BILFINGER BERGER
Facility Services

ROEDIGER VACUUM

SAWEA Dinner Meeting

Vacuum Sewer Systems

An Economic Alternative to Conventional Gravity Sewer Systems“

19th June 2011
Holiday Inn Corniche, Al Khobar, KSA

الجمعية العربية السعودية للبيئة المائية
Saudi Arabian Water Environment Association

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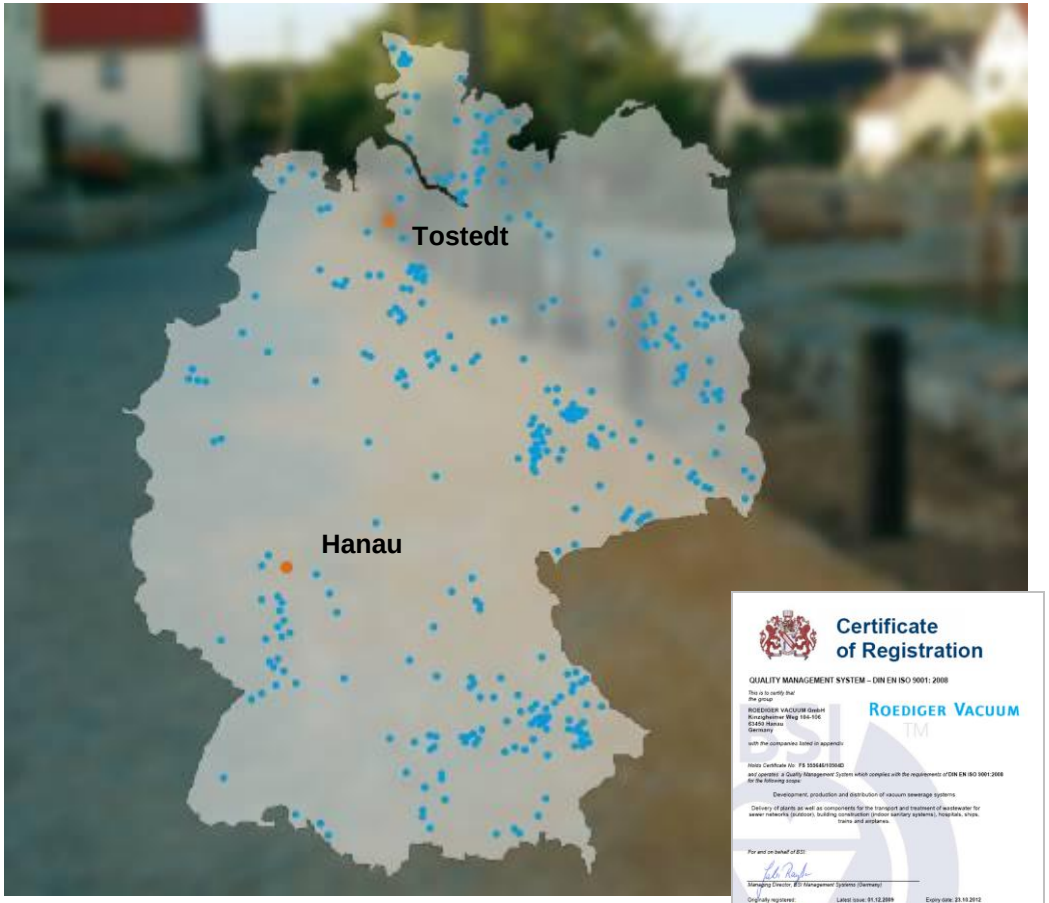
Vacuum Sewer Systems

Brief introduction of the company and activities in the Middle East

The Company



Certificate of Registration

QUALITY MANAGEMENT SYSTEM – DIN EN ISO 9001: 2008

ROEDIGER VACUUM

- Established 160 years ago and belongs to the Bilfinger Berger Multiservice Group
- World Market Leader for vacuum sewer and sanitation systems with more than 1500 vacuum sewer installations of the group worldwide
- Trained partners and own engineers in more than 50 countries world wide
- DIN EN ISO 9001 production facility close to Hamburg, made in Germany
- Head Office close to Frankfurt am Main
- Huge team of professional engineers and own technical personnel all over the world

The Company - Activities in Middle East

Activities in Middle East

- Active in the UAE since almost 10 years
- Middle East Office in Dubai since 2005 with own dedicated engineers
- Official Distributors in the UAE, Oman, Qatar and Bahrain
- Installations in UAE, Oman, Qatar, Bahrain and Kuwait
- More than 3000 vacuum valves distributed to the Middle East

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Vacuum Sewer Systems

Technical introduction, Benefits, Limitations, Application Fields

The Technology

Key questions

- What are vacuum sewer systems?
- What are the advantages?
- How does it work?
- Application fields!

