STATE OF IDAHO
DEPARTMENT OF
ENVIRONMENTAL QUALITY

IPDES Guide to Developing Hydrogen Sulfide (H_2S) Local Limits

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2 Purpose and Applicability

This document provides guidance to Publicly Owned Treatment Works (POTWs) wishing to develop and implement regulatorily defensible local limits for hydrogen sulfide (H_2S) in their collection systems. While this document frequently references the General Pretreatment Regulations, 40 CFR 403, it is not focused only on those POTWs that have an approved Pretreatment program. Any POTW may establish and enforce local limits to ensure continued compliance with the POTW's IPDES or Reuse permit, or sludge use or disposal practices.

The regulation 40 CFR 403.5(b) prohibits the introduction of certain pollutants into a POTW. Paragraph (2) prohibits "Pollutants which will cause corrosive structural damage to the POTW," and paragraph (7) prohibits "Pollutants which result in the presence of toxic gases, vapors, or fumes within the POTW in a quantity that may cause acute worker health and safety problems."

Further, 40 CFR 403.5(c)(1) reads: "Each POTW developing a POTW Pretreatment Program pursuant to § 403.8 shall develop and enforce specific limits to implement the prohibitions listed in paragraphs (a)(1) [*pass through and interference*] and (b) [*specific prohibitions*] of this section. Each POTW with an approved Pretreatment program shall continue to develop these limits as necessary and effectively enforce such limits." H_2S fits both prohibitions but is typically not included as a pollutant of concern in a local limits evaluation. This guidance aims to correct that oversight.

Because H_2S can be such a complex and pervasive problem in a POTW's collection system, this document acts only as a guide and does not provide a complete solution. POTWs facing H_2S issues are also encouraged to consult EPA guidance, *Detection, Control, and Correction of Hydrogen Sulfide Corrosion In Existing Wastewater Systems* (EPA 1992a) and *Guidance to Protect POTW Workers from Toxic and Reactive Gases and Vapors* (EPA 1992b). POTWs that hire wastewater experts should review the person's or firm's track record on tracking and remediating high H_2S levels in domestic sewer systems.

3 Summary of Guidance

This document provides guidance on developing either atmospheric H_2S limits or equivalent aqueous limits. Approaches are based on OSHA/NIOSH requirements (29 CFR 1910 Subpart Z; IDAPA 58.01.01) using time-weighted averages or conversions of OSHA/NIOSH ceiling concentrations to aqueous equivalent concentrations to determine Industrial User effluent screening limits. Additionally, this document provides guidance on decreasing the generation of H_2S using pretreatment of industrial wastewaters and other procedures for mitigating the deleterious effects of H_2S throughout the POTW. The key to a successful H_2S program will be having sufficient legal authority to enact and enforce the options presented.

4 Definitions

ACGIH	American Conference of Governmental Industrial Hygienists—A charitable scientific organization that advances occupational and environmental health.
AEGL-2	Acute Exposure Guideline Levels are used by emergency planners and responders worldwide as guidance in dealing with releases of chemicals into the air and are expressed as specific concentrations at which health effects may occur. Level 2 toxicity effects include irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
aerobic	Biological processes that occur in the presence of oxygen.
anaerobic	Biological processes that occur in the absence of oxygen.
BMPs	Best Management Practices—Schedules of activities, prohibitions of practices, maintenance procedures, and other management practices to implement the prohibitions listed in 40 CFR 403.5.
BOD	Biological Oxygen Demand—An analytical parameter representing the amount of dissolved oxygen consumed by aerobic bacteria, measured in milligrams per liter (mg/L).
CFR	Code of Federal Regulations—The codification of the general and permanent regulations promulgated by the executive departments and agencies of the federal government.
COD	Chemical Oxygen Demand—An indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution, measured in mg/L.
DAF	Dissolved Air Flotation—A treatment process in which suspended solids and FOG are removed by the action of tiny bubbles formed from air injected into the waste stream, which attach to the suspended matter and float it to the surface where it can be removed by a skimming device.
DO	Dissolved Oxygen—The amount of oxygen present in a volume of water, measured in mg/L.
EQ tank	Equalization Tank—A large tank that allows for mixing of multiple process wastewaters to mitigate or equalize various parameters such as pH, temperature, or flow prior to discharge to a POTW.
Flocculation	The process of clumping together of suspended matter in wastewater with or without the addition of chemical coagulants, allowing the material to float or sink more efficiently.
FOG	Fats, oils, and grease—Organic compounds derived from plant or animal sources that are composed of long chain fatty acids. “Yellow” grease is typically used fryer oil and can be recycled into animal feeds, soap, or biodiesel. “Brown” grease is FOG that has been washed into the sewer drains and captured in a grease removal device. It typically is harder to reclaim because of contaminants like food and trash.
Henry’s Law	The 1803 gas law, formulated by William Henry, states that the solubility of a gas in a liquid is directly proportional to the partial pressure of the gas above the liquid.
Henry’s Law Constant	The proportionality factor of a particular chemical species for use in finding the solubility of a gas in a liquid (typically water).

