Plumbing systems & design

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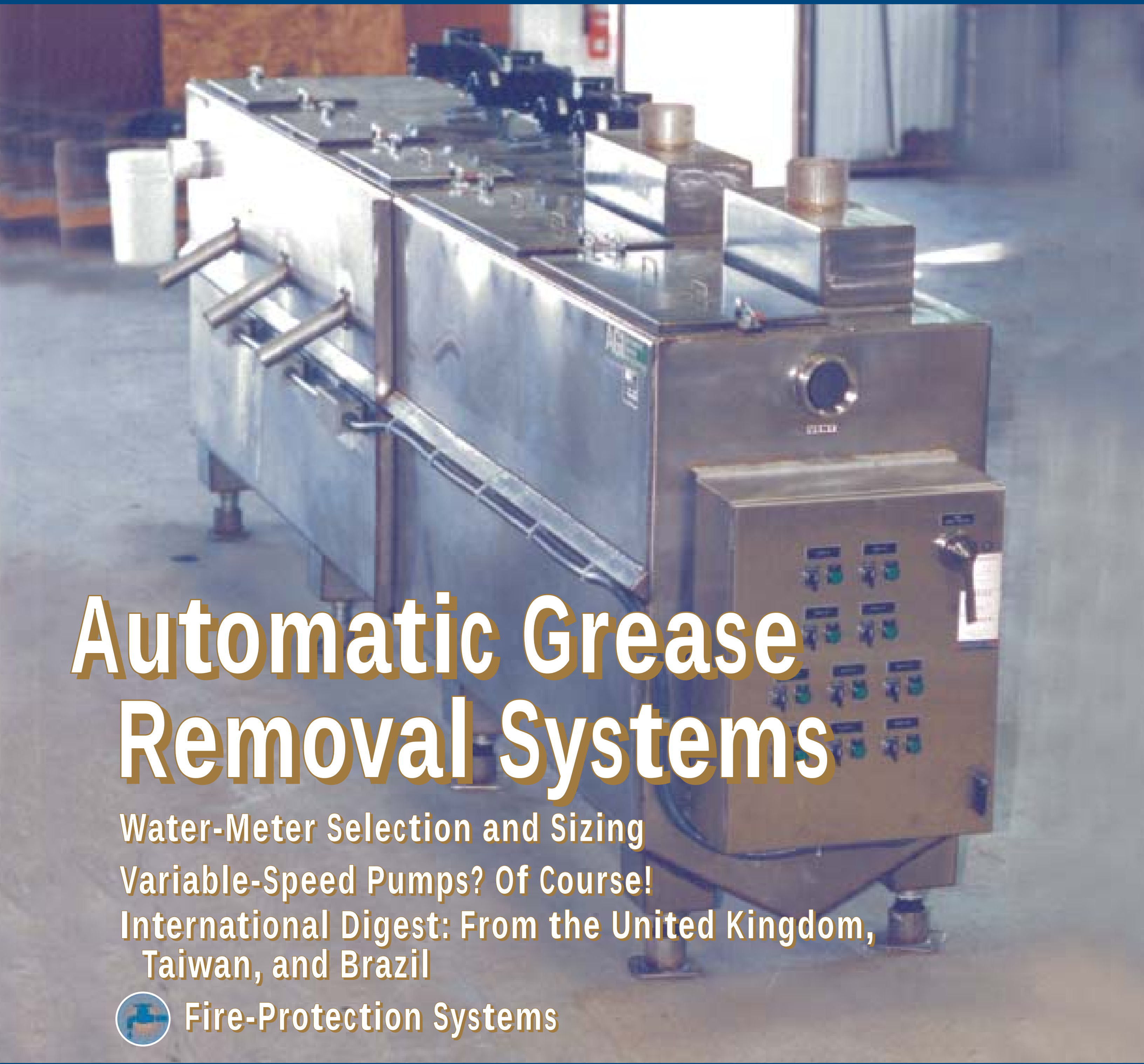

Automatic Grease Removal Systems

Water-Meter Selection and Sizing

Variable-Speed Pumps? Of Course!

