Industrial and Municipal Vacuum Liquid & Waste Water Negative Pressure Conveyance Systems

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Airvac Vacuum Technologies
Aqseptence Group
ASPE PHL & NJ Chapters
February 15, 2019

Airvac

A brand of
Aqseptence Group

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About this Course

- This course is approved for ASPE CEU credits only
- This course is not approved for PDHs for PEs
- CPDs (Certified in Plumbing Design) or CPDTs (Certified Plumbing Design Technician) can use this course towards their recertification
    - aspe.org/CPD
    - aspe.org/CPDT
- This course may or may not be accepted for PE renewal
- Individuals must inquire with their state to determine if this is eligible for PE renewal or PDH credits

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About the Speaker- Philip Crincoli

> Environmental Business for 25+ years

> 2 Tours of Duty with WM National Sales

> Integrated Facility Management for 10 years

> Former VP of IFMA-NJ

> Member of ASPE PHL & NJ Chapters

> Chemistry Council of NJ

> US Green Building Council – NJ

> 40 Hour HAZWOPPER in 1993

> LEAN Certification in 2015

> Airvac Industrial Segment and NE Regional Manager since 2017

Introduction

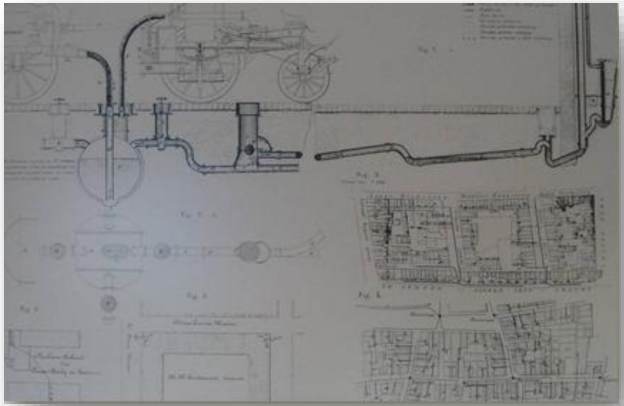
Course is a rudimentary introduction to vacuum wastewater conveyance systems

- Systems are under negative pressure
- Systems can be indoor, outdoor or integrated
- Municipal Sewer Systems
- Private Developer
- Industrial applications
- Targeted audience: Plumbing and Fire Protection Designers, Construction Managers, Civil Engineers, Plant Renovation Teams, Municipal Plumbing and Sewer Engineers and Managers, Architects

GENERAL

History of Vacuum Technology

- 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. First US Municipal system was installed in the early 1970's
- Several vacuum manufacturers have been involved in the indoor US systems since the 60's but now only 2 are active (Airvac and Acorn). Same story in the Municipal market where only 2 are presently active (Airvac and Flovac)
- Several other vacuum manufacturers are active globally, primarily in Asia and Europe



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

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GENERAL
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.

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

This presentation will cover both indoor systems as well as municipal systems

GENERAL

Various Applications – Indoor & Outdoor

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

INDOOR SYSTEMS

INDOOR SYSTEMS

How It Works

https://www.youtube.com/watch?v=kixDx78EJN0&feature=youtu.be

INDOOR SYSTEMS

How It Works

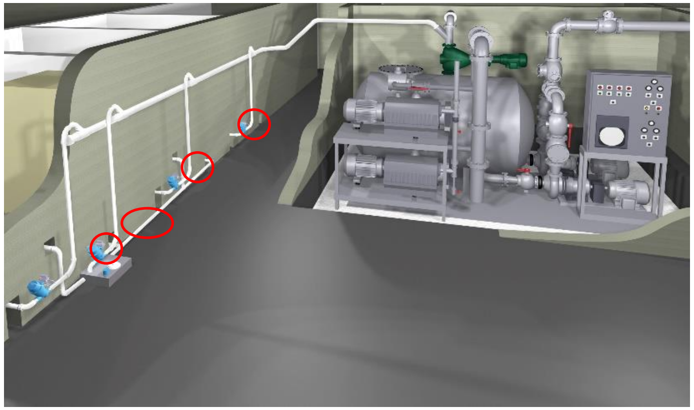
> Liquid flows from facility sources to various evacuation units

> Normally closed pneumatic interface valve opens & constant vacuum within the piping pulls liquid into the pipe

> Vacuum station applies negative pressure to the small diameter piping network & centrally collects the liquid

> Multiple waste streams can be collected & discharged separately

> Basic principles + proven reliability = effective solutions



EVACUATION UNITS

INDOOR SYSTEMS

How It Works

- Liquid flows from facility sources to various evacuation units
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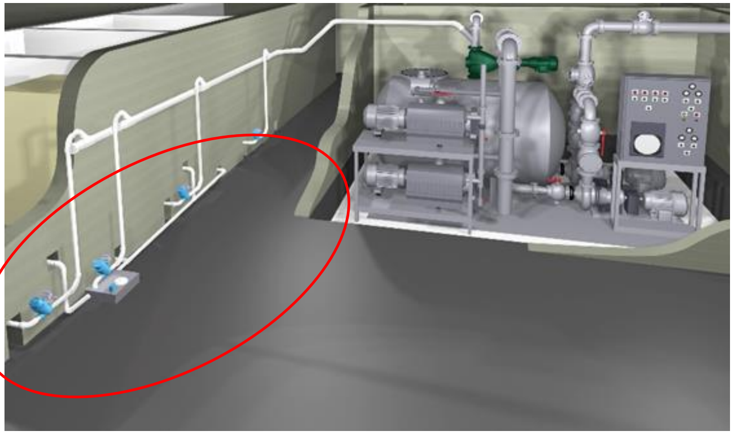
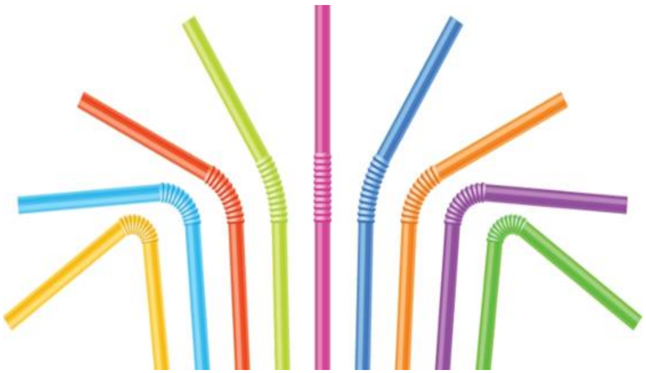


PIPING NETWORK



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INDOOR SYSTEMS

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VACUUM STATION

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INDOOR SYSTEMS

How It Works

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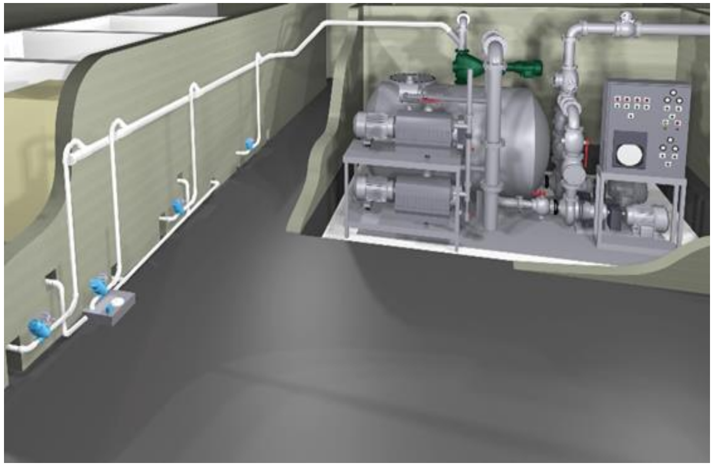

MULTIPLE WASTE STREAMS

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INDOOR SYSTEMS

How It Works

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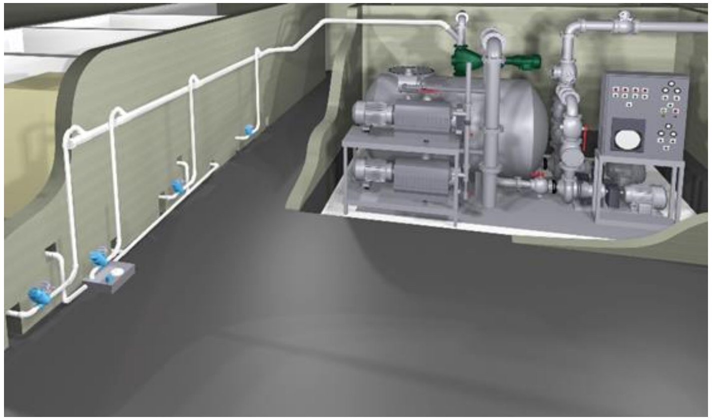

SOLUTION

INDOOR SYSTEMS

Key System Advantages

> Vertically lift liquid 20’+ without electricity at the source

> Eliminate blockages due to high scouring velocities

> No infiltration or exfiltration into/from piping

> Construction duration up to 60% shorter & installation COST less than gravity as piping can be installed in walls & ceiling

> Separation of Contaminated Liquids

> Maintenance outside Controlled Environments

> Indoor, Outdoor and Integrated Systems

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INDOOR SYSTEMS
(Cleanroom) – Validated Environment

Background & *Situation*

- One of the largest vaccine manufacturing sites in world
- Location undergoes frequent renovation
- Syringe Washing operation in Cleanroom (Gardasil, Hep C)
- Needed wastewater conveyance system to separate streams
- Cleanroom in tight space would not allow gravity system
- Access to area limited & many obstacles in place
- Zero tolerance system leaks & no room for dual containment

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INDOOR SYSTEMS

(Cleanroom) – FDA Validated Environment

Solution

> Piping & system controllers placed in walls/ceilings/attics

> Separation of chemical & biological streams in 3 vats

> Single vacuum source maintains negative pressure - no leaks

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INDOOR SYSTEMS

Roche-Basel, Switzerland (Labs & R&D)

Background & Situation

- New 10 floor facility w/ modular design for frequent changes
- Over 70 small labs & 4 large full floor labs, office, R&D
- High visibility state-of-art campus in downtown Basel
- Areas can be changed from office to lab to R&D
- All furniture, basins are movable
- Moves allow for easy hook ups and change outs
- S3 Level (BSL 4) in certain areas includes air burned

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INDOOR SYSTEMS

Roche-Basel, Switzerland (Labs & R&D)

- **Solution**

> 270 vacuum floor drains installed allow optional flexible usage

> 12 autoclaves in basement also on vacuum

> 2 vacuum stations supply negative pressure for building

INDOOR SYSTEMS

Leidos Corporation-Boyers, PA (R&D Lab)

