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Introduction to Continuing Education Class on Sanitary Drainage Systems for Utah Plumbers (Video)

Hello and welcome to this class on Sanitary Drainage Systems and Grease Interceptors.

The simplest way to describe a sanitary drainage system is that it's a system of pipes and other components designed to effectively move effluent discharged from plumbing fixtures and other equipment to an approved point of disposal such as a public sanitary system or private onsite water treatment system.

This class addresses the integral components of this system from the drain to the sewer, without attempting to address traps, vents, or the point of disposal. Although we'll briefly cover alternative sanitary drainage systems, the class won't attempt to deal with grey water or water recapture and reuse systems. The material covered in this class can certainly be applied to grey water systems but, for the purposes of this class, we'll be assuming that the effluent from soil drains and waste drains are to be combined into a single sanitary drainage system. As you know, soil drains, soil stacks, and so on refer to any that carry water contaminated with fecal or other organic wastes, while waste drains, waste stacks, and so on refer to any that carry the clear water from sinks and other fixtures or equipment.

We'll be looking at both the nuts and bolts of a well-designed sanitary drainage system and at some of the principles behind a well-designed system. The intent is not to tell you what materials or methods to use, but to improve the tools that you'll be using to select and assemble system components.

There's a lot to cover, so let's get started.

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What distinguishes a soil stack from a waste stack?	A soil stack carries effluent containing organic wastes; waste stack effluent is uncontaminated	Effluent in a soil stack is uncontaminated by fecal or other organic wastes; waste stack	A soil stack is a type of waste stack that carries effluent containing solid matter in suspension; all	A soil stack is a larger sanitary drainage pipe designed to carry the effluent from

	by fecal or other organic wastes	effluent contains organic wastes	vertical piping that transports effluent of any kind is a waste stack	multiple waste stacks

[QUESTIONBOTTOM]

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Basics of Sanitary Drainage Systems

The basics of a sanitary drainage system include installation of the building drain and sewer; joining methods for pipe and fittings; drainage fixture units for sizing the drainage system; sumps and ejectors; selection of materials; cleanouts; vent sizing and lengths of vents; public and private sewage disposal; and testing. This class will address only the elements that go into the system for bearing effluent from fixture and equipment drains to the sewer, without addressing vents, testing, or points of disposal.

The components of a typical sanitary drainage system include:

- Horizontal branches;
- Vertical stacks;
- Cleanouts;
- A building drain inside the building; and
- A building sewer from the outlet of the building drain to the point of disposal.

Additional components required for some sanitary drainage systems include separators and interceptors, sump pumps and ejectors, and floor drains.

The goal of a well-designed sanitary drainage system is to use the smallest possible pipes capable of rapidly carrying away wastewater from all sources in the building such that the pipes are cleared after use, without any clogging or solids left behind. At the same time, pipes should be large enough so as to avoid generating undue noise or excessive pneumatic pressures at points past the trap seal (particularly where the fixture drains connect to the stack), that could create siphonage of or back pressure on the trap seal.

Note: In order to understand the effect of pneumatic pressure on a trap seal, think of a subway moving rapidly through a tunnel, pushing the air in front of the train so as to increase positive pressure ahead of the train, while sucking air from behind the train, causing negative pressure in that part of the tunnel. Effluent flowing rapidly down horizontal sanitary drainage piping can create enough negative pressure behind the flow to draw the trap seal water away from the trap, *and can create enough positive pressure ahead of the flow to push any effluent that is present between the trap seal and horizontal piping back into the fixture.*

Backflow and Sewer Gases

A well-designed sanitary drainage system effectively drains effluent. It must also prevent, to the greatest extent possible, against infiltration back into the structure of sewer gases or effluent.

Hydrogen sulfide (also known as swamp gas), a colorless gas known for its pungent "rotten egg" odor at low concentrations, is a primary component of sewer gases. It is extremely flammable and highly toxic. Hydrogen sulfide occurs naturally in sewers and well water (when organic matter breaks down). In addition to hydrogen sulfide, sewer gases may contain ammonia, methane, carbon dioxide, sulfur dioxide, and nitrous oxide. Unlike hydrogen sulfide, some of these gases (such as methane and carbon dioxide) are odorless but all are asphyxiants and several are explosive.

Water seals in interior plumbing pipe traps are primarily intended to prevent sewer gases from entering the structure. If the liquid in the trap seal is siphoned away or dries up, the water seal is lost and sewer gases are likely to enter the structure, with unpleasant and potentially catastrophic effects.

Components of a Sanitary Drainage System

Drainage Piping [Drains and Stacks]

Sanitary pipes designed to descend from a fixture or fitting can either take the form of a fixture or equipment drain, designed to serve one source of effluent, and a stack, which is the vertical portion of the main avenues usually used to transport effluent from multiple sources.

Sizing fixture and equipment drains is relatively simple, since it only has to be adequate to carry the discharge from a single source. In order to avoid self-siphonage, the diameter should be large enough so that the drain flows little more than half-full under projected maximum discharge conditions.

From the initial drain, most often past a trap seal, the effluent is transported through horizontal piping to a vertical stack that collects effluent to transport to the building drain, and from there to the sewer. Sizing of these vertical stacks is more complicated than the drains, since the multiple sources aggregated into the stack are only used intermittently and often in sequence rather than simultaneously.

Flow from horizontal drains or branches empty into a vertical stack fitting, which may be a short-turn or sanitary tee or a long-turn tee wye. The fitting must be oriented so that the flow is already heading down when it meets the stack. Depending on the rate of flow out of the drain into the stack, the diameter of the stack, the type of stack fitting, and the flow down the stack from higher levels (if any), the discharge from the horizontal branch may or may not fill the cross-section of the stack at the level of entry.

Principles of Vertical Sanitary Drainage

Once the effluent enters the stack, it rapidly accelerates downward, due to the effects of gravity. It also flows away from the center as it falls, creating an effluent "sheet" around the wall of the stack, with the center of the pipe open for the flow of air. This creates a core of air at the center of the stack. The air flow within the stack is complex – air behind is pulled, air in front is pushed, and the air on the core is dragged along with the effluent by friction, albeit at a somewhat slower speed. A supply source of air must be provided to avoid excessive pressure differentials in the stack. A stack vent system is usually employed for this purpose. When the stack is properly sized and vented, the combination of a core of air and replenishment through ventilation prevents wide pressure differentials.

The effluent sheet described above will accelerate until the friction from the wall of the stack and the air in the pipe equals the force of gravity. This top vertical speed is known as "terminal velocity" and the distance the sheet falls before reaching terminal velocity is known as "terminal length." From that point on, unless interrupted by drainage from other branches, the thickness and velocity of the sheet remains unchanged until the bottom of the stack. A typical terminal velocity may be anywhere from 10 to 15 feet per second, with this velocity typically reached within 10 to 15 feet of the point of entry.

This explains why a longer stack (such as within a high-rise) will not have an appreciably faster flow rate down the stack than a shorter stack. If this were not so, the destructive potential of the flow in a long vertical stack could be massive. Instead, the difference in velocity at the base of a 100-story stack versus a four-story stack would be insignificant. That doesn't mean that a longer stack would not be under increased pressure from its own weight. All vertical stacks must therefore be supported at each floor so as to displace the pressure of the weight along numerous points.

When the vertical sheet meets flow from a lower horizontal stack, the sheet would tend to deflect that water unless there is sufficient pressure from the branch to allow its effluent to effectively mix with or deflect the rapidly moving sheet. When properly designed, it allows the newly added effluent from the branch to rapidly meet and match the velocity of the sheet, leading to lower pressure behind the branch flow, which in turn increases the velocity in the branch as well.

Horizontal Branches and Drains

When the water passes the trap into a horizontal branch, it slows and tends toward the top of the pipe and continues to mass until (if there is sufficient volume) it will fill the branch. In order to avoid this mass creating backflow, the length of the branch is usually limited and, when it hits the vertical stack, the back-pressure created in the branch will help to clear it effectively.

When the sheet of water reaches the bend at the base of the stack, it makes a nearly 90-degree turn into the building drain. Although a building drain is sloped gradually downward, the slope isn't enough to maintain the terminal velocity of the sheet. As the water slows, it also masses until it fills either the building drain or sewer, at which point the hydraulic pressure creates a funnel-shaped surge of the effluent that can speed up to the limits allowed by the friction from the drain or sewer walls. This phenomenon is called "hydraulic jump". The distance from the stack/building drain junction to the point of hydraulic jump can be as short as just past the junction to a point downstream equal to approximately 10 times the diameter of the stack (if the drain is the same diameter as the stack). The hydraulic jump would occur at a greater distance if the horizontal drain is larger than the stack. Similarly, if the flow is insufficient even when slowing to reach enough mass to create a hydraulic jump, it may never occur. This situation has become increasingly prevalent since the adoption of low-flow toilets and other low-flow fixtures.

It should be noted that these hydraulic principles are reflected in codes, such as the following from the IPC®:

> **704.3 Connections to Offsets and Bases of Stacks.** Horizontal *branches* shall connect to the bases of stacks at a point located not less than 10 times the diameter of the drainage *stack* downstream from the *stack*. Horizontal *branches* shall connect to horizontal *stack* offsets at a point located not less than 10 times the diameter of the drainage *stack* downstream from the upper *stack*.

Cleanouts

A cleanout is a removable plug for the piping system that allows both horizontal and vertical pipes to be accessed for maintenance and inspection. When closed, the cleanout plug should be airtight (i.e. gas-tight) and water-tight, yet allow for quick and easy removal, and the cleanout has to be large enough to accommodate tools capable of clearing obstructions such as grease accumulation, hair, or a solid object. Many plugs are made with neoprene to prevent being frozen or bound shut. Where a cleanout is placed beneath a driveway, patio, etc., the cover above that cleanout spot must be code-approved and capable of bearing the weight or other demands it will face while still being easily removed to access the cleanout. Functionality and aesthetics often need to be taken into consideration, since this will often face a public area, but even a cleanout without a cover may need to take the aesthetic of its environment into account.

Sumps and Ejectors

When a building drain can't use gravity to empty directly into a sewer, its contents must be raised to the level that will permit a gravity connection to the sewer. The pumping action to a higher level of a sump and ejector is essentially identical – the distinction is that a sump is for waste effluent and an ejector is for soil effluent so that a sump is limited to serving effluent where solids are very small (such as dirt, etc., so that it can easily service muddy water), while an ejector can eject larger solids. Each typically operates from within or attached to a catch basin. Since ejectors handle sanitary wastes, the catch basin must be airtight to prevent sewer gas from escaping but vented to avoid creating pressure differentials. Sump catch basins need not be airtight nor vented as long as there is no odor or other issue arising from the wastewater.

Well-designed systems often use dual pumps, each capable of fulfilling 100% of the load, so that a backup pump can deploy if the other fails. Greater longevity of the system can be created by using the two pumps in sequence as long as both are operable.

