A Review of Odour Discharges and Control in Rendering and Related Activities

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Introduction

Rendering inedible raw materials gives valuable by-products and avoids significant disposal problems such as costly land filling. Rendering involves thermal or thermo-mechanical breakdown of meat, fish, and poultry materials into solids, fat or oil, and water; separation of these components; drying of solids; and refining of fat. The contained solids and fat in wastewater are occasionally extracted in a waste heat evaporator. Most plant now employs 'low temperature rendering' (LTR). LTR is the thermo-mechanical disintegration and phase separation of raw material components typically at 90-95°C, with product drying following the rendering/reduction (wet processing) stage. High temperature "dry" rendering is a thermal process requiring temperatures of at least 125-140°C to achieve raw material disintegration and phase separation accompanied by and/or followed by evaporative drying. While low temperature rendering has lower air pollution potential than high temperature rendering, its nuisance potential can still be high. Blood is normally heat coagulated, blood solids separated from blood water and dried by application of heat, and blood water discharged to the drain.

Odorous Contaminants

A significant consequence of rendering and drying activities is the discharge to atmosphere of odorous contaminants (pollutants). The following classes of contaminants may be generated to a greater or lesser degree from rendering and blood drying operations. Sulphides and disulphides such as hydrogen sulphide and dimethyl sulphide, mercaptans such as methyl mercaptan, and other odorous sulphur compounds; ammonia, and volatile amines such as methyl amine and trimethyl amine, and other odorous compounds of nitrogen; hydrocarbons, and partially oxidised hydrocarbons such as the aldehydes 2-methyl butanal and 3-methyl butanal; and volatile carboxylic acids such as the fatty acids butyric acid; and pyrolysis products of paunch and gut contents, protein, connective tissue, and fat. Collectively, these and other contaminants are termed odorous compounds (odours). Specific compounds present and their discharge concentrations depend on raw material type and quality, processing method (especially rendering and drying temperature), and discharge control equipment efficiency.

Low temperature rendering vessel temperatures are not high enough to degrade raw material and cause odour generation, but are sufficient to drive off volatile contaminants resulting from putrefaction. In high temperature rendering, some reduced sulphur compounds such as hydrogen sulphide, as well as resulting from putrefaction, are generated in high concentration from the thermal breakdown of skin, hair, wool, and hooves. Partially oxidised hydrocarbons such as the aldehydes 2-methyl butanal and 3-methyl butanal and volatile carboxylic acids such as fatty acids, are all thermal breakdown products of fat. Overheating or over-drying meal (which is abnormal operation), especially if the meal fat content is too high, will generate "burnt" odours and sulphides. The presence of gut and paunch contents in meal cake may generate 'burnt grass' odours in direct-fired driers. The potential for over-drying is the same for low temperature and high temperature rendering if drying temperature is not well controlled. Likewise, processing of 'stale' raw material could result in the discharge of malodours at any stage in the rendering process. Processing sour blood, and burning blood during drying, generates objectionable odour.

Minimising Generation/Discharge of Odorous Contaminants

Environmentally acceptable and cost-effective rendering and blood drying requires good quality raw materials, well designed and maintained processes, and good management. Ensure that raw materials processed are of good quality; operate processing equipment to minimise generation of objectionable odours; contain all significant process odour sources then ventilate to odour control equipment; maintain good housekeeping to minimise background odour; and ventilate processing buildings to minimise build-up of contaminants and to maintain a satisfactory workplace environment. Not only is such a program necessary to minimise the discharge to atmosphere of odorous contaminants and preventing over-loading of odour control equipment, but proper processing of good quality raw material maximises product quality.

<u>Raw Material Quality.</u> Raw material quality definitions were developed by the Department of Health in 1985. These were frequently applied as conditions of Clean Air Licences for rendering processes. Many regional councils have applied them or variants as conditions of air discharge permits under the Resource Management Act. A current definition of "good quality" <u>inedible soft offal</u> is:

(a) *Meat material which is cut and washed substantially free of paunch material and is rendered within eight hours from kill providing stored material is maintained at a temperature less than 25 degrees Celsius, and in any case does not have an objectionable odour;* or

(b) *Meat material which is cut, washed, and maintained as above which is adequately stabilised (preserved) as soon as possible but not later than eight hours from kill by cooling the whole mass to less than 20 degrees Celsius or by treating with acid to ensure the whole mass maintains a pH less than (more acid than) 4.5 , or preserved by equivalent means, and is processed within 24 hours from kill, and in any case does not have an objectionable odour. pH shall be determined from the liquid derived from the offal.*

The quality of other raw materials, including DAF sludge, are also defined. Regional councils may change requirements depending on raw material type and processing method. The above definition of soft offal is conservative. I now believe that temperature stabilisation, while desirable, is not as important as previously thought. Washing cut paunch and gut material with hot water to substantially remove bacteria and enzymes (and grass material) gives substantial benefits over no washing, therefore, the definition can be amended as follows:

(a) *Soft offal which is cut and washed substantially free of paunch and gut material and is rendered as soon as practicable but in any case within ten hours from kill, and does not have an objectionable odour.*

<u>Containment of Odorous Contaminants.</u> Discharges from high temperature rendering equipment such as batch melters, continuous cookers and presses; from LTR render vessels, presses, decanters, liquid phase tanks and screens, etc; from blood coagulation equipment; from drying equipment; and in some cases meal and blood mills; should be contained or hooded and ventilated (usually through a condenser) to appropriate odour control equipment. Material conveyors prone to significant fugitive odour discharge should be contained or hooded then ventilated to odour control equipment. Some processing equipment is difficult to contain or hood and ventilation of processing building air to odour control equipment may be the only option especially for plant located in sensitive areas.

