**CITY OF NORFOLK DEPARTMENT OF UTILITIES**
**DESIGN AND CONSTRUCTION STANDARDS**
**Appendix F5 – Wastewater Pump Stations Odor Control Assessment Guidelines**

This document is meant to serve as a guidance document for odor control assessments performed on City of Norfolk Wastewater Pump Stations. The procedures laid out in this document are not required to be followed, however, the information presented has been vetted by the Department and deemed to be a satisfactory method for determining which odor control technology best suits each specific pump station condition.

The four gas-phase odor control technologies mentioned in this document are technologies that the Department is familiar with and the Engineer should consider each technology for use at the subject pump station. This document is not meant to limit the Engineer in his or her evaluation, but is intended to be used as a basis for determining which technology best suits the Department's needs. The Engineer should consider alternate technologies that are not listed below, but are current in the industry and found to be suitable for treating odors at wastewater pump stations. It is the responsibility of the Engineer to determine if additional testing or more stringent sizing criteria should be used based on individual project specifics.

## Pre-Design Testing

*Existing Facilities*

Hydrogen Sulfide Monitoring

Odor loggers (field odor monitoring tools that measure hydrogen sulfide concentrations in ambient air) should be used to determine the hydrogen sulfide (H2S) loading in wastewater pumping stations and collection facilities. The odor logger should be hung inside the wet well or within the headspace of the manhole of interest at an elevation above the high-water level.

The odor logger should continuously measure the ambient $H_2S$ concentration within these facilities, providing a measurement every 1 to 5 minutes, depending on the odor logger model and the range of measurable concentration selected.

The measured $H_2S$ concentrations should be recorded by the odor logger in a data file that can be downloaded onto a personal computer and analyzed. The field odor emission data should be exported in both graphical and tabular format and analyzed for the entire monitoring period and in shorter increments, as appropriate for identifying trends in $H_2S$ concentrations in the monitored space.

The following table list the standards for H2S monitoring protocols for wastewater pump stations and collection facilities. For anticipated H2S concentrations of less than 2 parts per million (ppm) on a continuous basis, a low-range odor logger should be used. H2S sampling shall occur in the summer months to capture the yearly peak H2S concentrations.

| Hydrogen Sulfide Monitoring Standards | | | |
|---|---|---|---|
| Odor Source | OdaLog Type | Install Location | Minimum Duration of Monitoring |
| Pump Station Wet Well | Standard [a] | In the wet well at least 1 ft. above the high water level | 2 weeks [b] |
| Pump Station Fence Line | Low-Range | Typically hung on fence, tree, or an installed pole or post | 1 week |
| Manhole | Standard [a] | Beneath the manhole covers (may be installed in multiple manholes to ascertain $H_2S$ variations) | 2 weeks [b] |

[a] *OdaLog measurement range dependent on known or project $H_2S$ concentration range.*

[b] *1 week for expected minimal $H_2S$ variation in wet well headspace; 2 weeks for expected greater $H_2S$ variation in wet well headspace and/or significant weekend changes in flow or sulfide loading.*

Following collection of the H2S data plots, the following data should be identified and utilized in subsequent odor study reports and designs for odor control improvements:

• Average H2S concentration throughout the monitoring period
• Peak H2S concentration throughout the monitoring period
• Average daily maximum H2S concentration (average of the peak H2S concentrations for each full day of monitoring)
• Times of day or night where peak H2S concentrations occur (identify established trends as repeated three or more times over the course of a week)

Liquid-Phase Sampling

Liquid-phase sulfide testing may be conducted to identify the potential for odor emissions in the form of H2S from a wastewater pumping facility. When this testing is specified, liquid wastewater samples should be drawn from multiple locations along the collection system and pumping facilities and tested in the field for total and dissolved sulfides using a LaMotte test kit (or approved equal), as well as pH and biological oxygen demand (BOD). Liquid-phase testing shall occur during the summer months to capture the yearly peak sulfide concentrations.

The following liquid-phase analyses listed in the table below should be conducted for samples collected at wastewater pump stations and collection facilities. Other liquid phase properties that may in some cases be measured are dissolved oxygen, temperature, sulfate, and alkalinity:

| Liquid-Phase Analysis Standards | | | | | | |
|---|---|---|---|---|---|---|
| | | | Tests Conducted | | | |
| Odor Source | Number of Samples | Test Type | Total Sulfides | Dissolved Sulfides | pH | Biochemical Oxygen Demand (BOD) |
| Pump Station Wet Well | 3 [a] | Grab | X | X | X | X |
| Manhole | 3 [a] | Grab | X | X | X | X |

[a] *Sample during peak and average $H_2S$ conditions (according to reviewed OdaLog results)*

*New Facilities*

The selection of odor control technologies for new facilities should be determined by conducting tests at a comparable existing wastewater pump station and applying the data to the study and design of the new facility.

If no comparable wastewater pump station exists, wastewater samples should be collected from a location where the wastewater will be ultimately conveyed to the new facility and tests shall be conducted on those samples. Liquid-phase sampling as described above is applicable and mathematical calculations should be used with supporting empirical data to extrapolate measured liquid-phase sulfide data to arrive at theoretical corresponding gas-phase $H_2S$ concentrations.