Care should be taken that backflow from the sewer (which is at a higher elevation than the sump catch basin) does not flood the basin and allow it to overflow. An ejector basin can't overflow. The pumps must be designed not to operate when there is no effluent and to turn on whenever the effluent is present in enough quantity, often with a “float” switch or similar sensor-activated switch.

Backwater Valves

When the building drain is lower than the sewer line, additional protection against backflow should be used. A number of different models of backwater valves are available, but they should be designed specifically for sewer connection and for simplicity and durability. The placement should be accessible to allow for routine maintenance, since sediment can prevent them from closing fully if it's allowed to accumulate. This point of accessibility can also serve as a cleanout location.

Other situations that might require a backwater valve might arise where old municipal sewers may suffer high rates of infiltration and back up into the sewer for that property or where a combined sanitary and storm sewer could overwhelm the sewer lines.

Floor Drains and Floor Sinks

Floor drains and floor sinks may not be considered a component of the sanitary drainage system. They are essentially a type of fixture that is served by the sanitary drainage system.

They are treated much as any other fixture. Floor drains and sinks are similar in functionality, except that sinks are used to drain the surrounding area, while a sink is designed to collect the effluent transported by way of indirect piping and an indirect connection (i.e. air gap). The sanitary drainage system must, however, make special provisions for these features since they are far more prone to backup and overflow than a fixture several feet above floor level. The connection should also prevent any unpleasant odors or sewer gases from percolating up through the drain or sink.

Interceptors and Sediment Buckets

Interceptors and separators will be addressed in the second part of this class. Generally, only employed in commercial settings, interceptors and separators are used to protect the sanitary drainage system from any contaminants that might block or undermine the integrity of the system, such as grease and oil.

A sediment bucket is a simpler type of interceptor. It is used in both commercial and residential applications. It’s essentially a strainer within the drainage piping designed to collect solids, trash, or grit that could plug piping.

Supports

The final component of the sanitary drainage system to be addressed is not incidental to a well-designed system. Supports are vital to maintain a slope that is as uniform as possible both at the time of installation and after extended use.

Selection of supports must take into account the type of material in the piping, whether it’s prone to expansion and contraction or unable to support its own weight over extended lengths. If possible, the degree to which the structure will be prone to settling or earth movements, etc., should also be considered.

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[QUESTIONHEADER]

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In the class presentation on vertical stacks, what was listed as a typical “terminal velocity” (i.e. top speed) for effluent traveling downward in a vertical stack?	10 to 15 feet per second	10 to 15 miles per hour	50 feet per second	There is no top speed for effluent traveling downward in a vertical stack; it just continues to gain downward velocity

[QUESTIONBOTTOM]

[SLIDECUT]

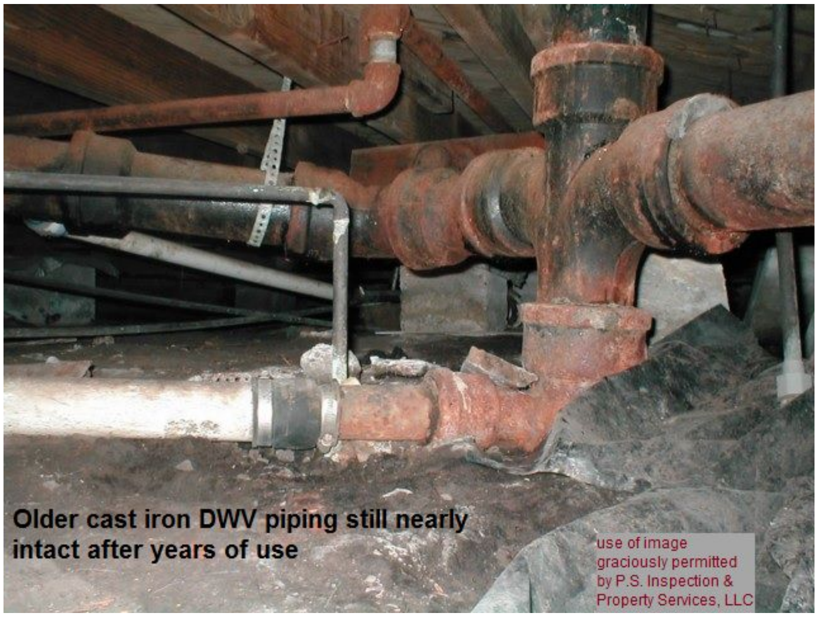
Installation

Piping

The same piping material is used to plumb drain lines and vent pipes. It's often referred to as DWV (drain-waste-vent) pipe.

The demands placed on sanitary drainage piping are very different from those placed on water service piping. Contamination during transport is far less of an issue (since it doesn't transport potable water). DWV piping is not typically pressurized, unlike water supply where water pressure is key. DWV relies mainly on gravity and pressure differentials within piping and the volume of flow to operate. On the other hand, the need to withstand harsh or highly acidic effluent as well and (when buried) its ability to bear weight are far greater for DWV piping. Durability in a watertight condition is also paramount.

Older DWV systems are largely cast-iron, with some using galvanized steel and (for the building drain run to the sewer) clay pipes. cast-iron pipes have been manufactured and used in the U.S. since the early 1800s, initially just for water distribution and later as DWV pipes. Although other piping materials were also used, cast-iron's durability allowed it to become nearly ubiquitous until PVC pipe was introduced in the late 1960s and early 1970s. PVC proved much cheaper and easier to install and quickly became the DWV piping of choice for most new home construction. Other types of plastic piping later joined PVC as widely used DWV options. Older cast-iron DWV pipes remain in buildings from the 1970s or earlier (albeit occasionally replaced when older homes are renovated). It continues to be used in some commercial, industrial, and municipal plumbing projects and even in a small number of residential plumbing installations. Iron alloys (i.e., galvanized steel) share many of the advantages of cast-iron and reduce some of the disadvantages other than being even more expensive.



Older cast iron DWV piping still nearly intact after years of use

Other possible materials for DWV piping include copper, copper alloys, and bronze, all of which are rarely used except for aesthetic reasons or in specialized applications due to their much higher cost and more demanding installation requirements. Borosilicate glass DWV is only used in industrial settings when its transparency and low reactivity are needed. Corrosive wastes require suitable acid-resistant materials such as high-silicon cast-iron, borosilicate glass, or polypropylene. Concrete and “clay” piping is only used for underground drains.

The benefits and disadvantages of each of these piping choices is as follows:

Cast-iron and Galvanized Steel

A high-quality cast-iron pipe, installed under optimal conditions, has a life expectancy of 75 to 100 years (possibly more). We're all familiar with how easily it rusts but, as it turns out, the rust serves as a barrier layer over the piping that protects it from further rusting – assuming the pipe is thick enough. Cast-iron has developed an undeserved reputation for premature deterioration as a result of some lower quality manufacture before current Standards were enforced that rusted through after a few decades of use. When manufactured up to current standards cast-iron has high tensile strength and resistance to penetration; it is more vulnerable to highly acidic soils and the joints are more vulnerable to shifting earth than PVC.

Though cast-iron has fallen out of favor since the advent of more affordable plastics, it does offer one chief advantage over PVC – its density and thickness minimizes the noise of effluent flow as well as reduce pipe vibration, making it very "quiet".

One reason cast-iron is more expensive to install is because it's so heavy. Galvanized steel piping is somewhat lighter as well as able to withstand some contaminants that degrade iron. It does rust, but far more slowly than cast-iron, and it is considered more aesthetically appealing. Its vastly greater flexibility than cast-iron allows it to compensate for shifting structures or earth in a way that cast-iron cannot. It is, however, significantly more expensive and therefore not as widely used.

Plastic DWV Piping

Among plastic DWV pipe, the choice is usually between Polyvinyl Chloride (PVC) and Acrylonitrile-Butadiene-Styrene (ABS). They generally cost about the same and differences between the two are negligible for DWV applications other than those exposed to sunlight, with a slight advantage going to ABS for its one-step installation, since it requires only solvent cement whereas PVC requires an application of purple primer. Some dislike the look of purple primer after installation – a newer "non-purple" primer (viewable only under UV light) is available and acceptable in most codes. Additionally, PVC must be held together for 7 to 10 seconds when joined, while ABS glues immediately, making its installation slightly faster.

In normal use conditions for drainage piping, both PVC and ABS pipe are durable and corrosion-resistant (notably resistant to hydrogen sulfide and sulphuric acid which are common in sanitary drainage). It's only ruled out for DWV piping when high-pressure conditions for the effluent would need the higher tensile strength of copper, iron, or steel – a very uncommon circumstance. Proper installation (support, minimal turns, etc.) and proper maintenance is key for preventing most of the common issues with plastic pipes that include leaking, cracking, or breakage when not properly installed.

Plastic DWV piping cannot be used where it is exposed to sunlight, particularly the ultraviolet (invisible) spectrum, unless protected against the sun's rays. The sensitivity of ABS pipe to sunlight has been well-known for years. ABS piping is primarily used in non-pressurized DWV applications beneath cabinets and floors or behind walls where it is unlikely to be exposed to sunlight for any length of time. Usually black in color, it must nevertheless be coated with UV protecting pigment if installed outdoors. It is prized for its impact resistance, wide temperature range, and ease of installation. The sensitivity of PVC to sunlight is less well-known than that of ABS. Discoloration of PVC when exposed to sunlight over a long period of time has been observed but, of greater concern, recent studies have revealed that PVC becomes more brittle after prolonged exposure. It could therefore shatter when struck – its ability to withstand water pressure is undiminished. Mainly due to its sensitivity to light, it isn't favored for trenchless outdoor installation.

For no good reason other than tradition, PVC is more favored for DWV piping in the Eastern U.S., while ABS has been more favored in the West.

High-Density Polyethylene (HDPE) Pipe

A newer option for plastic DWV is HDPE. It's stronger than PVC or ABS yet more flexible so ideal for installation where shifting structures or earth could place shearing pressure on the piping. Although just as prone to decay as other types of plastic piping when exposed to sunlight for long periods, its higher tensile strength makes it a realistic choice for trenchless outdoor installation (as long as it has a protective coating; usually black in color). It is also resistant to corrosion in some environments that would damage PVC or ABS. It is, however, more expensive and more vulnerable to extreme cold than other types of plastic DWV.

HDPE has become very widely used for DWV piping in Europe but has yet to enjoy the same popularity in the U.S.

Clay Pipe

Clay pipe is only used for building sewers and (occasionally) for building drains.

Older clay pipes varied enormously in quality. Some were not much better than terra cotta tubes, prone to rapid deterioration as they absorbed water, easily penetrated by roots and burrowing animals, and becoming increasing brittle over time so that a minor shock could shatter the pipe. As modern Standards began to be enforced in the 50s, 60s, and 70s, the quality of clay pipe became more uniform and the piping far more reliable.

Modern clay pipe is wholly different in its composition from older clay pipe and is more akin to a ceramic. The proper term for it is "vitrified clay" pipe, which is made by combining clay and shale at high heat to attain increased hardness and durability. Polyurethane and other materials are utilized at joints to make them more durable and less prone to absorb liquid.

