Vacuum Sewer System Applications Brownfield, Industrial and Municipal

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Airvac

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Learning Objectives



- 1. Overview of Vacuum Wastewater Technologies
- 2. Types of Systems-Industrial & Municipal Outdoor
- 3. Components of a Vacuum Wastewater System
- 4. How It Works, Why, Costs, Design and Advantages
- 5. Case Studies including Industrial and EPA Superfund Site

General Overview Why vacuum sewers?



What are some reasons why you should consider vacuum sewer systems?

- 1. Lower Construction cost
 - 1. Reduce trench depth and width
 - 2. Eliminate manholes in streets
 - 3. Eliminate lift stations
- 2. Less maintenance than other alternative sewers
- 3. Operates during power outage
- 4. No odors as it's a closed system
- 5. No exfiltration / leaks to the environment
- 6. Less disruptive and safer construction

History



- First used in Europe in 1870. Patented in US in 1888
- Technology introduced to the U.S. by the Electrolux Company
- First US indoor/industrial system was installed in the late 1960's by other manufacturers. Several municipal systems were also installed by others late 60's/early 70's.
- First Airvac sewer systems was installed in 1972 in Talbot County (St. Michaels) Maryland and in Alabama (Scott Paper / Kimberly Clark).



Drawing showing early vacuum system principles And layouts of actual system In Prague and Amsterdam – circa 1870

Airvac Systems





400+ Airvac vacuum systems in North America Including Puerto Rico & Bahamas 700 additional Airvac vacuum systems in 32 countries around the world



States with Airvac Vacuum Systems As of end of 2021



437 vacuum systems in 31 states, Puerto Rico & the Bahamas

| ТҮРЕ | # |
|------------|-----|
| Municipal | 336 |
| Commercial | 18 |
| Industrial | 10 |
| Marine | 31 |
| By others | 42 |
| Total | 437 |



Vacuum Liquid Conveyance Systems

Technology Applications

- FDA Regulated and Food Processing Facilities
- Manufacturing Sites (Steel, power & Chemical Plants)
- Brownfield Site Construction
- Green and LEED Projects (Solvis & Calamigos)
- Stadiums, exhibition halls & Arenas
- Transportation: Trains, Planes, Cruise Ships
- Municipal Sewer Systems



Airvac



How it Works



Vacuum technology uses a pressure differential between atmospheric pressure and negative pressure (vacuum) as the propelling force to move liquid in a sealed piping system

The vacuum is created by vacuum pumps at a central vacuum station.

Vacuum technology is used a many markets. The 2 primary ones are

- Indoor vacuum systems used in a variety of applications
- Outdoor/buried systems used in the municipal market

How It Works





Valve opens, contents sucked out, followed by atmospheric air.

Differential pressure propels sewage toward vacuum station

Vacuum mains connected to the tank extend the vacuum to each valve pit.

As valves open and admit atmospheric air, vacuum levels in the main drop. This is sensed at the vacuum station & the vacuum pumps turn on run to restore vacuum to an acceptable level.

Vacuum pumps create a vacuum on the collection tank then shut off

Vacuum Technology Systems Key Points



Key Points

- Small diameter piping (4-8 inches)
- Scouring velocity of 15-18 feet per second (i.e. no blockages)
- Average pipe burial depth 3-5 feet
- Narrow trench width from 3-5 feet
- Closed loop system no external leaks, no exposure to confined spaces & trapped gases



Major Components





House / Pit / Main relationship







BUILDING SEWER FROM HOUSE

1. VALVE PIT





Top & bottom chambers are completely sealed from each

> Operator not exposed to raw



Valve Pit Operation



Positive pressure: Atmospheric air from Air Terminal

Negative pressure: Vacuum in main

Vacuum from in front of valve is applied to the back of the valve via tubing

Differential pressure propels sewage toward vacuum station

As sump fills, air trapped in <u>sensor pipe</u> is transmitted via tubing to the valve controller



Valve opens; contents are sucked out of the sump via the <u>suction pipe.</u>

This is followed by several seconds of atmospheric air

3" (78mm) Interface Valve





Cast Iron Cover





- H-20 traffic rated (not just the cover but the entire valve pit)
- Usually installed in right-of-way
- Concrete collar for traffic situations





