Grease Interceptor FACTS and MYTHS

Fact: Fats, oils, and grease (FOG) accumulation is the greatest single factor in sanitary sewer overflows (SSOs), accounting for more than 40 percent of all events.

Fact: SSOs are the greatest single clear and present danger to municipal drinking water supplies.

The U.S. Environmental Protection Agency (EPA) estimates that between 23,000 and 75,000 SSOs occur each year throughout the United States, resulting in releases of 3 billion to 10 billion gallons of untreated wastewater.[1] The majority of SSO events are caused by sewer blockages that can occur at any time.

From where is all that grease coming? U.S. restaurant sales were $399 billion in 2001, an increase of 5.2 percent over 2000. The current rate of annual growth is approximately 7 percent, and during a typical day, the restaurant industry posts average sales of $1.1 billion from more than 450,000 establishments—approximately 1.4 establishments per 1,000 people.[2]

Per capita generation of spent FOG has been estimated by the Department of Energy to be approximately 1,400 pounds annually. Field data is sketchy, and sampling methods are extremely varied, making precise categorization by restaurant type an imprecise exercise at best. I have been collecting interceptor influent data from various sources for more than 10 years and found the following from Mosely & Bardon (2002) to be indicative (all amounts rounded):

- Cafeteria: 4,500 milligrams per liter (mg/L)
- Chinese: 1,900 mg/L
- Italian: 1,000 mg/L
- American: 950 mg/L
- Indian: 800 mg/L
- Thai: 400 mg/L
- Open-air markets: 50 mg/L
- Average: 1,650 mg/L

Of course, each establishment within a category will vary from another as well as itself from day to day. However the problem of FOG in sewers is measured, the conclusion is the same: a lot of grease is flowing into sewers and causing a lot of damage.

In my previous article, "Clearing the FOG" in the July/August 2007 issue of *PS&D,* I stated: "Grease interceptor maintenance alone is a topic worthy of a separate article." Well, here we are. I'm sure many readers are now asking, "What do I care about interceptor maintenance? My responsibility ends with sizing the unit and designing the installation."

Correct, that may be where the task ends; however, learning the facts and myths surrounding FOG and interceptor operation and maintenance relative to the type of facility is where the task should begin. Selection of interceptor type, sizing, and correct installation are of marginal value if the result is a system that cannot function properly in the given environment, such as an interceptor installed at ground level for a 12^{th} floor cafeteria.

First, let's explore facts and myths surrounding the offending substance, FOG, starting with the acronym. Fats, oils, grease: the terms seem redundant, and that supposition is *somewhat* true. Each term describes hydrocarbon—in this case, polar (irregular electron distribution and typically dissolves in water). The term refers to the general physical state of the substance at room temperature:

- Fats = Solid
- Oils = Liquid
- Grease = Viscous, but not capable of flow

However inaccurate in the world of chemistry, the application of the acronym is suitable for our purposes.

By Max Weiss

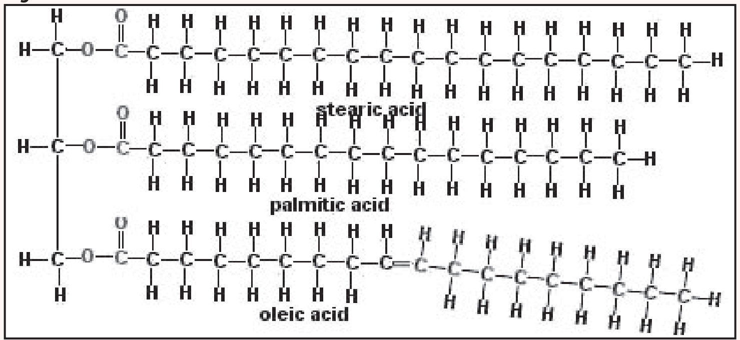
Know the truth about operation and maintenance to properly select the type of interceptor to specify.

NATURE OF FOG

Three characteristics of FOG are fundamental to understanding the world of interceptors.