Vitrified clay has advantages over cast-iron and steel because it is less prone to corrosion as well as significantly cheaper. Installation is made more difficult by the limitations in the length of individual pipes (since it must be kiln-fired). It is almost always buried but is sometimes used in trenchless installations if it is suitably protected.

Concrete Pipe

The final widely used material choice for DWV piping is concrete. Properly installed, concrete pipe can last for decades, but if exposed to highly acidic or corrosive soils or improperly installed, it may fail very quickly. Also, extremely acidic soil or chemicals can degrade concrete pipe. In order to prevent rapid deterioration, it's often coated with corrosion-resistant plastics.

Concrete pipe has a much higher breaking point than clay, allowing for higher operating pressures and less risk of root/soil intrusion. It is, of course, extraordinarily heavy and can only be installed with equipment designed for the purpose. Because of its affordability and other advantages, it is an attractive alternative for municipal sewers where access to heavy equipment and personnel trained for this type of installation are available.

Cleanouts

As discussed earlier in this class, sanitary drainage piping must incorporate accessible cleanouts sufficient to reach the interior of the pipes so that any blockages or reduction of the inside diameter of the pipe by deposits can be cleared. Waste lines are typically buried deep enough to provide adequate backfill over the joints, with the cleanouts extended to floor or ground level by pipe extension pieces. If a pipe extension would provide adequate access due to it being more deeply buried, a small pit below surface should be provided, topped with a manhole cover.

The size of the cleanout within a building cannot be any less than the diameter of the piping, up to 4 inches. Although 4-inch cleanouts are permitted with larger pipe sizes, a 6-inch cleanout is usually recommended in order to accommodate a wider range of equipment and easier access for video inspection. A maximum distance between cleanouts of 50 feet for piping four inches or smaller and 75 feet for larger piping should be maintained. If the piping serves a structure that tends to introduce high volumes of grease into wastewater, cleanouts should be no more than 40 feet apart.

The following cleanout locations are mandatory:

- Five feet outside or inside the building at the point of exit;
- At every change of direction greater than 45 degrees;
- [For underground sanitary sewer piping larger than 10 inches in diameter]: at every change of direction and every 150 feet;
- At the base of all stacks; it’s a good practice to install cleanouts a minimum of six inches above the flood rim of the highest fixture served on the lowest level; and
- Any other locations required by applicable codes.

Optional locations include:

- At the roof stack terminal;
- At the end of horizontal fixture branches or waste lines; and
- At fixture traps, which can be pre-manufactured with cleanout plugs [Note: some codes prohibit this type of fixture trap].

Joining Methods

Drain and cleanout outlets are manufactured in the following five basic types:

1. Inside Caulk

- In order to make an inside caulk joint, the pipe is extended up into the drain body, and oakum is packed around the pipe tightly against the inside of the outlet. Molten lead then is poured into this ring and later stamped or caulked to correct for lead shrinkage. Current installation methods use a flexible gasket for the caulking material;

2. Spigot Outlet
    - Spigot outlets employ the caulking method outlined above for inside caulk, except that the spigot outlet is caulked into the hub or bell of the downstream pipe or fitting;
3. Push-Seal Gasketed Outlet
    - The push-seal gasketed outlet utilizes a neoprene gasket similar to standard ASTM C564 neoprene gaskets approved for hub-and-spigot cast-iron soil pipe. A ribbed neoprene gasket is applied to the accepting pipe, thus allowing the drain outlet to be pushed onto the pipe;
4. IPS or Threaded Outlet
    - The threaded type uses a tapered female thread in the drain outlet designed to accept the tapered male thread of a downstream piece of pipe or fitting; and
5. No-Hub Outlet
    - This type of joint is becoming increasingly popular. It employs a spigot (with no bead on the end) stubbed into a neoprene coupling with a stainless steel bolting band (or other type of clamping device), which is able to accept a downstream piece of pipe or headless fitting.

Noise Transmission

When making joints, it’s best to prevent direct metal-to-metal connections in order to reduce noise transmission along pipes.

Another method for reducing noise transmission is simply to use heavier materials which are more noise-insulating and less prone to vibration. In addition, isolating piping with resilient materials, such as belts, plastic, or insulation may reduce noise transmission to the building.

Prohibited Joints

Joints must be approved for the type of installation. The following types of joints and connections are prohibited:

- Cement or concrete joints;
- Mastic or hot-pour bituminous joints;
- Joints between different diameter pipes made with elastomeric rolling O-rings;
- Solvent-cement joints between different types of plastic pipe; and
- Saddle-type fittings.

Supports

Manufacturer's instructions usually provide adequate guidance on the spacing of supports and hangers. Maximum spacing may also be mandated by codes. Buried pipe should be continuously supported by a consistent bed or blocking under the full length. Where earth movement or seismic factors are to be considered, additional support or strapping may be required.

When using hangars, factor in the tendency for residents to intermittently use piping to support themselves. A minimum ability to withstand a 250-pound weight is generally adequate.

Where special circumstances require more involved support systems, a qualified engineer should be consulted.

Thermal Expansion, Waterproofing, Protection from Damage

In addition to support for normal conditions, anchors, expansion joints, or expansion loops may be necessary where excessive thermal expansion could affect the slope or pipe descent enough to interfere with clearing the pipes. A balance between preventing undue movement and avoiding placing excessive stress on pipes during expansion and contraction should be maintained.

Whenever expansion and contraction could compromise water-tightness of connections, a flange and gasket system can prevent excessive seepage.

Finally, there are some common ways that drains and drain piping may be damaged if not protected, as follows:

- ➢ Expansion and contraction –
  - ○ Use flexible joints, loops, swing joints, or offsets;
- ➢ Seismic activity and structural settlement –
  - ○ Brace pipe and provide flexible joints at connections between piping braced to walls or the structure and piping braced to the ceiling and between stories (where differential movements will occur). When embedded in concrete, cover piping with three layers of 15-pound (6.8-kg) felt;
- ➢ Wood shrinkage –
  - ○ Provide slip joints and ½ to ¾ inches of clearance where piping penetrates wood;
- ➢ Abrasion when penetrating the slab or other structural elements –
  - ○ Use plastic or rubber sleeves or insulation;
- ➢ Corrosion –
  - ○ Use material suitable to the environment or coat with corrosive-resistant plastic or other resistant material;
- ➢ Sunlight –
  - ○ Only use thermoplastic pipe manufactured with protective covering or insulate or enclose in a jacket;
- ➢ Heavy earth loads –
  - ○ Use stronger pipe or pipe sleeves;
- ➢ Fire –
  - ○ Plastic piping can emit toxic fumes when burning. Use metal piping where higher fire ratings or at critical penetrations can alleviate this hazard;
- ➢ Heat –
  - ○ Keep thermoplastic pipe away from sources of heat or use insulation;
- ➢ Condensation –
  - ○ Insulate piping;
- ➢ Nails –
  - ○ Use ferrous pipe, steel sleeves, or steel plates or do not locate pipe near possible nail penetration areas; and
- ➢ Vandalism –
  - ○ Supported hanging pipe to withstand 250 pounds; install pipe above reach or in areas protected by building construction.

[SLIDECUT]

[QUESTIONHEADER]

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How are vitrified clay pipes manufactured?	Clay and shale are combined and molded then	Clay is hardened by intense pressure to	Clay is coated with glass then heated in a kiln	Clay is mixed with chalk then heated to a very high

	raised to a very high temperature in a kiln	remove moisture, then dried in a kiln	until the clay and glass fuses	temperature in a kiln until it turns into a type of ceramic

[QUESTIONBOTTOM]

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[VIDEOHEADER]

Codes, Technical Considerations, Alternative Systems & Grease Interceptors (Video)

The next lesson in this class will look briefly at some typical codes that apply to Sanitary Drainage Systems.

This class has focused on some underlying principles and vital considerations that go into installing and maintaining a well-designed sanitary drainage system. Along the way, we've also looked at some typical codes and standards related to those principles. Remember, always, that it's the codes and standards that have been adopted in your municipality that must be followed. None of the material presented in this class is intended to take the place of the codes and regulations where you are.

In the next lesson, we'll draw from some of the more interesting model codes from the 2015 editions of the International Plumbing Code and Uniform Plumbing Code. The codes selected are those most often misapplied along with a few that have either recently changed or been added.

After a look at these sample model codes, the class will explore some key technical considerations and some alternate ways to make these systems work. We won't be able to delve too deeply into these topics, but we'll introduce them so you can follow up with engineering manuals and the appropriate referenced standards if you'd like to. The class will finish with a guide to the selection and installation of grease interceptors.

The first model codes we'll look at in the next lesson relate to drainage fixture units.

[VIDEOBOTTOM]

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[QUESTIONHEADER]

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Which of the following has the final word on acceptable methods and materials for the installation of sanitary drainage systems?	The codes, standards, and regulations adopted by the municipality where it is to be installed	The independent testing laboratory issued Standards for each component	The customer (who is, by definition, always right)	Your own best judgment

[QUESTIONBOTTOM]

[SLIDECUT]

Codes and Standards

Drainage Fixture Units

A drainage fixture unit (DFU) is not, purely speaking, a flow rate. It's more like "currency". Before monetary currency existed, the barter system was clumsy and imprecise. How many ears of corn are worth a goat? The solution was to translate every commodity into a certain amount of currency – an ear of corn is worth 1 shekel and a goat is worth 300 shekels – and transactions become simplified. It's the same with DFUs. By relating the outflow of each fixture to a common currency, it's easier to add their total effluent as well as multiply or divide based on frequency, calculate ventilation needs, etc. This system was originally proposed in 1923 by Dr. Roy B. Hunter as a way to apply the amount of effluent discharged by fixtures in conjunction with the probability of the simultaneous use of the fixtures to establish the maximum permissible drainage loads expressed in fixture units rather than in gpm of drainage flow.

> What IS a Drainage Fixture Unit? *A DFU is equal to one cubic foot of effluent draining in a 1¼-inch pipe over a one-minute period of time.*

In other words, the DFU for the same fixture may vary depending on the type of occupancy, frequency of use, etc. It's also NOT necessarily equal to the supply fixture unit. The amount of water needed to fill a bath, for example, may be twice the amount that drains from the tub over the same period of time.