6" Air Terminal (AT) 1 per Valve Pit





Valve Pit

Air Terminal

Air terminal has 2 functions:

- 1. Source of atmospheric air needed for valve operation
- 2. Prevents vacuum from pulling traps dry



Air Terminal





Available in simulated stone or utility green

Can add options such as cycle counter or alarm monitoring system

Operator accessible in R-O-W

2 - VACUUM MAINS







Vacuum

Gravity

Pipe Material





- 4", 6", 8", 10" & 12"
- SDR 21 PVC
- "Rieber" Type Gasket

Rieber Gasket







- Factory installed, double-lipped lockedin gasket
- Reduces installation
 problems
- Leak proof joints





Ensures that the vacuum level created at the vacuum station is transferred throughout the entire piping network to the vacuum main extremity.

This is done by keeping an open passageway at the top of the pipe (1/3 sewage and 2/3 air)



Pit to main connection Flex Connector





This is a fixed point

Flex connector provides a degree of flexibility to allow connection while avoiding overuse of fittings

This also is a fixed point most likely at a different elevation than the valve pit opening



3 – VACUUM STATION



Equipment typically housed in a 2-level building



Sewage Pumps & Collection tank in basement

Vacuum Pumps & Control Panel on top floor

EFI Prefab Building Option





Example of an EFI prefabricated building

- Single enclosure dimensions up to 16' x 62'
- Placement on piers, slab or foundation wall
- Available with or without floors
- Code constructed
- Electrical and mechanical systems outfitted
- Various exterior finishes
- Various roof shapes and materials

Prefabricated Vacuum Station











Vacuum Station Skid At Airvac factory





(on back side)

COLLECTION TANK

SEWAGE PUMPS

VACUUM PUMPS

Emergency Generator





A standby generator provides uninterrupted service during power outages.

May be either a fixed, permanent generator or a portable generator

Odor control Bio-filter









Exhaust from vacuum pumps is distributed evenly throughout bio-filter

In some cases, exhaust is just piped directly to atmosphere

Buffer Tanks





Airvac valve(s) installed in a 4' diameter fiberglass manhole with formed sumps



Single Buffer Tank





Optional: Concrete manholes w/formed sumps can also be used

Dual Buffer Tank

Advantages & Applicability



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Cost Savings



Vacuum



Shallow, narrow trenches = less excavation

Dewatering minimized

Smaller equipment

Smaller diameter pipes

1 vacuum station can replace 6 or 7 lift stations Gravity







Reduced Impacts From Construction



- Less surface disruption
- Less restoration
- Vertical & horizontal routing flexibility







Operator & Eco Friendly





Completely sealed system

(no spillage = no permit violations)

- No operator contact with raw sewage
- Self scouring
- Infiltration & Inflow eliminated





Operator Friendly





Completely sealed system

No operator contact with raw sewage









Vacuum stations are typically designed to take on the character of the neighborhood





The vacuum station on the left is in the same neighborhood as the house on the right

Advantages in hurricane prone areas



WWTP not inundated with I&I

Sealed system prevents I&I so plant is not overwhelmed

Less preparation required

In coastal areas 1 vacuum station typically replaces 7 lift stations; less storm prep required of staff

Uninterrupted service

All vacuum stations have emergency generators which provide uninterrupted service to the customer

Safer working conditions

Fixed generators automatically start...no need to expose maintenance staff to severe weather

As last resort the system can be shut down If water levels rise to the point where the Air Terminals are flooded, the system can be powered off to prevent damage to system components. After the threat is over, service to customers can quickly be restored

Energy Conservation



Gravity: 3-20 ft deep



1 vacuum station can replace 6 or 7 gravity lift stations eliminating the need to pump & re-pump





| 1 Vacuum Station | 7 Lift Stations |
|-----------------------|------------------------|
| 2 vacuum pumps | |
| <u>2</u> sewage pumps | <u>14</u> sewage pumps |
| 4 pumps total | 14 pumps total |

Also, with no I&I there can be a reduced wastewater load to the treatment plant

Design Process



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Areas of Applications/Limitations



- An existing community on septic tanks
- Private developments/Phased Projects
- 100 to 2000 connections per station
- Primarily residential
- Flat topography or not much elevation to overcome
- One or more subsurface difficulties to overcome
- In perfectly flat areas, 1 station can serve an area of 16 sq miles (station located centrally and lines going 2 miles in every direction.