Processing Building Ventilation Air Control. Ventilation of processing buildings at 10-15 air changes/hour or more should provide an acceptable working environment, will minimise condensation of steam on cool internal surfaces, and will avoid build-up of odorous contaminants which can escape when access doors are opened. If raw material quality, process containment, and housekeeping, is good and the locality is not highly sensitive or topographically complicated, discharge of ventilation air through a chimney sufficiently high to avoid building downwash and to maximise dispersion may be acceptable. Discharged air must not impinge on high buildings or elevated ground down wind. The alternative is treatment of ventilation air before discharge. Processing buildings should be designed (including minimising volume) to enable retro-fitting a controlled ventilation air system if it proves necessary.

Condensers. Process gases and fugitive discharges having significant water content should be routed to condensing equipment. Gas streams containing a high proportion of air (and possibly excessive particulates) can be treated in spray (direct) condensers but this produces contaminated cooling water. Re-circulation of cooling water through a heat exchanger is necessary for heat recovery, or to avoid contamination of evaporative cooling towers. Other gas streams can be treated in an indirect (shell & tube) condenser which has the added advantage of keeping foul condensate and cooling water separate. Foul condensate and spray condenser blow-down water temperature should be as low as practicable (preferably less than about 40°C) and discharge to an impervious drain.

Treatment of Non-condensable Gases. A variety of equipment is available to substantially destroy (with varying degree of success) odorous non-condensable gases. The principal methods used in New Zealand are incineration, chemical scrubbing, and biofiltration. Choice of method (and satisfactory performance) depends on nature and volume of non-condensable gases, required odour destruction efficiency, space limitations, whether or not waste heat utilisation is practicable, and capital and operating costs.

Incineration. Non-condensable gases (and smoke from direct-fired driers) can be incinerated in a boiler firebox or in a dedicated thermal reactor (afterburner). Odorous gases must be raised to a temperature of at least 750°C for 0.5 seconds residence time with adequate oxygen to maximise oxidation and to minimise pyrolysis products. Adding the gas stream with boiler primary air may be practicable providing boiler oxygen requirements are met, gas stream volume is not excessive, and the appliance has sufficient thermal output to achieve the temperature/time requirements. The gas stream must not be introduced into the boiler back-end or stack - at best only partial oxidation will occur and the 'burnt' smell may be as objectionable as the untreated gas stream. The method has minimal capital and operating costs. However, some engineers are cautious about introducing potentially corrosive and fouling gases to boilers (pre-treatment by water scrubbing may address this concern). A better, but more costly, alternative is use of a thermal afterburner. At least one N.Z. company provides a range of high destruction efficiency afterburners which can be equipped with waste heat recovery systems to pre-heat inlet gases and combustion air, and to generate hot water. They have high capital cost, and generally high fuel costs unless a high degree of waste heat recovery is practicable.

Chemical Scrubbing. Most scrubbers used in N.Z. are either one or two stage packed tower or cross-flow units using a dilute acid first stage to remove ammonia and amines, followed by an oxidising stage using alkaline sodium hypochlorite solution or alkaline hydrogen peroxide solution. Most single stage scrubbers have only the oxidising stage. Scrubbers should be equipped with automatic reagent dosing systems but auto-regulation of hypochlorite reagent strength at concentrations above about 200mg/litre is difficult. Generally, N.Z. rendering industry experience is discouraging. An excellent development (but not yet available in Australasia) is the ICI Katalco 'Odorgard' catalyst system attached to the hypochlorite stage - this significantly increases odour destruction efficiency and low reagent concentrations can be used. Chemical scrubbers are able to treat large volumes of relatively cool gas, and ventilation air, with reasonable space requirements, but their capacity to remove smoke generated by direct-fired driers is limited. Capital cost and running costs are relatively high.

Biofiltration. Treating non-condensable gases cooled to 40°C or less and ventilation air in an appropriately designed and maintained biological filter can achieve high odour destruction, although excessive smoke from direct-fired driers may cause problems. Current biofilters use compost, pinus radiata bark, soil and sand, or a mixture of these, to adsorb most rendering odorous contaminants for sufficient time to be oxidised by aerobic bacteria. Media must be porous and kept damp and gas flow to media volume kept low. If too wet, increased back pressure causes problems; if too dry media contracts and develops fissures. Biofilters may be constructed below or above ground, but if above ground walls must be gas-tight. They must have good drainage, and to avoid discharges to land the base should be impervious and drainage routed through a gas-tight trap to a receiver. Roofing the filter prevents rain water flooding and minimises drying out but adds appreciably to capital cost and limits access. Media life depends on filter construction, media type, contaminant load, and ability to maintain good moisture levels. Good quality bark should last for at least 3 years; and more if roofed. Biofilters should be equipped with pressure drop indication (logged daily), and inlet gas temperature indication. If over-heating is possible (eg. through loss of condenser function) the biofilter inlet duct should be equipped with an alarm system, a heat-sensitive frangible; and/or with automatic heat source cut-out. Inlet gas temperatures much exceeding 45°C, if water saturated, may cause saturation of media by condensation leading to high back pressure and defective operation. The capital cost of large biofilters is high and land area required is large, but running costs relatively low although media replacement must be budgeted. Proprietary multi-tiered biofilters using synthetic media are available in Europe, North America, and in Australia, but these, while being compact, are expensive.

Other Odour Control Methods.

De-odorising reagents are marketed to control odours by application as a spray on contaminated surfaces and into air. Some are claimed to neutralise odorous molecules through polymerisation and esterification and are not masking agents or counteractants. Other reagents contain both neutralising compounds and masking agents (masking agents should be avoided). Some reagents appear effective especially when applied to contaminated surfaces. There is only limited published scientific trials quantifying their effectiveness. The capital cost of spray applications is usually modest, and operating cost reasonable if rate of application is limited.