corrosion, since the cooking vapours are likely to contain ammonia and the oxidation of any reduced sulphur compounds will lead to an acid leachate. The choice of an appropriate protective paint is a matter for Teys, and will determine the life expectancy for the container. In a similar application where a shipping container was used by another TOU client a 2-pack epoxy paint was successfully used. The internals of the biofilter (floor and supports) shoud also be corrosion resistant. For this reason polypropylene crates and support mesh are recommended. These have been used in other biofilters designed by TOU. The roof of the container will be removed.

4.3.2 Volumetric Loading

A conservative design flow rate of 5,000 m3/hr is recommended. At this flow rate the 28.8 m2 biofilter bed area and 1.6m bed depth will result in loadings of 174 m3/m2/hr and 109 m3/m3/hr respectively. These loading rates are consistent with those described in Section 2, and should result in acceptable biofilter performance A fan duty of 2.5 kPa is recommended. It is understood that Teys propose to install a variable speed drive on the fan, to enable the airflow to be matched with the slow increase in biofilter back-pressure as the biofilter medium matures/ages.

4.3.3 Temperature

It is essential that the temperature of the foul air stream to a biofilter be maintained at less than 45 0C, and ideally less than 40 0C. This results in a biofilter bed temperature of less than 40 0C. Based on the 2005 data provided to TOU that indicated cooker exhaust temperatures around 35 0C should not be an operational issue. However, as stated earlier, this recorded temperature is low for a cooker exhaust, and low compared to the reading taken on 28/2/2008, and confirmation that it is actually within the desired range is needed. The implications of temperatures between 35 0C, and 45 0C, when compared to lower operating temperatures, are shorter bed life, due to accelerated composting of the biofilter medium.

4.3.4 Odour Loadings

It is clear that the 2005 odour concentration data is unreliable (less than 150 ou). Based on other TOU biofilter installations at rendering plants, odour concentrations of up to 12,000 ou into biofilters present no operational or performance problems. Data from the Throsby biofilter at Singleton NSW (2002) showed that odour destruction from 11,585 ou to less than 200 ou was achievable, at a conservative design loading of 120 m3/m3/hr. Biofilter performance tends not to be influenced by inlet odour concentration levels to the extent that a chemical scrubber would be affected.

However, because the actual loading on the modular biofilter is not accurately known, it is not possible to predict the odour destruction performance of the biofilter, until the unit is installed and commissioned. In the event that the odour concentration to the biofilter exceeds 50,000 ou it is possible that odour destruction efficiencies of only 85- 90 % will be achievable.

4.3.5 Innovation

As previously mentioned, the approach proposed by Teys is considered innovative in that it seeks to isolate and treat the strongest of the odour streams, as ameans of cost effectively decreasing the loadings on the existing odour control system. While there is a similarly configured biofilter on the market (the CleanTeq design) the suitable applications for this particular biofilter are well outside the application proposed at Beenleigh. The design of this commercial unit is approaching the complex/sophisticated end of the biofilter design spectrum, and it is not a serious candidate for this particular, ‘heavy duty’ rendering plant application.

The challenge for the Beenleigh Modular biofilter will be to accommodate the high odour loads and temperatures, and attain an acceptable odour destruction performance. The lack of any theoretical design basis for biofilters in this application requires the actual plant-scale testing proposed by Teys to determine the efficacy of the modular biofilter in rendering plants situations.

4.4 Cost issues

The proposed modular biofilter represents a low cost option for odour control. At this preliminary stage of investigation the costs of constructing a modular biofilter, based on a 12m shipping container are as follows:

Container purchase (by Teys)	$4,000
Internal corrosion protection (by Teys)	$1,000
Modifications to the structure (inlets, sealing of door etc)	$3,000
Polypropylene plenum floor (including mesh floor and supports)	$4,000
Biofilter medium (supplied and loaded)	$6,000
Biofilter bed irrigation	$1,000
Fan and VSD	$9,000
Ducting and. Biofilter mounting support frame (by Teys)	tbd
Design and project management	$10,000
Performance testing	$30,000
(olfactometry and physical testing for 6 months, reporting)	

4.5 Intellectual property issues

The design of the modular biofilter would be based on an internal and existing TOU design. The availability of this design removes the need to experiment with designs at the prototype stage of testing. As such the IP for the design would need to reside withTOU. While this is not an issue for the Teys prototype, it may be an issue in the event that the design is made available and is adopted throughout the meat industry.

Consideration may need to be given to a licence fee or royalty to be payable to TOU for the commercial use of the design.

4.6 Project delivery

The design of the modular biofilter is available and working drawings can be provided within 2 weeks. A prototype plant-scale modular biofilter could be completed within 4 weeks of the delivery of the shipping container. The biofilter internals (plenum floor and supports) are freely available. A source for the biofilter medium has been found close to the Beenleigh area. The fan is expected to have a delivery time of 4-6 weeks. The ducting and biofilter support frame could be supplied and installed within 8 weeks. On this basis a realistic timeframe for the installation of a modular biofilter at the Beenleigh site is 8-10 weeks from the time a decision is made to proceed.

4.7 Project management

TOU would be available to project manage the construction and installation of the modular biofilter, and supply the entire biofilter internals package (plenum floor, supports, biofilter medium and surface irrigation system) and fan as a lump sum item, if required. Teys would be required to purchase and paint the container, arrange for the ducting modifications and the biofilter support frame above the DAF. TOU would also supervise the connection and the commissioning of the unit, and carry out the odour performance testing during the test period.