Bioremediation Pretreatment Systems

CEU 262

Continuing Education from the
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Note: In determining your answers to the CE questions, use only the material presented in the corresponding continuing education article. Using information from other materials may result in a wrong answer.

The pretreatment of effluent prior to discharge is a requirement established by federal legislation and implemented by federal, state, and local regulations. Pretreatment requirements apply to both direct discharges (i.e., to drain fields, streams, lakes, and oceans) and indirect discharges such as in collection systems leading to treatment works. Pretreatment is required of all discharges other than those from a domestic residence.

Pretreatment can involve the removal of metals and organic compounds or pH adjustment. CFR Title 40: *Protection of Environment,* published by the U.S. Environmental Protection Agency (EPA), defines pretreatment as "the reduction of the amount of pollutants, the elimination of pollutants, or the alteration of the nature of pollutant properties in wastewater prior to or in lieu of discharging or otherwise introducing such pollutants into a POTW [publicly owned treatment works]. The reduction or alteration may be obtained by physical, chemical, or biological processes, process changes, or by other means, except as prohibited."

Bioremediation is a pretreatment method that simultaneously removes a pollutant from the waste stream and disposes of it by altering its chemical or physical structure such that it no longer depreciates water quality (in the case of direct discharges) or causes interference, blockages, or pass-through (in the case of indirect discharges). Generally, bioremediation can be described as the action of living organisms on organic or inorganic compounds to reduce in complexity or oxidize the compound. Typically, bioremediation processes are conducted at the source of the pollutant to avoid transporting large quantities of polluted wastewater or concentrations of pollutants.

The most common application of bioremediation to drainage plumbing systems is for the disposal of fats, oils, and grease (FOG). The bioremediation systems described in this chapter do not include the practice of adding enzymes, bacteria, nutrients, or combinations thereof (additives) to grease waste drainage or grease interceptors. The use of additives in conventional apparatus is a cleaning method resulting in the removal of FOG from the apparatus and its re-deposition downstream. Recombined FOG is usually in mineral soap form, which is more difficult to remove from sewer mains and lift stations than the substance not altered by the application of additives.

DESIGN STANDARDS

Certain fundamental materials and methods utilized in the design and manufacture of bioremediation systems are described in the following standards:

- ASME A112.14.6: *FOG (Fats, Oils, and Greases) Disposal Systems*
- ASTM C33: *Standard Specification for Concrete Aggregates*
- ASTM C94: *Standard Specification for Ready Mixed Concrete*
- ASTM C150: *Standard Specification for Portland Cement*
- ASTM C260: *Standard Specification for Air-Entraining Admixtures for Concrete*
- ASTM C618: S*tandard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete*
- PDI G101: *Testing and Rating Procedure for Grease Interceptors*
- PDI G102: *Testing and Certification for Grease Interceptors with FOG Sensing and Alarm Devices*
- ACI 318: *Building Code Requirements for Structural Concrete*
- IAPMO PS 1: *Tank Risers*
- UL 5085-3: *Low Voltage Transformers—Part 3: Class 2 and Class 3 Transformers*
- U.S. EPA Test Method 1664

PRINCIPLES OF OPERATION

Bioremediation systems are engineered systems containing the essential elements of a bioreactor that can be operated by the kinetic energy imparted from flowing water or mechanically agitated by various pumping and aeration methods. Bioremediation systems can be aerobic (requiring oxygen for the metabolic activity of the organisms, see Figure 13-1), anaerobic (not requiring oxygen), or a combination of both. The type of bioremediation system employed is determined mainly by the target compound and the organisms necessary to metabolize that compound. In the case of FOG, typically the application of bioremediation is aerobic.