HS^-	Bisulfide—The conjugate base of H_2S. Present mostly at neutral to mid-high pH.
H_2S	Hydrogen Sulfide— A colorless gas that is toxic, corrosive, and flammable and is heavier than air. Trace amounts create the pungent odor associated with “rotten egg” smell. At higher levels, H_2S can quickly deaden the sense of smell.
H_2SO_4	Sulfuric acid—A strong acid manufactured by microbes living in slime layers inside sewer collection system as a part of their biologic processes in the presence of H_2S.
IDAPA	Idaho Administrative Procedures Act—A compilation of all administrative rules that are currently in effect and fully enforceable.
Local Limits	Specific technically based pollutant prohibitions or limits on pollutants or pollutant parameters developed to control the amount of pollutants allowed to be discharged into the POTW. Required by 40 CFR 403.5 and are deemed enforceable Pretreatment Standards.
mg/L	Milligrams per liter—Common measurement of pollutants in water, equal to parts per million (ppm).
NIOSH	National Institute for Occupational Safety and Health—A division of the Centers for Disease Control and Prevention in the Department of Health and Human Services.
OSHA	Occupational Safety and Health Administration
pH	A logarithmic scale of 0 to 14 used to specify the acidity (below 7) or basicity (above 7) of aqueous solutions. A pH of 7 is considered neutral and is the pH of pure water.
POTW	Publicly Owned Treatment Works—A treatment works that is owned by the state or municipality, including any devices and systems used in the storage, treatment, recycling, and reclamation of municipal sewage or industrial wastes of a liquid nature. It also includes sewers, pipes, and other conveyances if they convey wastewater to a POTW treatment plant.
PVC, PE	Polyvinyl Chloride and Polyethylene—Plastic pipe material that is resistant to corrosion from sulfides.
SIU	Significant Industrial User—A nondomestic user of the sewer system that discharges industrial process wastewater to a POTW and meets the definition provided in 40 CFR 403.3(v).
SO_4^{2-}	Sulfate—Soluble anion usable by microbiology as a source of oxygen.
SO_3^{2-}	Sulfite—Naturally occurring anions often used as a food preservative.
SRB	Sulfate-reducing bacteria—Bacteria that use the oxygen in sulfate for metabolic processes, instrumental in converting sulfate to hydrogen sulfide.
STEL	Short Term Exposure Limit—The acceptable average exposure to a chemical substance over a short period of time, typically 15 minutes.
SUO	Sewer Use Ordinance—A legal mechanism implemented by a local government entity that sets out, among others, requirements for the discharge of pollutants into a POTW.
Surcharge	An extra fee charged to a user of the sewer system to mitigate the cost of treating industrial wastewaters of higher strength than domestic waste.

TLV	Threshold Limit Value—Airborne concentrations of chemical substances under which it is believed that nearly all workers may be repeatedly exposed, day after day, over a working lifetime, without adverse health effects.
TSS	Total Suspended Solids—A measurement of waterborne particles that exceed 2 microns in size and consist of any pollutant that floats or suspends in water.
TWA	Time-Weighted Average—A method of calculating a worker's daily exposure to hazardous substances, typically averaged over 8 hours in a day.
WWTP	Wastewater Treatment Plant—A mechanical and biological operation that works to remove pollutants from wastewater to clean it sufficiently for reuse or release into the environment.

5 Hydrogen Sulfide Background

5.1 Causes of Hydrogen Sulfide

H_2S is generated by the metabolic processes of sulfate-reducing bacteria (SRB), such as *Desulfovibrio* and *Desulfobacter*, during the decomposition of organic matter in wastewater. The conditions that encourage growth of these bacteria and formation of H_2S include high strength, acidic, and warm wastewater under stagnant and anaerobic conditions. Figure 1 illustrates factors that influence the formation of H_2S in wastewater.

High strength wastewater contains higher amounts of organic materials, measured as biological oxygen demand (BOD) or chemical oxygen demand (COD). High BOD/COD wastewater is far more likely to lead to formation of H_2S simply due to the higher amount of organic material translating to higher populations of bacteria. High strength wastewater can occur due to spills of raw or other materials, standard industrial processes, or even water-saving measures.