- **Background & Situation**

> Facility is located 220 feet underground

> Leidos needed a highly secure R&D facility for experiments

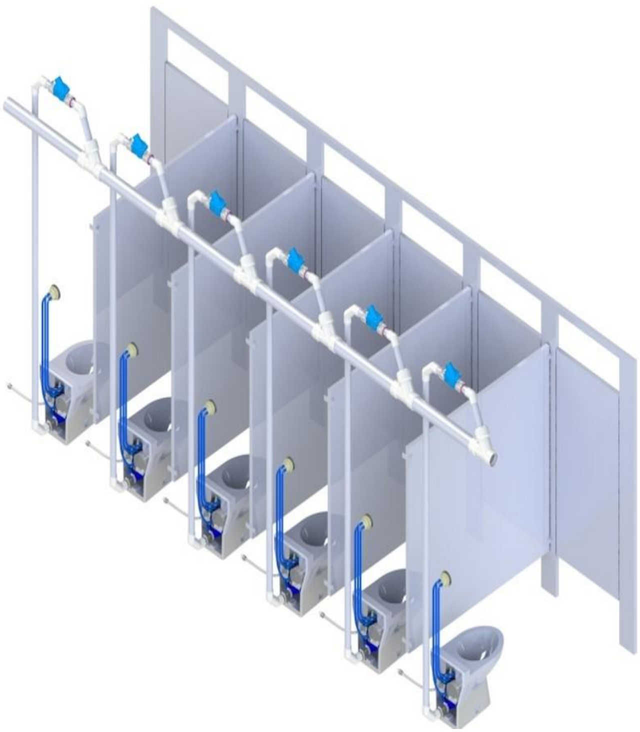
> Former division of SAIC Corporation

> Location part of Iron Mountain high security facility

> Due to facility depth, no gravity option on wastewater

> Minimization of wastewater discharge due to cost

> Sustainable solution that recycles almost all water on site



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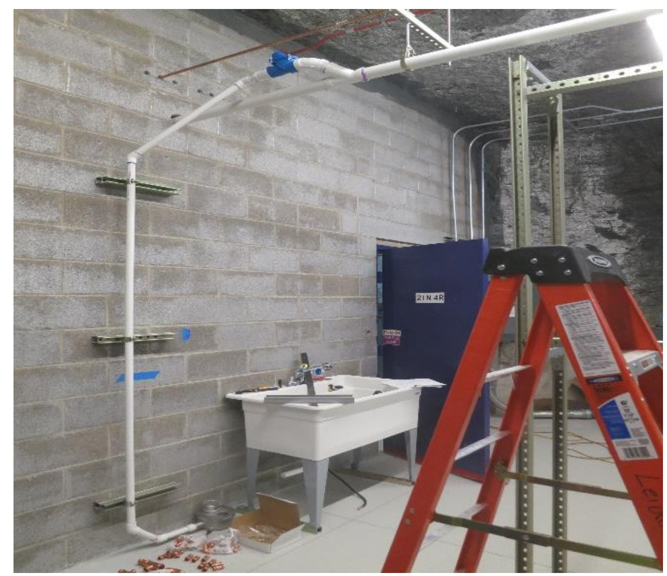
INDOOR SYSTEMS

Leidos Corporation-Boyers, PA (R&D Lab)



- **Solution**

> The vacuum system hooked to bioreactor treatment

> All lab & gray water, & most of black water recycled on site

> Small filter sludge disposed offsite

INDOOR SYSTEMS

Industrial applications (underground outdoor)

- **Background & Situation**

> Major firms in pharmaceuticals, chemicals & manufacturing

> Industrial Outdoor Systems with similar challenges

> Locations in Indiana, Louisiana and Alabama

> 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

INDOOR SYSTEMS

Industrial Applications-Underground Outdoor

- **Solution**

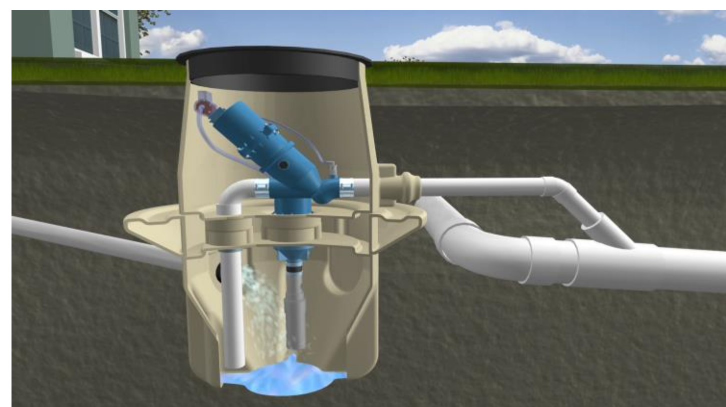
  > Vacuum sewage systems tie in multiple buildings

  > System avoids all natural and man made obstacles

  > Closed system solves problem of high water table

  > The system conveys all wastewaters (Black & Gray)

  > Systems have been operational since the 1970s with many original products



INDOOR SYSTEMS

Calamigos Ranch, Malibu, CA (Net Zero Project)

- **Background & Situation**

> 200 acre privately owned Ranch that serves as Corporate Conference Center, Movie Set and Amusement Park.

> Rapidly deteriorating ecological problems include decreasing fresh water table with groundwater pollution seeping into ocean, creating unsafe & unhealthy conditions along coast.

> Sources of fresh water decreasing due to drought

> Old and failing Septic Systems dry & non functional

> Calamigos wanted a practical, yet fully sustainable solution with a Net Zero goal

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INDOOR SYSTEMS

Calamigos Ranch, Malibu, CA (Net Zero Project)

- **Solution**

> The vacuum system pilot will modernize & centralize sewer system in private area devastated by drought, fires and other natural disasters

> Wastewater treatment partner will provide on site Bio treatment of Black water with recycled sludge, Gray water will be reused and energy supplied will be via H2 fuel cells and solar energy

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INDOOR SYSTEMS

International Construction Firm, Montreal, Canada

Background

A major jet engine manufacturer operates a catastrophic test burn facility in Montreal Canada for determining integrity duration of jet engines, should they catch on fire during flight operations. Once test burning is complete, the jet engines are extinguished with combination of fire retardants and water.

Situation

An international construction firm was selected for construction of wastewater collection area to protect sensitive environmental areas, that will segregate the liquids contaminated with jet fuel, water and fire retardants, which could exceed 26K gallons over 5-10 minutes. The site is located a short distance from a large river and area aquifer.

INDOOR SYSTEMS

International Construction Firm, Montreal, Canada

- Solution

The vacuum system replaces the existing gravity system. The vacuum wastewater system will be able to safely segregate contaminated fluids and send them for specialized pre-treatment, protecting area aquifers in a closed system.

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INDOOR SYSTEMS
Additional Indoor Systems and Uses

> Bayer Pharmaceutical—Design for Cleanroom vacuum wastewater conveyance system in Berlin

> Beta Gama Services– LLRW contaminated liquids for a food irradiation plant in Germany

> NECCO Revere, MA – Floor wand, drain and vacuum system customized by Airvac in candy factory.   Factory closed in 2018

INDOOR SYSTEMS

Sample Product and Componentry Details: Vacuum Station

Vacuum Pumps

- Maintains constant vacuum range (16-20” Hg) on tank & piping

Collection Tank

- Centrally collects liquid
- Multiple liquid streams can be collected via one vacuum station

Discharge Pumps

- Discharges collected liquid for reuse, pre-treatment &/or treatment

Misc.

- All pumps alternate lead/lag & redundancy
- Fabricated & pretested at factory & commissioned onsite

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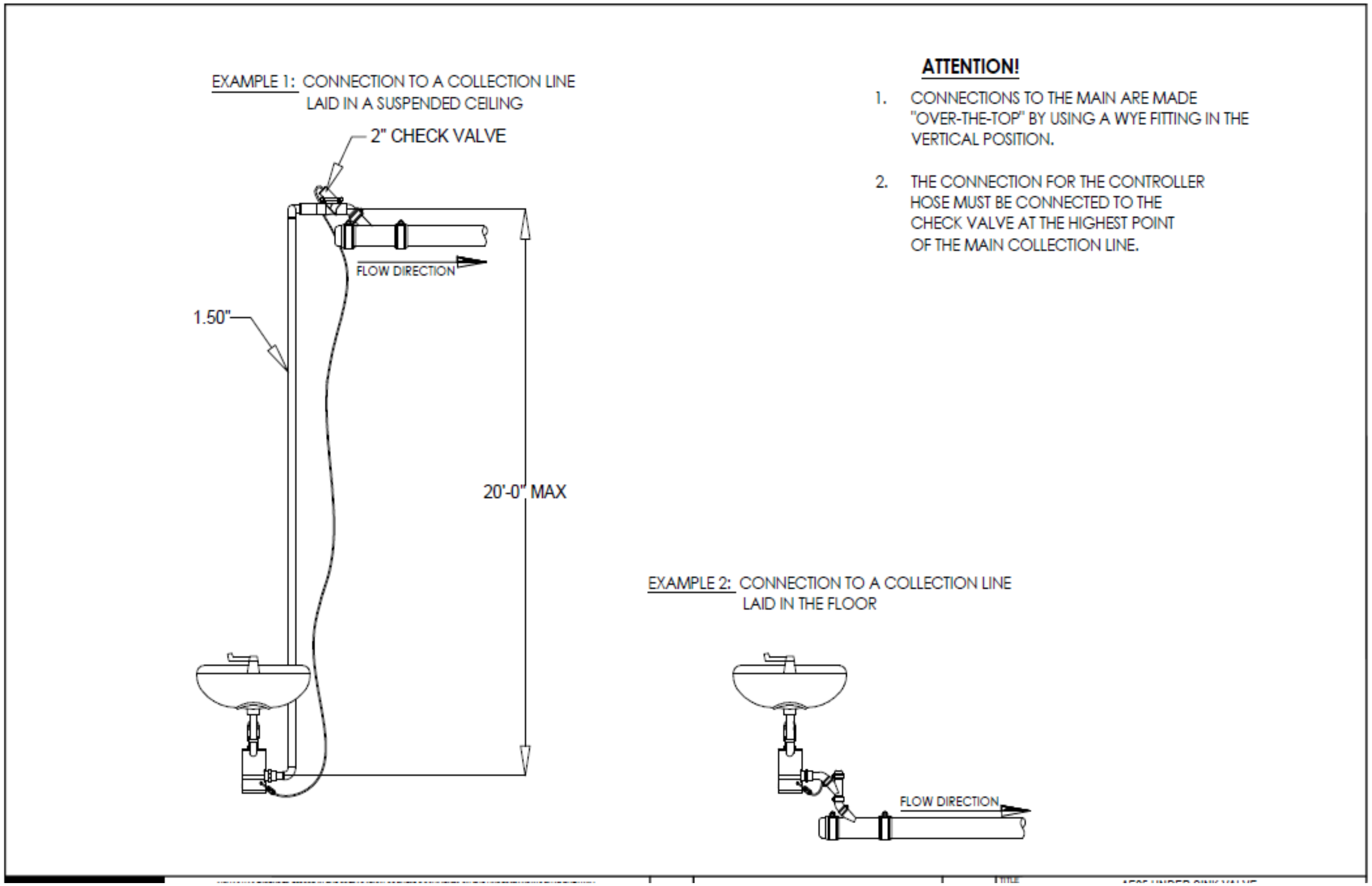
INDOOR SYSTEMS

Sample Product and Componentry Details: Liquid Collection

AE25 Basin Sump

- 20’ lift max
- 1 ½” pipe connection
- Liquid only
- Mounts under sink
- .06 gal / cycle
- 2 GPM