Fact: FOG typically dissolves in water. Given sufficient time, FOG will hydrolyze (react with water) sufficiently to cause complete loss of buoyancy in water. Hydrolysis begins almost immediately upon contact with water, eventually causing a break in the molecular bond between the fatty acids and glycerols comprising the FOG molecule (see Figure 1). The speed of the molecular break increases in direct proportion with the concentration of and contact with detergents and sanitizers. This is important in the world of interceptors because the resultant compounds aren't conducive to storage in an interceptor, and they are not friendly to the collection system. Glycerols are semi-soluble in water and are heavier than water. They also serve as an excellent carbon source for biomass propagation. Free fatty acids are corrosive and have a greater potential for surface attachment, especially to oxygen-rich compounds such as iron oxide, and strong detergents and sanitizers are prevalent in a kitchen environment. The brownish, goopy material at the bottom of an interceptor is mainly glycerols. The harder mass near the water surface is largely fatty acids.

Figure 1 FOG molecule



Myth: FOG separates more efficiently in cool, non-turbulent water. That statement is the underpinning of a large portion of the engineering response and administrative policies regarding FOG abatement. However, scientific evidence developed through testing more than 50 years ago by the American Petroleum Institute demonstrates that a less dense, viscous substance rises faster in warm water than cool water and that turbulence can cause either a reduction in separation time or an increase in separation time depending on the presence, absence, and orientation of deflection. Stokes' Law (discussed later) and the Navier-Stokes equations describe precisely how this occurs.

Fact and myth: FOG is recyclable. When dealing with the topic of FOG recycling, it is necessary to understand the two relevant federal classifications of FOG.

1. Yellow grease: FOG recovered from dry filter hoods, grills, and fryers that has not been in contact with water. Yellow grease can be recycled for uses such as biodiesel, glycerin for cosmetics, soaps, and other uses involving human contact except food. Yellow grease previously was used in animal feed supplements, but that use has been discouraged since animal nerve and blood materials have been associated with mad-cow disease. It is very difficult to determine if those substances have been in contact with spent FOG.
2. Brown grease: FOG that has been in contact with drain water such as from water wash ventilation hoods, grease interceptors, and other drain-connected fixtures. Brown grease post-use is restricted to those uses that do not involve human or animal contact such as paints, lubricants, compost, and methane generators. Non-post-use disposal consists of landfill, designated wastewater plant receipt, land application, and incineration. Non-use disposal is losing popularity as greater attention is being paid to possible alternate energy sources. Brown grease is not suitable for biodiesel production because of contaminants and partial hydrolysis; however, experimentation with methane production using brown grease in conjunction with agricultural waste is increasing.

Therefore, if spent FOG is not amenable to extended storage in contact with water, is efficiently separated in warm to hot water, and local disposal or post-use opportunities have to be considered, knowledge of the FOG generator is obviously instrumental to informed interceptor specification. For example, if the facility is not likely to generate sufficient flow to keep a large interceptor volume warm, small units near the source may be more suitable. If the facility is located where brown grease disposal opportunities are limited, FOG disposal systems may be appropriate. If a vigorous local post-use program is available or removal costs are low, a grease removal device is the logical choice.

OPERATION AND MAINTENANCE

The physical, chemical, and regulatory characteristics of FOG, considered in the context of the facility, bear significantly on operation and maintenance, which, in turn, influence interceptor type selection. In addition, universal to all grease interception are three inextricably interdependent aspects of operation and maintenance of every type of grease interceptor. They are separation, retention, and disposal.

Separation. Separation of FOG from kitchen wastewater never was as simple as allowing it to rise to the top of a container, and the task is becoming ever more problematic with the advent of dense frying oils. The specific gravity of lard is approximately 0.87–0.89; vegetable oil is 0.90–0.93; and zero-trans-fat oils is 0.96–1.0+. When you add advances in the emulsifying properties of detergents and the cracking effects of some sanitizers, separation becomes a formidable first task, and what can't be separated obviously can't be retained.

Separation efficiency is affected, apart from cleaning chemicals' influence, mainly by globule size, temperature, and FOG viscosity. FOG globule size and temperature are also a function of the degree of mechanical agitation produced by velocity and distance of run. Non-emulsified FOG ranging in globule size from 30–100 microns requires 15–25 minutes to rise 3 inches in

68°F water unassisted by deflected current based on the application of Stokes' Law.