Once the theoretical $H_2S$ concentrations are determined, the appropriate odor control technology should be selected and a footprint of the selected technology (foundation, chemical pumps for liquid-phase systems, fans for gas-phase systems, etc.) should be incorporated into the pump station design. Upon completion of construction of the new facility, additional gas-phase and liquid-phase testing should be conducted to substantiate the selected odor control technology and verify system size, air flow rates, etc.

## Technology Selection

*Air Flow Quantification*

The required air flow rate of the odor control system is based on generating a negative air pressure within the wet well. The following calculation can be used to determine the required air flow rate:

Required air flow rate = 1 cfm per sf of wet well surface area + air being dragged into the wet well by peak influent flow or 6 air changes per hour, whichever is greater.

*Technology Selection*

Each of the technologies explored should be evaluated based on several criteria, including treatment capabilities, footprint, maintenance requirements, sustainability, and capital and operational costs. Decisions on project implementation should be based on a combination of life-cycle cost analyses and non-economic criteria and considerations.

As an initial step in screening the four technologies mentioned below, a general rule-of-thumb determination summarized in the table below should be considered. The table identifies preferred technologies given the projected inlet H2S concentration and airflow rate to be treated, in cubic feet per minute (cfm).

| Odor Control Technologies Selection: Rule-Of-Thumb Criteria | | | |
|---|---|---|---|
| Parameter | Low $H_2S$ Concentration <10 ppmv | Medium $H_2S$ Concentration 10-100 ppmv | High $H_2S$ Concentration >100 ppmv |
| Low Flow ≤10,000 cfm | Carbon Absorber | Carbon Absorber<br>Biofilter | Biofilter |
| High Flow >10,000 cfm | Carbon Absorber | Biofilter<br>Biotrickling Filter<br>Chemical Scrubber | Biofilter<br>Biotrickling Filter<br>Chemical Scrubber |

**System Sizing**

The following are design parameters used for sizing odor control technology applications during preliminary and detailed design phases. Note that any of the values in the tables may be adjusted in the field to optimize conditions under actual loads.

| Chemical Scrubber Design Criteria | | | |
|---|---|---|---|
| Parameter | Units | Value | Notes |
| Gas flow loading | lb./hr./ft$^2$ | 1,800-2,250 | Typical range per WEF MOP No. 25 |
| Gas velocity | ft./min | 300-500 | Typical range per WEF MOP No. 25 |
| Liquid flow rate | lb./hr./ft$^2$ | 3,000-4,000 | Typical range per WEF MOP No. 25 |
| Gas-liquid contact time | Sec | 1-2 | Typical range for hypochlorite/caustic scrubbers |
| Packing height | Ft | 5-10 | General range in to reduce pressure drop |
| pH setpoint | - | 9-11 | Selection dependent on anticipated $H_2S$ load to scrubber |
| ORP setpoint | mV | 600 | Typical minimum for sufficient oxidation of $H_2S$ to non-odorous compounds |
| Blowdown rate | % | 1-2 | Percentage of recirculation rate |

| Biotrickling Filter Design Criteria | | | |
|---|---|---|---|
| Parameter | Units | Value | Notes |
| Media contact time | sec | 5-15 | Will vary depending on odor/$H_2S$ load and selected manufacturer |
| Media depth | ft. | 10-20 | Will vary depending on manufacturer preference |
| Makeup water | gpm/ft$^3$ | 0.0015 | Standard value |
| Gas velocity | ft./min | 50-70 | Typical range |
| Liquid loading rate | gpm/ft$^2$ | 1-2 | Standard range (may be higher for non-recirculating systems) |
| Maximum pressure drop | inches of water column | 4 | Typical value used by manufacturers (inlet flange to outlet flange of vessel) |
| Blowdown rate | % | 1-2 | Percentage of recirculation rate |

| Biofilter Design Criteria | | | |
|---|---|---|---|
| Parameter | Units | Value | Notes |
| Empty bed residence time (EBRT): organic media | sec | 60 | Minimum value typically recommended |
| EBRT: engineered media | sec | 30-45 | Depending on manufacturer and odor load |
| EBRT: soil media | sec | 90 | Typical for Bohn biofilter media |
| Media depth | ft. | 4-8 | Higher values acceptable for engineered media; lower values typical for organic media |
| Projected media life: organic media | yr. | 3-5 | Based on previous experience |
| Projected media life: engineered media | yr. | 10-20 | Provided in previous designs from biofilter manufacturer (warrantied against compaction) |
| Length: width ratio | - | 2:1 to 3:1 | Appropriate for evenly distributed air loading to plenum |
| Pressure drop through media | Inches of water column | 0.75-1 | Common range given by engineered media manufacturers |
| Inlet air relative humidity | % | 95 | Minimum for no negative impacts on media (drying) |
| Irrigation rate | gpm/$ft^3$ | 0.0015 | Standard value for organic media (alternate values will be provided by manufacturers for engineered media) |

