Gravity Grease Interceptors: Lifting the Fog on FOG

NPCA file photo

Important factors to consider when designing a **precast concrete gravity grease interceptor** system

By Claude Goguen, P.E., LEED AP

Is the image of raw sewage spewing from a manhole in front of your house scary? Imagine how it sounds to municipalities and other jurisdictions whose jobs are to keep those sewers functioning. That's one reason why local public health and water officials are always concerned about FOG – fats, oils and greases – entering into the community wastewater system.

If sufficient amounts of FOG enter the sewer pipes, the resulting product will begin to collect on the top and sides of the pipe. Eventually, more grease becomes trapped and the buildup continues. These masses of FOG can grow dramatically based on the size of the pipe and lead to complete blockages, which can then lead to sanitary sewer overflows or SSOs.

For precast concrete producers who manufacture gravity grease interceptors, the burning question is this: Is my tank design optimal for separating FOG? It's important to ask, because the design of a grease interceptor must include many factors that will dictate its efficiency. We're not just talking about a septic tank with longer baffles. This is a different piece of infrastructure with different functions and different design considerations. As a precast concrete producer, you're already using the best material; however, it's also important to ensure you're using the best design.

FOG'S ORIGINS

In order to understand some crucial design principles, we need to learn about the substances we're trying to separate. Let's lift the fog on FOG. According to the Environmental Protection Agency, grease from restaurants, homes and industrial sources is the most common cause of reported blockages in sanitary sewer systems.[1] Restaurants and food service establishments generate FOG every day as they prepare food and clean dishes, utensils and cookware. Residential sewer customers can also contribute significant amounts of FOG to the sewer system.

FOG has evolved over the years as animal fats such as lard have been replaced by vegetable oils, cleaning agents have changed, and hand-washing dishes is now accomplished by dishwashers discharging effluent at a higher

temperature. Each of these factors plays a key role in what type of grease globule enters the interceptor.

GREASE GLOBULES

When grease globules enter a GGI, they will vary in chemistry, size and density and the fluid that surrounds them will vary in chemistry, density and temperature. This disparity will govern whether the grease globule will rise, fall or make its way through the interceptor into our infrastructure. We are trying the avoid the latter situation, so our hope is that globules will rise and stay in the tank, and solids will settle to the bottom.

This is where we look at Stokes's Law. This law, named after British scientist Sir George Stokes, is based on the forces acting on a particle in a fluid. It contains a mathematical equation that expresses the rising or settling velocities of small spherical particles in a fluid medium. Basically, the rising velocity is dependent on the globule's size. Larger globules will rise faster than smaller globules of similar density. Calculations of this vertical velocity can be made based on Stokes's Law.

If the density of the globule is less than the density of the fluid, the globule will rise, and vice versa. For example, a 200-micron-diameter grease globule (.00066 feet) with a density of 54 lbs./ft.^{3} in water with a temperature of 50 degrees Fahrenheit will rise at approximately .24 ft./s. If we were to divide that globule size in half to 100 microns (.00033 feet), the globule would rise at 0.06 ft./s. Therefore, for more effective separation, larger grease globules are optimal. Several factors influence globule size, as outlined below.

Oils used in cooking

The type of oil used can affect the rise velocity of the grease globule based on its density. For example, bacon grease has a density closer to 54 lbs./ft.^{3} (an 8.4-pound difference from water) while zero-trans fat oils are closer to 60 lbs./ft.^{3} (a 2.4-pound difference from water). The closer the grease's density is to that of water, the slower it will rise.

Emulsifying cleaners

Detergents used in today's kitchens may contain emulsifiers to aid in the removal of FOG from dishware and kitchen utensils. Emulsifiers work to prevent FOG from coalescing by reducing the interfacial tension that makes grease globules attract. This process enhances the removal of FOG from utensils and dishware but reduces the size of the grease globules, lessening the ease of separation from the effluent.

Temperature

At higher temperatures, water tends to prevent FOG from coalescing. As such, hotter water may also result in smaller grease globules. Additionally, newer, larger dishwashers can generate a hotter flow. Hot water flow into the grease interceptor containing cooler wastewater can produce a temporary upflow effect due to the lower relative density of the influent stream. However, the short-term impact of this density upflow has a minor effect on the effluent FOG concentration. Over time, the effluent FOG concentration will be similar to previous uniform influent/bulk temperature results.