Codes regarding DFUs are among the most often misapplied in the practice of plumbing. Far too often, systems are installed that exceed the DFU capacity of drainage piping or that fail to provide sufficient ventilation to the DFU rating of portions of the piping system. It's worth reviewing the differing approaches of the UPC® and IPC® to DFUs. [Note: Both of these model codes devote Chapter 7 to Sanitary Drainage and most (but not all) of the codes that apply to these systems can be found in Chapter 7 and in the Standards referenced in these Chapters. A sample of DFUs from these two model codes is shown in the chart, below]

Fixture	IPC®	UPC®
Bathtub	2	3
Clothes washer	3	3
Dishwasher	2	2
Floor drain 1¼-inch trap loading 1½-inch trap loading 2-inch trap loading 3-inch trap loading 4-inch trap loading	3 – – – – –	– 1 3 4 6 8
Laundry tray	2	2
Lavatory, single	1	1
Lavatory, in sets of two or three	2	2
Shower (each head)	2	2
Kitchen sink (including dishwasher and garbage disposal)	3	3
Toilet (1.6-gpf gravity tank)	4	4
Toilet (1.6-gpf flushometer tank)	5	5
Toilet (1.6-gpf flushometer valve)	4	4

IPC® Section 709 Fixture Units

The two model codes approach calculation of DFUs slightly differently. IPC® provides ample detail in two Tables for DFUs:

> **IPC® 709.1 Values for Fixtures.** Drainage fixture unit values as given in Table 709.1 designate the relative load weight of different kinds of fixtures that shall be employed in estimating the total load carried by a soil or waste pipe, and shall be used in connection with Tables 710.1(1) and 710.1(2) of sizes for soil, waste and vent pipes for which the permissible load is given in terms of fixture units.

Notes to Table 709.1

a. For traps larger than 3 inches, use Table 709.2.

b. A showerhead over a bathtub or whirlpool bathtub attachment does not increase the drainage fixture unit value.

c. See Sections 709.2 through 709.4.1 for methods of computing unit value of fixtures not listed in this table or for rating of devices with intermittent flows.

d. Trap size shall be consistent with the fixture outlet size.

e. For the purpose of computing loads on building drains and sewers, water closets and urinals shall not be rated

at a lower drainage fixture unit unless the lower values are confirmed by testing.
f. For fixtures added to a bathroom group, add the dfu value of those additional fixtures to the bathroom group fixture count.
g. See Section 406.2 for sizing requirements for fixture drain, branch drain and drainage stack for an automatic clothes washer standpipe.
h. See Sections 709.4 and 709.4.1.

UPC® Section 709.2 Fixtures Not Listed in Table 709.1. Fixtures not listed in Table 709.1 shall have a drainage fixture unit load based on the outlet size of the fixture in accordance with Table 709.2. The minimum trap size for unlisted fixtures shall be the size of the drainage outlet but not less than 1¼ inches (32 mm).

UPC® Sections and Tables on DFUs

The UPC directs the user to consider trap size when calculating DFUs, describes how to compensate for intermittent use, and provides different DFUs for three broad categories for occupancies:

UPC® 702.1 Fixture Unit Equivalents
702.2 Trap Size. The unit equivalent of plumbing fixtures shown in Table 702.1 shall be based on the size of the trap required, and the unit equivalent of fixtures and devices not shown in Table 702.1 shall be based on the size of trap or trap arm. Maximum drainage fixture units for a fixture trap and trap arm loadings for sizes up to 4 inches (100 mm) shall be in accordance with Table 702.2(a).

702.3 Intermittent Flow. Drainage fixture units for intermittent flow into the drainage system shall be computed on the rated discharge capacity in gallons per minute (gpm) (L/s) in accordance with Table 702.2(b).

702.4 Continuous Flow. For a continuous flow into a drainage system, such as from a pump, sump ejector, air conditioning equipment, or similar device, 2 fixture units shall be equal to each gallon per minute (gpm) (0.06 L/s) of flow.

UPC® Section 709.3 Values for Continuous and Semi-Continuous Flow. Drainage fixture unit values for continuous and semi-continuous flow into a drainage system shall be computed on the basis that 1 gpm (0.06 L/s) of flow is equivalent to two fixture units.

2015 UPC® Chapter 7 – General Requirements

The following model codes provide a useful survey of the proper application of materials and methods in sanitary drainage:

UPC® Section 701.2 Drainage Piping. Materials for drainage piping shall be in accordance with one of the referenced standards in Table 701.2 except that:

(1) No galvanized wrought-iron or galvanized steel pipe shall be used underground and shall be kept not less than 6 inches (152 mm) aboveground.

(2) ABS and PVC DWV piping installations shall be installed in accordance with applicable standards referenced in Table 1701.1 and Chapter 14 “Firestop Protection.” Except for individual single- family dwelling units, materials exposed within ducts or plenums shall have a flame-spread index of a maximum of 25 and a smoke-developed index of a maximum 50, where tested in accordance with ASTM E 84 and UL 723.

(3) No vitrified clay pipe or fittings shall be used above-ground or where pressurized by a pump or ejector. They shall be kept not less than 12 inches (305 mm) below-ground.

(4) Copper or copper alloy tube for drainage and vent piping shall have a weight of not less than that of copper or copper alloy drainage tube type DWV.

(5) Stainless steel 304 pipe and fittings shall not be installed underground and shall be kept not less than 6 inches (152 mm) aboveground.

(6) Cast-iron soil pipe and fittings shall be listed and tested in accordance with standards referenced in Table 1701.1. Such pipe and fittings shall be marked with country of origin and identification of the original manufacturer in addition to markings required by referenced standards.

701.3 Drainage Fittings. Materials for drainage fittings shall comply with the applicable standards referenced in Table 701.2 of the same diameter as the piping served, and such fittings shall be compatible with the type of pipe used.

701.3.1 Screwed Pipe. Fittings on screwed pipe shall be of the recessed drainage type. Burred ends shall be reamed to the full bore of the pipe.

701.3.2 Threads. The threads of drainage fittings shall be tapped so as to allow ¼ inch per foot (20.8 mm/m) grade.

701.3.3 Type. Fittings used for drainage shall be of the drainage type, have a smooth interior water-way, and be constructed so as to allow ¼ inch per foot (20.8 mm/m) grade.

Gravity Drainage Requirements

These model codes provide the functional minimum requirements for effective use of gravity for sanitary drainage.

UPC® 708.1 Grade of Horizontal Drainage Piping – 708.2 General. Horizontal drainage piping shall be run in practical alignment and a uniform slope of not less than ¼ inch per foot (20.8 mm/m) or 2 percent toward the point of disposal provided that, where it is impractical due to the depth of the street sewer, to the structural features, or to the arrangement of a building or structure to obtain a slope of ¼ inch per foot (20.8 mm/m) or 2 percent, such pipe or piping 4 inches (100 mm) or larger in diameter shall be permitted to have a slope of not less than ⅛ inch per foot (10.4 mm/m) or 1 percent, where first approved by the Authority Having Jurisdiction.

709.1 Gravity Drainage Required. – 709.2 General. Where practicable, plumbing fixtures shall be drained to the public sewer or private sewage disposal system by gravity

718.0 Grade, Support, and Protection of Building Sewers
718.1 Slope. Building sewers shall be run in practical alignment and at a uniform slope of not less than ¼ inch per foot (20.8 mm/m) toward the point of disposal.

Exception: Where approved by the Authority Having Jurisdiction and where it is impractical, due to the depth of the street sewer or to the structural features or to the arrangement of a building or structure, to obtain a slope of ¼ inch per foot (20.8 mm/m), such pipe or piping 4 inches (100 mm) through 6 inches (150 mm) shall be permitted to have a slope of not less than ⅛ inch per foot (10.4 mm/m) and such piping 8 inches (200 mm) and larger shall be permitted to have a slope of not less than $^1/_{16}$ inch per foot (5.2 mm/m).

718.2 Support. Building sewer piping shall be laid on a firm bed throughout its entire length, and such piping laid in made or filled-in ground shall be laid on a bed of approved materials and shall be properly supported as required by the Authority Having Jurisdiction.

718.3 Protection from Damage. No building sewer or other drainage piping or part thereof, which is constructed of materials other than those approved for use under or within a building, shall be installed under or within 2 feet (610 mm) of a building or structure, or part thereof, nor less than 1 foot (305 mm) below the surface of the ground. The provisions of this subsection include structures such as porches and steps, whether covered or uncovered; breeze- ways; roofed *porte cocheres*; roofed patios; carports; covered walks; covered driveways; and similar structures or appurtenances.

IPC® Section 715.1 Sewage Backflow

Protection from sewage backflow when a structure is below the accessible public sewer system is critical.The Exception, below, is a new addition to the model code:

715.1 Sewage backflow. Where plumbing fixtures are installed on a floor with a finished floor elevation below the elevation of the manhole cover of the next upstream manhole in the *public sewer*, such fixtures shall be protected by a backwater valve installed in the *building drain*, or horizontal *branch* serving such fixtures. Plumbing fixtures installed on a floor with a finished floor elevation above the elevation of the manhole cover of the next upstream manhole in the *public sewer* shall not discharge through a backwater valve.

Exception: In existing buildings, fixtures above the elevation of the manhole cover of the next upstream manhole in the public sewer shall not be prohibited from discharging through a backwater valve.

This new exception addresses a common problem when attempting to install a backwater valve in an existing building. As explained in the 2015 Significant Changes to the IPC publication: "Existing buildings built before the code required backwater valves for fixtures on floor levels below the elevation of the next upstream manhole cover [that] are at risk for sewage backflows caused by public sewer problems. In some cases, many years will pass without the public sewer creating a fixture overflow in an older building. As more building sewer connections are made to the public sewer, and as stormwater infiltration increases as the public sewer ages, surcharging and clogs in the public sewer can develop. Usually, a building owner will experience only one sewage overflow in the building before he or she consults with a plumbing contractor to provide a solution to protect against these sometimes catastrophic events."

The problem is that older buildings usually have the drainage systems for all floors interconnected. As the 2015 Significant Changes publication concludes: "This exception allows, for existing buildings only, installation of a backwater valve for all fixtures in a building, even if those fixtures are on a floor above the next upstream manhole cover elevation. A building owner should have the ability to protect his or her property from public sewer surcharging that could cause an overflow in the building. Without a backwater valve installed in these situations, multiple overflow events and property damage could continue to occur unabated."

New IPC® Sections 716 [Vacuum Drainage Systems] & 717 [Replacement of Sewers by the Pipe-Bursting Method]

The 2015 edition of the International Plumbing Code has added two new notable Sections to Chapter 7. Both bring systems that were only regulated through published Standards and a waiver from building officials for alternative methods into the code book for easier and more consistent application.

These two relatively new approaches to Sanitary Drainage System design and installation will be covered later in this class, in the lesson on Alternate Sanitary Systems.

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[QUESTIONHEADER]

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UPC Section 708.2 sets the minimum slope of horizontal drainage piping at ¼ inch per foot to the point of disposal, which translates to the following percentage of decline:	2 percent	1 percent	5 percent	one-quarter percent

[QUESTIONBOTTOM]

[SLIDECUT]

Technical Considerations & Sanitation for Sanitary Drainage Systems

There's a paradox at the core of sanitary system design, as explained below, it's simultaneously very easy (A) and nearly impossible (B):

A. Very Easy: Sanitary drainage has precisely the same flow rates, reaction to friction, and tendencies as water – how hard can that be to design?

