Report

Emissions Equipment Criteria

DGL Group - Unanderra

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Contents

1. Introduction

Advitech Pty Limited (Advitech) was engaged by DGL Group to broadly assess the parameters pertinent to its emissions and likely future emissions at the 201 Five Islands Road, Unanderra site.

Additional air dispersion modelling has been requested by the NSW Department of Planning, Industry and the Environment (NSW DPIE) to verify the social acceptability of projected/modelling outcomes. The initial basis for establishing the social acceptability of the development will be to ensure all equipment and process emissions conform to the published NSW EPA emission standards. These standards are understood to be the minimum compliance requirements within the context of the DGL Group liquid waste treatment plant (LWTP) development (SSD 8304).

It should be noted that this report was prepared by Advitech Pty Limited for DGL Group ('the customer') in accordance with the scope of work and specific requirements agreed between Advitech and the customer. This report was prepared with background information, terms of reference and assumptions agreed with the customer. The report is not intended for use by any other individual or organisation and as such, Advitech will not accept liability for use of the information contained in this report, other than that which was intended at the time of writing. [Optional clause for draft reports]: It should also be noted that information contained within any draft report is subject to change as a result of final checking or the availability of additional information.

2. Objectives

The specific request for data from the air quality/dispersion modelling contractor (Todoroski Air Sciences) included information regarding the following:

- The scrubber to service the LWTP neutralisation reactors (in Building E) including:
  - Type, specification and control efficiency; and
  - Exhaust outlet parameters such as velocity, temperature, diameter, flow rate and release height.
- The rotary kiln dryer to dry the filtered solids post neutralisation (in Building E) including:
  - Detailed specification of kiln dryer;
  - Type and specification of kiln dryer; and
  - Exhaust outlet parameters - velocity, temperature, diameter, flow rate and release height.
- The dust cyclone servicing the kiln dryer including:
  - Detailed specification of dust cyclone;
  - Type, specifications and control efficiency; and
  - Exhaust outlet parameters - velocity, temperature, diameter, flow rate and release height.
- Particulate solids and any aerosol droplets (i.e. composition of) emitted from the pressed slurry material processed through the rotary kiln dryer.
- The scrubber currently servicing the existing used lead acid battery (ULAB) facility at the site (Building G) including:
  - Historical stack emission testing for the ULAB scrubber; and

Specifications of ULAB scrubber including control efficiency information.

The objectives of this assessment task and report include:

- Determination/verification of the applicable regulatory emission standards;
- Assessment of the likely ability of existing equipment (used lead acid battery (ULAB) scrubber) to achieve governing regulatory emission thresholds;
- Assessment /confirmation of the capability of previously ordered emission control equipment (rotary kiln dryer and cyclone) associated with the liquid waste treatment plant (LWTP) to achieve regulatory compliance under proposed operating conditions; and
- Suggesting appropriate design parameters/specifications for assuring the compliance of other LWTP emission control equipment yet to be designed/selected. This equipment included the SO_2 scrubber and NH_3 scrubber to be used to treat any off-gas from the neutralisation reactors.

3. References

The analyses in this report were based on the following NSW emission standards, Australian Standards, codes and/or design references:

1. Protection of the Environment Operations (Clean Air) Regulation 2021 – Schedule 4 Standards of Concentration for Scheduled Premises – General Activities and Plant, NSW Regulations available at: Protection of the Environment Operations (Clean Air) Regulation 2021 - NSW Legislation.
2. National Air Quality Standards – Australian Government State of the Environment Report 2016 available at: https://soe.environment.gov.au/theme/ambient-air-quality/topic/2016/national-air-quality-standards.
3. Perry's Chemical Engineers Handbook 6th Edition, McGraw Hill – 1984.
4. Chemical Engineering Vol. 1 3rd Edition - Pergamon Press, Coulson and Richardson – 1977.
5. Principles Of Unit Operations 2nd Edition – John Wiley & Sons, Foust et al – 1980.
6. Transport Phenomena - John Wiley & Sons, Bird R B, Stewart W E, Lightfoot E N, - 1960.
7. FEECO International Proposal E004332 Rev 1 including process calculations – Baxter D, - 9th May 2017.
8. FEECO International Proposal E004332 Rev 1 Addendum – Baxter D, - 18th May 2017.
9. Hercules Plastics Pty Ltd Scrubber Specification/Performance Sheet HFS450.
10. Absorption of mixtures SO2-N-2 in solutions of NaOH, - Rodriguez V B, et al, Researchgate January 2000 available at: Absorption of mixtures SO2-N-2 in solutions of NaOH | Request PDF (researchgate.net).
11. Composition analysis of filter cake (dry basis) – Jeremy P.
    Email correspondence dated 26 October 2021.