| Activated Carbon Design Criteria | | | |
|---|---|---|---|
| Parameter | Units | Value | Notes |
| Face velocity | ft./min | 60-70 | Industry standard, provided in WEF MOP No. 25 |
| Bed depth | Ft | 3 | Typical maximum to avoid excessive pressure drop |
| Foul air relative humidity | % | 50 | Maximum given in literature for minimal impact on pore spaces |
| Media moisture content (by weight) | % | 3 | Maximum typically specified |
| $H_2S$ breakthrough capacity (virgin carbon) | g $H_2S$ adsorbed / g carbon | 0.04 | Minimum typically specified |
| $H_2S$ breakthrough capacity (high-capacity carbon) | g $H_2S$ adsorbed / g carbon | 0.4 | Minimum typically specified |
| Media pressure drop | In | 5 | Maximum specified for 3-ft beds |

### Treatment Performance

The following tables list the minimum removal efficiency requirements for each specific treatment technology. In each application the treatment requirements must be checked with manufacturers of the equipment to assure that the technology will be able to meet the specified level of removal.

| Removal Efficiency Requirements<br>Chemical Scrubbing | | |
|---|---|---|
| Odor Parameter | Treatment Requirement | Inlet Loading Condition |
| $H_2S$ Concentration | 99.9 percent removal | ≥ 50 ppmv |
| $H_2S$ Concentration | ≤ 0.050 ppmv | < 50 ppmv |
| Odor Detection Threshold | 90 percent removal | ≥ 3,000 D/T |
| Odor Detection Threshold | ≤ 300 D/T | < 3,000 D/T |

| Removal Efficiency Requirements<br>Biotrickling Filter | | |
|---|---|---|
| Odor Parameter | Treatment Requirement | Inlet Loading Condition |
| $H_2S$ Concentration | 99 percent removal | ≥ 5 ppmv |
| $H_2S$ Concentration | ≤ 0.050 ppmv | < 5 ppmv |
| Odor Detection Threshold | 70 percent removal | ≥ 1,000 D/T |
| Odor Detection Threshold | ≤ 300 D/T | < 1,000 D/T |

| Efficiency Requirements<br>Biofilter | | |
|---|---|---|
| Odor Parameter | Treatment Requirement | Inlet Loading Condition |
| $H_2S$ Concentration | 99 percent removal | ≥ 5 ppmv |
| $H_2S$ Concentration | ≤ 0.050 ppmv | < 5 ppmv |
| Odor Detection Threshold | 70 percent removal | ≥ 1,000 D/T |
| Odor Detection Threshold | ≤ 300 D/T | < 1,000 D/T |

| Removal Efficiency Requirements<br>Activated Carbon | | |
|---|---|---|
| Odor Parameter | Treatment Requirement | Inlet Loading Condition |
| $H_2S$ Concentration | 99.9 percent removal | ≥ 50 ppmv |
| $H_2S$ Concentration | ≤ 0.050 ppmv | < 50 ppmv |
| Odor Detection Threshold | 90 percent removal | ≥ 3,000 D/T |
| Odor Detection Threshold | ≤ 300 D/T | < 3,000 D/T |

### Operations and Maintenance Manual

An Operations and Maintenance (O&M) manual should be provided to the City for each new odor control facility installation. The engineer should consider the following activities to be included in the O&M manual.

| Suggested Maintenance Requirements for Odor Control Systems | | |
|---|---|---|
| **Odor Control Technology** | **Maintenance Activity** | **Frequency** |
| Chemical Scrubbing | Acid cleaning of nozzles | Quarterly |
| | Chemical metering pumps maintenance | Semi-annual |
| | Chemical metering pump instrumentation | Monthly |
| | Recirculation pumps: verify discharge pressure | Quarterly |
| | Recirculation pumps: motor maintenance | Semi-annual (replace motors every 5 years) |
| | Fan maintenance | Quarterly |
| | pH/ORP probe testing and calibration | Weekly |
| Biotrickling Filters | Recirculation pump routine maintenance | Semi-annual |
| | Recirculation pump instrumentation | Monthly |
| | Recirculation pumps: verify discharge pressure | Quarterly |
| | Recirculation pumps: motor maintenance | Semi-annual (replace motors every 5 years) |
| | Pressure gages: routine maintenance | Quarterly |
| | Nutrient feed system inspection | Weekly |
| | Fan maintenance | Quarterly |
| | pH probe testing and calibration | Weekly |
| Biofilters | Irrigation metering pump routine maintenance | Semi-annual |
| | Irrigation metering pump instrumentation | Monthly |
| | Pressure gages: routine maintenance | Quarterly |
| | Humidification chamber routine maintenance | Semi-annual |
| | Weed removal | Weekly (less frequent for engineered and soil media) |
| | Media replacement | Every 3-5 years (organic media only) |
| | Fan maintenance | Quarterly |
| Activated Carbon | Inspect instrumentation (pressure gages) | Monthly |
| | Media testing (for breakthrough) using field probes or sending samples to laboratory | Varies (depending on $H_2S$ and odor loading) |
| | Media replacement | Varies (depending on $H_2S$ and odor loading) |
| | Fan maintenance | Quarterly |