B. Nearly Impossible: Unlike water supply where pressure is consistent and manageable, sanitary drainage is characterized by wide fluctuations in volume, surges within the flow, cross currents, organic deposits on interior pipe surfaces, and a need for flow to be fast enough to clear and cleanse the pipes – is it even possible to design it to take into account all of these variables?

When taking on this paradoxical challenge, there are benchmarks that need to be met. For example, sanitary systems should be designed, wherever possible, to achieve a flow rate of 2 feet per second (2 fps). This is the rate which studies have determined is sufficient to "scrub" the pipe – not that the pipe will be clean, but it will prevent undue accumulation of organic material and thus be in a "sanitary" state. The degree of sanitation within the sanitary system relies on flow rates and volumes. Since all sizing is based, in part, on the friction within the pipe, any deposits on the interior pipe surface can cause this to shift. The goal of 2 fps will not be met at all times, so the goal is to have it fluctuate more or less around the ideal velocity.

Drainage piping functions at its optimal level when the pipes are roughly half-filled. This allows sufficient room for air to maintain even pressure and avoid back-pressure or siphoning of trap seals. As discussed earlier in this class, the downward stream in stacks reaches terminal velocity unless the rate is slowed by the intrusion of a new branch. The effect of the branch flow on the downward stream also sets an upper limit on the fill ratio. Similarly, the effluent from the downward stream will slow when turning into a building drain until reaching the point of hydraulic jump, after which it can achieve a consistent flow rate over relatively long distances as long as the proper slope is maintained and no blockages are allowed to form. A good fill ratio for this consistent flow is between ½ and ⅝ full.

The third goal of a well-designed system is to have proper sizing and venting so that an optimal air flow is maintained. Where air flow is constricted, pneumatic pressure rises. Where insufficient air replacement behind the flow is allowed to develop, pneumatic pressure falls. Some pneumatic pressure fluctuations are unavoidable. A good rule of thumb is that any pressure change that is plus or minus one inch of water column is safe. This is a fairly small limit, equivalent to less than ½ psi.

To review, the three goals outlined thus far are:

1. A flow rate of 2 fps;
2. Pipes filled at ½ and ⅝;
3. Pneumatic fluctuations no more than $^{+}/\text{-}1$ inch of water column.

Overview of Material to Be Covered

This lesson cannot provide hands-on guidance in all technical considerations. First, the class is intended for working plumbers, not architects and engineers. It may be nice to know some of the more arcane technical considerations, but it wouldn’t help in the normal tasks of a plumber. Second, it would take too long.

Nevertheless, it is extraordinarily useful to “dip a toe” into these technical considerations so that you can more effectively install and maintain a well-designed system, and so that you may be able to spot design flaws when called for a malfunction or at least to be aware that a recurrent malfunction may be due to a design error.

Offsets

The earlier discussion of stacks only considered vertical stacks that pursue a single straight course. A great many installed stacks, of course, cannot pursue a straight vertical line, and instead employ a number of sideways shifts of position, called offsets, before turning back downward.

If the offset does not involve any turns greater than 45 degrees, it can be treated as an interrupted portion of the stack. Any turn greater than 45 degrees should be sized and treated much as if it was a building drain, until it turns downward once again. The flow rate will decrease and, if the offset is long enough, it may manifest the hydraulic jump characteristic of longer drain piping.

Connections to Branches

Whenever there is a new inflow of effluent into a stack, a critical intersection is formed. The effluent from the branch can enter the stack only by mixing with the stream flowing down the stack or by deflecting it. The optimal operation of both the stack and the branch are facilitating when the new stream mixes with the downward flow. The degree of deflection of the high-velocity stream coming down the stack increases with the hydrostatic pressure from the stack – that makes intuitive sense. If you pour water from a pitcher and shoot it with a water pistol, the downward flow will only be mildly disturbed, while if you shoot it with a fire hose, no water from the pitcher will continue to flow downward. Even mixing will cause some level of disruption. The downward flowing effluent in the stack exerts pressure against the incoming flow and would prevent its entry unless the pressure from the sideways flow is strong enough to force its way into the stack.

In other words, the flow from the branch can't be at such a high pressure it would deflect the downward flow but must be fast enough to overcome the outward pressure of the downward flow. This situation is amplified by the fact that these flows occur in confined space. A critical factor is the degree of fill in each element – if the downward flow half-fills the pipe and the branch flow half-fills the pipe, the intersection won't overfill the junction. Any ratio close to filling the available space and even more so any ratio that would overfill the junction will result in the water to back up into the branch. This backup shouldn't be of a magnitude that would cause the water to back up into a shower stall or cause sluggish flow in the branch.

One means to minimize this risk is to have the branch flow already moving downward when it hits the stream. A long-turn tee wye employed where the branch connects to the stack has a greater vertical velocity when it enters the stack than if a sanitary tee is employed. Where the pipes are at or near 50% capacity at the intersection, this can be critical.

Slope of Horizontal Drainage Piping

You may have noticed that slope was not included as one of the three goals for drainage piping. The reason for this is that the minimum slope necessary to each system varies so greatly depending on the size of pipes used, friction within the pipes, volume and ratio of flow, etc. There are two key considerations when ensuring slope is adequate:

1. Sanitary systems must rely on gravity; and
2. Horizontal drains should be sloped sufficiently to avoid operating above half-full capacity under uniform flow conditions in order to minimize pressure fluctuations.

Codes mandate minimum slopes for different pipe sizes for branches and drains. In truth, these minimums are not hard and fast and, under some conditions, the limits may be violated by the system engineer. Similarly, the necessary minimum slope is greater with smaller-diameter pipe since the risk of exceeding 50% fill ratio is greater where there is both less space and where a higher percentage of the flow touches the interior wall, but the rule may also occasionally be violated by the engineer. In most cases, however, the following minimum slopes would apply [check with local codes for any variations on this chart]:

Inside diameter of pipe	Minimum Slope
3 inches (80 mm) and smaller	¼ inch per foot (6.4 mm/m)

4 to 6 inches (100 to 150 mm)	⅛ inch per foot (3.2 mm/m)
8 inches (200 mm) and larger	$^{1}/_{16}$ inch per foot (1.6 mm/m)

The optimal sizing and slope of drainage piping is calculated through a variety of formulas that take into account friction from the inside piping wall, average flow velocity, pipe length, volume of effluent, etc. Here is an example of one such formula [shown for illustrative purposes, only – students not expected to master the formula]:

Q = AV

[Where Q = Quantity rate of flow, cubic feet per second (cfs) (m/s3)
A = Cross-sectional area of flow, square feet (m^2)
V = Velocity of flow, fps (m/s) –
Velocity is derived by the following

Where R = Radius
S= Slope
n = Derived from Manning Formula, based on the roughness of the pipe and the pipe diameter.
Sample table showing R to the ⅔ power when the pipe is half-full (A_H) or full (A_F)

This is just one type of formula used and is provided only as an example, not intended to be adopted as such into your practice.

Drainage Loads

Small buildings and single-family houses will typically contain a standard selection of plumbing fixtures, including one or more bathroom groups consisting of a toilet, lavatory, and bathtub or shower stall, as well as a dishwasher, washing machine, kitchen sink and (in some cases) laundry sink. Each of these fixtures are used with irregular frequencies that vary greatly during the day, rather than being in continuous usage, and even within this period of usage, flow rates will increase and decrease, and simultaneous use of multiple fixtures also varies. The discharge characteristic curves and likelihood of standard fixtures has been factored into their designated DFU. As existing systems are updated with low-flow fixtures, however, critical design calculations change. The flow rate may change enough to render the existing pipe size too large to facilitate full clearance of the pipes. The same would occur with an added bathroom, significant change in type of occupancy, etc.

Fixtures where drainage flow has higher peaks and valleys would have an outsized impact on calculations. In other words, a toilet has more significant surges in outflow than a typical dishwasher or kitchen sink. That is the reason why horizontal drains are heavily restricted in regard to the number of toilets they are allowed to serve.

Calculating the capacities of horizontal or sloping drains is complicated by surging flow and intermittent use. This consideration is far more complex where there are multiple floors. As a general rule of thumb, branches draining from two floors into a main stack can be designed in a similar manner to a single floor, branches draining from three floors would need to take possible surges from multiple floors and design drains to avoid fill ratios above ⅓ of capacity. Any more than branches from three levels that empty in a single stack are more tightly restricted and require proper engineering and design.

Stack Capacities

As mentioned in the first lesson in this class, stack capacity is calculated at the point of terminal velocity. Needless to say, where the downward flow has not yet reached terminal velocity, there will be a higher volume of effluent per section of pipe than there would be for exactly the same amount of effluent at terminal velocity. In order to take this into account, the maximum fill ratio at terminal capacity is usually set between ¼ and ⅓. The maximum capacity of 7/24 is commonly applied.

Where pneumatic pressure that could result in siphonage or backflow exists, a common solution is to have the stack piping one size larger than the minimum size derived from the accumulated DFUs to be transported. Unlike drainage piping that may not achieve sufficient velocity if sized too large, the terminal point will change, but the downward stream will always attain terminal velocity if the run is of sufficient length.

Sanitation

The befouling of a sanitary system can seriously undermine its performance. The situation is most likely to occur where optimal flow in fps is not achieved or where the effluent contains potential blockages such "disposable" wipes, excessive grease, etc.

In such situations, the drainage system can become "unsanitary". This is a serious systemic malfunction and should be addressed. Where possible, prevention is better than repair. Use of the appropriate traps, separators, interceptors, and signage to elicit higher compliance rates from users in terms of refraining from misusing sanitary drainage. Where contamination has nevertheless occurred, water is the ideal means to restore the system into a sanitary condition. A flushing valve installed upstream of any anticipated problems can be opened and closed when conditions require. A water jet cleaning that uses sufficient pressure of water forced through the blocked section is likely to be far less destructive than a rotary blade style means for cleaning pipe. Even after a rotary blade cleaning, water must be forced through the pipes to regain a sanitary condition.

In extreme situations and where pipes are excessive, removing and cleaning sections of pipe may be necessary.

Maintaining Consistent Pneumatic Pressure

As effluent hurtles down stack piping, it pulls the air in the core with it. This is vital to maintain relatively stable pneumatic pressure at intersections and to facilitate the development of the hydraulic surge, but it tends to create a partial vacuum in the piping above the stream. As long as air is replenished steadily there will be a slight drop in pressure above the stream but the drop is minimal as new air rapidly restores most of the stable air pressure. [Note: Although this is a minor consideration, anaerobic decay of sewage produces methane, which is valuable if harvested for the production of energy but otherwise a harmful and dangerous gas as well as a powerful greenhouse gas].

In flood conditions, the supply of air may be cut off and the drainage system forced backward. Blockages in the pipe that restricts air flow can also result in spikes in pneumatic pressure. A small increase in pneumatic pressure will occur in the building drain even if the airflow is not completely blocked by a hydraulic jump or by submergence of the outlet and the building sewer. This is due to the decrease in cross-sectional area available for airflow when the downward stream flows into the drain and must change its dynamics to suit the slope and diameter of the drain.

