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THE WATER AND WASTEWATER ISSUE

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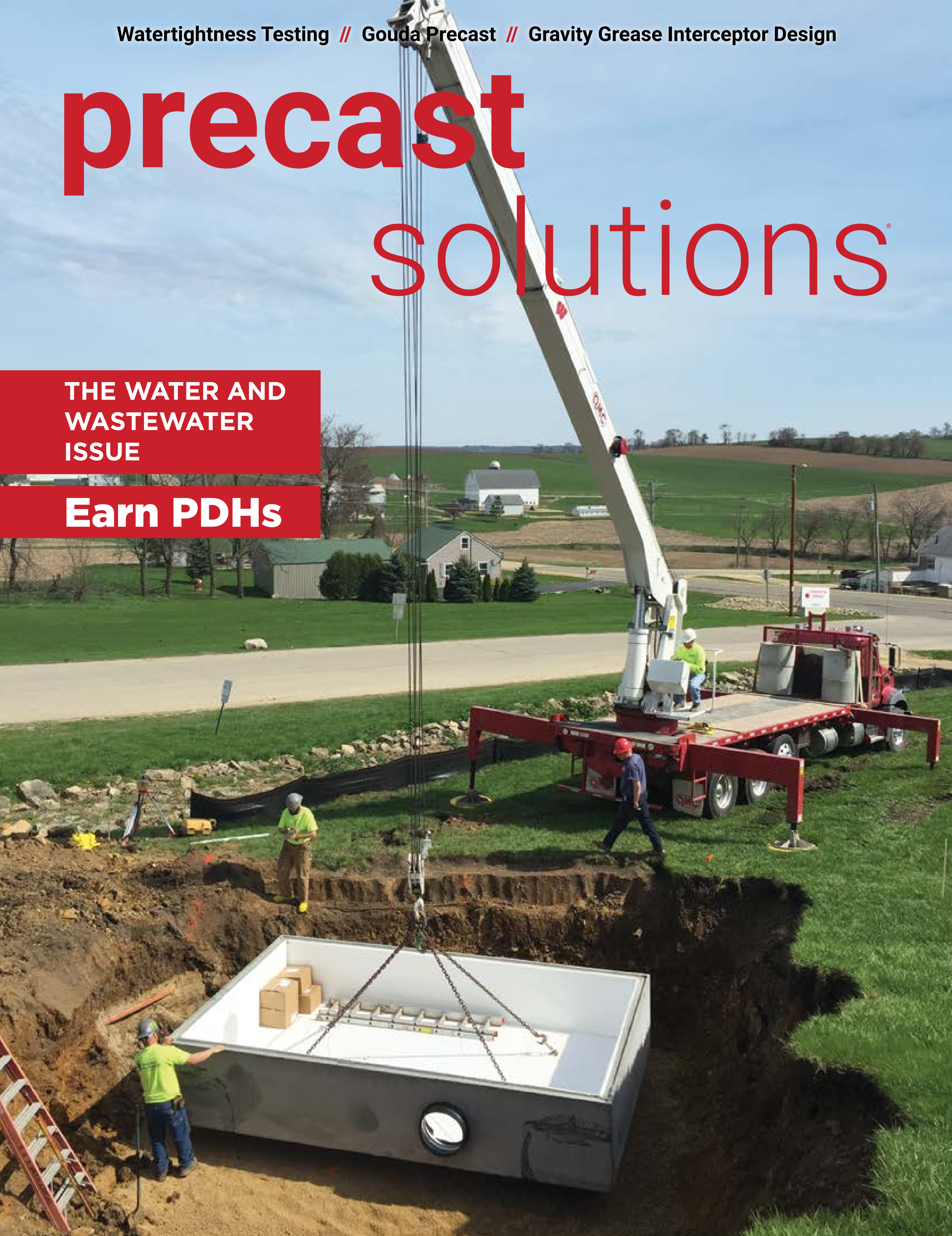

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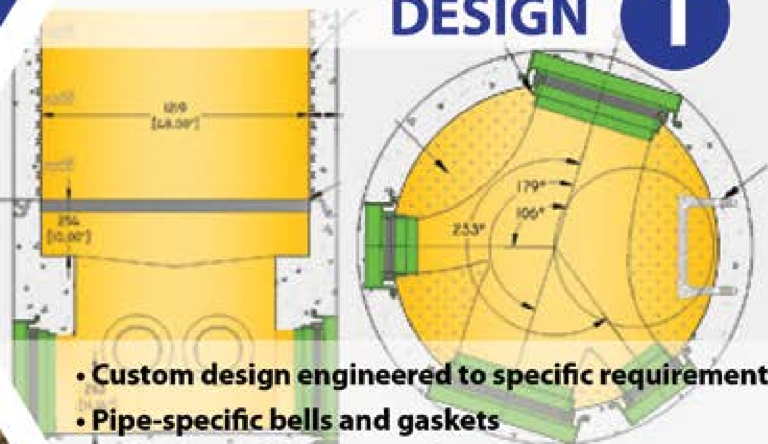

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WHAT'S INSIDE

Photo courtesy of Dalmaray Precast Concrete Products

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THE WATER AND WASTEWATER ISSUE

ON THE COVER:
The Big Cheese: The expansion of Grande Cheese's plant in Juda, Wis., required a product capable of withstanding wastewater with a high temperature and acidity level. These needs – combined with a compressed construction schedule – could have spelled disaster. But thanks to the use of a variety of precast concrete wastewater products, the project was a major success. Learn more on page 20.

Photo courtesy of Seaman Corporation.

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Precast Shines
Treatment Plan

Package wastewater treatment plant showcases post-tensioned precast concrete's ability to successfully handle 500,000-GPD capacity.

By Shari Held

All photos courtesy of Mack Concrete Industries

s in nt Project

A variety of precast concrete products served as the optimal solution for a new wastewater treatment plant in Knox Borough, Pa.

Knox Borough, Pa., is a quaint community of approximately 1,000 residents tucked away in the northwestern quadrant of the state. Its original cast-in-place wastewater treatment plant was built in the 1930s and had only been upgraded twice – once in the '50s and again in the '70s.

The plant's tanks showed evidence of spalling so severe that the reinforcement in the walls was exposed. The plant didn't have the hydraulic or organic capacity to handle its customer base. It needed to be expanded or replaced quickly to keep Knox Borough in compliance with the Pennsylvania Department of Environmental Protection.

