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# Biofilters for control of rendering odours M.060

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MEAT & LIVESTOCK
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# CONTENTS

# 1. EXECUTIVE SUMMARY

## BIOFILTERS

Biofilters have been used in a number of countries to treat industry odours, in particular they have become increasingly common in Europe, U.S.A. and New Zealand.

Applications in the meat industry have concentrated in treating rendering odours. In particular attention has focussed on treatment of odours where large volumes of air are involved, for instance forced air driers, etc.

In Australia most rendering is conducted in either batch cookers or continuous cookers dry rendering units. The major odour source is the non condensable gases from the condenser. This odour stream is usually required to be treated through an afterburner. Afterburners are expensive to operate, require significant maintenance and control and are susceptible to failure. Biofiltration provides a technology that has the potential to overcome these problems.

## PRINCIPLE OF BIOFILTERATION

Biofilters consist of large beds of compost, peat moss or soil that absorb odorous gaseous compounds which are then broken down through aerobic biological action to non-odorous compounds.

Although the air stream may pass through the filter medium quickly, the compounds absorbed within the pores may reside in the bed for hours before being degraded by microbial action. The filter medium is then regenerated by the action of the micro-organisms on the absorbed pollutants.

The biofilter medium can vary significantly depending on the application and the desired end result. If compost is used, it is usually of a fibrous nature. Soil has also been used with success although different types of soil vary widely in permeability and microbial activity.

Biofilters have been used for the control of odorous gases from processes such as the rendering of animal matter, anaerobic digesters, refuse composting and pig and poultry farms.

## OPERATIONAL PARAMETERS

### *Temperature*

The optimum temperature of the filter bed is 35°C. The incoming odour stream should not exceed 40°C.

### *Moisture*

Too little moisture causes cracking and odour release while too much fills the void space in the filter bed and prevents absorption.

### *pH*

The pH of the filter bed should be maintained between 7 and 8. In order to achieve this figure lime can be added.

### *Pressure Drop*

The pressure drop across the bed should be 20/30 mm water gauge or better.

## MRC - BIOFILTRATION PROJECT

There is little international experience in the application of biofiltration to concentrated non-condensable gases which are produced in a continuous dry rendering system.

This biofiltration project involved two pilot trials and the construction and operation of a demonstration biofilter to treat the non-condensable odour stream from rendering vessels.

A biofilter was constructed using composted anaerobic pond crust. The biofilter had a loading of $15m^3/m^2/hr$ (volumetric gas flow divided by filter area).

The unit demonstrated better than 90% odour reduction and caused no known odour nuisance.

It is estimated that the capital cost of the biofilter was recovered from savings in the operation of the afterburner in a period of less than 8 months.

# 2. INTRODUCTION

## THE PRINCIPLE OF BIOFILTRATION

Biofilters are large beds of compost, peat moss soil or other organic matter arranged in such a way that when odorous gaseous compounds are passed through the bed the odour component is absorbed and then broken down through biological action to non-odorous compounds.

The vapour stream passes through the filter medium quickly, however, the odorous compounds are absorbed within the structure of the filter bed material and may reside in the bed for hours before being degraded by microbial action. The filter medium is continually regenerated by the action of the micro-organisms on the absorbed pollutants.

Because of the long retention times of the pollutant by the filter material, biological treatment is generally restricted to low pollutant concentrations such as treating air streams contaminated by low concentrations of highly odorous compounds.

Micro-organisms are available in such great variety that all kinds of organic and inorganic pollutants can be removed. For most pollutants, there will be either a species suitable for degrading the particular compound or a suitable species will adapt through the natural process of biological evolution. As aerobic microbial activity only occurs to any degree in solution, the pollutants and oxygen must be transferred to the very thin film of water that adheres to the surface of the solid material in the biofilter medium.

As polar compounds tend to be more easily absorbed, they are more readily biodegradable. Soil has been reported as having the capacity to sorb a wide range of both organic and inorganic pollutants including sulphur dioxide, hydrogen sulphide, methyl mercaptan, carbon monoxide and polynuclear organic material.

There are two principal groups of micro-organisms suitable for the treatment of odorous gases; autotrophic and heterotrophic bacteria. Autotrophic bacteria obtain their carbon requirements solely from carbon dioxide and their energy requirements from the oxidation of a range of inorganic compounds including molecular hydrogen, ammonia, nitrite, thiosulphate, hydrogen sulphide and sulphur.

Heterotrophic bacteria gain their nutrients and energy by the oxidation of organic compounds which makes them well suited for the conversion of organic pollutants. This process is much faster than the oxidation of inorganic compounds by autotrophic bacteria, but requires aerobic conditions.

Biofilters have been used for the control of odorous gases from processes such as the rendering of animal matter, anaerobic digesters, refuse composting and pig and poultry farms.

## HISTORY OF BIOFILTRATION

Suggestions to treat odorous off-gases by biological methods can be found in literature as early as 1923. Reports on the application of this concept dating back to the 1950s were published in the U.S. and in West Germany. Pomeroy received U.S. Patent No.2,793,096 in 1957 for a soil bed concept and describes a successful soil bed installation in California. Around 1959 a soil bed was also installed at a municipal sewage treatment plant in Nuremberg, West Germany for the control of odours from an incoming sewer main.

In the U.S., the first systematic research on the biofiltration of $H_2S$ was conducted by Carlson and Leiser in the early 1960s. Their work included the successful installation of several soil filters at a waste water treatment plant near Seattle and demonstrated that biodegradation rather than sorption accounted for the odour removal.

During the following two decades, several researchers in the U.S. have further studied the soil bed concept and demonstrated its usefulness in several full scale applications. Much of the knowledge about the technology is owed to Hinrich Bohn who has investigated the theory and potential applications of soil beds for more than 15 years. Successful soil bed applications in the U.S. include the control of odours from rendering plants, and the destruction of propane and butane released from an aerosol can filling operation.

Biofilter technology has similarly developed in NZ where the principal application has been to deodorise high volume vapour streams from meal drying operations in wet rendering plants. Such vapour streams are uneconomic to treat by flame incineration and difficult to deal with by gas scrubbing technology. Biofiltration was seen as the solution and there is now some 10/12 biofilters operating at rendering plants in NZ.

In at least two European countries, West Germany and The Netherlands, biofiltration has developed since the early 1960s into a widely used air pollution control technology which is now considered "best available control technology" in a variety of odour control applications.

A limited number of reports on experiences with biofiltration in other counties can also be found, including Switzerland, Japan and Austria.

During the 1960s and 1970s, biofilters were successfully used in West Germany to control odours from a variety of sources, including sewage treatment plants, facilities for rendering, composting and food processing, as well as chicken and pig farms. Various designs, (for example for the air distribution system), and several filter materials with higher biological activities and lower flow resistance than soil were used as filter material as early as 1966. The need for humidification of the off-gas at higher flow rates was also recognised.

The basic processes determining the efficiency of a filter were understood qualitatively in the 1960s. However, the approach to designing biofilter systems was usually empirical. Mobile pilot units were used for treatability studies and the sizing of full scale system.

Since the early 1980s , biofiltration has increasingly been used in Germany to control volatile organic compounds (VOC) and air toxins emitted from industrial facilities such as chemical plants, foundries, print shops and coating operations. This development was brought about primarily by new federal regulations that required the control of emissions of VOC and air toxins from new and existing sources. A well funded development program run by the East German Federal Environmental Agency, Umweltbundesamt (UBA), and the formation of several engineering firms have reportedly addressed and resolved some of the initial technical problems with biofiltration.

## CHOICE OF FILTER MATERIAL

Materials having significant biological activity are suitable as media for use in biofilters. The contact or residence times needed for the odorous compounds to be reduced to an acceptable level appear to be practically identical regardless of the particular filter material used. The filter bed material must however be selected to allow uniform flow in the bed without stream formation (i.e. fissuring). Stream formation will cause odours to bypass the filter media and cause the biofilter to fail.

There are two principal types of media used in biofilters, compost based and soil based.

Compost filters consist of beds of compost material, peat moss or fibrous peat. Garbage compost, mushroom compost, paunch compost and garden compost have been successfully used in biofilters. If peat is used, it should be "rooty" peat with long bulky fibres, found at a depth of one to two metres in its natural state. Compost should be well matured and well turned to ensure an open structure. Constructing a filter with lumpy, unmatured compost is generally unsuccessful as this results in streaming of gas through the bed.

The best compost material for biofilters have high surface area, high air permeability, high water permeability and water holding capacity and high microbial population. Compost containing extensive growth of fungal mycelia is not desirable as this can lead to non-homogeneous gas flow through the bed. This can result in channelling of the air flow through only part of the bed. Compost filters have been successfully applied to treating odours from a wide range of processes including plant ventilation air discharged from rendering plants (up to 150,000 cubic metres/hr).

Soil filters consist of a bed of sandy or loamy soil, or a fine sand layer topped with soil. Soils vary widely in permeability and microbial activity. The performance of a soil filter depends on the internal pore structure which in turn depends on the type of soil used. Soil with a large internal void space does not necessarily have a highly porous internal structure as the pore structure is also dependent on surface area and particle size. For example, coarse sand, when compared to clay or loam, has a high permeability due to its large void space but, since the particles are larger and denser, it has a relatively low internal pore structure. Normal humus or clay soil may not be suitable for use in biofilters because variations in humidity, lead to cracking resulting in a high maintenance input to ensure effective operation.

Soil filters tend to be cheaper to construct than compost filters unless there is a ready supply of compost available. However, this is offset by the lower porosity of soil which results in a lower flow rate per cubic metre of volume (ie the bed needs to be proportionately larger) and higher operating pressures (ie increased operating costs). Soil filters have been used successfully for treating process gases from rendering plants and ventilation air control at a sewage treatment plant.

## APPLICATION OF BIOFILTRATION TO RENDERING

Since the early 1980's biofilters have been used in rendering facilities in a number of countries including Germany, Netherlands, U.S.A. and N.Z. Application of the biofilters has generally been in two areas:

1. Treatment of high volume vapour streams from pneumatic (air) driers including ring driers, rotary kiln driers, disc driers etc.

2. Treatment of fugitive vapour streams either captured in hood and duct systems or from within buildings operated under negative air pressure.

Biofilters have been ideal for these applications because:

- High vapour volumes make flame incineration uneconomic.
- Chemical scrubbers can be unreliable and require constant attention.
- The nature of these streams; less than 40°C; containing high air and moisture content; and containing organic volatiles is ideal for the application of biofilter technology.

Volatile organic compounds identified in rendering vapours have been found by Van langenhove et al (ref 10) to include:

| Compound | Present in a | b | c | Sensory evaluation odour character | Compound | Present in a | b | c | Sensory evaluation odour character |
|---|---|---|---|---|---|---|---|---|---|
| dichlorodifluoromethane | x | | | | chlorobenzene | x | | x | |
| 2-methylpropane | x | | | | ethylbenzene | x | x | x | |
| 1-butene | x | x | x | | dimethylthiophene | | | x | |
| butene | x | x | x | | m,p-xylene | x | x | x | |
| methanethoil | x | | x | putrid, bad | nonene | x | | x | |
| trimethylamine | x | x | x | fishy, ammonia | styrene | x | | x | |
| 2-methylbutane | x | | | | nonane | x | x | x | |
| trichlorofluoromethane | x | x | x | | o-xylene | x | x | x | |
| pentene | x | | x | | heptanal | x | x | x | fatty |
| pentane | x | x | x | | α-thujene | x | | | |
| 2-propanone | x | x | x | acetone | propylcyclohexane | x | | | |
| diethylether | x | | x | ether | methyl propyl disulfide | x | | | putrid |
| dimethyl sulfide | x | x | x | putrid | α-pinene | x | x | x | fir |
| propanal | x | x | x | sharp | terpene (mol wt 136) | x | | | fresh |
| carbon disulfide | x | | x | | camphene | x | | x | |
| dichloromethane | x | | x | sweet, ethereal | benzaldehyde | | | x | |
| 2,3-dimethylbutane | x | | | | propylbenzene isomer | x | x | x | |
| 2-methylpropanal | x | x | x | malty | methylethylbenzene isomer | x | x | x | |
| 2-methylpentane | x | x | x | | methylethylbenzene isomer | x | x | x | |
| 3-methylpentane | x | x | x | | sabinene | x | | | |
| hexene | x | | x | | dimethyl trisulfide | x | | | putrid |
| hexene | x | x | x | | β-pinene | x | x | x | |
| butanal | x | | x | malty, burnt | 2-pentylfuran | x | x | x | |
| 2-butanone | | | x | solvent | decane | x | x | x | |
| trichloromethane | x | | x | ethereal | trimethylbenzene isomer | x | x | x | |
| methylcyclopentane | x | x | x | | α-phellandrene | x | | | |
| ethyl acetate | x | | | fruity | octanal | x | x | x | faaty,oily |
| tetrahydrofuran | x | | x | | $\Delta^3$-carene | x | | x | |
| trichloroethane | | x | x | sweet | butylbenzene isomer | x | | x | |
| 3-methylbutanal | x | x | x | buttery | butylbenzene isomer | x | | x | |
| cyclohexane | | x | x | | o-dichlorobenzene | x | x | x | sanitary |
| thiophene | | | x | | tetramethylbenzene | x | x | x | |
| tetrachloromethane | x | | x | | limonene | x | x | x | lemon |
| benzene | x | x | x | | m-dichlorobenzene | x | x | x | sanitary |
| 2-methylbutanal | x | x | x | aldehydic | tetramethylbenzene isomer | x | x | x | |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 3-methylhexane | | x | x | | terpene (mol wt 136) | x | | | |
| 2,2,4-trimethylpentane | x | | x | | undecane | x | x | x | |
| heptene | x | | x | | nonanal | x | x | x | fatty, oily |
| heptane | x | x | x | | tetramethylbenzene isomer | x | x | x | |
| pentanal | x | x | x | fatty, pungent | dodecane | x | x | x | |
| trichloroethylene | x | x | x | | naphthalene | x | x | x | naphthalene |
| methylcyclohexane | x | x | x | | tridecane | x | | x | |
| dimethyl disulfide | x | x | x | putrid | decanal | | x | | citrus fruit |
| toluene | x | x | x | | methylnaphthalene | x | | x | |
| octene | x | | x | | terpene (mol wt 136) | x | | | |
| methylthiophene | | | x | | tetradecane | x | | x | |
| octane | x | | x | | terpene (mol wt 136) | x | | | |
| hexanal | x | x | x | fatty, green | pentadecene | x | | x | |
| pentanol | | x | | | pentadecane | x | | x | |
| tetrachloroethylene | x | x | x | | | | | | |
| octadiene | x | | | | | | | | |

**Key: a,** scrubber outlet samples; **b,** air sampled in factory buildings; **c,** ambient air samples

These volatile organics are considered to be a family which can be appropriately treated with biofiltration.

## THE AUSTRALIAN SCENE

Prior to 1990 there appears to have only been two significant biofilter installations in Australia. These were installed at:

**Uncle Bens - Bathurst**
Treating odour from dry petfood manufacturing operations.

**Davis Gelatine - Botany**
Treating odour from gelatine manufacturing operations.

Since 1990 there has been a number of installations occur. These include:

1. **Friskies - Blayney**

   Treating odour from dry petfood manufacturing.

2. **Fielders - Lane Cove**

   Treating starch manufacturing odours.

3. **Mackay Casings - Wangaratta**

   Treating casing manufacturing odours.

4. **Australian Poultry - Adelaide**

   Treating poultry waste odours.

5. **Dynamic Lifter - Tamworth**

   Treating composting odours.

6. **Unichema - Port Melbourne**

   Treating tallow fractionation non condensables.

There has also been a number of installations in the rendering industry, including:

**<u>Camilleri Bros - Maroota, NSW</u>**

| | |
|---|---|
| **Treating:** | Meal drier (including feather drying). Non condensable and tramp odours. |
| **Filter Material:** | Mushroom compost and bark. |
| **Size:** | 200m² |
| **Vapour Flow:** | 4000m³/hr |
| **Odour Removal:** | 96-99% |
| **Controls:** | Temp 38°C, vapour humidifier installed, intermittent surface spray. |
| **Comments:** | A second similar sized biofilter is currently being installed. installation costs approximately $50,000. Savings on afterburner fuel costs $160,000/year. |

**<u>Southern Meat Processors - Goulburn, NSW</u>**

| | |
|---|---|
| **Treating:** | Process odours and odours captured in negative pressure building. |
| **Filter material:** | Rice husks. |
| **Size:** | 300m² |
| **Vapour Flow:** | 40/50000m³/hr |
| **Odour Removal:** | Unknown |

**Hazeldene Poultry - Hazeldene, Vic.**

| | |
|---|---|
| **Treating:** | Meal drier ( including feather drying), non condensable and tramp odours. |
| **Filter Material:** | Ti-tree and Pinebark |
| **Size:** | $140m^2$ |
| **Vapour Flow:** | Unknown |
| **Odour Removal:** | Unknown |
| **Controls:** | The odour stream passes through water scrubbers which removes particles and humidifies air. |
| **Comments:** | High drier temperatures cause some smoking which passes through the biofilter without significant effect. |

**Peerless - Laverton, Vic.**

| | |
|---|---|
| **Treating:** | Tramp vapours from meal milling and building ventilation. |
| **Filter Material:** | Rice husks/animal manure. |
| **Size:** | $500m^2$ (2 beds) |
| **Vapour Flow:** | $30,000m^3/hr$ |
| **Odour Removal:** | Very good. |
| **Control:** | The vapour stream is extensively cleaned using filter bags, mesh filters, venturi scrubber and wash humidifying tower. |
| **Comments:** | Extensive weed growth on filter surface assists operation but causes difficulty when turning media. Currently installing 2 more beds to take increased plant ventilation. |

**Tallowman - Hazelmere, WA**

| | |
|---|---|
| **Treating:** | Tramp odours from building venting. |
| **Filter Material:** | Oat husks/bark. |
| **Size:** | $600m^2$ |
| **Vapour Flow:** | $70,000m^3/hr$ |
| **Odour Removal:** | Approximately 95/97% |
| **Controls:** | Humidifier installed aids temperature control |
| **Comments:** | Operates better than satisfactory. Requires daily monitoring. |

**Under Construction/Design:**

- Rendering Plant - Moruya, NSW.
- Universal Casings - Wagga Wagga, NSW.

There has also been installed in a number of countries, including Australia, soil beds to control sulphide odours from wastewater treatment plants. These soil beds are a form of biofilter however they have not been generally applied in industrial processes. R J Gilbertson - Melbourne, have a unit installed to treat odour from a waste water discharge point. This study focuses on biofilters that utilise higher void space organic materials.

Since the technology is perceptibly simple it is generally considered that there is also likely to be a number of "home-made" units installed in Australia which work on a "better than nothing" basis.

Problems with biofilters in Australia have mostly been associated with general operational factors, in particular:

- **Drying** of the bed, principally caused by an unsaturated vapour stream.
- **Blinding** of the bed caused by carry over of fat and particulate matter in the gas streams.
- **Cracking and streaming** in the bed, caused by drying and poor filter material selection.
- **High** vapour **temperatures** causing failure of the microbial mass.

Experience is also beginning to suggest that high ammonia and sulphide levels can cause problems by lowering pH levels and poisoning the filter bed.

Interest in the application of biofiltration has grown significantly in Australia in recent years.