The change in direction and slowing of the flow means that there will be more prolific deposits of sediment, exacerbating the differentials in pressure. [Note: This also explains why having readily accessible cleanouts at the base of all stacks is so critical.]

Maintaining Flow Rates Through the Building Sewer

The final technical consideration is the need to have a building sewer suitable to the system. The critical technical considerations include appropriate sizing and materials, but the consideration unique to this portion of the system is the type of soil and overall geological conditions. It’s critical to have stable and consistent support to avoid having the piping shift or settle, which can cause dips where deposits will drop out of suspension, accumulate, and ultimately prevent full emptying, which will then tend to force similar problems upstream.

Where there are no undue geological considerations and it’s possible to reach fully compacted levels below ground (or bedrock), it is sufficient to lay the pipe on properly compacted fill (sand or pea gravel) in conformity with the slope needed to sustain full clearance into the private or public sewer system. Indentations in the fill should be provided to account for the additional diameter at the piping joint or bell hub. Where the trench isn’t deep enough to reach fully compacted soil or bedrock, the exposed soil should be pre-compacted before a compacted fill layer is laid down or a deeper trench dug and more easily compacted material like crushed stone laid down to prepare for the fill layer.

Improper backfilling (i.e., covering the pipe with earth or other materials) can also interfere with drainage slope and consistency. The amount of pressure placed on the backfill to prepare it for landscaping, paving, etc., should be calibrated to protect the piping. Mechanical means of compacting backfill are prone to errors. A recommended method is to lay down the backfill in four to eight-inch layers so that the pressure needed for compaction is far less (since the amount of material to be compacted is so much less).

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[QUESTIONHEADER]

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What is the minimum flow rate in horizontal sanitary drainage piping needed to properly clear and cleanse pipes (according to the material covered in this lesson)?	Two feet per second	Six feet per second	Forty feet per minute	Five feet per second

[QUESTIONBOTTOM]

[SLIDECUT]

Alternate Sanitary Systems and Methods

Engineered Systems

Alternative engineered plumbing systems are permitted in all codes, provided that they have been designed by a licensed professional engineer, including designation of required maintenance and operation protocols. In other words, the engineer is responsible not only for the design of an alternative plumbing system but also for the proper use of the system, once installed. Alternate designs may include reduced venting (or none at all, replacing the vents with aerators or Air Admittance Valves).

It's likely that pipe sizes will be larger for some of these systems to allow for single stack venting or combination drain and vent system. Larger pipe sizing adds to the cost of this component, but overall savings are achieved by reducing the amount of vent piping. Additionally, one-pipe systems often employ oversized, unvented S traps in place of conventionally sized and vented P traps with trap seal primers that ensure the trap seal is replenished. The trap arm length is also limited and the stack is oversized to reduce the buildup of negative pressure in the trap arm.

The considerations that go into these alternate systems are beyond the scope of this class. These systems are intended for taller buildings where reduction in space devoted to vent piping is more valuable. If you are involved in the installation or maintenance of these systems, it’s vital to be properly directed by the engineer and/or protocols created by the engineer.

Vacuum Drainage Systems

Vacuum drainage systems technology and design is well-proven over many, many years of use in a variety of applications. Vacuum drainage systems are less prone to clogging than gravity drainage systems and are not required to have conventional trap venting systems or carefully sloped drainage piping and have therefore been commonly used to transport wastewater in ships and prisons. Recently, however, vacuum drainage systems have been seen as an alternative to gravity drainage systems for all types of buildings that can conserve water.

A vacuum drainage system is an engineered system consisting of three basic components:

1. A vacuum generating and temporary waste collection center

2. A vacuum drainage piping network

3. Vacuum valve and control components used to isolate the vacuum piping network from atmospheric pressure and to collect waste at its point of origin

Vacuum waste drainage system operation is based on the use of differential air pressure to transport waste in a piping network that is typically maintained under a continuous vacuum pressure of 16” – 18” Hg. The waste is transported from its point of origin, which is at atmospheric pressure, through a vacuumized waste-piping network, to a central collection point, also under vacuum pressure. Waste is temporarily held at this central collection point before being discharged to the facility's sanitary waste line or containment vessel. The advantages this system claims include:

➢ Unlike gravity drainage piping, there is no requirement for a continuous slope.

➢ Since the waste drainage volume is significantly less in a vacuum waste drainage system, it’s also possible to use pipes of less diameter than in a traditional waste drainage system.

➢ If a leak develops in a gravity waste pipe, effluent drips (or gushes) into the environment. If a leak develops on a vacuum waste pipe, air rushes into the pipes, containing the leak. An alarm system can be utilized to notify about leaks, so they can be repaired.

➢ If a vent in a gravity plumbing system becomes clogged, gas cannot escape and air cannot push water through the pipes, so dangerous waste, gas, and bacteria can back up into the drains and fixtures. Vacuum plumbing systems, in contrast, are virtually self-venting, requiring no waste stacks nor vents protruding from the exterior of the building, eliminating the expense of penetrating through the building envelope. In addition, unlike gravity systems, blockages in pipes are routinely broken up and forced through the system in a vacuum plumbing system.

➢ Vacuum plumbing reduces annual water use, with estimated reduction in a commercial setting from 3.6 gallons per day per person in traditional systems to 1.5 gallons per day per person with a vacuum waste system. According to the EPA, toilets consume the largest amount of water of all indoor fixtures and appliances (27%), with this percentage higher in many commercial applications. Traditional flush toilets require 1.6 gpf. High-efficiency toilets reduce this to 1.2-1.3 gpf whereas a vacuum plumbing system needs only .5 gpf.

New Code Sections

In response to the development of these systems, the IPC® added a new Section to Chapter Seven that lays out how a building official should approach these systems. Selected Sections include the following:

716.2 System design. Vacuum drainage systems shall be designed in accordance with the vacuum drainage system manufacturer's instructions. The system layout, including piping layout, tank assemblies, vacuum pump assembly and other components necessary for proper function of the system, shall be in accordance with the manufacturer's instructions. Plans, specifications and other data for such systems shall be submitted to the code official for review and approval prior to installation.

716.4 Written Instructions. Written instructions for the operation, maintenance, safety and emergency procedures shall be provided to the building owner. The code official shall verify that the building owner is in receipt of such instruction.

Replacement of Sewers by the Pipe-Bursting Method

A relatively new option for replacing a sewer line where excavations are difficult or costly (such as under a paved surface or structure) is the "pipe-bursting" method. Minimal excavations are required to access the sewer line and where connections to other sewer lines occur. The method uses a hydraulically activated tapered head or mandrel, pulled through the existing sewer line by a cable, chain, or rod. The mandrel expands to break the pipe and pulls behind it the replacement pipe, so the entire operation is accomplished with a single step.

These methods are being widely used throughout the country, despite which the plumbing codes had no provisions related to this method until recently.

IPC® Section 717

The 2015 edition of the IPC added a new Section to Chapter Seven that provides enforceable codes for those states that adopt this part of the IPC. Some of the codes from the new Section 717 (Replacement of underground sewers by pipe-bursting methods) are as follows:

717.2 Applicability. The replacement of building sewer piping by pipe bursting methods shall be limited to gravity drainage piping of sizes 6 inches and smaller. The replacement piping shall be of the same nominal size as the existing piping.

717.4 Pipe. The replacement piping shall be manufactured with an SDR of 17 and in compliance with ASTM F714.

717.5 Pipe fittings. Pipe fittings to be connected to the replacement piping shall be of extra high molecular weight PE3408 material and shall be manufactured with an SDR of 17 and in compliance with ASTM D2683

717.7 Post-Installation Inspection. The completed replacement piping section shall be inspected internally by a recorded video camera survey. The video survey shall be reviewed and *approved* by the code official prior to pressure testing of the replacement piping system.

It should be noted that the only code-approved product for replacement pipe is polyethylene with an SDR 17 wall thickness (ASTM F714). This pipe is an outer-diameter-and wall-thickness-controlled product that provides for an inside diameter very close to the inside diameter of PVC and cast-iron sewer piping of the same size. If the previous installation lacked cleanouts up to current code requirements, those cleanouts must now be installed.

An internal video camera survey of the completed installation, including all connections to the replacement pipe, must be reviewed by the code official prior to pressure testing.

Combination Waste Vent Systems and Wet Venting

Combination Waste and Vent Systems that used to be an alternative method have become more widely accepted as well as included in adopted codes in most states.

In a combination waste and vent system, the drain serves both as a drain and as the vent for the fixture. The system is intended to be a horizontal piping system, with the only vertical piping [limited to 8 feet (2438 mm) in height] being the vertical portion of a fixture drain located above the level of the combination waste and vent. The type of installations required is reflected in the following Table, drawn from the 2015 IPC®:

SIZE OF COMBINATION WASTE AND VENT PIPE

DIAMETER PIPE (inches)	**MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (DFUs)**	
	Connecting to a horizontal branch or stack	**Connecting to a building drain or building subdrain**
2	3	4
2-1/2	6	26
3	12	31
4	20	50
5	160	250
6	360	575

For SI: 1 inch= 25.4 mm.

The system requires that the combination drain and vent pipe be oversized for two reasons. First, the velocity of the drainage flowing in the pipe is greatly reduced by oversizing the pipe, which reduces the possibility of creating siphon or blowback action. More to the point, the depth of waste flow in the pipe is reduced by increasing the drainage pipe size, providing adequate area of the pipe above the flow of drainage to permit the movement of air for venting. Since piping for a combination waste and vent is oversized and has less of a slope, the flow velocity and depth are insufficient to carry soil drains or, in fact, any sanitary drainage containing solids. Codes therefore bar them from carrying the discharge from water closets, food waste grinders, clinical sinks, and other fixtures that might discharge solids.

A dry vent pipe must connect somewhere within the combination waste and vent system or the system must connect to a horizontal drain that is dry-vented and which permits the free flow of air, unimpeded by the liquid flow level in the drainpipe. Because the combination waste and vent system is both a drain and a vent for its entire length, it is not important where the dry vent connects to the system. The horizontal length of a combination waste and vent system is unlimited.

Wet venting is not the same as a combination waste and vent system. Typically, wet venting is an expedient to use a small portion of drainage piping to also serve as a vent when that stretch of piping is near enough to another trap to prevent siphonage of the trap seal. [A combination waste and vent system may have a longer developed length.] The objective of using wet vents is to minimize the vent piping required by employing one pipe to serve two functions. According to the ASPE, there are three fundamental rules to follow when utilizing a wet vent [From the ASPE July 2012 standard CEU 189 on Vent Systems]:

1. At top floor no more than 1 FU is discharged into a 1½-in. wet vent nor more than 4 FU into a 2-in. wet vent; at lower floors the wet vent must be 2 inches, minimum
2. Length of drain does not exceed maximum permissible distance between trap and vent.
3. Branch connects to the stack at the water closet connection level or below.

