

《室外真空排水系统工程技术规程》

前言

根据“中国工程建设标准化协会 2004 年第一批标准制、修订项目计划的通知”，以上海建筑设计研究院为主编、德国洛蒂格真空和住宅技术公司为主要参编单位申报的《建筑真空排水系统技术规程》已经获得批准。

本规程主要包括：总则、术语符号、系统组成、系统设计、施工、调试、验收、维修保养。

该规程由德国洛蒂格真空和住宅技术公司提供国外的资料。

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1 总 则

1.0.1 为在室外真空排水系统工程的设计、安装施工及验收中，确保工程质量、提高经济效益，特制定本规程。

This Chinese standard specifies the designing, installation, system testing and supervision for outside vacuum sewerage system outside buildings.

1.0.2 室外真空排水系统一般用于污废水的收集，系统中的真空状态避免了污废水外泄。本规程适用于新建、扩建和改建的城镇、工业企业及居民区的永久性室外排水工程，尤其是农村、地面坡度不足的区域、村庄或建筑物位置较低时的连接、需要跨越障碍物（如：小河、管沟、供水管）、地下水位较高、人口密度低、水源保护区、临时排污点（营地、度假村）、由于施工可能影响交通的地方等等。凡有特殊要求的排水工程设计、施工及验收，而未为本规程所包含的，应另按有关规范、标准、规定执行。

Outside vacuum sewer system can be applied to sewage collection. The negative pressure inside pipeline can prevent sewage leakage from vacuum pipe. This standard is available for pipelines in new area, extending area or reconstruction area. It also can be applied to industrial plants, inhabitation area and commercial area especially to the rural, the area where it has not enough slope or the buildings inside has low elevation, water protection area, low population density area, high flow variation area, obstruction area, and some special area. The design, construction method and acceptance method should be acted according to other standards if the information is not included in this standard.

1.0.3 真空管道和真空站构成一个枝状型真空排水管网。真空排水管网的选择应当根据当地地形，地质条件，服务对象的标高，受纳水体标高，雨水排放途径，污水处理地点，以及外界气压，地下水水位，和穿越地区地下永久性构筑物等情况综合考虑。

Vacuum lines form a ramification network with a central vacuum station. The vacuum network should be chosen according to site topography, geology, service construction elevation, water elevation, discharge route for drain, wastewater treatment site and atmosphere outside, underground water level, obstruction or construction underground on the way of the pipelines.

1.0.4 真空排水是一种特殊的排水方法，对于其经济性的评价需要结合其他相关专业，例如除了排水设备本身的价格之外，还需要综合考虑土建费用，安装费用，运行费用和维护费用等。

Vacuum sewer system is a special method. Its commercial evaluation should include construction fee, installation fee, operation fee and maintenance fee besides equipment fee.

1.0.5 室外真空排水系统安装工程所使用的材料、成品和附件，应符合有关标准的规定。

Material, finished products and accessories etc for installation of vacuum sewage system should be meet the related requirements.

1.0.6 室外真空排水系统安装工程应按设计文件和施工图纸施工，变更设计必须经设计单位同意。

The installation works for vacuum system should be performed according to designing documents, construction drawings and design modification certificate confirmed by design institute.

1.0.7 室外真空排水系统安装工程必须遵守有关安全、消防、环保和文明施工等方面的规定。工程施工必须严格工序控制，及时进行中间质量检验和隐蔽工程验收，合格后方可进行下一道工序施工。

Installation works for vacuum system should obey related rules for safety, fire prevention, environment protection and . The construction work should be

done according to quality control system. The quality supervision and 隐蔽工程 acceptance should be done on the processes of working. The next step can be started when this works are confirmed.

1.0.8 室外真空排水系统安装工程的设计、施工及验收应符合本规程以外，尚应符合现行国家和地方相关标准的规定。

Designing, installation, testing requirements for vacuum system should meet the local rules as well.

2 术语和符号

Definition

2.1 术语

2.1.1 房屋接户管：从构筑物内的卫生器具到污水收集箱（污水收集腔的一部分）之间的重力管道为房屋接户管。

House connection pipe (gravity line): Gravity pipe from the sanitary of the house to the collection sump(part of collection chamber).

2.1.2 收集腔：收集腔由污水收集箱和真空阀单元[zhou]组成，和房屋接户管相连[zhou]。当污水收集箱中的污水量达到一定水位时，真空阀单元开始动作，排除污水收集箱内的污水。污水收集腔用 PE 制成。

Collection chamber: Collection chamber consists of collection sump and vacuum valve control unit. The PE collection sump provided to store flows of domestic wastewater from house connection pipe until sufficient has been accumulated to activate the vacuum valve control unit[1, P5].

[Zhou]: I added PE as chamber's material acc. To the description from C-2.

2.1.3 真空阀单元：真空阀单元由真空阀，控制器和相应的配件组成，安装在收集腔内或其他的结构中。

Vacuum Valve control unit : Valve unit components consist of interface valve, controller and some accessories[1, P5]. This unit can be installed inside collection chamber or other chambers or structures. [3, D-2]

2.1.4 真空阀：真空阀将真空管道中的真空同接户管中的污水和大气相隔绝。真空阀工作时，大气压力同真空之间的压力差将污水和空气通过真空阀压入真空管道。

Interface valve: Interface valve is the interface between atmospheric pressure and vacuum [3, D-2]. This valve admits the flow of sewage and air into the vacuum sewer via the interface valve [1, P5].

2.1.5 真空控制器：真空控制器通过感知液位测量管内的压力，控制真空阀门的启闭。

valve controller: Valve controller sensors the pressure inside sensor pipe and control the valve operation accordingly.

2.1.6 液位测量管：液位探头通过感知液位管中的压力来判断污水收集箱中的水位。液位管中的污水在真空阀起作用后能够全部排空。

Sensor pipe: Level sensor knows the level of sewage against the pressure inside level indicator pipe. And the sewage inside level indicator pipe can be evacuated when the interface valve actives.

2.1.7 检修阀：检修阀用于隔离真空管路或污水管路，以便进行设备和管路的维护和设备检修。

Cut-off valve: Cut-off valve is used to separate vacuum pipe or sewage pipe for convenience for pipe maintenance or equipment repairation.

2.1.8 真空管路：管内压力为负压的管路称为真空管路。真空管路又分为真空支管和真空主管。真空支管为从收集腔到真空主管之间的管路；真空主管为真空支管汇集的管路。

Vacuum pipeline: Vacuum pipeline means pipeline under negative pressure inside[1, P5]. Vacuum pipeline can be sorted into service connection pipe and vacuum sewer. The service connection pipes connect the single connection chambers to the vacuum sewer[1, P5, 3.10]. The vacuum sewer is the pipeline into which the service connections feed. [1, P5,3.14]

2.1.9 真空泵站：真空泵站由数台真空泵，数台排水泵，真空罐体以及其他的一些辅助设备组成的一套完整的系统。通过这套泵站可以控制真空系统的压力以及排出系统内部的污水。

Vacuum station consists of several vacuum pumps, several discharge pumps, vacuum vessel and other accessories. The pump station can control the pressure inside vacuum vessel and discharge the sewage water from the system.

2.1.10 真空罐：真空罐安装在真空主管段的末端，内部可以储存污水，同时保证一定的真空度[3, G-2 15row]。真空罐同真空发生器，真空管路以及污水泵相连接。

Vacuum vessel: Vacuum vessel is installed on the end of vacuum sewer [zhou]. It can store sewage water and reserve the pressure inside vessel. Vacuum vessel connected to the vacuum generator, vacuum sewer and sewage pump. [1, 3.16]

2.1.11 真空发生器：真空发生器为真空系统提供足够真空度，例如液环泵，旋转叶轮泵或水射器等。

Vacuum generator is the device, which have sufficient capacity to serve the system such as liquid ring pump, rotary vane pump or ejector pump.

2.1.12 生物过滤池：利用生化原理，对臭味进行过滤的构筑物
Biofilter tank: The construction can remove odor by bio-chemical principle.

2.1.13 单位管长人口密度：主干管流经区域内人口数量，包括所有的分支管线所服务的人口，除以主干管长度的值。

EDL: Number of the population values connected to a main line as for the number of sinks taking into consideration in all other side lines, divided by the length of the main line[2 P8 3.19].