International Digest: From the United Kingdom, Taiwan, and Brazil

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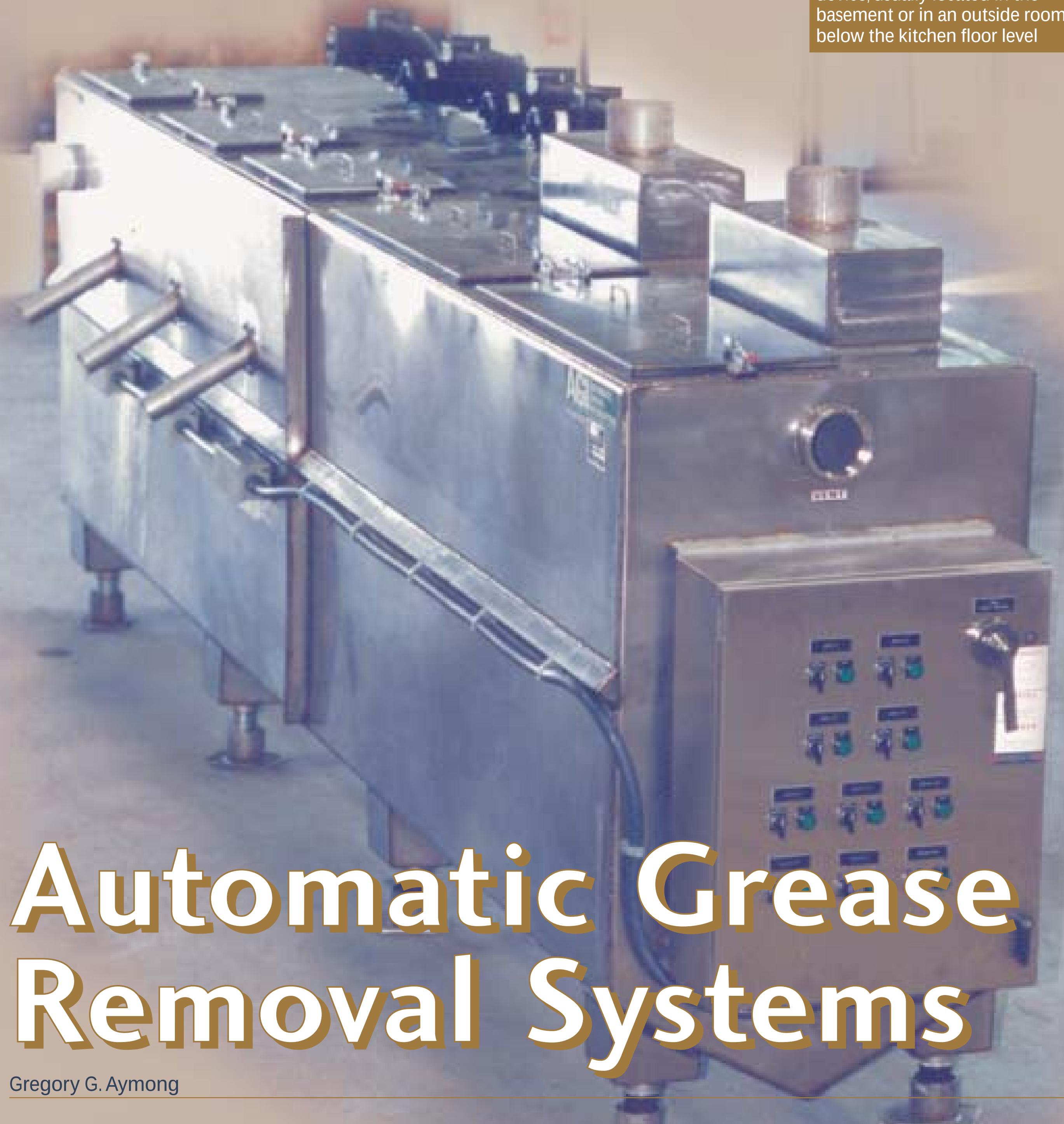