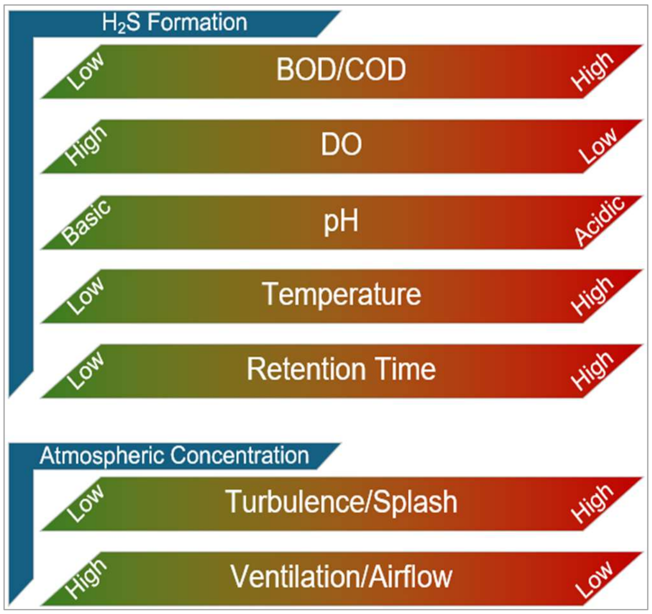

Figure 1. Factors influencing H2S formation and release.

Low dissolved oxygen is often a result of bacterial action within the wastewater and is the primary driver of H_2S formation. As the dissolved oxygen (DO) in the wastewater is used up, aerobic strains of bacteria begin to die off, and SRB will begin to increase in population, using sulfate (SO_4^{2-}) and sulfite (SO_3^{2-}) as energy sources.

An acidic environment can result from acidic equipment wash waters, and SRB are most efficient at reducing sulfate in slightly acidic wastewater, between pH 5.5–6.5. Lower pHs also allow the wastewater to contain more dissolved H_2S and prevent ionization to HS^- as seen in Figure 2.

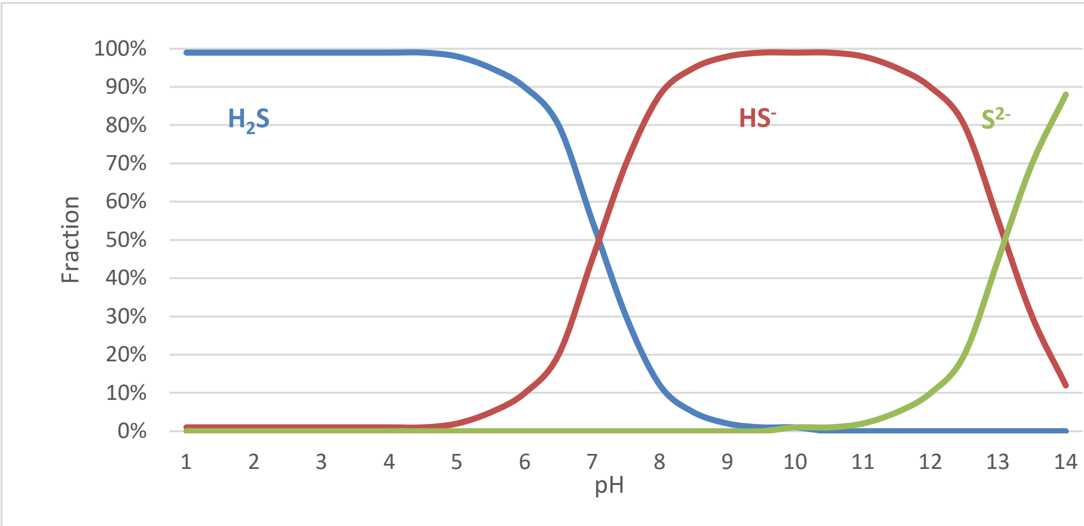

Figure 2. pH dependent forms of sulfide.

Acidic conditions, together with temperatures above 25 °C, provide a favorable environment for SRB and promote increased sulfate reduction rates and higher H_2S formation rates.

Longer retention times, for example in an oversized equalization (EQ) tank, allow for more microbial activity and decomposition of organic materials increasing H_2S formation.

To illustrate, consider a wastewater storage tank that accepts high BOD wastewater and warm, acidic equipment wash waters. Bacteria within the storage tank will quickly use up any free oxygen in the wastewater creating anaerobic conditions. Sulfur-reducing bacteria increase in population, creating H_2S, and keeping the pH acidic. When this wastewater tank is discharged, the turbulence caused by the wastewater's travel into and through the collection system causes the H_2S to escape from solution and become airborne where it becomes a hazard to personnel and infrastructure.

On the other hand, introduction of oxygen into the storage tank will allow other bacteria to proliferate, reducing the available BOD, and moderating the action of SRB.

Once in the collections system, dissolved H_2S will be liberated by turbulence within the wastewater, either through sewer pipe architecture, e.g., tees or other right angles, or through drops in elevation, as into a bigger pipe, manhole, or a lift station. Once liberated, low airflow conditions allow the H_2S to act directly on any exposed metal infrastructure or to be used by sulfur-oxidizing bacteria in slime layers in the sewer system, creating sulfuric acid (H_2SO_4), which corrodes concrete and metal in the collection system.