4. Design Regulatory Compliance Limits

The following assumptions were made in the design assessment tasks:

- The appropriate regulatory air emission standards to apply to the development are referred to as the Group 6 emission standards. These emission standards are outlined in the Protection of the Environment Operations (Clean Air) Regulation 2021. Clause 33 (1) (f) of that document states:
  *"Subject to this Division, an activity carried out, or plant operated, on scheduled premises…….belongs to **Group 6** if it commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005."*
- Regulatory limit for solid particulates ex drying system cyclone – 20 mg/m^3.
- The airflow and hot gas flow calculations by FEECO International (equipment designers and suppliers) in relation to the rotary kiln dryer burner and gas train are correct.
- Regulatory limit for SO_2 ex neutralisation reactor off-gas scrubbing system – 1,000 mg/m^3.
  This regulatory limit applies
- Design limit for SO_X ex neutralisation reactor off-gas scrubbing system – 100 mg/m^3.
  This design limit is chosen given that some entrained SO_3 and H_2SO_4 mist egress the second (NH_3 scrubbing tower) if the circulating acid medium chosen for operations is itself SPL.
- Design limit for NH_3 ex neutralisation reactor off-gas scrubbing system – 20 mg/m^3.
  This design limit was chosen to likely achieve regulatory approval without detailed review being required. No specific published regulatory limit has been determined for NH_3 and very low emission levels can be readily achieved, even in 'worst-case' neutralisation reactor release scenarios.
- Design limit for SO_X ex ULAB scrubbing system – 100 mg/m^3.
  This design limit applies to stack emissions. However, given the release from this scrubber unit is internal to Building G, I'm unsure of the requirements in relation to emission through Building G doors, etc. I'm also unsure as to how this level relates to the historical human health monitoring records from inside Building G. The Human Health Report by EP Risk in relation to the recent LWTP EIS makes the following observation in relation to sulfuric acid mist within Building G:
  "Based upon observations made during the inspection of the Site, the potential for sulfuric acid mist exposure from the solution to workers in this building is considered unlikely."

5. Analysis Details and Results

5.1 Particulate Emissions – Ex Rotary Kiln and Cyclone

The FEECO design documents and equipment selection is based upon the following:

- Maximum kiln output will be 10,000 kg/hr of dried filter cake.
- Moisture content of the filter cake will be reduced from 50% w/w ex the filter presses down to 10% w/w ex the rotary kiln dryer outlet.
- Particle size range of the individual filter cake is between 200 mesh (77 micron) to 80 mesh (174 micron).

Additional design/operational information includes:

- Within the particle size range specified, a typical moderately rated cyclone should have a removal efficiency above 99.5%. Higher efficiency cyclones can achieve 90% removal of particles as small as 5 microns. The cyclone should exhibit very high efficiency if:
  - It is not physically overloaded (such circumstances are not foreseen); and
  - The surfaces within the cyclone and ductwork are prevented from falling below the dewpoint temperature.
- Consequently, lagging the air ductwork and the cyclone external surfaces is strongly recommended. It is noted this is not currently allowed for in the FEECO quotation(s). The dewpoint temperature of the waste gas is calculated to be around 72 ^{O}C and undesirable separation inefficiencies will occur where equipment wall temperatures drop below this temperature.
- At the specified rotary kiln dryer air throughput (18,300 acfm as specified by FEECO International) of 31,090 am3/hr, the maximum allowable particulate discharge of 20 mg/m^3 equates to a mass loss of 0.622 kg/hr of solids as fine particulates.
- Working backwards, a cyclone particulate removal efficiency of 99.5% would necessitate over 124 kg/hr being transported from the rotary kiln. This equates to about 1.24% of the dry feed weight being elutriated from the dryer in order for a regulatory exceedance to occur. This is considered to be a most unlikely scenario given the outlet solids condition is expected to be 10% moisture content.
- Stack height and stack discharge velocity are both variables and can be adjusted to achieve any particular maximum ground level concentration outcome. Generally, stack exit diameter can be adjusted to achieve an exit velocity of 15 m/s. The air dispersion modellers will be able to specify the minimum stack height required.
- The typical concentration of a number of minor component species within the filter cake follow. At these typical concentrations, the emission of these species (assuming a 20 mg/m^3 particulate emission rate) is also specified:
  - Arsenic (As) <5 mg/kg in filter cake. Maximum emission rate <0.1 µg/m^3.
  - Cadmium (Cd) <30 mg/kg in filter cake. Maximum emission rate <0.6 µg/m^3.
  - Hexavalent Chromium (Cr(VI)) <0.5 mg/kg in filter cake. Maximum emission rate <0.1 µg/m^3.
  - Lead (Pb) <600 mg/kg in filter cake. Maximum emission rate <12 µg/m^3.
  - Nickel (Ni) <100 mg/kg in filter cake. Maximum emission rate <2 µg/m^3.
  - Selenium (Se) <5 mg/kg in filter cake. Maximum emission rate <0.1µg/m^3.

  Reference to the Group 6 emission standards within the Protection of the Environment Operations (Clean Air) Regulation 2021 – Schedule 4 Standards of Concentration for Scheduled Premises, does not indicate any individual component/species emission requirement.

5.2 SO_2 Emission – Ex Neutralisation Reactor Scrubber Train

The NSW Protection of the Environment Operations (Clean Air) Regulation 2021 – Schedule 4 Standards of Concentration for Scheduled Premises (**Reference 1** in **Section 2**) specifies the maximum Group 6 emission concentration for SO_2 as 1,000 mg/m^3. However, given the potential for release of droplets and vapour from the NH_3 scrubber (assuming it will be operated using spent pickle liquor (SPL) as the absorbing fluid medium) in adverse operating conditions, the train has some potential to release both SO_2 and other SO_X species.

As a consequence, the design outlet emission condition/concentration has utilised the more stringent maximum emission guideline of 100 ppm SO_X for the preliminary design estimates for the SO_2 scrubber. Further comments on this analysis are as follows:

- Assumed ventilation rate from neutralisation reactor = 180 m^3/hr. A 100 mm diameter duct sizing would be sufficient for this with the fan/blower located after the second "in-series" scrubber (ammonia). The air flow is essentially identical for the SO_2 and NH_3 scrubbers.
- The SO_2 scrubber column will be approximately 400 mm diameter and contain 1.5 metres of packing. (Preferably plastic pall rings or similar).
- The liquid circuit for the first of the scrubbers (SO_2 scrubber) should be a dilute caustic solution. The concentration of the solution will not be critical given the mass transfer of SO_2 will be driven almost exclusively by diffusion conditions in the gas phase. Therefore, potential exists to utilise the waste caustic solutions within this circuit.
- The SO_2 scrubber should be irrigated with around 2,000 L/hr of its dilute caustic scrubbing solution. This equates to using around 25 mm pipe to convey the pumped liquid to the top of the SO_2 scrubber.
- The SO_2 scrubber column can be drained by gravity into the dilute caustic solution feed tank located beneath it. A 150 mm drainpipe to the dilute caustic scrubbing solution tank will be adequate for this purpose.
- The SO_2 scrubber column needs to be suitably lined or be of stainless steel. Stainless steel is not a perfect solution given the potential for chlorides to be present in some unusual circumstances (scenario 2b from the LWTP PHA). Fibreglass lined steel or PVC sections would be suitable. 18" PVC pipes and flanges have a minimum internal diameter of around 400 mm and would be suitable. Flanges, blank flanges, etc are all available in the United States and could be imported (if required). One example of an 18" flange can be found at:
  18" PVC Duct Socket Flange 1034-SF-18 | Wholesale PVC Duct (commercial-industrial-supply.com)
- Even in Scenario 2d (from the LWTP PHA), the SO_2 emission from the scrubber train could achieve compliance (< 100 mg/m^3) with the equipment specified above. This analysis assumes the maximum transfer rate of waste caustic between the Building E storage and the neutralisation reactors is 0.5 kL/hr.