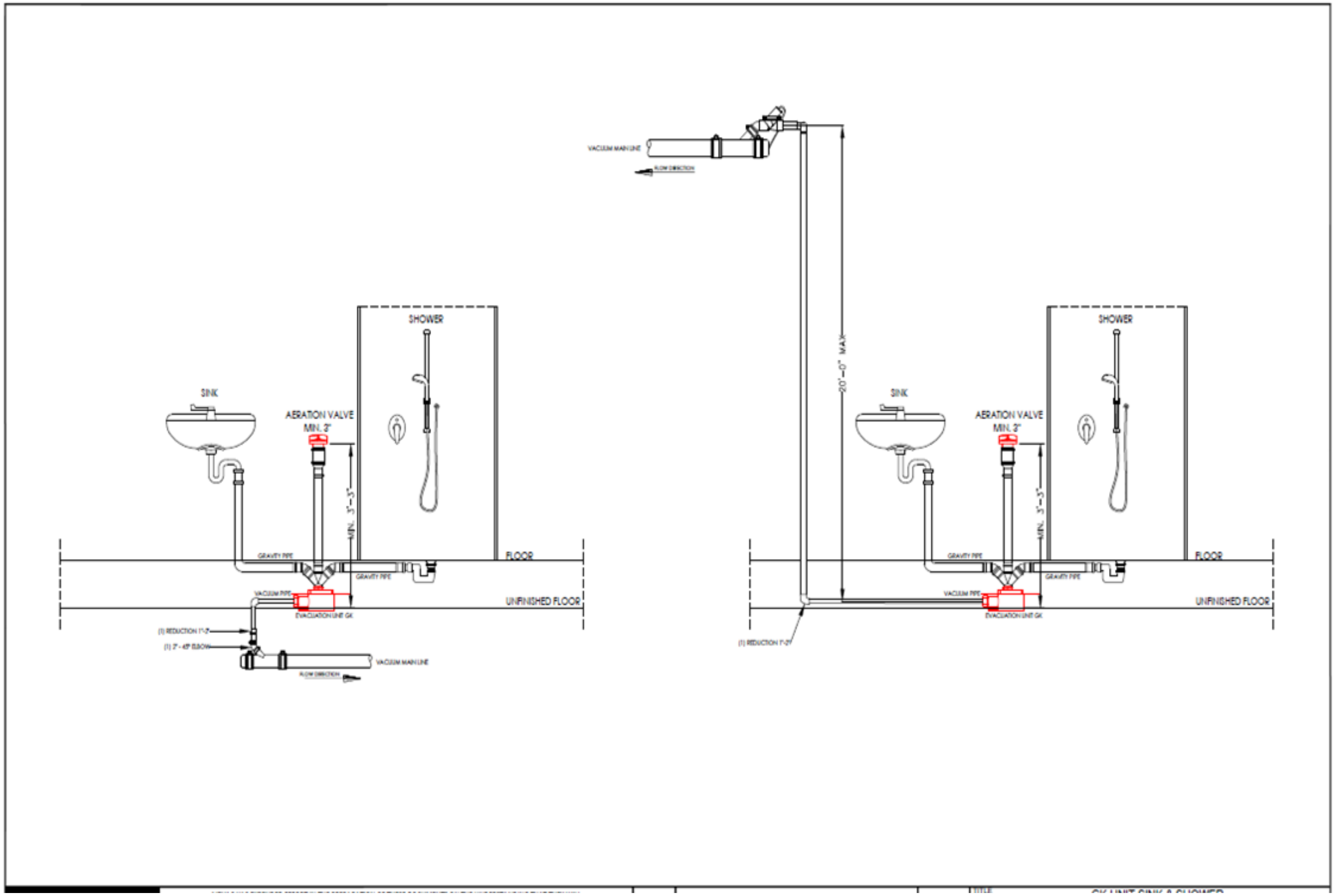


INDOOR SYSTEMS

Sample Product and Componentry Details: Liquid Collection

GK Unit Multi-Sump

- 20’ lift max
- 1” pipe connection
- Liquid only
- Stainless stel
- .26 gal /cycle
- 8 GPM

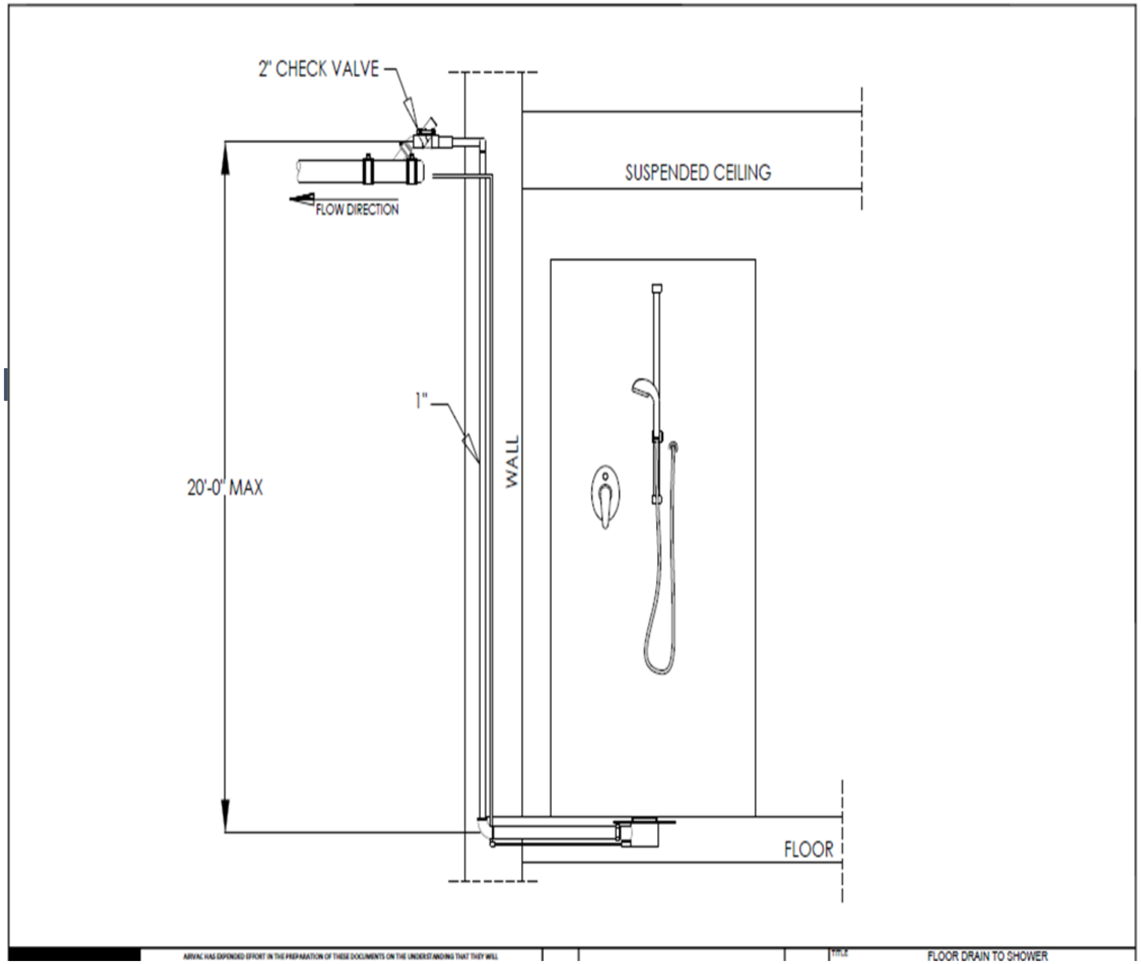


INDOOR SYSTEMS

Sample Product and Componentry Details: Liquid Collection

Floor Drain

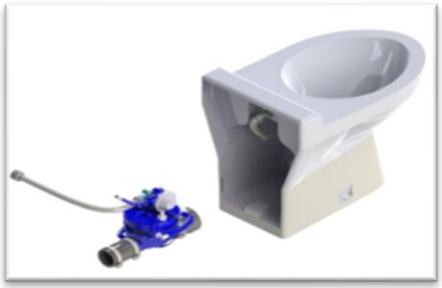
- 20’ lift max
- 1” pipe connect
- Liquid only
- Stainless steel
- .27 gal /cycle
- 8 GPM



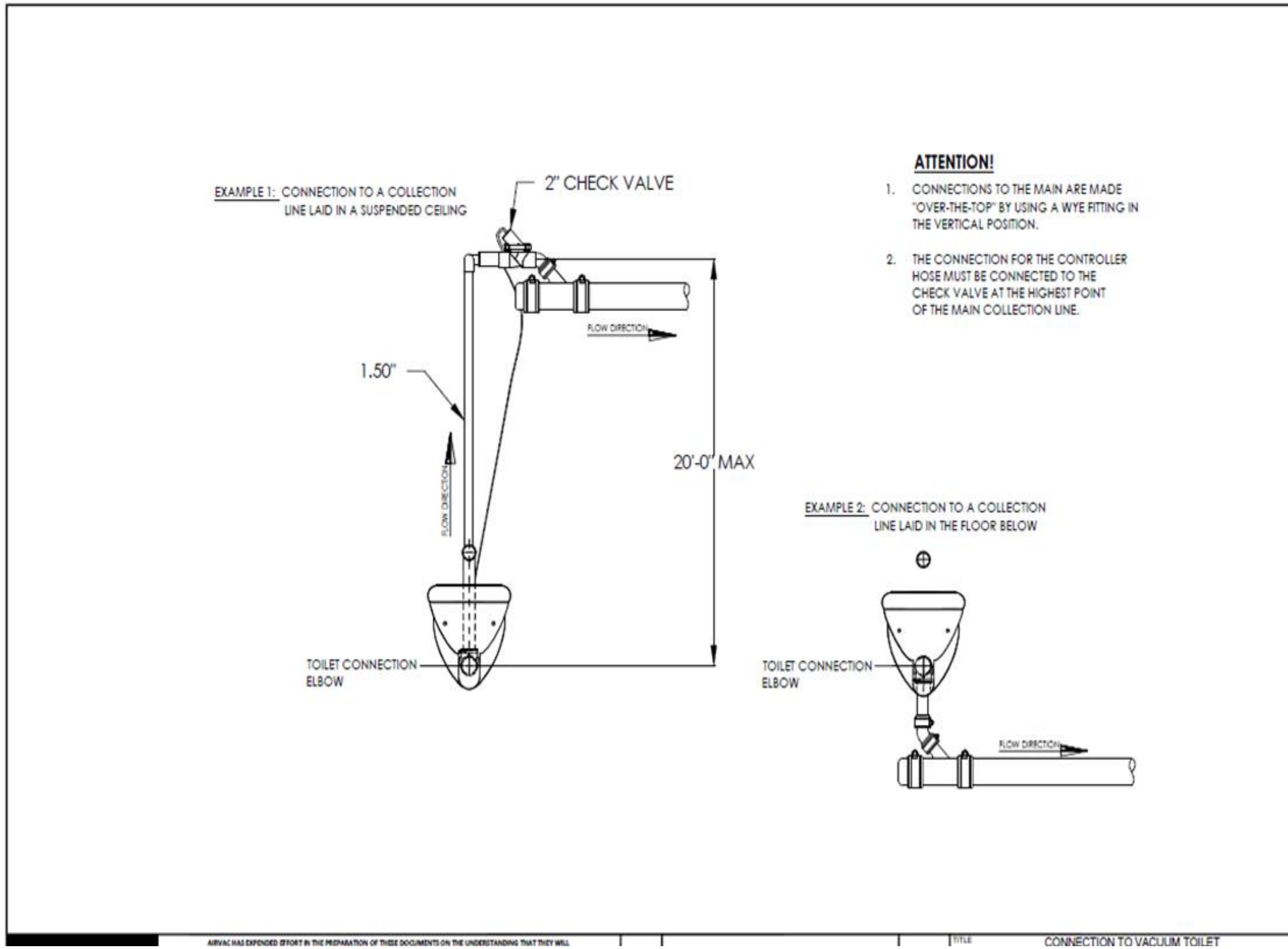
INDOOR SYSTEMS

Sample Product and Componentry Details: Liquid/Solid Collection

Vacuum Toilets



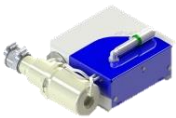
- 1 ½” connection
- 78 dB
- Vertically lift 20’+
- Floor mount
- Wall mount
- Stainless steel



INDOOR SYSTEMS

Sample Product and Componentry Details: Liquid/Solid Collection

Collection Sumps



Sizes ¾ to 50 gallons

Liquid & solids

Vertically lift up to 20’