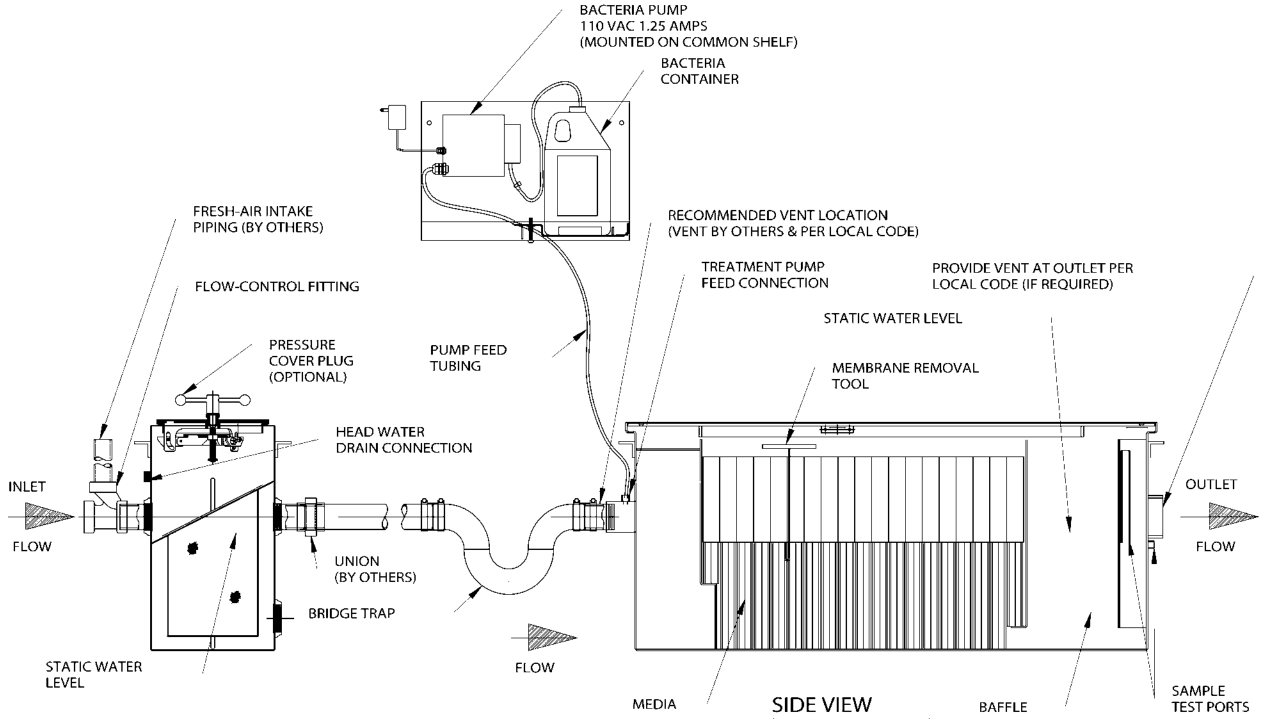
Central to the operation of all onsite bioremediation systems applied to FOG are:

- Separation, or the removal of FOG from the dynamic waste flow
- Retention, allowing the cleaned wastewater to escape, except for the static water content of the device
- Disposal, or the metabolic disassembly of FOG to its elements of hydrogen, oxygen, and carbon, usually in the form of water and carbon dioxide

Incidental to the application of a bioremediation system for FOG are:

- Sizing, or the calculation of the potential maximum flow over a designated interval
- Food solids removal from the liquid waste stream
- Placement, to minimize the length of untreated grease waste piping

Figure 13-1 Kinetically Operated Aerobic Bioremediation System



Separation

Separating FOG with the greatest efficiency, measured as the percentage of FOG present in the waste stream and the time necessary to effect separation, is essential to retention and disposal. The standards for this measurement are PDI G101, PDI G102, and ASME A112.14.6.

Separation can be effected by simple gravity flotation, in which case the device must be of sufficient volume to provide the proper retention time and quiescence to allow the ascension of suspended FOG (see Chapter 8). Separation also can be effected by coalescence, coagulation, centrifugation, dissolved air flotation, and skimming. In these instances, for a given flow, the device is typically smaller in dimension than in the gravity flotation design.