A Co-operative Research Centre (CRC) has been formed to conduct R & D into Waste Management and Pollution Control. The overall program is scheduled to run until 1998 and has an annual budget of $8 million. Within the overall program there is a module devoted to the development of biofilter technology. The University of NSW is the lead institute with support from ICI, the Sydney Water Board and ANSTO.

The biofiltration project module is based on a preliminary commercial review which showed that there is a place for improved biological methods in a market in which chemical scrubbers, activated charcoal and incineration already jostle for a place. Overseas investigations by the CRC indicated a world market for biological odour control in excess of $300 million a year, and a local market above $20 million.

To answer this need, the project is breeding specific cultures of micro-organisms with an appetite for the chemicals whose odours are causing the problem, such as the volatile emissions from various industrial processes. The success of the project will depend on the careful integration of three lines of expertise; knowledge of the chemical nature of the odours, advanced microbiology and design skills from chemical engineering.

The project is under the leadership of Terry Schulz from the University of NSW. ANSTO, ICI and the Water Board are contributing expertise and a budget of $500,000 has initially been set up for expenditure over one year to June 1994. Many of the CRC partners have direct experience of the community response to odours, and will benefit from both the technology and the consulting capability arising from this project.

## THE MRC BIOFILTER PROJECT

In 1990 a contract was established between ProAnd Associates and the Meat Research Corporation (MRC) to undertake a project titled Meat Processing Odour Control using Biofilters.

The principle objective was to provide a demonstration of the ability of biofilter technology to reduce odour nuisance from rendering plants.

The objectives and methodology proposed at the time were:

### Objectives

I. To evaluate biofilter technology as a lower capital and operational cost technology in the treatment of odours from rendering plants.

II. To provide an environmentally benign technology approved by Australia's regulatory agencies.

### Methodology

**Stage I** *Literature and Industry Review of Biofilter Technology*

In this stage information databases were to be searched and biofilter users in other industries contacted in order to assist the biofilter design process and the selection of appropriate filter media for trial.

**Stage II** *Design and Construction of Pilot Plant*

The pilot plant to be designed in-house with advice being sought from mechanical and environmental engineers.

Construction of the pilot plant to be sub-contracted.

**Stage III** *On-site Evaluation of Pilot Plant*

The evaluation of the pilot plant would include physical characteristics such as:

Filter Bed Weight
Filter Bed Depth
Air Volume Treated
Contact Time
Air velocity
Pressure Difference

The evaluation would also sample and analyse influent and effluent air over time in order to obtain an efficiency rating for odour removal.

Initial trial of two filter media material was assumed.

**Stage IV** *Design of Demonstration Biofilter*

With results of the pilot plant information and advice from civil, mechanical and environmental engineers, the design for the demonstration unit would be finalised.

**Stage V** *Construction of Demonstration Unit*

During this period the demonstration unit would e constructed by sub-contractors.

**Stage VI** *Evaluation ofDemonstration Plant and Presentation of Results and Recommendations*

Evaluation of demonstration plant to be conducted and the results and recommendations prepared and presented.

**Stages I, II and III** were completed as proposed and the results are provided within this report.

The initial project envisaged installation of the full scale biofilter in a plant to be constructed in N.S.W. The timetable for construction of the new plant slipped and it was decided to renegotiate the location of the demonstration biofilter.

During this period there had begun to be activity within the rendering industry for installation of biofilters to treat fugitive and drier odours. These developments have been described earlier in this report (see: **The Australian Scene**). As a consequence it was proposed to change the location of the demonstration plant to Queensland Meat Exports - Townsville (QME). The project also became focussed on treatment of the non-condensable odour stream that was derived from the rendering plant condenser that has traditionally been treated in an afterburner (flame incinerator).

It is generally considered that because of the long retention times of the pollutant by the filter material, biological treatment is restricted to very low pollutant concentrations such as treating air streams contaminated by low concentrations of highly odorous compounds. Literature had indicated that non-condensable rendering odours demonstrated odour concentrations upwards from 50,000 OU (Odour Units)

It was also discovered that there was available in Townsville a material derived from long term composting (18/36 months) of anaerobic pond crust. It is well known that an anaerobic pond with a solid crust cover (no cracks etc) does not cause odour offence. Organic material in the pond will however be decomposing and giving off odorous gases. Although it is likely that conditions in most of the crust will be anaerobic it is also likely that upper layers will be aerobic. In any case the crust appears to act as a self created "biofilter" that satisfactorily treats odours caused by the anaerobic decomposition of meat waste.

With this information a decision was made to pilot trial the composted anaerobic pond crust as a biofilter material for non-condensable rendering odours.

As a consequence of the success of the second pilot trial it was decided to install a demonstration biofilter at QME using composted anaerobic pond crust to treat non-condensable odours that resulted from the continuous render plant. A demonstration biofilter was designed and installed at QME Townsville.

The overall project program was:

| | |
|---|---|
| **1990** | Literature Survey<br>Construct Pilot Plant<br>Operate Pilot Plant (AJ Bush - Rouse Hill) |
| **1991** | Report on Rouse Hill Pilot Trial<br>Pilot Plant Trial (QME - Townsville)<br>Report Townsville Trial |
| **1992** | Design Demonstration Biofilter<br>Construct Demonstration Biofilter |
| **1993** | Commission Demonstration Unit<br>Demonstration Biofilter Evaluation |
| **1994** | Final Report |

## LITERATURE SURVEY

The principal documents sourced during the study and an abstract of each is provided in Appendix 1. In general it was established from the literature survey, conducted during 1990 that:

- Biofiltration for the control of rendering odours is being used extensively in Europe (particularly Germany), U.K. U.S.A. and N.Z.

- The main application is on the treatment of odour streams from dryers used in association with low temperature rendering or solvent extraction plants. The high volume flue rates of these installations make incineration impractical.

- The current installations perform well and give odour reduction efficiencies of 85% - 95%. The main problems for biofilters involve drying, cracking and bypassing of the filter media.

- Generally design information is available, particularly from German Guideline VDI 3477, however this requires pilot scale confirmation for odour control from continuous cooker type rendering plants.

- Two biofilters had recently been installed in Australia. These were at:

**David Gelatine** - Sydney
**Uncle Bens** - Bathurst

### Operational Parameters Indicated in Literature

Several of the literature sources indicated the broad physical environment for successful use of biofiltration technology. The most important parameters to be considered are temperature, moisture, pH, and pressure drop. Guidelines established from the literature are included in the following table:

| |
|---|
| ***Temperature***<br>The optimum temperatures of the filter bed is 35°C. The coming odour stream should not exceed 40°C. |
| ***Moisture***<br>Too little moisture causes cracking and odour release while too much fills the void space in the filter bed and prevents absorption. The best scenario is to have a saturated vapour entering the biofilter. |
| ***pH***<br>The pH of the filter bed should be maintained between 7 and 8. In order to achieve this figure, lime can be added |
| ***Pressure Drop***<br>The pressure drop across the bed should be 20/30 mm water gauge or better. |

There was little international experience discovered in the application of biofiltration to concentracted non-condensible gases which are produced in a continuous dry rendering system. However the opportunity for adaptation and application of biofiltration technology to the treatment of odours from a continuous dry rendering plant appeared good.

Advantages over flame incineration were considered to include:

- **Lower capital costs**
- **Lower operation costs**
- **Easier monitoring the management**
- **More environmentally benign technology**

Since some time had elapsed since the initiation of the study a supplementary literature database search was conducted in October 1993. The papers thus discovered are also provided in Appendix 1 and clearly demonstrate the growing international interest in this technology.

# 3. PILOT PLANT TRIALS

## INTRODUCTION

This section of the report outlines the following aspects:

- Description of the pilot plant, sampling procedure and technique.
- Sampling of the odourous air streams in the pilot trials.
- Odour emission assessment.
- Sampling results.
- Biofilter materials.

The layout, design, construction, installation, arrangement of sampling equipment, odour analysis, and operational data evaluation generally followed instructions and procedures described in publication No.33477 (VDI3477) of the German Institution of Engineers.

## CONSTRUCTION OF THE PILOT BIOFILTER PLANT

A transportable biofilter pilot plant was designed and constructed; incorporating 4 test beds, an induction fan and ducting on a large trailer. The layout of the unit is provided in Figures 1 and 2 attached.

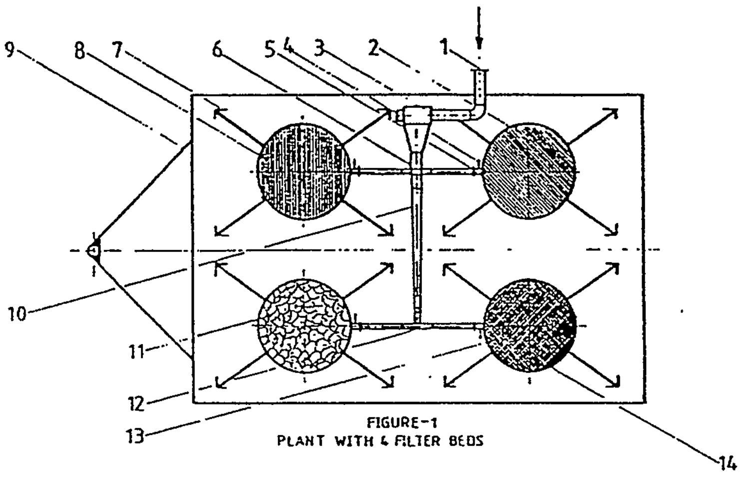



FIGURE-1
PLANT WITH 4 FILTER BEDS

1 ODOROUS AIR INFLOW
2 SANDY LOAM BIOFILTER BED
3 FAN UNIT
4 INLET AIR FLOW REGULATOR
5 FLANGE
6 INLET AIR DISTRIBUTOR (1)
7 BIOFILTER SUPPORT STAND
8 COMPOSTED PINEBARK BIOFILTER BED
9 TRAILOR CARRYING BIOFILTER PILOT PLANT
10 DUCTING TO AIR DISTRIBUTOR (2)
11 MUSHROOM COMPOST BIOFILTER BED
12 AIR INLET DISTRIBUTOR (2)
13 MIXED BIOFILTER BED (PEAT, SANDY LOAM & ASH)
14 BIOFILTER BED STEEL CONTAINER
15 CONTAINER HOLDING RING
16 FILTERBED SUPPORT SCREEN
17 DRAIN OUT POINT

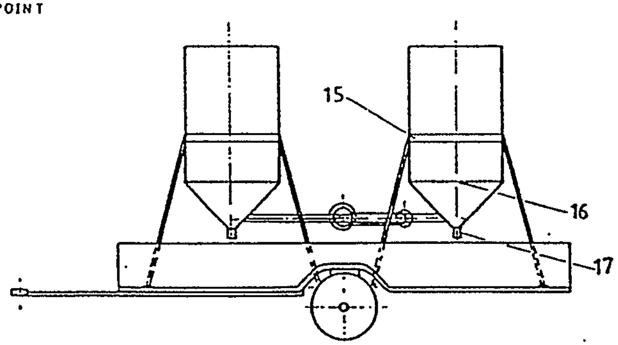



FIGURE-2

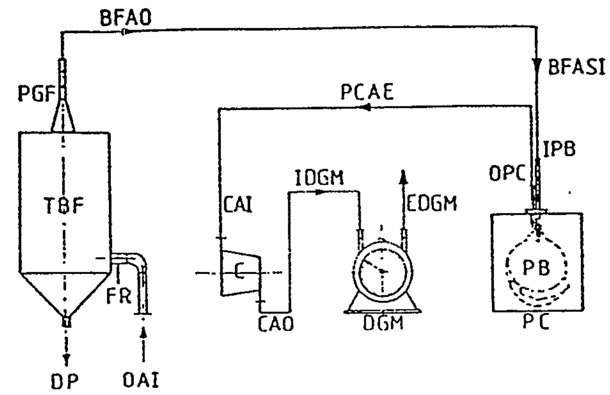



FIGURE -3
ODOUR SAMPLING ON BIOFILTER

| | |
|---|---|
| OAI | ODOROUS AIR INLET |
| FR | FLOW REGULATOR/OR ANEMOMETER |
| DP | DRAIN OUT POINT |
| TBF | TEST BIOFILTER |
| PGF | PYREX GLASS FUNNEL |
| BFAO | BIOFILTERED AIR OUTLET |
| CAI | COMPRESSOR AIR INLET |
| C | COMPRESSOR |
| CAO | COMPRESSOR AIR OUTLET |
| IDGM | INLET DRY GAS METER |
| DGM | DRY GAS METER |
| EDGM | EFFLUENCE DRY GAS METER |
| BFASI | BIOFILTERED AIR SAMPLE INLET |
| PB | PLASTIC BAG FILLED WITH AIR SAMPLE |
| PC | PLASTIC CONTAINER CARRYING PB |
| PCAE | PLASTIC CONTAINER AIR EFFLUENCE |
| IPB | INLET PLASTIC BAG |
| OPC | OUTLET PLASTIC CONTAINER |

ProAnd associates LIMITED

PROJECT: MEAT PROCESSING ODOUR CONTROL USING BIOFILTERS
TITLE: PILOT PLANT BIOFILTERS

| DATE | DRAWN | SCALE |
|---|---|---|
| 15.08.1990 | GCS | N.T.S. |

NUMBER: M-60-1



| ITEM | DESCRIPTION | REQ'D | MATERIAL | REMARKS |
|---|---|---|---|---|
| | ODOUR CONTROL PILOT PLANT 4 TYPES OF BIOFILTER BEDS | | | |

SYDNEY BRANCH
EDGECLIFF CENTRE, NSW 2027





Figures 1, 2, & 3

## Installation and Operation

The transportable biofilter pilot plant was installed and connected to the continuous rendering plant systems at AJ Bush, Rouse Hill. This rendering plant operates from Monday to Saturday with variable quantities and contents of meat waste input including mixed abattoir material and butchers fat and bones. The pilot plant consisted of the four filter beds with filter materials using sandy loam (Bed 1), composted pinebark (Bed 2), mushroom compost (Bed 3) and a mixed bed (Bed 4) comprising peat, sandy loam and ash.

The biofilter was connected to the duct system that included a mixture of non-condensable odours, tramp odours and plant ventilation. This plant ducting system returned the enclosed vapour stream to the firebox of the plant boiler for incineration. Odorous waste air from this ducting system passed through the biofilter fan unit and was distributed through the pilot plant ducting system to each of the four filter beds.

### Sampling and Odour Analysis

Sampling operations were carried out according to the arrangement described in Figure 3.

The odour samples were collected from the pilot biofilter plant in plastic bags contained in plastic containers and transported to the University of N.S.W. for dynamic olfactometric analysis in accordance with the Standard Analytical Procedure B4 of the EPA (Victoria).

The inlet gas velocity and temperature together with the differential pressures and inlet gas moisture content were recorded and tabulated as required.

### Filter Bed Materials

Four different filter bed materials were used in the trial at Rouse Hill.

Bed 1 - Sandy Loam Soil
Bed 2 - Composted Pine Bark
Bed 3 - Mushroom Compost
Bed 4 - Peat/Sandy Loam/Ash

The materials used for these four different pilot biofilters have been investigated in order to determine physical properties including density and void fraction.

Figure 4 has been prepared to compare density (D), void fraction ($\varepsilon$), mean maximum odour reduction rate (ORR max) and mean maximum olfactometric efficiency ($\eta$ max) with the mean sphere diameter of the filter bed material.

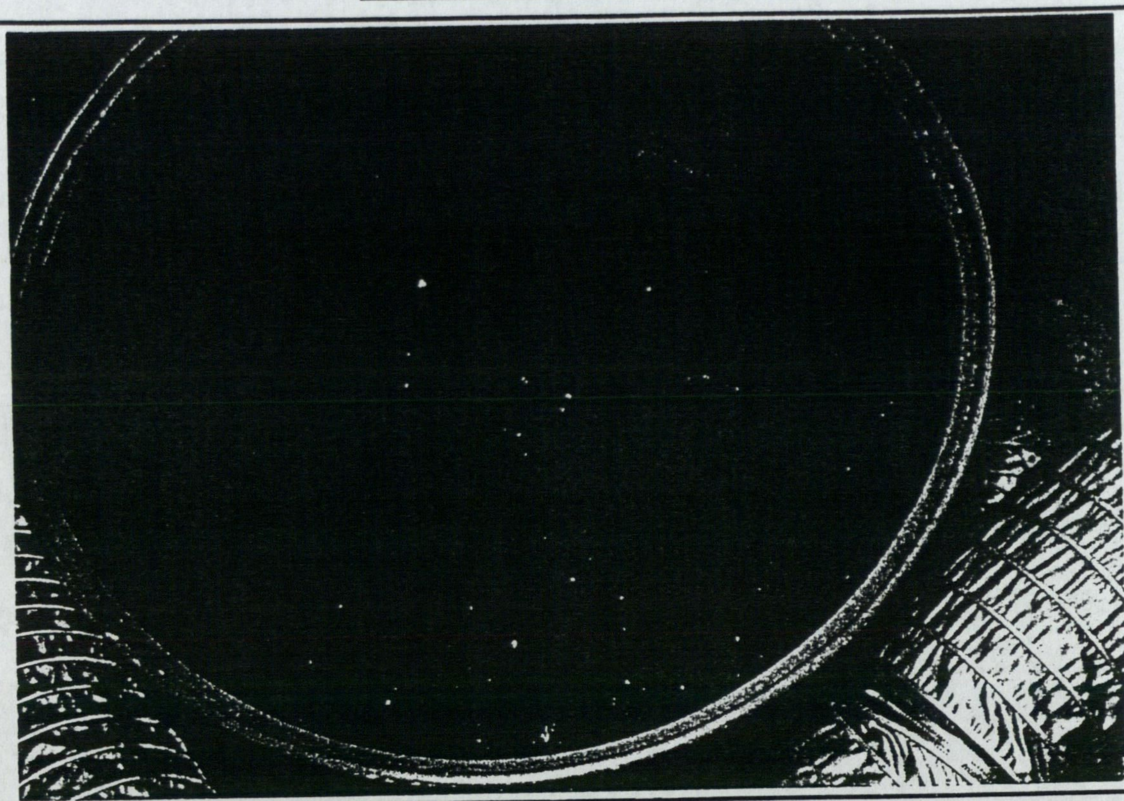
The four horizontal lines drawn on Figure 4 represent mean sphere diameters as follows:

| |
|---|
| Dp = 0.087 mm for Bed No.1 representing the filter material "sandy loam soil"; |
| Dp = 0 200 mm for Bed No.2 representing the filter material "composted pinebark"; |
| Dp = 0.150 mm for Bed No.3 representing the filter material "mushroom compost"; |
| Dp = 0.099 mm for Bed No.4 representing the mixed bed filter material. |

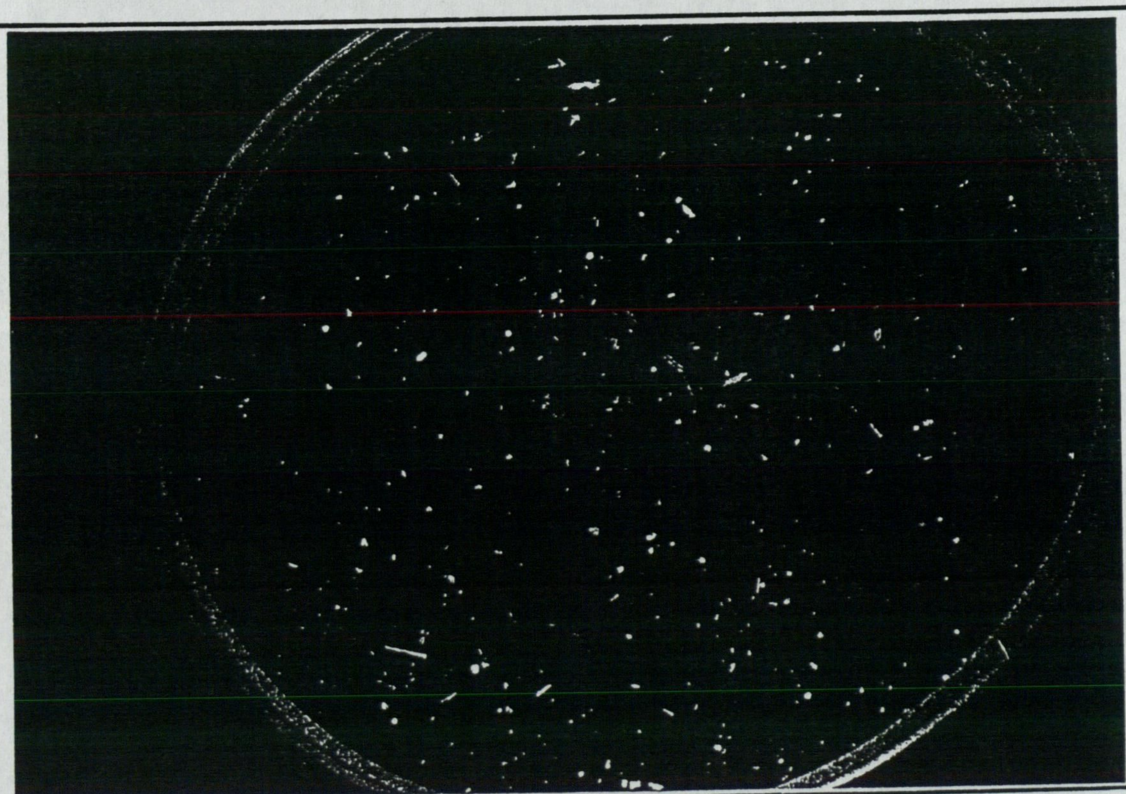
The average sphere diameters were measured using a Sedigraph Particle Size Analyser.

