

Introduction to Vacuum Sewage and Plumbing Systems

by AcornVac, Inc.

What is a Vacuum Plumbing System?

Vacuum Plumbing Systems are simply a viable alternative to underground piping that uses the combined energies of vacuum pressure and gravity for the collection and disposal of waste through a piping network that can be routed above grade. Hundreds of vacuum drainage systems are in operation around the world and are accepted by most code authorities. Also, Vacuum Systems are included as a viable drainage solution in the latest edition of the IPC and IAPMO.

What are the advantages of vacuum drainage?

Vacuum drainage systems offer a number of benefits to a variety of types of installation:

All types of construction:

- Vacuum toilets use only ½ gallon of water per flush to efficiently and effectively rinse down and refill the toilet bowl. This provides a significant savings in water supply and sewage disposal costs.
- Vacuum plumbing systems use smaller diameter piping (PVC, copper or stainless) and smaller diameter fittings, and are self venting thereby eliminating vent stacks and reducing material and labor costs.
- The drainage piping network servicing a vacuum plumbing system can be installed vertically or horizontally, providing flexibility in layout and building design, as well as providing solutions for renovation project piping.
- Vacuum plumbing systems accommodate an open architectural environment by eliminating the need to provide vent and waste stacks.
- Vacuum drainage systems allow existing buildings with limited drainage to be developed when traditional underground piping upgrades are cost prohibitive because of structural limitations (post tension slab foundations), restrictive site issues (bedrock, inappropriate inverts, historical building categorization), or embedded contaminants in the floor (asbestos).

Prisons and Correctional Facilities:

- Direct connection of two toilets into the same waste stack is eliminated, thereby preventing prisoners from communicating or passing contraband between cells.
- The operational dynamics of a vacuum plumbing system result in fewer in line blockages, reducing maintenance cost and disruption. When toilet blockages do occur, they are easily located and abusers can be readily identified.
- In a shake-down, sections or pods can be isolated from the piping network, thereby preventing prisoners from flushing their toilets and disposing of contraband or creating disruption.

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Supermarkets:

- Vacuum drainage systems eliminate the need for costly underground drainage piping in the sales area.
- Vacuum drainage systems work in concert with the new "open" architectural store environment where electrical and refrigeration services are brought to display cases from overhead. Drainage can now follow these services, allowing for unprecedented flexibility in store layout.
- Vacuum drainage systems are completely adaptable to last minute merchandising changes.
- New construction projects can be completed faster, saving construction costs and allowing a facility to be brought online in a more timely fashion. Often, projects can be completed during inclement weather because the facility can be closed before the weather conditions prohibit construction.
- Vacuum drainage systems create a cleaner environment and reduce health hazards associated with gravity drains.
- Vacuum drainage systems allow existing buildings with limited drainage to be developed for supermarket use when traditional trenching and underground piping upgrades are cost prohibitive because of site conditions – post tension slab, bedrock, asbestos, high water tables, etc.
- Because trenching is eliminated, store remodel activities are less expensive, safer, more sanitary, and take less time.
- Vacuum drainage equipment can be capitalized and taken with the owner if the facility is abandoned.

How does it Work?

A Vacuum Drainage System consists of three or four basic components, 1) a vacuum generating station, 2) a piping network that allows for transport of waste from its' point of origin – ex. toilet, wash basin, mop sink, shower, refrigerated food case, air condenser, etc. to the vacuum generating station, and 3) vacuum interface components that isolate the vacuum piping network from atmospheric pressure at the point of origin and allow condensate to be removed, 4) purpose made toilets, designed to rinse and re-fill on ½ gallon of water.

Vacuum Generating Station

Referred to as the "Vac Center", the vacuum generating station includes vacuum pumps to create a constant vacuum pressure within the piping network, and storage tanks that collect and discharge the waste into the facilities' sewer main through a code compliant air gap.

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Operation of the pumps, collection tanks, historical data recording, and alarm reporting is fully automated by controls provided with the Vac Center. The vacuum pumps run only on demand, and full redundancy is always provided.

Piping Network

The piping network for a vacuum waste system is maintained under continuous vacuum and is generally fabricated out of PVC, Copper, or other smooth bore, non-porous material. The network consists of "risers" or "droppers" which transport the collected waste vertically from the point of origin to horizontal mains and branches leading to the Vac Center. The mains and branches are sloped at a rate of 1/8" per foot toward the Vac Center and thus, for the most part, waste travels by gravity to the Vac Center, just as it does in traditional underground drainage piping.

A major benefit of this technology to the designer, installer, and user, compared to traditional gravity-only drainage is the ability of the vacuum piping to be routed around obstacles, and to allow slope recovery if the slope from the point of collection to the Vac Center cannot be maintained at the 1/8" per foot recommendation. This is done by creating traps in the running branches and mains which are cleared by differential pressures that exist between the point of origin and the Vac Center during a waste extraction cycle.

