Introduction to
Vacuum Sewage and Plumbing Systems - Prisons

by AcornVac, Inc.

AcornVac, Inc. is a single source manufacturer of vacuum plumbing fixtures, vacuum valves, vacuum center equipment, and integrated systems design and engineering. AcornVac has provided vacuum plumbing equipment and design assistance for over 250 projects including over 3000 vacuum flush valve assemblies and fixtures for use in medium to large detention facilities around the world.

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 or below floor 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-
Security Benefits:

- Direct connection of multiple toilets into the same waste stack is eliminated, thereby preventing inmates from passing contraband between cells.

Prisons and Correctional Facilities- Security Benefits – (continued):

- Vacuum toilets eliminate cell-to-cell communication that inmates often use to create "planned plumbing chaos" by organizing large "group flushes" that are typical for gravity drainage systems.

- 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. Furthermore, inmates who routinely try to vandalize the plumbing system by attempting clog the system are easily identified promoting significantly improved security and control.

- Individual cells or groups of cells can be "turned off" prior to a security sweep to prevent contraband or other incriminating evidence from being flushed away.

Maintenance Benefits

- Because of the small diameter flush line from the toilet to the main or branch piping connection, practically anything that can be flushed through the toilet will flow through the system to the vacuum storage tanks. Articles large enough to block the piping network in a typical gravity installation are stopped at the vacuum toilet. This significantly reduces the amount of ongoing maintenance normally associated with unclogging gravity drainage piping networks.

Health Benefits

- Vacuum flush toilets do not splash during the flush cycle, significantly reducing the spread of bacteria within the facility, promoting a healthier environment for the prison population.

Construction Benefits

- Vacuum toilets do not require vent stacks or networks resulting in fewer roof penetrations and a reduction in material and labor costs.

- Vacuum flush toilet systems typically use smaller diameter lines for connecting toilets to main or branches – 1.5" diameter for vacuum vs. 3" or 4" diameter for gravity, resulting in reduced material and labor costs.

- Use of the vacuum flush toilet system results in less cluttered plumbing chases, making for a faster, less expensive installation and/or the opportunity to significantly reduce the chase size. Smaller chase sizes can result in smaller cell/chase footprint, resulting in a reduction in overall building footprint and construction costs.

Prisons and Correctional Facilities- Construction Benefits – (continued):

- Since vacuum toilets are designed to flush on 0.5 gallons of water, smaller diameter water supply lines (typically ½" diameter) can be used to service these units, resulting in savings on material and labor costs.

- Slope recovery capability:
  a. Vacuum drainage systems do not require continuous slope on long pipe runs resulting in shallower mains and less trenching, reducing the material and labor associated with trenching, shoring, backfilling, and future maintenance.
  b. Because continuous slope is not required on long pipe runs, vacuum drainage systems can easily route over or under mechanical obstacles, such as duct work or beams that would otherwise require costly accommodation in a gravity drainage system.

- Vacuum drainage systems can be designed to require minimal under slab drainage piping, offering additional opportunity for construction cost savings.

- Vacuum drainage systems require fewer plumbing stub-ups when finishing floors, reducing construction time, repairs, and labor expense.

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, 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 waste 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' sanitary sewer main.

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, stainless steel, 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 1/4" per foot toward the Vac Center and thus, for the most part, waste travels to the Vac Center in much the same manner as it does in traditional gravity drainage piping.

A major benefit of vacuum 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 the1/4" per foot recommendation. This is done by creating offsets 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 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 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 four seconds.

When the AcornVac vacuum flush valve is activated and controlled by the Master-trol Electronic Valve Control System, the vacuum flush valve operation can be programmed to allow a limited number of flush cycles over a set period of time.

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.

Frequently Asked Questions

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?

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.

Frequently Asked Questions

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: 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.