A WINNING SOLUTION

Replacing the wastewater treatment plant was the less expensive and more practical option. One of the first decisions to be made was what building material to use. The capacity of the new plant was 500,000 GPD, making it too large for steel, which

poses issues with durability. Steel plants have a lifespan of 25-to-30 years, while concrete plants can last more than 50 years.

Martin English, P.E., an engineer with the EADS Group of Clarion, Pa., considered using cast-in-place concrete. Ultimately, though, he chose post-tensioned precast.

"Preventing leakage was our number one priority," English said. "The post-tensioning support available with precast concrete makes it a very advantageous product for both strength and durability in environmental structures."

The design for the new extended aeration plant called for two 45-foot (outside diameter) circular clarifier tanks and a 153-foot-by-76-foot rectangular tank subdivided into two aeration chambers, two digester chambers, a flow-splitter chamber and a return-activated sludge chamber. Precast caps on the wall tops create a walkway around the tanks.

Mack Industries' headquarters plant in Valley City, Ohio, produced the precast for the treatment plant, built it, and installed the tanks and equipment. The company, which had worked with

Using precast concrete products helped general contractor Global Heavy Corporation successfully navigate on-site space constraints while also allowing for a quicker installation.

English before, began consulting on the project more than two years prior to receiving official approval to begin.

"We are unique in that our salespeople are working with the engineer in the early stages of a project," said Betsy Mack Nespeca, president, Mack Industries. "The key to a customized solution is working hand-in-hand with the engineer."

Mount Braddock, Pa.-based Global Heavy Corporation served as the general contractor for the project.

CHALLENGES ALONG THE WAY

Timing was a big challenge. English was concerned about meeting DEP-imposed deadlines.

"We had an implementation schedule that had to be met from start to finish," English said. "It definitely helped knowing we could meet our schedule for installing the tanks."

On-site construction began in February 2016 under frigid conditions. Sub-freezing temperatures can impact the grouting and sealing process. Fortunately, precast panels can be set in the

ground until there's a deep frost, unlike cast-in-place concrete.

Because the original plant remained operational during construction, workers had to contend with space constraints. And making a safe conversion from the old system to the new one involved some tricky logistics.

FABRICATING FOR A FAST INSTALLATION

The cast-in-place, steel-reinforced base (approximately 130 feet by 70 feet) was produced with keyways running through it. Mack Industries fabricated 130 precast wall panels, each measuring slightly more than 17 feet high and weighing about 10 tons. The 32 precast caps, which measured 4 feet, 6 inches wide by 12 inches thick, were various lengths, depending on the chamber size.

"Due to our large storage yard, we can produce precast components ahead of time," said Jim Thompson, general manager of the Valley City plant. "With the number of slabs, panels and caps required, we had several months of actual production time,

The new treatment plant became fully operational in September 2016.

but everything was delivered and set within days."

Once the base was prepared, the wall panels were set in the keyways to form the tank and the chambers. The caps were placed in position and grouted and the rails were installed.

"The time savings came with the installation of the wall panels," said Tom Setzer, the Mack Industries sales representative for the project.

At that point, the plant was post-tensioned to form the watertight tank and seepage tests were conducted. The plant was fully operational in September 2016 and is currently running at slightly more than half capacity.

Now that the plant is operational, the results are receiving positive feedback.

"We're so glad we used precast," English said. "It provides a nice, finished product, and we don't have to worry about those tanks failing. PS

Shari Held is an Indianapolis, Ind.-based freelance writer who has covered the construction industry for more than 10 years.

Staying Cool w

Custom precast concrete wastewater solution serves key role in the production of new automobile refrigerant.

By Mason Nichols

All photos courtesy of Gainey's Concrete Products

with Precast

The floor of the custom precast wastewater structure was hand-sloped around 8-inch-by-8-inch support beams at a fixed angle leading to a sump blockout in the floor.

Millions of drivers around the globe rely on air conditioning systems to regulate the temperature in their vehicles. For more than two decades, many of these vehicles have employed a refrigerant known as R134a to make the process work. However, efforts are underway to replace R134a with a new, more environmentally friendly solution. One result of those efforts is the development of Solstice yf.

Created by Honeywell, Solstice yf boasts a global warming potential of less than one, a massive reduction from R-134a's GWP of 1,300. The drastic difference in GWP between the two materials means that – with a complete shift from R134a to Solstice yf in all vehicles – greenhouse gas emissions from vehicle air conditioners could be reduced by 99.9%.[1]

To produce its new refrigerant, Honeywell constructed a $300 million plant in Geismar, La., in 2017. Manufacturing Solstice yf creates hydrofluoric acid, a corrosive and potentially explosive substance. As a result, Honeywell required a structure capable of safely and efficiently capturing the generated wastewater. The company's solution was precast concrete.

Just an hour up the road, Gainey's Concrete Products of Holden, La., designed and manufactured a 14-foot-by-14-foot I.D. precast concrete secondary containment structure for the Honeywell plant. The tank was produced with 12-inch-thick, 6,500-psi walls. According to Cyndi Glascock, senior design manager, the structure included many unique characteristics.

"The floor had to be hand-sloped around 8-inch-by-8-inch support beams at a fixed angle leading to a sump blockout in the floor," she said.

Including the beams, the containment structure weighed 75,000 pounds – the largest piece ever manufactured in the production facility at Gainey's. In addition to the tank's impressive size, care had to be exercised to ensure the structure could be quickly and efficiently installed once it reached the job site.

"We had to cast in expanded coil ferrule inserts at extremely precise locations so that the contractor could lock the precast riser sections together in the field with galvanized plates," Glascock said.

Once the massive structure was delivered to the facility, project contractor Beard Construction got to work. Terry Overton, project superintendent, explained that – despite the tank's size – installation was a breeze.

"The precast concrete components went in with ease and speed," he said. "There was nothing difficult about it."

Overton added that the use of precast meant the contracting team knew exactly what to expect when the work began, allowing the owner to save money. Beard Construction completed installation in just one day.

Glascock noted that the use of precast also brought other benefits to the job.

"Precast concrete offered a rapid installation option for Honeywell's safety-intense site so that the contractor could close up the excavation as soon as possible," she said. "Additionally, the

Project contractor Beard Construction completed installation of the precast concrete containment structure in just one day.

higher density properties of precast versus cast-in-place will offer better containment for the wastewater created by the manufacturing process."

With the completion of the project, Honeywell is primed to continue its quest to provide an environmentally friendly refrigerant for automobiles. And thanks to a custom precast concrete solution, company officials can remain confident that the wastewater generated in producing Solstice yf will be safely contained. PS

Mason Nichols is the managing editor of Precast Solutions magazine and is NPCA's director of strategic outreach.