Because food particles generally have a specific gravity greater than 1 and are oleophilic (have an affinity for oils and not for water), the presence of food particles materially interferes with the efficient separation of FOG from the waste stream. Food grinders typically are not used upstream of bioremediation systems for this reason and because of the increased biological oxygen demand (BOD) that the additional waste places on the system.

Retention

The retention of FOG in a bioremediation system is essential to its disposal by a reduction in its constituent elements. Retention is facilitated by baffles, compartmentalization, or sedimentation, depending on the system design. Because only 15 percent of suspended FOG (at a specific gravity of 0.85) is above the water's surface, bioremediation systems that retain FOG removed from dynamic flows generally have greater retention efficiencies and capacities than those that rely on suspension alone.

Disposal

The disposal of FOG by biochemical processes within an onsite system is the most distinguishing feature of bioremediation systems. The organisms responsible for metabolizing the FOG may be endemic to the waste stream or, more likely, seeded by means of a timed or flow-sensitive metering device. Crucial to disposal, equal to ongoing separation and retention rates, is a sufficient population of organisms in contact with the FOG. While this is a function of sizing (see the section on sizing guidelines later in this chapter), it is also a function of system design.

The mechanism typically utilized to provide a stable, structured population of organisms in a bioremediation system is a biofilm, which is a controlled biological ecosystem that protects multiple species of organisms from washouts, biocides, and changing environmental conditions in the bioremediation system. Biofilm forms when bacteria adhere to surfaces in aqueous environments and begin to excrete a slimy, glue-like substance that can anchor them to many materials, such as metals and plastics. Biofilms are cultivated on structures in various configurations of the greatest possible surface area per given volume. The structure or structures generally are referred to as media. The media may be fixed (i.e., stationary relative to the device and the waste flow), moved by a mechanism such as a series of rotating discs or small, ball-shaped elements, or moved randomly by the energy of the waste stream flow and/or pump or aerator agitation. The organisms inhabiting a biofilm reduce the FOG to carbon dioxide and water through a process called beta-oxidation, in which fatty acid chains are shortened by the successive removal of two carbon fragments from the carboxyl end of the chain.

Bioremediation systems utilizing structured biofilms are much more resistant to the effects of biocides, detergents, and other chemicals frequently found in kitchen effluent than systems using the planktonic application of organisms. The efficiency of bioremediation systems in terms of disposal depends on the total surface area of the media relative to the quantity of FOG separated and retained, the viability and species diversity of the biofilm, system sizing, and installation.

FLOW CONTROL

Flow control is sometimes used with bioremediation systems depending on system design. When flow control devices are prescribed by the manufacturer, generally they are best located near the discharge of the fixtures they serve. However, because bioremediation systems are engineered systems, the use and placement of system elements are prescribed by the manufacturer. In instances in which elements of a bioremediation system may be common to the plumbing industry, the manufacturer's prescription for the application of those elements to the system shall prevail over common practice or code requirements.

SIZING GUIDELINES

The following guidelines are intended as a tool for the engineer to quantify the maximum hydraulic potential from a given facility. Typically, fixture unit equivalency prediction sizing methods and other estimation tools based on weighted utilization rate factors are not acceptable sizing tools for bioremediation systems. Bioremediation systems must be capable of accommodating maximum hydraulic events without experiencing upsets, blockages, or pass-through.

Fixture Inventory

Itemize every fixture capable of liquid discharge to the grease waste piping system, including but not limited to sinks, hoods, ware washers, floor sinks and drains, and kettles. Grinder pulpers are generally not discharged to bioremediation systems. Review the manufacturer's requirements for each particular system.

