shaping the future

# Report

**Date:** 18 June 2020

**To:** Nabil Askari, Shane Flitcroft, Kevin Leonard

**From:** Rhys Kevern

**Subject:** Review of Odour Control Techniques

# Table of Contents



# Tables



# Figures

# Executive Summary

Greater Wellington Regional Council has requested NCI to review further odour control techniques as part of the air discharge permit application process for the Upper Hutt plant predominantly in relation to the aluminium aerosol coating operations.

## Odour Control Options

The following odour control options have been reviewed to treat volatile organic compound (VOC) emissions from the Aluminium Aerosol Can and Tinplate Assembly Lines.

**Table 1 Odour Control Option Summary**

| Odour Control | Comment |
|---|---|
| Dilution/dispersion | This is the current solution, increasing stack height is unlikely to markedly change the ambient odour concentrations but a modelling exercise could be undertaken to assess the benefits or otherwise of this. |
| Masking compounds and neutralising agents | These are more commonly used for open air situations like landfills. Masking just tries to hide the smell and can actually produce more odour. |
| Biological treatment | Biofilters are suitable for low temperature flows of reasonably natural odours. The area required to treat a reasonable amount of air is quite large. They can either use solid material or a biofilm in a wet scrubber configuration |
| Incineration/afterburning | These units are very expensive (a second hand one was $810,000). The ongoing natural gas usage is significant as well. |
| Adsorption | Carbon filter units have a high efficiency until the carbon is saturated with VOC and then there is the cost of replacement and disposal of the used carbon (estimated to be M$1.5/yr). A unit to treat all of the emissions would be in the order of $20,000 capital cost. |
| Dry Scrubbing | This is more suited to acid gases such as sulphur dioxide or fluorides. |
| Dry Chemical Scrubbing | This is more suited to reduced gases such as ammonia and hydrogen sulphide. |
| Absorption wet scrubbing | As this is a wet process it works best on soluble species, the solvent VOC at NCI are not very soluble so this method isn't considered an effective option. |
| Condensation | Condensation works best on high concentrations of volatile material in low air flows. The concentration of NCI's VOC would mean a large condenser would be required to cool the air flow and it would probably need to be refrigerated to work effectively. |
| UV Oxidation | The reaction time is too long for this method to treat the solvents. This method was tested in 2013. |
| Non Thermal Plasma | This is a developmental technology mainly for coal fired boiler emissions so is not applicable to NCI. |

## Conclusion

A range of odour control options have been reviewed with four being recommended based on the gas flow and VOC concentration. These are increased dispersion, biofiltration, regenerative adsorption and incineration.

Increasing the stack height may lower ambient concentrations but as the current stack heights are above the influence of downdraft, small increases in height are unlikely to significantly change ambient concentrations. Increasing the stack height may impact elevated receptors at Kingsley Heights.

Adsorption would work very well as long as the activated carbon wasn't saturated. The capital cost is reasonably high and the ongoing cost of carbon replacement and disposal is prohibitive.

Incineration of the odour would be effective but this technology is typically applied to higher concentrations of VOC. The purchase cost excluding freight and installation for a second hand unit, albeit a larger unit than is necessary, is $810,000. Afterburners also use a significant amount of natural gas to run which is an additional expense.

Biofiltration of the specific solvent based odour at NCI needs to be trialled to verify it will treat those type of compounds as biofiltration is better suited to natural compounds. To make an effective difference to ambient odour a reasonably large biofilter area would be required, which for treating the internal lacquer/assembly stack would be around 96 $m^2$ which may also approach the cost of the carbon filter (adsorber) but without the frequent replacement cost. If a bioreactor was chosen it would have a smaller footprint but a higher capital and operating cost.