Photographs of the filter materials and a general picture of the pilot plant in operation are attached.

**Pictures 1 and 2**



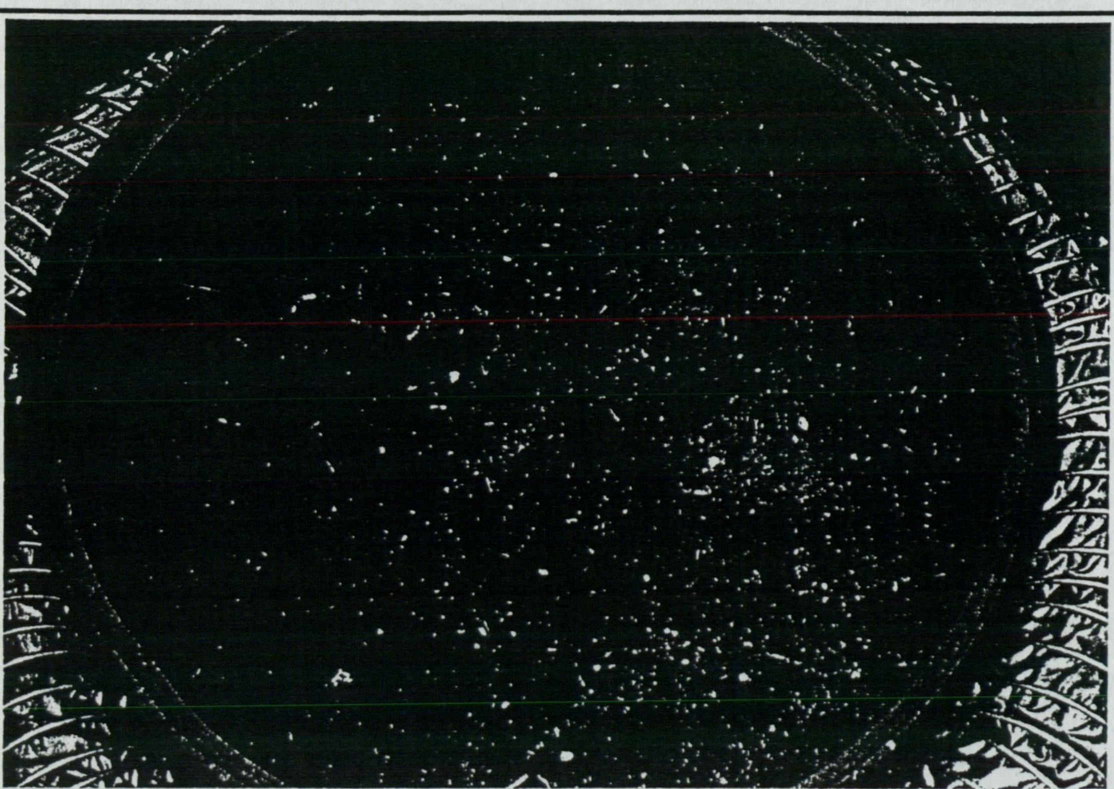
Picture 1: Sandy Loam Material



Picture 2: Composted Pinebark Material

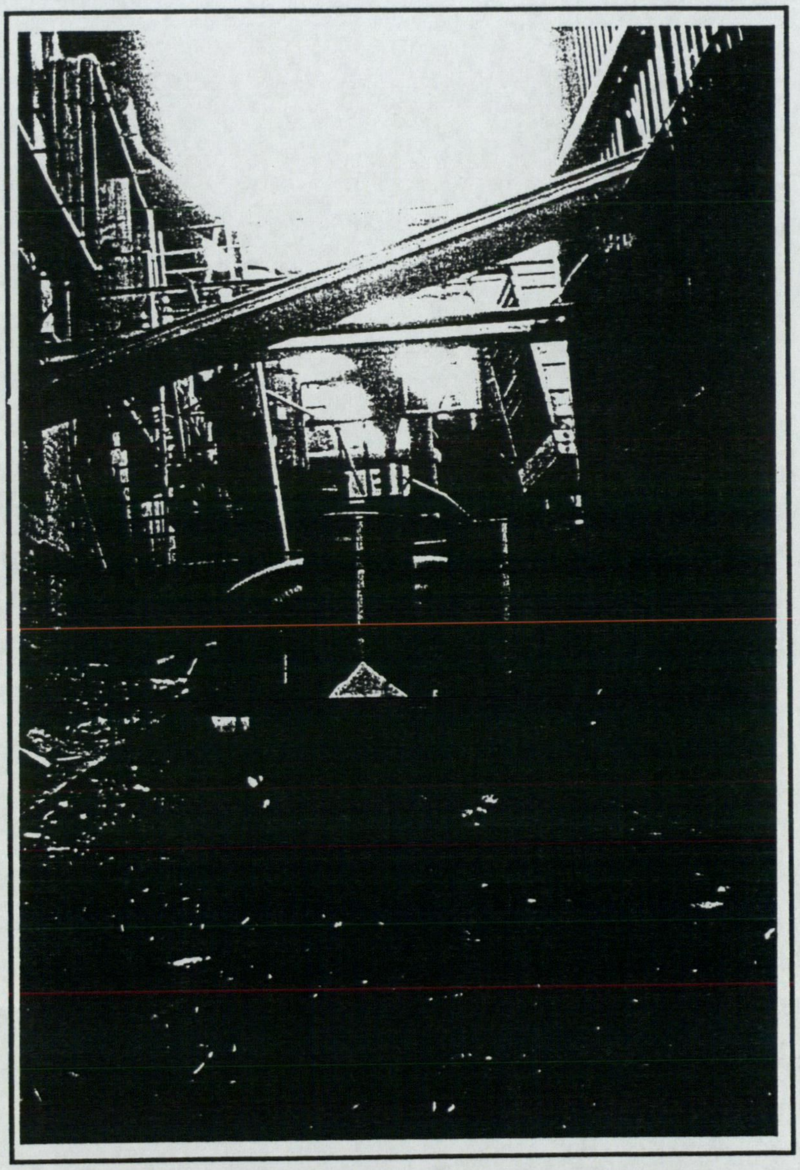
## Pictures 3 and 4

Picture 3: Mushroom Compost Material



Picture 4: Mixed Material (Peat, Loam, Ash)

**Picture 5**





**Picture 5: Overall View of Rouse Hill Installation**
*Showing Pilot Plaht in foreground &*
*odour control system in background*

## Operational Characteristics of the Biofilter Beds

The values of the inlet gas concentration for the first operation week proved to be unusable due to vapour temperatures above 52°C. The data that has been used in the analysis therefore results from the odour results of the samples collected for the last 3 weeks of operation of the pilot plant .

The odour results have been graphically represented in Figures 5 and 6. Each of the curves (week 2, week 3 and week 4) indicate that the biofilter inlet gas odour concentration increases as the rendering operational time proceeds later into the week.

The four parameters plotted on the abscissa of Figure 4 are of two different categories:

Void fraction and filter material density represent the physical properties of filter materials.

The other two parameters that have been plotted have been determined from operational data. These parameters are:

Mean maximum olfactometric efficiency
( $\eta_{max}$ in %), and

Mean maximum odour reduction rate
($ORR_{max}$ in $OU/m^3$).

## Odour Reduction Rate and Olfactometric Efficiency

The odour reduction rate (ORR in odour units per $m^3$ filter material), is the difference between the inlet and outlet gas concentration per unit volume of biofilter material. This parameter provides a measure of the odour reduction capacity for the biofilter, related to the volume and material properties of the filter material.

The olfactometric efficiency $\eta$ in % is the difference between the mass portions of crude gas components leaving the filter media, related to the total crude gas mass portion entering the filter media.

The values of $ORR_{max}$ are calculated from the maximum ORR and 3 values of the operational weeks 2, 3 and 4 with reference to the corresponding filter bed.

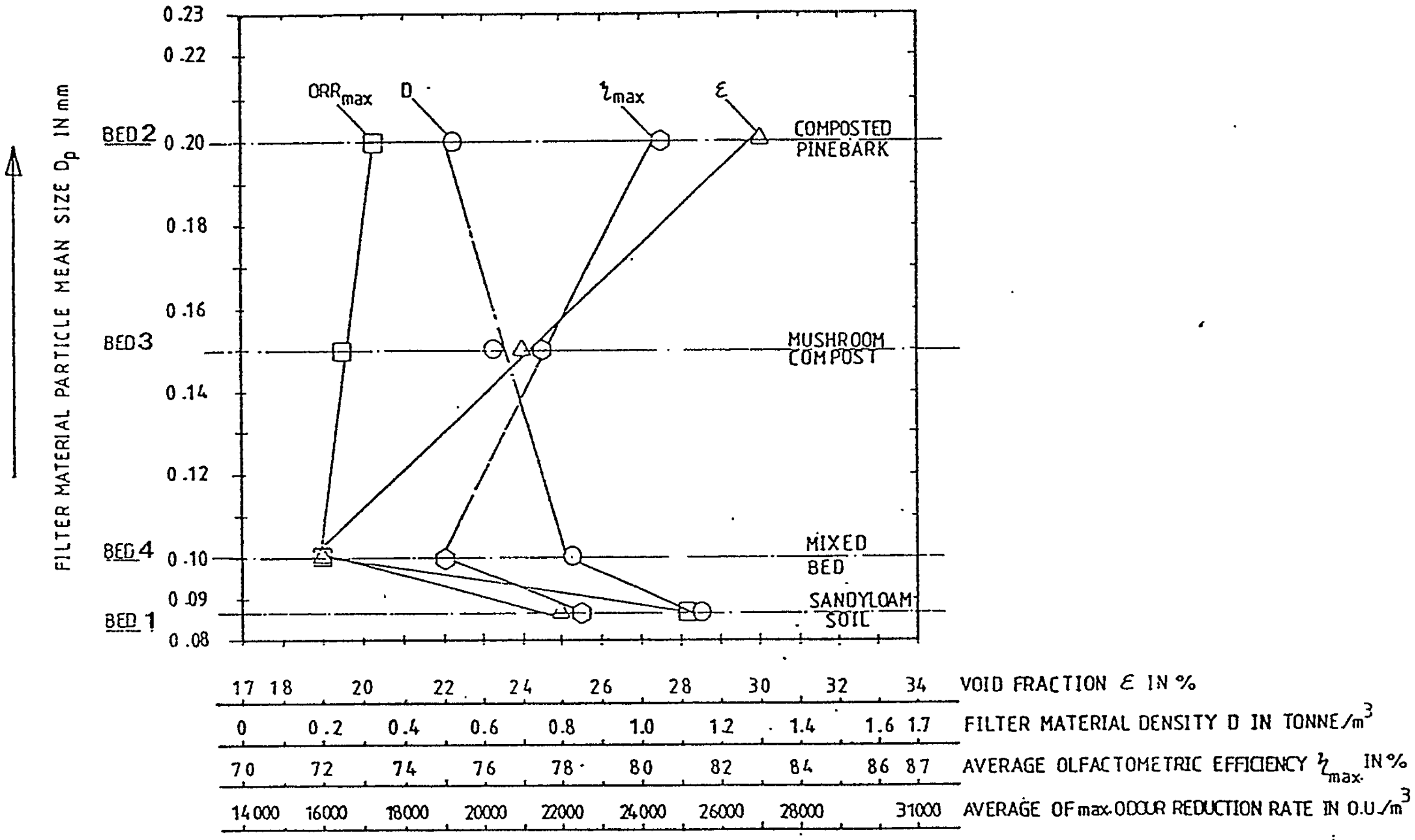



FIG.4

| ITEM | DESCRIPTION | REQ'D | MATERIAL | REMARKS | |
|---|---|---|---|---|---|
| | REPRESENTATION OF $D_p$ FOR 4 BIO-FILTERS AS FUNCTION OF ε, η, D & ORR | SCALE | | PASSED | DATE 16.11.1990 |
| | PROAND ASSOC. LTD. SYDNEY | DRAWN | GCS | DRAWING NUMBER | |
| | | TRACED | | | |
| | | CHECKED | | | |

Figure 4

# Biofilter Test Results

## Rouse Hill Pilot Trial
## (Aug - Sept 1990)

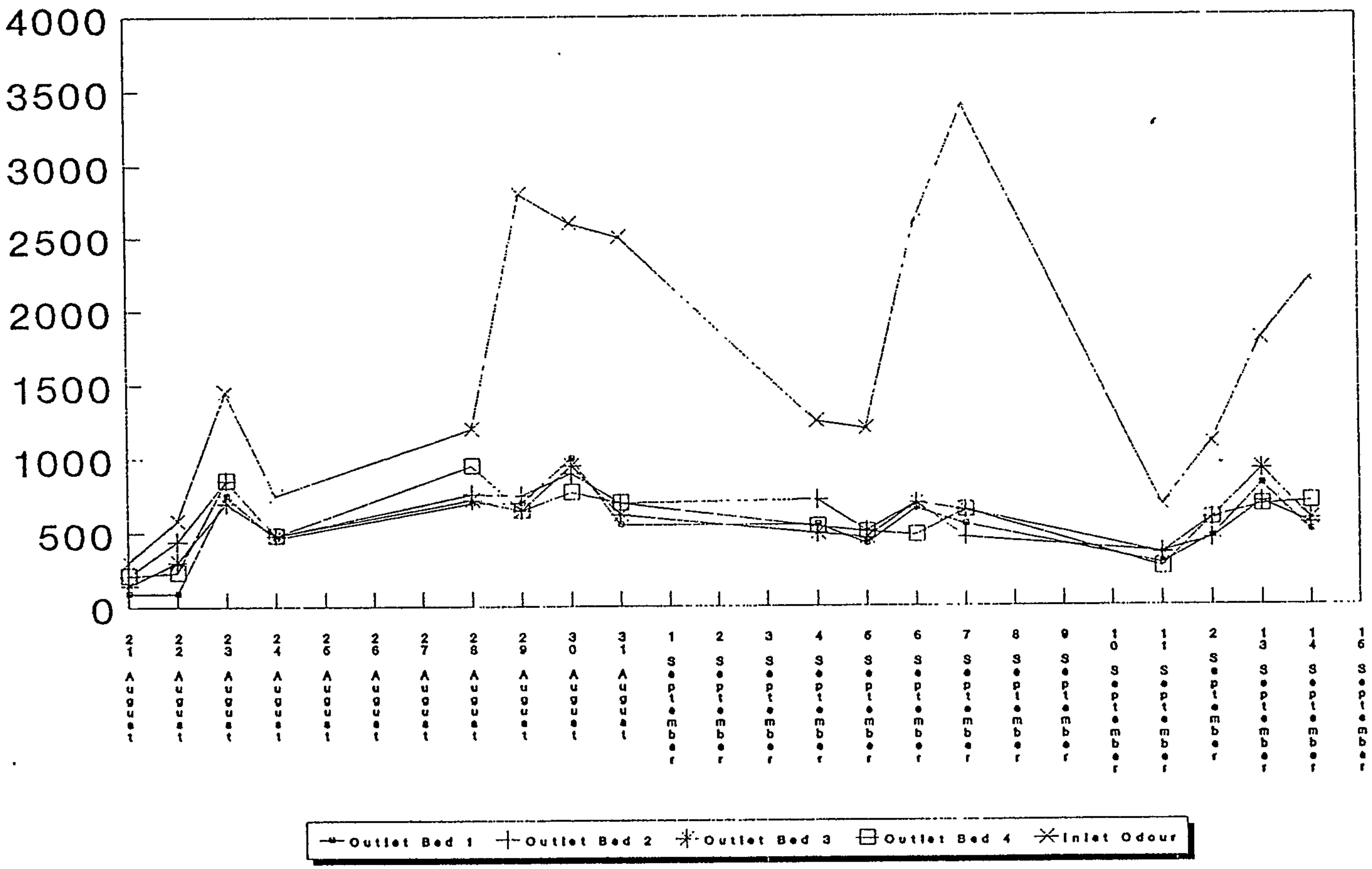



Figure 5

Graph - ProAnd Associates Australia

For filter material mean particle diameters greater than Dp =0.1mm, the values of void fraction $\varepsilon$, average olfactometric efficiency $\eta$, and average of maximum odour reduction rate ORR appear inversely proportional to the values of the mean sphere diameter Dp. For values less than Dp = 9.98 x $10^{-2}$mm, the value of $\varepsilon$, $\eta$, D and ORR appear to be directly proportional to the values of Dp.

The averaged maximum odour reduction rate of a composted pinebark bed is lower than that achieved by sandy loam while the efficiency $\eta$,max achieved by pinebark is higher than that of the sandy loam. But sandy loam is not considered as the most suitable filter material for the construction of bigger biofilters, due to the differential pressure drop across the filter bed created by the low particle diameter, and the high density.

**Conclusion**

The conclusion reached from this pilot plant study showed the composted pinebark to be the most suitable biofilter material trailed.

Information provided by this study builds up the knowledge of design parameters in order to assist in the determination of construction characteristics that lead to the optimisation of the techniques of biofiltration.