Capacity Calculation

Calculate the capacity of liquid-retaining devices such as sinks as follows:

- Capacity, in cubic inches = Length × width × depth
- Total capacity, in cubic inches = Capacity × number of compartments
- Gallons capacity = Total cubic capacity ÷ 231
- Rated discharge, in gallons per minute (gpm) = Gallons capacity × 0.75 (fill factor)

Note: If a two-minute drain duration is used, divide the rated discharge by two.

Rated Discharges

Fixtures such as ware washers with a manufacturer's rated water consumption or a single discharge rate are calculated at the greater rate.

Floor Sinks and Drains

Floor sinks and drains generally are rated at 4 gpm. Count the number of floor drains and sinks not receiving indirect discharges from the fixtures calculated above and multiply by four to determine the gpm potential. If this number exceeds the total supply to the facility, select the smaller of the two figures.

Loading Influences

Some manufacturers may prescribe multipliers for various facility characteristics such as cuisine to accommodate any anticipated increase in organic content per gallon of calculated discharge. Refer to the manufacturer's requirements for specific systems.

MATERIALS

Concrete

If concrete is used as the container material for a bioremediation system, the concrete and reinforcement should be of sufficient strength to resist stress caused during handling and installation without structural cracking and be of such corrosion-resistant quality to resist interior and exterior acids that may be present.

Concrete should have a minimum compressive strength of 3,500 pounds per square inch (psi) (24,132 kPa) and a maximum water-cementing materials ratio of 6 gallons per sack of cement. Concrete should be made with Type II or V, low-alkali Portland cement conforming to ASTM C150 and also should include the sulfate expansion option as specified in ASTM C150 for Type II or V. Concrete should contain 4 to 7 percent entrained air utilizing admixtures conforming to ASTM C260. Concrete aggregates should conform to ASTM C33. If ready-mix concrete is used, it should conform to ASTM C94. Fly ash and raw or calcined natural pozzolan, if used as mineral admixture in Portland cement concrete, should conform to ASTM C618.

Stainless Steel

Stainless steel used in bioremediation systems should be type 316 or some other type with equal or greater corrosion resistance.

Fiberglass-Reinforced Polyester

Bioremediation systems constructed principally of fiberglass-reinforced polyester (FRP) should comply with the minimum requirements expressed for septic tanks in IAPMO PS 1.

Polyethylene

Bioremediation systems constructed principally of polyethylene (PE) should comply with the minimum standards expressed for septic tanks in IAPMO PS 1.

STRUCTURAL CONSIDERATIONS

Bioremediation systems should be designed to handle all anticipated internal, external, and vertical loads. Bioremediation system containers, covers, and structural elements that are intended for burial and/or traffic loads should be designed for an earth load of not less than 500 pounds per square foot (24 kPa) when the maximum coverage does not exceed 3 feet (0.9 m). Each system and cover should be structurally designed to withstand all anticipated earth or other loads and should be installed level and on a solid surface.

Bioremediation systems, containers, covers, and structural elements for installation in traffic areas should be designed to withstand an AASHTO H20-44 wheel load and an additional 3-foot (0.9-m) earth load with an assumed soil weight of 100 pounds per square foot (4.8 kPa) and a fluid equivalent sidewall pressure of 30 pounds per square foot (1.4 kPa).

The internal construction of separations, coalescing surfaces, baffles, and structures that may compartmentalize fluids should be designed to withstand the maximum expected hydrostatic pressure, which includes the pressure exerted by one compartment at maximum capacity with adjacent compartments empty. The internal structures should be of suitable, sound, and durable materials consistent with industry standards.

In buried applications, bioremediation systems should have safe, reasonable access for prescribed maintenance and monitoring. Access could consist of horizontal manways or manholes. Each access opening should have a leak-resistant closure that cannot slide, rotate, or flip. Manholes should extend to grade, have a minimum diameter of 20 inches (0.5 m) or be 20 × 20 inches (0.5 × 0.5 m) square, and should comply with IAPMO PS 1.