Endnotes

[1] https://www.honeywell.com/newsroom/news/2016/11/time-to-cool-drivers-easily-and-effectively

Denise H. Wright (right) with a precast concrete septic tank at the Indiana State Fair.

Specifier Q&A

For this special issue, Precast Solutions magazine sits down with Denise H. Wright of the Indiana State Department of Health to discuss her involvement with precast concrete in the on-site sewage system industry.

All photos courtesy of Indiana State Department of Health, Environmental Public Health Division

Name: Denise H. Wright

Title: Training Officer

Company: Indiana State Department of Health, Environmental Public Health Division

Q: What is your field of focus and what particular products do you specialize in?

A: My field of focus is the on-site sewage system industry, where I serve as a state-level regulator. My responsibilities include developing regulatory language, standards and policies; training designers, installers and regulators on the proper interpretation and application of public health laws; working with manufacturers to develop new and improved methodologies for introducing products into the marketplace; and educating any stakeholders – including homeowners – about OSS design, installation, function and maintenance. I commonly work with concrete components in the OSS industry, especially septic tanks, dosing tanks and distribution boxes.

Q: What are the benefits of using precast concrete products, particularly in on-site wastewater applications?

A: Some of the benefits of using precast concrete in Indiana for OSS include the industry's familiarity with the product lines and manufacturers as well as industry-wide confidence in the concrete products. Additionally, installers seem to be comfortable with both the installation of precast concrete products in the OSS market and our beneficial relationship with the National Precast Concrete Association. Our state's local regulators, manufacturers and installers have benefited from technical classroom training and field assistance provided by NPCA staff. Our regulators in Indiana are better informed today than ever before thanks to the cooperative spirit of the NPCA staff and certified concrete manufacturers throughout Indiana. Precast topics specific to the OSS industry have been included in our annual training sessions. These topics include MIC, inspecting for watertightness and precast production quality expectations.

Q: How has the Indiana code regulating septic tanks evolved over the years, and what language do you believe needs to be in every set of septic tank codes?

A: Our OSS state codes have evolved over the years. Our codes no longer allow for cast-in-place constructed septic tanks. Our current residential code (IAC 6-8.3, effective May 9, 2014) and commercial code (IAC 6-10.1, effective May 17, 2014) set standards for concrete septic tank construction with two of the sections in particular that have served our OSS industry very well. First, for concrete septic tanks, pipe connectors are required to be a resilient rubber type that use an expansion ring, tension band or a take-up device to create a watertight connection between the pipe

Wright explained that Indiana's regulators are better informed today than ever before as a result of working with NPCA and certified precast manufacturers throughout the state.

and septic tank. Second, the lower section of the riser assembly is to be cast into the tank lid or sealed to the top of the tank with the proper materials to provide a watertight seal. Our regulations are supporting the precast manufacturers' effort to produce watertight components.

I have had the opportunity to talk with many other professionals in the OSS industry, including members of academia, manufacturers, designers, installers, service providers and regulators. After many lively conversations about OSS, I believe there are a few things in addition to the pipe and riser connections discussed above that I would put on my septic tank wish list for OSS in all states. These include:

1) Both an inlet and outlet baffle
2) A minimum of two compartments
3) Fitted with an outlet/effluent filter
4) The NPCA certified manufacturer requirement

My wish list items would serve regulators, designers and installers, but most importantly would positively impact the end user of the OSS with a septic tank designed and manufactured to provide outstanding performance.

Q: Your current role at ISDH is training officer. How do you train your inspectors on precast concrete products?

A: Our Indiana training efforts with local health departments include explaining the intent of the state code, but we go into more detailed training about the technical design specifications and installation inspections. The design state of an OSS project is an opportunity for the designer to explain through a written plan how they are going to meet the demands of the project (flow) and site (space, soils, slope, etc.). Our staff members work with local regulators and designers to assist them in understanding and complying with the requirements of the rule. Indiana codes place the responsibility of developing design plans on the applicant. It is the responsibility of the regulator to confirm that the designs have met the minimum requirements of the rule, standard, policy and/or ordinance.

During the OSS installation, the regulators have the responsibility – required by state code – to inspect the components, installation techniques and OSS performance to ensure and document that the construction permit requirements have been met. This stage of the project is very important because the various OSS components can be viewed and inspected to confirm consistency with the approved design plan, proper installation, product integrity and quality. Our training includes the instruction to document observations. Local regulators are encouraged to utilize checksheets during the installation inspection. ISDH has generated inspection checksheets and we also advise collecting digital images of the components for the project file. We strongly urge local health departments to use Indiana's Tracking of Onsite Sewage Systems database. iTOSS allows for the project file to identify specific component manufacturers, materials and sizing, and it can serve as a useful tool to track OSS trends among participating counties.

Concrete tanks and distribution boxes have a long history of use in Indiana. Our regulators look forward to continued work with the staff of NPCA and the OSS concrete producers to strive for consistent quality manufacturing of concrete products to ensure a high-quality OSS infrastructure. PS