The conventional way

What are vacuum sewer systems

Vacuum sewer systems are…

- **Collection Systems** for domestic waste water
- **Easy to install** systems for waste water within low and medium dense residential, industrial, commercial or mixed use areas
- **State of technology**, eco-friendly, safe and operator friendly systems (DWA-A 116-1, EN1091)
- **Alternatives for conventional gravity sewer systems** under difficult conditions

Vacuum sewer systems are NOT…

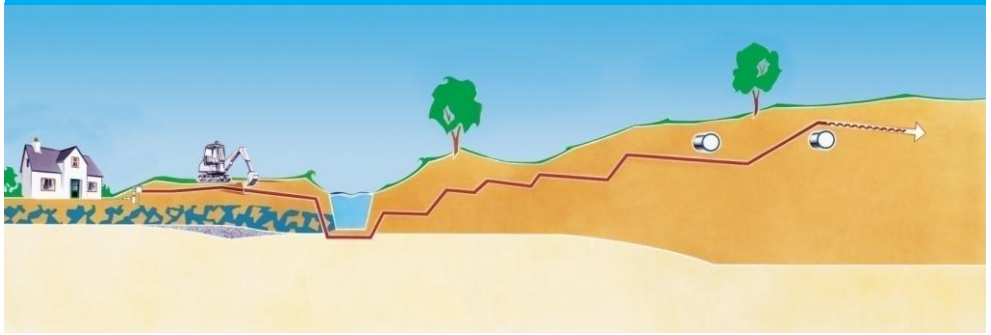
- Transportation system for waste water (pumping station replacement)
- Main collectors for large sewer systems

How does it work?

Please **click on Image** to start animation

Advantages_Construction

Vacuum sewer system



Gravity sewer system

- **Small pipes**, flexible installation (90-250mm)
- **Shallow and small trenches** (average 1.2m deep)
- **No manholes, no lift stations**
- Centralized vacuum station instead of many lift stations
- Saving of construction time
- Saving of construction and operation costs

Advantages_Construction

Advantages – Operation

Worker suffocates to death in sewage hole

- Centralized vacuum station: Energy supply, maintenance and operation from one central location
- **Maintenance free pipe network**, no sedimentation
- Minimum maintenance at vacuum valves and collection chambers
- Full remote monitoring of valves and vacuum station is possible
- **No hazardous conditions for maintenance personnel** (no manholes)
- **Less H_2S and other fouling gases**
- No dumping of solid waste possible
- Comparable low energy costs

Advantages - Eco Friendly

- **Exfiltration free** – No contamination
- **Infiltration free** – Reduced flows
- Minimum impact to the environment from construction
- Fresh water saving as no flushing is required for the pipe network
- Vacuum sewer systems are the only systems allowed to be installed in ecologically sensitive areas and drinking water protection zones
- Vacuum sewer system are the only systems allowed to be installed in the same trench with drinking water pipes
- No Odors

Application fields

“The more problems a gravity system has, the more interesting a vacuum system gets!”

- The following conditions will benefit a vacuum sewer system:
  - **Flat terrain** und lack of natural slope
  - **Little flows and long distances** within expanded municipalities with
  - **Seasonal flows** within Resorts
  - **High ground water** tables
  - **Unstable underground** (Rocky, sandy or swampy)
  - **Ecologically sensitive** areas
  - **Existing infrastructure,** limited construction space

Application fields

Typical and most common application fields

- **Low dense** residential, industrial, commercial or mixed used **developments**
- Holiday resorts with villas and bungalows and/or seasonal flows
- Marinas, Corniche promenades and harbours
- Rehabilitation of existing sewer systems
- Installation of sewer systems within existing developments (e.g. old town or village areas with septic tanks)
- Natural or artificial Islands, reclaimed land
- Flood areas or areas exposed to sea and river tides