Stokes' Law relates the terminal settling or rise velocity of a smooth, rigid sphere in a viscous fluid of known density and viscosity to the diameter of the sphere when subjected to a known force field (gravity). The equation is:

$$V = (2gr^2)(d1 - d2)/9\mu$$

where

V = Velocity of rise (cm/sec)
g = Acceleration of gravity (cm/sec^2)
r = Equivalent radius of particle (cm)
$d1$ = Density of particle (g/cm^3)
$d2$ = Density of medium (g/cm^3)
μ = Viscosity of medium (dyne sec/cm^2)

The natural rate of ascension is of most importance to separation affected by gravity alone. Obviously, if the unmodified horizontal flow rate in a gravity interceptor allows the inflow to reach the outlet in less time than it takes for the FOG to rise above a zone of increased velocity surrounding the outlet, the FOG will not be separated (see Figure 2). In the case of a hydromechanical interceptor that utilizes entrained air and vertical current deflection, if the flow velocity exceeds the rated flow of the interceptor, decreased separation efficiency and scouring of FOG will occur.

Figure 2 Excessive FOG accumulation in gravity grease interceptor

Reduction of globule size from sustained water temperatures above 150°F, concentration of detergents alone or in conjunction with other chemicals, mechanical emulsification via excessively long runs, or all of the preceding will have a dramatic effect on ascension rates. For example, a globule reduction to 20 microns will increase the time to rise 3 inches to nearly an hour with all other variables being the same.

Sizing to accommodate calculated peak discharge, proper installation to ensure shortest possible distance and least vertical drop, measured use of chemical and thermal emulsifiers, and sufficient interceptor warmth all are essential to adequate water/FOG separation, whichever interceptor type is being considered. Adequate separation should be considered 90 percent or greater (refer to the influent estimates previously mentioned). Whether a local jurisdiction has official numerical water quality standards or not, 100 mg/L is considered a reference benchmark beyond which surcharges, increased monitoring, best management practices, enforcement, and other remedial measures may be imposed by the pretreatment control authority.

Dissolved air flotation, chemical coagulation, and electrical coagulation are also methods of separation, but they are typically features of engineered systems, not of the common hydromechanical or gravity interceptor. However, given the trend of denser oils and more effective cleaning chemicals, such extraordinary methodologies may become necessary just to maintain current levels of separation efficiency.

Retention. The term "retention" is used to mean either the amount of grease—capacity—an interceptor can store before materially diminishing separation efficiency or the theoretical time it takes a flow to exit an interceptor, typically gravity type. The term is sometimes stated as RT (retention time) or HRT (hours retention time). In the context of hydromechanical interceptors, use of the term meaning time is inaccurate since that type of interceptor does not operate exclusively according to Stokes' Law. The element of time relative to separation in gravity interceptors was discussed above. The following discussion treats the term in the context of capacity and cleaning intervals.

Two types of interceptors are least concerned with this aspect of interceptor operation and maintenance. The first is grease removal devices (GRDs), which mechanically transfer separated FOG from the area within the interceptor actively involved in separation to a container for proper disposal. This transfer is accomplished generally by four methods:

1. Drum, which involves a rotating drum or drums constructed of oleophilic material such as stainless steel and a wiper blade scraping the attached FOG to a catchment or conduit
2. Disc or discs, operating on the same principle
3. Belt of fiber or stainless steel, using a wiper
4. Artificial fiber rope, using a squeezing method

The second type of interceptor is the FOG disposal system, which utilizes various methods for FOG mass and volume reduction, such as fixed film bioreactors with either an internal and external stationary or moving bed design (not to be confused with putting additives in a conventional interceptor, chemical oxidation systems, or thermal oxidation systems). (See the article "Clearing the FOG" in the July/August 2007 issue of *PS&D* for specifics on GRDs and FOG disposal systems.)

Service interval extension is the design motivation for GRDs and FOG disposal systems, and both types accomplish that goal to greater or lesser degrees depending on field factors. Due to the effects of hydrolysis and increased FOG density diminishing separation and retention efficiency, these types of interceptors have added relevance in the changing world of FOG.