The following model Code Sections from the National Standard Plumbing Code emphasize the restrictions on wet venting:

908.1 Vertical Wet Venting. Wet venting is limited to vertical drainage piping receiving the discharge from the trap arm of one and two fixture unit fixtures that also serves as a vent not exceeding four fixtures. Wet-vented fixtures shall be within the same story; provided, further, that fixtures with a continuous vent discharging into a wet vent shall be within the same story as the wet-vented fixtures. No wet vent shall exceed 6 feet (1829 mm) in developed length.

908.1.1 Piping Size. The vertical piping between any two consecutive inlet levels shall be considered a wet-vented section. Each wet-vented section shall be not less than one pipe size exceeding the required minimum waste pipe size of the upper fixture or shall be one pipe size exceeding the required minimum pipe size for the sum of the fixture units served by such wet-vented section, whichever is larger, but in no case less than 2 inches (50 mm).

908.1.2 Vent Connection. Common vent sizing shall be the sum of the fixture units served but, in no case, smaller than the minimum vent pipe size required for a fixture served.

908.2.1.2 Wet Vent Size. The wet vent shall be sized based on the fixture unit discharge into the wet vent. The wet vent shall be not less than 2 inches (50 mm) in diameter for 4 drainage fixture units (dfu) or less, and not less than 3 inches (80 mm) in diameter for 5 dfu or more.

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[QUESTIONHEADER]

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Pursuant to the newly added 2015 IPC® Section 717, what is the final step when installing a pipe bursting system prior to performing a pressure test?	Review and approval of a recorded video camera survey from within the repaired section of pipes (fulfilling inspection requirements)	Verification by the code official that the building owner is in receipt of written instructions for operation, maintenance, safety and emergency procedures	Application for a permit	Allowing a 24-hour period for curing

[QUESTIONBOTTOM]

[SLIDECUT]

Grease Interceptors

Industrial Interceptors and Oil Separators

i

In addition to the far more common commercial grease interceptors that are the focus of this lesson, some industries, car repair or oil change garages, etc., may need separators and interceptors designed for the type of harmful wastes that would otherwise discharge to the sewer system. The 2015 UPC adds a new requirement for these products in some locations:

UPC® 1009.0 Industrial Interceptors (Clarifiers) and Separators. 1009.1 Where Required. Interceptors (clarifiers) (including grease, oil, sand, solid interceptors~~,~~ etc.) shall be required by the Authority Having Jurisdiction where they are necessary for the proper handling of liquid wastes containing grease, flammable wastes, sand, solids, acid or alkaline substances, or other ingredients harmful to the building drainage system, the public or private sewer, or to public or private sewage disposal.

The International Association of Plumbing and Mechanical Officials (IAPMO) Technical Committee explains: “There has been an increase in the number of interceptors being produced that can properly handle solids and an increase in their use has been noticed. The determination of the requirement for an interceptor will be identified during the code review process, Inspectors will have to verify that an interceptor designed to handle solids is present if it is deemed necessary. Installers must be aware of the requirement early on in the construction process,” adding that failure to install the proper interceptor can result in damage to the sewage system.

Similarly, oil interceptors may be required in commercial establishments such as all forms of gasoline dispensing stations (car, airplane, etc.), auto repair and oil change shops, dry cleaners, industrial plants, and process industries having machine shops, metal-treating process rooms, chemical process or mixing rooms, processes that involve wax, etc. Oil interceptors are designed to separate and collect oils and other light-density, flammable or volatile liquids that would otherwise be discharged into the drainage system, resulting both in contamination and serious fire or explosion hazard. Oil interceptors are sized in accordance with the maximum anticipated flow rate of wastewater that could be discharged through a tailpiece and are customarily protected from back-siphonage by a vacuum breaker at the tailpiece entrance.

If the establishment has alternate means for preventing contaminants from entering drains, the interceptor may not be required. Some repair garages, for example, use dry absorbent compounds to soak up spills rather than to allow volatile substances to accumulate in a well or chamber.

image from ICC®

Required Locations

Grease Interceptors are a commercial product, mainly for food service locations. They intercept and collect free-floating fats, oils, and grease (FOG) from wastewater discharge before it can enter the sanitary drainage and sewer systems. Residential dwellings seldom discharge FOG in sufficient quantity to need a grease interceptor. They are required by codes and regulations to intercept the drainage from fixtures and equipment with FOG-laden wastes, including institutional and commercial kitchen pre-wash sinks, pot sinks, dishwashers or automatic hood-wash units, dishwashers, wok stations or griddles, and soup kettles or floor drains or sinks into which kettles are drained.

A loophole in these legal requirements is provided to sinks or dishwashers that discharge through a food waste grinder. The food wastes from grinders can quickly plug up a grease interceptor with solids, so codes have been written with an exception for food waste grinders. Unfortunately, out of a desire to avoid the expense, labor costs, disposal costs, and the nasty odors that can come from grease interceptors, many establishments routed a great deal of their grease-laden wastes through a fixture with a food waste grinder, resulting in an unacceptable discharge of FOG into drains and sewers. Codes have been revised in many cases to replace the exemption with a requirement to install a solids interceptor between the food waste grinder and the grease interceptor. The additional cost of a solids separator is significant and this code is often violated. The importance of a solids separator can't be underestimated. Pre-wash (prep, pot washing, etc.) sinks with a food waste grinder are probably where the most grease enters the waste system. When grease adheres to food particles it acts like the aggregate or filler in a concrete mix and makes a gooey ball, which will aggravate blockages in downstream drains and sewers. *[Note: See below for a sample model code and an advertisement for one type of solids interceptor.]*

IPC® 1003.3.2 Food Waste Disposers. Where food waste disposers connect to grease interceptors, a solids interceptor shall separate the discharge before connecting to the grease interceptor. Solids interceptors and grease interceptors shall be sized and rated for the discharge of the food waste disposers. Emulsifiers, chemicals, enzymes and bacteria shall not discharge into the food waste disposer.

Why They Are Necessary

Clogged sewer drains can cause serious sanitary problems and backflow either into the originating kitchen and dining area or further along in the sewer system and manholes. The EPA is in charge of enforcing violations, and has levied some significant fines on water and sewer districts after sanitary sewer overflows contaminated waterways, because local codes and grease interceptor ordinances were found to be inadequate, and because they did not address the issue after earlier citations. Municipal systems, faced with the considerable expense of cleaning the sewers or being fined for failing to do so are increasingly pushing enforcement of grease separator code requirements in institutional and commercial kitchens.

The problem may also not travel as far downstream as the establishment believes it will, and the grease clog could result in blockages right there in their own kitchen traps and drains sufficient to make the kitchen unusable until maintenance clears the drainage lines.

image by AYPO

Types of Grease Interceptors

There are two generally accepted categories – gravity (GGI) and hydromechanical grease (HGI) interceptors [Note: HGIs were formerly known as grease traps]. In truth, both rely on gravity to do their work. The only difference is that an HGI seeks to control the flow rate of the effluent to hasten the gravity-based separation process [i.e., grease separation is facilitated by longer, slower flow], while a GGI is a simple chamber where the unregulated flow rate means an open-ended time to separate (a minimum of 30 minutes). GGIs are therefore much larger and most often installed outside the kitchen (to isolate the nasty odor), while an HGI is typically within the kitchen to facilitate regular disposal of the separated FOG – sometimes mechanically removed from the HGI to a separate well by pump or skimmer wheel. The IPC® defines the two types as follows:

Gravity. Plumbing appurtenances of not less than 500 gallons (1893 L) capacity that are installed in the sanitary drainage system to intercept free-floating fats, oils, and grease from wastewater discharge. Separation is accomplished by gravity during a retention time of not less than 30 minutes.

Hydromechanical. Plumbing appurtenances that are installed in the sanitary drainage system to intercept free-floating fats, oils, and grease from wastewater discharge. Continuous separation is accomplished by air entrainment, buoyancy, and interior baffling.

Not only are they different sizes and have different time frames for separation, but the two types are usually made of different materials. Although a GGI may be made of from fiberglass or thermoplastics, they are most often engineered (either prefabricated or field-formed) concrete-constructed units. Protected steel tank GGIs, built to UL specifications for structural and corrosion protection of the interior and exterior, typically use a two-part polyurethane, high-build coating with interior coating options of polyurethane, epoxy, or a proprietary material to minimize corrosion. GGIs use large volumes of water and retention time to separate FOG from the facility's accumulated waste stream. HGIs are typically thermoplastic (HDPE, or polypropylene) or steel, typically located in proximity to the fixture or fixtures served or at the discharging fixture point of use. They are relatively compact in size and utilize hydraulic flow characteristics, internal baffling, air entrainment, and the difference in the specific gravities between water and FOG to separate and retain FOG from the fixture waste stream. [Note: The Table, below, lists selected specific gravities, measured at “room temperature”, i.e. about 70°F, and some would change at higher or lower temperatures.]

In addition to GGIs and HGIs, other FOG retention and removal devices are categorized as either grease removal devices (GRDs) or FOG disposal systems (FDSs) which may be either free-standing or appurtenant to a grease interceptor where FOG can be reduced to a less-liquid form, thereby extending the required cleaning intervals of the tank.

Note: The currently available models of the above-described devices vary greatly, depending on the proprietary design of their manufacturer. The good news is that the devices have been steadily and rapidly improving, developing new ways to isolate and reduce the volume of the FOG and minimizing how much odor escapes.

Installing Grease Interceptors and FOG Disposal Systems (Automatic Grease Removal Devices)

Although a large volume facility may seem best suited to a GGI, possibly installed outside or underground, the GGI is not a preferred option where there is any possibility of selecting a more highly engineered and accessible interceptor. Many installations benefit when a FOG Disposal device supplements the HGI.

HGIs are sized based on the gpm they will need to process. Size alone, however, is not necessarily the key to proper selection. Velocity of the flow is even more critical to interceptor selection and design:

- ➢ If the fluid moves too quickly, smaller grease globules have inadequate time to rise an adequate distance to be captured by the interceptor and will be transported onward and out into the drainage lines.

- ➢ The American Society of Plumbing Engineers (ASPE) has set a standard of at least three inches for the grease to rise within the effluent in the baffles of an HGI.
- ➢ If the HGI is sized to allow the effluent to slow sufficiently in the baffles to achieve efficient separation, there will be far less need for maintenance and removal of the FOG and the stated capacity of pounds of grease retained per gpm can be either exceeded or fail to be met.
- ➢ In the years to come, it is hoped that improved design will continue to increase the pounds per gpm of flow that can be processed by HGIs.