Poor ventilation in areas prone to H_2S release can also create levels of H_2S that can injure or kill sewer workers or members of the public. Section 5.2 provides additional information on the deleterious health effects of H_2S in the sewer system.

5.2 Effects of Hydrogen Sulfide

H_2S is a colorless gas with a strong, distinct odor often described as smelling like “rotten eggs.” While the odor is a useful initial warning, the sense of smell becomes rapidly fatigued and cannot be relied upon to warn of the continuous presence of the gas. H_2S gas is both an irritant and a chemical asphyxiant with effects on both oxygen utilization and the central nervous system. Workers are primarily exposed to H_2S by breathing it. It causes a wide range of health effects which depend on how much H_2S was inhaled and for how long. Exposure to very high concentrations can quickly lead to death. Table 1 provides common symptoms and effects from exposure to various concentrations of H_2S gas.

In addition to health effects, H_2S gas can lead to significant damage to the POTW’s collection system. H_2S directly attacks metals such as copper, iron, and steel. This exposure can cause damage to equipment and infrastructure in the collection system such as electrical components, process instrumentation, air conditioning and ventilation units, metal ladders, grates, bar screens, and guard rails. Additionally, H_2S can be converted biologically in the presence of moisture to sulfuric acid, which is damaging to concrete structures used in the conveyance and treatment of sewage. Figure 3 illustrates extreme H_2S damage on the influent channel of a wastewater treatment plant (WWTP).

Figure 3. H_2S corrosion in WWTP influent channel.

Table 1. Health effects of exposure to H_2S gas.

Concentration (ppm)	Symptoms/Effects
0.00011-.000033	Typical background concentrations.
0.01-1.5	Odor threshold (when the “rotten egg” smell is first noticeable to some). Odor becomes more offensive at 3–5 ppm. Above 30 ppm, odor described as sweet or sickeningly sweet.
2-5	Prolonged exposure may cause nausea, tearing of the eyes, headaches, or loss of sleep. Airway problems (bronchial constriction) are reported in some asthma patients.
20	Possible fatigue, loss of appetite, headache, irritability, poor memory, dizziness.
50-100	Slight conjunctivitis (“gas eye”) and respiratory tract irritation after 1 hour. May cause digestive upset and loss of appetite.
100	Coughing, eye irritation, loss of smell after 2–15 minutes (olfactory fatigue). Altered breathing, drowsiness after 15–30 minutes. Throat irritation after 1 hour. Gradual increase in severity of symptoms over several hours. Death may occur after 48 hours.
100-150	Loss of smell (olfactory fatigue or paralysis).
200-300	Marked conjunctivitis and respiratory tract irritation after 1 hour. Pulmonary edema may occur from prolonged exposure.
500-700	Staggering, collapse in 5 minutes. Serious damage to the eyes in 30 minutes. Death after 30-60 minutes.
700-1000	Rapid unconsciousness, “knockdown,” or immediate collapse within 1 to 2 breaths, breathing stops, death within minutes.
1000-2000	Nearly instant death.

6 Local Limit Development for Controlling Hydrogen Sulfide

Since H_2S is prohibited in quantities that may cause violations of either or both of two specific prohibitions (40 CFR 403.5(b)(2) and (7)), a POTW that is experiencing elevated levels of H_2S in their collection system originating from industrial users should develop local limits for H_2S. H_2S can be monitored and regulated as a gas, in the liquid phase, or both. The approach is up to the POTW. Unlike other pollutants in wastewater, where local limits are evaluated based on removal efficiencies at the WWTP and compared to environmental limits in receiving streams, biosolids, or permit requirements. H_2S local limits are based either on nationally established personnel safety limits or limits designed to minimize damage to infrastructure. Background levels of sulfate in the community’s drinking water must also be evaluated during local limit development (section 7.5). The following local limit development methods are based on Chapter 8 of the EPA’s Local Limits Development Guidance (EPA 2004a; EPA 2004b).

6.1 Atmospheric Time-Weighted Local Limits

The POTW can develop a time-weighted local limit if the primary goal is to protect POTW personnel from excess exposure to H_2S. Time-weighted averages should be developed over a 10 or 15-minute time frame by either averaging individual instantaneous readings each minute or using monitoring equipment that provides an automatic time-weighted average (TWA) or a short-term exposure limit (STEL). Table 2 provides a selection of published safety standards designed to protect workers. The POTW, in consultation with city management and legal counsel, should choose the standard to be used from Table 2 or a different standard designed to protect the public and POTW personnel, which will serve as the local limit.