While grease globules in hot water may be smaller in diameter, the surrounding fluid also has a lower viscosity at higher temperatures. This allows the globules to rise faster. Also, large-volume precast concrete tanks act as a heat sink and are effective in reducing influent water temperature, which allows for the coalescence of smaller globules.

Water conditions

Stokes's Law is only applicable in static water, meaning the environment is calm and without velocity spikes and currents. As a result, it's imperative to maintain a quiescent environment in the tank. According to a study by the Water Environment Research Foundation[2], more effective FOG separation was achieved when fluid velocities near the inlet and outlet were kept below 0.6 in./s.

SIZING OF GREASE INTERCEPTORS

For some, taking the maximum flow rate in gallons per minute and multiplying that figure by 30 minutes is the extent of the gravity grease interceptor sizing exercise.[1]

For example, if you expect no more than 75 gallons per minute to enter the tank, multiply 75 by a 30-minute retention time and the result is 2,250 gallons. This may work in some situations, but information is being left out of this calculation that may lead to a tank too small or too large for the application.

There are some consistent themes when comparing commonly used formulas for sizing grease interceptors. Most of the sizing formulas consider the maximum flow rate into the tank. It's the method of establishing this specific influent flow rate that differs from one formula to another. The most commonly used sizing formulas employed in the U.S. include the U.S. EPA Method; Uniform Plumbing Code, 2003, Appendix H; and Uniform Plumbing Code, 2006 and 2009.

U.S. EPA METHOD

The 1980 version of the EPA formula, which is still used today, calculates the influent flow rate as 5 gallons per meal.

For restaurants, the sizing formula is:

$$GI\ Liquid\ Capacity = D \times GL \times ST \times \frac{HR}{2} \times LF$$

Grease Interceptor Liquid Capacity, U.S. EPA Method.[2]

Where:

D = Number of seats in dining area
GL = Gallons of wastewater per meal, normally 5 gallons
ST = Storage capacity factor – minimum of 1.7, on-site disposal, 2.5
HR = Number of hours open
LF = Loading factor

a) 1.25 – interstate freeways
b) 1.0 – other freeways
c) 1.0 – recreation areas
d) 0.8 – main highways
e) 0.5 – other highways

2006 AND 2009 UNIFORM PLUMBING CODE METHOD

In 2006, the Uniform Plumbing Code was revised to change the sizing methodology from the Appendix H Method above to a sizing method using drainage fixture units. Dr. Roy Hunger developed DFUs in 1940, which are assigned to individual fixtures based on their potential load-producing effect on the plumbing and wastewater systems. Chapter 7 of the Uniform Plumbing Code contains tables to be used for this sizing method. Chapter 10 of the Uniform Plumbing Code includes Table 1014.3.6 (Table 1), which has recommended grease interceptor volumes based on total DFUs.

One of the issues with using this formula is that while DFU is a common term for plumbers, it is uncommon for pretreatment coordinators and officials dealing with the regulation of GGIs. Also, the DFU does not differentiate between flow from a fixture and flow from a draining sink. When plumbing fixtures do not drain from filled sinks, the faucet flow is used.

DFUs	Interceptor Volume
8	500 gallons
21	750 gallons
35	1,000 gallons
90	1,250 gallons
172	1,500 gallons
216	2,000 gallons
307	2,500 gallons
342	3,000 gallons
428	4,000 gallons
576	5,000 gallons
720	7,500 gallons
2112	10,000 gallons
2640	15,000 gallons

Table 1. Gravity Grease Interceptor Sizing Based on DFUs.[3]

2003 UNIFORM PLUMBING CODE, APPENDIX H SIZING METHOD

The 2003 Uniform Plumbing Code (UPC) contained a sizing formula in Appendix H. This formula is similar to the EPA formula, where it is based on hydraulic loading and the storage factor.

The formula is:

$$GI\ Liquid\ Capacity = Meals\ Per\ Peak\ Hour \times Waste\ Flow\ Rate \times Retention\ Time \times Storage\ Factor$$

Grease Interceptor Liquid Capacity, UPC 2003.