5.3 NH_3 Emission - Ex Neutralisation Reactor Scrubber Train

- For simplicity, the design for the NH_3 scrubber column is assumed to be identical (packing and packing height) to that of the SO_2 scrubber column.
- The liquid circuit for the second of the scrubbers (NH_3 scrubber) should be a dilute acid solution. The concentration of the solution will not be critical given the mass transfer of NH_3 will once again be driven almost exclusively by diffusion conditions in the gas phase. Therefore, potential exists to utilise the waste SPL solutions within this circuit.
- Even with maximum NH_3 content in the SPL (300 mg/L) being supplied to the neutralisation reactors, the maximum likely concentration of NH_3 after scrubbing is around 15 ppm. This analysis assumes the maximum transfer rate of SPL between the Building E storage and the neutralisation reactors is 1 kL/hr.
- The NH_3 scrubber should be irrigated with around 2,000 L/hr of its dilute acid scrubbing solution. This equates to using around 25 mm pipe to convey the pumped liquid to the top of the NH_3 scrubber.
- The NH_3 scrubber column can be drained by gravity into the dilute acid solution feed tank located beneath it. A 150 mm drainpipe to the dilute acid scrubbing solution tank will be adequate for this purpose.
- The NH_3 scrubber column also needs to be suitably lined or be of stainless steel. Once again, stainless steel is not a perfect solution given the potential for chlorides to be present in some circumstances. Fibreglass lined steel or PVC sections would be suitable. It is recommended the SO_2 and NH_3 scrubbers be constructed of the same materials.

5.4 SO_X Emission – Ex ULAB Plant Scrubber

I have not committed much time to assessing this scrubber at this stage. However, given there is no external emission to Building G, the emissions from this scrubber are essentially zero from an air modelling perspective. If necessary, the emissions from Building G doorways, etc could be estimated from the ambient air quality levels within the building as measured during past human health studies.

6. Recommendations and Conclusions

6.1 Rotary Kiln and Cyclone

Given the rotary kiln dryer has already been purchased from FEECO International, DGE Group should ensure this equipment meets stipulated performance requirements during commissioning.

Given the cyclone and particulate removal equipment and ductwork is yet to be purchased, it is recommended the design calculations from FEECO International are rechecked prior to a purchase contract being finalised. In particular, that contract should:

- Nominate the regulatory requirements and in particular, the maximum particulate emission concentration of 20 mg/m^3; and
- Include performance guarantee clauses.

Ensure the ductwork is appropriately lagged to prevent any chance of the waste gas reaching the dewpoint prior to discharge. This should include a safety margin to allow for moisture ingress and damage to lagging over time.

6.2 Neutralisation Reactor - Scrubber Train

Under most conditions the emissions from the neutralisation reactor scrubbers will be essentially zero. The previous design calculations and commentary has related strictly to maintenance of regulatory compliance in the nominated "worst case" scenarios. The envisaged process flowsheet and some of the preliminary design information is shown in **Figure 1**.