# 1 Introduction

Greater Wellington Regional Council (GWRC) has requested NCI to review further odour control techniques as part of the air discharge permit application process for the Upper Hutt plant predominantly in relation to the aluminium aerosol coating operations. The submitters to the application have highlighted at the prehearing meetings that they consider NCI odour is the main source of the significant (in their opinion) odour effect on them and that they do not wish the current situation to continue. At the second prehearing meeting GWRC asked whether NCI would review odour controls again.

In December 2013 a review of odour controls was undertaken on the following options.

- Production rate changes
- Chemical formulation changes
- Chemical application rate changes
- UV-ozone Treatment
- Incineration/afterburner
- Carbon filtration
- Further stack height increases
- Off-site odour investigations
- Turning off the Line

# 2 Odour Control Recommendations

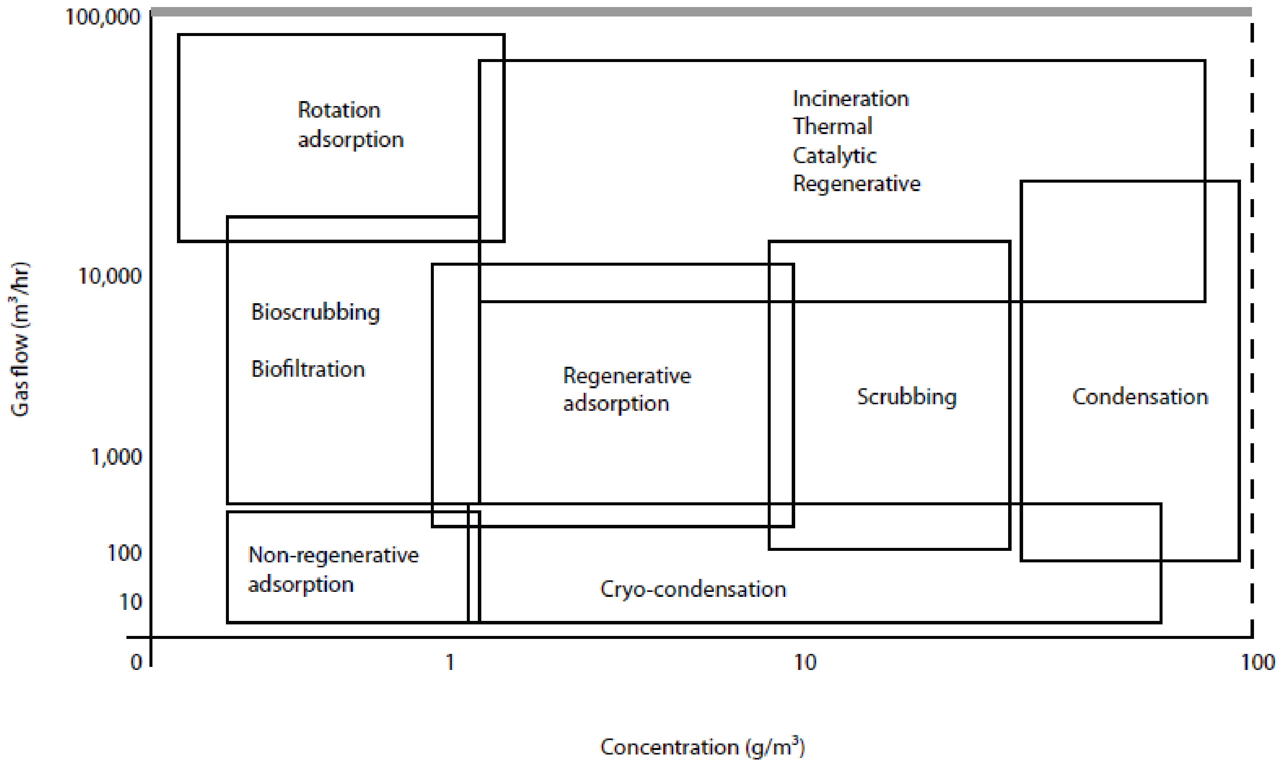
The UK Department for the Environment produced a Concise guide to Odour Control in 1980 (DfE1980). Some general comment on odour control techniques is as follows:

"There are five known types of abatement, namely, absorption, adsorption, thermal incineration, catalytic oxidation and biological destruction. Simple water washing is not normally effective on its own, ozone in the gas phase is too slow if effective at all and masking agents and odour counteractants have a use limited in both scope and distance. Chimney dispersion might perhaps also be regarded as a kind of abatement, since it reduces the odour intensity in the reception area (housing estates etc)." The abatement methods quoted above are also those mentioned in the Air Pollution Engineering Manual and The Biotechnology for Odour and Air Pollution control book.

"In general one can say that incineration and catalytic oxidation are used for low flowrates at high concentrations, adsorption for low flow rates at low concentrations and absorption at higher flowrates."

The Scottish Environmental Protection Agency produced an Odour Guidance document in 2010 (SEPA2010). A generalised diagram of control options from that document is copied as Figure 2-1.

**Figure 2-1** **Generalised techniques for odour abatement**




The actual discharge rate of both stacks is 8,700 – 9,200 m³/hr, corrected to 0ºC and 1 atm pressure this becomes 6,500 - 7,100 m³/hr. The total emission concentration of total petroleum hydrocarbons is about 1.1 g/m³. Based on these two figures biofiltration, regenerative adsorption or possibly incineration would be recommended control methods. NCI has primarily used dispersion to reduce off site concentrations of odour.

As the internal lacquer/assembly stack has around 60% of the odour emissions, if that stack was considered for treatment only, the flow would be 4,457 m³/hr which corrected to 0ºC and 1 atm pressure this becomes 3,735 m³/hr. The emission concentration of total petroleum hydrocarbons from this stack is about 0.24 g/m³. Both of these factors would show biofiltration as the recommended technology.

# 3 Method of Controls Operation

The following comment is sourced from the SEPA and biotechnology book sources.

## 3.1 Dilution dispersion

Dilution and dispersion are usually achieved via discharge through a tall stack. A stack will be appropriate for very low intensity or non offensive odours, discharged at low rates and as a final step following treatment of an odorous gas stream.

## 3.2 Masking compounds and neutralising agents

Masking compounds and neutralising agents are products available for treating fugitive odours such as from landfill working faces, tanneries, intensive farming of animals and wastewater treatment plants.

The products available can be classified as follows.

• Masking agents are mixtures of aromatic oils that cover up an objectionable odour with a more desirable one.

• Chemical counteractants are mixtures of aromatic oils that cancel or neutralise odour and reduce the intensity.

• Digestive deodorants contain bacteria or enzymes that eliminate odour through biochemical digestive processes.

• Chemical scavengers are chemicals that can be added to materials to react with the potentially odorous substances. Use includes removal of sulphur from spills of crude oil.

### 3.3 Biological Treatment

Biological treatment relies on the organic odorous compounds being metabolised and consequently degraded by naturally-occurring micro-organisms into non-odorous products. All systems are therefore required to be able to support a population of micro-organisms (a damp environment for microbial activity, oxygen and provide trace nutrients) and to enable sufficient contact between the population and foul gas. Once established the microbial population will undergo a degree of self-selection to adapt to the defined odorous gas stream. Biofilters work best on more natural compounds such as hydrogen sulphide, amines, alcohols, aldehydes etc.

Bio-reactors/scrubbers apply the same principles as biofilters however the odorous gas is passed up a packed tower through a counter current flow containing a population of microbes. The packing provides support for the microbes as they adhere to it (microbial film) allowing contact with the passing gas. Packing can be organic as the non soil filters above or be of an inorganic nature.