PE, FG & SS

Pneumatic/no power requirements

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INDOOR SYSTEMS

Vacuum vs. Gravity - Material vs. Labor Cost

Material

- Evacuation units
- Vacuum station
- Piping

*Vacuum more 40%

Labor

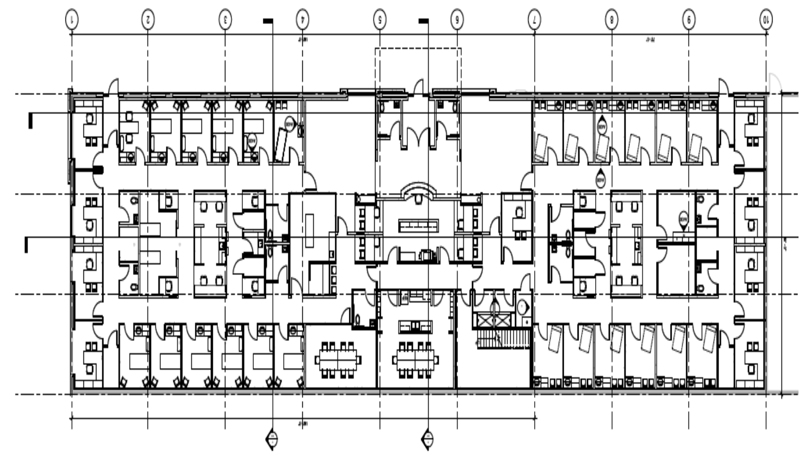
- Small diameter pipe
- No cutting concrete
- No dual containment pipe
- Installed in walls & ceiling
- Easily overcome obstacles

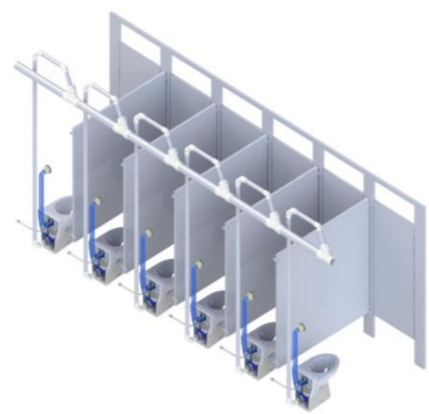
Vacuum less 80%

Brownfield Example

Total Cost

Vacuum 6% less





***Vacuum station includes an additional 10% in pump redundancy**


Q
&
A

OUTDOOR SYSTEMS

OUTDOOR SYSTEMS
Extent of Use

~400 municipal vacuum systems in North America including Puerto Rico & Bahamas

There are ~2,000 additional vacuum systems in 40 countries around the world

OUTDOOR SYSTEMS

States with Municipal Vacuum Systems

~400 vacuum systems in
32 states, PR & Bahamas

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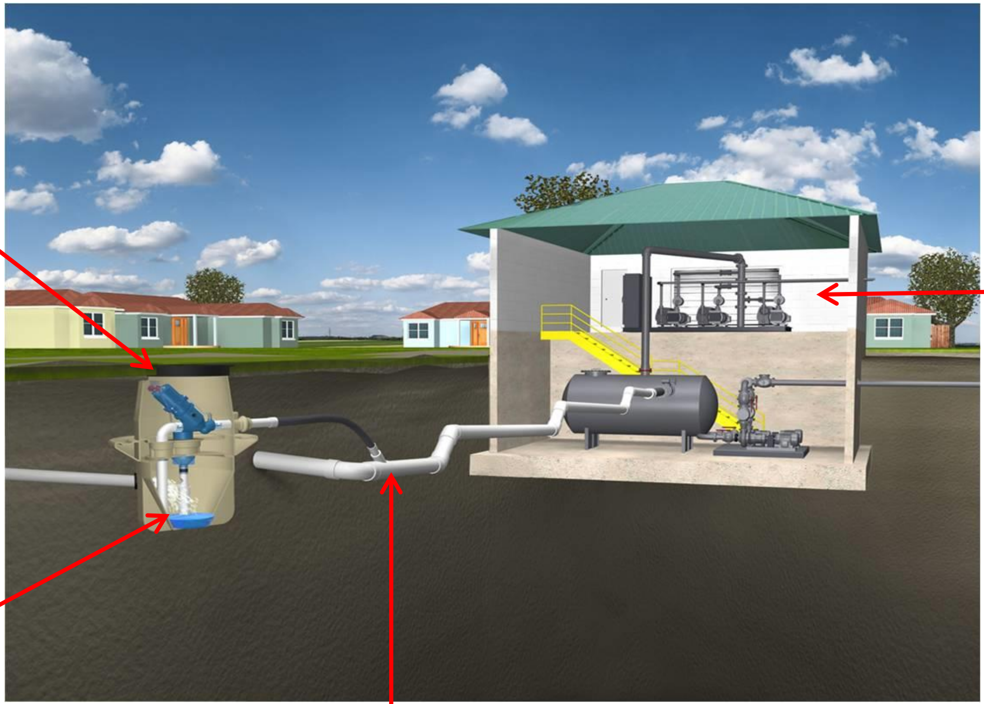
OUTDOOR SYSTEMS
How it works

As valves open and admit atmospheric air, vacuum levels will drop to 16" Hg. This is sensed at the vacuum station & the vacuum pumps come on to restore vacuum to 20" Hg.

3) A normally closed interface valve in the valve pit keeps vacuum on the main

4) Interface valve opens, contents sucked out, followed by atmospheric air and differential pressure propels sewage toward vacuum station



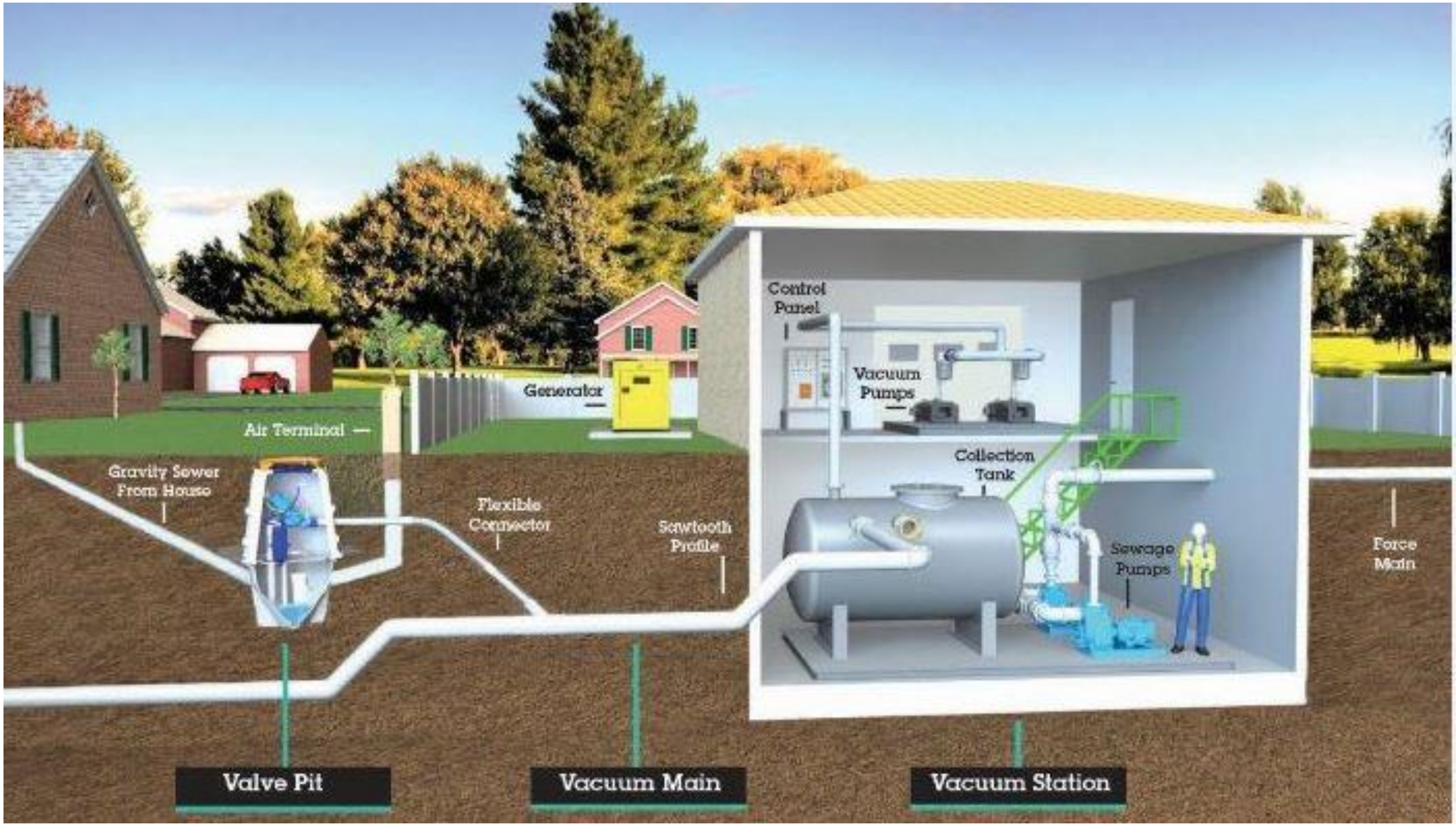
1) Vacuum pumps create a vacuum on the collection tank & then shut off