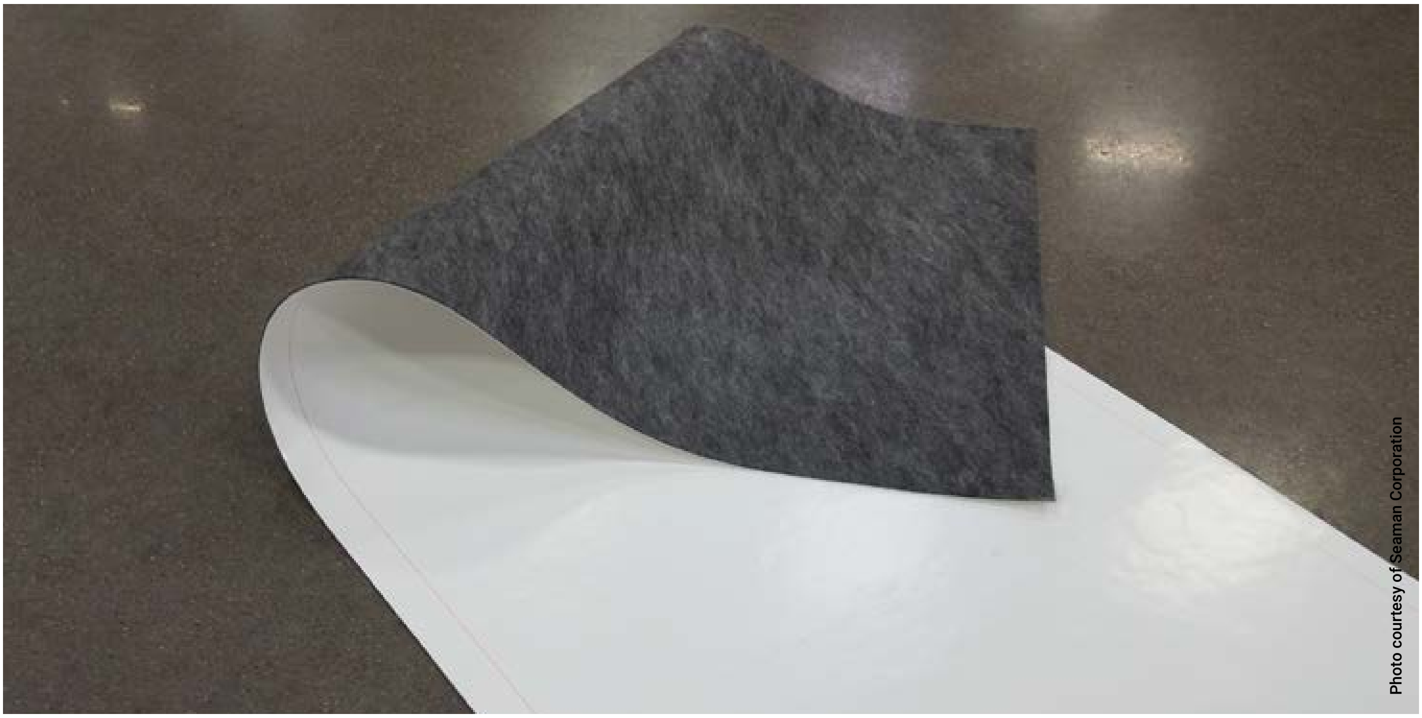
Precast Tanks a Gouda Solution for Cheese Plant

Precast concrete products with a specialized liner provide an **optimal solution** for a Wisconsin project with an accelerated timeline and unique requirements.

By Kirk Stelsel, CAE

Photo courtesy of Dalmaray Precast Concrete Products

Dalmaray Precast Concrete Products manufactured an 8,000-gallon cooling tank, a 6-foot-diameter wet well manhole and a 5-foot-diameter process manhole for Grande Cheese.



The specialty liners used on the project, which include a PVC side and a fibrous side, were produced to exacting dimensions.

The precast concrete cooling tank is capable of withstanding wastewater with both a high temperature and acidity level.

Wisconsin is known for many things: The Green Bay Packers, a rich history of beer production and native son Frank Lloyd Wright. What the state is perhaps most famous for, though, is its status as America's Dairyland – and in particular, the cheese that results from all that milk.

The state's dairy numbers are staggering. Close to 150 cheese plants in the state manufacture more than 3 million pounds of product every year, totaling 26.2% of all cheese production in the U.S.[1] One such plant, Grande Cheese, is among the top 20 natural cheese producers in the U.S. and has seven locations in southern Wisconsin.

At its plant in Juda, Wis., an expansion created the need for new wastewater infrastructure, but the manufacturing byproduct is anything but typical. The tanks needed to be capable of withstanding wastewater with a high temperature and acidity level, and the time frame was short. All pieces had to be delivered in a three-week construction window, leaving very little opportunity to conceptualize and fabricate a solution.

Dalmaray Precast Concrete Products in Janesville, Wis., was up to the challenge. The company immediately went to work creating a long-lasting solution to meet the needs of Grande and the contractor.

OUTLINING THE SOLUTION

Bryan Kranig, president of Kranig Excavating in Albany, Wis., made the decision to use precast tanks. His company has been doing outside excavating, utility work and plumbing for about 15 years at that location.

"All the projects get thrown to me," he said. "They leave it up to my discretion and really value my opinion, and with the circumstances of the site and what we were going to be doing, it was obvious precast was what we needed for the job. With the terrain of the job site, there really wasn't a way to pour anything in place, and with the ability of Dalmaray to design the precast, it was a no-brainer."

Prior to the project, the team at Dalmaray had never installed a product with a sheet liner in the field. However, Aaron Ausen, vice president at Dalmaray, had created a relationship with

Seaman Corporation and the team had conducted a series of tests at the plant to prepare for the moment. Although Ausen said the market for sheet liners is not strong in his area, the promise of a liner that was cheaper and easier than a hand-applied coating was appealing.

"We are trying to set ourselves apart from the competition and offer something else," Ausen said. "The way the liner had been presented to us as easy-to-use and cost-effective was very attractive. To my knowledge, I didn't think there was any kind of liner for a square structure.

"When somebody tells me they can do something faster and cheaper, I'm going to look at it."

In partnership with Seaman, Dalmaray manufactured three major structures – an 8,000-gallon cooling tank, a 6-foot-diameter wet well manhole and a 5-foot-diameter process manhole. In addition, Dalmaray delivered six other 4-foot-diameter manholes.

As specified by the engineer of record, each structure needed to withstand 180-degree F, 10% acidic wastewater produced while making cheese. The precast tanks provided the desirable, durable housing and the Seaman XR5 PVC liner system is rated to handle the water specified.

"The liners are very important in the tank and the manhole," Kranig said. "First, the hot water is running through them constantly, and they also have high-strength waste going through them. The liners were new to me, so as soon as I saw they needed liners I called Dalmaray and asked them to work their magic."


Photo courtesy of Seaman Corporation

UNIQUE NEEDS, SIMPLE SOLUTION

Although the products were right in Dalmaray's wheelhouse, the accelerated timeline, along with some changes during the job and the first in-the-field application of the lining, made the project anything but ordinary.

The time crunch was due to the project getting fast-tracked. In addition, midway through production the customer had some changes in the order and they wanted the products sooner. Dalmaray met those needs.

"The tank and manhole we were all pretty comfortable with, but the liner is what threw a wrench in the system," Ausen said. "We don't work with liners often up here. We've done model fits and testing and we've done coatings, which are pretty common."

The liners are premade to the exact dimensions of the product and shipped to the precaster. There, they are laid out and then stretched over the form with the PVC side facing the interior of the structure prior to placement of reinforcement and concrete. The back side is fibrous, which allows the concrete to bond to the liner. The experience went smoothly, with only minor adjustments needed.

"The installation was very good," Kranig said. "Dalmaray was on time with everything and explained everything very well. It was a breeze."

LOOKING AHEAD

With a successful job under its belt, Dalmaray sees other opportunities for liners in its market.