### 3.4 Incineration or Thermal Oxidation

The process of incineration or thermal oxidation can be used for the effective destruction of odorous compounds and may be described as the process whereby waste (odorous gas) is heated with either air or oxygen at high temperature in a combustion appliance. If the combustion is complete and the wastes (odorous gas) are organic compounds, then the products of combustion will be carbon dioxide, water and oxides of nitrogen. Complete combustion is dependent upon uniform mixing of fuel, the odorous gas stream and combustion air. The configuration of burner, mixer and combustion chamber are important to effective mixing.

### 3.5 Adsorption

The process of adsorption is where one substance adheres to the surface of another substance. In this instance there is a mass transfer of gas molecules (odorant) from the bulk of gas through diffusion until the molecules are finally adsorbed onto an internal surface (adsorbent). Adsorbents are most commonly activated carbon but silica gel, alumina and zeolite are also used.

### 3.6 Dry Chemical Scrubbing

Dry chemical scrubbing is effectively a sub-set of adsorption; non-regenerative adsorption.

The oxidising chamber contains a support material which is impregnated with oxidising material (eg chlorine dioxide, potassium permanganate etc.). The odorous gas passes up through the oxidising chamber where it is adsorbed and then oxidised to non-odorous by-products.

### 3.7 Wet Scrubbing (including oxidation)

Typically highly alkaline solutions would be used to absorb acidic gases such as hydrogen sulphide. Other scrubbing systems could us oxidants such as hypochlorite, ozone, permanganate, hydrogen peroxide and iron III compounds.

### 3.8 Condensation

Separation is achieved by condensing or liquefying VOC vapours from a non condensable gas such as air. The condensation is achieved by either a heat exchanger or spraying cooled liquid directly into a gas stream.

### 3.9 UV Oxidation

Ultra violet light is used with oxidising chemicals such as ozone to convert VOCs into $CO_2$ and water vapour.

### 3.10 Non Thermal Plasma (Electrochemical)

The VOC gases are passed through a high voltage AC (10-30kV) high frequency field to produce free radicals which react with the VOCs or sulphur dioxide or nitrogen dioxide changing their form.

## 4 Biofilter Design

GWRC specifically asked about the applicability of using Biofiltration for odour reduction. The following reviews potential design options for biofiltration.

The main design criterion for biofilters is the empty bed residence time which is calculated by dividing the volume of the bed by the volume flow rate of gas being treated. Therefore the volume of bed material can be calculated if the air flow and desired residence time are known. If only the Internal Lacquer/assembly stack was treated then the volume treated would be 4,457 $m^3$/hr at actual conditions. The Auckland Council recommends in TP152 that biofilters should be designed to have no more than 50 $m^3$/hr per $m^2$ of biofilter surface area, (presumably 1 m deep).

The Biotechnology for Odour and Air Pollution control book recommends a gas loading rate of 30-50 $m^3$/hr per $m^3$ of biofilter volume and a residence time 72-120 s for an air stream less than 40ºC using a bark-soil mix.

A trial biofilter using a small air blower is being built to determine whether the epoxy VOCs of the internal lacquer application process can be treated biologically. Several treatment volumes have been assessed in Table 1. One biofilter option would treat just the internal lacquer application emissions (930 $m^3$/hr) which would treat 1,400 odour units per second (OU/s) as measured in 2012, out of around 5,161 OU/s (odour discharged from the Internal Lacquer/Assembly Sidestripe stack as measured in 2018).

A reduction of approximately 60% of site odour would come from treating all of the Internal Lacquer/Assembly Sidestripe stack emissions but the size of the biofilter increases markedly. An option for treating all of the site emissions has been calculated as well.