FOG retention capacity is quantified differently between the two general categories of grease interceptors. Hydromechanical grease interceptors are tested and certified according to flow velocity, separation efficiency, and retention capacity as prescribed by Plumbing and Drainage Institute Standard G101: *Testing and Rating Procedure for Type 1 Hydromechanical Grease Interceptors* and ASME International Standard A112.14.3: *Grease Interceptors*. Both standards require 90 percent or greater separation efficiency and retention capacity of 2 pounds of FOG for each gallon per minute (gpm) of rated inflow velocity. For example, a

50-gpm rating equals 100 pounds of minimum retention achievement while maintaining at least 90 percent separation efficiency.

Gravity grease interceptors currently do not have prescribed performance standards requiring a specific separation efficiency or retention capacity. The expectations of performance of separation efficiency and retention capacity are addressed in gravity grease interceptor sizing methods in which the calculated peak discharge from a given facility is multiplied by the local retention time requirement, generally 30 minutes. For example, 50-gpm peak discharge x 30 minutes = 1,500-gallon capacity.

Myth: Regarding the cleaning interval, "six months for the outdoor type and one month for the inside type or less if we have problems" is a myth, a dangerous myth. (That cleaning interval prescription is a direct quote from an online pretreatment forum.) The extended cleaning interval is a budget/administrative prescription based on stretched resources typical of pretreatment programs. It is not science-driven. In my opinion, such methods are akin to testing temperature with a tender part of the body or electricity with the tongue—probably workable, but dangerous at worst and very uncomfortable at best.

How do you know when to clean an interceptor and why is that a consideration for the specifier? Interceptors began principally as usable resource-capturing devices, evolved to piping maintenance devices, and now are utilized mainly for Clean Water Act-mandated industrial pretreatment requirements. Administrative responsibilities are similarly evolving. Also, usable resource capture is again peeking over the horizon. Unfortunately, common knowledge of interceptor cleaning requirements has not evolved equally with the changing purpose of the device. Ironically, cleaning intervals were probably shorter when FOG was viewed originally as a valuable by-product.

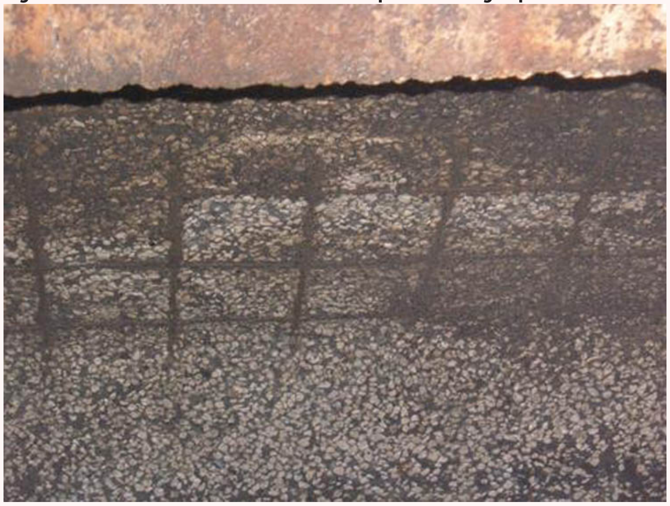
Fact: All things old are new again. An obvious required cleaning interval of any interceptor is when it's full of FOG. Actually, however logical that statement first appears, it is false. When the interceptor is full, it is too late. It is too late to maintain water quality, and it is too late to prevent damage to the interceptor, the building's drainage piping, and the collection system. A rule of thumb, though not formally prescribed by code and rarely by pretreatment administrators, is 25 percent of the wetted area of the interceptor. That is, whenever accumulated material floating or at the interceptor bottom, whichever occurs first, or the two combined equal 25 percent of the vertical height of the wetted surface at static (non-flowing) conditions, the interceptor requires cleaning. The simplest method to estimate the time it takes a given interceptor to reach 25 percent is inspecting frequently, perhaps daily in heavy loading circumstances, and recording the intervals between cleaning until a pattern of accumulation is apparent. Under no circumstances should that interval be greater than 30 days, with the exception of GRDs and FOG disposal systems, where manufacturers' instructions prevail.