## TOWNSVILLE PILOT TRIAL

### Installation and Operation

The pilot plant was set up in April 1991 to treat the process odour stream resulting from the spiral heat exchanger used to condense the cooking vapours from a continuous day rendering machine. This odour stream is commonly known as non-condensable odours from the cooker. Traditionally the vapour is combusted in a flame incinerator to reduce odour nuisance. Occasionally this stream is treated in water or chemical scrubbers. At Townsville a flame incineration was installed. Photographs of the installation are attached (Pictures 6-9).

The pilot biofilter was connected to the non-condensable vapour line between the condenser and the flame incinerator. As shown in the attached results sheet, the crude vapour stream temperature averaged over 70°C. It was therefore necessary to dilute the stream with ambient air to achieve a inlet temperature for the biofilter of 30/35°C. It was estimated that this would require an ambient air dilution of around 5 to 1. Surprisingly this dilution had a dramatic effect on the odour component reducing the odour by an average factor of 60:1

### Filter Bed Material

As previously discussed in this report, it was decided to trial composted anaerobic crust material in the pilot plant at Townsville.

It is well known that an anaerobic pond with a solid crust cover (no cracks etc) doe not cause odour offence. Organic material in the pond will however be decomposing and giving off odorous gases. Although it is likely that conditions in most of the crust will be anaerobic it is also likely that upper layers will be aerobic. In any case the crust appears to act as a self created "biofilter" that satisfactorily treats odours caused by the anaerobic decomposition of meat waste.

A soil supplier in the Townsville area was composting the crust material for 18 months to 3 years and mixing it at 1 to 4 with loam to produce a good quality garden soil.

The composted anaerobic crust material had the following characteristics:

| | |
|---|---|
| **Density:** | **400kg/m³ approx.** |
| **Particle Size:** | **.11 mm average** |
| **Void Fraction:** | **0.60 (0.27 capillary, 0.33 free)** |
| **pH:** | **5.2** |
| **Phosphorus:** | **26 ppm** |
| **Nitrogen:** | **170 ppm** |
| **Odour:** | **Musty** |

It was therefore considered that the composted anaerobic crust was a suitable biofilter media except that is required pH adjustment. The acidity was subsequently adjusted using agricultural lime to a value around pH 6.5 to 7.

**Sampling and Odour Analysis**

The logistics involved in the analyses for odour concentration proved difficult. After searching for local and state (Qld) olfactrometric facilities and finding none it was decided to continue to have the University of NSW make the analysis. This meant sample collection in the morning, air freight to Sydney for collection next day, transport to UNSW and then analysis proceeded. This 24 hour delay in analysis is at the limit of sample stability. In particular the crude gas sample which included moisture and particulate matter was considered to be suspect.

The odour reduction apparent across the biofilter filter beds averaged 80% (range 54% to 94%). It was also quite clear from observation in the area of the biofilter test beds that outlet odours of 800-1500 odour units would be unlikely to cause an odour nuisance. The biomass material itself retained an odour when closely approached but at a distance of 1 to 2 metres the odour was imperceptible.

The filter beds took approximately two weeks to adapt to the new environment after which the odour reduction efficiency stayed in the 90% range.

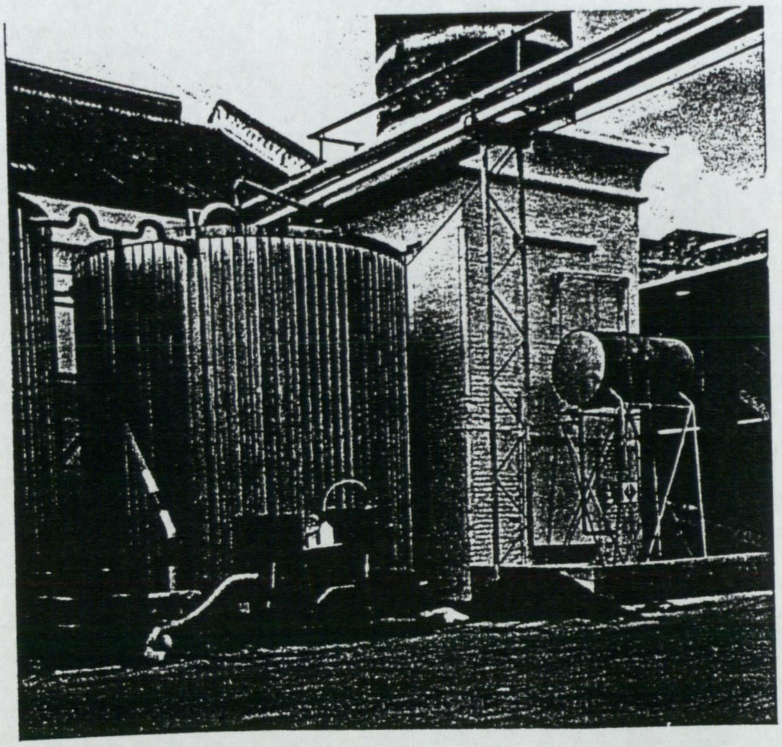
The estimated residence time in the filter bed was 38 secs.

The temperature of the odour stream was generally maintained below 35°C, however, a continuous recorder indicated the temperature occasionally reached 43/45C for short periods.

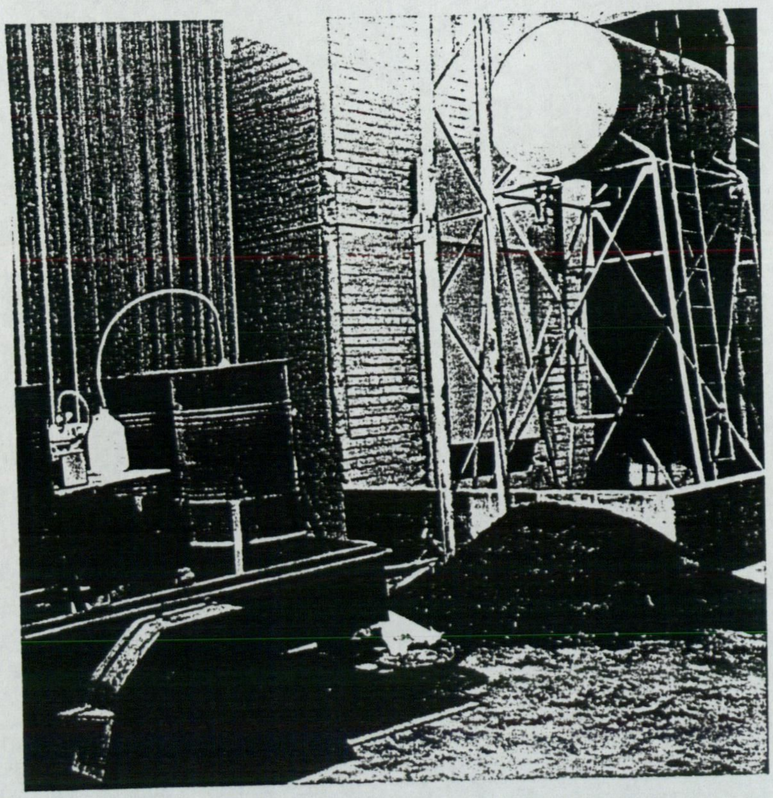
The pressure drop across the filter bed was around 8-10mm water gauge.

## Pictures 6 & 7

**Pilot Plant installed next to hot water tanks**

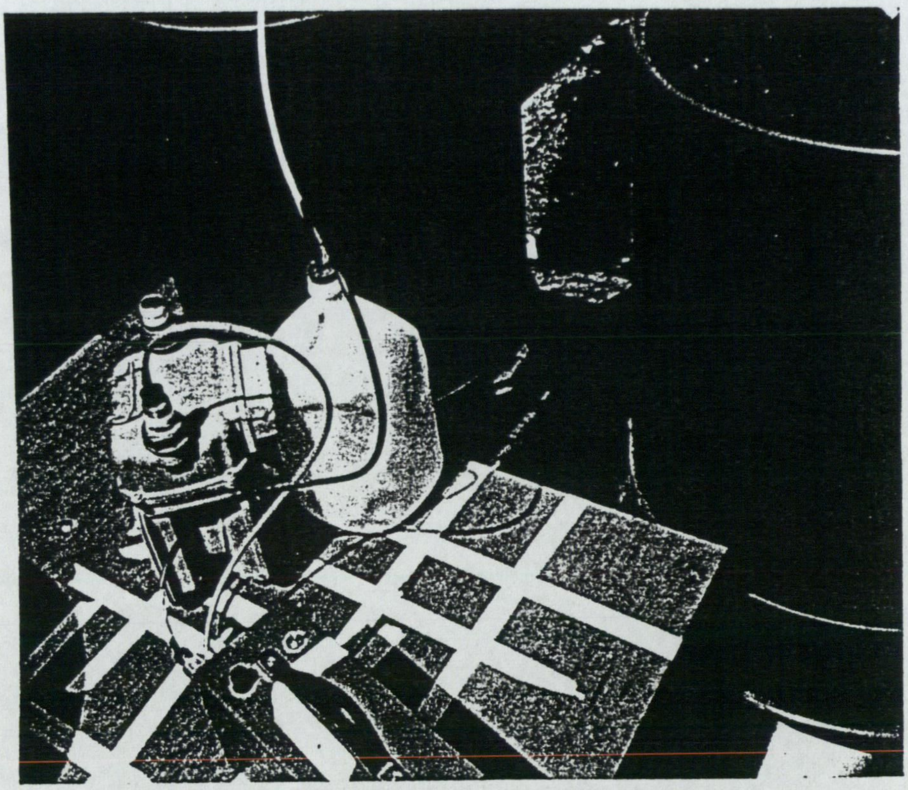


**Pilot Plant showing filter bed media in background**

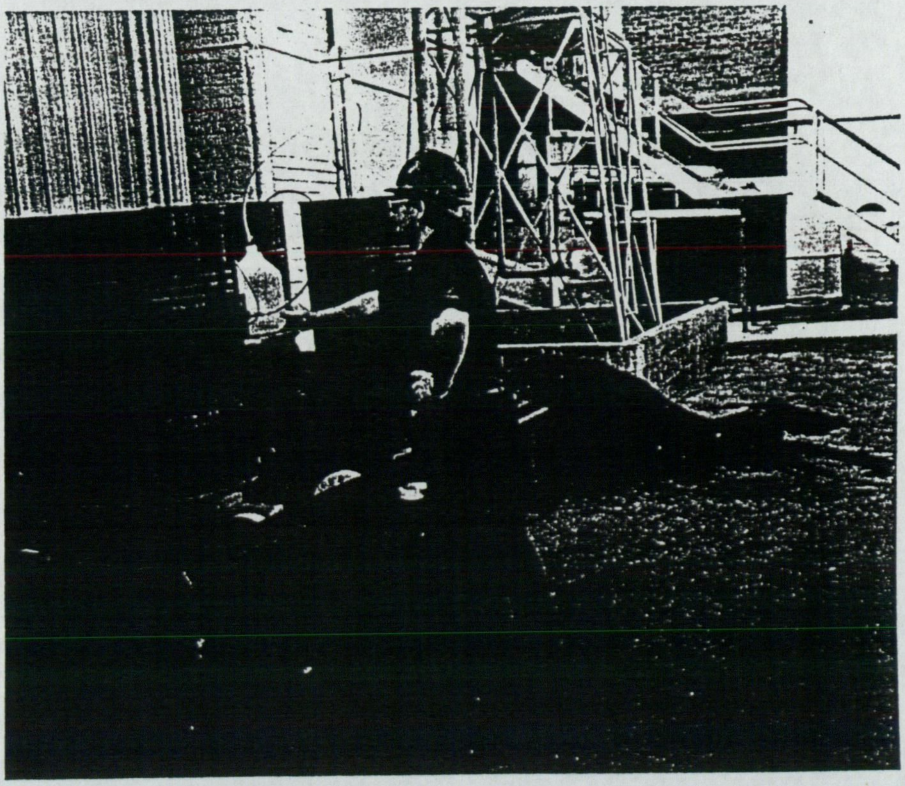


Pictures 8 & 9

**Odour collection equipment showing pump, meter and sample bottle**



**Technician collecting sample**



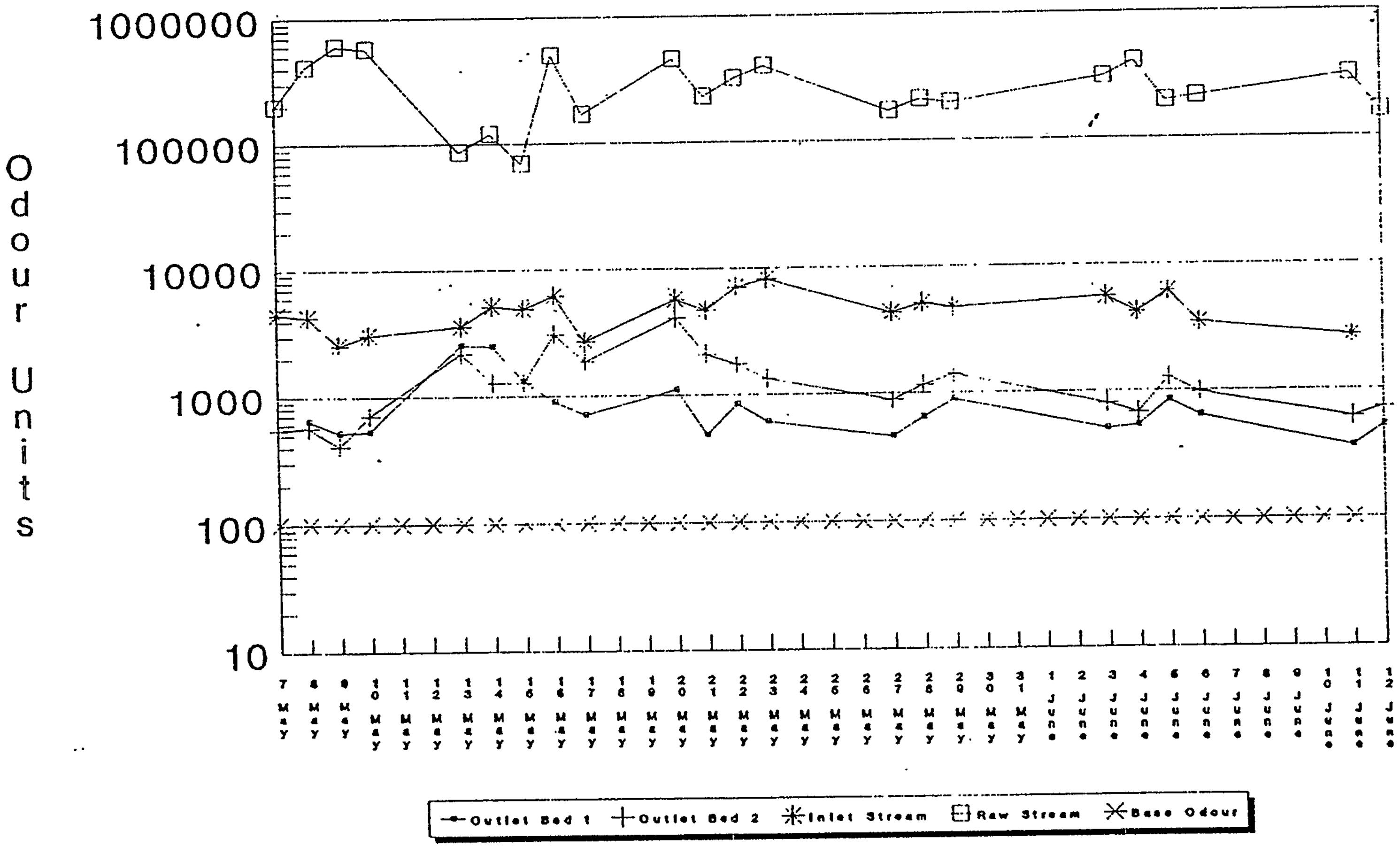
Pilot Plant Raw Data

## TOWNSVILLE BIOFILTER PILOT PLANT TEST RESULTS

| | Day | Ambient DegC | Crude DegC | Inlet 1 DegC | Inlet 2 DegC | #P 1 mm H2O | #P 2 mm H2O | Vel 1 M/sec | Vel 2 M/sec | Bed 1 OU | Bed 2 OU | Inlet OU | Crude OU | Red Eff % Bed 1 | Red Eff % Bed 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7-May-91 | 1 | | 85 | 34 | 34 | 10 | 10 | 0.1 | 0.2 | 550 | 550 | 4500 | 200000 | 90% | 90% |
| 8-May-91 | 2 | 33 | 73 | 35 | 36 | 10 | 10 | 0.2 | 0.1 | 640 | 570 | 4300 | 415000 | 87% | 89% |
| 9-May-91 | 3 | 32 | 74 | 36 | 37 | 10 | 10 | 0.1 | 0.1 | 520 | 410 | 2560 | 600000 | 84% | 88% |
| 10-May-91 | 4 | 34 | 75 | 35 | 36 | 10 | 10 | 0.2 | 0.15 | 530 | 700 | 3100 | 580000 | 86% | 81% |
| 11-May-91 | 5 | | | | | | | | | | | | | | |
| 12-May-91 | 6 | | | | | | | | | | | | | | |
| 13-May-91 | 7 | 27 | 72 | 28 | 28 | 10 | 10 | 0.1 | 0.2 | 2560 | 2200 | 5600 | 86000 | 56% | 63% |
| 14-May-91 | 8 | 28 | 70 | 28 | 28 | 8 | 8 | 0.2 | 0.2 | 2490 | 1280 | 5160 | 120000 | 54% | 77% |
| 15-May-91 | 9 | 29 | 74 | 26 | 27 | 8 | 8 | 0.2 | 0.2 | 1320 | 1270 | 4940 | 70000 | 75% | 76% |
| 16-May-91 | 10 | 31 | 70 | 34 | 35 | 8 | 8 | 0.2 | 0.2 | 900 | 3100 | 6200 | 500000 | 87% | 52% |
| 17-May-91 | 11 | 32 | 70 | 32 | 33 | 8 | 8 | 0.2 | 0.25 | 700 | 1880 | 2720 | 169000 | 78% | 35% |
| 18-May-91 | 12 | | | | | | | | | | | | | | |
| 19-May-91 | 13 | | | | | | | | | | | | | | |
| 20-May-91 | 14 | 27 | 72 | 29 | 29 | 7 | 7 | 0.2 | 0.25 | 1100 | 1110 | 5730 | 460000 | 83% | 82% |
| 21-May-91 | 15 | 32 | 70 | 32 | 32 | 6 | 6 | 0.2 | 0.15 | 490 | 2110 | 4720 | 231000 | 92% | 57% |
| 22-May-91 | 16 | 27 | 70 | 27 | 27 | 7 | 7 | 0.1 | 0.2 | 840 | 1760 | 7120 | 320000 | 90% | 77% |
| 23-May-91 | 17 | 29 | 78 | 29 | 29 | 7 | 7 | 0.1 | 0.15 | 610 | 1330 | 8210 | 400000 | 94% | 85% |
| 24-May-91 | 18 | | | | | | | | | | | | | | |
| 25-May-91 | 19 | | | | | | | | | | | | | | |
| 26-May-91 | 20 | | | | | | | | | | | | | | |
| 27-May-91 | 21 | 30 | 70 | 31 | 31 | 6 | 6 | | | 460 | 890 | 4360 | 170000 | 92% | 82% |
| 28-May-91 | 22 | | 70 | 37 | 37 | 7 | 7 | | | 640 | 1150 | 5160 | 210000 | 90% | 80% |
| 29-May-91 | 23 | | 72 | 34 | 34 | 5 | 5 | | | 890 | 1410 | 4740 | 197000 | 83% | 72% |
| 30-May-91 | 24 | | | | | | | | | | | | | | |
| 31-May-91 | 25 | | | | | | | | | | | | | | |
| 1-Jun-91 | 26 | | | | | | | | | | | | | | |
| 2-Jun-91 | 27 | | | | | | | | | | | | | | |
| 3-Jun-91 | 28 | 29 | 70 | 32 | 32 | 6 | 6 | 0.1 | 0.5 | 510 | 800 | 5600 | 310000 | 93% | 88% |
| 4-Jun-91 | 29 | 29 | 70 | 30 | 31 | 6 | 6 | 0.2 | 0.2 | 540 | 670 | 4210 | 410000 | 90% | 86% |
| 5-Jun-91 | 30 | 31 | 68 | 33 | 33 | 5 | 5 | 0.1 | 0 2 | 840 | 1270 | 6100 | 196700 | 88% | 81% |
| 6-Jun-91 | 31 | 31 | 72 | 33 | 33 | 5 | 5 | 0.1 | 0.1 | 635 | 970 | 3470 | 214000 | 85% | 75% |
| 7-Jun-91 | 32 | | | | | | | | | | | | | | |
| 8-Jun-91 | 33 | | | | | | | | | | | | | | |
| 9-Jun-91 | 34 | | | | | | | | | | | | | | |
| 10-Jun-91 | 35 | | | | | | | | | | | | | | |
| 11-Jun-91 | 36 | 29 | 72 | 31 | 31 | 0.4 | 0.4 | 0.1 | 0 2 | 360 | 610 | 2700 | 314000 | 90% | 81% |
| 12-Jun-91 | 37 | 31 | 72 | 33 | 33 | 4 | 4 | 0.1 | 0.2 | | 520 | | 160000 | | |
| AVERAGE | | 30 | 72 | 32 | 32 | 7 | 7 | 0.15 | 0.20 | 863 | 1207 | 4819 | 287850 | 84% | 76% |