"We are going to test it with grease interceptors and farm applications where there's acidity and high temperatures such as milk house wash water and manure pits," Ausen said. "We think there are a few different markets where we can use it." PS

Kirk Stelsel, CAE, is NPCA's director of communication.

Endnotes

1 wmmb.com/assets/images/pdf/WisconsinDairyData.pdf

Watertightness Testing for Septic Tanks and Grease Interceptors

An examination of **standard testing procedures** for watertightness of precast concrete **septic tanks and grease interceptors**.

NOTE: By reading this article along with the "Gravity Grease Interceptor Design" story on page 32 and passing the associated online exam at precast.org/wwwpdh, you will receive a certificate for PDHs. Please check your state licensure board on specific PDH acceptance requirements.

By Kayla Hanson

All photos are NPCA file photos

Take the online exam associated with this article and earn PDHs.
precast.org/wwwpdh

A tank is considered to have passed the vacuum test if the pressure is held at 4 inches Hg for a duration of 5 minutes.

Precast concrete septic tanks and grease interceptors are designed to be strong, durable, watertight and resilient. Watertightness depends on many factors and starts with the raw materials used to manufacture concrete, but structural design, mix design, manufacturing, curing, handling and installation all play key roles. A low water-cementitious material ratio can lead to low porosity, high density and low permeability, which all work together to enhance concrete's watertightness.

ASTM C1227, "Standard Specification for Precast Concrete Septic Tanks," and ASTM C1613, "Standard Specification for Precast Concrete Grease Interceptor Tanks," discuss design requirements, manufacturing practices and performance requirements for both monolithic and sectional precast concrete septic tanks and grease interceptors prior to installation or backfill. IAPMO Z1000, "Prefabricated Septic Tanks," and IAPMO Z1001, "Prefabricated Gravity Grease Interceptors," discuss requirements for design, materials, performance, testing and markings for septic tanks and grease interceptors. ASTM C1719, "Standard Test Method for Installed Precast Concrete Tanks and Accessories by the Negative Air Pressure (Vacuum) Test Prior to Backfill," is also a valid test. Tank watertightness tests shall be performed in accordance with the applicable sections of the aforementioned standards or the requirements set forth by the authority having jurisdiction, whichever is more stringent.

Watertightness testing is imperative for underground storage structures including, but not limited to, septic tanks and grease interceptors as they are designed, manufactured and installed to keep their contents contained until exiting the proper outlet as well as to keep groundwater and other external substances out of the tanks entirely.

Vacuum tests should not be performed on-site after backfilling, as no industry standard exists for this situation. If a vacuum test were to be performed on a backfilled septic tank or grease interceptor and an issue were to arise, it would be difficult to identify the cause and locate and repair the affected area. Additionally, other loads such as soil and groundwater have the potential to cause a system failure during a vacuum test of a backfilled tank if the loads are not taken into account.

FIRST THINGS FIRST

Before beginning a vacuum test, ensure the tank has reached sufficient strength to undergo the test. The concrete should reach at least 75% of its design compressive strength prior to testing. It is imperative that the concrete has developed enough tensile and compressive load capacity prior to inducing loads by vacuum.

Prior to beginning a watertightness test, perform a visual inspection of the tank to locate any potential issues that could cause problems during the test. These issues should be resolved before conducting a vacuum test on the tank.

TANK VACUUM TESTING

Appropriate personal protective equipment must be worn during the test. Care must also be taken to keep testing personnel a safe distance away from any pressurized tank. Vacuum testing

should be performed on a tank surrounded by other precast concrete tanks. In the rare case that a tank experiences sudden structural failure during a vacuum test, fragments of the tank could be propelled into the air, creating a dangerous situation for those in the vicinity.

The tank must be assembled with joint sealants. In addition, the lid or top half of the tank must be in place before beginning the test. Once the empty tank is assembled, determine to which tank opening the vacuum device will be affixed. All other access points, including inlet and outlet openings, must be temporarily, yet thoroughly, sealed.

After properly sealing the tank, attach the vacuum device to the unsealed access point. Because the device will draw air from the tank and measure the resultant negative pressure, the vacuum device must be capable of drawing a minimum vacuum pressure of 7 inches of mercury (Hg) and must employ a calibrated gauge, mercury manometer or water manometer accurate to within 0.2 inches Hg. However, if a vacuum gauge is used, its range may not exceed 0-to-10 inches Hg. When possible, two gauges should be used to ensure one is not malfunctioning.

To prepare the vacuum test, slowly and steadily begin introducing negative pressure into the tank – up to 4 inches Hg – using the affixed vacuum device. It is imperative to allow the pressure to stabilize before beginning the test period. Once the pressure reading is stable, begin timing a five-minute test duration. The test is completed at the end of the period.

- **Pass:** If the pressure in the tank remains at 4 inches Hg for the entire five-minute test duration, the tank passes the test.
- **Retest:** If at any time during the test the pressure drops below 4 inches Hg, the tank may be retested by resetting the pressure, allowing it to stabilize at 4 inches Hg and restarting the five-minute test duration. The tank must maintain 4 inches Hg for the entire period for the tank to pass the test.
- **Troubleshooting:**
  - Inspect the equipment and ensure the connection and access points are properly sealed. Oftentimes, the equipment seal is the source of the leak.
  - Inspect the tank and listen for a hissing sound caused by air seeping in. If the tank is leaking and the source cannot be located, spray soapy water inside the tank, assemble and reseal the tank, and repeat the vacuum test. Once the test is complete, open the tank and look for bubbles, which will form at the site of the leak.
  - If needed, the manufacturer can specify repair material and procedures for the tank before retesting.

In addition to verifying a septic tank or grease interceptor's watertight integrity, vacuum testing can also be used to validate watertightness and structural integrity of other precast products, like installed manholes.

SEPTIC TANK HYDROSTATIC TESTING

The septic tank must be assembled and sealed before the hydrostatic test may commence. Fill the tank with water to its operable level – typically taken as the effluent invert – and let the tank stand undisturbed for 24 hours. Some water absorption into the interior concrete surface may occur, and the water level may drop as a result. Restore the tank to its initial water level after 24 hours, if necessary. Once the tank is refilled, the one-hour test duration may begin.

- **Pass:** If the water level remains constant for the entire period, the septic tank passes the test.
- **Retest:** If the water level falls during the period, restore the tank to its initial water level. Once the tank is refilled, begin timing another one-hour test duration. The tank must maintain the water level for the entire one-hour period to pass the test.
- **Troubleshooting:**
  - If at any time during the test period the water level drops, the tank may be repaired per the manufacturer's recommendations in accordance with ASTM C1227 and the test procedure may be restarted from the beginning.