Large automatic grease removal system
An end-of-pipe treatment device, usually located in the basement or in an outside room below the kitchen floor level

Automatic Grease Removal Systems

Gregory G. Aymong

Commercial and institutional kitchens, food-processing plants, cosmetics and toiletry manufacturers, and food warehouses generate millions of pounds of grease every year. Grease is one of the primary causes of stoppages, backups, and overflows in a wastewater collection system. (The term *grease* includes combinations of fats, oil, and grease called FOG.)

Why Grease Is a Problem

When grease first enters a wastewater system, usually it is hot or warm. In a short time, it cools and coagulates on the system piping and in the lift stations. As grease solidifies on the interiors of pipes, sewage flow becomes restricted. Grease buildup in the sewers causes capacity problems and blockages. Any solid or viscous substance can cause obstruction of wastewater collection systems; lift station pumps and sensors can be fouled by grease or by malfunction. Sewers with minimal slope or small lift stations often are the first to clog due to grease buildup. Sewer blockages and lift station failures resulting from grease buildup are expensive to repair and a burden to a municipality's budget.

Sewer blockages can cause raw sewage or waste to back up and spill out of manholes onto city streets or properties and into basements. At worst, the raw sewage can overflow into a storm sewer or directly into a stream, river, lake, or oceans. Sanitary sewer overflows (SSOs) are unsightly and unpleasant, and they present a health hazard. Clean-up can be difficult, time consuming, and costly. SSOs are illegal and constitute a serious environmental, economic, and public health threat. Therefore, reducing or eliminating SSOs is a high priority for pretreatment coordinators employed by a publicly owned treatment works (POTW).

At a treatment works, grease may partially block the screens and affect the scum draw-off systems. In the secondary treatment phase, grease accumulates into grease balls appearing in the secondary clarifier and may cause clogging or ponding on trickling filters. If a large amount of grease is present in the final sludge, it can foul sludge pumps and pipe work, cause a shock load on sludge-digesting microorganisms, and reduce the overall efficiency of the digestion process, resulting in lower quality discharges directly into the plant's receiving waters.

The U.S. Environmental Protection Agency (EPA) estimates that more than 40,000 SSOs occur annually. EPA now requires that municipal sewer authorities implement pretreatment or "source control" programs to regulate and control grease discharges and thereby, reduce or eliminate SSOs. More than 1,500 POTWs are required to implement local pretreatment programs. By reducing the levels of grease discharged into the POTW, the program protects America's multibillion-dollar public investment in treatment infrastructure as well as the country's water quality.

Most food-service facilities that discharge wastewater into a sanitary sewer are affected by the new EPA regulations. Facilities with grossly undersized or inoperable grease traps or grease interceptors are now required to capture and properly dispose of the grease generated by their operations. (Grease interceptors are large underground wastewater-treatment tanks constructed of concrete, protected steel, or another material designed to receive wastewater by gravity flow from the food-service facility, separate grease and floating and settleable solids, and prevent their discharge into the sanitary sewer collection system.) In some cases, establishments not previously regulated must examine their discharges to the local sewer.

Essentially, the control authority and EPA will scrutinize all food-service facilities more closely. But food-service facilities should expect their annual operating costs for discharge to sanitary sewers to increase. To comply with grease discharge requirements, they may also be required to install

Small automatic grease removal system
A point-source treatment device usually connected to the drain lines between the pot-washing sink or prerinse station sink and the sewer drain

pretreatment systems such as high-performance automatic electrical-mechanical grease removal systems. Many POTWs require installation of a modern automatic electrical-mechanical grease removal system in new or existing facilities instead of a conventional "under the sink" manual grease trap.