# Biofilter Test Results

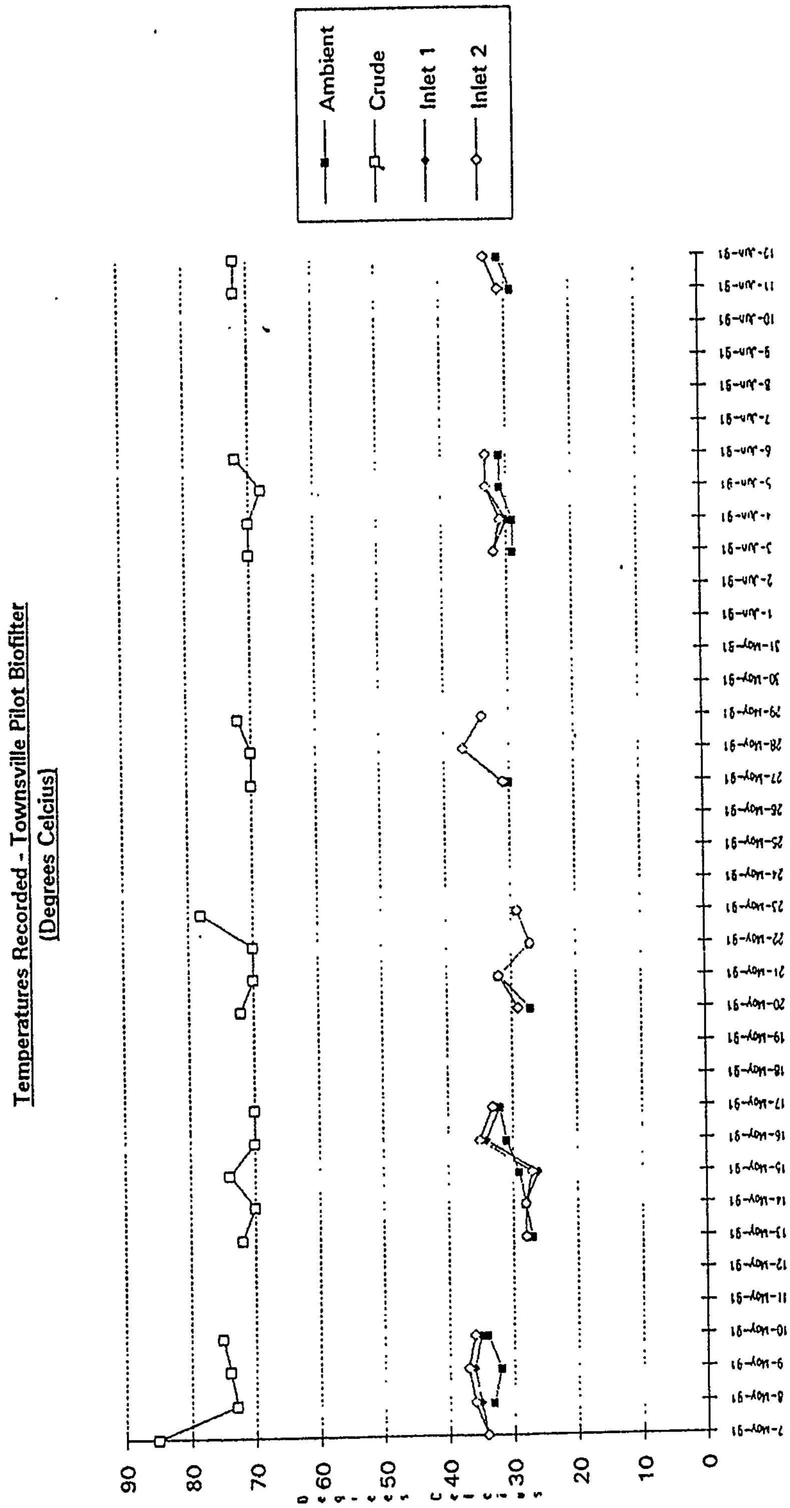
## Townsville Pilot Trial
## (May - June 1991)




Graph - ProAnd Associates Australia

Figure 6

## Figure 7


Temperatures Recorded - Townsville Pilot Biofilter
(Degrees Celcius)
Ambient
Crude
Inlet 1
Inlet 2
90
80
70
60
50
40
30
20
10
0
Degrees Celcius

### Conclusions

On the basis of this pilot trial it was assumed for design purposes that:

- A loading of $35m^3/m^2/hr$ would give a 95% odour reduction in a 1 metre deep filter bed after the biomass stabilised.

- A biofilter outlet odour of 2000 OU would not cause offence.

- That the crude odour concentration was likely to be over estimated due to inclusion of particulates in the samples and the 24 hours delay between collection and analysis. Other references suggested odour levels of 50,000 OU, 100,000 OU for non-condensable streams. 50,000 OU was more consistent with a 5:1 air dilution to control temperature into the biofilter. for design a figure of 50,000 OU would be assumed.

# 4. DEMONSTRATION BIOFILTER

## BIOFILTER DESIGN

The flow of non-condensible vapours from the continuous cooker was estimated by QME to be 300 cfm (500$m^3$/hr). This flowrate was confirmed as expected by Keith Engineering, the suppliers of the rendering system. Flow measurements using a hot wire aerometer further confirmed this flowrate.

The temperature of the non-condensable stream was 70°C. This needed to be cooled to 35°C. It was decided to install a fin coil cooling unit using refrigeration condenser water as the coolant. This unit was designed by QME and installed prior to the biofilter.

On the basis of the data available from the pilot plant the demonstration biofilter was sized at 15$m^2$. However, in the area available, and due to some concern with the actual level of inlet odour, it was decided to be conservative and double the biofilter area to approximately 30$m^2$.

It was also kept in mind that since a flame incinerator was already installed the biofilter would be able to take either all or part of the non-condensable stream by diverting the appropriate flows through a series of valves.

Copies of drawings are attached:

| | |
|---|---|
| *Drawing 13337* | Biofilter Plan, Section & Details |
| *Drawing 13338* | Coiler for Biofilter |
| *Drawing 13339* | Biofilter Layout - Plans & Schematic |

Controls included in the design of the overall system were:

1. *Temperature Control*

   Thermostatically controlled water sprays in chamber following the vapour cooling units.

2. *Humidity Control*

   Humidity sensor set to control the overhead sprays for wetting the bed.

### 3. *Filter Backpressure*

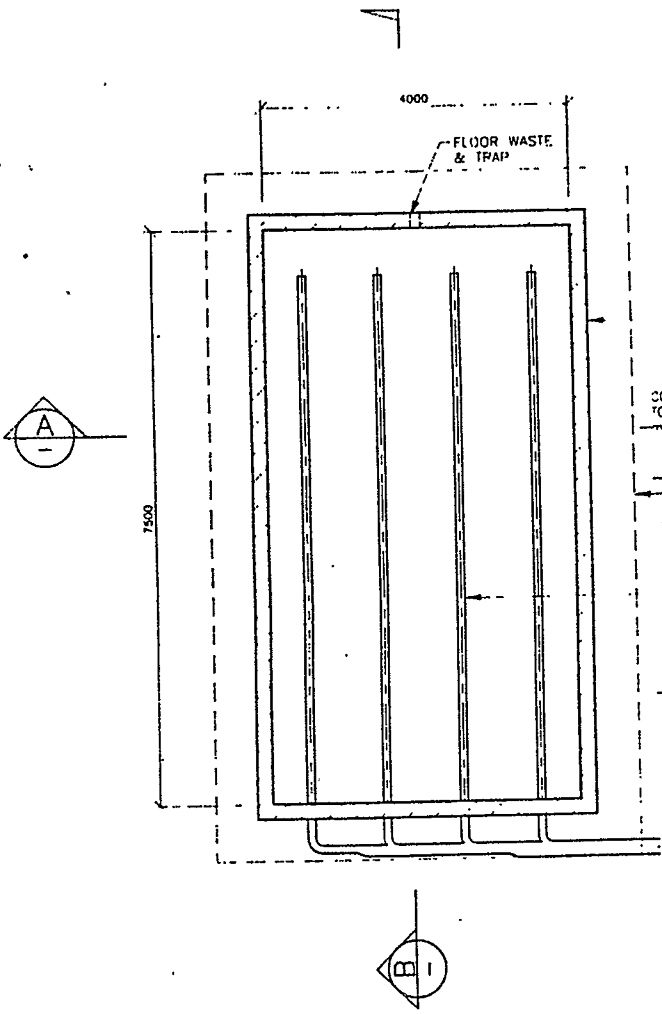
A U-tube monometer to provide a manual readout of the filter backpressure.

Drainage from the cooling chamber and from under the biofilter bed is piped into the trade waste stream and merged with condensed water from the spiral condenser.

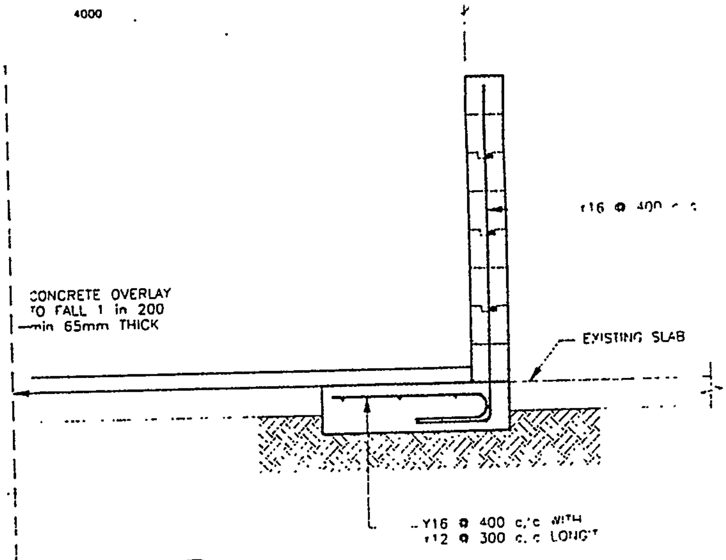
## Drawing 13337

*Refer to dawing next page*

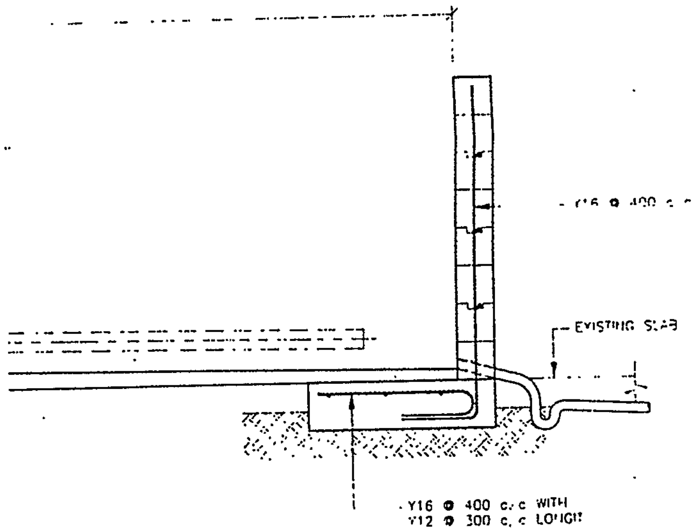
*Refer to dawing next page*

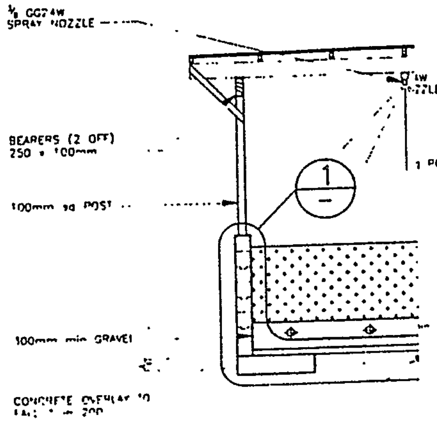



BIO-FILTER PLAN
SCALE 1:50




DETAIL 1
SCALE 1:20




SECTION
SCALE 1:50

| Amendments | Date | Name | Rev |
|---|---|---|---|
| | | | |

**THE ANGLISS GROUP**
213-219 Miller Street, North Sydney NSW 2060 AUSTRALIA
Telephone (02)922 3644 Fax (02)922 6927
W. ANGLISS INVESTMENTS PTY LTD ACN 000 130 709

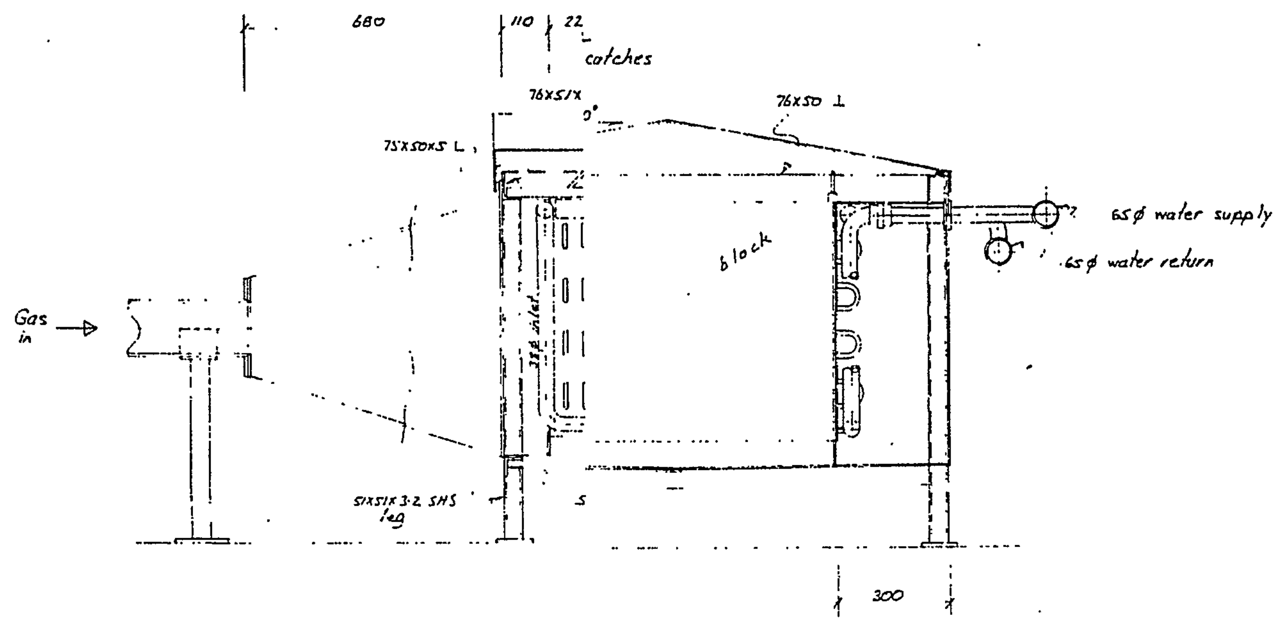
Works: Queensland Meat Export Co. Pty Ltd
TOWNSVILLE

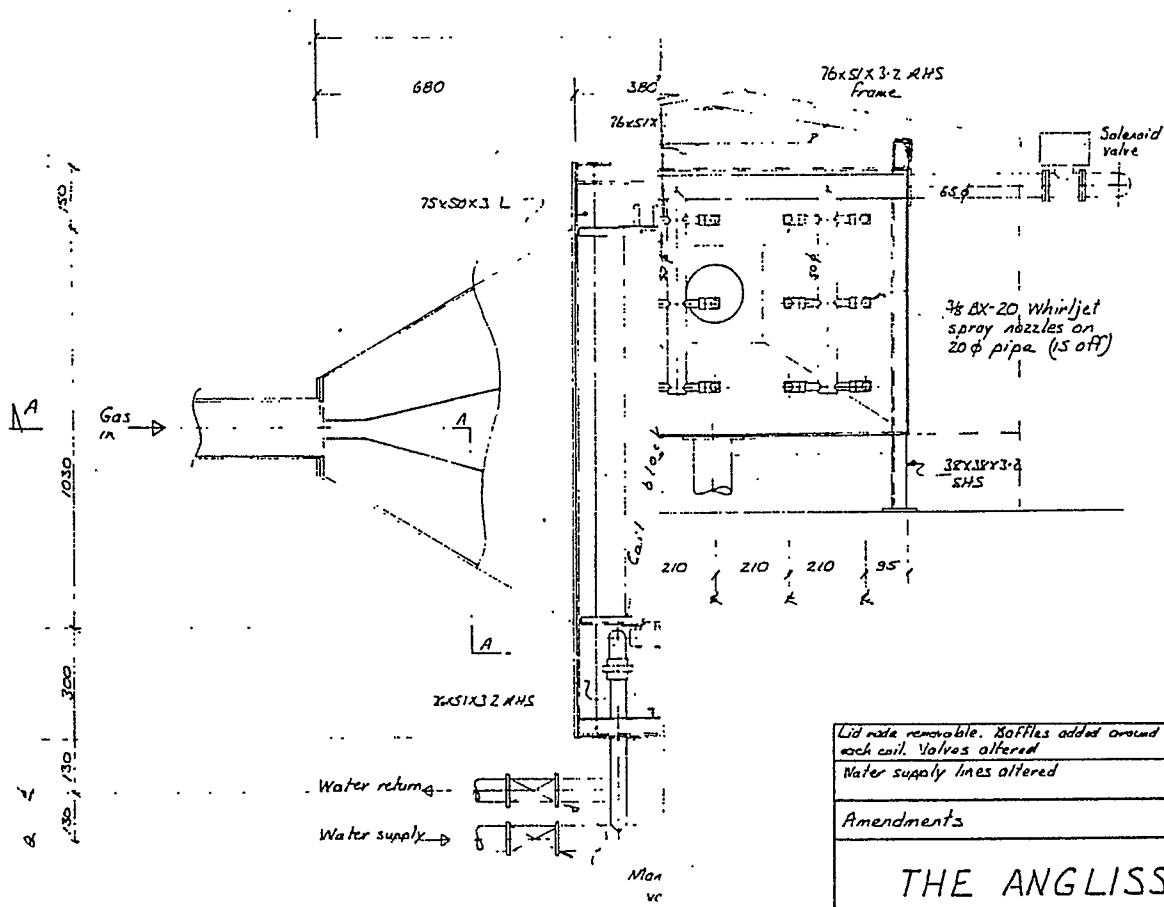
Title: PROPOSED BIO-FILTER – PLAN, SECTIONS AND DETAILS