**Table 4-1 Biofilter Design Calculations**

| Trial | | Trial | Just Int Lacquer | Int Lac/ Ass Stk | Both Stacks |
|---|---|---|---|---|---|
| Max Estimated Odour reduction (90% efficiency on the biofilter) | % | | 14 | 54 | 90 |
| Diameter of Stack | Dstk (m) | 0.03 | 0.20 | 0.45 | 0.64 |
| Velocity in stack | Ustk (m/s) | 10.50 | 8.20 | 7.78 | 7.52 |
| Stack flow | Q($m^3$/s) | 0.0074 | 0.2576 | 1.2374 | 2.4194 |
| | Q(L/min) | 445.3 | 15456.6 | 74241.3 | 145166.7 |
| | Q($m^3$/hr) | 26.7 | 927.4 | 4454.5 | 8710.0 |
| Bed Vol required based on TP 152 (at 50 m3/hr per m2 (1m deep)) | $m^3$ | 0.53 | 18.55 | 89.09 | 174.20 |
| Residence Time | s | 90 | 90 | 90 | 90 |
| Bed Depth | m | 0.65 | 1.2 | 1.2 | 1.2 |
| Area Required | $m^2$ | 1.03 | 19.32 | 92.80 | 181.46 |
| length one side | m | 0.95 | 4 | 12 | 15 |
| length other side | m | 1.15 | 5 | 8 | 12 |
| Area Chosen | $m^2$ | 1.09 | 20.00 | 96.00 | 180.00 |
| Actual Biofilter Volume | $m^3$ | 0.71 | 24.00 | 115.20 | 216.00 |
| Actual Residence Time | s | 95.7 | 93.2 | 93.1 | 89.3 |
| Actual Residence Time | min | 1.59 | 1.55 | 1.55 | 1.49 |
| Actual biofilter loading rate | $m^3$/hr/$m^2$ | 24.5 | 46.4 | 46.4 | 48.4 |

To achieve a 50 – 60% reduction in odour (depending on whether the biofilter works) a filter of 96 $m^2$ would be required.  To treat both stack emissions 180 $m^2$ would be required.

# 5 Control Techniques Review

The SEPA guide provides some discussion on the Pros and Cons of different odour control techniques which has been summarised in Table 5-1.

**Table 5-1 Odour Control Techniques Assessment**

| Technique | Advantages | Disadvantages | Issues |
|---|---|---|---|
| **Dilution/dispersion** – dispersion from a tall stack | Dispersion has a moderate capital cost but low running costs. Odour dispersion modelling is one of the only tools that can predict the potential effects of a new odour-emitting activity. | The magnitude and frequency of the peaks in concentration are often the factors that determine whether an exposure is acceptable or not. Odours can be detected at low levels and can have an impact over a very short period of time.<br>Simply building a tall chimney does not guarantee that there will be no impact from the release of odours as this will be dependent on a number a factors not least the weather and local topography.<br>The amount of the odorous substance in the waste gas should be minimised by the use of effective abatement techniques prior to discharge to the atmosphere. | Increasing the effective chimney height may reduce or eliminate complaints close to source but may not reduce complaints further afield. Complaints from further afield may actually increase with increased effective chimney height if dispersion is poor. Reducing the mass emission is often more effective than increasing the chimney height.<br>Typically the maximum ground level concentration will occur between 10 and 20 stack heights down wind of a stack. The maximum ground level concentrations are inversely proportional to the square of the stack height. The rate of release of the odorant governs the maximum ground level concentration not the final concentration in the stack. |
| **Masking compounds and neutralising agents** –using other more pleasant odours to hide the odour discharge. | Modest capital outlay. Atomiser units are portable, can be rapidly deployed. Highly visible means of being seen to take action over a problem.<br>They are more often applied to open air settings such as the fence line of a landfill. | The application of odour counteractants can be problematic because an emission may vary in concentration or nature with time. These variables make it difficult to ensure that unpleasant odours are “blotted out” at all emission levels.<br>The odour of the modifying agent can itself become a source of annoyance. Factors such as differing diffusion characteristics of the modifier and the odour itself may cause the odour to separate from the modifying agent at a distance, thus producing two distinctly different odours at different points. | Care needs to be taken with the use of masking agents because the combination of chemicals may result in an odour that is even more objectionable or offensive. Application should not be considered where the odorous emission carries a risk to health or the odour itself serves as a safety warning.<br>The operator can sometimes feel that this is a ‘simple fix’ to an odour problem on site and so either not identify the root cause of the problem or dismiss other alternatives. |