2.1.14 气/水比：标准状态下，被吸入的空气体积或空气量与被吸入的污水体积或污水量之比。

AWR: Ratio of the air volume suctioned or airflow under standard conditions to the wastewater volume suctioned or sewage flow.

2.0.15 检修管：检修管安装在真空主管路或真空支管上，用于检查和诊断真空管路所用。

Inspection pipe: inspection pipe is installed on the vacuum sewer and vacuum service connection pipe as checking and judging devices for vacuum pipelines. [zhou]

2.2 主要符号

Main symbol

d_a	[mm]	管道外径
d_i	[mm]	管道内径
DN	[-]	管道的公称直径
EDL	[E/m]	沿管长方向的人口密度
EW	[PE]	人数值（人口和人口当量的总数）
EW _i	[E]	管段 i 服务的人口数
f	[1/h]	电动机的最高启动频率
g	[m/s ²]	重力加速度
H	[m]	真空上升管的高度，等于低点同下一个高点之间的高度差
h	[m]	真空上升管的最大压力水头
h _i	[m]	管段 i 的最高水头压力
h _{man}	[m]	压力释放的水头
L _i	[m]	管段 i 的长度
l _i	[m]	管段 i 最低点之间的长度
AWR	[-]	气/水比
AWR _i	[-]	真空支管段 i 的气/水比
n _i	[-]	管段 i 的低点数量
n _L	[-]	真空泵的数量
n _s	[-]	污水泵的数量
P _{max}	[kPa]	真空罐的最高绝对压力
P _{min}	[kPa]	真空罐的最低绝对压力
P _{ave}	[kPa]	真空罐的绝对压力均值
P _u	[kPa]	大气压力
P _{L,p}	[kw]	真空泵的输入功率
P _{S,p}	[kw]	污水泵的输入功率
Q _L	[m ³ /h]	正常情况下排放气体的峰值
Q _{L,s}	[m ³ /h]	运行情况下排放气体的峰值
Q _{L,p}	[m ³ /h]	正常情况下负压装置所需气体量
Q _{L,p,s}	[m ³ /h]	真空泵吸入气体量
Q _s	[l/s]	污水设计流量
Q _{s,d}	[m ³ /h]	每天的平均污水量
Q _{s,p}	[l/s]	污水泵的输送量
R	[m]	管道铺设的最小弯度
SF	[-]	负压装置设计的安全系数
t _{L(d)}	[h/d]	真空泵每天的运行时间
t _{S(d)}	[h/d]	污水泵每天的运行时间
V	[m ³]	真空罐的最小容积
V _s	[m ³]	计算真空罐容积时，需要考虑的真空管内

的气体体积		
V_w	$[m^3]$	真空罐中污水的最小体积
$W_{s,d}$	$[l/(E,d)]$	平均每人每天的污水量
$W_{(d)}$	$[kwh/d]$	平均每天消耗电量
$W_{(EW)}$	$[kwh/(E,a)]$	平均每人每年消耗电量
$W_{(V)}$	$[kwh/(m^3)]$	单位体积污水消耗电量
ΔP_{hydr}	$[KPa]$	水力压差
ΔP_{geo}	$[KPa]$	地形高差
ΔP_{man}	$[KPa]$	沿程损失
ΔP_{vac}	$[KPa]$	真空罐内的最大真空度
η_L	$[-]$	真空泵的效率
η_s	$[-]$	污水泵的效率
k	$[-]$	气体绝热率
P	$[kg/m^3]$	水密度
Σh_1	$[kwh/(m^3)]$	最大水力高差

3 系统描述

System description

(依据：EN1091、ATV-DVWK-A116、ROEVC 真空污水排导系统设计手册)

真空排污系统作为低压排污系统的一部分，起源于上个世纪末。随着近十年以来真空部件的日益进步以及真空系统设计的不断完善，真空排污系统被越来越多地应用于工程实践当中。[2, 4.0, 1~8]

Vacuum sewer system known as low-pressure system, was invented at the end of the last century. Vacuum sewage systems are applied to many projects in the process of refined components and improved designing. [2, 4.0, 1~8]

3.1 真空系统的特点

Vacuum sewage system has the following characteristic:

真空排污管路不会有泄露现象

No sewage leakage will be happened in vacuum sewage system

真空排污系统中的污水以气水混合物的形式，通过较高的速度在管道内行进，以防止管道内污物的沉淀

the high transport velocity of the air/water mixture in the vacuum pipelines prevents sediments.

3.2 真空系统的优点

Vacuum sewage system has the following advantages:

真空排污系统相对于其他排污系统有以下显著的优势：

Vacuum swage system has following advantages against other sewage systemes.

1. 真空排污管路的布置不需要重力坡降

No natural fall required

2. 相同的过流量，真空管路的管道直径小

Small pipes

3. 真空管路中的污水上升不需水泵提升

Rise without pumping

4. 给水和排水管线可以在同一个管渠内

Water and sewer in the same trench

5. 减少检查井的修建费用

Costly inspection chambers eliminated

6. 减少对环境的影响

Minimal environmental impact

7. 维护安全，清洁

Cleaner, safer maintenance

8. 减少泄露和污染

Eliminates leakage and contamination

9. 污水管线可以很容易地通过障碍物

Easy avoidance of obstruction

3.3 真空系统的使用范围

Application for vacuum system

1. 低密度（平均每个住家多于 50 英尺排污管，服务范围大于 50 个住家）

Low population density (more than 50 feet of sewer pipe length per connected house hold and more than 50 EDUs connected).

2. 缺少重力坡度的平原

Terrain with insufficient slope for gravity transport (flat terrain)

3. 排水管道需要通过障碍物的地区（例如，溪流，沟渠，现有的管线等）

Obstacles to be crossed (e.g. streams, trenches, existing utility lines, etc)

4. 高地下水的地区

High ground water table

5. 岩石地区

Rocky ground

6. 不稳定的地区

Unstable ground

7. 流动性高的场所（例如，宿营地）

High flow variation (e.g in resorts)

8. 水源保护地

Water protection areas

9. 危险排出物或工业废水

Hazardous commercial or Industrial effluents

10. ???

Arctic climate (common ducts with water and sewer pipes)

真空系统的经济性

~~The vacuum evacuateion technology is a special drainage procedure which might under certain circumstance be considerably cheaper than the conventional gravity lines sewage system or pressure lines sewage system.~~

真空排污系统是一种特殊的排水系统。在某些特定的场合，真空排水系统的总投资要低于传统的重力排水系统或压力排水系统。

对于真空排污系统的经济性评价

~~cost comparesion charts should consider all follow-on costs as for depreciateion, interest, operation and maintenance. [A116, P9, last row]~~

经济性评价需要考虑真空排污设备费用，包括真空排污管道，真空泵站，真空收集系统，和设备相关的主建费用，供电或取信号的电缆费用，运行和维护的费用等。 [A116, P9, last row]

Storm water is not normally disposed of in this manner. [A116, P10, first row]
雨水通常不在真空排污系统的考虑范围内。 [A116, P10, first row]

3.3 真空排污系统

3.3.1 系统简介

真空排污系统是以中心真空泵站为中心，以向外呈支状延伸的真空排污管网为依托，以真空收集腔为管网末端的收集点，收集从重力管路或构筑物中排出的污水。

Vacuum lines form a ramification network with a central vacuum station and suctioned sewage from collection chamber which is the interface between vacuum line and gravity line. [A116, P10, 3rd row]

一般情况下真空以一个真空泵站为重心的真空主管路的长度为 4 公里（平原地区），真空管路上升的地区，真空主管路的长度比 4 公里略短，在真空管路向下铺设的地区，真空主管路的长度比 4 公里略长。

The length of main branches is up to 4km im case of plain terrain. In case of ascending terrains into flow diretion the length is shorter and it can be longer in case of descending areas. [A116, P10, 3rd row]

在大的服务区域内，可以划分出多个单独的区域，每个区域内设置独立的真空泵站。泵站之间可以利用压力管道或重力管道相连接。

Larger areas can be subdivided into single sectors with their own vacuum stations and connected for instance via pressure-lines or gravity lines. [A116, P10, 6rd row]

3.3.2 收集腔和真空排水管道

Collection chamber and vacuum line [A116, P10, 8rd row]

室内重力排水管道与室外真空排水管道之间需要真空阀连接。大多数真空阀被安置在房屋外的管道连接井内。也可以安装在房屋地下室内。真空座便器可以直接同真空管道相连，其他卫生用具需要通过传输装置同真空管道相连接。这时应参照标准“室内真空排水系统”。

The transition from the conventional gravity line of a domestic installation into the vacuum line takes place inside the evacuation valve. In general it is placed outside the house in a shaft, but it can also be installed in the cellar. Vacuum toilets can be connected directly to vacuum lines inside buildings - other sanitary objects must be connected via evacuation units. In this case please read “Vacuum drainage systems inside of buildings”.