2) Vacuum mains connected to the tank extend the vacuum to each valve pit

OUTDOOR SYSTEMS
How it works—The Videos

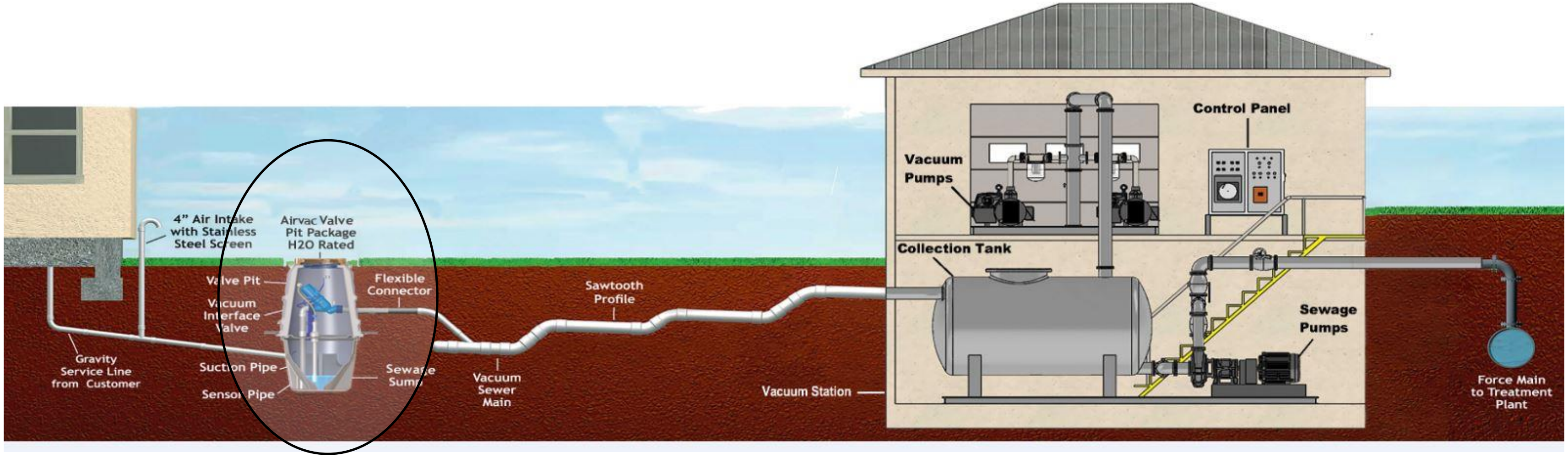
OUTDOOR SYSTEMS

Major Components



OUTDOOR SYSTEMS

Component 1: valve pit



Gravity flow from house to the valve pit

No electricity is required at the valve pit

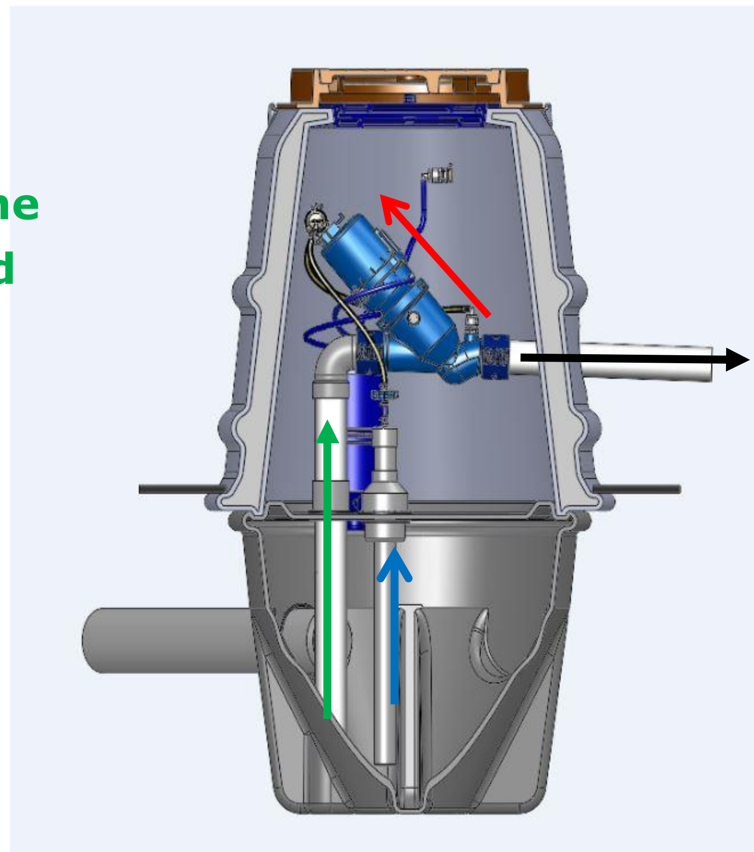
OUTDOOR SYSTEMS

Valve Pit Operation

Positive pressure:
Atmospheric air from Air Terminal

4) Differential pressure propels sewage toward vacuum station

Negative pressure:
Vacuum in main



3) Valve opens and the contents are sucked out of the sump via the suction pipe followed by several seconds of atmospheric air

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

1) As sump fills, air trapped in sensor pipe is transmitted via tubing to the valve controller

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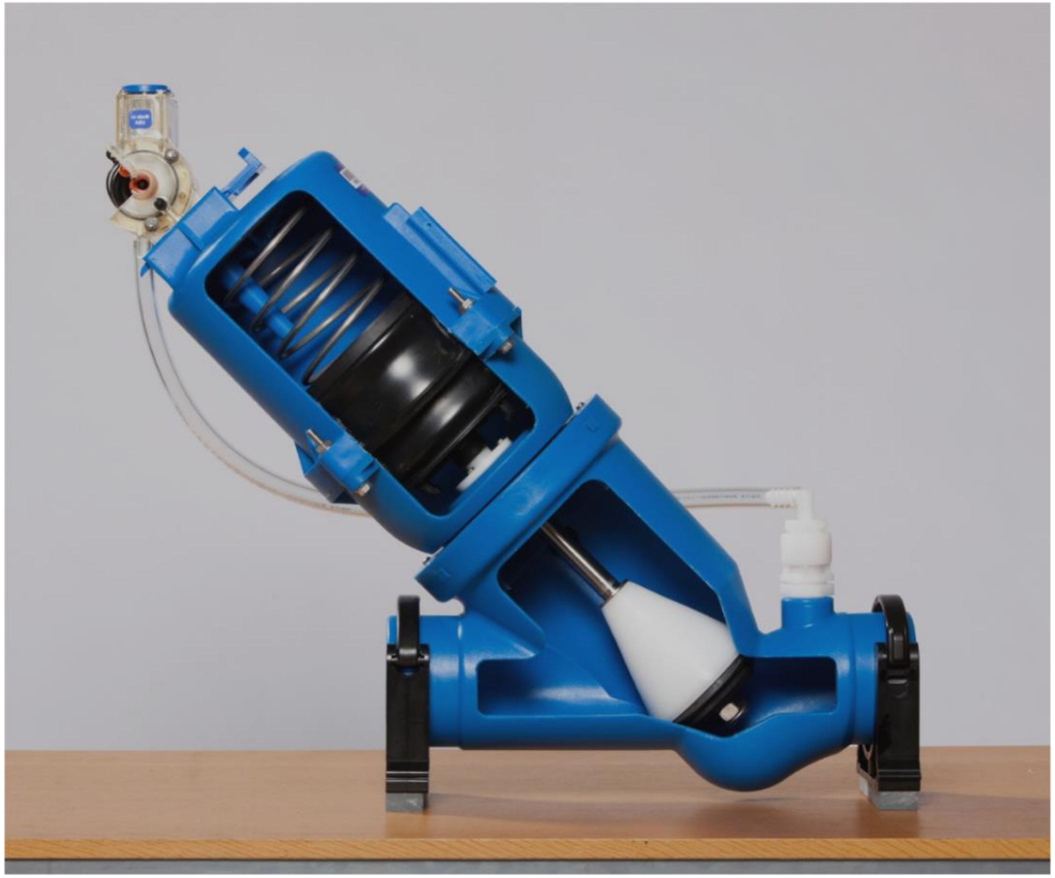
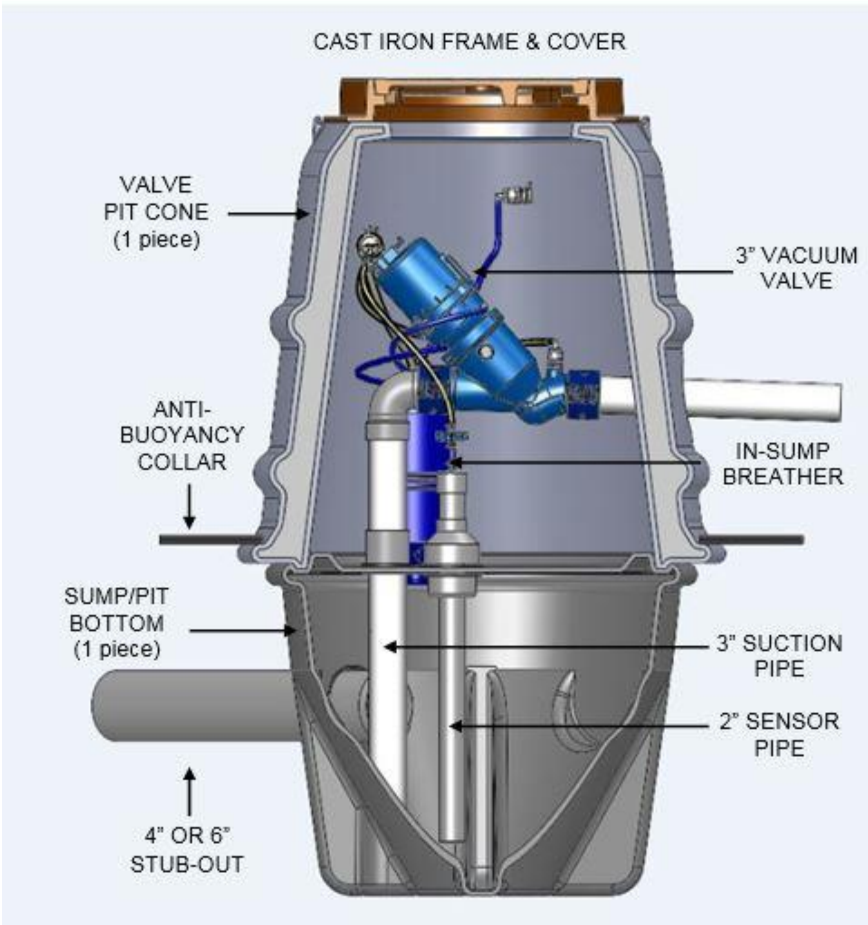
OUTDOOR SYSTEMS
Typical 3" Interface Valve



Shown is a cutaway Airvac 3" interface valve made in the US. Several foreign manufacturers make an interface valve that functions in a similar manner

- Vacuum valves are designed for Pneumatic operation- no electrical power is required
- Various sizes are available, but to meet codes, vacuum valves used in the municipal market must be capable of passing a 3" solid

OUTDOOR SYSTEMS
Typical Valve Pit Components



Shown is an Airvac valve pit. Valve pits are available from several manufacturers

All valve pits have the same basic components:

- A sewage sump
- A chamber to house the valve
- An interface valve
- Piping to transmit the sewage from the sump, through the valve and out to the vacuum main

OUTDOOR SYSTEMS
Cast Iron Valve Pit Covers

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

OUTDOOR SYSTEMS
Air Terminals

These are located near the valve pit in or near the R-O-W so that they are operator accessible

Air Terminal

Valve Pit

This has 2 functions:

1) source of atmospheric air

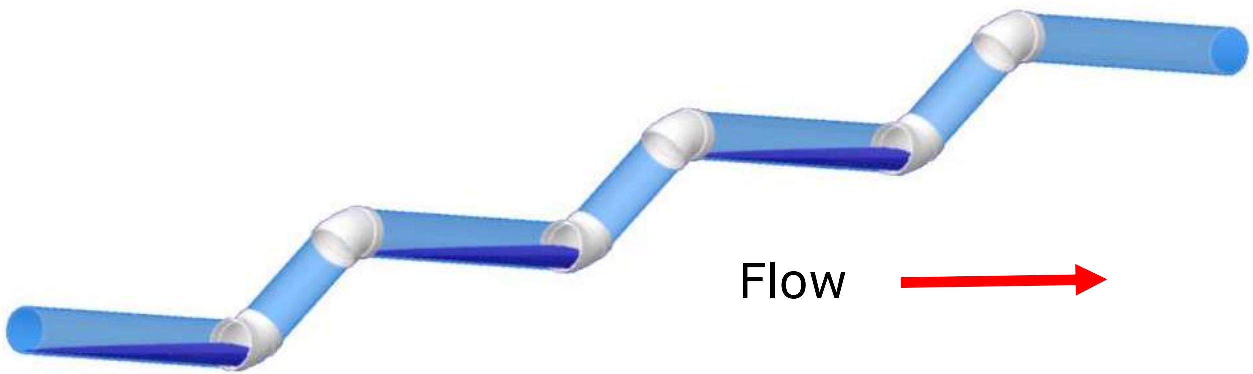
2) to prevent pulling traps dry

OUTDOOR SYSTEMS

Component 2: Vacuum Mains

OUTDOOR SYSTEMS
Sawtooth Profile ("Lifts")

Vacuum mains are laid with a sawtooth profile to ensures an open passage of air between the vacuum station and interface valve at the extreme end