- · Environmentally sensitive area
- High groundwater table
- Installation is typically an open cut at frost depth
- A vacuum station has a 1500gpm max peak flow



Reference material Vacuum sewers



There are 3 main reference documents on vacuum sewers







Case Studies



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Vacuum Liquid Conveyance Systems Municipal and/or Industrial Commercial





Case Study for Outdoor Industrial

Airvac

Eli Lilly-Eco Services (Solvay) - Kimberly Clark (underground)

Background

- Major firms in pharmaceuticals, chemicals & manufacturing
- · Locations in Indiana, Louisiana and Alabama
- Systems boast longevity and reliability. KC installed in 1972.

Situation

- · Excavation of these older sites was not safe or practical
- Site challenges included high water table, underground hazards: unknown utilities, buried chemicals and areas of high truck traffic subject to frequent ground shifting
- Brownfields site alternative for wastewater conveyance system

Solution

- Vacuum sewage systems tie in multiple buildings
- The system conveys all wastewaters (Black & Gray)
- Eco since 1979, KC since 1972 & Lilly since 1981







Background





Sharon Steel/Midvale Tailings Facility

Obstacles at the EPA Superfund Site



- Contaminated Soils Beneath the Liner
- Health and Safety Concerns
- Economic Feasibly
- Sanitary Sewer Options
 - Gravity
 - Pressurized (Force Mains)
 - Vacuum Sewer



Steps



- Determine sewer flows
- Determine limitations of the existing wastewater system
- Gravity Sewer Line Capacity
- Lift Station Capacity
- Wastewater Treatment Facility
 Capacity
- Design Site Plan (DSP)
- Work with Team to determine best design solutions



Midvale, Utah EPA Superfund Site





Alloway, NJ Vacuum Station





https://youtu.be/-jkN-gzzrIs

- Project saved over 25% over standard gravity
- Excavation was 4-6 feet vs 22-24 feet in depth
- Excavation was 4-6 feet wide vs entire street
- System was first in kind in State of NJ in 2009
- Design Firm working on new 2020 project now
- No sewage discharge during hurricane after area floods
- System remained fully operational during hurricane
- System is designed to work under water & power outage
- Limited I & I as system is closed under pressure
- Saved \$180 annually in sewer bills for residents

Cape May County, Villas, NJ Lower Township, NJ 2021



- Designed by Fralinger Engineering (did Alloway in 2009)
- Second vacuum sewer system in NJ. Third system overall.
- 2 Vacuum Stations are EFI buildings
- Construction July 2021 through 2023 with 2 phases
- Total estimated Value \$23M (\$4.5M)
- Area near CM Airport off Bayshore Road (4 miles from GSP)
- Very high-water table and tidal
- Leaking septic tanks
- 550 valve pits
- 1100 connections
- Smart Monitor System and Solar Light Alarm Systems
- Possible additions to system under consideration for campground including indoor vacuum toilets and fixtures and additional 1100 connections under consideration to current system



Review Benefits and Advantages of Vacuum Sewers



What are some other benefits of installing vacuum sewer systems?

- –Minimal impact on local traffic and businesses especially during construction
- -No confined space or trapped gasses issues during repairs.
- -Minimal exposure of employees to sewage
- -Best system in areas prone to flooding, heavy onshore flows and high groundwater
- -Standby generator at Vac Station allows operation thru catastrophic weather
- -Excellent solution for seasonal flow variation such as resort areas
- –Immediate leak detection and quick location avoids environmental problems
- –No line blockages as materials moves thru lines at 15-18 fps
- -All mains are PVC or PE which can flex in shifting ground
- -Only 1 source of power (no electrical homeowner service upgrade)
- -Up to 4 homes can be hooked to valve pit

Questions?



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