收集腔内的真空阀，如果是气动真空阀，只需要向真空泵站供电。然而如果真空阀是电动-液动阀门，则需要给每个真空阀供电。

In case of systems with pneumatic evacuation valve units a supply point for electrical current is necessary for the vacuum station only. However, in case of electrical-hydraulic evacuation valve units each domestic connection shaft needs a supply point for electrical current.

真空阀开启后，污水及空气将被吸进负压管线，流向真空泵站。真空系统内的平均气/水比按照当前的经验大约为 3: 1~15: 1。气水比随管线长度及要克服的高度差变大。基本上，干管末端的真空阀单元的气/水比要高于真空泵站附近真空阀的气水比。

On opening the evacuation valve wastewater and air are sucked into the vacuum line and flow through the pipe in the direction of the vacuum station. The medium air/water-ratio of vacuum systems based on available operating experience is approx 3:1 up to 15:1. It increases according to a bigger branch/trunk length accompanied with a height difference to be overcome. When the evacuation valve units are placed at the end of the trunk, the air/water-ratio is adjusted at a higher triggering point than in cases when they are placed nearer to the vacuum station.

3.3.3 真空泵站

Vacuum station [A116, P11, 3rd row]

在真空泵站内，借助于真空泵和一个或多个真空罐，将真空罐内的压力维持在60~70Kpa，也就是0.6~0.7bar,(40~30kpa 绝对气压)。污水经真空泵站继续被输送到污水处理厂。例如：可借助泵或者由压缩空气推动的提升设备。

The necessary under pressure for operation of normally 60 to 70 kPa resp. 0,6 to 0,7 bar (40 till 30 kPa absolute pressure) is developed and maintained in the vacuum station by means of vacuum pumps in one or several vacuum vessels/reservoirs. Then wastewater is conveyed/transported for further treatment of sewage for instance by means of pumps or pneumatic conveyance devices.

通常情况下，真空泵站位于所规划的排水系统的中心，地势低的位置。因为真空泵站会产生噪音并释放气味，建议同周围建筑物保持足够的距离。根据周围建筑物的类别和坐落的方向，距离应能预防噪音并防止气味散发。

Vacuum stations normally lie centrally within its allotted drainage area. With this, at the same time, the location in a low point on the ground is to be sought. Due to odour and noise emanations sufficient separation from the surrounding buildings is recommended. The size of the separation in detail is based on the type and position of the surrounding buildings as well as on measures for acoustic insulation and odor reduction.

生物滤器（池）与建筑物之间需要有 **15m** 的最小距离，或遵照当地的规范。
Minnum distance between buildings and bio-filter should be 15m or the distance should obey local rules.

4 系统组成

4.1 真空排水系统一般要求

4.1.1 应设置必要的防护措施防止收集腔内的污废水回流进入建筑物。

In case of back flooding out of the collection reservoir measures have to be taken in order to prevent inundation in of buildings. [A116, P11, last 6rd row]

【例如：当厕所低于室外地坪时，厕所出墙排水管上设止回阀防止回流。或者在回流发生时有必要的报警措施和截断设备，例如电动阀门】

4.1.2 真空阀和管道应在没有堵塞的情况下进行操作、运行。

Interface valve and vacuum pipe should be running and operated without any blockage.

4.1.3 真空排水系统不应影响附近的建筑物和设施；

Vacuum system should not affect round building and constructions

4.1.4 真空排水系统应不渗水、不漏气，不应产生臭气和其它有害物；

Vacuum system should anti-leakage for water and air. No nuisance odor or other noxious substance will be released from the system.

4.2 真空系统组件要求

4.2.1 接户管（重力管）

House connection pipe (gravity pipe)

室内排污管道需要通风。应当保证污水能够流入收集腔内。重力排水管道应通过室外检查井接入收集箱。

The domestic house connection pipes (gravity pipes) must be ventilated. It must be sure that only quantities of wastewater is forwarded into the collection rooms. [A116, P11, 5.2.1]

【室内污废水管道安装和验收按照国家现行相关规范实施，并且必须进行通风（ATV-DVWK-A-116 提出：必须进行通风，请问这里讲的通风是指室内环境要求通风，还是指室内重力管道系统必须通气？）

我认为应当是管路系统进行通风, 否则由于气堵导致没有水进入或者进水不足, 真空阀无法自动开启, 则管路内水积累越来越多就可能造成回水。

4.2.2 收集腔

1. 一般一个排水单元设一个收集箱。在超过 20 户排水单元的地方, 为能够保证恒定的气/水比, 为了安全运行的原因, 应安装有多套真空阀的收集箱。

In places where more than 20 inhabitants are to be connected for discharge due to reasons of operational safety a domestic connection chamber has to be equipped with several evacuation valve units, in order to assure a constant air/water ratio independent from the filling level in the emergency storage room. [A116, P11, 5.2.2]

(关于“一家”、“居民”一词是否可以换一个说法? 好像局限于居住建筑, 当用于公共建筑时怎样称呼? 是否可以称呼为“一个单元卫生间”? 如一户居民的厕所、一个男厕所或者一个女厕所) 的地方, 应安装一个有多套真空阀的收集箱。

2. 为了便于管理, 最好是一户住户安装一个收集腔。在特定的情况下, 多户住户或在高层建筑中多层住户也可以使用一个公用收集腔。前提是要满足第一条中的条件。

It has proved practiceal to provide each house with its own connection for reasons of liability. It is fundamentally possible, under certain conditions, to lead several residentiall units to one domestic connection. Houses with several stories are normally drained via one domestic connection. In this case the requirements defined last item are valid. [A116, P11, 5.2.3]

3. 收集腔一般靠近住宅污废水排出点设置, 可使重力排水管道很短, 尤其有益于埋设较深的水平管。

Domestic collection chamber is always located near the drainage point where wastewater comes from the building. This kind of pipe arrangement will short the gravity pipes. It is benefit for the deep pipe installation. [A116, P11, 5.2.3]

4. 带有监控系统的收集腔在实际中会使系统更加有效。

Devices for function monitoring might be useful according to certain circumstances. [A116, P11, 5.2.3]

[explain: 收集箱设有监控功能。例如：当发生回流或发生长时间开启真空阀的情况时，可通过就地的信号或远程数据传输装置进行监控。]

5. 安装在室外的收集箱，应安装牢固。在某些情况下，安装收集箱要考虑浮力的影响。

Collection chamber should be installed outside and fasten fixed. In specific situation, collection chamber should resist floating. [A116, P11, 5.2.3]

6. 收集箱应保证真空阀的干燥整洁，避免阀被水淹。在室内安装收集箱，应注意回流液位。

Collection chamber should prevent evacuation valves from flooding. For the domestic installation pay attention to the backflow level. [A116, P11, 5.2.4]

7. 收集腔必须够大，能够方便地去除粗大的颗粒，尽可能的保证真空阀的干燥整洁。

Collection room has to be easily accessible in order to facilitate the removal of rough particles. [A116, P11, 5.2.4]

[explain: 在真空阀检修时，需要清洁和吸干这些收集箱内的污水？ It must be possible to clean and suck off those rooms eluding the evacuation valve. [2,5.2.4]]

8. 当真空阀所安装的收集箱可能被水淹没时，需要考虑真空阀工作的卫生环境。

In case evacuation valve units are positioned where they can be flooded by wastewater work hygienic requirements have to be taken into account.