DIMENSION AND PERFORMANCE CONSIDERATIONS

Bioremediation systems differ regarding type and operating method, but all should have a minimum volume-to-liquid ratio of 0.4 gallon per 1-gpm flow rating and a minimum retention ratio of 3.75 pounds of FOG per 1-gpm flow. The inside dimension between the cover and the dynamic water level at full-rated flow should be a minimum of 2 inches (51 mm). While the air space should have a minimum volume equal to 10.5 percent of the liquid volume, air management and venting shall be prescribed by the manufacturer.

A bioremediation system's separation and retention efficiency ratings should be in accordance with PDI G101. Bioremediation systems should show no leakage from seams, pinholes, or other imperfections.

Performance testing of bioremediation systems should demonstrate performance equal to or exceeding manufacturer claims and should have a minimum discharge FOG content not to exceed 100 milligrams per liter. Performance testing should be conducted only by accredited, third-party, independent laboratories in accordance with current scientific methods and EPA analysis procedures.

INSTALLATION AND WORKMANSHIP

Installation should be in accordance with the manufacturer's requirements. Bioremediation systems should be free of cracks, porosity, flashing, burrs, chips, and filings or any defects that may affect performance, appearance, or serviceability.

Bioremediation systems should be provided with drawings as well as application and disposal function details. Descriptive materials should be complete, showing dimensions, capacities, flow rates, structural and process ratings, and all application and operation facts.

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Expiration date: Continuing education credit will be given for this examination through **August 31, 2019**.

CE Questions — "Bioremediation Pretreatment Systems" (CEU 262)
Test written by Hal Alvord, CPD, GPD

1. If ready mixed concrete is used for the container material, it should conform with ________.
   a. ASTM C260
   b. ASTM C94
   c. ASTM C618
   d. ASTM C150

2. Flow control devices are located on a bioremediation system as prescribed per ________.
   a. code requirements
   b. common practice
   c. the plumbing industry
   d. the manufacturer

3. Retention of a bioremediation system is facilitated by ________.
   a. baffles
   b. compartmentalization
   c. the size of the system
   d. both a and b

4. Bioremediation systems, containers, covers, and structural elements for installation in traffic access areas should be designed to withstand ________.
   a. AASHTO Big 44 wheel load
   b. a fluid equivalent sidewall pressure of 30 pounds per square foot
   c. an assumed soil weight of 500 pounds per square foot
   d. none of the above

5. Biofilms are cultivated on structures in various configurations of the greatest possible surface area per given ________.
   a. volume
   b. gallons per minute
   c. flow
   d. system size

6. Which standard discusses the design and manufacture of bioremediation systems?
   a. IAPMO PS1
   b. UL 5085-3: Low Voltage Transformers
   c. ACI318: Building Cold Requirements for Structural Concrete
   d. all of the above

7. Central to the operation of all on-site bioremediation systems applied to FOG is ________.
   a. bringing together the soils and water
   b. making sure the contained grease does not stink
   c. keeping the pipes flowing and not getting plugged up
   d. retention, allowing the cleaned wastewater to escape

8. Per Figure 13-1, which of the following is part of the kinetically operated aerobic bioremediation system?
   a. PVC DWV piping
   b. bridge trap
   c. skimming belt
   d. cleanout

9. To calculate the capacity of liquid retaining devices, the following should be used: ________.
   a. capacity in cubic feet
   b. total capacity in gallons per minute
   c. rated discharge in gallons per minute
   d. size of the pipe outlet

10. For sizing purposes, floor sinks and floor drains are generally rated at ________ gallons per minute.
   a. 1
   b. 2
   c. 3
   d. 4

11. Which document published by the U.S. Environmental Protection Agency (EPA) defines pretreatment?
   a. EPA-833
   b. EPA-305
   c. CFR Title 40
   d. ASME A112.14.3

12. Separating FOG with the greatest efficiency is addressed in which standard?
   a. PDI G102
   b. ASTM C820
   c. ASME A112.14.6
   d. both a and c