Undersized grease traps and the failure of maintenance personnel to clean and maintain grease traps properly are major causes of chronic grease discharges from food-service facilities. Most grease traps are not sized to allow enough detention time for the water and grease to separate. A grease trap, if not manually cleaned, will eventually operate to the point of failure. The grease and solids that accumulate inside the trap reduce the vessel's treatment volume, resulting in a reduction in retention time. At worst, the grease accumulates to the point of overflow and discharge to the sanitary sewer system.

Why an Automatic Grease Removal System Is Better

Numerous mechanical devices have been proposed for removing grease from food-service facilities. One of the most successful designs is the automatic electrical-mechanical grease removal system. It is a device placed inside the building either under or in close proximity to sinks and other plumbing fixtures likely to discharge grease, or at or near the end of the grease collection drainage. It is designed for gravity flow.

These systems intercept, separate, and retain grease and other related undesirable matter from wastewater and prevent their discharge into the sanitary sewer collection system. They are equipped with an electrically powered grease-skimming device designed to automatically remove grease periodically

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or continuously. An automatic grease removal system is generally larger than a grease trap to allow greater retention time for better separation and performance.

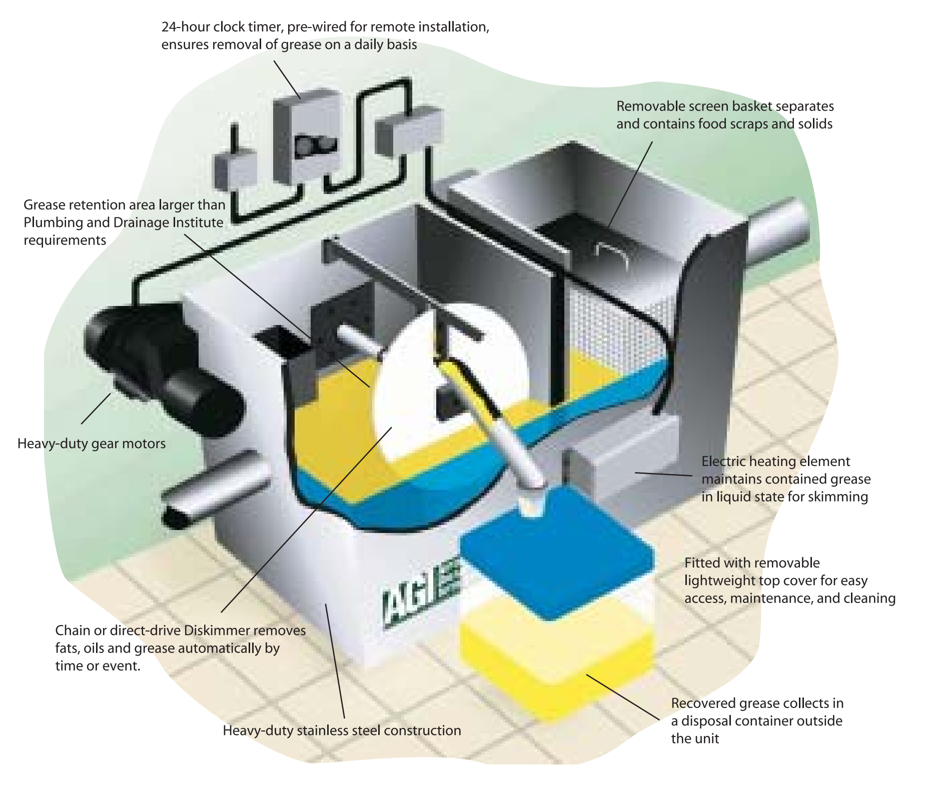
An automatic grease removal system is more efficient than a grease trap because it removes solid materials to a dedicated vessel or chamber. The remaining volume of the vessel is exclusively devoted to the interception and separation of grease. The accumulating grease mat that is common in a grease trap is not needed in an automatic grease removal system because the regular self-cleaning feature of the system keeps grease from building up inside the vessel. In addition, the automatic grease removal features of the system minimize manual maintenance requirements.