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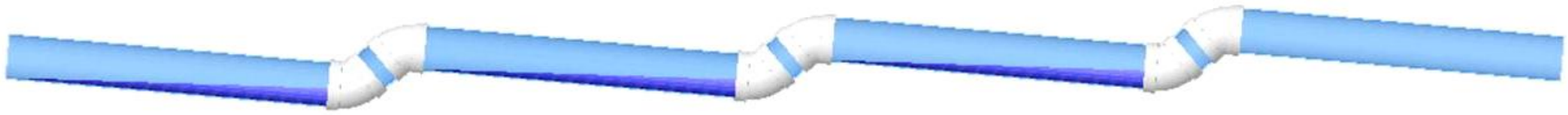
Vacuum Sewer Systems

Design Aspects, Components and Feasibility Aspects

Design Aspects

General design aspects

- Vacuum Sewer Systems are designed similar to gravity sewer networks under consideration of its advantages
- Vacuum Sewer Systems collect waster water from individual buildings and transport the collected waste water to a central vacuum station by means of negative pressure and air
- A **saw-tooth profile** has to be considered for the pipe profile
- No manholes are required



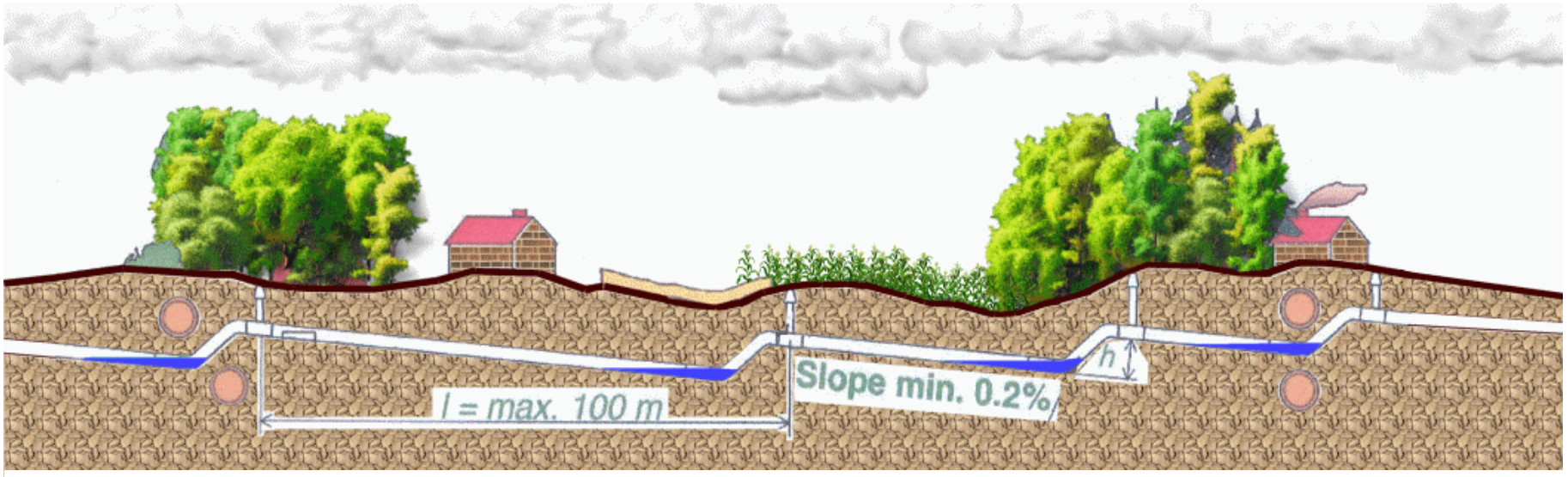
Design Aspects

The saw-tooth profile

- Air based transport of sewage
- A sawtooth profile will create small water pockets at lift low points
- Air-stream and turbulences will transport sewage water when vacuum valves open

Advantages

- Constant aeration of sewage water
- High velocities, no sedimentation
- Shallow pipes