[A116, P11, 5.2.4]

9. 收集箱内所有的连接元件和配件必须为防腐材料。如采用合成材料或不锈钢。

All connecting elements and accessories in the domestic connection chambers have to consist of non-corrosive material (for ex. synthetic material or of non-corrosive steel

4.2.3 真空阀

1. 真空阀在开启的状态下必须是一个完全畅通的通道，其通道不应小于40mm。

On opening evacuation valves have to offer a completely free passage of at least 40 mm. [A116, P11, 5.2.5]

2. 真空阀单元必须由稳固、适合的材料制成，例如 ABS 要求真空阀开启次数不少于 30 万次。

Evacuation valve units must be made of appropriate resistant material (ABS). The valve opening times should be more than 300 thousand times.

（什么是稳固、适合的材料？请 ROEDIGER 进一步明确说明，例如：ABS？HDPE？等等）

4.2.4 液位指示器

1. 液位测量管应在吸水时保证干净。

Sensor pipes have to be positioned in a way that they are cleansed by streaming during the evacuation process.. [A116, P12, 5.2.6]

设：什么意思？是否说应保持清洁？但用于污废水的管道，怎样保持清洁？

答：吸水管的管壁应当光滑。当压力达到一定值，污水还没有达到压力传感器时，真空阀开始工作，利用真空将测量管内的污水以一定的速度快速吸走，达到测量管内部干净的状态。

2. 不宜使用浮球开关。

Floating switches are not appropriate due to their contamination sensitivity[2,5.2.6]

设：请 ROEDIGER 提供使用什么型式的液位指示器较好？

答：浮球开关不适合使用在对污染物极其敏感的地方。浮球开关在污染物在其表面聚集后，精度下降。因此应当使用和污染物质没有接触的液位仪，例如利用压力原理的压力变送器等。

4.2.5 阀门的控制

1. 真空阀应在真空管道内至少有 15Kpa (0.15bar) 压力时才能被打开。

The evacuation valve may only be opened by the control unit if the occurring vacuum pressure is at least at 15 kPa (0,15 bar). [A116, P12, 5.2.7]

2. 如果需要将安装在真空阀下方 1.0m 处的收集箱内的水分抽干，真空阀的控制单元需要在更大的真空度时才能开启。

In case collection rooms with a chamber bottom of more than 1,0 m beneath the evacuation valve are sucked off, the control unit is to open the evacuation valve only in case of relevant stronger under pressure. [A116, P13, 5.2.7]

3. 阀门的开启应当保证气水比的恒定，而同真空压力的大小无关。

The valve control must keep the air/water-ratio roughly independent from the occurring vacuum pressure. [A116, P13, 5.2.7]

4.2.6 密封膜的使用寿命

密封膜使用寿命应当超过 30 万次开闭。

The life of membrane should be more than 30 times of opening or closing.

设：请 ROEDIGER 提供具体要求)

4.2.7 防爆

如果收集腔内接有电气设备，则这些电气设备必须防爆。

All electrical installation inside collection chambers have to be built in explosion-proof design.

4.2.8 管道材料

1. 真空排水管道的组成真空管道的材料性质必须稳定，工作压力不应小于 1.0MPa。

The material of vacuum pipes should has a stable characteristic. The pressure of these pipes should be more than 1.0MPa.

2. 所选管材应注意由化学和生物化学引起的管道内壁外壁的影响，应能够适应 35℃ 的工作环境，注意机械磨损造成的影响，特别需要注意能够承受负压。

Vacuum lines must be resistant against:

- Chemical and biochemical influences from inside and outside
- Temperatures up to 35° C
- Mechanical abrasion
- Pressure from in- and outside (according to DIN EN 1401)

Please pay attention also to special stress factors. [A116, P13, 5.2.10]

3. 真空排水管道的管径不应小于 DN65。污废水中粗大的固体物质应进行拦截，不应进入排水管道。

The minimum nominal width of vacuum conduits is DN/ID 65, the inlet of waste into the sewer network is forbidden. [A116, P13, 5.2.11]

[答：中国的管道是否有如此规定，如果没有真空管到的口径为多少？]

4.2.9 真空支管

1. 真空支管应能手动关闭，便于真空阀的维护和更换。

Domestic connection lines must be lockable manually in order to facilitate maintenance and replacement works of the relevant evacuation valves without occurring under pressure. [A116, P13, 5.2.12]

设：设置阀门才能关闭？但在实际工程中并没有设置阀门，如：F1 赛车场。

答：我认为在重力管线侧没有必要一定要设置阀门，但在真空管路中需要设置阀门以使得真空阀的真空侧在阀门维护时还处于真空状态，以免在阀门维修时损害整套真空系统。

2. 真空支管应以一个 55 度的角度顺着真空排水管道的流向安装。

They have to be inserted into vacuum pressure conduits with a an angle of at the most 55° in the direction of flow. [A116, P13, 5.2.12]

设：ROEDIGER 提供图？我们只有复印版的不是很清楚

答：

3. 支管连接

真空排水支干管应以一个最大为 45 度的角度顺主干管排水方向连接。

Subsidiary pipelines have to be inserted into vacuum pressure conduits with a an angle of at the most 45° in the direction of flow (see figure 3). [A116, P14, 5.2.13]

4. 主干管与支干管的高点的最低点，在铺设前应高于铺设后低点的最高点，避免污水回流。

Before connecting them the lowest points of the peaks in main and subsidiary pipelines must be at a higher level than the crown height of the lowest point

after connection in order to prevent a back flowing of wastewater. [A116, P14, 5.2.13]

设：该句话不太好理解，请 ROEDIGER 能够给出简捷易懂语句表达？

请 ROEDIGER 提供图？我们只有复印版的不是很清楚）】

答：

4.2.10 检修阀

1. 检修阀应采用闸阀，阀门应有防腐保护和防堵处理措施。真空排水管道中常使用不带橡胶销榫槽、内壁有防腐材料的楔型闸阀。阀轴应用不锈钢材料制作

Cut-off devices must be corrosion-proof, corrosion-protected and plug-free. Normally stop slide valves in an enamelled box without slot with rubber wedge are used. Extension spindles must be made of stainless steel. [A116, P15, 5.2.14]

2. 应在不超过 100 米的距离内、每个检查管前后安装检修阀，通过检修阀和压力表，可以监测真空排水系统是否泄漏。

Inspection pipes are to be placed at maximum intervals of 100 m. it is suggested to install inspection pipes in front or/and behind of each cut-off device in order to have an opportunity for cut-off and monitoring as well as for an exact leak detection - by means of inflatable balls. [A116, P15, 5.2.14]

3. 切断装置和检查管的位置，应设有明显指示牌，以符号“污”标注。

The location of cut-off devices and inspection pipes have to be marked by signs “污” which have to be included in the municipal canal registering..

4.2.11 真空罐

1. 真空罐宜埋入地下或设置在真空站内，应安装牢固。

Vacuum reservoirs can be buried into the soil or installed inside a vacuum station. [A116, P15, 5.2.15]

2. 真空罐的安装需要考虑浮力的影响。容器应能够承受 90KPa 的负压。

If necessary they must be secured against floating and resist to a vacuum

pressure of 90 kPa. [A116, P15, 5.2.15]

3. 钢制真空罐的内外表面均应当进行防腐处理

Steel vessels have to be coated from in and outside with appropriate coating materials.

设：请 ROEDIGER 提供具体的材料要求和钢板型号)

答：凡是同污水接触会产生腐蚀的钢制罐体都应当进行防腐处理。

4. 当采用多台真空罐时，应在容器前通过阀门和连接管连接在一起。当一个容器停止工作时，保证系统还可以运行。当只有一个容器时，应考虑它可以被更换。

In case of several vacuum pressure vessels the incoming vacuum conduits must be connected to each other in such a way by means of sliders and cross-links that a correct operation is secured also in case of failure of one tank. If there is only one tank available possibilities for its substitution have to be taken into account. [A116, P15, 5.2.15]

5. 连接真空罐的排水管道应设止回阀，避免污水回流。

Sewage discharge pipe should be equipped check valve to prevent back filling.