| Technique | Advantages | Disadvantages | Issues |
| --- | --- | --- | --- |
| | | The ongoing cost of the modifying agent can be very expensive and maintenance costs can be high as fine spray nozzles can be prone to blockage. Some of the components such as surfactants can make surfaces slippery. Careful consideration needs to be given to the selection of the agent as it may in itself be harmful to human health or the environment. | |
| **Biofiltration (biofilters and bioreactors)** – using microbes to convert odourus compounds to non odourous ones | Non soil filters can be up to 95% efficient while Soil filters and bio-reactors can be more than 99% efficient.<br><br>Minimal secondary pollution (wastes generated)<br><br>Relatively inexpensive to install and maintain compared to other abatement options Bioreactors have additional benefits in that they have a small footprint compared to biofilters and the replacement of the support medium is not required.<br><br>Bioreactors have additional benefits in that they have a small footprint compared to biofilters and the replacement of the support medium is not required. | Processes can not be treated where there are high levels or variability in odour concentrations (the micro-organism population is slow to adapt) or interruptions in process flow and batch processing.<br><br>In order to ensure high removal efficiency, inlet conditions (temperature, pH and humidity) must be maintained within narrow bands and regular maintenance is required. Large land areas required for biofilters, also larger biofilters tend to have problems with even distribution and maintenance.<br><br>Bio-reactors have higher running costs than soil biofilters which in turn have higher running costs than other biofilters with different media.<br><br>Additional nutrients may be required to support the microbial population. Contingency plans are needed in case the microbial population is destroyed/poisoned and when bioreactor media is changed. Monitoring can be difficult unless it is covered (can measure at the outlet). The removal efficiency is limited by ambient conditions. Collapse of the biomass in a bioreactor can occur where microbes break away from the inert support. | Moisture/drying: It is essential to ensure that the media remains wetted otherwise this can cause cracking (see below) and reduce the micro-organisms population and available interface for odour removal. Once the bed has dried out is difficult to re-wet. Over wetting should be avoided because it is important to maintain aerobic conditions. Frost can cause similar problems. (You could cover system) (You could recycle effluent water however need to consider pH (acidification), nutrient loading and natural airborne compounds $H_2S$).<br><br>Blockage can also be caused by flooding. (results in over watering/poor drainage) Bed structure: inspections should be carried out to ensure that an even distribution of foul gas through the bed is being achieved.<br><br>Cracks and holes in the bed can form as well as areas of compaction (you could consider turning bed) leading to preferential paths reducing residence time and allowing gas to escape untreated. (You can look for dry/cold patches/steam rising).<br><br>Frost damage Contingency: biofilters are often used as contingency where primary odour abatement has failed. The biofilter is unlikely to abate the odour |