GREASE INTERCEPTOR HYDROSTATIC TESTING

The grease interceptor must be assembled and sealed before the hydrostatic test begins. Fill the tank with water to its operable level – typically the effluent invert – and let the tank stand undisturbed for 8-to-10 hours. If the water level does not drop throughout the 8-to-10-hour duration, timing of the one-hour test period may begin. If the water level does fall during the 8-to-10-hour period as a result of moisture being absorbed by the interior concrete surface, refill the tank to its initial water level and let the tank sit for another 8-to-10 hours. Afterward, there should be no further drop in the water level, and timing of the one-hour test period may begin.

- **Pass:** If the water level remains constant for the entire one-hour test period, the grease interceptor passes the test.
- **Retest:** If at any time during the 8-to-10-hour test period the water level drops, the grease interceptor may be repaired per the manufacturer's recommendations in accordance with ASTM C1613 and the test procedure may be restarted from the beginning.

BEYOND THE TEST METHODS: VACUUM TESTING

Vacuum testing is a relatively quick watertightness integrity test that uses easily transportable equipment and a straightforward procedure. These attributes make vacuum testing the watertightness test method of choice for many manufacturers. Because the test requires very little space, it can be performed in the yard or even on-site.

Vacuum testing is also a conservative approach to watertightness testing and is more stringent than hydrostatic testing. Tanks in service do not operate in a theoretical vacuum, nor do they experience perfectly uniform maximum pressure on all four sides, the lid and the base. However, these considerations validate the performance ability and strength of precast concrete tanks. Hydrostatic testing ultimately applies very little pressure to the upper portions of tank walls.

BEYOND THE TEST METHODS: HYDROSTATIC TESTING

Filling the tank with water up to the top of the tank, into the riser or to the top of the riser is unnecessary and is not specified in the aforementioned standards. Typically, filling the tank to the flow line of the outlet is sufficient.

NPCA PLANT CERTIFICATION CRITICAL SECTION REQUIREMENTS

Watertightness testing is necessary and beneficial for many underground storage and conveyance vessels, including septic tanks and grease interceptors. NPCA Plant Certification requires watertightness testing to be demonstrated in accordance with the applicable section(s) of ASTM C1227, ASTM C1719, IAPMO/ANSI Z1000 for septic tanks; and ASTM C1613, ASTM C1719, IAPMO/ANSI Z1001 for grease interceptors; or the requirements set forth by the authority having jurisdiction, whichever is more stringent. A minimum of one test per year on a septic tank produced in each septic tank form used at the plant must be performed and documented. The same testing frequency applies to grease interceptors. PS

Kayla Hanson is NPCA's director of technical services.

Gravity Grease Interceptor Design

Take the online exam associated with this article and earn PDHs.
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Important factors for consideration during the **design of precast concrete gravity grease interceptors.**

NOTE: By reading this article along with the "Watertightness Testing for Septic Tanks and Grease Interceptors" story on page 26 and passing the associated online exam at precast.org/wwwpdh, you will receive a certificate for PDHs. Please check your state licensure board on specific PDH acceptance requirements.

By Claude Goguen, P.E., LEED AP

When we talk about fog, it's typically the clouds near the earth's surface that often serve as the backdrop of a horror film. This fog can be frightening, but a different type of fog evokes horror for public health officials in every municipality. Fats, oils and grease, also known as FOG, can build up in sewers and cause partial or complete blockages, which can then lead to sanitary sewer overflows.

One of the most reliable ways to manage FOG and prevent an SSO from occurring is to use a precast concrete gravity grease interceptor. How do we size and design this important piece of infrastructure to maximize its effectiveness? This article highlights the design principles needed to achieve this goal.

FOG'S ORIGINS

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] FOG is generated every day at restaurants or food service establishments as food is prepared and dishes, utensils and cookware are cleaned. Residential sewer customers can also contribute significant amounts of FOG to the sewer system.

The Water Environment Research Foundation conducted a study in 2008 that led researchers to deduce that FOG deposits are basically metallic soaps.[2] The reaction that leads to the formation of this soap begins at discharge. FOG is removed from dishware during cleaning and interacts with excess cleaners and sanitizers to begin saponification, the process that produces soap.

If sufficient amounts of FOG enter the sewer pipes, the resulting product will begin to collect on the top and sides of the pipe. As flow continues, more grease becomes trapped and the buildup continues until the flow is significantly restricted. These masses of FOG can grow dramatically based on the size of the pipe.

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 has been replaced by dishwashers discharging effluent at a higher temperature. Each of these factors plays a key role in the type of grease globule that enters the interceptor.

GREASE GLOBULES

As a grease globule enters a grease interceptor, the globule's size, density and temperature will impact its destination. Larger globules will rise faster than smaller globules. Calculations of this vertical velocity can be made based on Stokes' Law.

The formula to calculate velocity of a grease globule is:

$$V = \frac{(p_m - p_w)d^2}{18u}$$

Formula 1. Grease Globule Velocity.

Where
V = Velocity of globule (ft./s.)
Pm = density of grease (lbs./ft.^{3})
Pw = density of fluid (lbs./ft.^{3})
d = diameter of globule (ft.)
u = dynamic viscosity of fluid (lbs. s./ft.^{2})

If the density of the globule is less than the density of the fluid, the globule will rise at velocity V, and vice versa. For example, in static water, 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 0.007 ft./s. If we were to divide that globule size in half to 100 microns (.00033 feet), the globule would rise at 0.002 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 temperature 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 is minor 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, 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.

Stokes' 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 one WERF study, more effective FOG separation was achieved when fluid velocities near the inlet and outlet were kept below 0.6 in./s.[3]

GRAVITY GREASE INTERCEPTORS

The International Association of Plumbing and Mechanical Officials defines a GGI as a "plumbing appurtenance identified by volume and intended to be installed in a sanitary drainage system to intercept, using gravity only, nonpetroleum fats, oils, and greases from a wastewater discharge."[4] It is usually installed underground outside food service establishments, where it can be properly serviced and maintained by qualified personnel. Installing the unit in this location also removes the risk of having used grease stored within the same area where food is prepared and served.

The tank can be made in different shapes and configurations, but must be effective in intercepting the grease. Many factors contribute to the efficiency of a GGI.