4.2.12 液位计监控

真空罐的最高液位应不超过容器高度的 1/2，当超过最高液位时，应自动关闭负压装置。

Vacuum reservoirs may only be filled up to the half by wastewater. In case the maximum filling level is exceeded the vacuum pumps have to switch-off automatically. [A116, P15, 5.2.17]

4.2.13 负压装置

1. 负压装置设于真空站室内。
2. 必须保证负压装置安全运行。
3. 安装负压装置的房间，室内温度应保证维持在 1℃~35℃之间，应有隔热、通风、保温的措施。

Vacuum pump should be installed inside vacuum station room

Vacuum pump must be worked safety

For safe operation of the system the ambient temperature in the vacuum station has to be maintained between $+1^{\circ}\text{C}$ and $+35^{\circ}\text{C}$. Appropriate insulation, ventilation and heating are to be taken into account. [A116, P15, 5.2.18]

设：（是否可以称呼为真空泵？）

答：真空泵是负压装置的一种

4.2.14 排水泵

1. 应至少有两台或两台以上有相同运行能力的污水排水泵，其中一台为备用泵。运行排水泵的排水能力要求满足真空罐的排水要求，并且应考虑当其中一台排水泵作为备用时，其他排水泵应继续满足真空罐的排水要求。

The capacity of drainage pumps should be meet the discharge requirement. One pump can be removed without loss of system capacity 。At least two devices of the same operational capacity must be available for the onward conveyance of wastewater away from the vacuum reservoirs, one of them as redundancy. [A116, P15, 5.2.19]

2. 排水泵可以采用干式离心式排水泵或潜水泵。泵吸入侧自由通道的直径同真空阀的口径应当相互匹配。除非在泵自身带有切割装置。

Submersible or dry-mounted pumps can be installed. [designer: dry type centrifugal pump prefer to install inside vacuum station room]

The diameter of free passage must correspond at least to the free passage of the largest suction pipe before the evacuation valves, unless pumps with cutting facilities are installed. [A116, P15, 5.2.19]

3. 如果排水泵安装在真空罐的内部，更换或移动排水泵的时间不能超过 4 小时。如果系统不能接受 4 小时的停工时间，排水泵必须在真空罐外部安装，

除非有两个以上真空罐，正被使用并且系统可以在一个罐不使用的情况下操作。

4. 排水泵应保证下水道在负压状态下工作，没有阻塞和没有气蚀现象，并应每小时启动次数不小于 12 次。
5. 潜水排水泵设置的位置应考虑方便维修、更换水泵。
6. 每台排水泵出水管上应设止回阀、检修阀。

Where submersible pumps are installed inside vacuum vessel it shall be possible to remove and replace a pump in not more than 4 hours. Where system shutdown for 4h is not acceptable pumps shall be installed externally unless two vacuum vessels are employed and the system can be operated with one vessel out of action. [1,5.2.21]

Forwarding pumps, where used, should be unchokable sewage pumps suitable for operating under negative pressure without cavitations. They shall be suitable for a minimum of 12 starts per hour. (vessel should be designed acc. To 12 starts)[1,5.2.20]

The installation position of every forwarding pump should be convenience for pump maintenance and exchange.

Every pressure pipe from the pump should be fitted with check valve and cut-off vavle.

4.2.15 真空泵站 Vacuum station

1. 当发生停水、排水泵停转、负压装置停止工作、负压装置或排水泵超时运转、最高和最低负压超限时，应及时报警。
2. 真空站是真空排水系统的最重要组成部分，所以要求即使在断电情况下也应能发出故障信息。
3. 真空罐与负压装置连接管上的电气装置应防爆。
4. 在真空罐和真空泵之间不要求安装阻火器。阻火器易引起管路堵塞。

The electrical equipment in vacuum reservoir and in the suction lines must be explosion-proof. Flame traps and detonation safety devices

between vacuum reservoirs and vacuum pumps are not requested, particularly as they tend to obstruction/occlusions. [A116, P16, 5.2.22]

5. 在真空泵输送易燃介质时，应使用惰性气体对管道进行吹扫。如：采用二氧化碳气体。在设备停机 48 小时后，在真空泵再次使用前，应用惰性气体清洗，此操作在设备运行指南中写明。

In case vacuum pumps which might be ignition sources are used please assure facilities for sweeping with inert gas (e.g. Carbon dioxide). After being in operation for more than 48 hours, before re-operation, a sweeping with inert gas of the vacuum pumps has to be executed. The procedure has to be described in the manual. [A116, P16, 5.2.22]

6. 真空泵站应设置通风管道，避免气味扩散到相邻建筑物。
7. 必要时应需设生物过滤器（池）对真空泵站中的空气进行过滤。

The ventilation pipelines are to be so laid that possible odour nuisance in the neighbourhood is to be avoided with certainty, with heavier intromission of odours an odour reduction, e.g. through compost filter plants (biofilter), is to be undertaken. [A116, P16, 5.2.25]

8. 生物过滤器中产生的有机物的滤液为污染物，需要随污水一同处理。
- Percolating water out of compost filter plants is contaminated organically and has to be discharged together with the wastewater. [A116, P16, 5.2.25]

9. 真空泵站应有控制噪音的措施，所产生的噪音不应超出国家或地方的有关规定。夜间允许的噪音值参照（ATV-DVWK-A116）标准为：

纯居住区	35db(A)
一般居住区	40db(A)
混合区	45db(A)
商业区	50db(A)
工业区	70db(A)

没有区域说明的，按照主要功能的标准执行。

The regulations of TA-Noise have to be observed. The maximum permitted

night noise intromission value according to TA-Noise is currently: [A116, P16, 5.2.26]

- For purely residential areas 35 dB (A)
- For general residential areas 40 dB (A)
- For mixed areas 45 dB (A)
- For commercial areas 50 dB (A)
- For industrial areas 70 dB (A)

10. 真空站应有备用电源。

Emergency power supply should be reserved.

4.2.16 管道及管配件

1. 在真空排水系统管路中，所有的管道和管件必须符合国家或欧洲标准，公称压力不小于 1.0MPa。

【在真空管路系统中，所有的管道和管件必须符合国家标准或欧洲 DIN EN 1333 标准，至少应大于 DIN EN 1091 标准的额定压力 1.0Mpa(10bar).】

2. 真空排水系统宜采用塑料管材。

3. 当采用 PVC-U 管材，应选用 SDR-21 级管道及配件，宜粘结连接。

【PVC-U 管材的真空管道，公称外径与公称壁厚之比为 SDR-21。PVC-U 管应满足于标准 DIN 8061、DIN 8075、DIN 19532 及 DVGW 手册 W320。应注意 PVC-U 管道热膨胀系数为 0.08mm/(m.k)。采用胶接头或适用真空排水系统的橡胶密封接头，依照标准 DIN 4060 应用。粘接连接应先清洗粘接面，并在生产商的指导下进行安装。】 [2,5.3.1]

4. 当采用 HDPE 管材，应选用 SDR-11 级管道及配件，宜焊接连接。

【HDPE 管材的真空管道，公称外径与公称壁厚之比为 SDR-11 级。HDPE 管应满足于标准 DIN 8074、DIN 8075、DIN12201 及 DVGW 手册 W320。应注意 HDPE 管道热膨胀系数为 0.2 mm/(m.k)。依照标准 DIN4060 使用焊接接头或适用真空排水系统的橡胶密封接头，当采用焊接接头，必须由专业厂家完成。】 [2,5.3.1]

设：请问洛蒂格公司是否可以采用钢管或者铸铁管？有何使用、安装要求？

答：可以采用铸铁管和钢管。只要管道和管道连接能满足承受压力为 10bar 即可。同时要保证在管道连接处的密封性。不能因为埋管后的沉降而引起连接错位，导致管路密封失效。

All pipeline and pipe fittings of vacuum drainage system should meet the requirement of European standard EN1333 or better than DIN EN 1061 or Chinese standard. The nominal pressure should not exceed 1.0MPa

The material of pipeline for vacuum system should be plastic type.