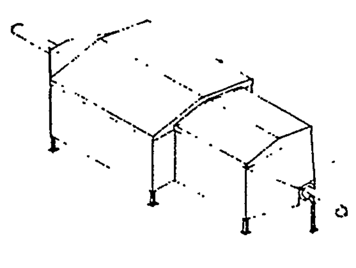
| Drawn | Date | Approved | Dwg No | Rev |
|---|---|---|---|---|
| JPL | 12MAR92 | | 13337 | |
| Scale | SHOWN | | | |

**Drawing 13338**

*Refer to dawing next page*



| | | | |
|---|---|---|---|
| Lid made removable. Baffles added around each coil. Valves altered | 3-4-92 | RJM | B |
| Water supply lines altered | 20-3-92 | RJM | A |
| Amendments | Date | Name | Rev |

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Works Queensland Meat Export Co. Pty. Ltd

TOWNSVILLE

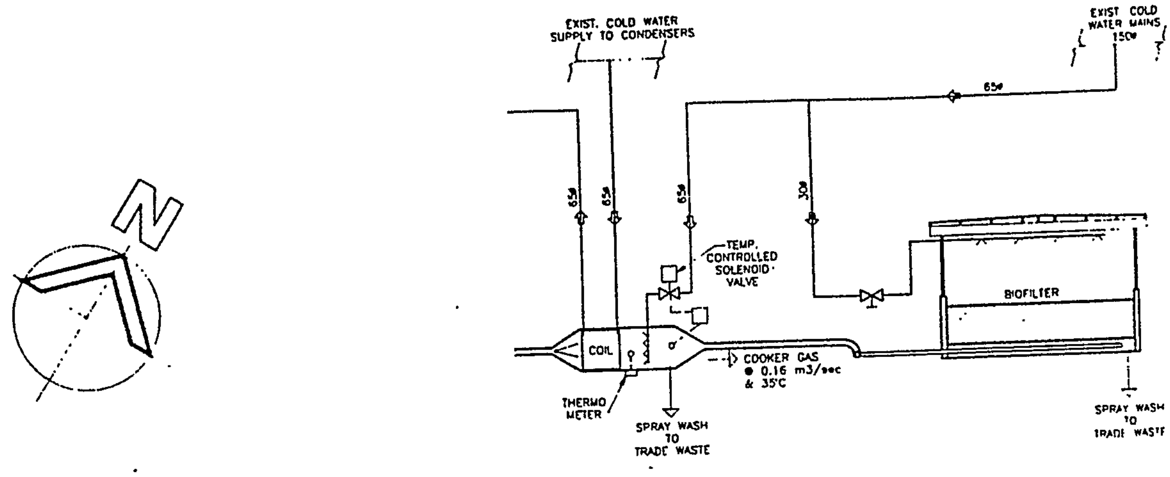
Title

GAS COOLER FOR BIOFILTER

| Drawn | Date | Approved | Drg. No. | Rev. |
|---|---|---|---|---|
| R.J.M | 18-3-92 | | 13338 | B |
| Scale: 1:10 | | | | |

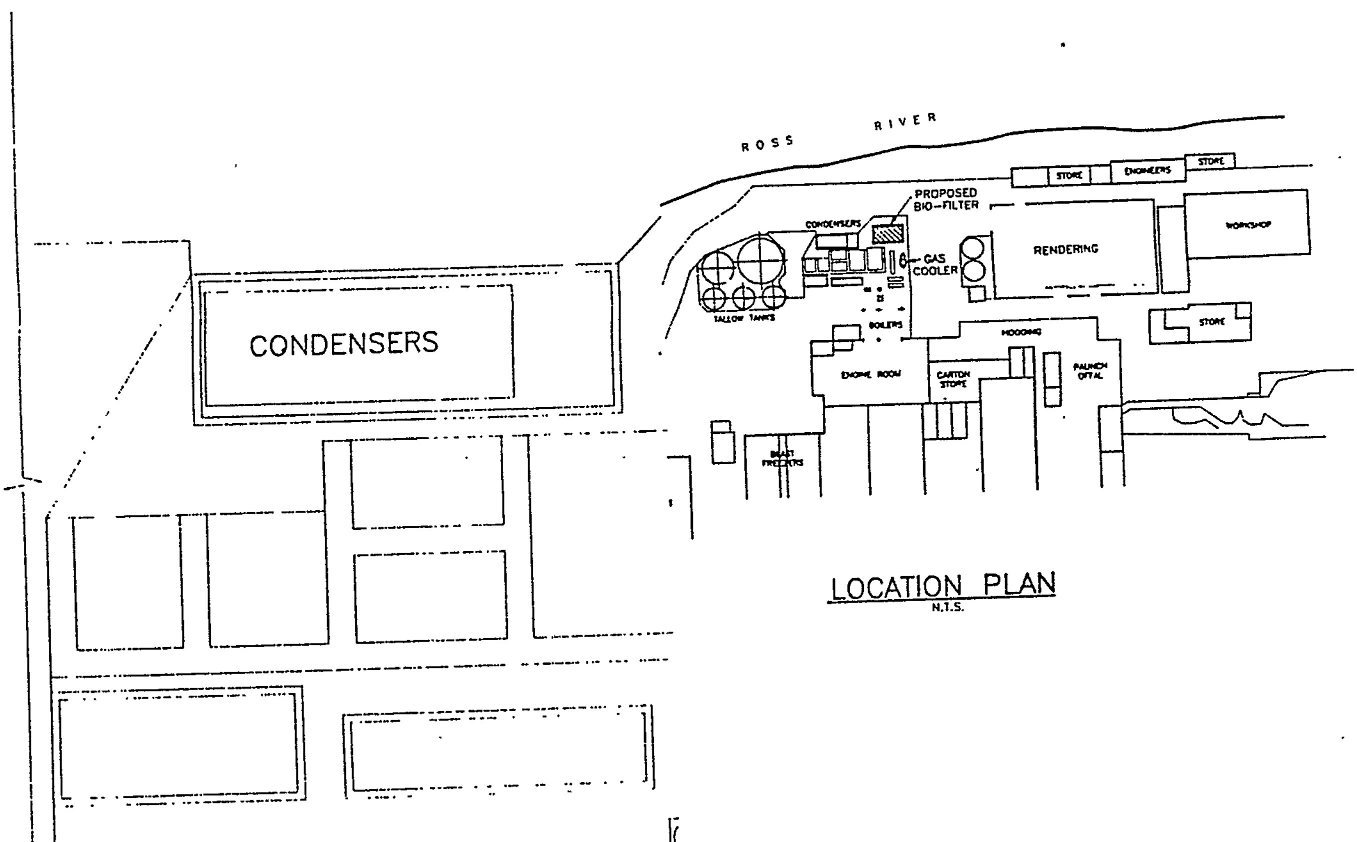
**Drawing 13339**

*Refer to dawing next page*




## R SYSTEM SCHEMATIC

N.T.S.




## LOCATION PLAN

N.T.S.

| Amendments | Date | Name | Re |
|---|---|---|---|

**THE ANGLISS GROUP**

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W. ANGLISS INVESTMENTS PTY LTD ACN 000 130 7'9

Works: Queensland Meat Export Co. Pty Ltd
TOWNSVILLE

Title: PROPOSED BIO-FILTER LAYOUT – PLANS AND SCHEMATIC

| Drawn | Date | Approved | Dwg No | Re |
|---|---|---|---|---|
| JPL | 19MAR92 | | 13339 | |
| Scale 1:100 | | | | |

## BIOFILTER CONSTRUCTION AND OPERATION

The demonstration biofilter was constructed during 1992 and actually operated for a short period (week) prior to the end of the production season at QME Townsville. The short operation during this period gave confidence to the ability of the biofilter to treat 100% of the non-condensable vapour stream.

The 1993 production season commenced at QME in late April, 1993. The filter bed had in the meantime dried out. The filter bed was turned and then moistened using the overhead sprays. With this preparation the biofilter appeared to take 1 to 2 weeks to settle down and provide good odour reduction. Since commencing in April, 1993, and until this report (October 1993) the biofilter has taken 100% of the non-condensable odours and the flame incinerator has been blanked off.

The biofilter has therefore operated for six months without any major problems.

The humidity sensor and control system did not work properly and has been removed. This is primarily due to problems with the sensor. From discussions on other operating biofilters, this is a common problem. The filter bed is monitored daily and if drying is observed the overhead wetting sprays are manually turned on.

A short system failure occurred when the condensate drain blocked causing build up in the vapour line, eventually flooding and stalling the fan unit. It is important that good draining is allowed in such units as the vapour stream is saturated and any cooling causes condensation. This saturated vapour stream is, of course, beneficial to the operation of the biofilter.

Since commencing operation the filter has required no maintenance (except for the fan failure) and no fouling of the cooling fins has been observed.

The normal operation of the unit is:

| | |
|---|---|
| **Temperature of Vapour Stream:** | 35°C (38°C maximum) |
| **Filter Backpressure:** | 10/12 mm $H_2O$ |

With the flame incinerator in operation it was common to receive 10 to 12 complaints per season of odour nuisance. Since the biofilter has been installed (almost a full season) there has been less than half the usual number of complaints. Complaints may of course be due to other odour sources around the plant.

Observation by a number of QME staff members is that although you can smell an odour immediately over the surface of the filter media, once the observer is 3 to 4 metres from the filter structure any odours are indistinguishable from other background odours normally associated with a meatworks.

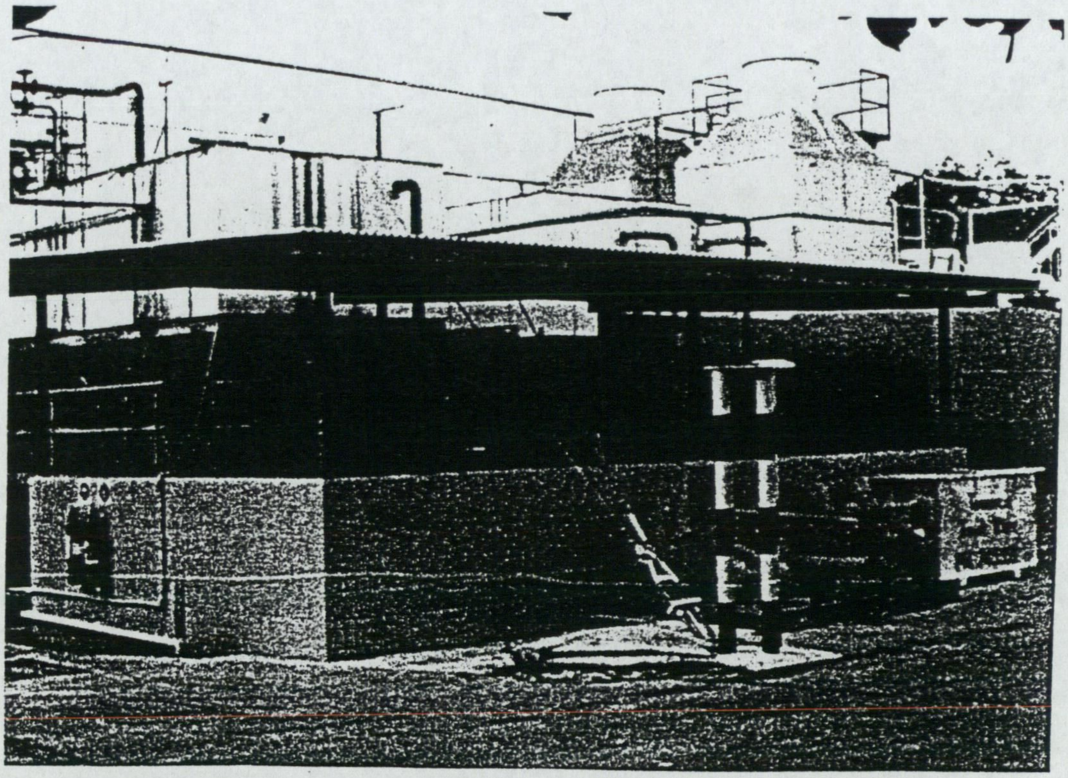
Personal observation is that the filter media has a significant attached odour that does not travel.

Regional Officers of the Queensland Department of Environment and Heritage, who are responsible for air pollution, have observed the biofilter installation in operation and are reportedly very happy with its performance.

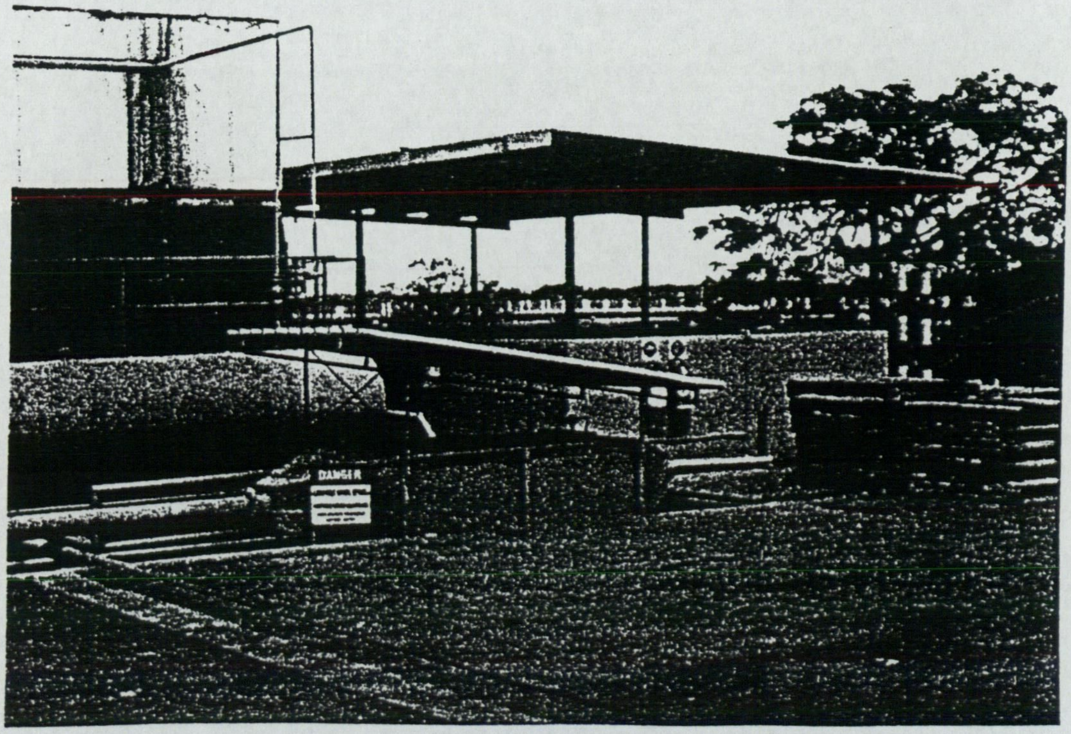
Photographs of the biofilter are attached.

**Pictures 10 & 11**

Demonstration Biofilter

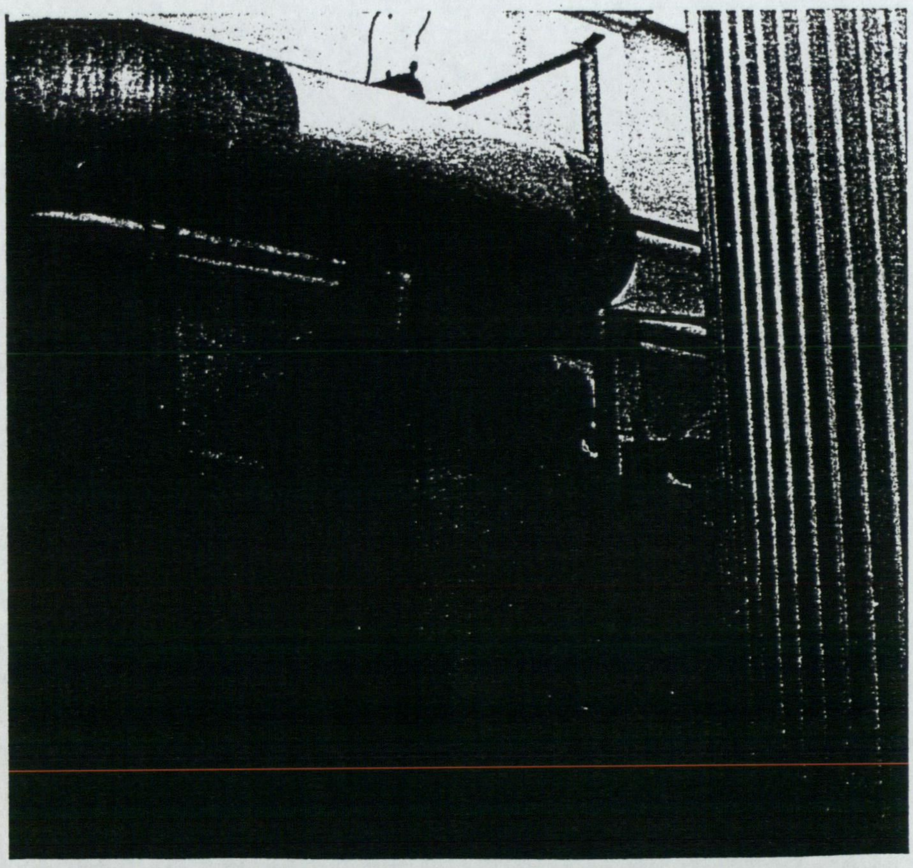


Vapour cooling unit in foreground and biofilter in background

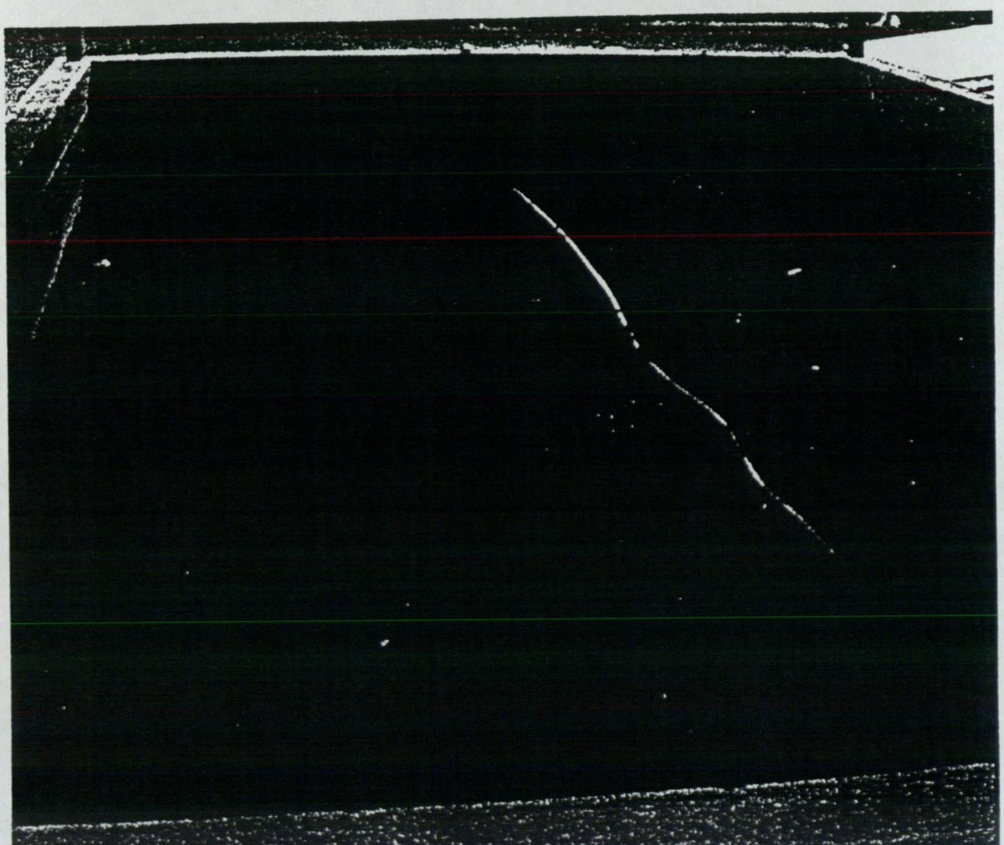


## Pictures 12 &13

Spiral condensor



Biofilter surface showing plant growth



## ODOUR REDUCTION IN DEMONSTRATION BIOFILTER

During October 1993 odour samples were taken before and after the demonstration biofilter to establish the performance of the unit.