How They Work

A typical device injects biofilm (i.e., live bacteria cultured and maintained for this purpose) into the accumulated FOG. The biofilm then breaks the bonds between fatty acids and glycerol as well as the bonds between the hydrogen, carbon, and oxygen atoms within each, thereby reducing the FOG volume substantially. Drainage continues through the media chamber around the outlet baffle, where it then is discharged to the sanitary system. FOG disposal systems significantly reduce the need for manual FOG removal or the handling of mechanically removed FOG materials, but it also increased the need for monitoring to ensure that all components are working properly and have not been contaminated by materials not susceptible to being broken down, which can undermine performance unless cleaned out. Gravity grease interceptors can also be fitted with FOG disposal systems so that FOG can be reduced to liquid form, thereby extending the required cleaning intervals of the tank.

Ambient heat is also a critical determinant of performance. The longer the distance between fixture outlet and interceptor, the more critical that ambient heat be high enough to prevent the FOG from congealing and blocking pipes. A heat trace system for connecting drain pipes can be used wherever ambient temperatures may dip below 40°F. Heat also affects the specific gravity of the FOG, so that warmer globules will more readily rise. Some HGIs may have heating elements where ambient temperatures are too low for efficient operation. It's best if the HGI is close to fixtures, without abrupt changes in elevation and orientation (vertical to horizontal).

Maintenance

It's important to remember that FOG is unstable in an aqueous environment. Hydrolysis begins upon FOG's first contact with water and the triglyceride molecules comprising the FOG begin to break down, which results in pH decline, oxygen depletion, a release of heat energy and the characteristic unpleasant odors. Cleaning products and bacteria in a grease interceptor accelerate this decomposition. A lack of regular service can result in the release of system-damaging compounds, noxious odors, and excessive interceptor corrosion.

[Note: As the bonds are broken, mass increases, as does specific gravity, so that the material collected gradually submerges.]

Along with proper maintenance is the disposal of the accumulated, processed FOG. Owners and operators should be conversant and compliant with local rules and ordinances on FOG disposal. Under no circumstances should the accumulated FOG be poured down a drain or emptied into a sewer line. Similarly, this material should never be deposited on or buried under soil surfaces.

Proper disposal of FOG generally requires the use of a licensed collection service.

Brief History of Grease Interceptors

image by AYPO, adapted from Schier Products Company Brochure

Late 1800's
- The first gravity grease interceptor patented.

1949
- PDI-G101 Standard is first issued, rating grease interceptors up to 50 GPM

1949-Present
- Performance Standards: ASME A112.14.3, PDI-G101, CSA B481
  - Defined today as *hydro mechanical grease interceptors*
- Design Standards: ASTM F2649-08, IAPMO Z1001, All of the local standards
  - Defined today as *gravity grease interceptors* – ***modified septic tank***

1973
- The EPA Clean Water Act establishes regulatory framework to limit what commercial buildings discharge to the local treatment plant, among other things. Opens the door for EPA to fine municipalities for Sanitary Sewer Overflows (SSOs)

Late 1970s
- Pretreatment managers continue to have problems with SSOs even though plumbing codes require grease interceptors that are supposed to protect our sewers.
- Pretreatment and sewer authorities develop local requirements for grease interceptors.
- Size of required grease interceptors increases dramatically, typical size for new buildings is 1,000 gallons regardless of restaurant type and size. *Bigger is better* thinking begins.

1980s-Present
- Failure of large units. The *bigger is better* mentality has its own unique set of problems, including access, pump-out cost, buildup of H^2S gases from extended pump-out frequencies, corrosion resistance, cost, required footprint, etc.

Summer of 2008
- 2 dead, 1 permanently disabled following inhalation of noxious H^2S gases from a large Grease trap at the Orleans Hotel & Casino in Las Vegas

Sample Codes and Standards

Standard	Publisher	Type of interceptor covered
PDI G-101	Plumbing and Drainage Institute	Passive Hydromechanical Grease Interceptor (HGI)
PDI G-102	Plumbing and Drainage Institute	Grease Interceptor Sensing and Alarm Devices
ASME A112.14.3	American Society of Mechanical Engineers	Passive Hydromechanical Grease Interceptor (HGI)
ASME A112.14.4	American Society of Mechanical Engineers	Automatic Grease Removal Device (GRD)
ASME A112.14.6	American Society of Mechanical Engineers	FOG (fats, oils and greases) Disposal Systems
CSA B481	Canadian Standards Association	Passive Hydromechanical Grease Interceptor (HGI)
IGC 273	International Association of Plumbing and Mechanical Officials	Passive Hydromechanical Grease Interceptor (HGI)
ASTM C1613	ASTM International	Precast Concrete Gravity Grease Interceptor (GGI)
IAPMO/ANSI Z1001	International Association of Plumbing and Mechanical Officials	Prefabricated Concrete Gravity Grease Interceptor (GGI)

The following published standards apply to Grease Interceptors and FOG Disposal Devices:

- PDI G101-2015 *Testing and Rating Procedure for* Hydro Mechanical *Grease Interceptors with Appendix of Installation and Maintenance*
- PDI G102-2009 *Testing and Certification for Grease Interceptors with FOG Sensing and Alarm Devices*
- ASME A112.14.3 -2000 *Grease Interceptors*
- ASME A112.14.4-2001 *Grease Removal Devices*
- ASME A112.14.6-2010 *FOG (Fats, Oils, and Greases) Disposal Systems*

The 2015 IPC® and 2015 UPC® both address grease interceptors in their Chapter 10 (Interceptors and Separators in the IPC® and Traps, Interceptors and Separators in the UPC®). The provisions of the UPC® are more detailed than those in the IPC® and include a separate Section 1015 on FOG Disposal Systems. These differences can also be seen in their treatment of “Where Required”:

2015 IPC® 1003.1 Where Required. Interceptors and separators shall be provided to prevent the discharge of oil, grease, sand and other substances harmful or hazardous to the public sewer, the private sewage system or the sewage treatment plant or processes… Where lack of space or other constraints prevent the installation or replacement of a grease interceptor, one or more grease interceptors shall be permitted to be installed on or above the floor and upstream of an existing grease interceptor. **1003.3.3 Grease Interceptors and Automatic Grease Removal Devices Not Required.** A grease interceptor or an automatic grease removal device shall not be required for individual dwelling units or any private living quarters.

2015 UPC® 1014.1 General. Where it is determined by the Authority Having Jurisdiction that waste pre-treatment is required, an approved type of grease interceptor(s) in accordance with ASME A112.14.3, ASME A112.14.4, CSA B481, PDI G-101, or PDI G-102 and sized in accordance with Section 1014.2.1 or Section 1014.3.6, shall be installed in accordance with the manufacturer's installation instructions to receive the drainage from fixtures or equipment that produce grease-laden waste located in serving areas of establishments where food is prepared or other establishments where grease is introduced into the drainage or sewage system in quantities that can effect line stoppage or hinder sewage treatment or private sewage disposal systems. A combination of hydromechanical, gravity grease interceptors, and engineered systems shall be allowed in order to meet this code and other applicable requirements of the Authority Having Jurisdiction where space or existing physical constraints of existing buildings necessitate such installations. A grease interceptor shall not be required for individual dwelling units or for private living quarters. Water closets, urinals, and other plumbing fixtures conveying human waste shall not drain into or through the grease interceptor.

International Plumbing Code

The following is a selection drawn from the 2015 IPC®:

2015 IPC® 1003.3.4.2 Rate of Flow Controls. Grease interceptors shall be equipped with devices to control the rate of water flow so that the water flow does not exceed the rated flow. The flow-control device shall be vented and terminate not less than 6 inches (152 mm) above the flood rim level or be installed in accordance with the manufacturer's instructions.

1003.3.5 Automatic Grease Removal Devices. Where automatic grease removal devices are installed, such devices shall be located downstream of each fixture or multiple fixtures in accordance with the manufacturer's instructions. The automatic grease removal device shall be sized to pretreat the measured or calculated flows for all connected fixtures or equipment. Ready *access* shall be provided for inspection and maintenance.

1003.3.7 Direct Connection. The discharge piping from a grease interceptor shall be directly connected to the sanitary drainage system.

Uniform Plumbing Code

The following is a selection drawn from the 2015 UPC®:

2015 UPC® 1014.1.3 Food Waste Disposers and Dishwashers. Unless specifically required or permitted by the Authority Having Jurisdiction, no food waste disposer or dishwasher shall be connected to or discharge into a grease interceptor. Commercial food waste disposers shall be permitted to discharge directly into the building's drainage system.

1014.2 Hydromechanical Grease Interceptors. Plumbing fixtures or equipment connected to a Type A and B hydromechanical grease interceptor shall discharge through an approved type of vented flow control installed in a readily accessible and visible location. Flow control devices shall be designed and installed so that the total flow through such device or devices shall at no time be greater than the rated flow of the connected grease interceptor. No flow control device having adjustable or removable parts shall be approved. The vented flow control device shall be located such that no system vent shall be between the flow control and the grease interceptor inlet. The vent or air inlet of the flow control device shall connect with the sanitary drainage vent system, as elsewhere required by this code, or shall terminate through the roof of the building, and shall not terminate to the free atmosphere inside the building.

Exception: Listed grease interceptors with integral flow controls or restricting devices shall be installed in an accessible location in accordance with the manufacturer's installation instructions.

1014.2.1 Capacity. The total capacity in gallons (gal) (L) of fixtures discharging into a hydromechanical grease interceptor shall not exceed two and one- half times the certified gallon per minute (gpm) (L/s) flow rate of the interceptor in accordance with Table 1014.2.1 For the purpose of this section, the term "fixture" shall mean and include each plumbing fixture, appliance, apparatus, or other equipment required to be connected to or discharged into a grease interceptor by a provision of this section.

The UPC also offers a helpful example of how to use these sizing guidelines:

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[QUESTIONHEADER]

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According to the material covered in this class, Hydromechanical Grease Interceptors were formerly known as:	Grease traps	Gravity grease interceptors	FOG separators	Vented grease flow control separators

[QUESTIONBOTTOM]

[SLIDECUT]

[VIDEOHEADER]

End of the Class (Video)

That completes this class on Sanitary Drainage Systems.

We've had a chance to review some of the physics that sanitary systems must take into account, including gravity, friction, hydraulic and pneumatic pressure. In each case, the application of these principles to an effective design has been discussed, along with some of the codes and standards, best practices, and available options.

As I stated at the beginning of this class, the intent is not to tell you what materials or methods to use, but to sharpen the tools that you already have when working on these systems. By enhancing your understanding of their guiding principles, you may be better able to avoid the pitfalls and fulfill the promises of these critical plumbing systems.

Thank you for selecting AYPO for your continuing education needs. We hope to see you in some of our other classes and that you'll think of us down the road whenever you or a colleague has continuing education needs.

[VIDEOBOTTOM]

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[QUESTIONHEADER]

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What is the basic unit of Drainage Fixture Units (DFUs) – in other words, 1 DFU =	One cubic foot of effluent draining in a 1¼-inch pipe over a one-minute period of time	One cubic foot of effluent draining in a 3-inch pipe during one second	The capacity of a 2-inch pipe for one linear foot of developed length	Five gallons

[QUESTIONBOTTOM]

[SLIDECUT]