Vacuum lines made of PVC must meet the standards of SDR-class 21. As for PVC-U (Pipes made from unplasticised Polyvinyl Chloride) the standards of DIN 8061, DIN 8062, DIN 19532 and the Work Sheet W 320 of DVGW is to be applicable. The thermal expansion coefficient of 0,08 mm/(m.K) has to be taken into consideration. Adhesive and plug-in sleeves with seals made from elastomers compatible to vacuum pressure according to DIN 4060 can be used. Particular care has to be taken as for adhesive connections which can be done only after having cleansed the adherends carefully and in accordance with the processing manual of the manufacturer. [2,5.3.1]

Vacuum lines made of PE (Polyethylene) must meet the standards of SDR-class 11. As for PE-HD (Pipes made from High Density Polyethylene) the standards of DIN 8074, DIN 8075, DIN EN 12201 as well as the Work Sheet W 320 of DVGW is to be applicable. The thermal expansion coefficient of 0,20 mm/(m.K) has to be taken into consideration. Plug-in sleeves with seals made from elastomers compatible to vacuum pressure according to DIN 4060 or weld joints can be used. Particular care has to be taken as for weld joints and can only be done by specialised staff. [2,5.3.1]

5 系统设计

5.0.1 排水系统的设计依照标准 DIN EN 752-3。为了能使真空排水系统的设计更加准确和快速，初步设计应以如下部分为依据：

- 带地形平面图的解释报告
- 服务区域的人口总量
- 服务区域污水的排水当量
- 排水的峰值流量和峰值系数
- 特殊高水量用水单位的地点和用水量
- 服务区域和今后扩建区域
- 污水接纳点的位置和标高

5.0.2 在得到以上资料的基础上，系统商应结合实际情况提供以下文件：

- 真空排水管的总平面图
- 真空排水管网的横向剖面图
- 气水比的计算
- 真空泵站的尺寸
- 真空泵站的流程图
- 设备数量估算和费用的计算
- 费用比较计算
- 考虑周围排水系统

5.0.3 真空管道的高程断面必定在污水汇集的最低点产生，通过被后面的空气加速推动越过前面的高点。高程断面基本上有三种形式（见图 4）：

波浪型断面，没有成型件，靠管子的自身弯曲实现

锯齿型断面，有 45 度型管，管径的标称直径取 DN100 以上

袋型断面，与锯齿型断面相似但有区别，在 45 度上升段前有个额外的“U”型弯。袋型断面的标称直不超过 DN100。

高程断面和管道尺寸应与系统供应商协调解决。

5.0.4 气-水设计：最大的静压力是在所有坡面被水充满的条件下计算的。坡面的最大静压力高差是坡面最低点和随后最高点之间的高度差，再减去管道内直径 d 后得到的值。沿着主干管的最大静压力高度之和，通常情况下不允许超过 4m 至 5m。静压差太高时，要求在真空管道上安装自动通风阀。当真空管道内的真空度不足时，阀门将自动向真空管道内引入空气，以防止所有的坡面内同时充满水。

由于复杂的动态过程和气流状态的多样化，精确计算气-水的传输过程是不可能的。在缺乏理论依据的情况下，人们使用一张近似表，来计算真空管路中的气-水传输数据。

表 1 为气-水比估算表。

表 1：气/水比中值的近似估算

平均气/水比 (LWV)	沿干管长的居民密度 E/m			
主干管长度 m	0.05	0.1	0.2	0.5
500	3.5~7	3~6	2.5~5	2~5
1000	4~8	3.5~7	3~6	2.5~5
1500	5~9	4~8	3.5~7	3~6
2000	6~10	5~9	4~8	3.5~4
3000	7~12	6~10	5~9	4~8
4000	8~15	7~12	6~10	(5~9) *
*只在特殊情况下使用				

参照近似表中的数值，干管的公称直径可以根据上游相关区域的居民数量及上游的气/水比中值估算出来。需要注意的是，干管上游末端的气/水比平均值要比计算平均值高，而沿着真空泵站的方向，真空值逐渐下降，直到平均值。

以上的数据适用于大部分真空排水项目。这些项目中排水当量约为 0.005I/(s.E) 的排水量，服务地区相对平坦，排水管网的分布均匀。

很明显，在特殊条件下的项目是不可能按照此表的数据被全部计算出来的。此时推荐由系统供应商作指导，提供计算，并对计算结果做出解释。在某些项目中，可以通过使用附加的技术措施保证系统的运行安全性。例如：设置自动通风站或提供间歇性供水、气的真空阀单元。

如果在管道末端出现高峰流，并带有脉动现象，需要依据压力剖面图对系统进行详细计算。

表 2：估算标称直径的近似表

上游的气 /水比平 均值	主干管的标称直径						
	DN65	DN80	DN100	DN125	DN150	DN200	DN250
	上游的封闭区居民数量						
2	0-100	0-350	250-600	350-900	500-1400	750-2100	(1100-3000)
4	0-65	0-200	135-340	200-500	300-800	400-1200	(600-1650)
6	0-45	0-140	95-240	140-350	200-550	300-320	(400-1150)
8	0-35	0-105	75-185	105—270	150-425	220-625	(300-850)
10	0-30	0-85	60-150	85-220	120-340	175-500	(250-700)
12	0-25	0-75	50-125	75-180	100-200	150-425	(200-600)

*只在特殊情况下推荐使用

5.0.5 设计的基础

污水的额定排放当量应当参考本地的条件。除了可以考虑接入收集腔重力管道外渗入的水份之外，整套真空系统可以不考虑额外的水份。

5.0.6 真空泵站

最大的空气量 Q_L （在标准状况下）的获得是通过计算流量 Q_S 乘以平均气/水比值。 $Q_L=Q_S*LWV$

对于真空泵的计算需要再乘以安全系数 SF ， SF 在 1.2~1.5 之间。

单台污水泵的输送能力和污水泵的数量（ $Q_{S,P}$ 和 n_s ）以及单台真空泵的输送能力和真空泵的数量数量（ $Q_{L,P}$ 和 n_l ），应考虑每一种都应有一台作为备用设备。

如下：

$$Q_{s,p} \geq Q_s / (n_s - 1) \quad [L/s] \quad (1)$$

$$Q_{L,p} \geq Q_L * SF / (n_l - 1) \quad [L/S] \quad (2)$$

单个负压泵吸入气体体积：

$$Q_{L,p,s} \geq Q_{L,p} * P_u * 2 / (P_{max} + P_{min}) \quad [L/S] \quad (2a)$$

P_u 一是周围气压，

P_{max} 一真空罐中最大的绝对压力

P_{min} 一真空罐中最小的绝对压力

真空罐的最小体积，按照设备的最大开启次数 12/h 次计算。真空罐中最小的储水体积为：

$$V_W = 0.25 * Q_{S,P} / f \quad [L] \quad (3)$$

最小的气体体积:

$$V_L=0.25*Q_{L,P,S}*1/2*(P_{max}+P_{min})/[P_{max}-P] * n_L * f \quad [L](4)$$

选择的负压泵的数量 n_L 越多, 所需体积越小。当所有真空泵依次被打开时, 真空泵的总数 n_L 允许套入上述等式中使用。

计算得出的气体体积 V_L 再减去真空泵站之前管道内部的一部分气体体积 V_s 。对于从真空站出来那段管路, 最多只考虑一半容积, 在这段管路中的最大液体静态压力差小于 $P_{max}-P_{min}$ 。例如: 当水位压差 $P_{max}-P_{min}=10KPA$, 并且在真空容器前直接有超过 $1m$ 的最大液压静态压力差的高压时, 不允许将管路里的容积计算在内。

$$\text{真空罐所需体积;} V=V_W+V_L-V_s \quad [L] \quad (5)$$

$$\text{真空罐最小容积;} V \geq 3*V_w \quad [L] \quad (6)$$

真空泵和污水泵消耗的功率, 按照下列公式计算:

$$P_{L,P}=\{K/(K-1)*Q_{L,P,S}*1/2*(P_{max}-P_{min})*[1-(1/2*(P_{max}-P_{min})/ P_u)^{\{(K-1)/K\}}]/ \eta L \quad (7)$$

$$P_{s,p}=Q_{s,p} * \rho * g * h_{man} / \eta w \quad (8)$$

绝热常数 $K=1.4$

水环式和滑片式真空泵的能效范围在 $0.3 < \eta L < 0.6$ 之间 ($P_{min} \geq 30kPa$), 与此同时滑片式真空泵的能效要高于水环式真空泵, 带有水射器的滑片式真空泵的能效很低, 范围在 $0.05 \sim 0.1$ 之间。污水泵的能效范围在 $0.2 \sim 0.5$ 之间。

6 施工

6.1 施工准备

6.1.1 施工安装前，应具备下列条件：

The following documents or condition should be ready before installation

1. 施工图纸及有关技术文件齐全，已进行图纸技术交底，施工要求明确；施工单位应编制施工组织设计。

Installation drawings and related document are integrated.