Design Aspects

Design parameters

- Vacuum sewer systems use **standard design parameters for sewage systems** to dimension pipe networks and vacuum station
  - Daily flows per capita (usually 200-280 l/d•PE)
  - Peak factor (usually 3-4)
  - Air-to-liquid-ratio ALR (usually 5-10)
- Vacuum sewer systems might allow lower design flows per capita as any infiltration water can be terminated
- Vacuum sewer systems can be adapted to local design guides and requirements

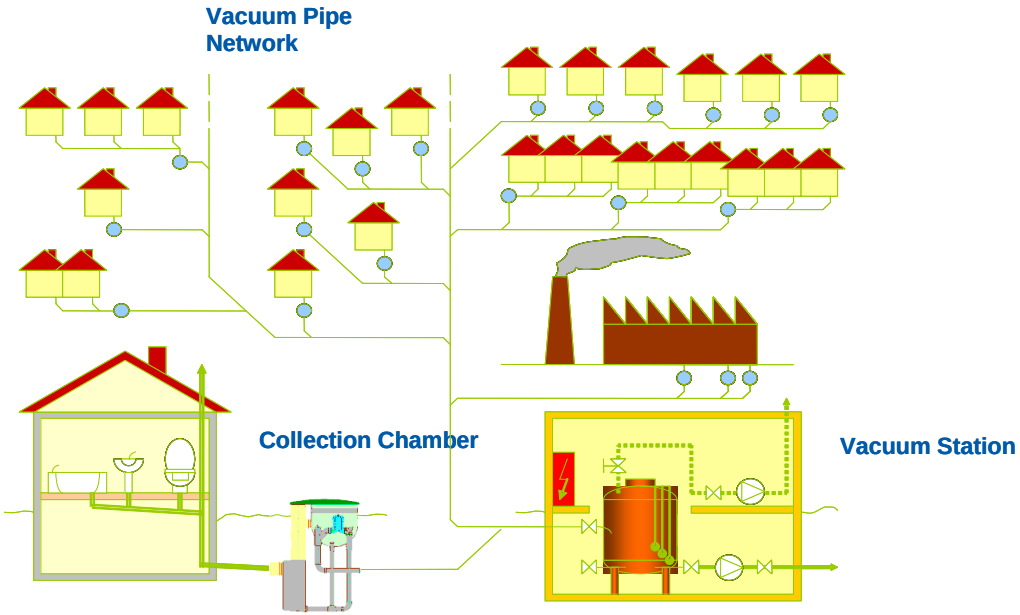
Design Aspects

Vacuum sewer systems have hydrostatic limitations

- The number of lifts within a saw-tooth profile (total head) is limited
- The following formula applies
  - The total hydrostatic lift height within a vacuum line may not exceed 4.0 m
  - $\sum h = \sum (H\text{-}D) \leq 4.0m$
    - h = hydrostatic lift height
    - H = lift height
    - D = internal diameter of the pipe
- This results in
  - **maximum 4 km long vacuum lines** in flat areas
  - **or a maximum catchment diameter of 8 km** around the central vacuum station

Components of Vacuum Sewer Systems

- Vacuum sewer systems contain of 3 main components
  - Central vacuum station
  - Collection chambers (with valves)
  - Vacuum pipe network



The collection chambers

- **Pre-manufactured** collection chambers (Interface Chambers)
- Collection chambers for **different load conditions**: pedestrian load, traffic load or special applications such as water villas
- Roediger Vacuum collection chambers are **durable, light weight, easy to install** and very maintenance friendly