If any of the following conditions exist, POTW also may require installation of a modern automatic electrical-mechanical grease removal system in a new or existing facility, instead of a below-ground grease interceptor:

- the existing grease interceptor is undersized
- it is overwhelmed by the volume of incoming grease and solids
- it is located near or over water, bedrock, or a gas, electric, water, or sewer system that prevents excavation and installation of a grease interceptor.

How an Automatic Grease Removal System Works

The idea of an automatic grease removal machine dates from the early 1970s. Jack Lowe, a prolific inventor in Lincoln Park, NJ, was confronted with the growing need of industrial and commercial facilities to recover spilled oil and grease from water before discharge into the sanitary sewer. In his small specialty machine shop, Lowe designed, built, and tested countless oil- and grease-skimming machines using a rotating endless belt loop constructed of various materials such as felts, fibers, foams, and multiply cloth. Lowe was frustrated until a plastic-handled tool fell into the hot grease-water test tank. When he recovered the tool, he noticed that grease coated the plastic part of the tool, but virtually no grease adhered to the metal part. The radical course change that resulted led to a shaft-mounted vertically rotating plastic disc complete with a pair of scraper blades to scrape the grease into a recovery trough. An entirely new series of tests began to determine the optimum material, number, rotation speed, and service life for the "diskimmer."



Small automatic grease removal system Cutaway view of a point-source treatment device

In operation, the vertical disk, which is partially submerged in the water and the overlying liquefied grease layer, rotates at a constant rotational velocity of approximately 7.5 rpm. When a point on the disk dips into the water and encounters the floating grease layer, the hydrophobic grease clings to the rotating disk, forming a thin film of grease on its surface at the grease-air interface. As the grease-covered portion of the disk passes through the underlying water, little or no water clings to the disk. Where the disk emerges from the water, a boundary layer of the underlying water, which gets its movement through the shear forces exerted on it by the rotating disk and the grease clinging to it, forms a barrier to prevent any other material from clinging to the disk. Due to the differences in the surface tension and viscosity of the water and the grease, the water layer is pulled back into the water, and the disk emerges with only the grease layer clinging to it. The scrapers scrape the disk clean of the grease film, and the scraped grease runs down the collection trough into the receiving grease reservoir.

A patent for the diskimmer was granted in 1977. Commercial application followed with immediate and noteworthy success. Although the original diskimmer has changed little in its 26 years of commercial use, the modern automatic electrical-mechanical grease removal system as a whole has undergone some important changes, mostly in vessel design and construction. The first grease removal units were manufactured of carbon steel, but soon the construction material was changed to stainless steel due to the corrosive nature of acidic grease-laden wastewater. A trash screen was added to remove solid food and waste products. On-site and field tests established the vessel configurations and baffling for optimum performance. Subsequent testing and calculations proved that longer, larger-capacity machines increased retention time and improved performance.

It has been determined that the basic principles governing the separation of grease from water by gravity differential can be expressed mathematically. The mathematical expressions, their relationship to the system's design, and their derivation all are an expression of Stokes' law for terminal velocity of spheres in a liquid medium. Stokes' law is applicable to the rate of rise of grease globules or the settling rate of solids in water.

Stokes' Law

$Vt = g\,(sw - sg)\,D^2/18\mu$

Where

Vt = rising velocity of the grease globule in cm/sec

g = gravity constant (980 cm/sec^2)

μ = viscosity of water in poises (0.01)

sw = densities (gm/cm^3) or specific gravity of water

sg = densities (gm/cm^3) or specific gravity of grease

D = diameter of the grease globule in cm.