Drawings have been explained to Installation Company.

Installation requirement is clear

Installation company should organize construction organization plan.

2. 施工方案和管材、管件、专用热（电）熔机具供应等施工条件具备。

Installation plan is ready

Pipeline, pipefitting and special welding machines are ready

3. 施工用地及材料贮放场地等临时设施和施工用电能满足施工需要。

Installation space and material storage place is ready

Water supply and power supply is ready

6.1.2 排污泵、真空泵、真空罐、真空阀、接户管、真空管道等设施及其附属管道的安装，应清除其内部污垢和杂物。管道系统安装过程中的开口处应及时封闭，并做好现场保护工作，如有损坏，应及时更换。

Before installation of sewage pump, vacuum pump, vacuum tank, evacuation valve, service connection pipe, vacuum pipe etc, Dirt solid or impurity inside pipes should be cleared up. Openings of pipeline should be closed as soon as the pipeline installation had been done. If something is broken or damaged, replacement should be done as soon as possible.

6.1.3 排污泵、真空泵、真空罐、真空阀安装后应采取安全可靠的防护措施。

Sewage pump, vacuum pump, vacuum tank and evacuation valve should be protected after the equipment installation work is finished.

6.1.4 应委托系统供应商,在开始施工时对建设单位的人员进行关于管道铺设和进户井的安装指导。

Pipeline and connection well installation should be instructed before installation.

6.2 真空泵站安装

installation of vacuum station

6.2.1 排污泵、真空泵的规格、型号应符合设计要求,并应有产品合格证和安装使用说明书。

The capacity and type of sewage pump, vacuum pump should meet the design requirement. The quality certification and installation brochure should be submitted before installation.

6.2.2 排污泵、真空泵等设备就位固定安装前,复核设备基础定位尺寸、外墙预留洞口径、标高是否符合施工图设计要求。若有不符设计图之处及时发现,并由设计制定解决方案。

Equipment foundation size, cutout holes and the level should be checked again before equipment installation. If there is some difference, equipment supplier or system supplier should explain to the designer about the difference. The final installation work should be based on drawings from design institute.

6.2.3 排污泵、真空泵的安装,应符合现行国家标准《机械设备安装工程施工及验收通用规范》GB50231、《压缩机、风机、泵安装工程施工及验收规范》GB50275的有关规定。

The installation of sewage pump, vacuum pump should meet the rule of Chinese standard GB50231, GB50275

6.3 真空罐安装

installation for vacuum tank

6.3.1 根据设计施工图定位尺寸开挖，并排除积水。

Digging the pit for vacuum tank according to installation drawing and draining water out of the pit

6.3.2 根据设计施工图真空罐设备基础尺寸、标高、定位要求施工。

Installation works should be done according to the requirement in the installation drawing.

6.3.3 复核真空罐设备基础标高。

The level of equipment foundation should be checked again before installation.

6.3.4 先将真空罐各接口予以封堵，后将真空罐吊装到位，并校核各接口的标高，待其满足设计要求。

Closing all the entrance of vacuum tank first, lifting the tank on the foundation and checking the entrance level again.

6.3.5 真空罐外壁及其固定配件采取防腐措施。

Outside wall and fixing fittings of vacuum tank should prevent from corrosion

6.3.6 将真空罐固定于基础上，并以素土填实，做好压力传感器、液位控制器等控制器的安全防护措施。

Fixing vacuum tank on the foundation and filling with secondary concrete.

Safety protection way should be made on pressure sensor, level controller.

6.4 真空阀安装

Vacuum valve installation

清理收集箱，确保清洁并将真空阀安装到位。同时连接各相应管线。

Clearing collection chamber and installing evacuation valve. Then connecting related pipes.

6.5 真空管道安装

Vacuum pipe installation

6.5.1 真空排污管道施工面广，施工工艺要求高，为确保工程质量、施工进度，必须做好与土建的配合工作，及时掌握管线的标高、坐标，保证管线敷设符合设计要求及验收规程，未经设计方同意，不得任意修改和改变设计。

The installation company should cooperate with construction company to install vacuum pipelines. The pipe level, pipe position etc information should be noticed all the time. The pipe arrangement should be met designing requirement and supervision standard. The pipe arrangement would not be changed without the confirmation from the designer.

6.5.2 真空管道要保证密闭性，所有管道的接口采用 45 度接头而不允许用 90 度的接头。管道和管道采用电熔连接，保证管道内部光滑。

Vacuum pipe should be air tight. All pipe connection should be 45 degree other than 90 degree. The pipes should be connected by electric welding connection. The welded pipe connection inside should be smoothly.

6.5.3 真空管道与真空罐用法兰和垫片连接，保证密闭不渗漏，真空管道接如真空罐前必须装有分流阀。

Flanges and gaskets are used between vacuum pipes and vacuum tank to prevent air out. Distributor valve should be installed on the vacuum pipes before it is connected to vacuum tank

6.5.4 管道铺设应防冻,应考虑到地下设施、交通设施、重力、碰撞承受力以及负压运行和密封性检验。地面管段必须考虑高温的影响，做紫外线防护和防机械防护。

Pipes installation should prevent anti-freeze. Pipe arrangement should consider construction underground, load of traffic vehicles, gravity load, pressure force, operation under negative pressure and air tight testing. The

pipeline above ground should be prevent from high temperature, ultraviolet radiation and mechanical force.

6.5.5 管道坡度大于 1: 150, 允许高点的高程位置和低点的高程位置与设计的高程断面的最大偏差范围为 2.5cm, 其间坡度应稳定。

Pipe gradation should be more than 1:150. the max deviation for the highest level between actual point and designing point should be less than 2.5cm. So did the max deviation for lowest level. The gradation should be stable.

6.6 收集箱安装

Collection chamber installation

6.6.1 收集箱的顶盖只能承载一个人的重量, 因此不能安装在有车辆经过的地方。

The cover of collection chamber should bear the weight of one person. So the cover could not be installed on the traffic way.

6.6.2 收集箱的安放应与水平面保持垂直, 铺设 50-60 厘米的沙固定。

Collection chamber should be installed vertically with ground. Sand 50~60 centimeter's thickenss should be put under the collection chamber

6.6.3 采用电熔连接真空收集箱和真空住户连接装置。

Vacuum collection chamber can be connected with vacuum connection pipe with electrical welding.

6.6.4 采用 PVC 强力胶水和垫圈连接重力入口和收集箱接口, 保证密闭不渗漏。

The chamber collection and gravity pipes should be connected by PVC glue and gasket to prevent water leakage

6.6.5 真空收集箱周围必须砌井, 井的最小直径为 1300mm, 用于维护和安装。收集箱要求安装牢固, 抗浮。收集箱主要是保护真空阀、信号传感模块。因顶盖、箱体均为塑料材质, 顶盖所能承受的荷载有限, 不能放置在车行道上, 可放置在绿化区域。

The well should be made around vacuum collection chamber. The min diameter of the well is 1300mm for maintenance and installation. Collection chamber installation should be fasten and anti-floating. Collection chamber is used for protect evacuation valve, signal sensor. The chamber cover and chamber body is plastic. The cover could not be installed on the traffic way for its limited bearing load. This kind of cover should be installed on the park.

7 调试

7.1 系统压力测试

Pressure commissioning

7.1.1 真空系统的测试应先划分成若干个区域测试，再进行总体调试。

Vacuum system commissioning should be tested one section by one section first and test whole system finally

7.1.2 分段密闭性测试包括以下内容：

section testing includes following contents:

1. 真空管道每隔 450 米左右进行一次测试。

Every test should be made on every 450m vacuum pipe

2. 真空收集箱连接真空主管道的每隔 450 米测试。

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7.1.3 分段测试的方法

Section test method

1. 关闭分流阀，用管帽密闭住户连接装置，将真空泵接入检查管，根据压力表显示加入 0.7-0.8bar 负压，并要求此负压维持至少 30 分钟，以后的两小时内压力变化不得超过 5%，以此作为分段密闭性测试的标准。

Closing all the entrance and exit expect inspection pipe. Connecting inspection pipe and vacuum pump. Operating vacuum pump till the pressure inside testing pipe reaches 0.7~0.8bar and maintaining at least 30 minutes. The following 2 hours, pressure loss should be less than 5%.