| Technique | Advantages | Disadvantages | Issues |
| --- | --- | --- | --- |
| | | | emissions in this case and is likely to be taken out of action due to high odour/temperature.<br><br>The filter material should typically last for 3 – 5 years. |
| **Incineration/ afterburning** – burning the odorous compounds to form non odorous prouducts | It can be applied to almost all odour control scenarios as all organic odorants can be oxidised at high temperature. It can handle very high inlet odour levels and has very high odour removal efficiencies.<br><br>Primary heat recovery is possible. The incinerator exhaust gas is used to pre-heat the incoming gas stream, reducing requirements to heat gases in the incinerator. Secondary heat recovery is achieved through the generation of steam and hot water. Existing boilers can sometimes be adapted for use as thermal incinerators. Catalytic incineration achieves effective destruction at lower operating temperatures and so requires less energy. Units also tend to be smaller. | Capital and operating costs are high. *The recent offer of a second hand incinerator was $810,000 without freight and installation.* Maintenance of smooth operation (burners) required. The volume of air requiring treatment can be a limiting factor in terms of cost, as can the requirement for high temperatures (e.g. for oxidising ammonia).<br><br>Further abatement: need to cope with $SO_2$ or HCl formed from compounds containing S or Cl. Acid gases create further odour issues. *(not applicable to NCI)*<br><br>Continuous monitoring for carbon dioxide and/or oxygen, carbon monoxide and oxides of nitrogen in the effluent gas stream is generally required. There is also a requirement that temperature is measured as a means of monitoring combustion conditions. Sampling and analysis techniques suitable for high temperatures are required. Spent catalyst waste stream requires disposal. | There are several potential difficulties: • not all boilers or kilns work for 24hrs/day and hence they may not be able to treat a continuous odour emission all the time. *(NCI's ovens are all electric so to use the heat they would all need to be changed and the site has no steam or hot water requirement at present)*<br><br>• physical methods for demonstrating residence time exist and should be employed to ensure adequate destruction is achieved;<br><br>• breakdowns can often require specialised parts/repair and may take some time to rectify. Consideration should therefore be given to the establishment of a maintenance contract to ensure speedy repair, back up systems for odour control and contingency plans to ensure odour is minimised in the event of a breakdown. |

| Technique | Advantages | Disadvantages | Issues |
|---|---|---|---|
| **Adsorption** - odorous gases adhere to the media which has a large internal surface area. | Depending on the chemical species involved, efficiency can be in excess of 99% for a new adsorbent.<br><br>Depleted adsorbent can often be regenerated and reused (larger applications, may not be cost effective on smaller units). Smaller applications can make use of easily replaceable, cartridge type units. *(New Zealand doesn't have off-site carbon regeneration facilities available)*<br><br>Relatively low cost compared to some other systems. High temperature and humidity may cause odour breakthrough. Temperatures less than 40°C are required for activated carbon systems. | *For treatment of the total flow a unit would cost around $20,000 and the replacement cost of adsorbent is estimated to be about $1,500,000 per year which is prohibitive.*<br><br>High concentrations of odorants will cause rapid saturation. Efficiency will deteriorate over a period as the bed becomes saturated. Disposal required for waste adsorbent which cannot be regenerated (for whatever reason). Pollutants may flash off unless contained. Regeneration will produce a gas stream which will require abatement.<br><br>Ancillary equipment may be needed to precondition the gas stream before the carbon bed/filter: this can add considerably to the cost. | Breakthrough: predicted and actual. Often the first sign is odour release. Many systems use two adsorption units in series and undertake monitoring between beds to alert of breakthrough.<br><br>Vapours (odours) will travel the path of least resistance. Care has to be taken with the system design to ensure that the backpressure exerted by the bed does not mean that odours never reach the adsorbent material. |
| **Dry Scrubbing** - acid gases are contacted with alkaline powders | Suited to acid gases so not applicable to VOC | NCI doesn't have those compounds | |
| **Dry Chemical Scrubbing** – gases are passed through solid oxidisers such as potassium permanganate to change their form | Suited to reduced species such as hydrogen sulphide and amines that can be oxidised. | NCI doesn't have those compounds | |