The samples were taken on four days of the week over two weeks and despatched to UNSW for analysis. The results are provided in the attached charts.

The first observation is that the crude odour after cooling and removal of particulate matter was indeed in the range of 30,000 OU to 60,000 OU. This finding emphasises the need to get "clean" odour samples and to analyse the samples promptly. Special care needs to be taken when sampling high temperature (above ambient), saturated vapour streams.

The second observation is that even though the odour measured off the top of the biofilter averaged over 3,000 OU this level was not causing any nuisance. The samples for analysis were taken by placing a glass funnel loosely on the surface of the filter bed. It would appear to be appropriate to take samples from around the filter rather than from the surface. This would, however, require a sophisticated sampling and analysis program that included allowance for background odours. Such a program was beyond the finances available for this project.

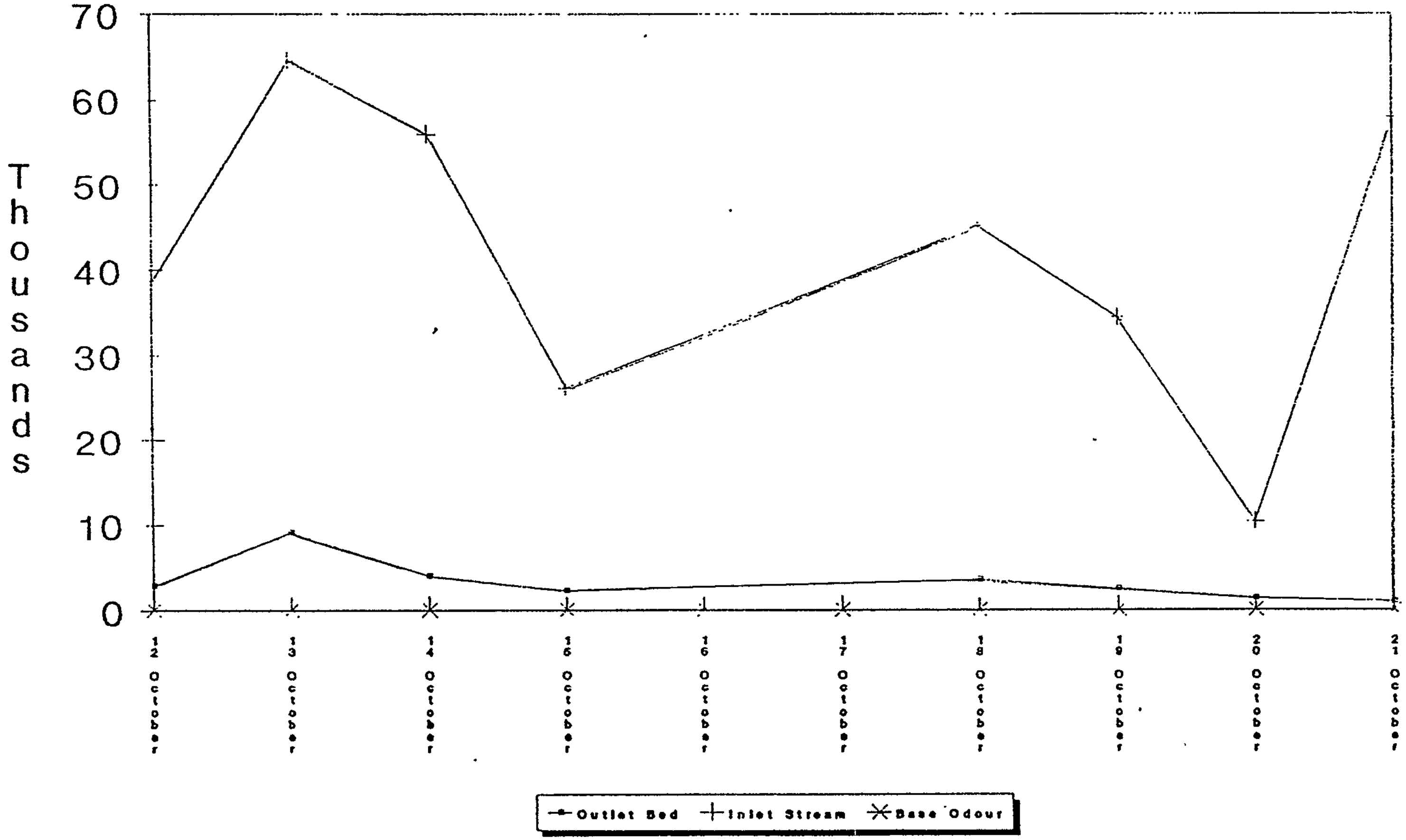
The results of the odour monitoring of the demonstration biofilter show average odour reduction of just over 90% (91%) varying in the range 80%-98%.

The high reading for outlet odour observed on 13th October may be an anomaly, however, it is important to note that during the two weeks of sampling no unusual occurrences or odours were observed.

The general consensus from meatworks personnel is that throughout the processing season the biofilter outperformed the normal operation of the afterburner.

# Biofilter Test Results

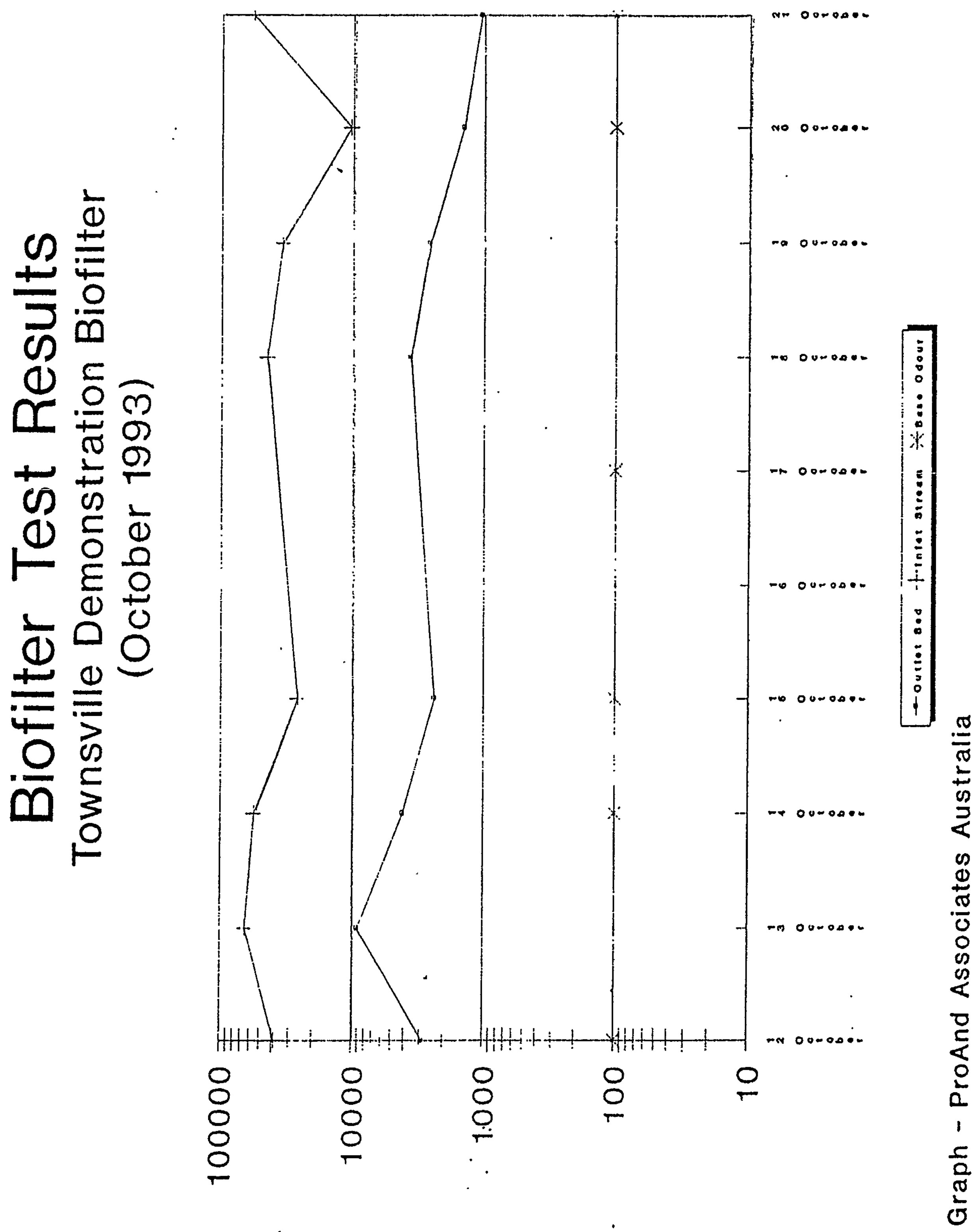
## Townsville Demonstration Biofilter
## (October 1993)




Graph - ProAnd Associates Austra

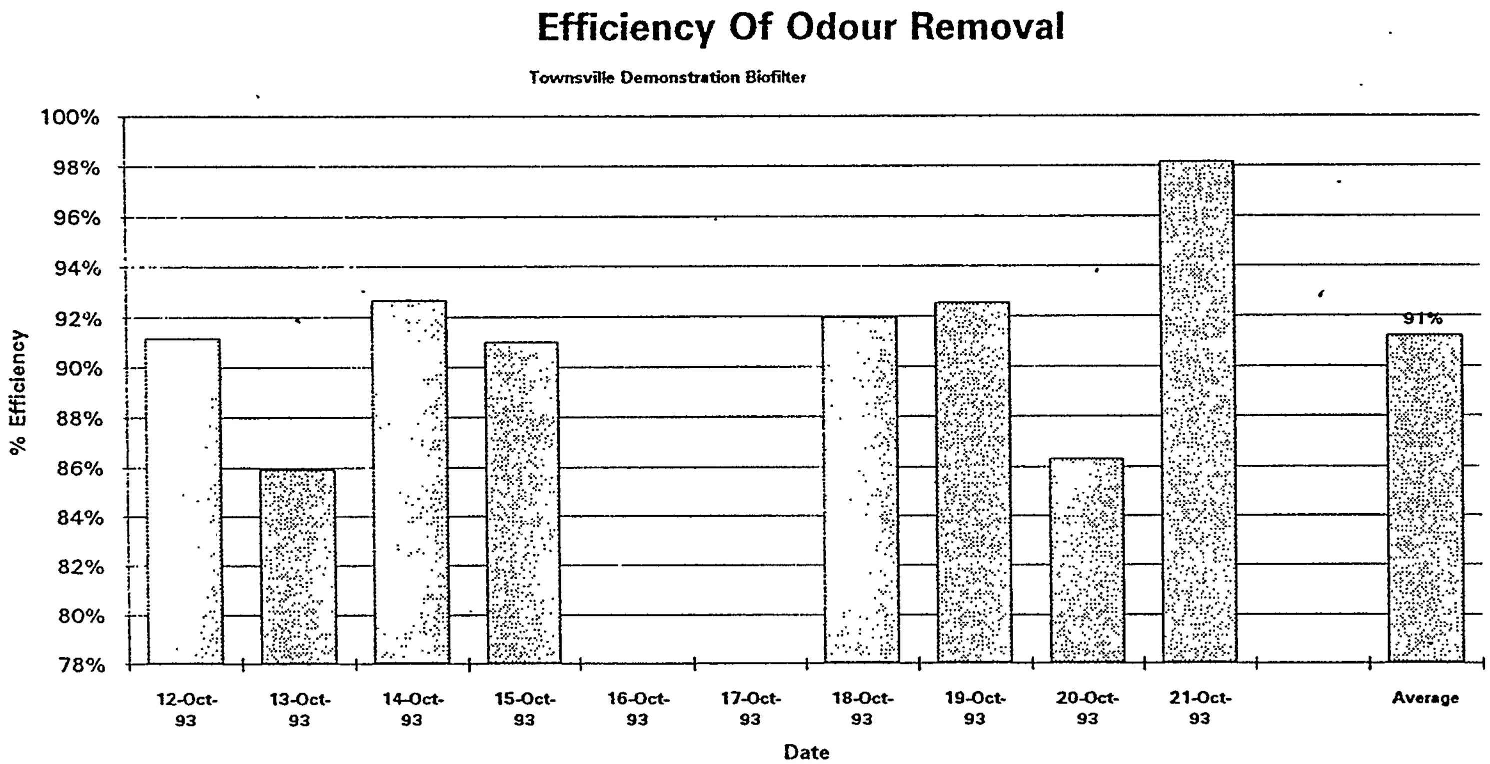
Graph 1
Townsville Demonstration Biofilter
October 1993

**Graph 2**
**Townsville Demonstration Biofilter**
**October 1993**



**Townsville Demonstration Biofilter Performance Results**

| Date | Efficiency | Inlet | Outlet |
|---|---|---|---|
| *12 October 93* | 91% | 32768 | 2896 |
| *13 October 93* | 86% | 64536 | 9096 |
| *14 October 93* | 93% | 55904 | 4096 |
| *15 October 93* | 91% | 26064 | 2344 |
| *16 October 93* | | | |
| *17 October 93* | | | |
| *18 October 93* | 92% | 45056 | 3620 |
| *19 October 93* | 93% | 34441 | 2560 |
| *20 October 93* | 86% | 10426 | 1425 |
| *21 October 93* | 98% | 57926 | 1063 |
| *AVERAGE* | **91%** | **40890** | **3388** |




Graph 3
Townsville Demonstration Biofilter
Efficiency of Odour Removal

## ECONOMIC ANALYSIS

The whole installation including the cooling unit had a capital cost in the vicinity of $45,000. This does not include the induction fan which was already in place servicing the flame incinerator. This capital cost contains an estimate for the cooling unit as a number of otherwise redundant parts were used (e.g. fin coils).

The only operating cost for the biofilter is for fan power which is necessary for any odour control system including flame incineration. In fact the fan used was the old afterburner fan.

QME reports that the fuel cost for the afterburner averaged $60,000 per season, and required $5,000 per annum repairs and maintenance.

The simple economic analysis is to look at the payback period for the biofilter to replace the afterburner.

**Payback Analysis**

*Capital Cost Biofilter*

| | | |
|---|---|---|
| Biofilter | $25,000 | |
| Cooling Unit etc | $15,000 | |
| **Total** | | **$40,000** |

*Annual Savings*

| | | |
|---|---|---|
| Afterburners Fuel | $60,000 | |
| Afterburners R&M | $5,000 | |
| **Total** | | **$65,000** |

*Payback Period*

$$= \frac{\text{Capital Cost}}{\text{Annual Savings}} \times 12 \text{ months}$$

$$= \frac{40{,}000}{65{,}000} \times 12 \text{ months}$$

$$= 7.4 \text{ Months}$$

The payback on replacing the afterburner with the biofilter in this instance is estimated to be less than 8 months.

In a new installation the advantage of the biofilter is even greater as the capital cost of the afterburner would be around twice the capital cost of a biofilter.

## 5. CONCLUSION

This project involved three phases and a number of conclusions and observations can be made about each stage.

### ROUSE HILL PILOT TRIAL

- This trial involved four filter bed materials:

  *Sandy Loam*
  *Composted Pine Bark*
  *Mushroom Compost*
  *Peat/Sandy Loam/Ash*

- The results indicated that the difference in performance of the materials was not dramatic, however, the composted pine bark and sandy loam performed the best.

- The high pressure drop across a soil (sandy loam) bed would cause composted pinebark to be preferred.

- Results and observations from this trial was used to assist and advise other renderers on the benefits and design needs of biofilters.

### TOWNSVILLE PILOT TRIAL

- That composted anaerobic crust performed well as a biofilter material.

- Once the pilot biofilter had adjusted to the environment then odour reduction rates of better than 90% could be achieved on a concentrated odour sourced from the non-condensable vapour stream off the condensor.

- The lack of local analytical resources for odour analysis caused delays to occur between sampling and analysis (samples had to be transferred from Townsville to Sydney). It is considered that this caused odour levels to be unstable particularly in the more concentrated samples.

- The outlet odour concentration was considered to include considerable background odour from the filter bed material.

## TOWNSVILLE DEMONSTRATION UNIT

- For design purposes the following data was assumed:

  - A loading of $35m^3/m^2/hr$ would give a 95% odour reduction in a 1 metre deep filter bed after the biomass stabilised.

  - A biofilter outlet odour of 2,000 OU would not cause offence.

  - That the crude odour concentration was likely to be over estimated due to inclusion of particulates in the samples and the 24 hours delay between collection and analysis. Other references suggested odour levels of 50,000 to 100,000 OU for non-condensable streams. 50,000 OU was more consistent with a 5:1 air dilution to control temperature into the biofilter. For design a figure of 50,000 OU would be assumed.

- Though the design was based on optimistic parameters, the layout would enable the biofilter to treat all or part of the odour stream.

- The performance of the biofilter from odour monitoring and odour complaint viewpoints has been satisfactory.

- Concern over the two aspects of odour analysis, stability between collection and sampling, and background odour from filter material continue.

- The capital cost of a biofilter can be recovered from the cost of operating an afterburner in a period of less than 8 months.

A biofilter can be designed to specifically treat non-condensable odours which result after the condensation of continuous dry rendering vapours.

Economic analysis shows that the biofilter had a payback period of less than 8 months as a replacement for the currently installed afterburner.

More information is required on the appropriate outlet odour concentration for biofilters and the ability of the odour to dissipate. It appeared that odour levels over 3,300 OU did not cause a nuisance in this study.