OUTDOOR SYSTEMS

Pipe material

- 4″, 6″, 8″, 10″ & 12″
- SDR 21 PVC or Sch 40 PVC
- “Rieber” –style Gasket

OUTDOOR SYSTEMS

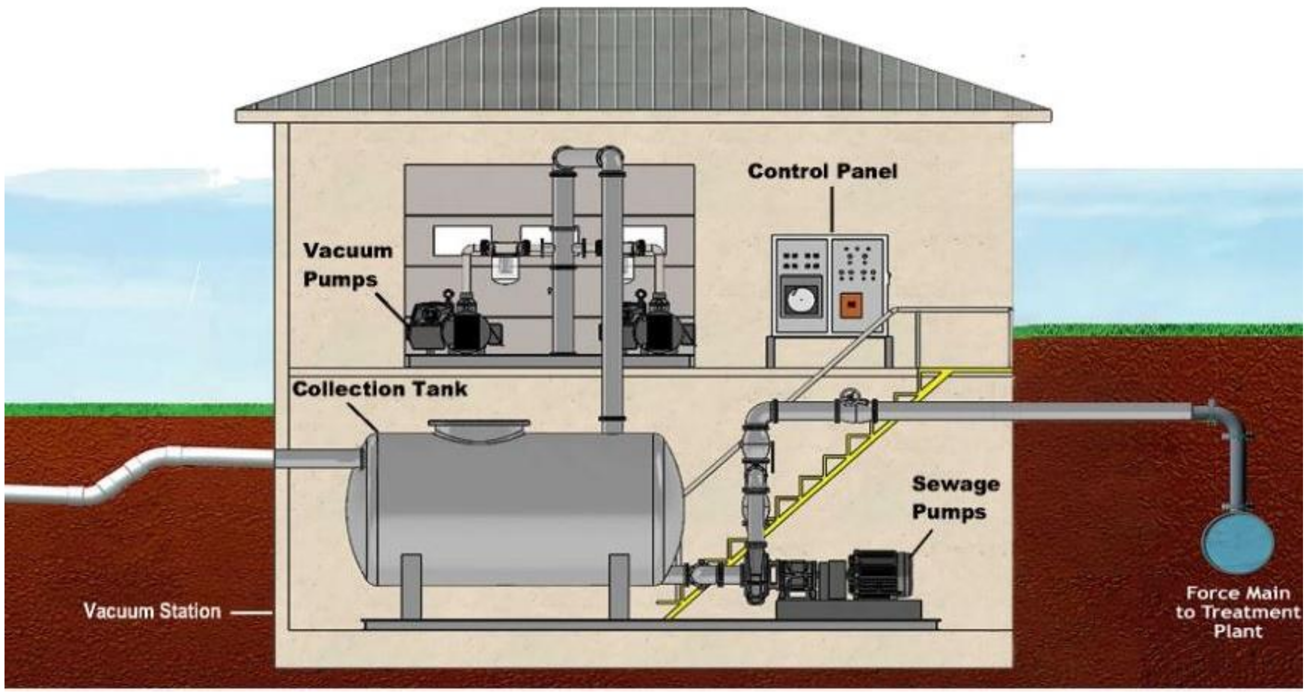
Component 3: Vacuum Stations

OUTDOOR SYSTEMS

Major Components: Vacuum Station

Equipment typically housed
in a 2 story building

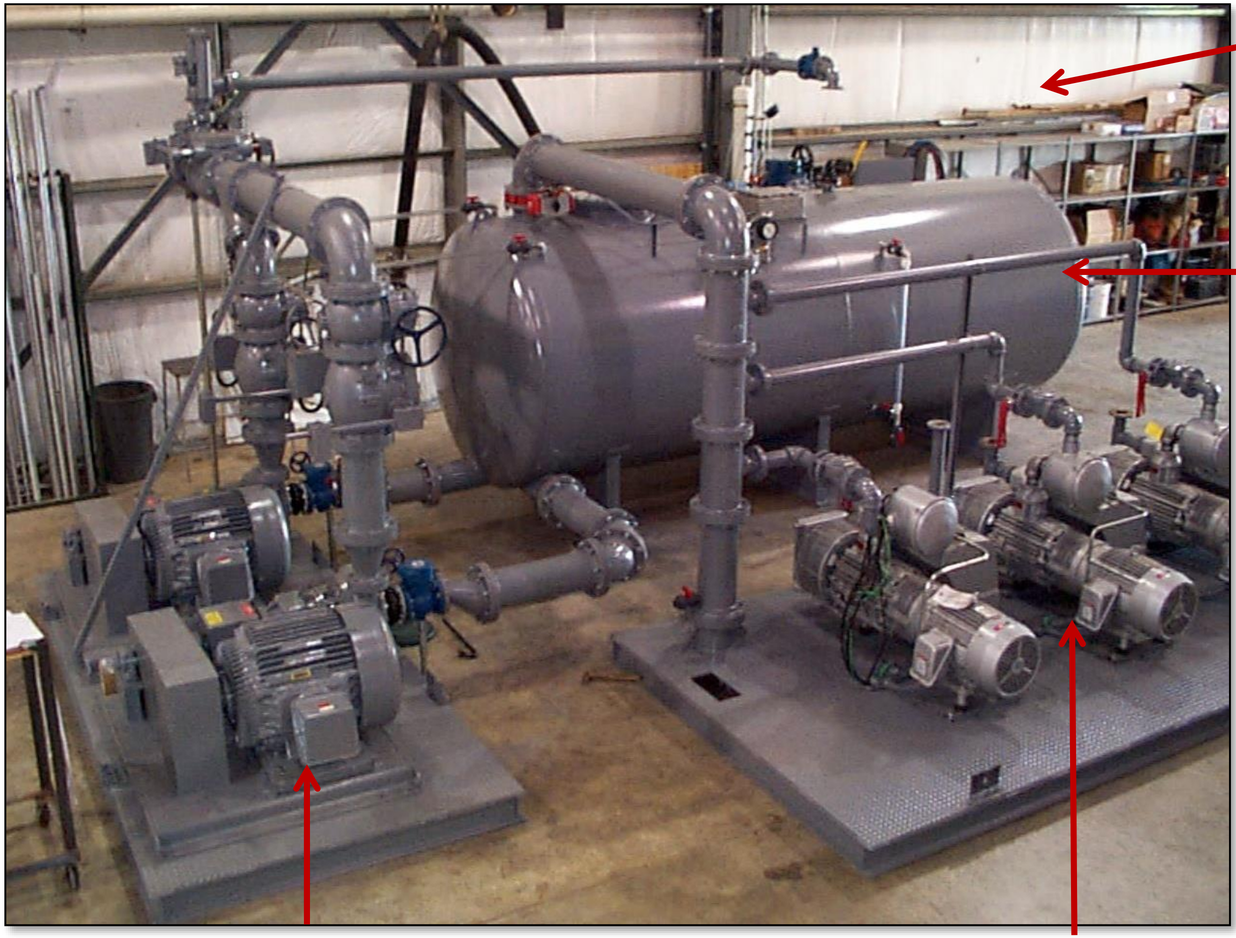
Vacuum
Pumps &
Control Panel
on ground
floor



Sewage Pumps & Collection
tank in basement

OUTDOOR SYSTEMS

Typical Vacuum Station skid



CONTROL PANEL
(on back side)

COLLECTION TANK

SEWAGE PUMPS

VACUUM PUMPS

OUTDOOR SYSTEMS
Emergency Generator

A standby generator provides uninterrupted service during power outages.

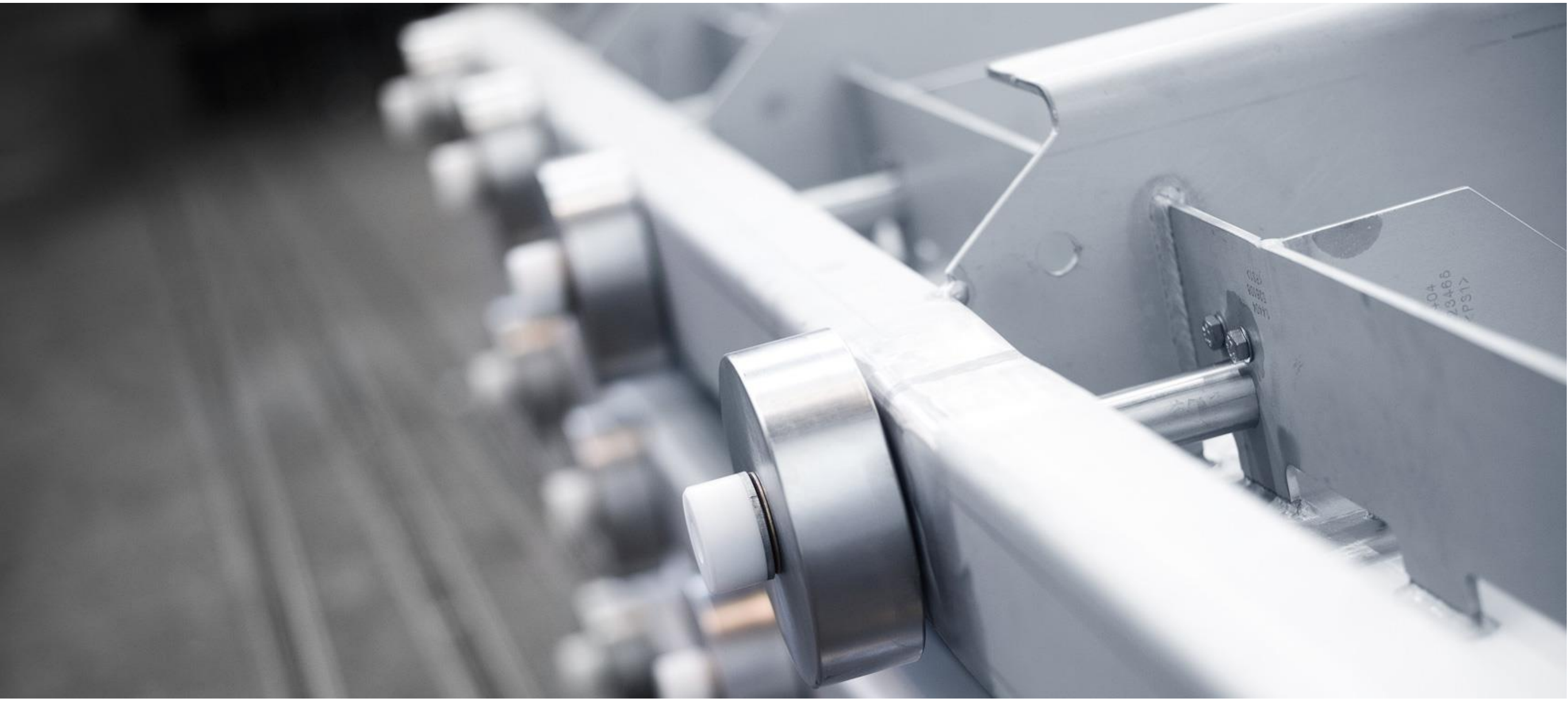
May be either a fixed, permanent generator or a portable generator

OUTDOOR SYSTEMS
Odor Control - BioFilter

Exhaust from vacuum pumps is distributed evenly throughout bio-filter

OUTDOOR SYSTEMS

Photos of Vacuum Stations



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Hooper, Utah Vacuum Station

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Alloway, NJ Vacuum Station

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OUTDOOR SYSTEMS
Plum Island, MA Vacuum Station

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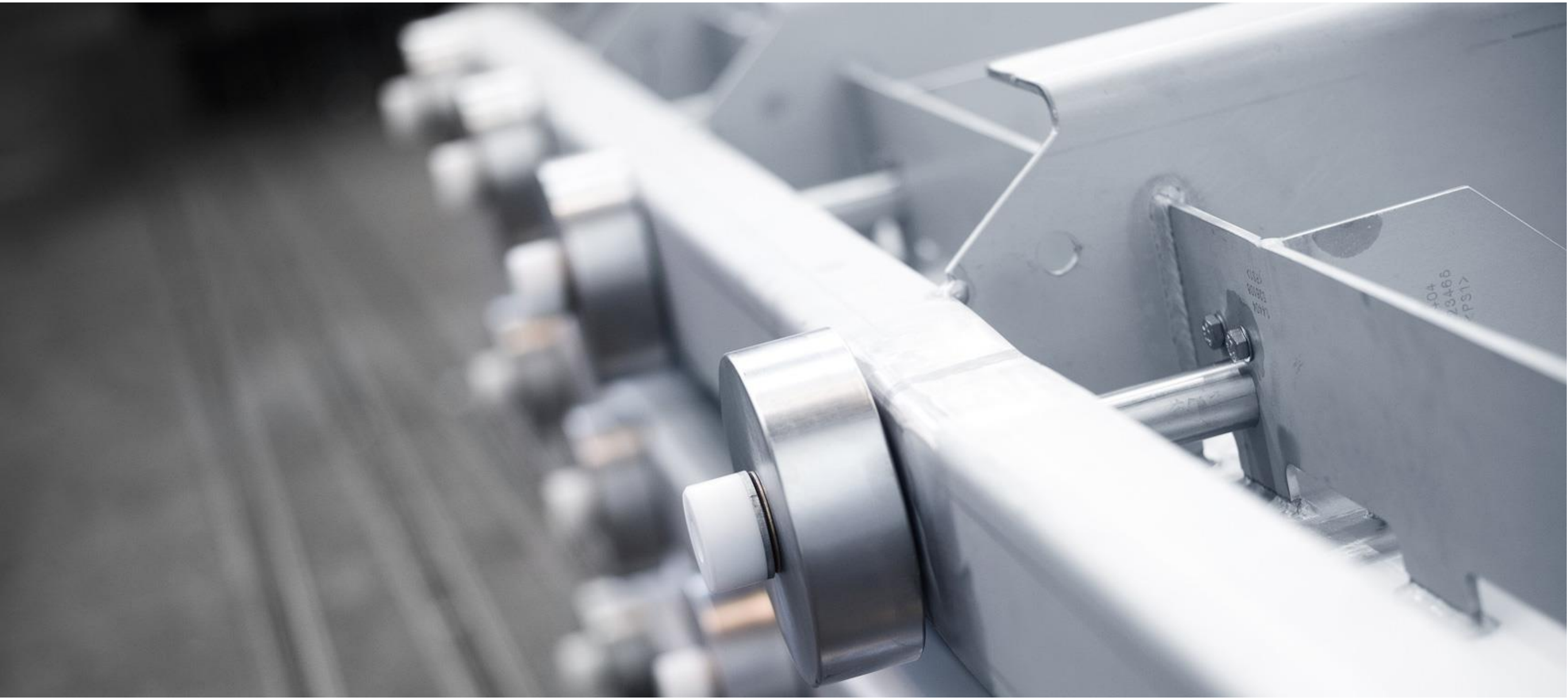
OUTDOOR SYSTEMS
Oak Island, NC Vacuum Station