Vacuum Interface Components

At the heart of a vacuum drainage system are the vacuum interface components that allow waste to be efficiently collected and transported to the Vac Center. These components include a normally closed vacuum interface valve (Extraction Valve) which separates the vacuum in the piping network from atmospheric pressure surrounding the fixture, and a control device (Controller) which assists in opening the vacuum interface valve in the presence of a pneumatically generated signal to remove waste from the plumbing fixture. In the case of gray water these components also include a temporary collection vessel (Accumulator) which is directly connected to the outlet of the plumbing fixture other than toilets.

When a pneumatic signal is generated at the Controller, it uses vacuum from the system to open the Extraction Valve, exposing the Accumulator and its contents to the vacuum pressure. The difference between the vacuum pressure in the piping network and surrounding atmospheric pressure causes air to enter the Accumulator, mixing with the waste, and transporting the resultant emulsion into the piping network. The extraction cycle lasts approximately 2.0 to 2.5 seconds.

With the AcornVac system, the Controller, which determines if waste is present and opens the Extraction Valve, is designed to operate only if sufficient vacuum pressure exists to completely remove the accumulated waste.

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Frequently Asked Questions

Q: What happens if the vacuum piping network develops a leak?

A: Since the piping is maintained under a continuous vacuum, any leaks that might develop will draw air INTO the pipes, preventing waste exfiltration.

Accepting that problems can occasionally develop with any mechanical system, the Acorn Vac Center is equipped with several alarm features that help alert maintenance personnel of any leaks that might develop in the vacuum piping network.

- ▶ For small leaks that lead to frequent pump cycling, an alarm will be generated indicating "Too Many Vacuum Pump Starts per Hour".
- ▶ For moderate leaks that might keep a pump running continuously, an alarm will be generated indicating that the "Vacuum Pumps have run too long".
- ▶ Should a major leak occur which causes the vacuum pressure to drop below minimum safe levels, the Vac Center will generate a "Low Vacuum Pressure" alarm.

Since the vacuum piping network exists in the overhead structure, finding and correcting vacuum system leaks is easily accomplished. By comparison, leaking pipes in an underground system may go undetected for years, possibly contaminating the surrounding area or water table.

Q: What about a catastrophic piping failure, say pipe breakage due to an earthquake?

A: Unlike underground piping, a catastrophic piping failure, regardless of the cause, will be immediately identified and easily repaired.

Q: Since the system uses electrically operated vacuum pumps, what happens if power fails?

A: Most facilities add the Vac Center to their standby power generating system. In fact, Acorn Vac offers a number of control features and hardware options to accommodate the unique needs of standby generator power sources.

If the facility does not have a generator, or chooses not to add the Vac Center to the standby power source, the drainage system is simply not available until normal power is restored.

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Q: Can the AcornVac system accept large water flows associated with multiple use scenarios, such as large office buildings or prisons?

A: Yes. Proper engineering ensures that the system is sized for such events.

Q What happens when unusually large debris gets into the system?

A: Debris typically found to inhibit the performance of gravity drainage systems typically has little detrimental effect on the performance of the vacuum drainage system. In fact, items that would typically block a gravity drainage system will pass directly through the vacuum piping network to the Vac Center collection tanks due to the fact that they are assisted in their movement by atmospheric pressures entering the system in the course of normal operations. Vacuum drainage systems virtually eliminate clogged piping.

Q: Are spare parts available or should the facility carry spare parts themselves?

A: All parts are supplied by AcornVac and are available for immediate shipment. However, a local factory certified maintenance contractor will stock a quantity of repair parts for emergency purposes.

Q: How fail-safe is our system? Is there any redundancy built-in?

A: The AcornVac system is designed to provide complete redundancy on all primary Vac Center components. This includes dual collection tanks and multiple pumps to ensure that the system can continue to operate so long as electrical power is available.

When the Vac Center is operating on an emergency power generator, it is designed to switch the pump control strategy to a method that is most compatible with this power source. For those facilities with generators that have marginal capability for starting induction motor loads such as a vacuum pump, we offer electronic motor starters which minimize the inrush current of a pump as it is being brought on-line.

Q: What are the recommended maintenance requirements?

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A: The primary service requirements would be at the Vac Center. The vacuum pumps are equipped with a small cartridge filter that we recommend be changed every twelve months. The pumps also have a cooling coil that should be cleaned once a year.

The AcornVac vacuum interface components have been tested to well over three million cycles without failure. These components have no regular required preventive maintenance. Should a problem occur with either a Controller or an Extraction Valve, the component is designed to be easily removed and replaced.

Q: In a supermarket, is the system odor free?

A: Yes. Any gasses or odors which might exist in the Vac Center collection tanks are discharged when the tank is drained, and any gasses or odors that might exist in the piping network are contained therein by the normally closed Extraction Valve and removed by the condensate extraction process.

Q: Can the vacuum lift piping or risers be higher than 22'?

A: Yes; however, the system must be engineered considering all load factors including anticipated activity and peak loads as well as diversity requirements. Call the AcornVac Engineering Department for design assistance.

Q: Where are the controller, valves, check valves, etc. made?

A: All vacuum parts are made in the USA.

Q: Does the vacuum system need vents (roof penetrations)?

A: No, the vacuum system does not need vent stacks. Air removed from the piping network by the vacuum pumps becomes the vent for the system.