An examination of Stokes' law discloses that the vertical velocity of a grease globule in water depends on (a) the density and diameter of the globule, (b) the density and viscosity of the water, and (c) the temperature. Specifically,

- the grease globules' vertical velocity is highly dependent on their diameter, with small globules rising much more slowly than larger ones. The larger the globule, the faster the rate of separation.
- the performance of the system is highly dependent on the difference between the specific gravity of the water and that of the grease. The closer the specific gravity of grease is to that of the water, the more slowly the globules will rise. The greater the density difference is between the grease and water, the faster the rate of separation will be.

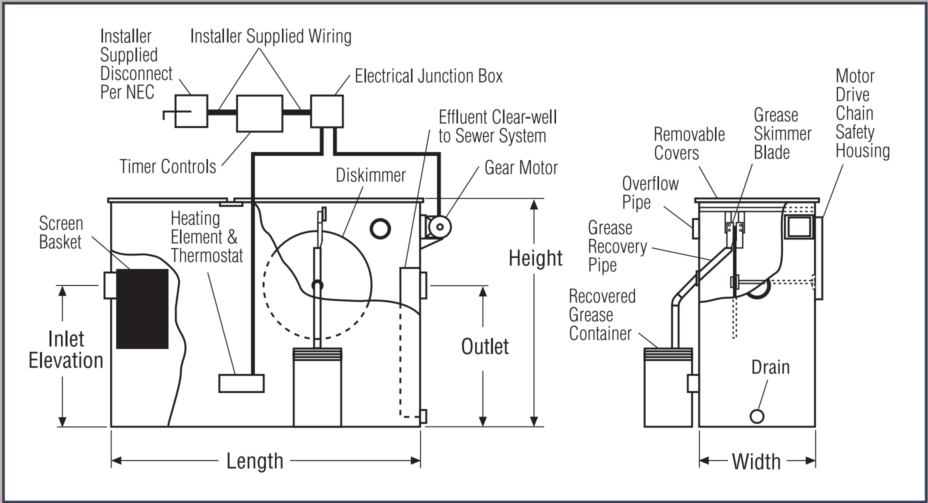


Diagram The skimmer removes and recovers almost 100% of the grease entering the system.

- Because the grease globules' rise rate is inversely proportional to the viscosity of the wastewater, the less viscous the carrier fluid, the faster the rate of separation will be, and vice versa. Grease globules rise more slowly at lower temperatures and more rapidly at higher temperatures. Grease, especially when hot or warm, is lighter than water and will not mix well with water.

In addition to retention time; grease-globule type, size, and distribution; and wastewater temperature, the difficulty of grease-water separation is a function of the presence of detergents, solids concentrations, inlet conditions, and maintenance practices.

Applications

Automatic electrical-mechanical grease removal systems are used in facilities operated regularly for the sale of prepared food and in many other types of facilities in which any type of food preparation (including heating or defrosting using an oven or heating device) takes place on the premises. Grease is predominantly generated from washing and cleaning operations in these facilities. The pot-washing sink, prerinse station, floor drains, and automatic and manual ventilation hoods are the major sources of grease discharges to the sewer system. Automatic grease removal systems are designed to intercept and remove large quantities of grease that might interfere with the proper drainage and treatment of municipal wastewater. The grease removal system separates the grease from water by gravity separation. Because grease is lighter than water, the grease floats and can be skimmed from the surface of the vessel.

The plumbing engineer or authority having jurisdiction (AHJ) may specify either a point-source or end-of-pipe system. Point-source treatment usually is for cafés, convenience stores, delicatessens, diners, pizza outlets, quick-serve restaurants, sandwich shops, or other small restaurants. It most often is used in existing restaurants that have an inadequately sized or malfunctioning manual grease trap or grease interceptor. The automatic grease removal system is usually connected to the drain lines between the pot-washing sink or prerinse station sink and the sewer drain. This style of automatic grease removal system is relatively small, allowing for installation near the sink or in another small space close to the source of the wastewater, where the wastewater is still hot to facilitate grease separation and skimming.