OUTDOOR SYSTEMS

VA Beach, VA Vacuum Station

OUTDOOR SYSTEMS

Case Studies



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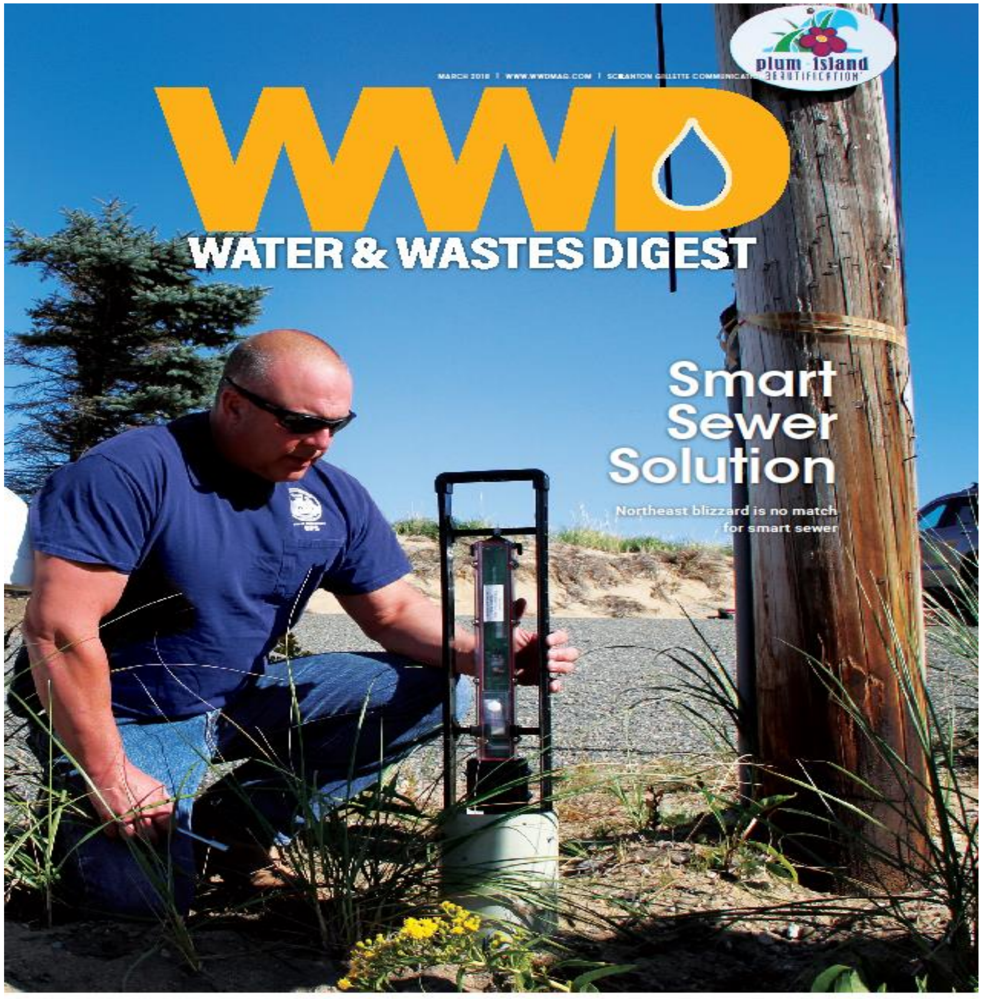
Outdoor Systems

SMART Sewer -Northeast Blizzard no Match for Smart Sewer



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Outdoor Systems
Case Study: *Plum Island, Newburyport, MA*

Background

Rising sea levels and sinking coastal plain have created unsafe conditions for septic systems in numerous locations in the coastal US including Plum Island

Situation

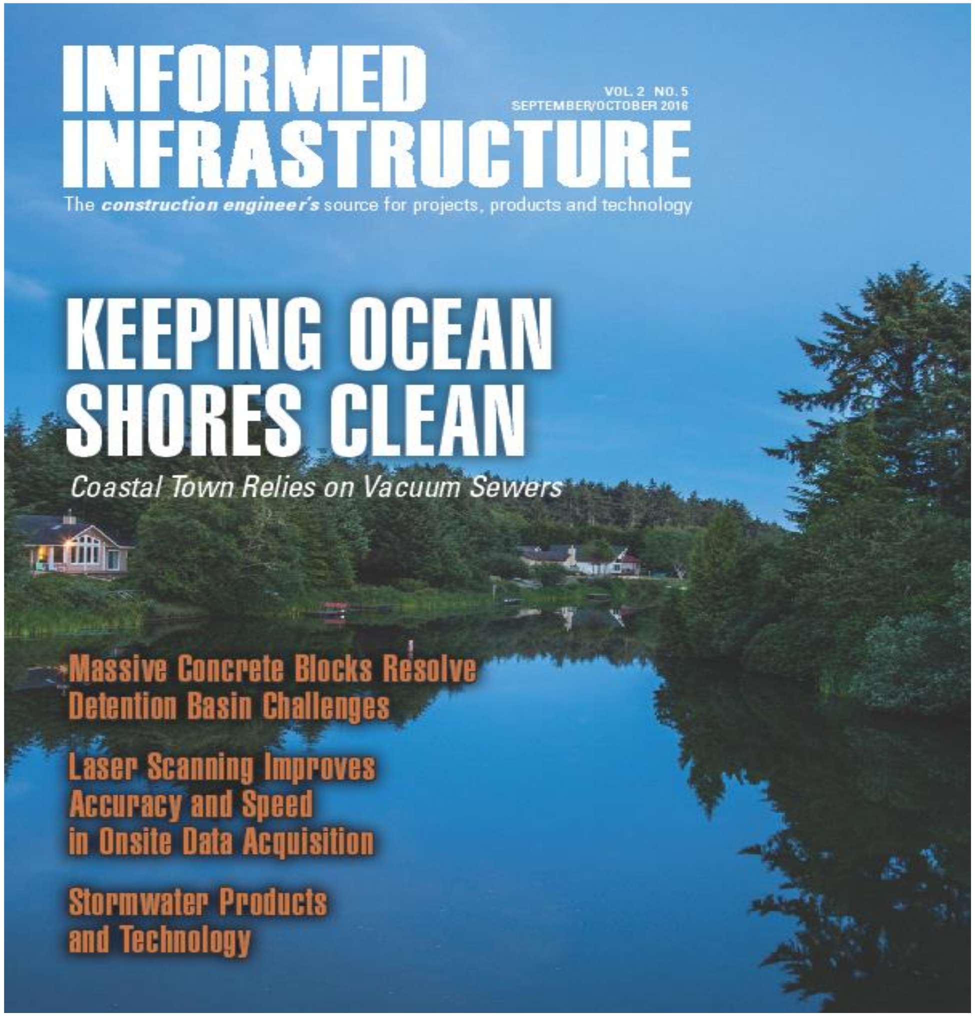
Barrier Island seasonal coastal community near NH border, installed our patented vacuum based sewer system. One vacuum station with over 600 valve pits connect this closed sewer system, which is highly sustainable and originally installed because of infiltration caused by failing existing and antiquated septic systems leaching into the groundwater and adjacent bodies of water.

Outdoor Systems
Case Study: *Plum Island, Newburyport, MA*

- Solution

In addition to a modern and environmentally sustainable sewer system, the City of Newburyport collaborated with our engineering team to develop a wireless customized monitoring and telemetry solution that reports real time conditions and locations of the valve pits and air terminals. Extreme weather conditions can sometimes bury these pits and terminals in upwards of 10 feet of snow in winter. As a result of this collaboration, future problems are more easily identifiable with significant downtime and the system is considered Best In Class in vacuum sewer technology by US EPA.

Outdoor Systems
Case Study: *Ocean Shores, WA*



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Outdoor Systems

Alloway Township, NJ

Tiny Alloway Township Saves Big with Vacuum Sewers

By Edwin Masker, Mayor, Alloway Township and Carl Gaskill, Public Engineer, Fralinger Engineering

No one will ever mistake Alloway for New York or Philadelphia. Alloway is a tiny town (population 2,500) located in the Southwest part of the state just a few miles from the Delaware River. Yet, Alloway has something that even major cities can only dream of—a state-of-the-art sewer system that's low maintenance and environmentally sound.