# APPENDIX 1

*References & Abstracts*

## 1. Biofilters and their application to the Australian Meat Industry.

*D R Smith - Unpublished.*

This document draws heavily on the Technical Note written by MS Bird (see reference 16). It also contains a listing of installations in Australia including:

- Gilbertsons Greenham - Treatment of odours from waste water discharge point.
- Hazeldene Poultry - Treatment of rendering plant drier odours.
- Petfood Plant - Drier odour treatment.

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## 2. Biofiltration - A New Technology in air Pollution Control

*A Dragt et al*
*1987 Air Pollution Conference Proceedings*
*pg 545 - 554*


Summary

In the past three years, biofiltration in the Netherlands has developed from a technique for odour abatement in sewage treatment to an important technique for air pollution control. The principles of biofiltration are based on the aerobic conversion (oxidation) of pollutants under the influence of micro-organisms (mostly bacteria). The micro-organisms are attached to a carrier based on organic material, such as compost or peat. Biofiltration has been applied for over 15 years as a technique for the treatment of odorous gases from sewage treatment plants in some western European countries. Disadvantages of this traditional so-called compost filter are its large space requirement and its limited applicability. Recent research has resulted in a completely new filter concept and process design in which these disadvantages are minimised. The filter was tested in a variety of industries and for a large number of different pollutants in about sixteen pilot plant investigations.

The test results show that pollutants, such as alcohols, ketones, aldehydes, esters, hydrogen sulphide, ammonia, styrene, toluene, acrylonitrile, dichloromethane and many other odorous components can be eliminated with high elimination capacities.

## 3. Biofiltration: An Innovative Air Pollution Control Technology for VDC - Emissions

*Gero Leson & Arthur M Winer,*
*Journal of Air & Waste Management Association*
*Page 1045 Volume 41 No.8*
*August 1991*

**Abstract**

Biofiltration is a relatively recent air pollution control (APC) technology in which off-gases containing biodegradable volatile organic compounds (VOC) or inorganic air toxics are vented through a biologically active material. This technology has been successfully applied in Germany and the Netherlands in many full-scale applications to control odours, VOC and air toxic emissions from a wide range of industrial and public sector sources. Control efficiencies of more than 90 percent have been achieved for many common air pollutants Due to lower operating costs, biofiltration can provide significant economic advantages over other APC technologies if applied to off-gases that contain readily biodegradable pollutants in low concentrations. Environmental benefits include low energy requirements and the avoidance of cross media transfer of pollutants. This paper reviews the history and current status of Biofiltration, outlines its underlying scientific and engineering principles, and discusses the applicability of Biofilters for a wide range of specific emission sources.

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## 4. Biofiltration: Organic Compound Removal from Waste Gases

*P L Voight & C Van Lith*
*Clean Air Technique*
*145 Errol Street*
*North Melbourne Aust 3051*
*Unpublished*

**Abstract:**

In recent years with the increased emphasis on environmental issues, great advances have been made in the area of biofiltration.

From its inception as a method o controlling odorous emissions from sewerage and composting plants, the technique has gained a high level of sophistication allowing it to be effectively used in a large number of applications. Commercialisation of the technique has seen over 20 full scale plants built for controlling the emissions of many potentially harmful compounds.

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## 5. Biological Odour Control in West Germany

*R A Simpson*
*Environmental Health*
*Page 86 April 1983*

**Abstract**

An account of a visit to Germany in October 1982 to investigate biological filters developed there to remove odour from exhaust air at some animal waste processing plants, (referred to hereafter as AWPP), to investigate filter applications, efficiency and whether the principle could be applied in Great Britain where chemical methods of odour absorption are widely used. Visited AWPPs in North and South Germany and also visited Munich University to meet a specialist in agricultural engineering who was involved in initial steps eight years ago to develop the use of natural filter media to deal with odour problems from animal rearing units and later, AWPPs.

It was evident that these biological filters ("bio-filters") are cheaper to build than the present generation of chemical washers and are simpler to maintain and run. All installations had a high degree of efficiency which only varied slightly with age and type of filling material. In principle no reason was seen why this form of odour control could not be widely adopted in Great Britain. The report (of which this is an abbreviated and updated version), has been accepted by the European Commission for translation within the EEC.

## 6. Biological Treatment of Odorous Air

*Richard D Pomeroy*
*Journal Water Pollution Control*
*Federation Page 1541, Vol 54, No.12*
*December 1982*


**Abstract**

The problem of purifying polluted air is similar to the problem of treating polluted water. In the last century, efforts to purify waste waters were confined to sedimentation, straining and a variety of chemical processes, mostly of limited effectiveness. Then it was realised that many microbes, particularly bacteria and fungi, are able to extract organic nutrients from water even at very low concentrations, and thus to purify the water. This is, in fact, a major purification process operative in nature, second only to distillation in providing the terrestrial ecosystem with a clean water supply. In water pollution control technology, the physical and chemical process are still important but in most treatment plants, major reliance is now placed on biological methods.

Microbes - and plants, too - play a role in the natural purification of air. The gaseous decomposition products of buried organic matter are usually oxidised in the overlying soil. In fact the most common application, by humans and even by some animals, of biological deodorisation is the burying of the odorous material. This includes the percolation of foul waste waters in underground pits and trenches.

Smith et al showed the capability of soil to sorb $SO_2$, $H_2S$, CH, SH, CO, $C_2H_2$ and $C_2H_4$. The sulfur gases are destroyed quite rapidly - the others more slowly. It was shown that microbial action is an important factor. They conclude that "soil is an important sink for gaseous pollutants and its potential for purification of polluted air deserves attention".

## 7. Biological Waste Air Purification - Biofilters

***VDI 3477 - December 1984***

***This document is the German engineering guideline for the design and operation of Biofilters in Germany.***

The Guideline deals with the cleaning of waste gas/waste air containing gaseous air pollutants and/or aerosols of low concentrations, particularly odours. The decomposition of pollutants is carried out in an aerobic process by micro-organisms settled on solid carrier substances.

The Guidelines gives a survey of the applicable solutions as well as of the pertinent fundamentals and evaluation criteria that are necessary for an appropriate design.

The process descriptions given in the Guidelines are examples of the application of biological waste air cleaning plants, some of which are also run as pilot plants. Apart from these applications, Biofilters have also been successfully tested in the following fields:

sewage plants, slaughterhouses, gelatine plants, blood meal factories, fact rendering plants, tobacco processing, sugar-beet drying, barm drying, oil reclaiming.

The Guidelines does not lay down the state of the art for particular fields of application; each individual case requires weighing of the planned measure in this respect, the following technical and economic criteria having to be taken into consideration:

- efficiency regarding the limitation of emissions,
- plant safety,
- plant availability,
- lifetime of the plant,
- reactions during start-up and shut-down of the plant,
- energy consumption,
- capital expenditure and operating costs,
- space requirement,
- generation of new emission and shifting of emissions onto other media (eg. from air to water).

| | Carbage Composting Plant | Rendering Plant | Rendering Plant | Poultry excrement drying plant | Animal fattening - pigs |
|---|---|---|---|---|---|
| *Filter material* | Garbage compost | Carbage compost | Fibrous peat/ spruce brushwood | Fibrous peat/ spruce brushwood | Fibrous peat/ spruce brushwood |
| *Volumetric crude gas flow* | 26,000 m³/h | 60,000 m³/h | 100,000 m³/h | 20,000 m³/h | 11,000 m³/h |
| *Filter area* | 264 ²m | 600 ²m | 800 ²m | 200 m² | 39 m² |
| *Filter bed/height of layer* | 1 m | 1 m | 0.8 m | 0.5 m | 0.4 m |
| *Weight per volume unit* | 0.5 to 0.6 t/m³ | 0.5 to 0.6 t/m³ | 0.4 t/m³ | 0.4 t/m³ | 0.4 t/m³ |
| *Void fraction of filter material* | 80 to 87% | 80 to 87% | 75 to 90% | 75 to 90% | 75 to 90% |
| *Mean retention time of gas in filter layer* | 27 s/42 s (divided filter area) | ≥28 x | ≥15 s | ≥10 s | ≥5 s |
| *Filter area load/ spec. air throughrate* | 100 m³ m² h | 100 m³/m² h | 125 m³/m² h | 100 m³/m² h | 282 m³/m² h |
| *Differential pressure in filter layer* | 700 to 1,300 Pa | 800 to 1,200 Pa | 150 Pa | ≤100 Pa | 40 to 70 Pa |
| *Moisture cont. of filter material (depending on temperature and moisture of waste gas)* | 50 to 60% | 50 to 60% | 50 to 70% | >75% | 25 to 75% |
| *pH value* | 7.2 | 7.2 | 3.5 | 3 to 4 | 3 to 4 |
| *Crude gas temperature* | 28°C | 30°C | 15 to 30°C | 35 to 55°C | 15 to 32°C |
| *Cleaning efficiency* | approx 96% | approx 92% | approx 93% | approx 95% | approx 90% |
| *Spec. energy consumption:* *a) water (p.a.)* | 0.4 to 0.7 m³ / m².a | 05 to 08 m³ / m².a | ∅ 1.25 m³ / m².a | ./. (fully satur. vap.) | 0.3 to 0.6 m³ / m².a |
| *b) current* | 1.5 to 2kWh/ 1,000 m³ (including exhaust air system) | 1.5 to 2kWh/ 1,000 m³ (including exhaust air system) | 0.08/0.44 kWh/ 1,000 m³ (with pre-separator and exhaust air system) | ./. (filtering plant charged by drier fan) | 522 kWh/ (a.1,000 m³ /h) (incl. pre-separator and sty ventilation system) |
| *Capital expenditure (level) (depending on the filter size)* | 250 to 350 DM/ m² (1979) without fan | 250 to 350 DM/m² (1979) incl. fan | 700 DM/m² (1981) incl. preseparator and fan | 790 DM/m² (1980) incl. preseparator | 258 DM/m² (1980) incl. preseparator |
| *Preseparator eg for dust, fatty vapours etc* | recommended | recommended | necessary | necessary | necessary |
| *Loss after smouldering of fresh compost (as a medasure of the portion of organic substances)* | 60% | 60% | 98% | 98% | 98% |

## 8. Case Study - Biofiltration Installation for Odour Control - Gilbertson Greenham Pty Ltd Altona, Victoria

*Into E & Braun H - Biomass Pty Ltd*

This paper describes the design development and construction of a biofilter to treat odours from a waste water discharge point at Gilbertson Greenham. The plant was installed in 1987 and has demonstrated 99.98% odour reduction efficiency (4,000 to 40/80 odour units).

## 9. Emission Control with Biofilters Applications, Design and Operational Experience

*W Werner, H Liebe, B Strieller*
*1987 Air Pollution Conference Proceedings*
*Pages 537 - 544*

**Summary**

For several years, emission control with Biofilters has proved to be successful in quite a number of technical applications in continuous operation. This is particularly true for the purification of waste gases with odorous, mostly organic components. The common application of this process covers farms (livestock), sewerage plants and well as processing plants for animal and vegetable raw materials, recent experience has shown, however, that Biofilters are also suitable for the reduction of gaseous emissions from industrial plants of completely different types.

The required dimensions of a biofilter are determined by measurements with an experimental plant through which a partial flow of the waste gas to be purified in conveyed.

Data on operation characteristics, performance assessment and maintenance are based on experience. Approximately 40 large plants have been in operation for up to six years and were designed for volume flows of up to 200,000 $m^3/h$. The careful consideration of efficiency, availability, maintenance expense,. service life and investment and operation expense lead to a favourable assessment of this emission control method.

## 10. Gas Chromatography/Mass Spectrometry Identification of Organic Volatiles Contributing to Rendering Odours.

*H R Van Langenhave et al*
*Environmental Science & Technology*
*Page 883 Vol 16 No.12 1982*

Organic compounds in rendering plant emissions, both in the factory building air and in neighbourhood ambient air of the plant, were identified by a gas chromatography/mass spectrometry system using capillary columns. Absorption on Tenax GC and selective solvent absorption of volatile organic acids were used as concentration techniques. The results indicated that 80% of the identified compounds, mainly aliphatic, aromatic, or halogenated hydrocarbons and terpenes, can be considered as ubiquitous volatiles, not contributing to the odour. Twenty-six volatiles including an amine, five sulfur compounds, eight volatile acids, one alcohol, and eleven aldehydes were identified as malodorants contributing to rendering odours, by matching each GC/MS analysis with the corresponding "odorogram".

## 11. Odour Abatement by Biofiltration and Dispersion.

*John M Green*
*Abattoir Waste Water and Odour Management*
*Pages 157*
*C.S.I.R.O. Division Food Processing*
*University of Qld*
*1993*

This paper gives an overview of biofiltration and includes information on the measurement of odour, principle of biofiltration; biomass materials; design, operation and maintenance considerations for biofilters.

## 12. Odour Control in Rendering Plants A Goal of the Environmental Code of Practice

*Ron Powell*
*Environment Protection Agency*
*CAPAA Engineers Conference 1987*

This paper predates developments in biofiltration but addresses itself to important aspects of odour control from a government agency viewpoint.

- Demonstrates the need for an industry code
- Outlines consultative process.
- Discussion practices and technologies.
- Looks to future community expectations.

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## 13. Report on Return to Duty

*W F Spooncer*
*C.S.I.R.O. Meat Research Laboratory*
*1988*
*Unpublished*

This document describes visits to three rendering plants in the U.K. using biofilters for odour control.

Main design features noted were:

1. Maximum velocity of air in the ducting to the fan was 15m/sec.

2. A water scrubber and humidifier were inserted in the air line immediately before the fan. The velocity of air through the scrubber was 3m/sec max.

3. The fan was sited as close to the filter bed as possible to avoid having pressurised air in the ducting.

4. Relative humidity of air entering the plant must be 85-90%. This was the only satisfactory means of maintaining a suitable moisture level in the filter bed.

5. The bed was sized to give a residence time of air in the bed of 15-20 secs. This was achieved by using 1 $m^3$ of bed for 120 $m^3$ $hr^{-1}$ of air, with a bed depth of 1m. The bed was as square as ground conditions allow.

6. The filter media was a mixture of young, fibrous peat and 2/3 year old heather.

7. The walls of the bed were dense concrete 170-200 mm thick.

8. The walls of the bed up to 400mm above the slats was sealed with thick polyethylene turned in over the slats to prevent untreated air working up between the walls and the media.

9. Resistance through the bed could be up to 15 millibars.

## General Comments

Biofilters can deodorise air from rendering plants but the success of the treatment depends on effective collection of polluted air from buildings and using the correct medium in the filter bed. The filter medium must allow for even distribution of air through the bed, must not be resistive to air flow but must be dense enough to filter odiferous compounds from the air. Filter media is made from mixtures of peat and heather. Apparently new biofilters in Europe will contain heather only, but the filter at Ebbw Vale will have a mixture of 10% peat and 90% heather. The peat must be fibrous, and this is a feature of relatively young peat. No inoculation of the filter media is required although it takes about four weeks for suitable microflora population to establish within the bed and for odours to be fully treated. To maintain the microflora population, the bed must be kept moist and this is done by introducing air at 90% relative humidity and the temperature of the air should be less than 40$^{o}$C. If the bed is allowed to dry out, it will crack and allow short circuiting of polluted air.

## 14. Soil Bed system for Control of Rendering Plant Odours

*William Prokof & Hinrich Bohn*
*Journal of Air Pollution Control Association*
*Page 1333 Vol 35 No.12*
*December 1985*

**Abstract**

Biofilter technology has been applied recently to treating rendering odours. Soil beds are one class of biofilter but as yet have not been used for this application. Although wet scrubbers have been a traditional method of odour control, their capital and operating costs are impacting more severely. Soil bed systems are less expensive to install and operate.

A soil bed system was installed at a rendering plant in Arizona and has been in operation since September, 1983. The soil bed treats 1100 $m^3/h$ (650 cfm) of cooker noncondensables with a surface area of 420 $m^2$ (4500 $ft^2$). The pressure drop across the soil bed is 5 cm (2 in.) of water. Odour sensory testing with the IITRI forced-choice triangle dynamic olfactometer indicates an odour removal efficiency of 99.9 percent is obtained with the soil bed. Soil bed odour removal efficiency is equivalent to or superior than that for incineration or scrubbing of high intensity odours from the rendering process. Recent experience during this past winter indicates a soil bed is a viable method for operation in a northern climate with severe winter weather conditions. Also, monitoring of the leachate from a soil bed indicated no contamination.

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## 15. Soil Beds Weed Out Air Pollutants

*Hinrich Bohn & Robert Bohn*
*Chemical Engineering*
*Page 74*
*25 April, 1988.*

The ideal gas-cleaning system would be effective for both organic and inorganic pollutants, be inexpensive to install and operate, require little or no maintenance, have a long life and be environmentally safe. For many applications, soil beds, also known as soil biofilters, satisfy these criteria better than such pollution-control technologies as incineration, wet scrubbing, or sorption by activated carbon or synthetic materials.

Soil beds can remove and safely dispose of approximately 99% of slightly volatile and easily biodegradable organic compounds such as aldehydes and organic acids, as well as $SO_2$, NOx, and $H_2S$, and about 90% of volatile and relatively non biodegradable gases such as methane, propane and carbon monoxide. In addition, they remove all liquids and solid particulates from the gas streams.

Soil beds are suitable for many uses. To date, they have been employed mostly for removing odours from waste gases, with installations in chemical and pharmaceutical manufacturing and food processing, as well as in storage tank vents and fuel and solvent-handling systems. Other well-known types of soil beds are the septic tank fields of rural homes, and the soil covers of sanitary landfills.

## 16. Technical Note - The Use of Biofilters for the Control of Non condensable Odorous Gases

*Bird M J*
*Air Pollution Control*
*Wellington NZ 1986*

This paper addresses the principles of biofiltration, choice of filter materials, residence time, design and construction, operation and maintenance and in summary concludes:


**SUMMARY**

The most important consideration for the design and operation of a biofilter system can be summarised as follows.

1. The biofilter should be designed to give a residence time of three minutes calculated on the basis of a free flow of air with a minimum compost depth of one metre or soil depth of 50cm.

2. The filter material used should be suitable for the particular application.

3. These systems can be either above ground or below ground. Above ground filters have advantages (unaffected by the water table, ease of drainage) but have a higher capital cost than the alternative below ground filters.

4. Compost filter beds will need to be covered by a roof for weather protection but this may not be necessary for a soil filter.

5. The bed will need to be maintained to make sure that it is operating with the required moisture content, pH, temperature and to ensure that no fissuring occurs.

6. The inlet gas will need to be pretreated to remove condensable vapours (except water), fat aerosols and protein solids.

7. Biological filtration is suitable for treating process gases and ventilation air. A combined system requires appropriate equalising of the gas flows to avoid one system back pressuring the other inlet.

In conclusion, biological filtration is suitable for treating polluted air streams, particularly those contaminated by low concentrations of highly odorous compounds. This method of odour control is particularly attractive as it is possible to achieve almost 100% removal of odorous compounds from contaminated gas streams. This can be done far more economically than alternative methods such as hypochlorite scrubbing and incineration. However, biofilters would not be suitable for the removal of "non biodegradable" organic gases produced by some chemical processes. Biofiltration is capable of achieving a total solution for all odorous plant gases as, with suitable design, both process and ventilation air can be treated in the same bio-filter. The most important factors for the effective operation of these units are regular maintenance and a good level of understanding and confidence on the part of the plant operators.

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