Using an air monitoring meter, which is calibrated at the manufacturer's recommended frequency, POTW personnel will monitor the sewer headspace upstream of, and as close as possible to, where the industrial discharge joins the POTW's collection system to prevent the possibility of upstream sources interfering with the results. Compare the results of monitoring to the selected standard. Exceedance of this standard will trigger compliance assistance, pollutant surcharges, or enforcement, as outlined in the POTW's Sewer Use Ordinance (SUO) and, if available, Enforcement Response Plan.

Table 2. Published safety standards for an atmospheric H_2S local limit.

Standard	Type of Standard	Source
41 ppm[1]	EPA AEGL-2, 10-minute[2]	epa.gov/aegl/hydrogen-sulfide-results-aegl-program
20 ppm[1]	acceptable ceiling concentration[3]	29 CFR 1910.1000 Table Z-2
10 ppm[1]	10-minute ceiling[4]	NPG[5], 2007, pg 170
14 (mg/m^3)[6]	occupational exposure limit[7]	IDAPA 58.01.01.585
5 ppm[1]	threshold limit value/short-term exposure limit[8]	acgih.org/hydrogen-sulfide/[9]

[1]parts per million
[2]Acute Exposure Guideline Levels are used by emergency planners and responders worldwide as guidance in dealing with releases of chemicals into the air and are expressed as specific concentrations at which health effects may occur. Level 2 toxicity effects include irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
[3]An employee's permissible exposure limit (PEL) for hydrogen sulfide shall not exceed at any time during an 8-hour shift the acceptable ceiling concentration limit, except for a time period, and up to a concentration **not exceeding** 50 ppm peak for 10 minutes once during an 8-hour shift, only if no other measurable exposure occurs (derived from 29 CFR 1910.1000(b)(2)).
[4]The ceiling recommended exposure limit (REL) should not be exceeded for more than 10 minutes.
[5]National Institute for Occupational Safety and Health (NIOSH) Pocket Guide to Chemical Hazards, 3rd Printing.
[6]milligrams per cubic meter
[7]Occupational exposure limit (OEL) is an upper limit on the acceptable concentration of a hazardous substance in workplace air for a particular material or class of materials.
[8]Threshold limit value/short-term exposure limit (TLV-STEL) is the 15-minute time-weighted average exposure not to be exceeded during a workday.
[9]American Conference of Governmental Industrial Hygienists TLV (2025).

6.2 Aqueous Equivalent Industrial Discharge Screening Limits

Rather than, or in addition to, monitoring atmospheric levels of H_2S at an industry's discharge into the collection system, the POTW might want to directly measure the amount of sulfide in an industry's effluent or require the industry to perform routine or continuous monitoring. The amount of sulfide discharged by an industry might not affect worker health and safety directly downstream of the industry, but may cause, or contribute to, worker health and safety or corrosion elsewhere in the POTW. A direct measurement of sulfide can be compared to an aqueous equivalent screening limit calculated from the selected standard in Table 2.

The aqueous screening limit is calculated using the Henry's Law Constant for H_2S. Henry's Law states: "At a constant temperature, the amount of a given gas that dissolves in a given type and volume of liquid is directly proportional to the partial pressure of that gas in equilibrium with that liquid."

To calculate the aqueous screening limit, select a standard from Table 2, normally the exposure limit selected for the Time-Weighted Atmospheric Local Limit. Convert this value from parts per million (ppm) to milligram per cubic meter (mg/m^3) to calculate the vapor phase concentration (C_{VAP}), which is then divided by the Henry's Law Constant to calculate the screening limit (C_{LVL}) (Equation 1 and Equation 2).

$$C_{VAP}\left(\frac{mg}{m^3}\right) = \frac{Standard\ (from\ Table\ 2)(ppm) \times molecular\ weight}{24.45}$$

Equation 1. Vapor phase concentration conversion.

$$C_{LVL} = \frac{C_{VAP}}{H}$$

Equation 2. Industrial User discharge screening limit.

Where:

C_{LVL} = Industrial User (IU) discharge screening limit (in mg/L)
C_{VAP} = Vapor phase concentration of the Selected Standard (in mg/m^3)
H = Henry's Law Constant (in (mg/m^3)/(mg/L))

For example, entering the NIOSH 10-minute ceiling standard and the molecular weight for H_2S into Equation 1, then entering the calculated vapor phase concentration and H_2S Henry's Law Constant, the IU discharge screening limit can be calculated:

$$C_{VAP} = \frac{10\ ppm \times 34.08}{24.45} = 13.94\ \left(\frac{mg}{m^3}\right)$$

$$C_{LVL} = \frac{13.94\left(\frac{mg}{m^3}\right)}{414.4\left(\frac{mg}{m^3}\Big/\frac{mg}{L}\right)} = 0.034\ \left(\frac{mg}{L}\right)$$

This method is considered conservative because Henry's Law assumes equilibrium between the aqueous phase and the vapor phase, and the method makes some simplifying assumptions:

- Standard Temperature and Pressure is assumed (STP, 1 atm, 25 °C);
- other constituents have no effect on the Henry's Law constant;
- the screening approach conservatively assumes that air flow is negligible;
- the vapor-liquid equilibrium is assumed to be instantaneous without consideration of volatilization rates.