The collection chambers

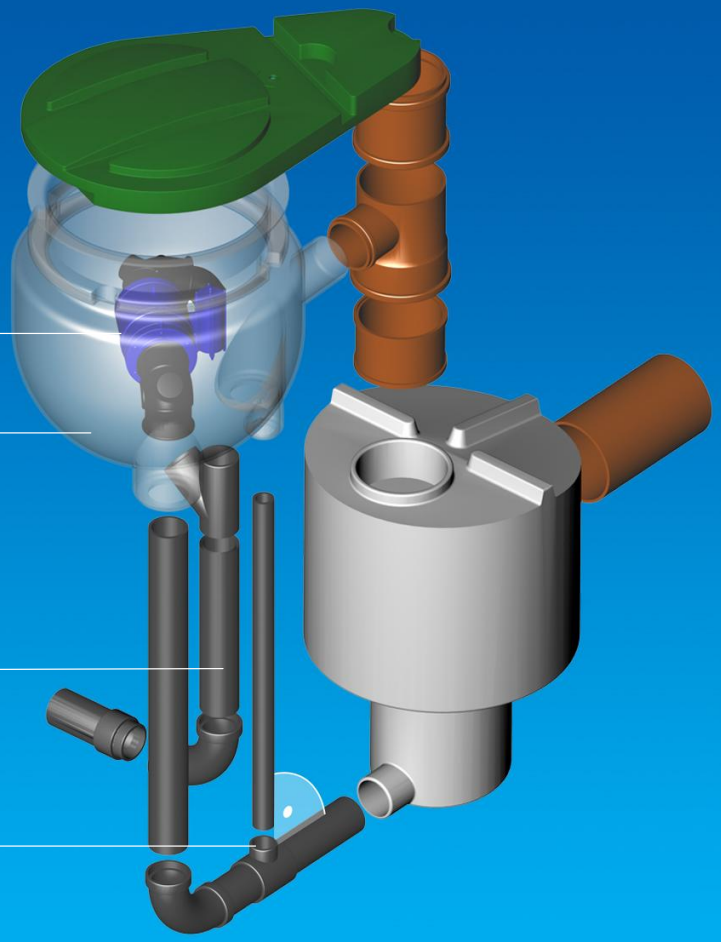
Separation between the vacuum valve unit and the waste water sump