SIZING

For some, taking the maximum flow rate in gallons per minute and multiplying that figure by 30 minutes is the extent of the GGI sizing exercise.[5] For example, if you expect no more than 75 GPM entering 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:

- U.S. EPA Method
- Uniform Plumbing Code, 2003, Appendix H
- Uniform Plumbing Code, 2006 and 2009

For the above formulas, calculations are performed based on the following scenario.

XYZ Restaurant, which is located near a highway, is open from 8 a.m. to 8 p.m. The restaurant contains 30 seats and at peak operation produces 40 meals per hour. The 20-foot-by-15-foot kitchen includes the following:

Appliances	One commercial dishwasher, rated max discharge 25 GPM Commercial food grinder, 2-inch trap with 5-GPM capacity
Sinks	Pre-rinse sink, 18 inches by 18 inches by 6 inches with 2-inch trap, 1.5-GPM faucet Special purpose two-compartment sink. Each compartment, 18 inches by 18 inches by 8 inches with 1.5-inch sink drain and trap Vegetable prep sink, 18 inches by 18 inches by 6 inches, 1.5-inch trap and 1.5-GPM faucet Wash sink with one set of faucets Mop basin, 24 inches by 24 inches by 6 inches, 2-inch trap, faucet at 5-GPM max
Other	Two floor drains, each with 2-inch trap

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:

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

Formula 2. Grease Interceptor Liquid Capacity, U.S. EPA Method.[6]

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

For XYZ Restaurant, we would have:

$$30\ seats \times 5\ gallons \times 1.7 \times \frac{12\ hours}{2} \times 0.8\ = 1{,}224\ gallons$$

2003 UNIFORM PLUMBING CODE, APPENDIX H SIZING METHOD

The 2003 Uniform Plumbing Code 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:

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

Formula 3. 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

For XYZ Restaurant, we would have:

$$40\ Peak\ Meals \times 6\ gallons \times 2.5\ hours \times 1.5\ = 900\ gallons$$

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 (DFUs). DFUs were developed by Dr. Roy Hunter in 1940 and 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.

Table 1. Gravity Grease Interceptor Sizing Based on DFUs.[7]

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

To obtain these DFUs, use Table 702.1 from Chapter 7 of the Uniform Plumbing Code, which contains assigned values for many different fixtures (Table 2).

Table 2. Drainage Fixture Values for Various Plumbing and Appliance Fixtures.[8]

Plumbing, Appliances, Appurtenances or Fixtures	Min. Size Trap & Trap Arm (inches)[7]	Private	Public	Assembly[8]
Bathtub or Combination Bath/Shower	1 ½	2.0	2.0	----
Bidet	1 ¼	1.0	----	----
Bidet	1 ½	2.0	----	----
Clothes Washer, Domestic, Standpipe[5]	2	3.0	3.0	3.0
Dental Unit, Cuspidor	1 ¼	----	1.0	1.0
Dishwasher, Domestic, with Independent Drain[2]	1 ½	2.0	2.0	2.0
Drinking Fountain or Water Cooler	1 ¼	0.5	0.5	1.0
Food Waste Grinder, Commercial	2	----	3.0	3.0
Floor Drain, Emergency	2	----	0.0	0.0
Floor Drain (for additional sizes, see Section 702.0)	2	2.0	2.0	2.0
Shower, Single-head Trap	2	2.0	2.0	2.0
Multi-head, Each Additional	2	1.0	1.0	1.0
Lavatory, Single	1 ¼	1.0	1.0	1.0
Lavatory, in Sets of Two or Three	1 ½	2.0	2.0	2.0
Wash Fountain	1 ½	----	2.0	2.0
Wash Fountain	2	----	3.0	3.0
Mobile Home, Trap	3	12.0	----	----
Receptor, Indirect Waste[1,3]	1 ½	See footnote 1,3		
Receptor, Indirect Waste[1,4]	2	See footnote 1,4		
Receptor, Indirect Waste[1]	3	See footnote 1		
Sinks	----	----	----	----
Bar	1 ½	1.0	----	----
Bar[2]	1 ½	----	2.0	2.0
Clinical	3	----	6.0	6.0
Commercial with Food Waste[2]	1 ½	----	3.0	3.0
Special Purpose[2]	1 ½	2.0	3.0	3.0
Special Purpose	2	3.0	4.0	4.0
Special Purpose	3	----	6.0	6.0
Kitchen, Domestic[2] (with or Without Food Waste Grinder, Dishwasher or Both)	1 ½	2.0	2.0	----
Laundry[2] (with or Without Discharge from a Clothes Washer)	1 ½	2.0	2.0	2.0
Service or Mop Basin	2	----	3.0	3.0
Service or Mop Basin	3	----	3.0	3.0
Service, Flushing Rim	3	----	6.0	6.0
Wash, Each Set of Faucets	----	----	2.0	2.0
Urinal, Integral Trap 1.0 GPF[2]	2	2.0	2.0	5.0
Urinal, Integral Trap Greater Than 1.0 GPF	2	2.0	2.0	6.0
Urinal, Exposed Trap[2]	1 ½	2.0	2.0	5.0
Water Closet, 1.6 GPF Gravity Tank[6]	3	3.0	4.0	6.0
Water Closet, 1.6 GPF Flushometer Tank[6]	3	3.0	4.0	6.0
Water Closet, 1.6 GPF Flushometer Valve[6]	3	3.0	4.0	6.0
Water Closet, Greater Than 1.6 GPF Gravity Tank[6]	3	4.0	6.0	8.0
Water Closet, Greater Than 1.6 GPF Flushometer Valve[6]	3	4.0	6.0	8.0

For SI units: 1 inch = 25 mm

Notes:

1. Indirect waste receptors shall be sized based on the total drainage capacity of the fixtures that drain thereinto, in accordance with Table 702.2(b).
2. Provide a 2-inch (50-millimeter) minimum drain.
3. For refrigerators, coffee urns, water stations and similar low demands.
4. For commercial sinks, dishwashers, and similar moderate or heavy demands.
5. Buildings having a clothes-washing area with units in a battery of three or more shall be rated at six fixture units each for purposes of sizing common horizontal and vertical drainage piping.
6. Water closets shall be computed as six fixture units where determining septic tank sizes based on Appendix H of this code.
7. Trap sizes shall not be increased to the point where the fixture discharge is capable of being inadequate to maintain their self-scouring properties.
8. Assembly [Public Use (see Table 422.1)].

If DFUs are not known, Table 702.2a of UPC Chapter 7 (Table 3) can be used to assign values based on the maximum DFUs allowed for the pipe size connected to the inlet of the interceptor.