To account for this conservative approach, the POTW may wish to utilize the screening limit only as a surcharge limit (see Section 7.3) while establishing an enforceable local limit equal to double or triple the calculated screening limit. This approach can provide adequate worker protection while establishing a limit for industry that isn't impossible to meet.

For example, using the various standards listed in Table 2, a POTW might implement an IU discharge screening limit ranging from 0.017 mg/L to 0.138 mg/L. The enforceable local limit might then be established anywhere from 0.034 mg/L to 0.414 mg/L.

One consideration about the implementation of a H_2S discharge screening limit is that H_2S tends to dissociate in water from H_2S into its ions HS^- (bisulfide) and S^{2-} (sulfide) as pH increases. This factor can be problematic for monitoring as not all H_2S sensors are designed to also read HS^-. A POTW implementing an IU discharge screening limit is encouraged to research the best method or equipment that will provide accurate sulfide levels at any pH. Figure 2 shows the approximate combination of these three forms of sulfide across the pH scale.

7 Other Methods for Controlling Hydrogen Sulfide

7.1 Industrial Pretreatment

The Water Quality Act of 1987 required EPA to study and report on H_2S corrosion in wastewater collection and treatment systems in coordination with the city and county of Los Angeles (EPA 1991). The report identified several aspects of industrial pretreatment that lowered the potential for sulfide generation and corrosion in sewer systems. These aspects include reduction of sulfide-bearing wastes, reduction in acidic wastes, reduction of high strength organic waste discharges, reduction in fats, oils, and grease (FOG), and reduction of high temperature discharges. These aspects match the factors that affect the generation of H_2S shown in **Error! Reference source not found.**. While the reduction of sulfide-bearing wastes and reduction in acidic wastes are addressed in section 7.2, the other three factors are discussed here.

7.1.1 Reduction of High Strength Organic Waste Discharges

High strength organic wastes include both high-BOD wastes and wastewaters high in total suspended solids (TSS). Because high strength organic waste provides food for bacteria, high strength discharges should be controlled. POTWs with high levels of H_2S in the collection system may choose to require industrial dischargers to install and use higher levels of treatment to reduce food for bacteria populations, which reduces oxygen uptake and depression of dissolved oxygen. Reduction of high strength discharges can be accomplished with treatment processes such as solids separation, and aerobic or anaerobic processes.

Common methods of solids separation include screening, dissolved air flotation (DAF), clarification, or filtration. Screening is usually a preliminary step to get the largest particles out of the waste flow. DAFs or clarifiers are often aided by chemical coagulants or polymers to increase flocculation and separation. Filtration is accomplished with fabric filters, sand filters, or membranes.

Aerobic processes include aeration chambers or basins, oxidation ditches, trickling filters, moving bed biofilm reactors (MBBR), or membrane bioreactors (MBR). All processes involve supplying oxygen to the wastewater flow to allow bacteria to break down organic wastes. Some require prefiltration, and all require postprocess solids separation.

Anaerobic processes include batching or continuous anaerobic digestion, upflow anaerobic sludge blanket reactors (UASBs), and expanded granular sludge bed reactors (EGSBs). As with aerobic processes, prefiltration may be required along with postprocess solids separation.

Both aerobic and anaerobic processes can substantially reduce both BOD and TSS in industrial wastewater. Because low DO is conducive to creation of H_2S from wastewater containing sulfates or sulfites, anaerobic treatment may be less desirable in waste streams that contain significant levels of sulfuric molecules. However, lower solids quantity, maintenance, and energy costs, along with the generation of biomethane as a beneficially reusable byproduct, makes anaerobic processes very attractive.

7.1.2 Reduction in Fats, Oils, and Grease Discharges

Industrial FOG discharges can play a number of roles in generating H_2S. When FOG is allowed to build up inside sewer lines, it causes reduced flow velocities and increased solids deposition, in addition to increasing the potential for sewer blockages. These reduced velocities and increased solids create ideal breeding grounds for SRB and promote H_2S generation.

Combating FOG discharges typically extends beyond the significant industrial users (SIUs) that are the main focus of this guidance. While SIUs can certainly reduce FOG discharges, using DAF or filtration, for example, other nondomestic dischargers (and domestic dischargers) play their parts in reducing FOG buildup in the collection system. A robust FOG program can significantly reduce levels of FOG generated from food service establishments by requiring the installation and maintenance of grease removal devices and by encouraging the recycling of “yellow” fryer grease. Additional information for developing and running a FOG program is available in the NPDES operator webinar, “What We Know After 23 Years of FOG Program Work” (EPA 2023).