Chamber body made of infiltration proof PE

Patented system

Flexible installation depths

Self-cleaning sensor pipe,
due to 90° connection with suction pipe



The collection chambers

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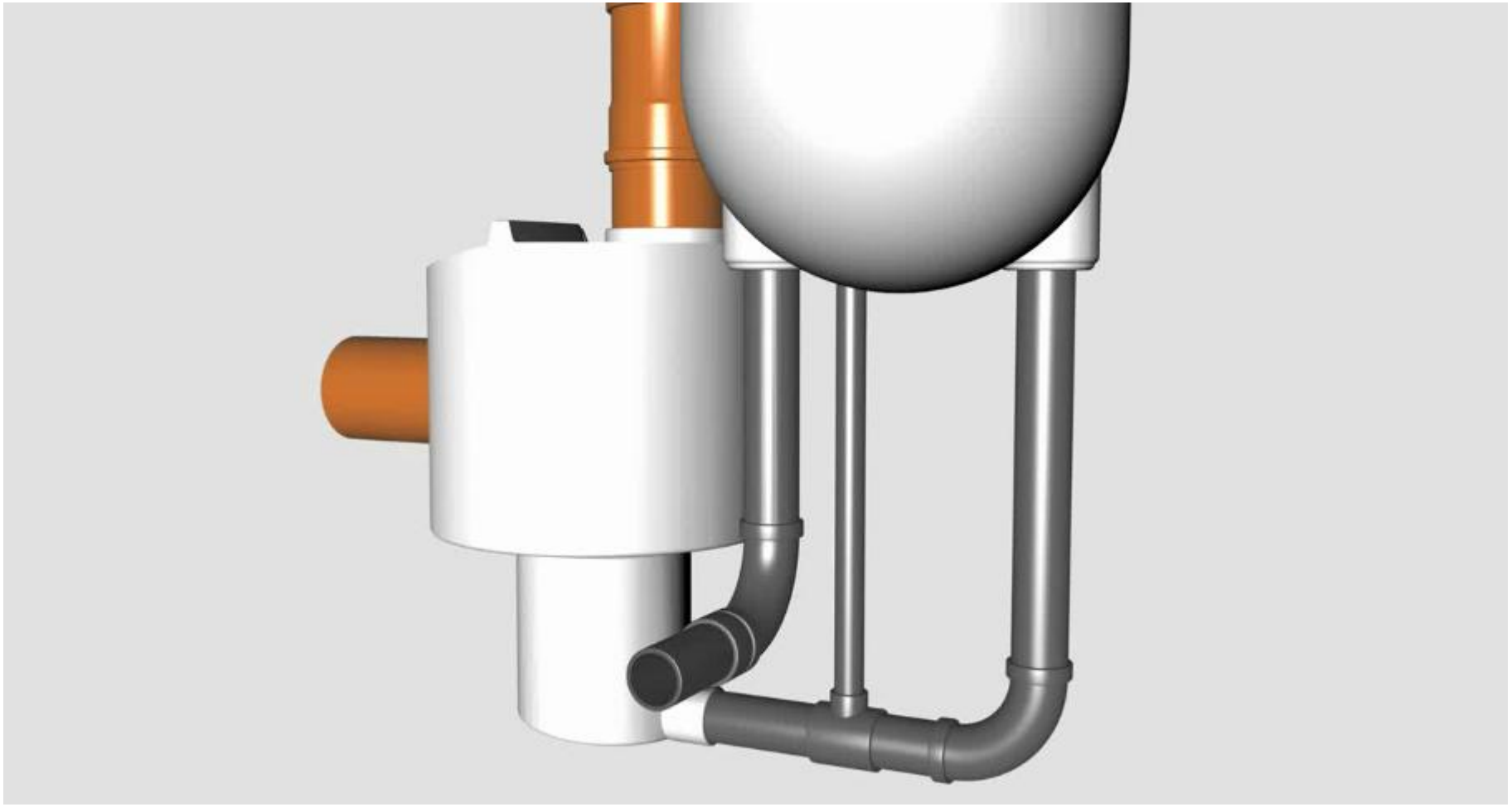
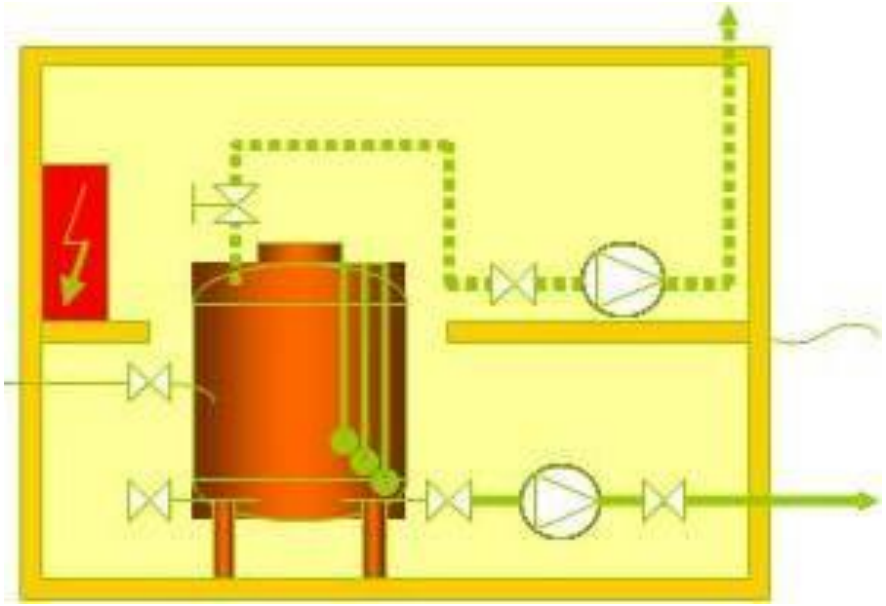


The vacuum station

- Only source with energy consumption
- Central point for maintenance and operation

- Main components
  - Vacuum pumps
  - Vacuum tank
  - Discharge pumps
  - Motor control centre (MCC)



The vacuum station

- Typical arrangement of 3 x 15 KW vacuum pumps (sufficient for approx. 2.000 - 2.500 PE)

The vacuum station

- A typical 25m³ vacuum tank during construction of the vacuum station

The vacuum station

- Different vacuum station buildings

The vacuum station

- Different vacuum station buildings

The vacuum station

- Typical MCC for vacuum stations

VDE German Standard

BS Standard form 3b

Feasibility and Cost Aspects

What does it cost?