Where:

Waste Flow Rate

- With dishwasher – 6-gallon (22.7 L) flow
- Without dishwasher – 5-gallon (18.9 L) flow
- Single-service kitchen – 2-gallon (7.6 L) flow
- Food waste disposer – 1-gallon (3.8 L) flow

Retention Time

Commercial kitchen waste

- Dishwasher – 2.5 hours

Single-service kitchen

- Single Serving – 1.5 hours

Storage Factor

Fully equipped commercial kitchen

- 8 hours of operation: 1
- 16 hours of operation: 2
- 24 hours of operation: 3
- Single-service kitchen: 1.5

ALTERNATE SIZING METHOD FROM TOWN OF CARY, N.C.

Officials from the town of Cary, N.C., developed a spreadsheet that allows for input of the various fixture types, sizes and characteristics for the calculation of the maximum flow rate into a GGI.[4]

NATIONAL PRECAST CONCRETE ASSOCIATION WHITE PAPER

In 2009, the National Precast Concrete Association published a white paper covering design considerations for precast GGIs.[6] The authors recommended that the 2003 UPC, Appendix H Method for sizing precast GGIs be used when no other code is specified or provided. However, the white paper did not include any data from the WERF studies mentioned above. As such, until further research is conducted, there is no "right" or "wrong" formula to use. Still, taking the maximum flow rate and multiplying by retention time is an ineffective approach, and leaves out many key factors.

In deciding what formula to adopt, the authority having jurisdiction should determine the installed performance of the systems in place and determine if the current design methods employed by code or engineering judgment are appropriate for their jurisdiction. It is important to ensure the formulas used are clear so that the assumptions behind the flow calculations are known.

RESOURCES:

1 Metcalf & Eddy, Burton, F. L., Stensel, H. D., & Tchobanoglous, G. (2003). *Wastewater engineering: treatment and reuse*. McGraw Hill.

2 Otis, R. J., Boyle, W. C., Clements, E. V., & Schmidt, C. J. (1980). *Design Manual; Onsite Wastewater Treatment and Disposal Systems*. Environmental Protection Agency Report EPA-625/1-80-012, October 1980. 412 p, 86 Fig, 82 Tab, 204 Ref. 1 Append.

3 *Uniform Plumbing Code*, 2012

4 http://www.ndwrcdp.org/documents/03-CTS-16T/GISizingSpreadsheetversion.xls

5 https://www.werf.org/a/ka/Search/ResearchProfile.aspx?ReportID=03-CTS-16Tb

6 https://precast.org/wp-content/uploads/2014/08/Grease_Interceptor_Design.pdf

DESIGN OF GRAVITY GREASE INTERCEPTORS

Grease interceptors work to remove FOG and other materials through separation by gravity or flotation. These mechanisms are time-dependent, so the design of the tank must allow for an appropriate amount of retention time and for a calm environment beneath the liquid level.

One important factor that must be regulated is velocity spikes. The tank should be designed to retain the wastewater long enough to allow for separation and must also avoid interaction with previously separated FOG or solids layers.

In addition, the accumulation of FOG and solids layers will, over time, reduce the clear zone. This will result in slightly accelerated velocity of fluid through the tank and reinforces the importance of periodic maintenance and cleaning of the tank. Tank designs should provide easy access that enhances the ability and willingness of owners to clean and maintain the interceptor.

Compartmentalization of GGIs is often used to achieve more separation. Two compartments are common, and three compartments are also sometimes specified. Although it is intuitive to assume that multiple compartments will yield more separation, this is not always the case. The effectiveness of the compartments depends on the connection opening or baffle system.

The Venturi effect, named after Italian physicist Giovanni Battista Venturi, describes how a fluid velocity must increase as it passes through a constriction (Figure 1).

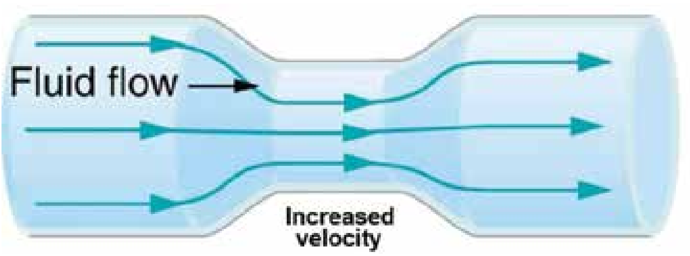

Figure 1. Venturi Effect on a Fluid Through a Constriction

When smaller openings or baffles are used to transfer fluid from one compartment to another, the resulting increased velocity of the fluid can cause the system to short circuit. The WERF study demonstrated that in some cases, single-compartment tanks performed better than dual-compartment tanks for this very reason (Figure 2). Therefore, compartment walls should be designed to distribute the flow and minimize the occurrence of high local fluid velocities. Larger slots or transfer ports are recommended.