Often the plumbing engineer or AHJ requires the use of a main, large-volume automatic electrical-mechanical grease removal system to serve an entire facility's kitchen fixtures, including floor drains. Common applications include communal

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kitchen facilities, casinos, churches, convention centers, correction facilities, cosmetics and toiletry manufacturers, food-processing plants, full-menu restaurants, grocery stores, healthcare facilities, hotels, meat-cutting and packaging facilities, military mess halls, nursing homes and day care centers that have kitchens, school cafeterias, shopping mall food courts, soup kitchens, sports arenas, strip malls, and truck stops. The end-of-pipe treatment device, because of its large size and need for gravity drainage of the kitchen's floor drains, normally is located in the basement or an outside room below the kitchen-floor level. Placing the system close to the source of the wastewater (in this case, the kitchen) facilitates grease separation and skimming. For proper design and installation, the engineer must always specify room clearances, grade-level elevations, and inlet and outlet invert elevations. The system is installed and connected to be easily accessible for inspection, cleaning, and removal of the separated grease and waste products.

> ***The plumbing engineer will have to determine the equipment size and establish how often grease must be removed.***

In operation, point-source and end-of-pipe systems are similar. When greasy water enters the system, it flows through the screen basket, which is designed to remove any floatable or settleable solids, and strikes the inlet underflow baffle. The baffle reduces the horizontal velocity and flow turbulence and, more importantly, completely isolates the inlet turbulence from the retention area, preventing the turbulent flow from disturbing the separating grease.

As the greasy water enters the retention area, the grease separates by gravity floatation in accordance with Stokes' law. The grease floats and remains in the retention area between the internal baffles. Thermostatically controlled electric immersion heaters elevate the temperature in the vessel to maintain the contained grease in a liquid state for optimum skimming from the water's surface.

The diskimmer, an electrically powered grease-skimming device that operates on a time- or event-controlled basis, has a 120-volt/60-hertz gear motor. Clock timers and on-off switches control the system. The system is designed to remove grease hourly or daily, depending on the facility; for a gambling casino, for example, systems are required to run at all times.

The diskimmer's oleophilic plastic disc rotates, causing grease to adhere to it wherever the disc enters the water. As the disk rotates, the grease is carried with it until it passes between the scraper blades. The skimmed grease is scraped from the disk surface, directed into the collection trough, and drained via a conduit into a disposal container, barrel, or tank, from which it can be recycled with restaurant's yellow grease by a rendering firm. The water flows under the discharge baffle and out of the system into the sewer drain.

If properly maintained, an automatic grease removal system is capable of reducing the floatable grease content of the discharge wastewater to 100 ppm (mg/L) or less. A proper maintenance schedule includes daily inspections and other regular maintenance, as outlined by the manufacturer. Regular screen-basket cleaning is fast and easy.

The engineer should know exactly where the effluent will be going and design for environmental or sewer discharge regulations governing the particular system. EPA regulations raise the issue of inspections, sampling, and analysis of wastewater. The AHJ may require installation of a sampling port on the discharge side of the grease removal system so that an inspector can verify proper treatment. Grease removal systems must be performance rated and capable of producing effluent discharges at a rate equal to or better than the controls established by the AHJ.

Sizing

An automatic grease removal system is generally sized according to local plumbing codes. It should be sized to handle the amount of wastewater and grease that will flow to it. A check of local ordinances and codes should always be made before a system is designed. Sizing is based primarily on the volume of wastewater (in gallons per minute) that can be discharged from the kitchen fixtures or the other equipment to be served. Sizing is based on hydraulic loading, so it can be calculated from the number and kind of sinks and fixtures discharging to the system. Most plumbing codes list drainage fixture-unit values for various plumbing fixtures. For fixtures not listed, codes usually show drainage fixture-unit values based on the drain outlet diameter.