Reduction of FOG from domestic discharges, while beyond the applicability of the Pretreatment regulations, can help reduce overall FOG levels in the sewer. Domestic dischargers can benefit from education campaigns such as door hangers, bill inserts, or general advertising as well as concrete programs such as distributing grease disposal containers or providing drop-off facilities for yellow grease. Large apartment complexes can be significant sources of domestic FOG discharges. Working with apartment management to educate or provide alternative disposal methods can also reduce these issues.

Finally, because no matter how robust a FOG program is, the best pretreatment efforts typically only remove approximately 80% of FOG. Therefore, a consistent and rigorous collection system cleaning program is required. Certain areas of the collection system are more susceptible to accumulation of FOG. These areas include particularly flat sections, older sections where pipe may have bellied, 90-degree turns, and sections downstream from heavy commercial or high-density residential areas.

7.1.3 Reduction of High Temperature Discharges

As previously mentioned, temperatures above 25 °C promote the activity of SRB and generation of H_2S. The most efficient and cost-effective way to reduce discharge temperatures may be heat recovery. This process involves passing high temperature wastewater through various types of heat pumps or heat exchangers. This allows reuse opportunities such as heating incoming water prior to entry into the manufacturing process or reducing reliance on fossil fuels for steam generation, product drying systems, or building heat. Heat recovery can be accomplished prior to entry into the pretreatment system or, in cases of digestion for pretreatment of high strength wastes where higher temperatures are typically desirable, after pretreatment prior to discharge to the collection system. Heat recovery at the individual industrial level may help reduce H_2S generation within the collection system and may potentially save the industry in energy costs over the long term.

7.2 Industrial Best Management Practices

Establishing an enforceable set of Best Management Practices (BMPs) is another option for addressing industrial discharges of H_2S and may be used in lieu of or alongside numerical local limits and surcharges. With the introduction of the 2006 Streamlining Rule Changes to 40 CFR 403, BMPs became enforceable alternatives to implement the general and specific prohibitions listed in 40 CFR 403.5 as well as other, locally developed, specific prohibitions.

To design a BMP for H_2S management, it is important to understand the conditions under which H_2S formation is most favorable. Reviewing these conditions in **Error! Reference source not found.** provides insight into prevention and treatment of H_2S in wastewater.

Typical BMPs to prevent H_2S are described in the following sections. DEQ encourages industry to consult a wastewater expert to ensure the chosen BMP will be effective and cost-effective and can be implemented safely.

7.2.1 Raising pH of Wastewater

Industries may limit the formation of H_2S in their wastewater by increasing the wastewater's pH. This BMP is accomplished by adding chemicals such as slaked lime (calcium hydroxide, $Ca(OH)_2$), caustic soda (sodium hydroxide, NaOH), or caustic potash (potassium hydroxide, KOH). Another chemical that provides similar results is magnesium hydroxide ($Mg(OH)_2$), but with potentially less safety issues of some other caustic chemicals. The industry must monitor the pH of its wastewater to prevent the addition of excessive chemicals, which could cause a violation of an upper pH permit limit. POTWs may also consider limiting the use of caustic chemicals, as they may mask actual levels of sulfide if monitoring equipment is not calibrated to read levels of bisulfide. Bisulfide is the form of sulfide most common at mid-level basic pH levels, as illustrated in Figure 2, and may revert to H_2S further along in the collection system as pH drops below neutral. This situation could cause issues far from the original discharger making correction and enforcement difficult.

7.2.2 Chemical Addition for Sulfide Removal

A common method to precipitate sulfides is the addition of iron salts, either ferrous chloride ($FeCl_2$) or ferric chloride ($FeCl_3$). Since iron has a high affinity for sulfides, iron sulfide (FeS) always forms in the presence of sulfides and precipitates from solution. Industrial facilities that are close to the POTW treatment plant should use caution dosing with iron salts, as the dark wastewater created from the presence of the iron may interfere with UV disinfection. Capturing the precipitated iron sulfide on-site would alleviate this issue; however, this creates an additional waste stream for the industry as these solids would need to be removed periodically for disposal.

7.2.3 Oxygenating Wastewater

Oxygenated wastewater contains and produces less H_2S. Industries may use aeration equipment or chemical addition within wastewater pretreatment systems to reduce the formation of H_2S. Aeration using physical mixers or forced-air diffusers creates an environment hostile to SRB, tipping the balance of four of the five pathways towards less H_2S generation. Aeration allows aerobic bacteria to thrive and consume the organic material present in the wastewater, lowering the levels of BOD/COD, and increasing DO. Aeration can also mitigate the effects of longer retention times by not allowing septic conditions to arise.