| Technique | Advantages | Disadvantages | Issues |
|---|---|---|---|
| **Absorption wet scrubbing** – odorous gases react with chemical solutions | Absorption (scrubbing):<br><br>Can handle large volumes of air Efficiency >90% (2 stage scrubber) – water.<br><br>Efficiency >99% - chemical. Automatic dosing can allow for rapid reaction to presence of peaks in concentration, provided they are not too Acute.<br><br>Catalytic scrubbing:<br><br>Acid scrubbing may not be required.<br><br>Total odour control in a single packed tower is possible. High odour removal efficiency for organic odorants. | Absorption (scrubbing):<br><br>Concentration of contaminants may require pre-dilution with clean air.<br><br>Chemical reagents needed unless dealing with water soluble compounds. Fairly specific; reagents must be matched to nature of contaminants. A multi-stage scrubber may be needed to deal with a stream containing, for example, acidic and basic components. This increases the cost and complexity.<br><br>Scaling and corrosion can be a problem, particularly when chemical reagents are used.<br><br>Salt formation (often in the form of a gel) can block pumps. Salts may also block packed scrubber systems with the subsequent formation of preferential routes for liquor through the packing, with adverse results. Maintenance requirements may consequently be quite high. Use of chemicals can be high – careful process monitoring and control is required.<br><br>Particulates can cause blockages in packed towers.<br><br>A mist eliminator may be required to prevent carry over of droplets.<br><br>Catalytic scrubbing:<br><br>Potential for catalyst fouling. Does not remove insoluble organic odours.<br><br>At high concentrations of basic odours, acid scrubbers may be more cost effective. | Saturation of contacting liquid can occur.<br><br>Fibrous packed columns are prone to blockage by particulates and growth of biomass. Oxidants can sometimes lead to the formation of odorous compounds in the scrubber which can create a secondary source of odour.<br><br>The effluent must be considered as part of the total environmental impact.<br><br>Spray nozzles may block from particulates in spray towers. Residues and precipitates can build up and may require flushing. Packed columns are more difficult to flush than spray towers. |

| Technique | Advantages | Disadvantages | Issues |
|---|---|---|---|
| **Condensation** – cooling the gas to condense it into a liquid | This technology is mainly applied to highly volatile liquid emissions such as from trichloroethylene degreasing baths or solvent distillation where the vapour can recovered as liquid and reused. | A large unit would be required to cool a low concentration air stream. If the air stream VOCs had a range of volatilities not all compounds would be collected at a specific temperature. | |
| **UV Oxidation** – use UV light to produce reactive chemicals which change the odorous chemicals | | As stated above, this was trialled in 2012 and did not work. The comment in the DfE1980 document was that the ozone reaction time was too long for it to be practical. | |
| **Non Thermal Plasma** – high voltage energy breaks up the organic compounds. | | This control method appears to be still in the development phase and is mainly being reviewed for application to coal fired boilers. | |

# 6 Conclusion

A range of odour control options have been reviewed with four being the more recommended based on the gas flow and VOC concentration. These are increased dispersion, biofiltration, regenerative adsorption and incineration.

Increasing the stack height may lower ambient concentrations but as the current stack heights are above the influence of downdraft, small increases in height are unlikely to significantly change ambient concentrations. Increasing the stack height may impact elevated receptors at Kingsley Heights.

Regenerative adsorption uses and adsorbent material such as activated carbon to capture the organic compounds and has a high efficiency until the media is saturated. The regenerative part of the process aims to use hot air or steam to purge the adsorbent to allow for further gas filtering however this requires some further treatment and a steam source. Without regeneration the activated carbon has to be dumped once it is full of solvent which is very expensive to replace (approximately $1,500,000 per year). The capital cost to treat both stack emissions would be in the order of $20,000.

Incineration of the odour would be effective but this technology is typically applied to higher concentrations of VOC. The purchase cost excluding freight and installation for a second hand unit, albeit a larger unit than is necessary, is $810,000. Afterburners also use a significant amount of natural gas to run which is an additional expense.

Biofiltration of the specific solvent based odour at NCI needs to be trialled to verify it will treat those type of compounds, as biofiltration is better suited to natural compounds. To make an effective difference to ambient odour a reasonably large biofilter area would be required which for treating the internal lacquer/assembly stack would be around 96 $m^2$ which may also approach the cost of the carbon filter (adsorber) but without the frequent replacement cost. A bioreactor/bioscrubber would take up less room but has a higher capital and operating cost.