Whether a food-service facility is being remodeled or has been cited for a grease discharge and therefore is required to install a new automatic grease removal system, the plumbing engineer will have to determine the equipment size and establish how often grease must be removed. The plumbing engineer can perform a flow test of the facility's existing drainage system to determine minimum, average, and maximum discharge flow. A flow test is one of the most reliable methods for determining the proper sizing for an automatic grease removal system or any other treatment equipment. ■

Gregory Aymong is vice president of wastewater treatment systems for Highland Tank, Inc., the largest producer of above-ground and below-ground storage and wastewater treatment tanks in the United States. He is the inventor of the patented Highland Tank Oil/Water Separator. He can be contacted at grega@highlandtank.com.

University of Wisconsin–Madison, with the developmental support of the American Society of Plumbing Engineers, presents

FLUID SYSTEMS ENGINEERING

AN OPTION PROGRAM IN THE DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

Fluid Systems Engineering Undergraduate Option

The University of Wisconsin–Madison Department of Civil and Environmental Engineering offers an undergraduate option to civil engineering students in fluid systems engineering (FSE). Students in this option will earn an accredited Bachelor of Science in Civil Engineering, and their transcript and graduate certificate will indicate the FSE option.

What is Fluid Systems Engineering?

FSE is the application of scientific and engineering principles, particularly fluid flow and fluid distribution, collection, processing, control and measurement; fluid machinery; and heating and cooling systems. These principles are used to meet industrial, commercial, institutional, municipal, and human needs. FSE is an important element for the health, welfare, and safety of the public.

Unique Job Opportunities in this Program

A major benefit of enrolling in the FSE option at the University of Wisconsin–Madison is the cooperative work program that will be available. The American Society of Plumbing Engineers will provide coordination for 6–12 cooperative work opportunities for semester and summer options. These cooperative opportunities will be in a variety of workplaces including consulting engineering firms, architectural/engineering firms, engineering departments of manufacturing companies, and other related engineering organizations. Only individuals enrolled in the FSE program will be eligible for these cooperative work programs. All cooperative work assignments will be paid at $12–$15 per hour and may include other benefits, if available, from individual firms. Students who undertake cooperative work assignments on a regular basis (e.g., two semesters or multiple summers) often find they have an opportunity for immediate employment upon graduation.

CURRICULUM

First semester
- Math 221 (Calculus & Analytical Geometry)
- ME 170 (Civil Engineering Graphics)
- Chemistry 109
- Natural science elective (Geology, Botany, or Zoology)

Second semester
- Math 222 (Calculus & Analytical Geometry)
- EMA 201(Statistics)
- CEE 251 (Engineering Spatial Measurement)
- Natural science elective (Geology, Botany, or Zoology)
- Liberal studies elective (Economics, Environmental Issues)

Third semester
- Math 234 (Calculus & Analytical Geometry)
- EMA 202 (Dynamics)
- EMA 303 (Mechanics of Materials)
- EMA/ME 307 (Mechanics of Materials Lab)
- CEE 320 (Introductory Transport Phenomena)
- Communication skills elective (Speech)

Fourth semester
- CS 310 (Problem Solving Using Computers)
- CEE 310 (Fluid Mechanics)
- CEE 322 or 316 (Hydraulic Engineering)
- CEE 340 (Structural Analysis)
- Stat 224 (Elementary Statistical Analysis)

Fifth semester
- CEE 311 (Hydroscience)
- CEE 330 (Soil Mechanics)
- Applied engineering elective
- Applied engineering elective (Natural Science)
- Communication skills elective (Writing)

Sixth semester
- CEE 395 (Materials for Constructed Facilities)
- Physics 202 or 208
- Economics 101 (Principles of Microeconomics)
- Applied engineering elective

Seventh semester
- Applied engineering elective
- Applied engineering elective (Natural Science)
- Communication Skills Part A
- Liberal studies elective

Eighth semester
- Applied engineering elective
- Applied engineering elective (Natural Science)
- Liberal studies elective

Total credits: 123 minimum

For more information

Contact Jae K. (Jim) Park, Department of Civil and Environmental Engineering, park@engr.wisc.edu.