- Costs vary depending of network size and project specifications
- **The cost saving factor is the network itself**, so a minimum project size is required to be competitive
- Vacuum sewer systems can achieve up to 25-40% costs savings compared to gravity sewer systems considering all aspects of construction

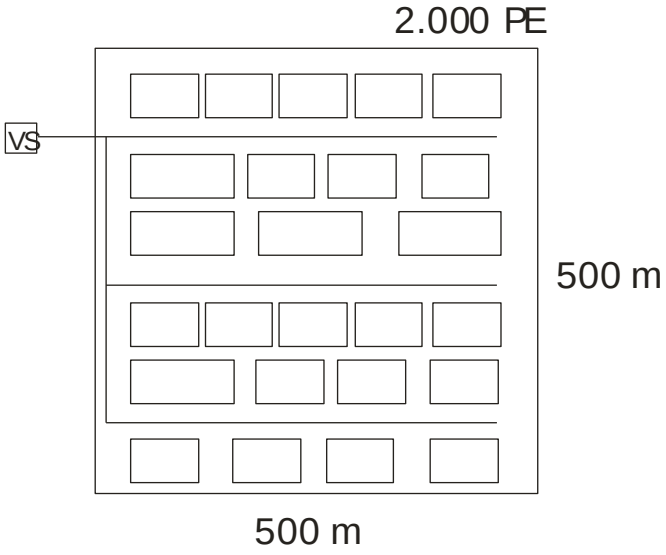
Again!

- Vacuum sewer system do not require manholes
- Trenching is limited to average 1.2 - 1.5m depth
- No interim pumping station for large networks in flat terrain
- Central M&E and central odour control

Case studies

Example A: High dense, compact area

- Characteristic
  - Small and compact area → Short pipe network, shallow
  - Apartment blocks, high rise → High flows
  - Straight roads → Few manholes required



Case studies

Example A: High dense, compact area

- **Vacuum costs:**

Pipes:	2.000 m x 50 €/m	=	100.000 €
Collection chambers:	100 CC x 2.000 €	=	200.000 €
Vacuum station:		=	200.000 €
Total:			**500.000 €**

- **Gravity costs:**

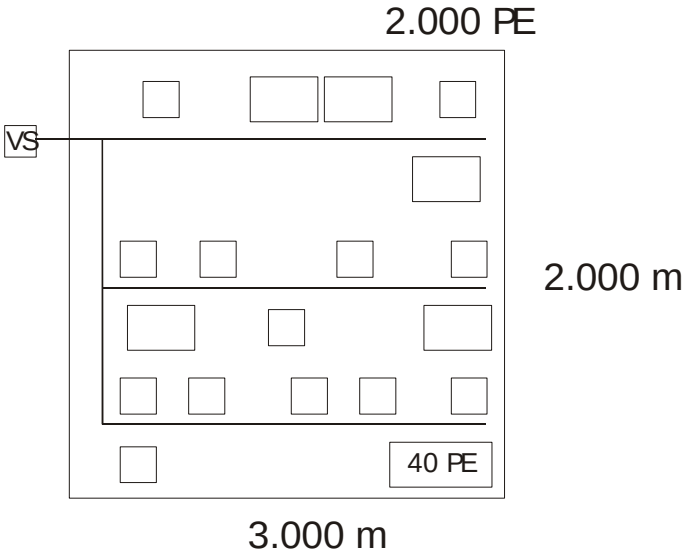
Pipes:	2.000 m x 100 €/m	=	200.000 €
Manholes:	40 x 300 €	=	15.000 €
Pump station:	1 x 50.000 €	=	50.000 €
Total:			**275.000** €

Note: Actual costs are depending on local prices, contractors, soils, etc.

Case studies

Example B: Low dense, wide area

- Characteristic
  - Wide area, non symmetric development → Long pipe network
  - Villas, town houses → Little flows spread over the area
  - Winding roads, not symmetric → Lots of branch connections



Case studies

Example B: Low dense, wide area

- **Vacuum costs:**

Pipes:	10.000 m x 50 €/m	=	500.000 €
Collection chambers:	130 CC x 2.000 €	=	260.000 €
Vacuum station:		=	200.000 €
Total:			**960.000 €**

- 30 %

- **Gravity costs:**

Pipes:	10.000 m x 100 €/m	=	1.000.000 €
Manholes:	200 x 300 €	=	60.000 €
Pump station:	4 x 50.000 €	=	2000.000 €
Total:			**1.260.000** €

Note: Actual costs are depending on local prices, contractors, soils, etc.

Operation and maintenance

Every sewer system requires operation and maintenance!