Another method for oxygenating wastewater is chemical addition, e.g., potassium permanganate ($KMnO_4$), hydrogen peroxide (H_2O_2), or calcium or sodium nitrate ($Ca(NO_3)_2$, $NaNO_3$). These chemicals serve as sources of oxygen that can be used by bacteria prior to the bacteria using sulfates, which delays the production of H_2S.

7.3 Surcharges

POTWs may already employ surcharges on BOD or TSS concentrations, often at a simple flat rate per pound. Increasing surcharge fees stepwise starting at domestic background strength is an approach that places a higher monetary burden on those who have a higher contribution to the system. These increased fees can then be used across the system to reduce and mitigate the generation of H_2S. For example, revenue from fees can be used to purchase chemical feed stations and chemicals to reduce H_2S generation within troublesome areas of the collection system or lift stations. In lieu of, or in addition to chemical treatment, fee revenue might be used to pay for increased sewer line cleaning, corrosion-resistant materials in susceptible structures, or sewer ventilation systems and carbon filters.

The damage and potential worker harm that H_2S causes in the collection system may be controlled through mitigation rather than prevention. Mitigation measures include wastewater oxidation, sulfide precipitation, elevating pH, and sewer ventilation. While many techniques for accomplishing mitigation have proven capable of reducing damage to collection systems and treatment plants and helping prevent worker exposure, they often come with high price tags. These costs can be alleviated through surcharges of discharges that contain sulfate.

Another potential outcome of sulfate surcharges is better pretreatment of industrial wastewater prior to discharge to the collection system. An industrial wastewater treatment system designed to remove sulfates and other pollutants may provide reasonable return on investment overpaying surcharges to discharge high strength wastewater.

To establish appropriate standard surcharges or sulfate surcharges, the POTW will want to perform a study on costs of mitigating H_2S in the collection system and treating sulfates and high strength waste at the wastewater treatment plant. Although an industrial discharge may not contain high concentrations of dissolved H_2S, the discharge can contain high levels of sulfates that contribute to the impact of H_2S throughout the collection system. The industrial discharge screening limit calculated in Section 6.2, or its equivalent sulfate concentration, might be used as a starting point for surcharges.

7.4 Engineering Solutions

When constructing new sections of the collection system, engineers should keep H_2S generation in mind. Several ideas can help reduce H_2S generation:

- Limit the use of force mains, inverted siphons, or surcharged sewers that promote anaerobic conditions.
- Keep required force mains as short as possible and flowing.
- Choose pipe sizes and slope to provide sufficient velocities to maintain aerobic conditions and prevent solids deposition.
- Avoid excessive detention times in wet wells and holding tanks.

In areas where H_2S generation is anticipated:

- Reduce the number of 90-degree corners and design junction structures and manholes to minimize turbulence and release of H_2S.
- Specify calcareous aggregate (high alkalinity) concrete with additional sacrificial cover over reinforcing steel.
- Specify corrosion-resistant PVC or PE liners for concrete pipe and junction structures.
- Use corrosion resistant pipe materials such as PVC, PE, and vitrified clay.
- Consider air/oxygen injection or chemical addition stations where appropriate.

7.5 Source Water Reductions

Because much of Idaho's drinking water is ground water, many communities' source water contains various levels of minerals, including sulfate. Sulfate is not an EPA-regulated drinking water containment and is not routinely analyzed by public drinking water systems, although EPA did publish a 2003 Drinking Water Advisory regarding sulfate, stipulating a recommended limit of 250 mg/L (EPA 2003). During the development of a local limit for sulfate or sulfide, the POTW should develop a background level of sulfate from the community's source water. Those POTWs with high levels of source water sulfate should take extra steps to work with the community's drinking water purveyor to reduce the levels of sulfate and work with industrial users to reduce their impact on the formation of H_2S with Pretreatment (section 7.1) or BMPs (section 7.2). A reduction in the overall background level of sulfate in the collection system will ultimately reduce instances of worker exposure and infrastructure corrosion.

8 Conclusion

After deciding on the approach and developing the local limits, the POTW must update its local limits in its SUO to make them enforceable.

For a POTW with an approved pretreatment program, the local limit development document and the changes to the SUO must be submitted to DEQ for approval prior to promulgation and implementation (40 CFR 403.18). Once approved by DEQ, the changes to the POTW's approved pretreatment program will then be approved by the city council, per established municipal guidelines, ensuring that at least a 30-day public comment period is provided. Additionally, individual notification to industrial dischargers must be provided per 40 CFR 403.5(c)(3). Once public comment is considered, and the local limits are promulgated, these limits, including any BMPs, become enforceable as a Pretreatment Standard.

DEQ's Municipal CWA Program is available to provide additional guidance or compliance assistance. Visit DEQ's Pretreatment web page for contact information.

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