For intermittent flow into the drainage system, DFUs can be calculated based on the rated discharge capacity in GPM using Table 702.2(b) of UPC Chapter 7 (Table 4). A commercial dishwasher would be an example where this table may be used.

For pumps, sump ejectors, air conditioning equipment or similar devices that may continuously flow into a system, 2 DFUs are assigned for each GPM of flow.

Table 3: Drainage Fixture Units Based on Trap and Trap Arm.[9]

Size of Trap and Trap Arm (Inches)	Drainage Fixture Unit Values
1 ¼	1 unit
1 ½	3 units
2	4 units
3	6 units
4	8 units

For SI Units: 1 inch = 25 mm

*Exception: On self-service laundries

Table 4: Drainage Fixture Units based on Intermittent Flow.[10]

GPM	Fixture Units
Up to 7 ½	Equals 1 fixture unit
Greater than 7 ½ to 15	Equals 2 fixture units
Greater than 15 to 30	Equals 4 fixture units
Greater than 30 to 50	Equals 6 fixture units

For SI Units: 1 GPM = 0.06 L/s

Note: Discharge capacity exceeding 50 GPM (3.15 L/s) shall be determined by the authority having jurisdiction.

For XYZ Restaurant, we would use Table 1 to get DFUs for sinks, floor drains and the food grinder.

- Special Purpose Sink (1 1/2”): 3 DFUs x 2 basins = 6 DFUs
- Pre-rinse Sink (2”): 4 DFUs
- Vegetable Prep Sink (1 1/2”): 3 DFUs
- Wash Sink (one set of faucets): 2 DFUs
- Mop Basin (2”): 3 DFUs
- Two Floor Drains (2”): 4 DFUs
- Commercial Food Grinder: 3 DFUs
- Commercial Dishwasher: 4 DFUs (based on Table 4 and 25-GPM discharge)

Total: 29 DFUs

Based on Table 1, we would need a capacity of 1,000 gallons. So far, we have three different capacities: 900, 1,000 and 1,224.

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; however, when a filled sink drains, Manning’s Equation should be used to determine the peak allowable flow.

$$V = \frac{k}{n} \times Rh^{\frac{2}{3}} \times S^{\frac{1}{2}}$$

Formula 4. Manning’s Equation

Where

V = cross-sectional mean velocity (ft./s. or m./s.)

k = 1.486 for U.S. units and 1.0 for SI units

n = Manning coefficient of roughness (Represents the roughness or friction applied to the flow by the channel. This depends on the material. For example, smooth concrete and steel has an *n* value of around 0.012. PVC values range from 0.009 to 0.011.)

Rh = Hydraulic radius (ft., m.) This is equal to A/P_w, where A is the cross-sectional area of flow in $ft.^3$ or $m.^3$ and P_w is the wetted perimeter in ft. or m.

S = Slope (ft./ft. or m./m.)

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.[11]

Using XYZ Restaurant data along with the assumption of 75-psi water pressure, a 30-minute retention time and a 25% storage factor, the maximum flow rate is 51.69 GPM. The resulting tank size is 2,132 gallons.

By using four different formulas, we've obtained grease interceptor volumes of 900, 1,000, 1,224 and 2,132 gallons, representing a 137% increase from the lowest to the highest value. These varying capacities can lead to some confusion.

The volume calculated via the town of Cary, N.C., equation represents a bit of an outlier, but it also is the most thorough, incorporating many factors the other equations do not. One WERF study references this spreadsheet and comments on the use of the maximum flow rate for the sizing of a GGI.[12] This flow rate is very conservative and highly unlikely because all fixtures would have to be running and all sinks would have to be draining simultaneously.

According to the study, observations of GGIs in the field revealed that 1/3 of the maximum flow rate would be appropriate for design. Applying this to XYZ Restaurant, the flow rate would drop to below 20 GPM, thus requiring a 750-gallon tank.

In 2009, the National Precast Concrete Association published a white paper covering design considerations for precast GGIs.[13] 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 ensure the formula is clear so that the assumptions behind the flow calculations are known.

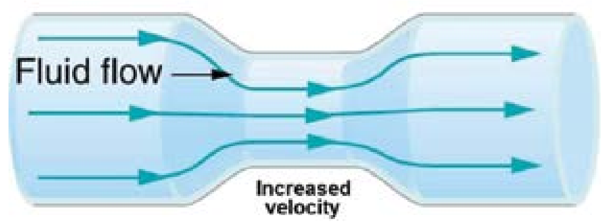
DESIGN

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. Velocity spikes must be minimized to allow for separation and to avoid potential interaction with previously separated FOG or solids layers. The accumulation of FOG and solids layers will effectively reduce the clear zone and will result in slightly accelerated velocity of fluid through the tank. This reinforces the importance of periodic maintenance and cleaning of the tank. Tank designs should enhance the ability to clean and maintain the interceptor.

Compartmentalization of GGIs is common 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 hole 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 holes 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 2. Comparison of Fluid Velocities in Single-Compartment and Two-Compartment Tank When Narrow Transfer Baffle is Used

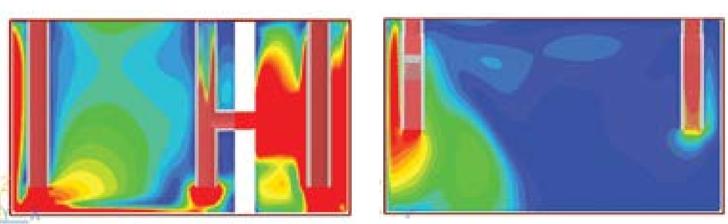


Figure courtesy of the Water Environment Research Foundation

Fluid velocity is indicated by color (blue is slow, red is fast).

The same 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 times 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).

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

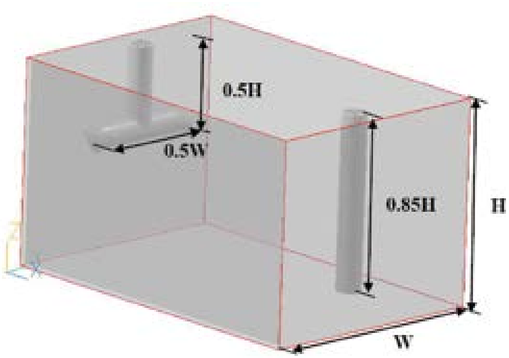


Figure courtesy of the Water Environment Research Foundation

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 separation effectiveness.

Precast concrete GGIs not only provide greater storage capacity and longer retention times, but 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. PS

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Endnotes

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