2. 每次测试必须有施工方、现场工程师、监理单位到场，并记录测试结果。

Installation company, system contractor and inspection representative should be on site and make a record.

3. 如果任何部分在测试中失败，则要求重新来过直到符合标准为止。

The test should be started again if any part of the equipment is failed.

7.1.4 整体管道的总体密闭性测试

air tight test for whole pipeline

1. 关闭所有的阀门，用管帽堵上所有管口，保证所检查范围的密闭。

Closing all valves and pipe entances except one inspection pipe

2. 将真空泵接入终端检查管，根据压力表显示加入 0.7-0.8bar 负压，并要求此负压维持至少 30 分钟，以后的四小时内压力变化不得超过 1%。

Connecting vacuum pump to the last inspection pipe. Running pump till the pressure inside pipeline reaches 0.7~0.8bar. Maintaining at least 30 minutes without pressure loss. The pressure inside can be reduced within 1% in the following 4 hours.

3. 测试必须有施工方、现场工程师、监理单位到场，并记录测试结果。
Installation company, system contractor and inspection representative should be on site and make a record.

7.1.5 收集箱内真空阀的测试

Evacuation valve test

1. 做测试前，必须保证收集箱内干净和干燥。

Collection chamber should be clean and dry before test

2. 在收集箱的污水容积内灌水，真空阀门会根据水位自动开启，容积内的水会被排走。

Filling up collection chamber with water. Evacuation valve should be operated automatically according to water level. Water inside collection chamber should be drained up.

7.1.6 真空罐的测试

Vacuum tank test

1. 关闭真空罐进口阀门、连接污水泵的阀门和连接引流管的阀门，打开位于真空泵和主管道前的阀门。

Closing valves to vacuum pump, sewage pump, by pass pipe and opening valves to vacuum pumps.

2. 启动泵房内的真空泵，根据压力表显示加入 0.7-0.8bar 负压，并要求此负压维持至少 30 分钟，以后的两小时内压力变化不得超过 5%。

Running vacuum pump till the pressure inside vacuum tank reaches 0.7~0.8bar. the pressure should be maintained at least 30 minutes.

The pressure loss should be less than 5% in the following 2 hours.

7.1.7 条 真空泵站的测试

Vacuum station test

1. 首先分别开启真空泵和污水泵，确保泵运行正常。

Running vacuum pump and sewage pump. They should be operated well.

2. 用管帽堵住所有管口，关闭真空主管道的分流阀门，手动开启一个真空泵，根据泵站内压力表显示加入 0.7-0.8bar 负压，并要求此负压维持至少 30 分钟，以后的两小时内压力变化不得超过 5%。

7.1.8 整体系统的测试

Whole system test

1. 上述所有的测试完成后，必须对整个系统进行整体测试。

After all test mentioned above are finished, system test should be performed.

2. 打开所有的分流阀门，根据泵站内压力表显示加入 0.7-0.8bar 负压，并要求此负压维持至少 30 分钟，以后的四小时内压力变化不得超过 1%。

7.2 系统防堵塞测试

Anti-block test

以下列物体为例，在水中浸泡 1-3 分钟以上，系统可以进行排放而不造成堵塞：

The following material which is immersed in water for 1~3 minutes should be discharged from system without blockage:

- 棉手帕 Cotton handkerchief:
 (400+-35) mm * (400+-35)mm; (15+-5) g 2 块 Pieces
- 塑料袋 Plastic bag:
 (300+-30) mm * (270+-20)mm 1 个 piece
- 塑料袋 Plastic bag:
 (200+-20)mm * (150+-15)mm 1 个 piece
- 金属软木塞 wood plug:
 直径 Diameter 25mm 2 个 pieces
- 男性避孕套 Condom: 2 个 pieces
- 尿布 Napkin:
 净重 Weight (45+-5) g 1 片 piece

整体系统验收必须有施工方、现场工程师、监理单位、投资方、管理单位到场，并记录验收结果。

8. 维修保养

8.0.1 运行记录

Operation record

8.0.2 建议与系统供应商签订合同

Signing with system contractor

8.0.3 运行人员应准备多套吸气阀单元用于更换

Evacuation valves should be stored several pieces as spare parts

8.0.4 建议制定预防维护措施，以便降低故障几率和查找时间

Making maintenance plan

8.0.5 自我监督机制和自我控制的规定

Self-supervision and self-control standard.

9. 计算实例

条件

某地 2500 户居民，
平均每人每天的污水排量为：200L/人·天，
最长的主干管长度为：1600m
其余部分管路长度为：2000m
污水排放的峰值系数取 4

污水量及空气量的计算

人口密度 $EDL = EW / L = 2500/1600 \approx 1.56E/m$
查表 1，可知气水比约为 6
污水当量 $Q_w = 200 \times 24 / 3600 / 24 \approx 0.009 l/(PE \cdot s)$
污水量 $Q_w = E \times W \times f_1 = 2500 \times 200 \times 4 / 3600 / 24 \approx 23.15 l/s$
空气量 $Q_L = Q_w \times AWR = 23.15 \times 6 \approx 138.89 l/s = 500 \text{ normal m}^3/h \text{ air}$

真空泵的选型

真空泵启动压力（绝对压力）设为 $P_{\max} = 45 \text{ KPa}$ ；
真空泵停止压力（绝对压力）设为 $P_{\min} = 35 \text{ KPa}$ ；
大气压力为 $P_u = 100 \text{ KPa}$
安全系数 $SF = 1.25$

运行情况下高峰流量的所需气体

$$Q_{l,s} = SF \cdot Q_L \cdot P_u / [(P_{\max} + P_{\min})/2]$$
$$= 1.2 \cdot 500 \cdot 100 / 40 = 1500 \text{ m}^3/h$$

参阅真空泵选型手册，选择处理能力为 400 m³/h，功率为 11kw

真空泵的数量为： $n_l = Q_{l,s} / Q_{l,p,s} + 1 = 1500/400 + 1 = 5$ 台

真空罐的选型

真空罐所需的最少空气体积为：

$$V_L = 0.25 \cdot Q_{l,p,s} \cdot 1/2 \cdot (P_{\max} + P_{\min}) / [(P_{\max} - P_{\min}) \cdot f \cdot n_l]$$
$$= 0.25 \cdot 400 \cdot 1/2 \cdot (45 + 35) / [(45 - 35) \cdot 12 \cdot 5]$$
$$= 6.7 \text{ m}^3$$

注：设每小时真空泵启动 12 次

真空罐所需最小污水体积为：

$$\begin{aligned}V_w &= 0.25 * Q_{w,p} / f \\ &= 0.25 * 23.15 * 3600 / 12 / 1000 \\ &= 1.74 \text{ m}^3\end{aligned}$$

注：设每小时污水泵启动 12 次

$$V = V_L + V_w = 6.7 + 1.74 = 8.4 \text{ m}^3$$

选择一个真空罐，罐体体积为 13m^3

排水泵的选择

已知排水泵损失 $30\text{mH}_2\text{O}$

污水量 $Q_w = 23.15 \text{ l/s}$

排水泵效率为 30%

排水泵功率为：

$$\begin{aligned}P_{\text{erf}} &= 1000 \times 9.81 \times Q_p \times h / 0.3 / 1000 \\ &= 1000 \times 9.81 \times 23.1 \times 30 / 0.3 / 1000 \\ &= 22.66 \text{ KW}\end{aligned}$$

因此选用 2 台泵，每台泵的功率为 18KW

- [1]. European standard vacuum sewerage systems outside buildings EN1091
- [2]. ATV-DVWK-A116 Special drainage procedures/systems Part 1: Vacuum Drainage outside of buildings
- [3]. Roovac Design Manual
- [4]. General description ROEVAC