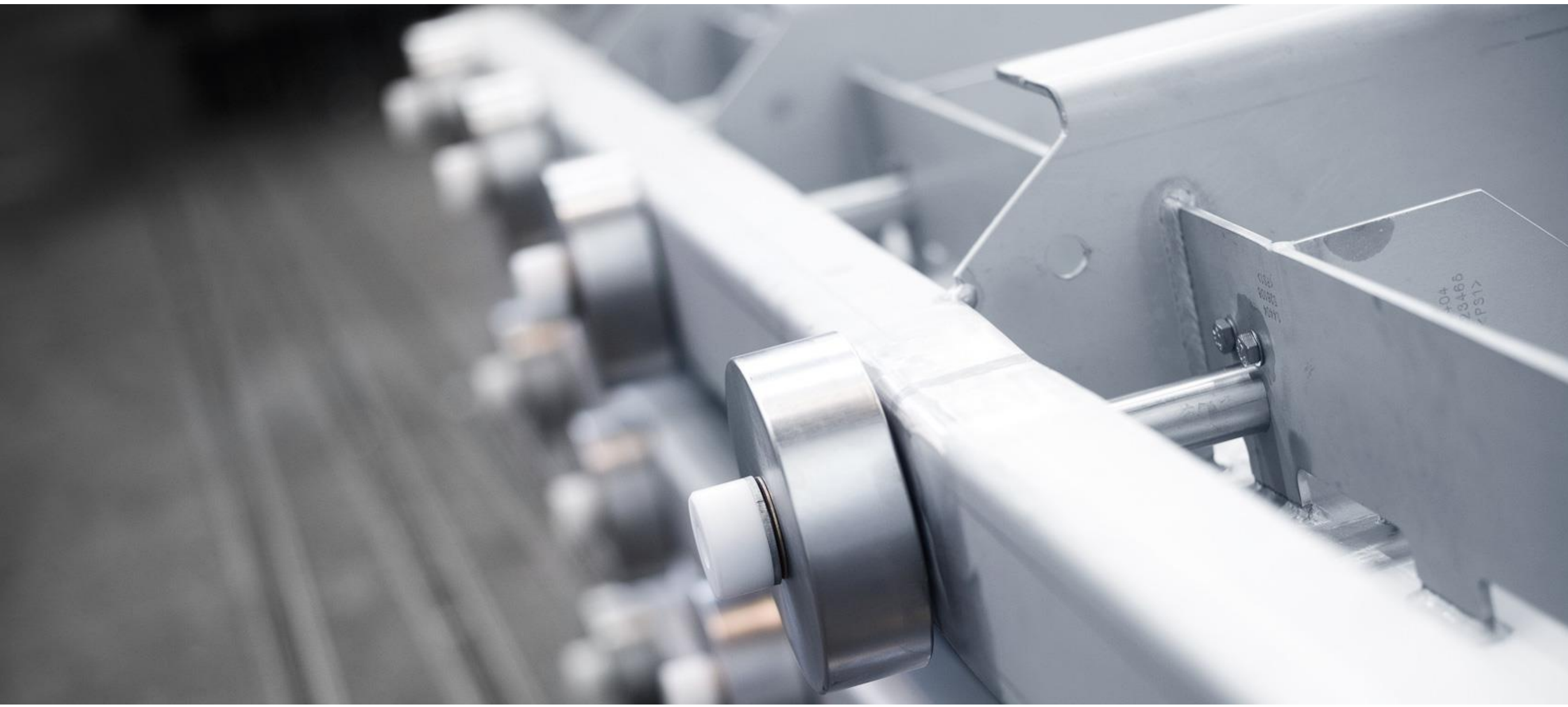
Alloway's new wastewater collection system, which was completed in September, 2009, is perhaps the most advanced sewer in the Mid-Atlantic region. Alloway is using vacuum sewer technology to convey the community's sewage to nearby Salem where the effluent is treated and discharged. The system replaces hundreds of septic tanks that were creating an environmental problem for local residents and New Jersey's Department of Environmental Protection.

INSTALLING AIRVAC SEWERS RATHER THAN GRAVITY SEWERS SAVED ALLOWAY TAXPAYERS APPROXIMATELY $1 MILLION, OR ABOUT $180 ANNUALLY FOR EACH USER OVER 40 YEARS.

Alloway had been looking to replace its septic tanks for decades. A new sewer was first proposed back in the early 1970s, but cost and inconvenience delayed the project until 2007. When engineers first looked at designing a conventional gravity sewer, they realized that Alloway presented numerous and significant installation obstacles.

Vacuum sewer installation causes minimal disruption to neighborhoods. Trenches are shallower, less excavation is required and streets can remain open to traffic.

Project Assistance & Support



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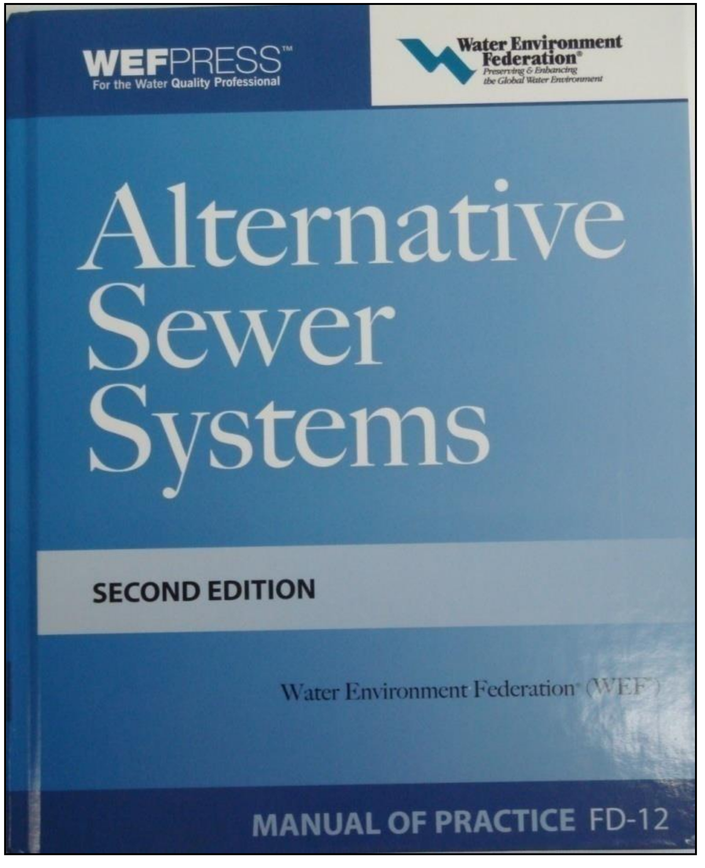
Water Environment Federation Manual

WEF MOP FD-12, 2nd ed



- > Contains most current information on vacuum sewers
- > Vacuum chapter authored by Rich Naret, P.E.
- > Includes sample regulations

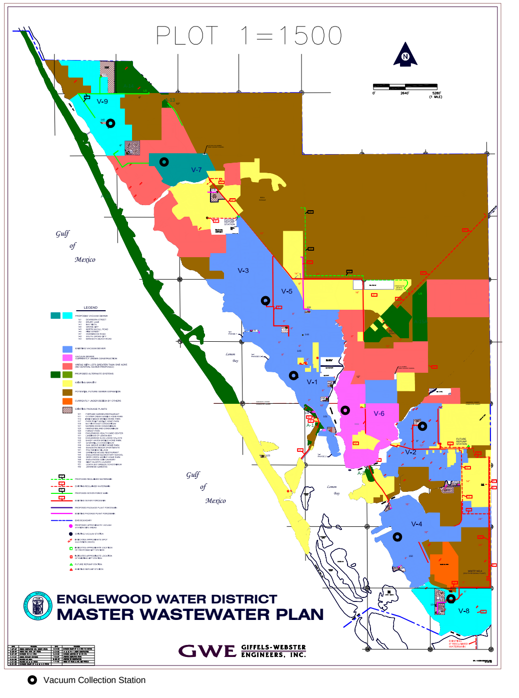
Preliminary Layout & Cost Estimate

Client provides:

- > Site plan defining service area
- > Topographic map (digital)
- > Flow data

AIRVAC provides:

- > System layout in ACAD
- > Technical report
- > Capital and O&M cost estimates
- > Supplemental information



Design Assistance

Once a decision has been made to use Vacuum, the following can be provided:

> Design seminar
> Standard details and specifications
> Vacuum station drawings
> Static and friction loss review
> Overall design review

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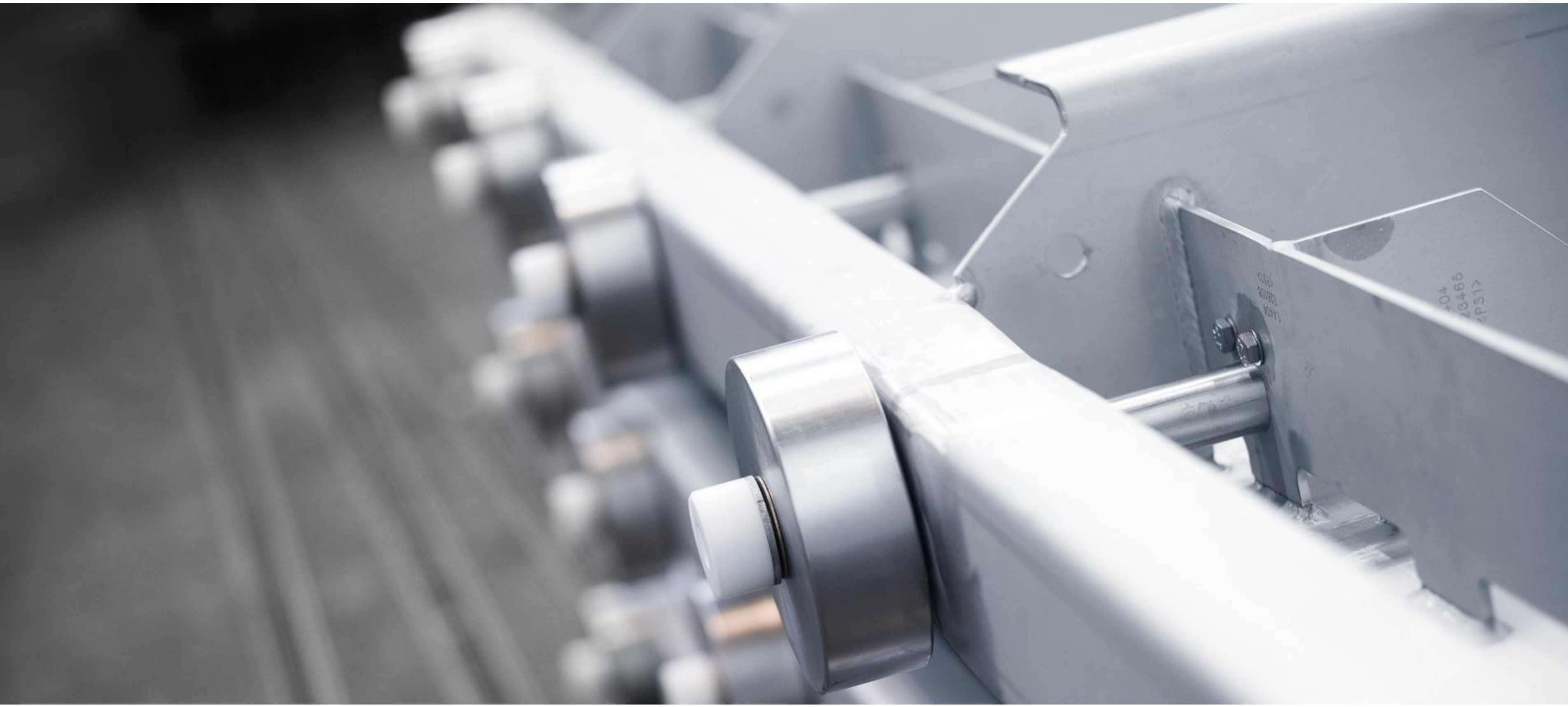
Cost Savings + Environmental Impacts



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Who Is A Candidate?

> Septic tank replacement projects
> Private development projects
> Failing gravity system replacement (CSO)


Where Does It Apply?

- Flat terrain
- High groundwater table
- Unstable and unsuitable soil
- Rolling hills
- Rocky terrain
- Sensitive eco-system

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Cost Savings

Shallow, narrow trenches =

Less excavation

Dewatering minimized

Smaller equipment

Smaller diameter pipes

1 vacuum station can replace 6
or 7 lift stations

(some that are deep)

Deep gravity lines = deep lift stations (can be 30^{+} ft deep)

OUTDOOR SYSTEMS

Advantage: Protects ecosystem

Completely sealed system

(no spillage = no permit violations)

Self scouring

(unlike gravity where period cleaning is req'd)

Infiltration & Inflow eliminated

A leak in a gravity sewer can go undetected/uncorrected and allowed to continue to pollute for a long period of time

A leak in a vacuum system is automatically detected and MUST be corrected for the system to continue to function economically

Reduced Impacts From Construction

> Less surface disruption

> Less restoration

> Less property disruption

> Vertical & horizontal routing flexibility

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Energy Conservation

No I&I = reduced wastewater load to treatment plant

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

1 Vacuum Station	7 Lift Stations
2 vacuum pumps	
2 sewage pumps	14 sewage pumps
4 pumps total	14 pumps total

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Operator Friendly

Completely sealed system = no operator contact with raw sewage

No confined space issues (no exposure to H_2S)

Customer Acceptance

Standby generator = uninterrupted service to the customer

Fewer lift stations = Fewer instances of “not in my backyard”

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Aesthetics

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

OUTDOOR SYSTEMS

Advantage: during Hurricanes

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

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