All interceptors containing excessive FOG and aged FOG will demonstrate dramatic reduction in separation and retention efficiency. In addition, the potential for interceptor and collection system obstruction increases exponentially with the duration of FOG retention. As FOG breaks down by hydrolysis, acidity increases as a product of fatty acid release. Microorganisms such as bacillus sulfurans that reduce sulfates to sulfides, which then bind with hydrogen producing hydrogen sulfide, and thiobacillus, which reduces hydrogen sulfide at the water/air interface to elemental sulfuric acid, add to the declining pH. It is not uncommon to see an interceptor with a pH at 4 or below.

The lowest pH condition exists in conjunction with reduced dissolved oxygen. Significant reduction in pH occurs with the presence of a large proportion of free fatty acids (FFA), and attachment of FFA to surfaces causes corrosion and collection system blockage. However, it is the generation of hydrogen sulfide and derivative sulfuric acid that supercharge corrosion rates. B. sulfurans is an anaerobic organism (thrives in the absence of oxygen). The anoxic conditions conducive to hydrogen sulfide production are more prevalent in gravity interceptors because of the absence of oxygen mixing from flow or mechanical air entrainment such as exist in hydromechanical interceptors. Increased hydrogen sulfide production generates increased populations of sulfuric acid-producing organisms. The result is accelerated corrosion, especially of concrete (see Figure 3) and iron with high carbon content (necessary for cell replication).

Hydromechanical interceptors, while less susceptible because of oxygen replenishment through air-influent mixing, are not immune to the problem. Incomplete cleaning can leave accumulations in corners and crevices within the interceptor, which seals those areas off from dissolved oxygen in the water. Thus, corrosion is increased at those sites. Consideration of the potential for corrosion and adhesion blockage within the context of facility characteristics is very important to dependable system function and durability.

Figure 3 Halo corrosion in concrete interceptor showing exposed rebar



Disposal. The number of myths surrounding proper disposal of brown grease are far too numerous to list. Suffice to say, brown grease cannot be fed to livestock, fowl or fish, humans, pets, birds, or anything else that walks, talks, squawks, squeals, moos, or barks. It cannot be dumped, spread, or burned privately. It cannot be mixed with yellow grease, unless the resultant mixture is classified as brown grease. Interceptor grease is not considered suitable feed for biodiesel production because of water content, physical and chemical contaminants, and altered glycerin/fatty acid ratio. A licensed hauler is required to transport brown grease, which must be stored and labeled separately, to a permitted disposal facility.

This is not to say interceptor FOG is a completely net negative substance. Simply, proper disposal opportunities must be considered when specifying interceptor type.

REUSE OPPORTUNITIES

Post-use opportunities are increasing every day. Advances in controlled, enhanced composting can utilize carbon-rich FOG in measured ratio with other high-cellulose material such as paper, weeds, leaves, lawn clippings, and organism-rich sewage sludge to produce nutrient-rich compost, which self-sterilizes because of the high temperatures produced in the process. Thus, three problematic materials produce a beneficial product.

Biogas (methane) generation is another growing use for interceptor FOG. The FOG is mixed with agricultural wastes, mainly from concentrated feeding facilities, in an anaerobic chamber called a digester and sometimes supplemented with microbial populations to produce biogas. Biogas contains other gases and compounds that must be scrubbed before being used. Several companies are producing economically viable quantities of methane for on-site energy production or distribution. Sewer treatment plants have been harvesting methane for decades, and now landfills are becoming major methane sources. The Solid Waste Disposal Act prohibits the disposal of bulk liquids like interceptor FOG in landfills. However, with increased attention to alternative energy generation, we soon may see modifications to solid waste regulations regarding substances rich in methane potential, since landfills are the most economic method of biogas production at this time.

Another recent development incorporating FOG as a feed with other municipal wastes for energy generation and resource recycling is plasma arc incineration. Simply put, waste material, including organics and inorganics, is fed through a plasma arc, melting recoverables and generating tremendous heat from the remainder. The heat then is used to generate power and preheat the feed.

The task of FOG separation, retention, and disposal (operation and maintenance as a function of type) is not a mundane, troublesome, incidental task to drainage system design. It is a daunting, dynamic, health-critical, evolving possible resource-related challenge requiring much more consideration than which sizing table to use for the one-type-fits-all interceptor (a myth). We may see the day when we say, "What were we thinking, throwing something like FOG away all of those years?" PSD

REFERENCES

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