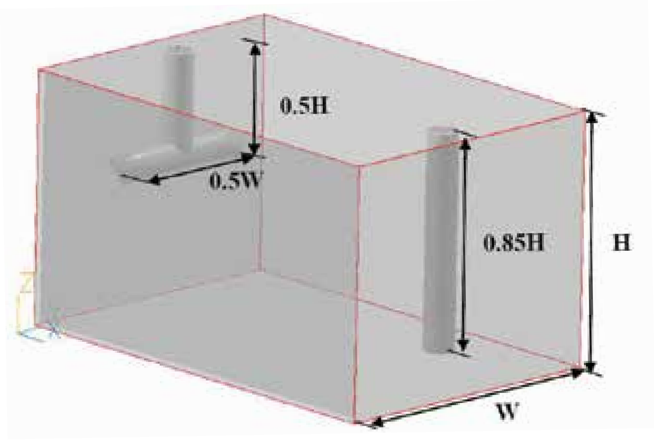

Figure 3. Example of an Influent Baffle System that Could Distribute the Flow Throughout the Grease Interceptor Tank

Figure courtesy of the Water Environment Research Foundation

This comprehensive study also shows that local fluid velocities could be reduced by distributing the flow across a larger cross-sectional area. Ideally, the area would occupy the entire cross-section of the of the grease interceptor (i.e., depth multiplied by height), as this setup would provide the lowest fluid velocities. To achieve this, the influent baffle would have to be designed to distribute the incoming flow (Figure 3).

PRECAST PEACE OF MIND

A properly functioning precast concrete GGI is key to keeping FOG-related issues from occurring in the treatment field or sewer system. The tank's performance will depend on its sizing and design. While flow rate is important in sizing, it is not the only factor that should be considered. Designing the tank to provide ease of maintenance while also maximizing retention time and creating a quiescent environment is essential for effective separation.

Not only do precast concrete GGIs provide the greatest capacity and longest retention times, they also offer the added benefits of structural integrity, design flexibility and a long service life. Outdoor concrete interceptors provide a level of health safety by removing this process from the food preparation environment. They also shift the maintenance responsibility from kitchen staff to third-party maintenance contractors, providing additional quality and safety assurance. As such, precast concrete GGIs are an efficient solution to a critical challenge, offering peace of mind to environmental professionals and facility owners. **PI**

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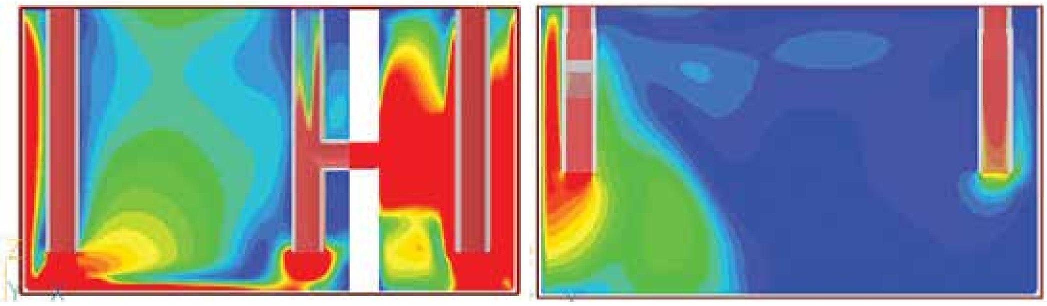

Figure 2. Comparison of Fluid Velocities in Single-Compartment and Two-Compartment Tank When Narrow Transfer Baffle is Used. *Fluid velocity is indicated by color (blue is slow, red is fast).*

Figure courtesy of the Water Environment Research Foundation

RESOURCES:

1 https://www3.epa.gov/npdes/pubs/pretreatment_foodservice_fs.pdf
2 http://www.ndwrcdp.org/documents/03-CTS-16T/03CTS16TAweb.pdf