The preliminary design specifications in **Section 5.2** and **Section 5.3** are strictly preliminary in nature are do not constitute finalised designs or design parameters. The information within those sections serves only to indicate the type and scale of equipment necessary to achieve the requisite air quality outcomes.

As is the case with the dryer system stack diameter and height, exit velocity and release height can be adjusted to achieve any particular maximum ground level concentration outcome. The air modelling endeavours should specify minimum stack heights and minimum discharge velocity. Generally, stack exit diameter is adjusted to achieve an exit velocity of 15 m/s.

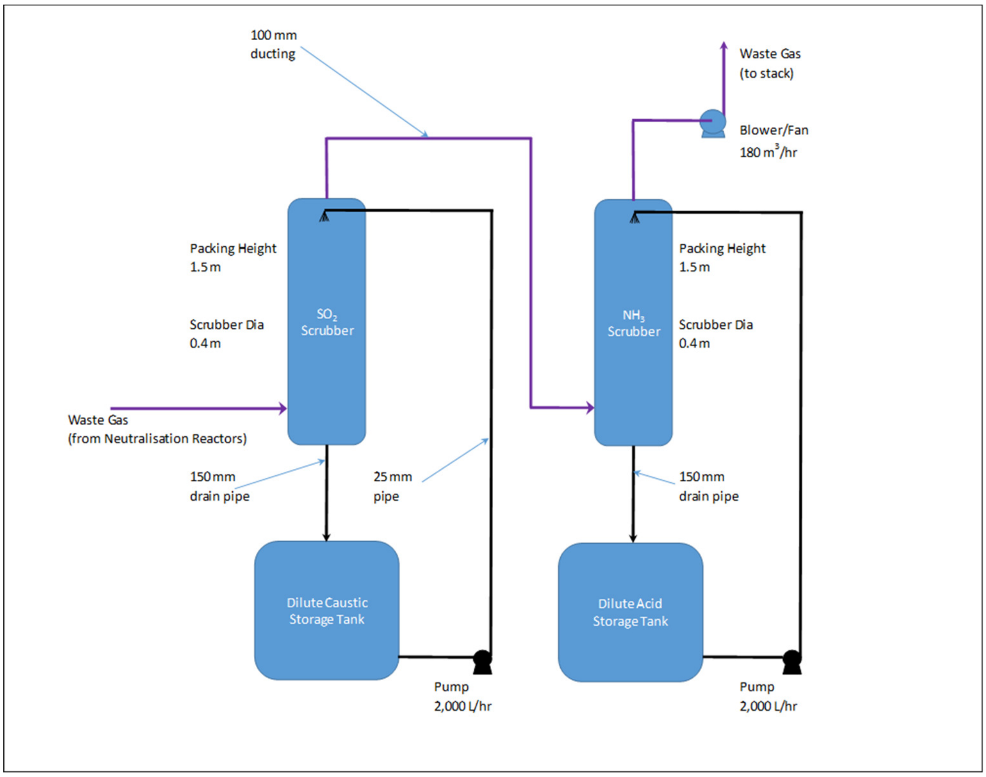

Figure 1 – Schematic Arrangement of Neutralisation Reactor Scrubber Circuits

6.3 ULAB Plant Scrubber

As previously mentioned, the discharge from the ULAB plant acid mist scrubber discharges directly into Building B. That arrangement has not been considered to constitute a human health risk as previously reported in **Section 4**.

The purpose of specifying maximum emission concentrations and venting factory/furnace/process environments to a stack is to ensure ground level concentrations of specific species do not constitute a risk to human health through either acute or chronic exposure. If the current arrangement is deemed as acceptable, it is considered most unlikely for modelling of air interchanges between Building G and its surrounds would constitute a concern from the perspective of modelling emissions at the site. However, it is noted that PPE to minimise acid mist exposure is required within Building G (ULAB Plant).

The air dispersion modelling software will be able to estimate the air interchange between Building G and its surrounds across the full range of meteorological conditions experienced. Access to health data in relation to internal acid mist concentrations will be all that is needed to facilitate the air quality modelling tasks required.