- Vacuum sewer systems require operation and maintenance, too!
- Maintenance works to be done mainly at the central vacuum station
- Little maintenance for the collection chambers and valves
- No maintenance for the pipe network

The myth: Gravity sewer systems are maintenance free!

The truth: A whole industry is built up for gravity sewer maintenance!

Operation and maintenance

Vacuum sewer system

Labour

- Regular check of vacuum station
- Annual check-up of collection chambers
- Odour control only at vacuum station (tight system)

Replacement/repair

- Lubricants and filters for vacuum pumps
- Valve parts (few pieces, membranes)

Gravity sewer systems

Labour

- Regular check of manholes
- Pipeline inspection, CCTV inspections
- Cleaning of sedimentations, slime and debris (jetting with high-pressure)
- Flushing of lines
- Odour control along the whole network (open system)

Replacement/repair

- Oil for lifting station pumps
- Manhole/Sewer rehabilitation

Operation and maintenance

Vacuum sewer system

Electricity consumption

- Electricity consumption of vacuum station (approx.10-20 kWh per capita and year)
- Only one central power supply at vacuum station

Cleaning the system

- Self cleaning due to high velocities

Sewage treatment

- Only waste water, no surface or ground water
- Constant aerated waste water
- No illegal connections possible; closed system

Gravity sewer systems

Electricity consumption

- Electricity consumption of lift- and pump stations
- Power supply for each and every pump and lift station

Cleaning the system

- H_2S deodorization
- Cleaning of pipes and manholes

Sewage treatment

- Waste, surface and ground water due to infiltration
- Aged and septic wastewater, major solids
- Illegal (storm water) connections

Operation and maintenance

Vacuum sewer system

Operation Safety

- No risks for operators at all
- No direct contact with waste water
- No open wet wells
- No manholes
- Less septic gases such as H_2S

Gravity sewer systems

Operation Safety

<u>Atmospheric hazards in confined spaces:</u>

- Low oxygen conditions
- Significant hydrogen sulphide (H_2S)
- Explosive concentrations of methane

<u>Physical hazards with confined space entry</u>

- Falling objects into manholes and wet well
- Ladders, high platforms

<u>Biological hazards:</u>

- Germs, diseases, viruses
- Pathogenic organisms
- Insects, animals
- Bad smell along the lines and manholes


Worker suffocates to death in sewage hole


Investigations launched after accident leaves one man dead

Trench collapse tragedy

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RoeVac® Vacuum Sewer Systems

References in the Middle East

References and application examples

The Palm Jumeirah, United Arab Emirates

- 2,300 villas
- 1200 vacuum collection chambers
- 23,000 PE
- No network manholes
- Shallow trenches
- One central vacuum station instead of several pump stations
- Saving of construction cost and time

References and application examples

The Palm Jumeirah, United Arab Emirates

2300 Villas

References and application examples

The Palm Jumeirah, United Arab Emirates

Only one central vacuum station

References and application examples

Durrat Al Bahrain, Bahrain

References and application examples

Durrat Al Bahrain, Bahrain

- 11 islands
- 10,500 PE
- 28 km vacuum lines
- 440 vacuum collection chambers
- Only 3 vacuum stations
- Short construction time
- Saving of construction costs

References and application examples

Durrat Al Bahrain, Bahrain

Up to 4 villas are directlz connected to 1 collection chamber.

No requirement for concrete manholes on the plots.

References and application examples

Qatalum Aluminium Plant, Qatar

References and application examples

Qatalum Aluminium Plant, Qatar

- Client: Qatalum (JV Qatar Petroleum + Hydro)
- Designer: SNC Lavalin, Canada
- 5.5 km pipe network
- 63 vacuum collection chambers
- 1 Vacuum Station
  - 20m³ vessel
  - 6 x 5.5 KW vacuum pumps
  - 2 x 13.5 KW discharge pumps

References and application examples

Qatalum Aluminium Plant, Qatar

References and application examples

Qatalum Aluminium Plant, Qatar

- All sewage water is collected with a vacuum sewer system
- Heavy traffic load collection chambers
- Highest project standards to be followed.
- Coordination with an industrial underground “life”.

References and application examples

Qatalum Aluminium Plant, Qatar